



# Ankle and Foot Disorders

Effective Date: July 16, 2018

## CONTRIBUTORS TO ANKLE AND FOOT DISORDERS GUIDELINE

### Editor-in-Chief:

Kurt T. Hegmann, MD, MPH, FACOEM, FACP

### Assistant Editor:

Matthew A. Hughes, MD, MPH

### Evidence-based Practice Ankle and Foot Panel Chair:

Nelson S. Haas, MD, MPH, FACOEM

### Evidence-based Practice Ankle and Foot Panel Members:

Patrick J. Beecher, MD, MPH, MBA, FACOEM

Mark Easley, MD

Hannah Edwards, MD, MPH

Harold Hoffman, MD, FRCPC

Steven Mandel, MD, FACOEM

RobRoy L. Martin, PhD, PT, CSCS

Pete Thomas, DPM, QME

*The Evidence-based Practice Ankle/Foot Panel represents expertise in occupational medicine, neurology, podiatric surgery, foot and ankle surgery, physical therapy, and rehabilitation science.*

### Guidelines Methodology Consultant:

Kurt T. Hegmann, MD, MPH, FACOEM, FACP

### Research Conducted By:

Kurt T. Hegmann, MD, MPH, FACOEM, FACP

Matthew A. Hughes, MD, MPH

Jeremy J. Biggs, MD, MSPH

Matthew S. Thiese, PhD, MSPH

Ulrike Ott, PhD, MSPH

Kristine Hegmann, MSPH, CIC

Atim Effiong, MPH

Holly Diane Uphold

Emilee Eden, MPH

Jenna K. Lindsey, BS

**Specialty Society and Society Representative Listing:**

ACOEM acknowledges the following organizations and their representatives who served as reviewers of the “Ankle and Foot Disorders” guideline. Their contributions are greatly appreciated. By listing the following individuals or organizations, it does not infer that these individuals or organizations support or endorse the ankle and foot treatment guidelines developed by ACOEM.

**2011 EXTERNAL REVIEWERS****American Physical Therapy Association**

Stephanie Albin, DPT, FAAOMPT, OCS  
Thomas G. McPoil, PT, PhD, ATC, FAPTA

**American Podiatric Medical Association**

Clinical Practice Advisory Committee (CPAC)

**California Orthopaedic Association**

Carol Frey, MD

**Other Reviewers:**

Kathryn L. Mueller, MD, MPH, FACOEM

**2015 EXTERNAL REVIEWERS****American Academy of Physical Medicine & Rehabilitation****American Association of Occupational Health Nurses**

Kimberly Olszewski, DNP, CRNP, COHNS-CM, FAAOHN

**American College of Foot and Ankle Surgeons**

Andrew J. Meyr, DPM, FACFAS

**American Occupational Therapy Association**

Michelle L. Bradshaw, DC, OTR/L  
Julie Dorsey, OTD, OTR/L, CEAS

**American Physical Therapy Association****American Podiatric Medical Association**

James R. Christina, DPM

**American Society of Anesthesiologists**

Andres Navedo, MD

**California Orthopedic Association**

Eric Gokcen, MD  
F. Ray Nickel, MD, MPH  
Tye Ouzounian, MD  
Steven Ross, MD  
Ronald Smith, MD

## Table of Contents

Impact .....	5
Summary of Recommendations and Evidence.....	5
Basic Principles and Definitions .....	6
Initial Assessment.....	7
Table 1. Red Flags for Potentially Serious Ankle and Foot Conditions .....	7
Medical History and Physical Examination.....	9
Medical history .....	9
Physical Examination .....	11
Diagnostic Criteria.....	13
Table 2. Diagnostic Criteria for Non-red-flag Conditions that Can Be Managed by Primary Care Physicians .....	13
Work-Relatedness .....	15
Work Activities .....	15
Initial Care.....	15
Follow-up Visits.....	15
Maximal Medical Improvement.....	16
Special Studies and Diagnostic and Treatment Considerations. . . . .	16
Achilles Tendinopathy .....	16
Achilles Tendon Rupture .....	53
Ankle Tendinopathies (Other than Achilles Tendinopathy) .....	77
Tenosynovitis (Including Stenosing Tenosynovitis) .....	77
Plantar Heel Pain (“Plantar Fasciitis”) .....	82
Foot Ulceration .....	146
Wound Care, Subungual Hematoma, Contusions .....	184
Charcot Joint (Neurogenic Arthropathy) .....	184
Paronychia.....	185
Foot Drop.....	186
Tarsal Tunnel Syndrome (TTS).....	187
Ankle Sprain .....	201
Mid-tarsus Pain and Sprains .....	294
Foot Neuroma (Morton’s Neuroma) .....	295
Bunions / Hallux Valgus .....	302
Hammer Toe.....	307
Ankle and Foot Fractures.....	308
Hindfoot Fractures (Calcaneus, Talus).....	345
Forefoot and Midfoot Fractures (Tarsal, Metatarsal, Phalangeal).....	357
APPENDIX: Low-quality Randomized Controlled Trials and Non-randomized Studies.....	365
FOOT ULCERATIONS.....	365

FOOT DROP .....	378
MORTON'S NEUROMA .....	380
ACHILLES TENDINOPATHY .....	380
ACHILLES TENDON RUPTURE .....	381
PLANTAR FASCIITIS.....	382
ANKLE SPRAINS.....	386
ANKLE FRACTURES.....	409
References .....	418

## **Impact .....**

According to the U.S. Bureau of Labor Statistics, ankle and foot claims account for approximately 11% of all reports of non-fatal occupational injuries and illnesses involving days away from work; constitute less than half (44%) the claims pertaining to the lower extremity; and are more common than head, neck, arm and shoulder claims. (BLS 2014 Table 17) However, the cost of medical treatment of the ankle and foot is less than for most other areas of the body. For example, the average workers' compensation claim in Texas was \$3,406, \$3,702, \$3,671, and \$3,665 in 2010, 2011, 2012, and 2013, respectively. (TX Dept Ins WC Res Grp 14) But, the average cost for ankle and foot soft tissue claim was \$1,313, \$1,361, \$1,619, and \$1,677, for each respective year from 1999 to 2002.(5) (TX Dep Ins WC Res Grp Med Cost Trends) Overall, ankle and foot soft tissue claims accounted for approximately 3% of medical costs for soft tissue claims of defined areas.(6) (TX Dept Ins WC ResGrp-Med Cost Qual Care)

This guideline addresses common and potentially work-related ankle and foot disorders. It encompasses assessment; including identification of "red flags" or indicators of potentially-serious injury or disease; diagnosis; special studies for identification of clinical pathology; work-relatedness; and management, including modified duty and activity, return to work, and an approach to delayed recovery. Red flags include fracture, dislocation, malignancy, metabolic disorders, infection, and other conditions.

## **Summary of Recommendations and Evidence**

**All guidelines include analyses of numerous interventions whether or not they are approved by the U.S. Food and Drug Administration (FDA). For non-FDA-approved interventions, recommendations are based on the available evidence. This is not an endorsement of their use. Many of the medications recommended are utilized off-label.**

The following is a general summary of the recommendations contained in this Guideline:

- Initially, perform a thorough assessment, seek red flags, and formulate a differential diagnosis. Assign a working pathological or tissue diagnosis when the likelihood of a specific disorder is high. If an accurate pathological or tissue diagnosis is not obvious, assign a symptomatic diagnosis. Additionally, assignment of a working diagnosis may be helpful.
- When red flags are present, take appropriate action, including referral. In the absence of red flags, focus on management of the ankle and/or foot disorder by monitoring for complications, facilitating healing, and relieving discomfort.
- The health care team should identify and eliminate causative factors and consider modifying symptom-provoking activities. Workstation ergonomic analyses and reduction of weight-bearing; force; awkward positioning; slip, trip, or fall hazards; and/or vibration may be helpful. Work technique and footwear should be considered; however, there is a paucity of information about what constitutes appropriate footwear in occupational environments. Footwear should fit well, be comfortable, and provide adequate protection.
- Assign activity limitations as appropriate. Discomfort may be relieved in the short-term by decreasing or modifying offending activities, administering analgesics, advising elevation of the affected limb, applying hot and cold compresses, using properly fitted footwear, using ankle or foot splints or supports and toe splints, and providing floor padding as appropriate. Individual treatment sections should be consulted for specific applications.
- Avoid immobilization except for short periods during post-operative recovery and initial stages of fracture healing. Apply measures to retain mobility as soon as possible when complete or partial immobilization of the ankle and/or foot is unavoidable.
- If symptoms that limit activities or require treatment persist beyond the expected time for recovery, reconsider the diagnosis and/or treatment approach. However, multiple ankle-foot conditions have poorly characterized, wide ranges for recovery times. If recovery is slower than expected, advance evaluation and consider referral, further diagnostic studies, and/or changes in management. Referrals to occupational physicians, physiatrists, physical therapists, occupational therapists,

orthopedic surgeons, podiatrists, orthotists, or others should be considered, depending on the presentation of the patient.

- Investigate and address non-physical factors (i.e., psychiatric, psychosocial, psychophysiological, workplace, or socioeconomic issues), particularly when there is a delay in recovery or return to work without purely-objective physical findings to validate reasons for delays. These factors are often not overt and specific inquiries may be required to identify whether delayed recovery and return to work is due to physical or non-physical issues.

## ***Basic Principles and Definitions***

**Bunion:** See hallux valgus.

**Fasciitis:** Inflammation of supportive band or covering.(7) (Thomas 85)

**Hallux Valgus:** Lateral deviation of the great toe at the metatarsophalangeal joint with respect to the midline of the body, generally defined as over 15° and occurring in most cases with medial deviation of the first metatarsal.(8, 9) (Magee 06; Dykyj 89; Meyr 14)

**Inflammation:** A tissue reaction marked by redness, warmth, swelling, and pain, usually in response to injury or infection.(7, 10) (Thomas 85; Gilkeson 97)

**Ligament:** A band or sheet of strong fibrous connective tissue connecting the articular ends of bones serving to bind them together and facilitate or limit motion.(7) (Thomas 85)

**Metabolic Disorder:** Any pathologic condition of any chemical or physical process that take place within an organism.(7) (Thomas 85)

**Metatarsalgia:** Pain in the forefoot at one or more of the metatarsal heads.(7, 11) (Thomas 85; Greene 01)

**Morton's Neuroma (Interdigital Neuroma):** A benign tumor of the neurovascular bundle of the intertarsal spaces that can be between any two distal metatarsal bones, although classically, "Morton's neuroma" describes the specific location only between the 3<sup>rd</sup> and 4<sup>th</sup> metatarsals.(7, 11) (Thomas 85; Greene 01)

**Neuroma:** A benign tumor composed of nerve cells.(7) (Thomas 85)

**Paratenon:** tissue filling the space between a tendon and its sheath. (Merriam-Webster Medical Dictionary: <http://www.merriam-webster.com/medical/paratenon.>)

**Plantar Fasciitis:** Pain in the plantar aspect of the heel that may also be present along the fascia of the arch of the foot (11, 12) (Richardson 92; Greene 01) determined by clinical criteria, and not clearly originating in the fascia of the plantar foot or caused by inflammation.

**Referred Pain:** Pain derived from pathology that is not at the location of the pain.

**Retinaculum:** A band or bandlike structure that holds an organ or a part in place. (Stedman Medical Dictionary 15)

**Sprain:** Injury, not necessarily permanent, of a ligament.(7) (Thomas 85)  
S, Grade I: overstretching or slight tearing without instability.  
S, Grade II: incomplete tearing.

S, Grade III: complete tear or rupture.

**Strain:** Injury, not necessarily permanent, of a muscle or musculotendinous unit.(7) (Thomas 85)

S, Grade I: overstretching or slight tearing.

S, Grade II: incomplete tearing.

S, Grade III: complete tear or rupture.

**Synovitis:** Inflammation of synovium.

**Tendinitis or Tendonitis:** Inflammation of a tendon.(7) (Thomas 85)

**Tendinosis:** A chronic degenerative tendon injury, unaccompanied by redness or heat. It is associated with pain and limited movement.(13) (Khan 00)

**Tendinopathy:** Any pathology of a tendon.

Acute, subacute, and chronic symptoms are generally defined as those present for less than 1 month, 1 to 3 months, and greater than 3 months, respectively.

## ***Initial Assessment***

General Approach to Initial Assessment and Documentation guideline) constitute an adequate initial assessment of a patient complaining of ankle or foot problems associated with employment. The initial evaluation should eliminate likely presence of red flags (see Table 1) and distal sources of foot and ankle pain. The absence of red flags eliminates the proximate need for special studies, referrals, or hospital admission, and allows reassurance of the patient during the period early in treatment and when spontaneous recovery is expected.

Foot and ankle complaints are classified as follows:

- **Potentially serious (red flag) foot and ankle conditions:** Fracture, dislocation, neurovascular compromise, tendon rupture, and neoplastic, inflammatory, metabolic, or infection disorders.
- **Mechanical disorders:** Derangements of the foot or ankle related to acute trauma, such as ligament strain.
- **Degenerative disorders:** Possible consequences of aging or repetitive use, or a combination thereof, such as degenerative arthritis and chronic tendinitis, tenosynovitis, or tendinosis.
- **Referred pain or paresthesias**
- **Nonspecific disorders:** Discomfort occurring in the foot or ankle that does not satisfy the diagnostic criteria of a serious condition, derangement, degeneration, or referred pain.

***Table 1. Red Flags for Potentially Serious Ankle and Foot Conditions***

<b>Disorder</b>	<b>Medical History</b>	<b>Physical Examination</b>
Dislocation	Significant ankle or foot trauma Ankle or foot deformity with or without spontaneous reduction or self-reduction	Edema Deformity
Fracture	Significant trauma Abnormal mobility Deformity with or without spontaneous or self-reduction Painful swelling of ankle or foot	Edema Ecchymosis or hematoma Deformity Abnormal mobility Bony crepitus
Infection	Swelling, redness, localized warmth of ankle or foot Fever or chills	Visible and/or palpable mass Local tenderness, heat, swelling, erythema

	Diabetes or immunosuppression (e.g., transplant, chemotherapy, HIV)	Systemic signs of infection (fever, tachycardia)
Inflammation	Inflammatory arthritis or autoimmune disease	Swelling, effusion, erythema, warmth, or edema
Metabolic disorder	Poor nutrition Changes in weight, appetite, energy level, skin, or bowel or bladder function Hair loss	
Acute gout	Sudden attack(s) of joint pain, redness, and swelling, usually monarticular, especially of the great toes Predisposing factors of being a man or postmenopausal woman, renal impairment, hyperuricemia, and use of diuretics or cytotoxic drugs(14) (Hellmann 95)	Swelling Red, tender, warm first metatarsal joint
Neoplasm	Neoplastic disorder Unexplained weight loss, fatigue, masses	Palpable mass Deformity of ankle or foot
Rapidly progressive neurological compromise	Neuropathy, decreased or absent sensation Neurologic disease Diabetes Dislocation or fracture May have sustained laceration, or direct trauma	Decreased sensation in feet and ankles Loss of vibratory or positional sense Altered sensation in a dermatomal distribution Absent ankle jerk Motor loss in specific distribution Painless swelling (Charcot's joint)
Rapidly progressive vascular compromise	Diabetes Peripheral vascular disease or bypass grafts Dislocation or fracture May have sustained laceration, or direct trauma	Decreased or absent foot and ankle pulses Decreased capillary filling Cold, pale extremity
Tendon ruptures and evulsions		
Achilles	Sharp pain to the posterior distal calf or ankle, may be accompanied by loud pop Forceful plantarflexion of the foot, or unaccustomed and vigorous running, hiking, or climbing May have sustained laceration, open wounds, crush injuries, or direct trauma May have degloving injury Administration of fluoroquinolones or local injections(14) (Hellmann 95)	Swelling and bruising Inability to point foot downward and stand or walk comfortably Positive Thompson test May have overlying signs of trauma including laceration, open wounds, puncture wounds, crush injuries
Peroneal	Pain and swelling of the lateral heel May have sustained laceration, open wounds, crush injuries, or direct trauma May have degloving injury	Impaired eversion strength(15) (Evans 66) May have overlying signs of trauma including laceration, open wounds, puncture wounds, crush injuries
Tibialis, Anterior	Swelling and pain in the anterior ankle May have sustained laceration, open wounds, crush injuries, or direct trauma May have degloving injury	Anterior ankle tenderness, probable impaired dorsiflexion strength, tenderness at the first metatarsotarsal joint(16) (Khoury 96)

		May have overlying signs of trauma including laceration, open wounds, puncture wounds, crush injuries
Tibialis, Posterior	Medial ankle pain and swelling, particularly if behind the medial malleolus, new or progressive flatfoot deformity (with or without pain) May have sustained laceration, open wounds, crush injuries, or direct trauma May have degloving injury	Flatfoot deformity, particularly when unilateral; tenderness of the posterior medial malleolus,(17, 18) (Rosenberg 88a, 88b) asymmetrical flat foot, difficulty with ipsilateral heel raise(19, 20) (Marcus 93, Karasick 93) May have overlying signs of trauma including laceration, open wounds, puncture wounds, crush injuries

## ***Medical History and Physical Examination***

### ***Medical history***

For foot and ankle injuries, the purpose of a medical history is to gather information that can be used to manage the case. The medical history is the foundation by which to identify the diagnosis, risk factors, complicating factors, causation, investigation plan, treatment recommendations, and fitness for work. A medical history requires a focused interview to obtain information about the main problem (presenting or chief complaint) – the issue that motivates the patient to seek attention. This is stated in a short sentence or phrase and usually volunteered by the patient early in the encounter. The following information also needs to be obtained:

1. *Circumstances at onset of symptoms:* May help with formulation of a mechanism of injury/disease etiology.
  - If there was a sudden onset, what was the nature of incident:
    - bending, twisting, inversions, eversion
    - trauma, blunt
  - Symptoms at onset:
    - acute or gradual onset;
    - anatomic location;
    - quantity;
    - quality;
    - duration;
    - aggravating factors;
    - alleviating factors;
    - associated symptoms.
  - Activities at onset:
    - routine activities;
    - unusual activities; or
    - single incident or accident.
  
2. *Current status of the foot or ankle problem symptoms:* Has the main problem severity, location, or other characteristics changed?
  - Quantity and quality: pain, weakness, limited motion, deformity, swelling, discoloration.
  - Constant or intermittent symptoms.
  - Aggravating and alleviating factors:
    - time of day or week when symptoms increase or decrease;
    - activities that increase or decrease symptoms;
    - footwear that increases or decreases symptoms; and/or,

- factors that make the problem better or worse.
  - Associated symptoms:
    - Are the problems located primarily in the foot or ankle?
    - Does the patient have pain or other problems elsewhere?
  - Impact on function:
    - Limitations in function due to the foot and ankle problems:
      - What can't the patient do now?
      - Is this problem limiting his or her activities?
      - Can he or she walk or bear weight?
3. *Occupation*: What are the working conditions that may be involved in disposing persons to accidents, causing disease, or provoking symptoms?
- Work situation:
    - specific job duties;
    - duration of individual tasks each day;
    - time on feet daily;
    - feet supports:
      - footwear,
      - orthotics, or
      - assistive devices;
    - physical factors:
      - floor surfaces (regular or irregular, slippery, hard or soft);
      - indoor or outdoor work; and
      - weight-bearing activities (e.g., standing, walking, climbing stairs, ladders, or equipment, jumping);
      - material handling (lifting, carrying, pushing, pulling);
    - psychosocial factors – What does the patient like and dislike about the job?
      - Are there good or bad relationships at work with co-workers and supervisors?
      - Does the patient find his or her job stimulating, monotonous, and/or stressful?
      - What is the patient concept of the cause of the problems? Is there a sense of blame and being wronged? Does the patient have or is the patient considering legal counsel?
4. *Activities*:
- Current work activities:
    - What are the patient's current and past avocational (home and recreational) activities (hobbies, exercise, sports, volunteer activities), and family responsibilities (e.g., caring for a disabled family member)?
    - Does the patient run, hike, jump, or climb?
    - Have these activities changed lately?
5. *Current treatments for foot and ankle problems*:
- medications;
  - foot, leg, and ambulation supports (footwear, orthotics, assistive devices); and
  - physical modalities (e.g., physiotherapy, podiatry, etc.)
6. *Patient goals*:
- health condition;
  - function;
  - return to work; and
  - finances.
7. *General inquiry (review of systems)* is used to detect concurrent conditions and avoid treatment pitfalls.

- Is there weight change, swelling, fever, or fatigue?
  - Problems in other body parts may indicate the need to examine these areas.
8. Past medical and health history:
- past diagnoses, treatment, and effects of treatment for the foot and ankle problems:
    - previous similar episodes;
    - previous investigations or consultations; and
    - previous treatments with results of treatments.
  - general medical conditions;
  - surgery; and
  - other medical or health conditions, activity intolerances, and medical treatment (e.g., medications).

Ambiguity in documentation can result in missed diagnoses, redundant testing and treatment, and delayed claim processing. The physician should be scrupulous in documentation, including noting which ankle or foot – left or right – is the subject of the patient’s complaints. For example, if a worker has prior work-related claim that involves the opposite ankle or foot, confusion may develop as to what should be done for the “old” or the “new” injury.

### **Physical Examination**

The physical examination should be guided by the medical history and encompass:

- General observation of the patient;
- Regional examination of the ankles and feet; and
- Neurovascular screening.

### **Objective Examination Findings**

The physician should seek objective evidence of pathology that is consistent with the patient’s subjective complaints. In many cases, truly objective findings such as swelling, deformity, atrophy, reflex changes, or spasm will be present. Observe for signs of serious injuries, e.g., degloving injuries, lacerations, puncture wounds open wounds and crush injuries. Any such findings should be thoroughly documented in the medical record both for reference during future visits and in support the patient’s claims. For example, in the case of muscle spasm, the physician must document in which muscle the spasm has occurred (see Measurement).

### **Subjective Components of the Examination Findings**

For some patients with ankle or foot complaints there are no objective findings. Meticulous documentation of the patient’s complaints at each visit is of the utmost importance in such cases, particularly if psychosocial complications appear to be present. Damage to tissue does not shift, and consistency of subjective examinations findings (e.g., tenderness, pain with manual muscle testing) may add to or detract from support for elements of the differential diagnosis. Consider palpating widely during multiple visits to determine consistency of findings. Tenderness, weakness, and specific changes in mobility should be predictable among visits. If symptoms and examination findings change unexpectedly, particularly in the absence of objective findings, suspect a non-anatomic/non-physiologic disorder.

### **Measurement**

To accompany both symptoms and objective and subjective examination findings, quantification should be part of the examination and record. For example, when swelling is claimed or edema present, the extent of the swelling or edema should be recorded with tissue-pen outlines and photographs and with circumference measurements; when limited range of motion (ROM) is present, angles of movement should be measured; and when weakness is present, maximal weights lifted should be recorded.

### **Anatomy**

A full description of the ankle and foot is complex and beyond the scope of these *Guidelines*. The ankle and foot has 14 bones (not including those in the toes), many ligaments, tendons, and muscles, and can be separated into the hind-, mid-, and forefoot. The hindfoot contains the ankle (talocrural) and subtalar

(talocalcanean) joints – the former is responsible for most of the plantarflexion and dorsiflexion of the foot – and the talus and calcaneus. The midfoot contains the remainder of the tarsal bones. Most supination, pronation, and rotation of the foot occur at the subtalar and mid-foot joints. The forefoot contains the tarsal bones and the toes. Additionally, the distal talofibial syndesmosis is part of the ankle.(8, 21) (Magee 06; Kapandiji 87 p. 148-65; Kapandiji 87 p. 166-215)

The movements of the ankle and foot include:

- flexion (dorsiflexion) – upward movement of the foot at the ankle;
- extension (plantarflexion) – downward movement of the foot at the ankle;
- eversion – twisting of the foot with the sole facing laterally;
- inversion – twisting of the foot with the sole facing medially;
- abduction – movement of the foot in the axis of the lower leg so that the forefoot and toes move laterally;
- adduction – movement of the foot in the axis of the lower leg so that the forefoot and toes move medially;
- pronation – a combination of dorsiflexion, eversion, and abduction that moves the plantar aspect of the forefoot and toes to face laterally; and
- supination – a combination of plantar flexion, inversion, and adduction that moves the plantar aspect of the forefoot and toes toward the midline.

Dorsiflexion and plantar flexion are achieved by muscles with attachments anterior and posterior of the malleoli, respectively. The dorsiflexors include the tibialis anterior, extensor hallucis longus, and extensor digitorum longus. The plantar flexors include the peroneus longus and brevis, gastrocnemius, soleus, flexor hallucis and digitorum longi, and tibialis posterior. These muscles, along with the intrinsic muscles of the foot, are responsible for pronation and supination.

### **Focused Foot and Ankle Examination**

*Observation* – Examine both feet and look for and note asymmetries. Note heel structure and position, including arch shape at rest and when the patient bears weight. Inspect medial and lateral dorsal and plantar aspects of the foot and ankle for skin integrity, edema, erythema, and/or ecchymosis that often occur over the injury site, and for deformities suggestive of degeneration, malformation, fracture, or dislocations. Observe for signs of serious injuries, e.g., degloving injuries, lacerations, puncture wounds, open wounds and crush injuries. The quality of findings may infer timing as well as location of ankle and foot disorders. Muscular atrophy arises only after weeks or months of problems. Ecchymosis may or may not betray diffusion of hemolysis that can take days to become evident. Observe weight-bearing skeletal alignment of the foot and ankle in relation to the whole body for local skeletal malalignment and correlated and compensatory motions and postures. Observe foot and ankle motion during gait, and during functional tasks (e.g., donning and doffing shoes), particularly those that are affected by the disorder. Usually, a person avoids placing weight on the injured or painful portion of the foot.

*Palpation* – Carefully palpate the ankles and feet for edema, tenderness, structural continuity, nodules and deformities including voids, and warmth. Close attention should be paid to the distal fibula, distal tibia, fifth metatarsal and calcaneocuboid joint because they are the areas most often injured in avulsion fractures. Palpation of the proximal fibula is also performed to help detect a Weber C ankle fracture. Palpate the tendons and their insertions, and the musculotendinous junctions. Always palpate bilaterally.

*Range of Motion* – The range of motion (ROM) of the foot and ankle should be determined both actively and passively. Check all axes of mobility (see Anatomy), and compare mobility of the affected and unaffected side. Expected mobility ranges can be found in sources such as the *AMA Guides to the Evaluation of Permanent Impairment*, and Hoppenfeld's *Physical Examination of the Spine and Extremities*.

**Strength** – Resisted ROM may be used to assess strength and the presence of injury in muscles, tendons, and their attachment points. Note weakness and distribution of pain and its anatomic correlation or lack thereof.

**Joint Integrity** – Stress the ligaments to assess the stability; include the anterior drawer tests of the ankle and talar tilt tests (supination of the ankle so that the lateral aspect of the talus faces down). The anterior drawer test is performed with the foot in neutral position, the foot held firmly at the heel, and posterior (sheer) force applied to the tibia. If significant anterior displacement of the foot relative to the distal tibia can be felt, it indicates a significant abnormality of the anterior talofibular ligament. (Lahde 88; van Dijk 96) The talar tilt test applies inversion force to the effected ankle while the lower leg is stabilized. A positive test indicates lateral ligamentous laxity. There should be comparable mobility in the contralateral side if both sides are normal. The squeeze test may be used to diagnose injury to the tibiofibular syndesmosis and involves placing the hands about 6 inches distal to the knee with thumbs on the fibula and fingers on the medial tibia, then squeezing the leg to bring the fibula and tibia together. Ankle or distal leg pain indicates syndesmotic injury.(8) (Magee 06)

**Neurovascular Screening** – Assess neurologic and vascular status of the foot and ankle (including skin temperature, peripheral pulses, and motor, reflex, and sensation of the foot and ankle and surrounding structures). Observe for signs of serious injuries, e.g., degloving injuries, lacerations, puncture wounds open wounds and crush injuries. Observe the skin for trophic changes. Examination of lumbosacral nerve root function also is in order because L5 radiculopathy can affect dorsiflexion and toe extensors and S1 radiculopathy can affect plantar flexion (see Low Back Disorders Guideline). Patients with peripheral neuropathy (e.g., diabetics) may have decreased sensation in the foot or ankle and neuropathic joints presenting as acute swelling or inflammation. Peripheral nerve entrapment may be manifested as foot drop if the peroneal nerve at the knee is involved or rarely, as tarsal tunnel syndrome, presenting as numbness of the plantar surface of the foot and toes. Foot drop can be seen in L5 neuropathy due to an L4-5 disc protrusion. Consider assessing the posterior tibial and dorsalis pedis pulses, and capillary refill time.

### Assessing Red Flags

Physical examination evidence of neurovascular compromise that correlates with the medical history and test results may indicate a need for immediate consultation. The examination may further reinforce or reduce suspicion of tumor, infection, tendon rupture, metabolic disorder, fracture, or dislocation.

## Diagnostic Criteria

Diagnoses should be based on symptoms and examination and study findings, using rational, evidence-based criteria for the diagnosis whenever it exists. Ideally, the criteria for the diagnosis specifies how a pathologic state is determined (symptoms, dysfunction); and how to distinguish the pathological state deviates from the healthy state to cause the symptoms and dysfunction (abnormal examination and study findings). When assigning a diagnosis, the more specific the signs and symptoms, the more certain the diagnosis. When complaints and examination findings are diffuse, certainty of diagnosis must be low as many diagnoses may apply.

**Table 2. Diagnostic Criteria for Non-red-flag Conditions that Can Be Managed by Primary Care Physicians**

Probable Diagnosis or Injury	Mechanism	Unique Symptoms	Unique Signs	Tests and Results
Ankle sprain	Inversion of ankle Eversion of ankle	Pain at or below lateral or medial malleolus Swelling	Swelling at or below malleolus	None (radiograph negative if obtained)

		over or near malleolus	Tenderness over medial or lateral ankle ligament With severe sprain, positive drawer sign for instability	
Forefoot sprain	Plantar flexion, dorsiflexion, or inversion beyond range	Dorsal foot pain Swelling of dorsal foot	Swelling in dorsum of foot Tenderness over dorsum of foot	None (radiograph negative if obtained)
Ankle or foot tendonitis	May be idiopathic, due to inflammatory conditions, and speculatively due to overuse	Heel cord pain Pain over specific tendon unit with plantarflexion or dorsiflexion	Pain over muscle/tendon unit on motion or resisted motion of tendon unit Tenderness of involved tendon	None
Neuroma	Idiopathic	Gradual onset of pain and paresthesias on both sides of web space	Reproduction of symptoms by pressing metatarsals together or pressing web space	None
Metatarsalgia	Idiopathic Degenerative changes Prolonged weight bearing	Gradual onset of pain under metatarsal heads with weight bearing	Reproduction of metatarsal pain on compression Decreased tissue padding under metatarsal heads	None
Bunion , hallux valgus	Degenerative change	Lateral deviation of first toe Pain in first toe from overlap with tight footwear	Lateral angulation of great toe	Metatarsal angle of >10°
Plantar fasciitis	Idiopathic	Pain across sole of foot Pain with 1st step upon rising in the morning	Tenderness on compression of plantar fascia	None
Heel spur	Degenerative change Idiopathic	Pain at heel with weight bearing First steps upon rising in the morning very painful in heel	Point tenderness over plantar calcaneus	Radiograph positive for plantar calcaneal spur (if obtained)
Metatarsal stress fracture	Repetitive load	Pain in the dorsal forefoot on weight bearing	Point tenderness over metatarsal shaft	Radiograph positive later in course of disorder Bone scan or spiral CT positive
Toe fracture	Direct trauma	Pain at fracture site (possibly)	Point tenderness Deformity Hematoma	Positive radiograph

Crush Injury	Direct trauma	Ranges from nonspecific pain to pain at fracture site	Point tenderness Deformity Hematoma Swelling	Positive radiograph(s)
Nonspecific foot or ankle pain	Unknown	Nonspecific pain in foot or ankle	None	None

## ***Work-Relatedness***

A thorough work history is crucial to establishing work-relatedness (see General Approach to Initial Assessment and Documentation guideline). Determining whether a complaint of a foot or ankle disorder is work related requires careful analysis and weighing of all associated or apparently causal factors operative at the time. A predominance of work factors suggests that worksite intervention is appropriate. A cluster of cases in a work group suggests a greater probability of associated work-design or management factors.

Prolonged weight bearing may exacerbate Morton’s neuroma, metatarsalgia, hallux valgus, and plantar fasciitis. However, a cause-effect relationship between any of these conditions and workplace factors has not been shown. Acute trauma at work can be associated with tendinitis, tenosynovitis, and ligament strains. Stress fractures can be related to a recent increase in walking or weight-bearing activities. The relation of “chronic strain” or degenerative joint disease to work in the absence of specific traumatic exposures has not been documented in well-designed studies.

## ***Work Activities***

Key factors to consider in disability duration are age and type of job, especially if the regular work includes activities likely to worsen the condition. It is important for the physician to clarify with patients and employers that:

- Even moderately heavy material handling may provoke foot and ankle symptoms caused by tendinitis, plantar fasciitis, heel spurs, metatarsalgia, and other conditions.
- Any restrictions are intended to allow for spontaneous recovery or time to build activity tolerance through exercise.

## ***Initial Care***

Comfort is often a patient’s first concern. Nonprescription analgesics, short-term non-weight bearing activities, cold application and elevation will provide sufficient pain relief for most patients with acute and subacute symptoms. If treatment response is inadequate (e.g., if symptoms and activity limitations continue), prescribed pharmaceuticals or physical methods can be added. Co-morbid conditions, side effects, costs, and provider and patient preferences guide the physician’s choice of recommendations.

## ***Follow-up Visits***

Patients with ankle and foot complaints should have re-evaluations dependent on their condition. Evaluations as frequently as three days after return to work, change in work limitations, or treatment may be appropriate, including to provide counseling on avoiding static positions, medication use, activity modification, and other concerns. Care should be taken to answer questions and make these sessions interactive so that the patient is fully involved in his or her recovery. These interactions may be done on

site or by telephone. Most treatment tested in clinical trials is delivered for short periods, usually no more than 4 weeks, and the effect of treatment is usually evident within a month. When treatment has little or no effect, using the timeframes indicated in Table 6 for guidance, a change in treatment approach should be considered.

## ***Maximal Medical Improvement***

After a patient has accepted all reasonable medical treatment and the condition demonstrates stabilization, a point of maximal medical improvement (MMI), also known as a “medical end point” or “medical end result” has been reached. When a point of maximal medical improvement is reached with full recovery, the patient should be discharged from treatment of the work-related ankle-foot problem. When a point of MMI is reached without full recovery, permanent activity limitations and ongoing treatment (if necessary) should be specified.

## ***Special Studies and Diagnostic and Treatment Considerations***

For most cases presenting with true foot and ankle disorders, special studies are usually not needed until after a period of conservative care and observation. Most ankle and foot problems improve quickly once any red flags are ruled out. Routine testing, i.e., laboratory tests, plain-film radiographs of the foot or ankle, or special imaging studies are not recommended during the first month of activity limitation, except when a red flag that is noted on history or examination raises suspicion of a dangerous foot or ankle condition or of referred pain.

## **Achilles Tendinopathy**

### ***General Approach and Basic Principles***

Achilles tendon disorders, including Achilles tendinitis, tendinosis, or tendinopathy, are painful conditions affecting the Achilles tendon, which is the largest and strongest tendon in the body, connecting the soleus, and gastrocnemius muscles in the leg to the heel at the calcaneus bone.(22) (Tan 08) The Achilles tendon plantar flexes the ankle and facilitates walking. Achilles tendon disorders can make walking difficult.

Proper management of Achilles tendon disorders should be distinguished on the basis of location – the distal insertion into the calcaneus (within 2cm of insertion) as opposed to the mid-portion of the tendon, often defined as the segment between 2cm and 6cm proximal to the calcaneal insertion, as these are different entities. Despite the differences that come with location, some studies do not clearly classify patients based on location. A distinction between acute, subacute, or chronic disorders is important in distinguishing between potential etiologies of pain and selecting the best intervention strategies, but the literature has inconsistent definitions of acuity.(23) (Magnussen 09)

The term “tendinopathy” in Achilles tendon disorders is the general reference term for the diagnosis of pain, swelling, and impaired performance.(24) (Maffulli 98) The term “tendinosis” now refers to a non-inflammatory disorder of the midport of the tendon (2 to 6cms proximal to the insertion) with tendon degeneration confirmed histologically(23, 25) (Alfredson 00, Mafi 01, Magnussen 09); devascularization is common.(26, 27) (Heckman 09, Reddy 09) The morphological feature is increased interfibrillar glycosaminoglycans and changes in the collagen fiber structure and arrangement. It may be considered a failed healing response.(28) (Rompe 09)

**Paratenonitis** is an inflammatory condition of the peritendinous structures, including the paratenon.(27) (Reddy 09) The Achilles tendon does not have a true tendon sheath, but a paratenon – a single layer of

cells composed of fatty, mesentery-like areolar tissue that is highly vascularized.(27) (Reddy 09) **Insertional tendinosis** is an inflammatory process involving the distal 2cm and is often associated with **Haglund's** deformity, which is a prominent posterior superior calcaneal tuberosity that contributes to changes in the overlying tissues (bursa, tendon). **Retrocalcaneal bursitis** is another source of calcaneal heel pain, caused by irritation of the retrocalcaneal bursa. The cause and pathogenesis of these disorders are unknown,(22, 23, 25, 29, 30) (Mafi 01, Furia 06, Tan 08, Magnussen 09, Rompe Disabil Rehabil 08) although age appears to be an important factor. Associations between Achilles tendinopathy and sports are reported, but a cause-effect relationship between Achilles tendon problems and activities has not been established. Inactive individuals acquire Achilles tendon problems(25, 29, 31) (Astrom 92, Mafi 01, Furia 06) – up to 30% of Achilles tendinopathy occurs in persons who do not participate in vigorous activity.(28) (Rompe 09) Compromise of microcirculation may play a role with Achilles tendinopathy, as well as other tendinopathies, such as patellar, supraspinatus, and bicipital tendinopathy (32) (Knobloch J Orthop Surg Res 08) (see Shoulder Disorders guideline).

### ***Initial Assessment***

Initial assessment should exclude Achilles tendon rupture, and systemic metabolic or inflammatory disorders, and determine the location and duration of symptoms.

### ***Medical History***

Pain from Achilles tendinopathy may occur at rest or during activity.(27) (Reddy 09) A history of activity may include running, jumping, and walking. Pain is the cardinal symptom of Achilles tendinopathy, which may manifest at the beginning and end of vigorous activity, but may become present throughout activity and in routine activities as it becomes more severe or chronic in nature. The pain may limit training or vigorous activity.(27) (Reddy 09) A detailed history of activity including running, jumping, and walking should be elicited.

### ***Physical Examination***

The Achilles tendon should be palpated for tearing, rupture, tenderness, edema, and warmth. Calf-squeeze or knee flexion tests are done (see Achilles Rupture). Single-leg heel raise, hop in place, or hop forward may provoke Achilles tendon pain. Pain from Achilles disorder will be isolated to the Achilles tendon.(30) (Rompe Disabil Rehabil 08) The Achilles tendon may have diffuse discomfort with swelling of the tendon mid-portion. Palpation may identify tenderness of both sides of the tendon. The medial side of the Achilles tendon is usually more tender as the medial fibers are subjected to more stress. Achilles tendon swelling may be fusiform or sausage-like. Palpable or audible crepitus should be noted if present as this denotes paratenonitis. Crepitus is not usually present with intra-substance tendinopathy. A fixed thickening indicates paratenonitis. Intratendinous nodules or thickening that move with the tendon indicate tendinosis.(26, 27) (Heckman 09, Reddy 09)

Tender nodules in the paratenon reflect hypertrophy of connective tissue. Decreased dorsiflexion at the ankle is due to tightness in the tendon complex.(26) (Heckman 09) Compression of the tendon at the calcaneal insertion with medial and lateral pinch that results in pain anterior to the tendon is indicative of retrocalcaneal bursitis. The Victorian Institute of Sport Assessment for Achilles tendinopathy (VISA-A) is a tool for assessing pain and function used in multiple studies cited in this guideline. There are other instruments for assessing pain and function.

### **WORK RESTRICTIONS**

Many patients with mild symptoms require no specific limitations. Patients with moderate or severe Achilles tendinopathies may be allowed to limit activities that provoke symptoms, and should limit activities that pose a safety risk. Consider limitation of jumping, high-force loading of the Achilles tendon, climbing, or activities that require agility or balance. Complete rest is not indicated. Patients may return to their usual jobs, but some may require relative rest.

### ***Special Studies, Diagnostic and Treatment Considerations***

Although diagnosing of non-rupture Achilles disorders is largely based on a careful history and examination, diagnostic imaging may be required to verify a clinical suspicion or to exclude other musculoskeletal disorders.(30) (Rompe Disabil Rehabil 08)

## **X-RAYS**

*Recommendation: X-ray for Diagnosis of Achilles Tendon Disorders, Retrocalcaneal Bursitis, or Blunt Trauma or Suspected Fracture*

**X-ray is recommended for diagnosing insertional Achilles tendon disorders or retrocalcaneal bursitis or evaluating blunt trauma or suspected fracture.**

*Strength of Evidence – Recommended, Insufficient Evidence (I)*

*Level of Confidence – Low*

### *Rationale for Recommendation*

There is no quality evidence for or against the use of x-ray for diagnosing Achilles tendinopathy. X-ray is non-invasive, has low adverse effect profile, but does result in radiation exposure and is of moderate cost. Radiography is poor at diagnosing soft-tissue disorders, and in the absence of trauma or suspected fracture, is not indicated as a first-line diagnostic tool for mid-portion tendon disorders. X-ray may reveal calcaneal spur, prominent posterior calcaneal tuberosity, or ossification of the Achilles tendon.(26) (Heckman 09) For other Achilles disorders, ultrasound or MRI are more effective. Therefore, plain radiographic film studies are recommended only for insertional Achilles tendinopathy or traumatic injury.

## **ULTRASOUND**

*Recommendation: Ultrasound for Diagnosis of Achilles Tendinopathy*

**Ultrasound is recommended for diagnosing Achilles tendinopathy and may be particularly useful for differentiation of paratenonitis and tendinosis and for identifying fluid in the retrocalcaneal bursa.**

*Strength of Evidence – Recommended, Insufficient Evidence (I)*

*Level of Confidence – Moderate*

### *Rationale for Recommendation*

There are no quality randomized trials evaluating the use of ultrasound in the diagnosis of Achilles tendinopathy. However, ultrasound is frequently used to diagnose midportion tendinopathy, and can reveal local thickening of the tendon and/or irregular tendon structure with hypoechoic areas and/or irregular fiber orientation.(28) (Rompe 09) Ultrasound reveals fluid surrounding the tendon acutely and chronically and can show adhesions that can be visualized as thickening of the hypoechoic paratenon.(27) (Reddy 09) Although limited in its ability to distinguish tendon degeneration from partial rupture, ultrasound has a sensitivity of 0.8 and specificity of 0.4, (PPV = 0.49. NPV = 0.68) compared to clinical diagnosis.(22) (Tan 08) Ultrasound is non-invasive, has low adverse effects, and is of moderate cost. However, ultrasound may be less sensitive than MRI; therefore it is recommended when the clinical diagnosis is uncertain.

## **MAGNETIC RESONANCE IMAGING (MRI)**

*Recommendation: MRI for Diagnosis of Achilles Tendinopathy*

**MRI is recommended for evaluating Achilles tendinopathies including paratendonitis, tendinosis, and retrocalcaneal bursitis.**

*Strength of Evidence – Recommended, Insufficient Evidence (I)*

*Level of Confidence – Moderate*

### *Rationale for Recommendation*

There are no quality randomized trials evaluating the use of MRI in the diagnosis of Achilles tendinopathy. MRI can demonstrate thickened paratenon with adhesions and offers extensive

information on the internal structure of the tendon and surrounding tissues.(26) (Heckman 09) Compared to clinical diagnosis, MRI has a sensitivity of 0.95 and specificity of 0.5 (PPV = 0.56, NPV = 0.94).(33) (Tan 09) MRI may be helpful in differentiating inflammatory from degenerative changes in soft tissue. MRI is more expensive than ultrasound, but may be more reliable because there is less chance for operator error and it provides a broader field of view relative to ultrasound. MRI is therefore recommended.

## **COMPUTERIZED TOMOGRAPHY (CT)**

*Recommendation: CT for Diagnosis of Achilles Tendinopathy*

**CT is not recommended for diagnosing Achilles tendinopathy.**

*Strength of Evidence – Not Recommended, Insufficient Evidence (I)*

*Level of Confidence – Moderate*

### *Rationale for Recommendation*

There is no quality evidence for or against the use of CT imaging for the diagnosis of Achilles tendinopathy. While CT is non-invasive and has a low adverse effect profile, it results in radiation exposure and is of moderate to high cost. CT is not helpful in differentiating inflammatory from degenerative changes in soft tissue. As the role of CT has yet to be defined in the literature and has limitations when compared to MRI, it is not recommended.

### **Initial Care**

For each of the Achilles tendon disorders causing pain, the initial management is non-operative. It is believed that early intervention is critical, as management becomes more complicated and less predictable when the conditions become chronic.(30) (Rompe Disabil Rehabil 08)

### **Medications**

#### **NON-STERIODAL ANTI-INFLAMMATORY DRUGS (NSAIDs) AND ACETAMINOPHEN**

The use of oral NSAIDs and acetaminophen are well-described interventions for numerous soft-tissue and musculoskeletal injuries including ankle sprains.(34) (Duranceau 86) The mechanism of action is unclear for musculoskeletal disorders that do not have significant components of inflammation, although some believe the mechanism nevertheless involves addressing some component of inflammation.(35) (Jakobsen 89)

1. *Recommendation: Acetaminophen for Acute, Subacute, or Chronic Achilles Tendinopathy Pain*

**Acetaminophen is recommended for treatment of pain from acute, subacute, or chronic Achilles tendinopathy.**

*Indications – Pain associated with acute, subacute, or chronic Achilles tendinopathy.*

*Frequency/Duration – Frequency and dose per manufacturer's recommendations; may be taken scheduled or as needed (FDA recommended daily doses is less than 4gm a day).*

*Indications for Discontinuation – Resolution, intolerance, adverse effects, lack of benefits, or failure to progress over a trial of 2 weeks.*

*Strength of Evidence – Recommended, Insufficient Evidence (I)*

*Level of Confidence – Moderate*

2. *Recommendation: NSAIDs for Acute, Subacute, or Chronic Achilles Tendinopathy or Post-operative Pain*

**NSAIDs are recommended for the treatment of acute, subacute, or chronic Achilles tendinopathy pain or post-operative pain or inflammation.**

*Indications* – Pain or inflammation associated with acute, subacute, or chronic Achilles tendinopathy, or post-operatively.

*Frequency/Dose/Duration* – Frequency and dose per manufacturer’s recommendations; may be taken scheduled or as needed. As not all NSAIDs have been shown effective for treatment of Achilles tendinopathy, if one NSAID is not effective within 10 days, consider another of a different sub-class (i.e. salicylates, indoleacetates, propionates, phenylacetates, enolates, naphthylalkanones) in its place.

*Indications for Discontinuation* – Resolution, intolerance, adverse effects, lack of benefits, or failure to progress over a trial of 2 weeks.

*Strength of Evidence* – **Recommended, Evidence (C)** – Acute  
**Recommended, Insufficient Evidence (I)** – Subacute, chronic, or post-operative pain  
*Level of Confidence* – High

#### *Rationale for Recommendations*

Acetaminophen is an analgesic and has no therapeutic effect. There is no quality evidence for or against the use of acetaminophen for the treatment of pain from acute and subacute Achilles tendinopathy. There is one low-quality study comparing the effect of paracetamol with ibuprofen for acute sports injuries, which showed ibuprofen to be superior, although the study had several methodological problems.(36) (Bourne 80) However, there is quality evidence that acetaminophen is superior to placebo for treatment of other musculoskeletal disorders, including low back pain, and has a very low adverse-effect profile. However, patients using acetaminophen should be screened for the absence of liver disease and liver-disease risk factors, advised about dosing, and warned of potential hepatotoxicity (see Chronic Pain guideline for acetaminophen use). Oral acetaminophen is recommended for short-term as it is not invasive, has a lack of adverse effects when used as directed, and is low cost.

There is one moderate-quality placebo-controlled study that showed improvement of pain and functional scores.(35, 37) (Jakobsen 88, Jakobsen 89) This study considered multiple acute (less than 48-hours duration) soft-tissue disorders in young (mean age 20.5 years, range 19 to 25 years) military personnel. Of 212 subjects, 71 had Achilles tendinosis that was treated with piroxicam, tenoxicam, or placebo. The study duration was 10 days. The tenoxicam group, but not the piroxicam group, experienced significantly better improvement than the placebo group. As the results for six disorders, including Achilles tendinopathy, were pooled in one analysis,(37) (Jakobsen 88) only the analysis of the Achilles tendinopathy sub-population(35) (Jakobsen 89) applies to this section. There is one low-quality study comparing the effect of paracetamol with ibuprofen for acute sports injuries, which showed ibuprofen to be superior, although the study had several methodological problems.(36) (Bourne 80)

A moderate-quality study of subacute and chronic Achilles tendinosis comparing piroxicam to placebo with both groups assigned stretching and strengthening exercises was negative.(31) (Astrom 92) In an additional study comparing indomethacin with injection of glycosaminoglycan,(38) (Sundqvist 87) the latter group fared significantly better than the former (NSAID) group; however, the study is not helpful for identification of efficacy of NSAIDs as there was no placebo control. There are no quality studies in post-operative patients; however, NSAIDs have been shown to be highly effective for several other post-operative conditions and thus are recommended (see Low Back Disorders; Hand, Wrist, and Forearm Disorders; and Hip and Groin Disorders guidelines).

NSAIDs are not invasive, have low adverse effects particularly in employed populations, and are low cost, thus they are recommended. If NSAIDs are used to treat clinically evident or presumed inflammation, they should be administered on a scheduled basis. If NSAIDs are used for analgesia, they should be taken as needed.

#### *Evidence for the Use of NSAIDs and Acetaminophen*

There are 4 moderate-quality RCTs incorporated in this analysis. There is 1 low-quality RCT in Appendix 1.

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
<b>NSAIDs vs. Placebo</b>						
Jakobsen 1988 RCT	6.0	N = 212 Army personnel with acute soft tissue injuries <48 hours duration	Tenoxicam 20mg vs. piroxicam 20mg vs. placebo once daily for 10 days.	Significantly better improvement comparing tenoxicam with placebo: global judgment Day 2 (p = 0.025); median difference, -0.2; 95% CI, -0.4 to +0.0); tenderness Day 7 (p = 0.019; median difference, -0.5; 95% CI, -0.9; -0.1); functional limitation Day 10 (p = 0.0048; median difference, -0.3; 95% CI, -0.8 to -0.0).	“The use of tenoxicam 20 mg daily is superior to placebo and at least equal to piroxicam 20 mg daily in the treatment of some specific soft-tissue injuries.”	Randomization, allocation, blinding details unclear. Data suggest NSAID superior for treatment of 6 acute injuries. Insufficient data for specific recommendation for Achilles tendinopathy.
Jakobsen 1989 (An analysis Achilles tendinopathy subgroup of Jakobsen 1988)	5.0	N = 115 Army personnel with tendinitis, periostitis or sprains <48 hours duration	Tenoxicam 20mg vs. placebo once daily for 10 days.	Clinical outcomes measured on 4-point scale (excellent, good, moderate, bad) based on spontaneous pain, tenderness, pain on movement, functional limitations, and adverse reactions. In tendonitis group, excellent or good results reached 71% vs. 31% in placebo (p = 0.008).	In this 10-day trial for acute Achilles tendinopathy “[The authors] find the effect of tenoxicam 20 mg/ day in the treatment of tendinitis of the Achilles tendon to be convincingly superior to placebo.” They found no significant difference between piroxicam and placebo.	Randomization, allocation, baseline, blinding details unclear. Military population (mostly male) and included other soft tissue disorders. For acute Achilles tendonitis, 40 of 46 completed study. Data support NSAID superior to placebo.
<b>NSAID plus Exercises vs. Placebo plus Exercise</b>						
Astrom 1992	5.0	N = 70 non-	Piroxicam vs. placebo for 30	No differences at any time	“We conclude that a non-	Details of randomization,

RCT		rheumatic patients with painful Achilles tendinopathy	days, both groups with stretching and strengthening.	between groups in pain, swelling, muscle strength or ankle joint movement. Pain and tenderness improved in both groups.	steroid anti-inflammatory agent (piroxicam) does not afford symptomatic relief in Achilles pain; a limited rate of success was noted, presumably due to the combined effect of rest, exercises and the placebo response.”	allocation, baseline comparability are sparse. Both groups underwent stretching and strengthening exercises, providing potentially major co-interventions. Data suggest no effect of NSAID.
<b>Glucosaminoglycan Injection vs. NSAID</b>						
Sundqvist 1987  RCT	6.0	N = 60 recreational athletes suffering from Achilles peritendinitis	Local injection glycosaminoglycan polysulfate (GAGPS) vs. indomethacin.	No difference in percentage with good response ratings in acute patients. Significant differences in chronic patients with GAGPS vs. indomethacin (59% vs. 12%, p <0.05).	“Local injections of GAGPS were shown to be more effective than high-dose indomethacin especially in chronic cases.”	Allocation, blinding details unclear. Possible co-interventions (orthotics, physical therapy). Data suggest injection superior to NSAID.

## SYSTEMIC GLUCOCORTICOSTEROIDS

Oral or intramuscular (IM) glucocorticosteroids are often administered for musculoskeletal complaints with anti-inflammatory mechanism(s) as a rationale for efficacy. There is limited efficacy for treatment of radiculopathy, but not low back pain (see Low Back Disorders guideline). However, the use of these medications for Achilles tendinopathy is not cited in quality studies. Injections are reviewed below.

*Recommendation: Systemic Corticosteroids for Treatment of Acute, Subacute, Chronic, or Post-operative Achilles Tendinopathy*

**Oral or intramuscular steroid preparations for the treatment of acute, subacute, chronic, or post-operative Achilles tendinopathy are not recommended.**

*Strength of Evidence – Not Recommended, Insufficient Evidence (I)*  
*Level of Confidence – Moderate*

### *Rationale for Recommendation*

There is no quality evidence for use of corticosteroids for treatment of Achilles tendinopathy. As evidence is lacking and evidence of efficacy is present for several other treatments, oral or intramuscular steroid preparations are not recommended pending publication of quality studies.

## OPIOIDS – Oral, Transdermal, and Parenteral (Includes Tramadol)

Opioids are frequently used for musculoskeletal conditions; however, these are generally spine-related disorders. Use for treatment of Achilles tendinopathy has not been well described. Opioids are widely used post-operatively.

1. *Recommendation: Opioids for Treatment of Acute, Subacute, or Chronic Achilles Tendinopathy Pain*  
**Opioids for treatment of acute, subacute, or chronic Achilles tendinopathy pain is not recommended.**

*Strength of Evidence – Not Recommended, Insufficient Evidence (I)*  
*Level of Confidence – High*

2. *Recommendation: Opioids for Treatment of Pain for Post-operative Achilles Tendinopathy*  
**Opioids are recommended for short-term use to treat pain after Achilles tendon surgery or for patients who have encountered surgical complications.**

*Indications – Post-operative pain management.*

*Frequency/Dose/Duration – Frequency and dose per manufacturer's recommendations; total treatment length usually ranges from a few days to up to 2 weeks.*

*Indications for Discontinuation – Sufficient pain management with other methods such as NSAIDs, resolution of pain, intolerance, adverse effects, lack of benefits, or failure to progress over a couple weeks.*

*Strength of Evidence – Recommended, Insufficient Evidence (I)*  
*Level of Confidence – High*

#### *Rationale for Recommendations*

There is no quality evidence supporting the use of opioids for treating acute or chronic Achilles tendon pain. The vast majority of patients with Achilles tendinopathy do not have pain sufficient to require opioids. Patients with such degrees of pain should generally have investigations performed for alternative diagnoses. Opioids are not invasive, but have very high dropout rates and otherwise high rates of adverse effects. They are moderate to high cost depending on treatment duration (see Chronic Pain guideline) and are not recommended for routine use.

Quality evidence for treating post-operative patients with opioids is absent. Some patients have insufficient pain relief with NSAIDs, thus judicious use of opioids may be helpful, particularly for nocturnal use. Opioids are recommended for brief use in select post-operative patients primarily at night to achieve post-operative sleep.

#### **VITAMINS – Including Vitamin B<sub>6</sub> (Pyridoxine)**

The use of vitamins including B<sub>6</sub>, C, and E has been described for musculoskeletal conditions as an antioxidant or is hypothesized as a promoter of tendon healing processes.

1. *Recommendation: Vitamin Therapy for Treatment of Achilles Tendinopathy*  
**There is no recommendation for or against use of vitamins as a therapeutic intervention or for prevention of Achilles tendinopathy in doses recommended by the U.S. FDA.**

*Strength of Evidence – No Recommendation, Insufficient Evidence (I)*  
*Level of Confidence – Low*

2. *Recommendation: High-dose Vitamin Therapy for Treatment of Achilles Tendinopathy*  
**The use of high doses (exceeding U.S. FDA recommendations) or expensive compounded preparation vitamins is not recommended for prevention of Achilles tendinopathy.**

*Strength of Evidence – Not Recommended, Insufficient Evidence (I)*  
*Level of Confidence – Moderate*

*Rationale for Recommendation*

There are no quality studies evaluating the use of vitamins to treat or prevent Achilles tendinopathy. If purchased in standard doses as standard stock item at food and drug stores, vitamins are usually inexpensive. If taken in doses that do not substantially exceed U.S. FDA recommendations, vitamins are safe. However, custom vitamin mixtures or compounds and high doses of vitamins may be harmful and expensive.

**Topical Medications**

**NSAIDs**

Topical NSAIDs are meant to deliver medication locally and superficially in musculoskeletal disorders, including Achilles tendinopathy, to reduce pain, swelling, improve range of motion, and return the patient to full functional capacity as early as possible.(39, 40) (Russell 91; Mason 04)

1. *Recommendation: Topical NSAIDs for Acute, Subacute, or Chronic Achilles Tendinopathy*

**Topical NSAIDs are recommended for treatment of acute, subacute, or chronic Achilles tendinosis.**

*Indications* – Mild, moderate, or severe Achilles tendinopathy. Only niflumic acid as a topical NSAID treatment for Achilles tendon disorders has been studied(41); (Auclair 89) thus, there is no evidence of comparative superiority of any other topical NSAID.

*Frequency/Duration* – Frequency per manufacturer’s recommendation. Niflumic acid was used for 1 week(41) (Auclair 89) and piroxicam for 1 to 3 weeks (study of mixed acute disorders, 3% were Achilles tendonitis).(39) (Russell 91)

*Indications for Discontinuation* – Resolution, intolerance, adverse effects, or lack of benefits.

*Strength of Evidence – Recommended, Evidence (C)* – Acute, subacute  
**Recommended, Insufficient Evidence (I)** – Chronic  
*Level of Confidence – High*

2. *Recommendation: Topical NSAIDs for Post-operative Achilles Tendinopathy*

**There is no recommendation for or against the use of topical NSAIDs for treatment of post-operative Achilles tendinosis.**

*Strength of Evidence – No Recommendation, Insufficient Evidence (I)*  
*Level of Confidence – Low*

*Rationale for Recommendations*

There is one moderate-quality placebo-controlled trial that found efficacy of treatment with topical niflumic acid for Achilles tendon disorders(41) (Auclair 89) that also demonstrated earlier functional return. The second placebo-controlled trial that used piroxicam to treat Achilles tendonitis also suggested efficacy; however, it included a small minority of Achilles tendinitis (3%), and a majority of other disorders – 51, 42, and 4%, respectively labeled as supraspinatus tendonitis, and ankle and acromioclavicular joint sprains.(39) (Russell 91) Additional support for the general effectiveness of topical NSAIDs in treating musculoskeletal disorders is derived from a systematic review of RCTs for multiple conditions without regard to type of disorder or anatomic location .(40) (Mason 04) However, this review contains no direct support for the use of topical NSAIDs in Achilles tendinopathy. Topical NSAIDs are not invasive, have low adverse effect rates, but may be moderate to high cost. They are recommended for treatment of

acute or subacute Achilles tendinopathy. There is no evidence of efficacy in patient with chronic Achilles tendinosis. Post-operative patients may be reasonable candidates after the incision is well healed.

### Evidence for the Use of Topical NSAIDs

There are 2 moderate-quality RCTs incorporated in this analysis.

Author/Y ear Study Type	Score (0-11)	Sample Size	Comparison on Group	Results	Conclusion	Comments
<b>Topical NSAIDs vs. Placebo</b>						
Russell 1991 RCT	6.0	N = 214 with 1 unilateral acute soft tissue injury (recent sprained ankle, sprained acromioclavicular joint, supraspinatus tendinitis or Achilles tendinitis)	Piroxicam 0.5% topical gel vs. placebo QID.	Piroxicam vs. placebo VAS Means Day 8. Spontaneous pain: 2.8 vs. 4.2, p <0.05; pain on movement: 5.0 vs. 9.5, p = 0.05; Pressure threshold ratio 0.79 vs. 0.58, p <0.05.	“This study demonstrates that piroxicam gel, administered on a q.i.d. basis for a total daily dose of 20 mg, is effective treatment for patients suffering from musculoskeletal injuries (sprains and tendinitis) and is significantly more effective than placebo while offering toleration equal to placebo.”	Allocation, blinding details unclear. Study included mixed diagnoses: Achilles 6 supraspinatus tendinitis 102/108, ankle sprains 84, AC sprain 6 subjects. No breakdown in analysis by specific disorder. Sample size too small for Achilles tendinitis subset to form firm conclusions.
Auclair 1989 RCT	5.0	N = 243 Achilles heel tendinitis	Niflumic acid gel (2.5%) applied to skin over tendon vs. placebo TID for 3 weeks.	Gel vs. placebo (p-value): pain improved on palpation (% and SD) 59.2 (35.8) vs. 48.0 (40.4) p = 0.028; attained previous sporting level 51 (44.7%) vs. 29 (28.7%) p = 0.015; global evaluation of efficacy by patient: Very good 21 (18.8%) 15 (13.8%) p = 0.043, Good 48 (42.9%) 39 (35.8%).	“The results of this study demonstrate the superiority of niflumic acid gel compared with placebo.”	Randomization, allocation details not included. Blinding stated but is unclear. All subjects were also on rest from activities. Data suggest efficacy.

## LIDOCAINE PATCHES

The use of lidocaine patches for various musculoskeletal disorders has been reviewed in other guidelines (see Hand, Wrist, and Forearm Disorders; Chronic Pain; and Elbow Disorders guidelines).

*Recommendation: Lidocaine Patches for Acute, Subacute, Chronic, or Post-operative Achilles Tendinopathy*

**There is no recommendation for or against the use of lidocaine patches for the treatment of acute, subacute, chronic, or post-operative Achilles tendinopathy.**

*Strength of Evidence – No Recommendation, Insufficient Evidence (I)*

*Level of Confidence – Low*

### *Rationale for Recommendation*

There are no quality studies of lidocaine patch use for treatment of Achilles tendinopathy. As the goal of most therapy for Achilles disorders is pain relief, this may represent a potential treatment on a short-term basis while other concomitant interventions, such as eccentric exercises, are being performed. However, there is insufficient evidence to recommend for or against this treatment.

## GLYCERIL TRINITRATE PATCHES

Topical application of glyceryl trinitrate has been used to stimulate collagen synthesis.(42) (Paoloni 04)

1. *Recommendation: Glyceryl Trinitrate for Treatment of Chronic Achilles Tendinopathy Pain*

**Topical glyceryl trinitrate is recommended for treatment of pain in select patients with chronic Achilles tendinopathies after other conservative treatment alternatives have failed.**

*Indications* – Moderate or severe chronic Achilles tendinosis. Treatment with other interventions such as NSAIDs, exercises, and potentially injection(s) should have been attempted previously.

*Frequency/Duration* – Apply 1/4 of a 5mg/24-hour patch over site of maximal tenderness (2 to 6cm proximal to Achilles tendon insertion; replace patch every 24 hours for up to 6 months.(42) (Paoloni 04)

*Indications for Discontinuation* – Resolution, intolerance, adverse effects, or lack of benefits.

*Strength of Evidence – Recommended, Evidence (C)*

*Level of Confidence – Low*

2. *Recommendation: Glyceryl Trinitrate for Acute, Subacute, or Post-operative Achilles Tendinopathy*

**There is no recommendation for or against the use of topical glyceryl trinitrate for acute, subacute, or post-operative Achilles tendinopathies.**

*Strength of Evidence – No Recommendation, Insufficient Evidence (I)*

*Level of Confidence – Low*

### *Rationale for Recommendations*

There is one moderate-quality placebo-controlled RCT(42) (Paoloni 04) with a 3-year follow-up report(43) (Paoloni 07) for the continuous use of glyceryl trinitrate (GTN) patch over 24 weeks for chronic non-insertional Achilles tendon pain. This trial included common, conservative co-interventions. The authors found improvement in clinical condition of the GTN compared to the non-GTN group by most of their outcome measures, with differences statistically significant by 6 or 12 weeks.(42) (Paoloni 04) The numbers needed to treat by 6 or 12 weeks were in the neighborhood of 2 or 3, and by 24 weeks, numbers needed to treat were <2. The trial suggested less night and loading pain at 12 and 24 weeks, with sustained effects at 3-years in the intervention group. GTN is non-invasive, has few reported adverse effects compared to placebo, but is likely moderate to high cost over a 6-month course. There

are no trials evaluating over-the-counter GTN topical ointments. Based on the limited evidence, this treatment appears hopeful, but currently there is insufficient quality evidence for a graded recommendation (A, B, C) in most Achilles' tendinosis patients.

#### *Evidence for the Use of Glyceryl Trinitrate Patches*

There is 1 moderate-quality RCT with a second report of an extended evaluation period incorporated into this analysis.

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Paoloni 2004  RCT	5.5	N = 65 chronic non-insertional Achilles tendinopathy	Topical glyceryl trinitrate (GTN) patch (1/4 of a standard 5mg patch placed applied to effected tendon) vs. placebo patch for 24 weeks.	GTN group had significantly less activity pain at 12, 24 weeks; less night pain and tenderness at 12 weeks only and pain with hop test at 24 weeks only.	"[C]ontinuous topical glyceryl trinitrate therapy can result in significantly decreased Achilles tendon tenderness by twelve weeks. For every 3-4 patients treated with topical glyceryl trinitrate, one will have an excellent result at 24 weeks that would not have occurred with placebo."	Study included 84 tendons in 65 patients. Co-interventions: rest, heel wedges, prolonged static stretching, eccentric stretching. Allocation and compliance unclear. Intervention a pro-drug of endogenous nitric oxide. Data suggest efficacy.
Paoloni 2007  RCT Follow-up of above study	5.5  (score from original)	N = 58 chronic non-insertional Achilles tendinopathy	Topical glyceryl trinitrate (GTN) patch vs. placebo patch; 3-year follow-up from 2004 study.	Of group treated previously with GTN, 88% asymptomatic vs. 67% rehab alone (p = 0.03).	"...suggests that this treatment provides more than simple analgesic effect on the tendon and that beneficial effects are present 3 years after therapy."	Of those that completed original study, 90% participated. No control for other treatments in interim period. Data suggest efficacy.

#### **Devices/Physical Methods**

##### **EXERCISE**

In the musculoskeletal literature, the term "exercise" is used to describe stretching, strengthening, and endurance programs. For Achilles tendinopathy, eccentric and concentric exercise are described, both of which are used to load the soleus and gastrocnemius muscles. Concentric exercise involves muscle contraction. Eccentric exercise allows muscle lengthening (stretching). It is possible that eccentric exercises result in increased oscillations in tendon force,(44) (Rees 08) reduction of tendon microcirculation,(45) (Knobloch 08) and promotion of tendon remodeling, including increased collagen fiber cross-linkage.(28) (Rompe 09)

1. **Recommendation: Education for Acute, Subacute, Chronic, or Post-operative Achilles Tendinopathy**  
Education is recommended for acute, subacute, chronic, or post-operative Achilles tendinopathy.

*Indications* – All patients with Achilles tendinopathy assigned eccentric exercises.

*Frequency/Duration* – One or 2 appointments to educate patients about the disorder, effects of activity, unhelpfulness of complete inactivity, prognosis, and to address other questions.

*Indications for Discontinuation* – Recovery or demonstration of intolerance or lack of efficacy.

*Strength of Evidence* – **Recommended, Insufficient Evidence (I)**

*Level of Confidence* – Moderate

## 2. Recommendation: Eccentric Exercises for Chronic Achilles Tendinopathy

**Eccentric exercises are moderately recommended for the treatment of chronic Achilles tendinopathy.**

*Indications* – Mild, moderate, or severe chronic Achilles tendinosis.(25, 46, 47) (Rompe 07; Silbernagel 01; Mafi 01)

*Frequency/Duration* – One or 2 sets of exercises per day until symptom resolution and generally 1 or 2 appointments for exercise instruction (an additional 1 or 2 appointments for reinforcement is often needed in more chronic cases). Data suggest more intense exercise regimens result in superior outcomes.(46) (Silbernagel 01)

*Indications for Discontinuation* – Resolution, intolerance, adverse effects, or lack of benefits.

*Strength of Evidence* – **Moderately Recommended, Evidence (B)**

*Level of Confidence* – Moderate

## 3. Recommendation: Stretching Exercises for Acute, Subacute, or Post-operative Achilles Tendinopathy

**Stretching and loading exercises, particularly eccentric exercises, are recommended for the treatment of acute, subacute, or post-operative Achilles tendinopathy.**

*Indications* – Mild, moderate, or severe acute, subacute and post-operative Achilles tendinosis.

*Frequency/Duration* – One or 2 sets of exercises per day until symptom resolution and generally 1 or 2 appointments for exercise instruction (an additional 1 or 2 appointments for reinforcement is often needed in more chronic cases). Data suggest more intense exercise regimens result in superior outcomes.(46) (Silbernagel 01) Post-operative patients may require additional instruction during the recovery period.

*Indications for Discontinuation* – Resolution, intolerance, adverse effects, or lack of benefits.

*Strength of Evidence* – **Recommended, Insufficient Evidence (I)**

*Level of Confidence* – Low

### *Rationale for Recommendations*

Two moderate-quality studies compared more intense to less intense exercise(46) (Silbernagel 01) or exercise to “active rest”(48) (Silbernagel 07) for treatment of chronic Achilles tendinopathy. There was no difference between the effects of more intense and less intense exercise.(46) (Silbernagel 01) Eccentric exercises were found superior to concentric exercises.(25) (Mafi 01) (A low-quality study found eccentric exercises to have a better outcome over concentric exercises.)(49) (Nielsen-Vertommen 92) There is one high-quality study comparing eccentric exercise with non-intervention and with shockwave therapy (Rompe 07) that found exercise and shockwave therapy both superior to observation.(47) (Rompe 07) However, the equivalence of exercise to shock wave therapy was not reproducible,(50) (Rompe J Bone Joint Surg Am 08) challenging the reproducibility and integrity of the study findings. Additionally, in these

studies, the uncertainty due to the instruments used to measure outcome(51) (Robinson 01) was not addressed, with the differences in findings based primarily on statistics and without fully considering the variability introduced by the clinical measurement.

There are no quality studies of exercise for treatment of acute, subacute, or post-operative Achilles pain. There are many additional studies that included exercise as part of the treatment, but did not have adequate controls to demonstrate the effects of exercise. Studies comparing exercise to other interventions generally used eccentric exercises. Stretching exercises and graded activity does not appear to differ in effect(48) (Silbernagel 07) suggesting that allowing patients to engaging in activities according to their comfort level does not worsen outcome.

Exercise is non-invasive, has few adverse effects, may benefit the individual's overall health compared to inactivity, and is not costly when self-administered. Exercise may be taught quickly by providers or therapists and is moderately recommended. For acute pain, there is a lack of evidence for effectiveness, but it is reasonable to infer that this intervention may be beneficial. Post-operative patients may benefit from a few additional supervised visits to help guide exercise and activity levels.

#### *Evidence for the Use of Exercise for Achilles Tendinopathy*

There are 2 high- and 3 moderate-quality RCTs incorporated into this analysis. There is 1 low-quality RCT in Appendix 1.

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
<b>Exercise vs. Other Intervention</b>						
Rompe 2007 RCT	9.0	N = 75 with a chronic recalcitrant (>6 months) noninsertional Achilles tendinopathy;(25 in each group)	ESWT vs. eccentric exercises vs. no treatment in persons with chronic Achilles tendinopathy.	No differences between SWT and EE in any outcome measure. Both significantly better than wait and see for outcomes of VISA-A score, Likert score, load induced pain, and pain threshold.	“Both eccentric loading and repetitive low-energy SWT led to a successful outcome in 50% to 60% of patients. This is absolutely within the range of results of surgery.”	Data suggest ESWT and eccentric exercises effective compared to no treatment.
Rompe J Bone Joint Surg Am 2008 RCT	8.5	N = 50 with chronic (≥6 months) recalcitrant insertional Achilles tendinopathy	ESWT (3 sessions over 3 weeks, 0.12mJ/mm <sup>2</sup> total energy) vs. daily regimen eccentric loading exercises for 12 weeks.	Eccentric loading vs. ESWT: VISA-A score; 63.4±12.0 vs. 79.4±10.4, p = 0.005 (higher score better); Likert scale: 3.7±1.5 vs. 2.8±1.6, p = 0.043; Loading pain scale: 5.0±2.3 vs. 3.0±2.3, p =	In this subset of “patients with recalcitrant insertional Achilles tendinopathy” results “demonstrate that the probability for recovery is significantly lower after eccentric loading as applied in the	No placebo control. All enrolled had failed local anesthetic injection, steroid injections, NSAIDs, physiotherapy and heel lifts. Data suggest ESWT superior to eccentric

				0.004 (favors ESWT); Tenderness at 3kg: 4.4±3.2 vs. 2.4±4.2, p = 0.031.	present study compared with repetitive low-energy shock wave therapy as applied.”	loading exercises.
<b>Comparisons of Different Exercises and of Exercise versus Rest</b>						
Sibernagel 2007 RCT	7.0	N = 42 with Achilles tendinopathy (as 4 dropped before final analysis, 38 patients with 51 tendons)	Tendon loading exercises with jumping, running during treatment vs. active rest (no physical activity that caused symptoms). Active group allowed to exercise to pain VAS of 5 as upper limit.	VISA-A score and pain not different between the groups at baseline or follow-up period of 12 months. No differences in rate of improvement between groups in any functional evaluations.	“No negative effects could be demonstrated from continuing Achilles tendon loading activity, such as running and jumping, with the use of a pain-monitoring model during treatment.”	Results indicate activity modification based on pain levels does not impact results of eccentric exercise program.
Silbernagel 2001 RCT	5.5	N = 49 proximal achillodynia (44 involved Achilles tendons); 9 withdrew before study started	12 weeks of less-intense vs. more-intense exercise program for (eccentric/concentric) in both arms in persons with chronic Achilles tendinopathy.	No significant changes between groups in any measures in the six-month follow-up period. Both groups improved from baseline.	“Measurement techniques and the treatment protocol with eccentric overload can be recommended for patients with chronic pain from the Achilles tendon. More patients achieved full recovery, had less pain during and after activity, and improved ankle range of motion in the experiment group.”	Study had 49 patients (69 tendons). Randomization, details sparse. Controls received part of experiment exercise interventions. Results focused on changes from baseline, but data favored intense exercise group.
Mafi 2001 RCT	5.0	N = 44 painful chronic Achilles tendinosis	Daily eccentric vs. concentric training regimens for 12 weeks.	Patient satisfaction at 12 weeks favored eccentric group: 82% vs. 36%, p <0.002.	“Treatment with eccentric calf muscle training in patients with painful chronic Achilles tendinosis yielded good short term clinical results and significantly	Small sample size; details sparse on compliance, avoiding co-interventions. No blinding.

					better results than concentric calf muscle training.”	
--	--	--	--	--	---	--

## CRYOTHERAPY/HEAT

Cryotherapy and heat are commonly used for analgesia. Cryotherapy may reduce inflammation in acute musculoskeletal injuries, including Achilles tendinopathy.(52) (Morelli 04)

1. *Recommendation: Cryotherapy for Acute, Subacute, Chronic, or Post-operative Achilles Tendinopathy*  
**Cryotherapy is recommended for acute, subacute, chronic, or post-operative Achilles tendinopathy.**

*Indications* – All patients with Achilles tendinopathy.

*Frequency/Duration* – Approximately 3 to 5 self-applications per day as needed.

*Indications for Discontinuation* – Resolution, adverse effects, non-compliance.

*Strength of Evidence* – **Recommended, Insufficient Evidence (I)**

*Level of Confidence* – Low

2. *Recommendation: Heat Therapy for Acute, Subacute, Chronic, or Post-operative Achilles Tendinopathy*  
**Heat is recommended for acute, subacute, chronic, or post-operative Achilles tendinopathy.**

*Indications* – All patients with Achilles tendinopathy.

*Frequency/Duration* – Approximately 3 to 5 self-applications per day as needed.

*Indications for Discontinuation* – Resolution, adverse effects, non-compliance.

*Strength of Evidence* – **Recommended, Insufficient Evidence (I)**

*Level of Confidence* – Low

### *Rationale for Recommendations*

There is one moderate-quality study of cryotherapy considering tendon blood flow as an outcome.(53) (Knobloch Am J Sports Med 08) Clinical outcomes were not included and this study’s usefulness is limited. There is no quality evidence for the use of cryotherapy or heat as treatments for Achilles tendinopathy. In a non-randomized prospective study, cryotherapy was demonstrated through Doppler ultrasound to result in temporary reduction in increased blood flow through the microcirculation.(54) (Knobloch 07) The use of ice has been implemented as part of a multi-intervention strategy,(55) (Mayer 07) although the individual contribution towards healing is unknown. Cryotherapy and heat are non-invasive, have few adverse effects, are not costly when self-administered, and are recommended.

### *Evidence for the Use of Cryotherapy and Heat for Achilles Tendinopathy*

There is 1 moderate-quality RCT incorporated into this analysis.

Author/Y ear Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments

Knobloch Am J Sports Med 2008  RCT	6.5	N = 60 healthy participa nts with no prior tendon problem s	Cryother apy with compres sion vs. cryothera py alone	No adverse effects from cryotherapy. Cryotherapy plus compression vs. compression: no differences in superficial or deep blood flow with treatment, higher capillary flow in recovery with cryo/compression group.	“Intermittent administration of 3 x 10-minute cryotherapy and compression is superior to cryotherapy alone as far as Achilles tendon micro- circulation is concerned.”	Baseline comparabil ity unclear. Results of study are of uncertain clinical significance.
--	-----	--	--	--	--	--

## NIGHT SPLINTING

Splints which hold the foot in 90° of dorsiflexion during the night are sometimes used to reduce morning pain and stiffness from Achilles tendinopathy.

1. *Recommendation: Night Splints for Acute, Subacute, or Chronic Achilles Tendinopathy*  
**There is no recommendation for or against the use of a night splint for treatment of acute, subacute, or chronic Achilles tendinopathy.**

*Strength of Evidence – No Recommendation, Insufficient Evidence (I)*  
*Level of Confidence – Low*

2. *Recommendation: Night Splints and Walking Boots for Post-operative Achilles Tendinopathy*  
**Night splints and walking boots are recommended for post-operative Achilles tendinopathy patients.**

*Strength of Evidence – Recommended, Insufficient Evidence (I)*  
*Level of Confidence – Low*

### *Rationale for Recommendations*

There are no quality studies of patients treated with night splints compared to non-splinted controls. There also are no quality studies in post-operative patients. There are two moderate-quality studies that included splints for treatment of subacute and chronic Achilles tendinopathy. In both studies, there is no evidence that splinting provided any additive benefit over eccentric exercises alone. (56, 57) (Roos 04, deVos 07) This suggests splinting provides no additive benefit. Night splints are non-invasive, have a minimal adverse effect profile although they may provide some level of nuisance, and are low to moderate cost depending on the product and whether the device is custom made. There is no recommendation for or against use of these splints. Evidence suggests that other interventions, particularly exercises, are preferable. Post-operative patients generally require walking boots during rehabilitation.

### *Evidence for the Use of Night Splinting for Achilles Tendinopathy*

There are 2 moderate-quality RCTs incorporated into this analysis.

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Roos 2004  RCT	7.0	N = 44 with Achilles tendinopathy	Eccentric exercises (EE) vs. night splint vs. EE plus	All groups improved significantly across all times. No	“[E]ccentric exercises seem to improve function and reduce pain in	Small sample size with low power for 3 interventions. All intervention

			anterior night splint (90° dorsiflexion) over 12 weeks with 1-year follow-up.	differences in pain between groups at any time. Clinically significant differences (>10 points) in mean pain score favored eccentric-only group over splint-only at 12 and 26 weeks (p value not reported).	primary care patients. The effects were apparent after 6 weeks and lasted for 1 year.”	groups improved over time and similar at 1 year. Conclusion may not be complete as co-intervention of night splint. As no arm comparing routine or no treatment, findings inconclusive for any intervention.
deVos 2007  RCT	6.0	N = 58 chronic midportion Achilles tendinopathy	Night splints plus eccentric exercises vs. eccentric exercises only for 12 weeks.	VISA-A score change: NS and EE only 50.1 to 68.8 and 49.4 to 67 (p <0.001)	“Splinting in addition to eccentric exercises did not lead to a significantly better outcome for patient satisfaction and VISA-A score. Both reduced pain and improved functional outcome.”	Seventy (70) tendons in 58 patients. Patient mix included subacute and chronic conditions. Lack of details on co-intervention. Data suggest no difference.

### Magnets

Magnets are commonly used as an alternative treatment for musculoskeletal disorders. However, there is no information found for their use in Achilles tendon disorders.

*Recommendation: Magnets for Achilles Tendinopathy*

**Magnets are not recommended for the treatment of acute, subacute, chronic, or post-operative Achilles tendon disorders.**

*Strength of Evidence – Not Recommended, Insufficient Evidence (I)*

*Level of Confidence –Moderate*

#### *Rationale for Recommendation*

There are no quality studies available evaluating the use of magnets for treatment of Achilles tendon disorders. However, magnets have been evaluated in quality studies involving the spine and hand and they have been found to be ineffective. Magnets are not invasive, have no adverse effects, and are low cost, but other interventions have documented efficacy. Thus, magnets are not recommended for treatment of Achilles tendinopathy.

## ORTHOTICS

Orthotic devices are commonly used for Achilles tendinopathy and are designed to modify the foot posture or place the hindfoot in a neutral position to reduce the load on the tendon. These devices include heel lifts, pads, and braces.(30) (Rompe Disabil Rehabil 08)

*Recommendation: Orthotic Devices for Acute, Subacute, Chronic, or Post-operative Achilles Tendinopathy*

**There is no recommendation for or against the use of orthotic devices such as, heel lifts, heel pads, or heel braces for treatment of acute, subacute, or chronic Achilles tendinopathy.**

*Strength of Evidence – No Recommendation, Insufficient Evidence (I)*  
*Level of Confidence – Low*

### *Rationale for Recommendation*

There are no quality studies comparing orthotics with non-interventional or control groups. A low-quality study comparing groups that used heel pads, molefoam pads, or no device found no difference in the use of these devices.(58) (Lowdon 84) There is one moderate-quality study of one specific device; however, the study did not include a non-intervention group so improvement with intervention could not be differentiated from the natural course of the condition, failed to demonstrate superiority of splints to exercises, and splints provided no additive benefits when combined with exercises.(59) (Petersen 07) Capillary blood flow in Achilles paratenons(45) (Knobloch Dis Rehab 08 1685-91) and tendons(60) (Knobloch Dis Rehab 08 1692-6) of patients with Achilles tendinopathy who wore an AirCast AirHeel ankle splint was investigated with mixed results between the two studies in microcirculatory effects, but no clinical changes demonstrated in those who wore splints. These devices are usually non-invasive and low cost if not custom-made. Although they are often prescribed, there is insufficient evidence to support a recommendation for or against their use.

### *Evidence for the Use of Orthotic Devices for Achilles Tendinopathy*

There are 3 moderate-quality RCTs incorporated into this analysis. There is 1 low-quality RCT in Appendix 1.

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Petersen 2007  RCT	4.5	N = 100 with chronic Achilles tendinopathy	AirHeel brace vs. eccentric training vs. both combined.	AOFAS scores improved in all groups. No between- group differences. At 1-year follow-up, AOFAS scores improved 10- 12% in all groups vs. baseline (p <0.001).	“This study could not demonstrate any significant differences between treatment with the AirHeel brace and an eccentric training program...”	Allocation, compliance details unclear. Data suggest orthotic provided no benefit.
Knobloch 2008  RCT	4.5	N = 116 with unilateral tendinopathy of main body of Achilles tendon	Eccentric exercise with and without use of AirHeel brace.	Excentric exercise plus AirHeel vs. excentric exercise alone – no difference	“Patient with tendinopathy of the main body of the AT experienced improved	Drop-out rate >20%. Effect on micro- circulation is of unknown clinical effect

				in superficial blood flow, paratenon blood flow. Blood flow at 2mm at insertion significantly reduced in excentric exercise alone (p <0.05). Oxygen saturation higher in excentric exercise plus AirHeel group (p <0.012)	clinical outcome with both management options. Tendon microcirculation was optimized in the combined group.”	as demonstrated by equivalency of clinical outcomes. Data suggest no difference.
Knobloch 2008  RCT – 2nd report of above study	4.5	N = 116 with tendinopathy of Achilles tendon	Eccentric exercise with and without use of AirHeel brace.	Capillary blood flow in tendon and paratenon not significantly different at 2 or 8mm tissue depths at 12 positions. Pain reduced p <0.05 in combined treatment groups vs. those that dropped out (labeled non-compliant).	“No microcirculatory changes are evident in non-compliant and compliant patients with Achilles tendinopathy undergoing 12 weeks of eccentric training.”	Second report of same study group. Initial report indicated compliance not known, but here reports 92/116 compliant, which appears to refer to those who completed study rather than compliance to exercise regimen or wearing AirHeel. Data suggest no difference.

### EXTRACORPOREAL SHOCKWAVE THERAPY (ESWT)

Extracorporeal shockwave therapy (ESWT), or “shockwave therapy,” has been utilized for treatment of multiple chronic soft tissue disorders including Achilles tendinopathy, plantar fasciitis, and lateral epicondylitis. The mechanism of action is unknown.(28) (Rompe 09)

1. *Recommendation: Extracorporeal Shockwave Therapy for Chronic Mid-portion Achilles Tendinopathy*  
**Extracorporeal shockwave therapy is recommended as an adjunct to an eccentric exercise for chronic, recalcitrant Achilles tendinopathy.**

*Indications* – Moderate to severe, recalcitrant Achilles tendinopathy. Patients should have failed NSAIDs, eccentric exercises, therapy, and local injection(s).(28, 50) (Rompe J Bone Joint Surg Am 08, Rompe 09)

*Frequency/Duration* – Three to 4 weekly sessions over 3 to 4 consecutive weeks, using 2,000 shocks at 0.1 to 0.2 J/mm<sup>2</sup> administered in conjunction with an eccentric exercise program.(28, 50, 61, 62) (Rasmussen 08; Rompe 07; Rompe J Bone Joint Sur Am 08; Rompe 09)

*Indications for Discontinuation* – Completion of course, resolution of symptoms, adverse effects, intolerance, non-compliance.

*Strength of Evidence* – **Recommended, Evidence (C)**

*Level of Confidence* –Low

2. *Recommendation: Extracorporeal Shockwave Therapy for Acute, Subacute, or Post-operative Achilles Tendinopathy*

**Extracorporeal shockwave therapy is not recommended for treatment of acute, subacute, or post-operative Achilles tendinopathy.**

*Indications* – Moderate to severe recalcitrant Achilles tendinopathy. Patients should have failed NSAIDs, eccentric exercises, therapy, and local injection(s).(28, 50) (Rompe J Bone Joint Surg Am 08, Rompe 09)

*Frequency/Duration* – Three to 4 weekly sessions over 3 to 4 consecutive weeks, using 2,000 shocks at 0.1 to 0.2 J/mm<sup>2</sup> administered in conjunction with an eccentric exercise program.

*Indications for Discontinuation* – Completion of course, resolution of symptoms, adverse effects, intolerance, non-compliance.

*Strength of Evidence* – **Not Recommended, Insufficient Evidence (I)**

*Level of Confidence* – Moderate

*Rationale for Recommendations*

Evidence of efficacy for ESWT in treatment of patients with chronic Achilles tendinopathy is conflicting. There are two high-quality RCTs comparing ESWT with sham ESWT(62, 63), (Rasmussen 08; Costa 05) and one high-quality study comparing ESWT with a non-treated control group.(61) (Rompe 07) Adequacy of blinding of ESWT is unclear.(62, 63) (Rasmussen 08; Costa 05) One sham-controlled trial failed to demonstrate efficacy(63) (Costa 05) while another showed statistically significant functional improvement, but questionable clinical improvement,(62) (Rasmussen 08) raising questions of treatment effectiveness. The dosing and treatment intervals were different between the trial that failed to demonstrate efficacy(63) (Costa 05) and those that did, which may have accounted for the variable effects. The trial with a non-treatment control group suggested ESWT was superior to non-treatment(61); (Rompe 07) however, the level of benefit was modest and there was no superiority of the ESWT to eccentric exercises.

Two trials evaluated patients with chronic Achilles tendon disorders who failed other treatment.(28, 50) (Rompe J Bone Joint Surg Am 08; Rompe 09) The first study compared ESWT and eccentric exercises and found statistically significant differences between the groups, with EWST patient outcomes superior.(50) (Rompe J Bone Joint Surg Am 08) The second study found a combination of eccentric exercises plus ESWT superior to exercises alone considering statistically significant differences alone.(28) (Rompe 09) However, although the groups receiving and not receiving ESWT had statistical differences, the clinical significance of the findings is uncertain because they were within the limits of reproducibility of one of the primary measurement instruments.(51) (Robinson 01) The investigators in

these trials administered ESWT with timing and number of shocks similar to the authors of the successful sham ESWT study.(62) (Rasmussen 08)

The effectiveness of ESWT is unclear as the studies that showed differences between ESWT and non-ESWT groups were modest and may have reflected statistically rather than clinically significant differences. ESWT has not conclusively shown itself to be invasive in the literature cited in this section when administered as specified by the investigators.(28, 50, 61, 62) (Rasmussen 08; Rompe 07; Rompe J Bone Joint Surg Am 08; Rompe 09) Tendon rupture was reported in one study(63) (Costa 05); however, the circumstances of the ruptures cast doubt on whether ESWT was a contributing factor. There are no quality studies for treatment of acute, subacute, and post-operative Achilles tendinopathy patients, and given other treatment options, ESWT is not recommended for acute, subacute, or post-operative Achilles tendinopathy.

*Evidence for the Use of Extracorporeal Shockwave Therapy for Achilles Tendinopathy*

There are 5 high-quality RCTs incorporated into this analysis.

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
<b>ESWT vs. Sham</b>						
Rasmussen 2008  RCT	9.0	N = 48 assigned to non- operative treatment of chronic Achilles tendinopathy	ESWT vs. sham ESWT (ESWT: 1 session each week for 4 weeks, 2000 shots 0.21-0.51 ml/mm <sup>2</sup> , 50 Hz); all patients assigned eccentric exercises.	AOFAS score increased more in intervention, 70 to 88 (p <0.05), than controls, 74 to 81. No difference in pain between groups.	“EWST appears to be a clinically relevant supplement to conservative treatment of tendinopathy. Currently, however, there is no convincing evidence for recommendation of ESWT.”	Conservative treatment included stretching and eccentric exercise training as co- interventions. AOFAS score measures pain (40 points), function (50 points), alignment (10 points). Clinical significance set at 10 point difference. Baseline lower AOFAS scores in ESWT group than controls. Data suggest no superiority of ESWT compared to sham.
Costa 2005  RCT	8.0	N = 49 with chronic Achilles tendon pain	ESWT vs. sham ESWT (ESWT: 1500 shocks at 0.2J/mm <sup>2</sup> , 1 a month for 3 months).	No differences between groups on pain at rest, during sports, ankle ROM, tendon or	“Results of our study do not provide any evidence for use of shock wave therapy for treatment of chronic Achilles tendon pain.	Difference in median age 58 vs. 48 (control). Treatment was guided by ultrasound data. Data suggest no differences.

				calf diameter, or functional scoring.	Complications in the treatment group included two tendon ruptures, suggesting caution in treating older patients with shock wave therapy.”	
<b>ESWT vs. Exercise</b>						
Rompe 2009 RCT	9.0	N = 68 with chronic recalcitrant (>6 months) non-insertional Achilles tendinopathy	Eccentric exercise vs. eccentric exercise plus shock wave therapy (3 visits over 3 weeks starting Week 4); 16 weeks follow-up. (ESWT: 2000 shocks at 0.1 J/mm <sup>2</sup> , 1 a week for 3 weeks.)	EE vs. EE + SWT at 4 months, Visa-A: 73 vs. 86.5 (p = 0.016); Likert Scale (1-6): 2.9 vs. 2.1 (p = 0.035); Load-induced pain, (0-10) 3.9 vs. 2.4 (p = 0.045); 56% vs. 82% reported complete or good recovery (p = 0.001). All groups significantly better than baseline.	“The likelihood of recovery after 4 months was higher after a combined approach of both eccentric loading and SWT compared to eccentric loading alone. Eccentric training plus SWT should be offered to patients with chronic recalcitrant midportion tendinopathy of the Achilles tendon.”	No blinding of patients. Study shows both groups improved over baseline. Still had 30% failure at 4 months. Of EE failures, 12/15 success with SWT at 12 months. Of EE+SWT failures, 3/6 success with surgery. Data suggest ESWT of additive benefit to eccentric exercises.
Rompe J Bone Joint Surg Am 2008 RCT	8.5	N = 50 chronic (≥6 months) recalcitrant insertional Achilles tendinopathy	ESWT (3 sessions over 3 weeks, 0.12 mJ/mm <sup>2</sup> total energy) vs. daily regimen eccentric loading exercises for 12 weeks. (ESWT: 2000 shocks at 0.12 J/mm <sup>2</sup> , 1 a week for 3 weeks.)	Eccentric loading vs. ESWT: VISA-A score; 63.4±12.0 vs. 79.4±10.4, p = 0.005 (higher score is better); Likert scale: 3.7±1.5 vs. 2.8±1.6 p = 0.043;	In this subset of “patients with recalcitrant insertional Achilles tendinopathy” the results “demonstrate that the probability for recovery is significantly lower after eccentric loading as applied in the	All enrolled had failed local anesthetic injection, steroid injections, NSAIDs, physiotherapy and heel lifts. Data suggest ESWT superior to eccentric exercise, however patients likely had prior

				Loading pain scale: 5.0±2.3 vs. 3.0±2.3, p = 0.004 (favors ESWT); Tenderness at 3 kg: 4.4±3.2 vs. 2.4±4.2, p = 0.031.	present study compared with repetitive low-energy shock wave therapy as applied."	exercise providing some potential bias against exercise group.
<b>ESWT vs. No Treatment</b>						
Rompe 2007 RCT	9.0	N = 75 chronic recalcitrant (>6 months) non-insertional Achilles tendinopathy (25 in each group)	ESWT vs. Eccentric Exercises vs. No treatment (ESWT: 2000 shocks at 0.1 J/mm <sup>2</sup> , 1 a week for 3 weeks).	No differences between SWT and EE in any outcome measure. Both active treatments superior to wait and see for VISA-A score, Likert score, load induced pain, and pain threshold.	"Both eccentric loading and repetitive low-energy SWT led to a successful outcome in 50% to 60% of patients. This is absolutely within the range of results of surgery."	Data suggest ESWT and eccentric exercises effective compared to no treatment.

## ACUPUNCTURE

Acupuncture is frequently described as an alternative intervention for musculoskeletal disorders. However, there is little information available pertinent to the treatment of Achilles tendinopathy.

*Recommendation: Acupuncture for Acute, Subacute, Chronic, or Post-operative Achilles Tendinopathy*

**There is no recommendation for or against the use of acupuncture for the treatment of acute, subacute, chronic, or post-operative Achilles tendinopathy.**

*Strength of Evidence – No Recommendation, Insufficient Evidence (I)*

*Level of Confidence – Low*

### *Rationale for Recommendation*

There is no quality evidence for or against the use of acupuncture for the treatment of Achilles tendinopathy. Acupuncture is minimally invasive, has minimal adverse effects, and depending on numbers of treatments, may be moderately costly. There are other interventions with documented efficacy. Therefore, there is no recommendation for or against use of acupuncture for treatment of Achilles tendinopathy.

## DRY NEEDLING

*Recommendation: Dry Needling for Acute, Subacute, or Chronic Achilles Tendinopathy*

**Dry needling is not recommended for treatment of acute, subacute, or chronic Achilles tendinopathy.**

*Strength of Evidence – Not Recommended, Insufficient Evidence (I)*  
*Level of Confidence – Moderate*

*Rationale for Recommendation*

There is no quality evidence for or against the use of dry needling techniques in treating Achilles tendon disorders. Dry needling is commonly used for the treatment of myofascial, back, neck, and other disorders (see Low Back Disorders, Chronic Pain, and Elbow Disorders guidelines), but is not well described for the treatment of Achilles tendinopathy. Dry needling is adequately invasive (where it should be avoided in treatment of Achilles tendinopathy) without evidence of efficacy, and is of moderate cost. As there are other effective treatments, dry needling is not recommended for treatment of Achilles tendinopathy.

**MASSAGE AND TENDON MOBILIZATION**

Deep tissue massage and tendon mobilization have been used as interventions for treatment of tendinopathy and paratendinopathy.(30) (Rompe Disabil Rehabil 08)

*Recommendation: Massage and Tendon Mobilization for Acute, Subacute, Chronic, or Post-operative Achilles Tendinopathy*

**There is no recommendation for or against the use of massage and tendon mobilization for treatment of acute, subacute, chronic or post-operative Achilles tendinopathy.**

*Strength of Evidence – No Recommendation, Insufficient Evidence (I)*  
*Level of Confidence – Low*

*Rationale for Recommendation*

There is no quality evidence for or against the use of massage and tendon mobilization to treat Achilles tendinopathy. It is possible for patients to self-administer these treatments, although there are no quality studies of self-administrations. Massage and tendon mobilization are not invasive, have minimal adverse effects, and depending on numbers of treatments, are low to moderate cost. There are other interventions with documented efficacy. Therefore, there is no recommendation for or against use of these treatments for Achilles tendinopathy.

**ULTRASOUND**

Therapeutic ultrasound is described as an effective initial conservative management strategy, as it is purported to reduce swelling and improve tendon healing.(30) (Rompe Disabil Rehabil 08)

*Recommendation: Therapeutic Ultrasound for Acute, Subacute, Chronic, or Post-operative Achilles Tendinopathy*

**There is no recommendation for or against the use of therapeutic ultrasound for treatment of acute, subacute, chronic, or post-operative Achilles tendinopathy.**

*Strength of Evidence – No Recommendation, Insufficient Evidence (I)*  
*Level of Confidence – Low*

*Rationale for Recommendation*

Although cited as a potential treatment for Achilles tendinopathy, there is no quality evidence for or against this intervention. A recent small pilot study suggested support for continuing to investigate ultrasound as a potentially effective treatment, finding no difference between therapeutic ultrasound compared to eccentric exercises.(64) (Chester 08) Ultrasound is non-invasive, has low adverse effects, is of moderate cost depending on the number of treatments, but there is no recommendation for its use pending publication of quality studies.

## IONTOPHORESIS

Iontophoresis purportedly uses an electrical field to drive ionized medication into tissue. It is generally utilized for treatments of more superficially located target tissue. Iontophoresis with topical steroids and NSAIDs have been used to increase healing and reduce pain of Achilles tendinopathy.

1. *Recommendation: Iontophoresis with Glucocorticosteroid for Acute, Subacute, or Chronic Achilles Tendinopathy*

**Iontophoresis with glucocorticosteroid is recommended for treatment of acute, subacute, or chronic Achilles tendinopathy.**

*Indications* –Acute, subacute, or chronic Achilles tendinopathy.

*Frequency/Duration* – Four treatments over 2 weeks with dexamethasone(65) (Neeter 03) or other glucocorticoid. Therapy should include a concurrent eccentric exercise program.

*Indications for Discontinuation* – Resolution, adverse effects, intolerance, non-compliance.

*Strength of Evidence* – **Recommended, Insufficient Evidence (I)**

*Level of Confidence* – Moderate

2. *Recommendation: Iontophoresis with Glucocorticosteroid for Post-operative Achilles Tendinopathy*

**There is no recommendation for or against the use of iontophoresis with glucocorticosteroid for treatment of post-operative Achilles tendinopathy.**

*Strength of Evidence* – **No Recommendation, Insufficient Evidence (I)**

*Level of Confidence* – Low

3. *Recommendation: Iontophoresis with NSAIDs for Acute, Subacute, Chronic, or Post-operative Achilles Tendinopathy*

**There is no recommendation for or against the use of iontophoresis with NSAIDs for treatment of acute, subacute, chronic, or post-operative Achilles tendinopathy.**

*Strength of Evidence* – **No Recommendation, Insufficient Evidence (I)**

*Level of Confidence* – Low

### *Rationale for Recommendations*

There is one moderate-quality, placebo-controlled RCT that compared iontophoresis using dexamethasone with saline for the treatment of acute and subacute Achilles tendinopathy,(65) (Neeter 03) which included the co-intervention of stretching and strengthening. Iontophoresis was applied twice weekly each week for 2 weeks. Three performance and four pain outcomes were measured at baseline, 2 and 4 weeks, and 3 and 6 months. Of 24 measurement points after administration of treatment, only two showed statistically-significant differences between treatment and placebo groups. A short-treatment series of iontophoresis is non-invasive and has a low adverse effect profile. Although evidence is minimal for efficacy in acute and subacute Achilles tendinopathy, iontophoresis with glucocorticosteroids is recommended for acute, subacute, or chronic Achilles tendinopathy, although the treatment has not been specifically tested among those patients.

### *Evidence for the Use of Iontophoresis for Achilles Tendinopathy*

There is 1 moderate-quality RCT incorporated into this analysis.

Author/Y ear Study Type	Score (0- 11)	Sample Size	Comparison Group	Results	Conclusion	Comments
----------------------------------	---------------------	----------------	---------------------	---------	------------	----------

Neeter 2003  RCT	6.0	N = 25 with acute (<3 months) pain from Achilles tendons)	Iontophoresis with dexamethasone 3ml suspension vs. iontophoresis with saline (4 treatments over 2 weeks); 1-year follow-up (volume specified, but not concentration; if dexamethasone suspension 0.4%, dose 12mg).	Performance and pain outcomes measured at 2 and 6 weeks, and 3 and 6 months. No differences between groups on toe-raising test, ROM, morning stiffness at any point. Of 16 measurement points for pain, treatment and control groups differed only at 6 month.	“[T]he experiment group (iontophoresis with dexamethasone) displayed better overall results compared with the control group in terms of less pain during and after physical activity and less pain during normal walking up and down stairs.”	Small sample size. Some details sparse. All placed in program including stretching, strengthening making co-intervention a significant consideration. Lack of randomization, allocation, blinding details. Data suggest iontophoresis with steroid may be modestly better.
------------------------	-----	---	---	--	---	--

## PHONOPHORESIS

Phonophoresis, the use of ultrasound to enhance delivery of topically applied drugs, has been used in an effort to enhance absorption of topically applied analgesics and anti-inflammatory agents. Phonophoresis is not a commonly described treatment for Achilles tendinopathy.

*Recommendation: Phonophoresis for Acute, Subacute, Chronic, or Post-operative Achilles Tendinopathy*  
**There is no recommendation for or against the use of phonophoresis for treatment of acute, subacute, chronic, or post-operative Achilles tendinopathy.**

*Strength of Evidence – No Recommendation, Insufficient Evidence (I)*

*Level of Confidence – Low*

### *Rationale for Recommendation*

Phonophoresis is non-invasive, has few adverse effects, and is moderately expensive. However, there is no quality evidence evaluating phonophoresis for treatment of patients with Achilles tendinopathy. Therefore, there is no recommendation for or against its use, pending publication of quality trials.

## LOW-LEVEL LASER THERAPY

Low-level laser treatment (LLLT) usually involves laser energy that does not induce significant heating. There are various theorized mechanisms of action including photoactivation of the oxidative chain, (66) (Fitz-Ritson 01) reduction of cell apoptosis, and promotion of collagen fiber synthesis.(67) (Stergioulas 08)

1. *Recommendation: Low-level Laser Therapy for Select Chronic Achilles Tendinopathy*  
**Low-level laser therapy is recommended for treatment of select patients with chronic Achilles tendinopathy.**

*Indications – Chronic Achilles tendinopathy; patients should generally have failed NSAIDs, eccentric exercises, iontophoresis, and injection(s).*

*Frequency/Duration* – Twelve sessions over 8 weeks (60mW/cm<sup>2</sup>, total dose 5.4J/session). Therapy should include a concurrent eccentric exercise program.

*Indications for Discontinuation* – Resolution, adverse effects, intolerance, non-compliance.

*Strength of Evidence* – **Recommended, Evidence (C)**  
*Level of Confidence* – Low

2. *Recommendation: Low-level Laser Therapy for Acute, Subacute, or Post-operative Achilles Tendinopathy*

**There is no recommendation for or against the use of low-level laser therapy for treatment of acute, subacute, or post-operative Achilles tendinopathy.**

*Strength of Evidence* – **No Recommendation, Insufficient Evidence (I)**  
*Level of Confidence* – Low

*Rationale for Recommendations*

There is no quality trial evaluating LLLT vs. sham treatment that did not include a co-intervention. There is one moderate-quality RCT evaluating treatment of patients with chronic Achilles tendinopathy that suggested benefits in pain intensity at 4, 8, and 12 weeks after an 8-week course of low laser therapy combined with eccentric exercises.(67) (Stergioulas 08) However, as the trial included eccentric exercises, it is unclear how much effect was attributable to LLLT and how much to exercises and whether adherence to exercise may have differed between the groups. LLLT is not invasive, has low adverse effects, but is high cost. LLLT is recommended for select patients who have failed treatments with greater evidence of efficacy or are considerably less costly, including NSAIDs, eccentric exercises, iontophoresis, and injection(s).

*Evidence for the Use of Low-level Laser Therapy for Achilles Tendinopathy*

There is 1 moderate-quality RCT incorporated into this analysis.

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Stergioulas 2008 RCT	7.0	N = 52 recreational athletes with chronic Achilles tendinopathy symptoms	Low level laser therapy (LLLT) with eccentric exercises (EE) vs. placebo LLLT with EE; 12 sessions, 8 weeks (60mW/cm <sup>2</sup> , total 5.4 J per session.	Mean pain intensity scores LLLT plus EE vs. placebo plus EE (0, 4, 8, 12 weeks): 79.8 vs. 81.8, 53.6 vs. 71.5, 37.3 vs. 62.8, 33.0 vs. 53.0, p <0.001 at all intervals after baseline.	“Low-level laser therapy with the parameters used in this trial seems to be a safe and effective method for more rapid recovery when combined with an EE regimen...using power densities below 100mW/ cm <sup>2</sup> seems to be important for obtaining good results.”	Withdrawal rate 23% (12/52) although included in ITT. Randomization, allocation unclear. Not clear what amount of effect due to eccentric exercises. Data suggest LLLT may be of modest additive benefit to eccentric exercises.

## ***Injection Therapies***

There are multiple injection therapies that have been utilized for treatment of Achilles tendinopathies. These include glucocorticosteroids, glycosaminoglycans, heparin, actovegin, apoprotinin, and polidocanol.

### **GLUCOCORTICOSTEROIDS INJECTIONS**

Injected glucocorticosteroids have been used to treat Achilles tendinopathies, especially the bursitis issues adjacent to the tendon. However, the use of these injections has been limited by concerns of the risk of tendon rupture. Oral or intramuscular glucocorticosteroids are reviewed above.

1. *Recommendation: Glucocorticosteroid Injections for Chronic Achilles Tendinopathy and Associated Paratendon Bursitis*

**Low-dose glucocorticosteroid injections are recommended as an alternative therapy for treatment of chronic Achilles tendinopathy and associated paratendon bursitis.**

*Indications* – Moderate or severe chronic Achilles tendinopathy. Treatment with other interventions such as NSAIDs and exercises should have been attempted previously and either failed or results were unsatisfactory. There may be cases in the late subacute stage in which these injections may be appropriate if other treatments have failed; thus, there is overall no recommendation for patients in the subacute stage.

*Frequency/Duration* – Up to 3 injections of triamcinolone 20mg over 3 weeks,(68) (Fredberg 04) with 2nd and 3rd injections performed if the 1st does not yield complete relief, the problem continues to be incapacitating, conservative treatment options have been exhausted, and the patient understands and accepts that Achilles tendon rupture is possible and may necessitate surgery. Other glucocorticosteroids may be effective; however, one trial showed no effect of 1 methyl prednisolone injection(69) (DaCruz 88) and quality trials with other glucocorticosteroids have not been reported.

*Indications for Discontinuation* – Resolution, intolerance, adverse effects, or lack of benefits.

*Strength of Evidence* – **Recommended, Insufficient Evidence (I)**

*Level of Confidence* – Low

2. *Recommendation: Glucocorticosteroid Injections for Acute, Subacute, or Post-operative Achilles Tendinopathy*

**Low-dose glucocorticosteroid injections are not recommended for treatment of acute, subacute, or post-operative Achilles tendinopathy.**

*Strength of Evidence* – **Not Recommended, Insufficient Evidence (I)**

*Level of Confidence* – Low

#### *Rationale for Recommendations*

One moderate-quality placebo-controlled RCT evaluating up to 3 triamcinolone injections under ultrasound guidance for treatment of Achilles tendinopathy,(68) (Fredberg 04) found evidence of short-term benefit. It is unclear if ultrasound guidance is necessary as the tissue is palpable. A second study found lack of efficacy.(69) (DaCruz 88) Glucocorticosteroid injections are invasive, have a low adverse effect profile as a single low-dose injection, and are moderately costly. They are recommended as a treatment for select patients, after more conservative treatments have been attempted and found insufficient.

#### *Evidence for the Use of Glucocorticosteroid Injections*

There are 2 moderate-quality RCTs incorporated into this analysis.

Author/Y ear Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Fredberg 2004  RCT	7.5	N = 48 (24 with Achilles tendinopathy; 24 with patellar tendinopathy) with diagnosis confirmed by ultrasound findings	Up to 3 injections of triamcinolone (20mg) injection vs. placebo under ultrasound guidance over 3-week period. Failures in placebo group received steroid protocol.	No significant changes in placebo group over 6 months. All received steroids at 6 months. Subjects treated with steroid improved in all measures between 1 and 4 weeks, but outcomes deteriorated by 24 weeks. Those in placebo group which then received steroid had similar outcomes as initially treated steroid group.	“Ultrasonographically guided injection of long acting steroid can normalize the ultrasonographic pathological lesions in the Achilles and patellar tendons, and has a dramatic [short-term] clinical effect but when combined with aggressive rehabilitation with running after a few days, many will have relapse of symptoms.”	Study excluded 2/3 of patients referred to study (those without ultrasound findings). High treatment failure rate in all groups, with 25% in Achilles steroid, 50% patellar steroid groups going on to surgery. Data suggest short-term but questionable long-term efficacy.
DaCruz 1988  RCT	4.0	N = 28 with Achilles paratendinitis	One peritendinous methylprednisolone 40mg injection vs. placebo.	Some evidence of short-term efficacy. Crossover of non-improving placebo group to treatment after 12 weeks. No significant differences between groups in pain scores, tenderness, activity level; 23 appeared to fail to respond to therapy, despite cross over.	“[I]t appears that locally-acting steroids have no role to play. Patients who did respond to treatment had only minimal signs and symptoms when they presented and recovered within six weeks.”	Study of 36 tendons in 28 patients. Lack of details for randomization, blinding. Co-interventions with physiotherapy, heel lifts. Twenty-three percent dropout. Study states it is a crossover but details unclear. Data suggest lack of efficacy.

## PLATELET RICH PLASMA

Injected platelet rich plasma has been used for treatment of Achilles tendinopathy.(70) (de Vos 10; di Matteo 15)

*Recommendation: Platelet Rich Plasma Injections for Achilles Tendinopathy*

**Platelet-rich plasma injections are moderately not recommended for treatment of Achilles tendinopathy.**

*Strength of Evidence – Moderately Not Recommended, Evidence (B)*

Level of Confidence – Moderate

*Rationale for Recommendation*

There is one high-quality trial for Achilles tendinopathy injections and it failed to demonstrate evidence of efficacy. (de Vois 10) This procedure is invasive, has low adverse effects, is high cost, but with lack of efficacy is not recommended. As there is only one published clinical trial, this recommendation could change based on additional quality evidence, particularly as there may be some evidence of potential efficacy for some other tendinopathies (see Elbow Disorders and Knee Disorders guidelines).

*Evidence for the Use of Platelet Rich Plasma*

There is 1 high-quality RCT incorporated into this analysis.

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
de Vos 2010 RCT	9.0	N = 54 patients, aged 18 to 70 years with chronic tendinopathy 2 to 7 cm above the Achilles tendon insertion	Eccentric exercises (usual care) with either a PRP injection (PRP group) vs. saline injection (placebo group). Randomization was stratified by activity level.	Mean VISA-A score improved after 24 weeks in the PRP group by 21.7 points (95% confidence interval [CI], 13.0-30.5) and in the placebo group by 20.5 points (95% CI, 11.6-29.4).	“Among patients with chronic Achilles tendinopathy who were treated with eccentric exercises, a PRP injection compared with a saline injection did not result in greater improvement in pain and activity.”	Data suggest lack of efficacy.

**GLYCOSAMINOGLYCAN POLYSULFATE LOCAL INJECTIONS**

Glycosaminoglycan polysulfate (GAGPS) is a group of carbohydrates containing amino sugars occurring in proteoglycans such as hyaluronic acid or chondroitin sulfate (see Hip and Groin Disorders; and Hand, Wrist, and Forearm Disorders guidelines). In chronic Achilles tendon disorders, the use of GAGPS is thought to stimulate healing and remodeling of collagen fibers.(71) (Mello 03)

1. *Recommendation: Glycosaminoglycan Polysulfate Local Injection (GAGPS) for Chronic Achilles Tendinopathy*

**Glycosaminoglycan polysulfate local injection is recommended as an alternative therapy for treatment of chronic Achilles tendinopathy.**

*Indications* – Moderate or severe chronic Achilles tendinopathy; treatment with other interventions such as NSAIDs and exercises should have been attempted previously and either failed or results were unsatisfactory.

*Frequency/Duration* – Up to 6 local injections into the paratendon area over a 2-week period; assess after 2 or 3 injections and if results are satisfactory, withhold and evaluate value of further injections while observing the clinical course.

*Indications for Discontinuation* – Resolution, intolerance, adverse effects, or lack of benefits.

*Strength of Evidence – Recommended, Evidence (C)*  
*Level of Confidence – Low*

2. Recommendation: Glycosaminoglycan Polysulfate Local Injection (GAGPS) for Acute, Subacute, or Post-operative Achilles Tendinopathy

**There is no recommendation for or against the use of glycosaminoglycan polysulfate local injection for treatment of acute, subacute, or post-operative Achilles tendinopathy.**

*Strength of Evidence – No Recommendation, Insufficient Evidence (I)*

*Rationale for Recommendations*

There is one moderate-quality RCT evaluating glycosaminoglycan polysulfate for treatment of Achilles tendinopathy.(38) (Sundqvist 87) However, instead of being placebo controlled, it is controlled with indomethacin 50mg, 6 doses administered at time of injections in the placebo group. Six local injections of GAGPS into the paratendon area over a 2-week period (6 injections total) in patients with symptoms greater than 3 months demonstrated significant improvement from baseline at 4 weeks, with 53% responding to treatment (moderate or good) and 59% responding at 1 year. The comparison group received oral indomethacin, in which responders were 19% at 4 weeks and 12% at 52 weeks. Therefore, this suggests there is limited evidence that GAGPS may be beneficial for patients with chronic symptoms of Achilles tendon conditions. Glycosaminoglycan injections are invasive, have a low adverse effect profile, and are moderately costly as a series of injections is required.

*Evidence for the Use of Glycosaminoglycan Injections*

There is 1 moderate-quality RCT incorporated into this analysis.

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Sundqvist 1987 RCT	6.0	N = 60 recreational athletes suffering from Achilles peritendinitis	Local injection glycosaminoglycan polysulfate (GAGPS) vs. indomethacin 50mg 3 times a week for 2 weeks.	No difference in percentage with good response ratings in acute patients. Significant differences in chronic patients with GAGPS vs. indomethacin (59% vs. 12%, p <0.05).	“Local injections of GAGPS were shown to be more effective than high-dose indomethacin especially in chronic cases.”	Allocation, blinding details unclear. Sixty-six percent of participants had co-intervention of orthotic. Data suggest benefit in chronic conditions over indomethacin. No placebo.

**HEPARIN INJECTIONS**

Low-dose subcutaneous heparin injection has been described as a potential treatment for acute insertional Achilles tendinopathy with a hypothesized mechanism of reducing edema and the formation of adhesions between the skin and underlying soft tissue.(72) (Larsen 87)

*Recommendation: Subcutaneous Heparin Injection for Acute, Subacute, or Chronic Achilles Tendinopathy*

**Heparin subcutaneous injection is not recommended for treatment of acute, subacute, or chronic Achilles tendinopathy.**

*Strength of Evidence – Not Recommended, Evidence (C) – Acute, subacute  
Not Recommended, Insufficient Evidence (I) – Chronic  
Level of Confidence – Low*

*Rationale for Recommendation*

There is one moderate-quality study comparing subcutaneous heparin injection to placebo for insertional or calcaneal tendinitis.(72) (Larsen 87) No significant differences were found between the groups. This study was possibly confounded by including the co-intervention of physical work in both groups, although the impact is unclear. Heparin injections are invasive, are likely low risk to most patients at the described daily dose of 5,000 IU, and are moderately costly when considering a course of injections for at least 1 week. Due to the lack of demonstrated efficacy, they are not recommended. There is no evidence to support the use of heparin in chronic conditions.

*Evidence for the Use of Heparin Injections*

There is 1 moderate-quality RCT incorporated into this analysis.

Author/Y ear Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Larsen 1987 RCT	6.5	N = 20 young males with acute calcaneal peritendinitis crepitans	Physical work plus heparin (5,000 IU) injection once daily for 5 days vs. physical work plus saline injections for acute Achilles calcaneal (insertional) pain.	During 1st week, total symptom score dropped 32% in heparin group and 34% in placebo from baseline. No difference between groups on outcomes measures over 2 week follow-up.	“The present study showed no certain effect of subcutaneous injections of heparin on the course of calcaneal peritendinitis.”	Small sample size, blinding details unclear. Data suggest not effective.

**ACTOVEGIN INJECTIONS**

Actovegin injection (deproteinized hemodialysate from calf-blood) into the paratendon for acute and chronic mid-portion Achilles tendinopathy has been described.

*Recommendation: Actovegin Injection for Acute, Subacute, or Chronic Achilles Tendinopathy*

**There is no recommendation for or against the use of Actovegin injection for the treatment of acute, subacute or chronic Achilles tendinopathy.**

*Strength of Evidence – No Recommendation, Insufficient Evidence (I)  
Level of Confidence – Low*

*Rationale for Recommendations*

There is one moderate-quality placebo-controlled trial of Actovegin that showed a significantly greater improvement in acute pain and reduction of Achilles tendon diameter after a series of 3 injections into the paratendon for acute and subacute mid-portion Achilles tendinitis.(73) (Pförringer 94) The treatment group demonstrated complete resolution of pain while walking on tip-toes at the 3-month follow-up. This treatment is invasive, has a low reported adverse effective profile, and is of moderate to high cost, but is

not FDA approved for this use. Therefore, there is no recommendation for or against the use of these injections.

#### Evidence for the Use of Actovegin Injections

There is 1 moderate-quality RCT incorporated into this analysis.

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Pförringer 1994 RCT	6.5	N = 60 with Achilles paratendinitis	Actovegin (5ml solution of deproteinized hemodialysate from calf-blood) vs. placebo injections into paratendon (3 injection series at days 1, 3-4, 9-10).	Competitive and recreational "athletes" who had achillodynia no more than 3 months. Mean Achilles diameter reduction from 13.5mm to 9.8mm (active treatment), 27.2±10.4% reduction. Mean diameter decrease with placebo from 14.2 to 12.9mm, a decrease of 9.3±7.5%, p <0.0001. Severe and moderate pain provoked by stress while standing on tiptoes in 43.3% at baseline decreased to 0% in active drug group vs. 26.7% in placebo group.	"Injection therapy with Actovegin ensures a high therapeutic success, both for acute and chronic Achilles paratendinitis. Due to the excellent low rate of side effects, a very favorable benefit/risk ratio is confirmed."	Conclusions state treatment effective for chronic pain, but cases over 3 months were excluded. Treatment is not FDA approved.

#### PROLOTHERAPY, Including POLIDOCANOL and HYPERTONIC GLUCOSE INJECTIONS

Prolotherapy is performed with various sclerosing agents, including polidocanol and hypertonic saline. (Yelland 10; Alfredson 05) These are typically injected into the site of neo-vascularization in the paratendon of Achilles tendinopathy.

##### 1. Recommendation: Prolotherapy Injections for Chronic Achilles Tendinopathy

**There is no recommendation for or against the use of prolotherapy injections for the treatment of chronic Achilles tendinopathy.**

*Strength of Evidence – No Recommendation, Insufficient Evidence (I)*

*Level of Confidence – Low*

##### 2. Recommendation: Polidocanol Injection for Acute, Subacute, or Post-operative Achilles Tendinopathy

**There is no recommendation for or against the use of polidocanol injection for acute, subacute, or post-operative Achilles tendinopathy.**

*Strength of Evidence – No Recommendation, Insufficient Evidence (I)*

*Level of Confidence – Low*

#### Rationale for Recommendations

There is conflicting evidence on efficacy of prolotherapy injections for chronic Achilles tendinosis. One moderate-quality trial using hypertonic glucose suggested lack of efficacy.(74) (Yelland 10) Another trial suggested polidocanol was effective.(75) (Alfredson 05) Thus, the overall evidence comparing treatment

to placebo conflicts. A high-quality study showed no dose response of sclerosing injections, however there was no placebo controlled group and the trial cannot infer efficacy.(76) (Willberg 08) Thus with conflicting evidence, there is no recommendation for or against these injections.

#### Evidence for the Use of Polidocanol Injections

There is 1 high- and 2 moderate-quality RCTs incorporated into this analysis.

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
<b>Prolotherapy vs. Placebo Injections</b>						
Yelland 2010 RCT	6.5	N = 43 with painful mid-portion Achilles tendinosis	Eccentric loading exercises (ELE) 12-week program (n = 15) vs. prolotherapy injections of hypertonic glucose with lignocaine alongside affected tendon (n = 14) vs. combined treatment (n = 14).	Mean (95% CI) increases in VISA-A scores at 12 months were 23.7 (15.6 to 31.9) for ELE, 27.5 (12.8 to 42.2) for prolotherapy and 41.1 (29.3 to 52.9) for combined treatment. At 6 weeks and 12 months, increases were significantly less for ELE than for combined treatment.	“For Achilles tendinosis, prolotherapy and particularly ELE combined with prolotherapy give more rapid improvements in symptoms than ELE alone but long-term VISA-A scores are similar.”	Small sample sizes. No placebo. Baseline differences in pain duration (21 vs. 24 vs. 6 months). Some data suggest earlier improvement with prolotherapy or combined groups but nearly all data suggest no long-term differences.
Alfredson 2005 RCT	6.0	N = 20 with chronic painful mid-portion Achilles tendinopathy	Sclerosing injection (polidocanol) vs. lidocaine w/epi injection into neovascularization in chronic AT.	Mean VAS scores during activity decreased 77±10 to 41±10 (p <0.005) vs. placebo 66±6 to 64±6, (p = 0.878) after 1 injection; 5 of 10 intervention group not satisfied after 1 injection; administered 2nd, all satisfied. All of placebo group crossed over	“Sclerosing injections with the substance Polidocanol, but not non-sclerosing injections with Lidocaine plus adrenaline, targeting the area with neovascularization of the Achilles tendon, led to significantly reduced pain during tendon-loading activity. Clinical	Baseline comparison data sparse and higher pain scores in active treatment group at baseline. Small sample size. Data suggest efficacy.

				after treatment failure; 90% satisfied after 1 injection (VAS 64±6 to 16±4, p <0.005). Outcome-observation period 3 months (range 6-20 weeks).	improvement corresponded with elimination of the colour Doppler appearance of neo-vascularization .”	
<b>High vs. Low Dose Treatment</b>						
Willberg 2008 RCT	9.5	N = 52 Achilles tendons (48 patients with chronic painful midportion Achilles tendinopathy)	Sclerosing injections with polidocanol: 5mg vs. 10mg (6-8 weeks between injections, up to 3 injections before initial evaluation) All had pain during loading of Achilles tendon and “long duration of symptoms”: 26-month mean (range 6-72 months) in low-concentration group; 28-month mean (range 2-120 months) in high-concentration.	Mean VAS score improvement: 5mg vs. 10mg: 66±14 to 25±28, p <0.05, 66±21 to 24±31, p <0/05. No difference between groups in VAS improvement, number of treatments, adverse effects.	“We found no differences in the clinical results, number of treatments or volume injected when treating chronic painful midportion Achilles tendinopathy with sclerosing Polidocanol injections.”	No placebo-control. Data suggest no differences, suggesting equal (in)efficacy.

### **APOPROTININ INJECTIONS**

Apoprotinin is a natural proteinase inhibitor – including matrix metalloproteinase (MMP) – obtained from bovine lung that is thought to be a collagenase inhibitor(77) (Brown 06) and is a described treatment for Achilles and patellar tendinopathies.

*Recommendation: Apoprotinin Injection for Acute, Subacute, or Chronic Achilles Tendinopathy*

**Apoprotinin injection is not recommended for treatment of acute, subacute, or chronic Achilles tendinopathy.**

*Strength of Evidence – Not Recommended, Evidence (C) – Chronic  
Not Recommended, Insufficient Evidence (I) – Acute, subacute  
Level of Confidence – Low*

### Rationale for Recommendation

There is one moderate-quality placebo-controlled trial comparing apoprotinin to placebo for the treatment of chronic mid-portion Achilles tendinopathy.(77) (Brown 06) A series of 3 weekly injections did not demonstrate any improvement of pain in the intervention group compared to placebo. However, this study allowed multiple co-interventions, including eccentric exercises in both groups, such that the impact of the intervention may be confounded. Regardless, as there was no improvement difference between the groups despite the co-interventions, it is unlikely that this intervention was effective as a treatment. It is invasive, has a small but serious risk for anaphylactic reaction as it is bovine in origin, and is likely moderate to high cost requiring multiple injections over several office visits. Therefore, apoprotinin injection is not recommended.

### Evidence for the Use of Apoprotinin Injections

There is 1 moderate-quality RCT incorporated into this analysis.

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Brown 2006  RCT	6.5	N = 26 with Achilles tendinopathy	Apoprotinin (weekly injection x 3 weeks) plus eccentric exercises vs. placebo plus eccentric exercises.	No differences between treatment groups at any follow- up (2, 4, 12, or 52 weeks).	“Apoprotinin did not show any statistically significant benefit over placebo.”	Thirty-three tendons in 26 patients. Allowed other conservative treatments to ensure enrollment (NSAIDs, heel pads, etc). Data suggest lack of efficacy.

### HIGH VOLUME IMAGE GUIDED INJECTION

High-volume image-guided injection (HVIGI) is a technique described to treat chronic Achilles and patellar tendinopathy to reduce neovascularization.(78) (Chan 08) Under ultrasound guidance, 10ml of local anesthetic (bupivacaine), 25mg of hydrocortisone and up to 40ml of normal saline are injected into the tendon at the site of maximal neovascularization.

### Recommendation: High-volume Image-guided Injection for Chronic Achilles Tendinopathy

**There is no recommendation for or against the use of high-volume image-guided injection for treatment of chronic Achilles tendinopathy.**

**Strength of Evidence – No Recommendation, Insufficient Evidence (I)**

**Level of Confidence – Low**

### Rationale for Recommendation

There is no quality evidence for or against the use of high-volume injection into the tendon for chronic Achilles tendinopathy. However, this is only a recently described technique that borrows the hypothesis that reducing neovascularization will reduce pain and improve healing from other effective treatments. A small prospective study of 30 subjects demonstrated significant improvement in pain and function at 4 weeks, lasting out to 30 weeks.(78) (Chan 08) HVIGI is invasive, has uncertain adverse effect profile but may carry an increased risk for tendon rupture with the use of injected steroid, and is of moderate cost. Quality studies are necessary to evaluate this treatment.

### Surgery

Quality, population-based studies for prognoses of Achilles tendinopathies have not been reported, and available published studies cited below are likely biased towards over-estimates of risk for surgery due primarily to selection and spectrum biases. It has been estimated that 24 to 45% of patients with chronic Achilles tendinopathy that fail 6 months of non-operative treatment have proceed to surgery.(33) (Tan 09) For paratendonitis, surgery is rare, but if required, usually is performed through a longitudinal incision

where the posterior and lateral aspects of the diseased paratenon are excised, sparing the anterior portion containing the vascular supply.(27) (Reddy 09) For mid-portion chronic tendinopathy, approximately 25% of patients have been estimated to fail non-operative measures. Surgical treatment consists of removing the areas of degenerated tendon, and may require tendon transfer if more than 50 to 75% of the tendon is removed.(27) (Reddy 09) For insertional tendinosis, 85 to 90% of cases improve with conservative measures. Surgical treatment frequently consists of a midline incision at the insertion and debriding calcific or degenerate regions.

1. *Recommendation: Surgery for the Treatment of Chronic Achilles Tendinopathy without Rupture*  
**Surgery is recommended for select cases of chronic Achilles tendinopathy without rupture. There is no recommendation for any particular procedure over another.**

*Indications* – Patients with moderate to severe chronic Achilles tendinopathies who have failed multiple non-surgical treatments and whose condition has lasted at least 6 months. Patients should generally have failed NSAID(s), eccentric exercises, iontophoresis, injection(s) and low level laser therapy.

*Strength of Evidence* – **Recommended, Insufficient Evidence (I)**  
*Level of Confidence* – Low

2. *Recommendation: Surgery for the Treatment of Acute or Subacute Achilles Tendinopathy without Rupture*  
**Surgery is not recommended for acute or subacute Achilles tendinopathy without rupture.**

*Strength of Evidence* – **Not Recommended, Insufficient Evidence (I)**  
*Level of Confidence* – High

#### *Rationale for Recommendations*

There are no quality trials comparing surgical intervention(s) with continued non-operative interventions for patients with Achilles tendinopathies. Further, there are no trials comparing different surgical techniques. There are several studies that indicate surgical success as measured by satisfied or very satisfied scores is up to 85%.(30) (Rompe Dis Rehab 08) Success rates at 7 months in a prospective study were higher for paratenonitis (88%) versus only 54% for those with intratendinous lesions, with complication rates of 6% versus 27% respectively.(79) (Paavola 02) Thus, while surgery appears to provide relief to the majority of patients, it is not without significant risk of complication, expense, and lack of comparison data to other non-surgical interventions. Therefore, surgery is not recommended until a course of at least 6 months of other non-operative treatments with demonstrated efficacy has been attempted and the patient's symptoms are sufficient to warrant the risks of surgical intervention.

## Achilles Tendon Rupture

### **General Approach and Basic Principles**

Spontaneous rupture of the Achilles tendon is uncommon, with incidence rates reported between 4 and 37 per 100,000 person years.(80-85) (Maffulli 99, Levi 97, Lapidus 07, Houshian 98, Suchak 05, Clayton 08) However, these rates appear to be increasing in the general population,(80, 81) (Maffulli 99, Levi 97) particularly among males in their 30s and 40s who participate in sporting activities,(82) (Lapidus 07) as well as in older persons involved in no sporting activity.(81, 84) (Levi 97, Suchak 05) Achilles tendon ruptures most frequently affect males 4-fold more often than females.(86) (Carden 87; Suchack 05; White 07) It is estimated that approximately 75% of all Achilles ruptures are related to sports and of these injuries, 75% occur in recreational athletes,(87-89) (Nistor 81, Leppilahti 98, Moller 01) mostly during a game.(90) (Cetti 93) The incidence of patients experiencing Achilles tendon symptoms prior to acute rupture is unknown, although it appears low, around 5%.(80) (Maffulli 99)

The primary mechanism for Achilles tendon rupture is presumed to be trauma from tensile forces, such as those encountered when pushing off during sprinting or running, sudden forceful dorsiflexion of the foot with slipping, missing a stair, jumping, or landing on the foot after falling.(26) (Heckman 09) Rupture from unusual tensile forces may occur. (Kannus 97; Kuwada 95; Waterston 97) However, when the tendon is degenerated and at risk for rupture, an eventual rupture may also occur without extraordinary stress especially when the degeneration is more marked. (Hastad 58; McMaster 33) Approximately 80% of tendon ruptures occur 3-6cm above the calcaneal insertion. (Maquirrian 11) Direct injury mechanisms are rare. The exact pathogenesis of acute Achilles tendon rupture as well as the mechanism of the healing process is unknown and controversial, although an underlying degenerative condition is believed to be uniformly present.(26, 44, 91-93) (Möller 02; Rees 06; Rees 09; Longo 09; Heckman 09) Similar to other ruptured tendons such as the supraspinatus (see Shoulder Disorders guideline), there are two predominate theories – mechanical and hypovascularity.(44, 92) (Rees 06; Rees 09) The mechanical theory hypothesizes tendon degeneration from “repetitive microtrauma”(94, 95) (Carr 89, Kannus 91) and failure of the inhibitory mechanism of the musculotendinous unit.(88) (Leppilahti 98) The vascular theory includes evidence that there is low blood supply to the Achilles tendon in the area of rupture,(94, 96, 97) (Ahmed 98; Carr 89; Chen 09) which is similar to that found for other tendons in the body that rupture including the supraspinatus, bicipital, Achilles, and tibialis posterior(44, 92, 94, 96, 97) (Ahmed 98; Carr 89; Chen 09; Rees 06; Rees 09) (see Shoulder Disorders guideline). Other factors associated with increased risk of Achilles tendon rupture include a 3- to 4-fold risk of rupture within 90 days after the use of fluoroquinolones(98, 99) (Sode 07, Corrao 06) and 43-fold risk after use of fluoroquinolones concomitantly with steroids. However, the overall incidence of rupture among users of fluoroquinolones is low.(99) (Corrao 06) Additionally, there is suggestion of a genetic component related to sequence variants of the tenascin C (TNC) gene, which regulates the tissue’s response to mechanical load.

### ***Work-Relatedness***

There are no quality epidemiological studies on work-relatedness of Achilles rupture and occupation. Determination of work-relatedness is based on speculatively identifying a mechanism such as trauma; however, there is no quantification of the amount of force necessary to cause rupture. In non-acute traumatic settings, there is a lack of quality epidemiological evidence of work-relatedness.

### ***Initial Assessment***

Attention is initially focused on differential diagnosis for ankle and foot disorders through a focused history and examination(Garras 12)

### ***Medical History***

The cardinal symptom of an Achilles tendon rupture is a sudden pain in the posterior heel that is often accompanied by a “pop” heard emanating from the heel.(26, 33, 100-103) (Heckman 09; Metzl 08; Tan 09; Deangelis 09; Cary 09; Jacob 07) There is generally no history of prior symptoms (pain, stiffness) prior to rupture.(80, 103) (Maffulli 99; Jacob 07)

### ***Physical Examination***

Diagnosis of an Achilles tendon rupture is most often based on loss of plantar flexion strength, palpation of a gap in the mid-portion of the tendon (proximal to the calcaneal insertion),(87, 89, 90) (Nistor 81, Cetti 93, Möller 01) and a positive squeeze test of the calf muscle that fails to elicit plantar flexion.(104) (Thompson 62) The examiner may encounter resting dorsiflexion on the side of the rupture. Other examination findings include the Matles knee flexion test. (Matles 75) Specific imaging is not required for most acute rupture cases.(26, 100, 101, 103) (Deangelis 09; Jacob 07; Metzl 08; Heckman 09)

### ***Diagnostic Criteria***

There are no other specific diagnostic criteria for Achilles tendon rupture. Acute rupture refers to rupture that presents for evaluation within 4 weeks, whereas chronic rupture refers to ruptures that present for evaluation 4 to 6 weeks after an acute injury.(105) (Maffulli 08)

### ***Workplace Intervention***

## WORK RESTRICTIONS

Workplace restrictions for an Achilles tendon rupture are dependent on treatment specifics. Historically, work limitations and rest have been prescribed.(44) (Rees 09) However, there is quality evidence that early weight bearing post-operatively is beneficial to recovery; therefore, activity modification to safely allow weight bearing is recommended (see Achilles Rupture – Post Operative Care).

### ***Special Studies, Diagnostic and Treatment Considerations***

Diagnosis of an Achilles tendon rupture is generally made through a clinical history and physical examination findings.(26, 33, 100-103) (Heckman 09; Metzl 08; Tan 09; Deangelis 09; Cary 09; Jacob 07)

## X-RAY

X-ray is generally not widely used for the diagnosis of acute Achilles rupture, although it may be helpful in identifying tendon calcification.(106, 107) (Gerster 77, Wick 08)

*Recommendation: Routine X-ray for Diagnosis of Acute Achilles Rupture*

**There is no recommendation for or against the routine use of x-ray to diagnose acute Achilles tendon rupture.**

*Indications* – Achilles tendon ruptures resulting from direct trauma or if suspected rupture involves the calcaneal insertion, or among patients with reasonable suspicion of tendon calcification.(106, 107) (Gerster 77, Wick 08)

*Strength of Evidence* – **No Recommendation, Insufficient Evidence (I)**  
*Level of Confidence* – Low

### *Rationale for Recommendation*

There is no quality evidence that obtaining x-ray studies for the evaluation of acute Achilles rupture significantly improves or changes the course of treatment. A case report used x-ray to confirm the diagnosis of a suspected rupture in a 69-year old male with diffuse calcification of the Achilles tendon,(107) (Wick 08) although it is unknown if the management course was altered with this finding. While most ruptures are diagnosed by physical examination, in cases of uncertainty, MRI and ultrasound are preferred over x-ray. Ruptures of the tendon at the calcaneal insertion are reported to be rare, although if suspected, radiography may detect avulsion of the bony insertion.(108) (Lui 09) Therefore, although x-ray is inexpensive and is readily accessible, it is unlikely to provide diagnostic benefit except in cases where direct trauma may have resulted in increased likelihood of fracture, when suspected rupture involves the calcaneal insertion, or where there is reasonable clinical suspicion of tendon calcification such as among those with many cardiovascular risk factors or calcium pyrophosphate deposition disease.

## ULTRASOUND

Ultrasound is widely used to evaluate Achilles tendon rupture particularly where there is diagnostic uncertainty.(26, 102) (Heckman 09; Cary 09)

*Recommendation: Ultrasound for Diagnosis of Acute Achilles Tendon Rupture*

**Ultrasound is recommended for the diagnosis of acute Achilles tendon rupture.**

*Indications* – Clinical suspicion of rupture is high but uncertain.

*Strength of Evidence* – **Recommended, Insufficient Evidence (I)**  
*Level of Confidence* – Moderate

### *Rationale for Recommendation*

There are no quality trials comparing the use of ultrasound as a diagnostic test for acute Achilles tendon rupture. There are a number of case series that suggest ultrasound has a high sensitivity and specificity. A case series of 100 patients with suspected acute Achilles rupture compared pre-operative ultrasound with intraoperative findings. All suspected tears were confirmed by ultrasound and there was a high correlation of rupture size (Pearson  $r = 0.940$ ). (109) (Margetić 07) Another study comparing operative results with pre-operative ultrasound confirmed a high sensitivity and specificity, with one false negative out of 26 cases. (110) (Paavola 98) Ultrasound has been described as a tool to plan surgical intervention, although there are no trials found that demonstrate this utility. Ultrasound is not invasive, has no adverse effects, and is moderately costly. It is recommended as the main confirmatory diagnostic test for Achilles ruptures, particularly when there is diagnostic uncertainty.

## **MRI**

MRI is sometimes used to evaluate the Achilles tendon particularly where there is diagnostic uncertainty, although ultrasound has been generally preferred. (26, 33, 102) (Heckman 09; Cary 09; Tan 09)

*Recommendation: MRI for Diagnosis of Acute Achilles Tendon Rupture*

**MRI is recommended for the evaluation of acute Achilles tendon rupture.**

*Indications* – Clinical suspicion of rupture is high but uncertain.

*Strength of Evidence* – **Recommended, Insufficient Evidence (I)**

*Level of Confidence* – Moderate

### *Rationale for Recommendation*

There are no quality trials evaluating the use of MRI in the diagnosis of Achilles tendon rupture. MRI has an advantage of providing a broader field of view compared to ultrasound. MRI is not invasive and has no adverse effects, but is high cost and more costly than ultrasound. MRI is therefore recommended for select use as an alternative when clinical suspicion is high but uncertain and particularly when other issues are unclear such as requiring a broader field of view.

## **Initial Care**

Upon establishment of the diagnosis, initial treatment is symptomatic until the definitive care plan is established. This may include relative rest, NSAIDs, acetaminophen and cryotherapy. There are few quality trials for evaluation of any interventions for treatment of Achilles ruptures. (26, 100, 111) (Metzl 08; Heckman 09; Almekinders 98)

## **Medications**

### **NON-STERIODAL ANTI-INFLAMMATORY DRUGS (NSAIDs) AND ACETAMINOPHEN**

The use of oral NSAIDs is a well-described intervention for numerous soft-tissue and musculoskeletal injuries including ankle sprains. (34) (Duranceau 86) The mechanism of action is unclear for typical musculoskeletal disorders that do not have traditional markers of inflammation, although some believe the mechanism of efficacy nevertheless involves addressing some component of inflammation. (35) (Jakobsen 89)

1. *Recommendation: Acetaminophen for Acute Achilles Rupture*

**Acetaminophen is recommended as analgesia for pain as a result of acute Achilles tendon rupture.**

*Indications* – Pain associated with acute Achilles tendon rupture.

*Frequency/Dose/Duration* – Frequency and dose per manufacturer's recommendations; may be taken scheduled or as needed. Providers are cautioned that an FDA advisory committee has recommended reduction in daily doses to below the prior recommendations of up to 4gm a day.

*Indications for Discontinuation* – Resolution, intolerance, adverse effects, lack of benefits.

*Strength of Evidence* – **Recommended, Insufficient Evidence (I)**

*Level of Confidence* – Low

2. *Recommendation: NSAIDs for Acute, Subacute, Chronic, or Post-operative Pain from Achilles Tendon Rupture*

**NSAIDs are recommended for pain treatment of acute, subacute, chronic, or post-operative Achilles tendon rupture.**

*Indications* – Pain associated with acute, subacute, or chronic rupture, or for post-operative pain management.

*Frequency/Dose/Duration* – Frequency and dose per manufacturer’s recommendations. May be taken scheduled or as needed. There is no evidence one NSAID is superior to another for treatment of Achilles rupture.

*Indications for Discontinuation* – Resolution, intolerance, adverse effects, lack of benefits, or failure to progress over a trial of a few weeks.

*Strength of Evidence* – **Recommended, Insufficient Evidence (I)**

*Level of Confidence* – High

#### *Rationale for Recommendations*

There are no quality trials for treatment of these patients with NSAIDs or acetaminophen. However, these medications have evidence of efficacy for treatment of numerous musculoskeletal disorders (see, for example, ankle sprains section and Shoulder Disorders and Low Back Disorders guidelines). NSAIDs and acetaminophen are not invasive, have low adverse effects and are low cost. They are recommended for treatment of these patients (see Hip and Groin Disorders guideline for discussion of gastroprotective and cardiovascular issues).

#### **OPIOIDS – Oral, Transdermal, and Parenteral (Includes Tramadol)**

Opioids are frequently used to treat the pain of musculoskeletal conditions and are widely used in post-operative settings; however, most of the trials generally evaluated patients with spine-related disorders (see Low Back Disorders and Chronic Pain guidelines). Use of opioids for treatment of Achilles rupture has not been well described.

1. *Recommendation: Opioids for Pain from Acute or Post-operative Achilles Tendon Repair*

**Limited use of opioids for the treatment of acute Achilles tendon rupture is recommended as a treatment option for select patients presenting with acute or moderate to severe pain related to Achilles rupture. Limited use of opioids for a few days is also recommended for select patients who have undergone recent Achilles tendon repair or those who encountered surgical complications.**

*Indications* – Acute rupture or post-operative pain management for patients with moderate to severe pain.

*Frequency/Dose/Duration* – Frequency and dose per manufacturer’s recommendations; may be taken scheduled or as needed; generally taken for short courses of a few days, with subsequent weaning to nocturnal use if needed, then discontinuation. Total length of treatment usually ranges from a few days to up to 2 weeks. Generally should be utilized to supplement pain relief in addition to an NSAID or acetaminophen to reduce total need for opioid and the consequent adverse effects.

*Indications for Discontinuation* – Sufficient pain management with other methods such as NSAIDs, resolution of pain, intolerance, adverse effects, lack of benefits, or failure to progress over a couple weeks.

*Strength of Evidence* – **Recommended, Insufficient Evidence (I)**

*Level of Confidence* – Moderate

2. *Recommendation: Opioids for Pain from Subacute or Chronic Achilles Tendon Repair*

**Opioids are not recommended for treatment of pain from subacute or chronic Achilles tendon repair.**

*Strength of Evidence* – **Not Recommended, Insufficient Evidence (I)**

*Level of Confidence* – High

*Rationale for Recommendations*

There is no quality evidence evaluating the use of opioids for the treatment of pain from acute Achilles tendon rupture. Approximating 50% of patients do not tolerate opioids (see Chronic Pain guideline). A large percentage of patients with Achilles tendon rupture do not report pain sufficient to require opioids. Opioids are not invasive, but have very high dropout rates and otherwise high rates of adverse effects, including very high associated death rates that have been reported to exceed motor vehicle crash death risks in two states.(112, 113) (Hall 08; CDC MMWR 06) Opioids are moderate to high cost depending on duration of treatment (see Chronic Pain guideline). They are not recommended for routine use. Some patients have insufficient pain relief with NSAIDs, thus judicious use of opioids for acute management may be helpful, particularly for nocturnal use. Opioids are recommended for brief, select use in post-operative patients with primary use at night to facilitate adequate post-operative sleep.

**Physical Methods**

**CRYOTHERAPY/HEAT**

Cryotherapy and heat are commonly used as an initial intervention for analgesia, and cryotherapy in particular is thought to reduce pain associated with acute musculoskeletal injuries.

*Recommendation: Self-application of Cryotherapy or Heat Therapy for Acute, Subacute, Chronic, or Post-operative Achilles Tendon Rupture*

**Self-application of cryotherapy or heat therapy is recommended for treatment of acute, subacute, chronic, or post-operative Achilles tendon rupture.**

*Indications* – Acute, subacute, chronic, or post-operative patients with Achilles tendon rupture.

*Frequency/Duration* – Approximately 3 to 5 self-applications per day as needed.

*Indications for Discontinuation* – Resolution, adverse effects, non-compliance.

*Strength of Evidence* – **Recommended, Insufficient Evidence (I)**

*Level of Confidence* – Low

*Rationale for Recommendation*

There are no quality trials for modality applications in improving outcomes for Achilles tendon rupture. Cryotherapy (ice) and heat appear effective in treating musculoskeletal disorders involving other body parts. Ice may be of short-term benefit in reducing swelling and pain for acute rupture. Heat may be helpful particularly for healing particularly a few days after the rupture or surgery. These treatments are not invasive, have low adverse effects, are low cost, and thus are recommended.

**Surgical Considerations**

The optimal management of Achilles tendon rupture is controversial.(26, 80, 89, 90, 100, 114-116) (Inglis 76, Cetti 93, Maffulli 99, Moller 01, Twaddle 07, Metz 08; Metz 08; Heckman 09) The objective of operative and non-operative management is to approximate the ruptured tendon ends. Non-operative management achieves this by keeping the foot in plantar flexion with a rigid cast or brace and allowing natural healing without sutures or other surgical intervention.(26, 33) (Heckman 09; Tan 09) There are various protocols for rigid casting that differ in initial foot angle positions, duration of non-weight bearing, and timing of repositioning and activities. Functional braces or splints rather than casting have been described as an alternative to casting.

Surgical repair provides mechanical approximation of the ruptured tendon ends through a variety of described operative and suturing techniques. There is evidence that re-rupture rates are lower with operative compared to non-operative care in some, but not all trials.(26, 33, 89, 117, 118) (Tan 09; Heckman 09; Khan 05, Moller 01, Moller Scan J Med Sci Sports 02) For example, in a meta-analysis that included four studies, each comparing operative to non-operative management of rupture, there were 6 and 23 tendon reruptures in operative and non-operative groups of 173 and 183, respectively, yielding a number of operations – needed to treat, 11; and needed to harm, 3.2.(117) (Khan 05) The interpretation of the results of the studies comparing operative to non-operative rupture management is additionally confounded by the facts that: 1) complications from surgery were generally minor; 2) operative and non-operative groups may use different care routines that may bias the study in favor surgical care(89) (Moller 01); and 3) most of the outcome measures beyond rerupture and wound infection do not clearly favor one approach over the next. Untoward outcomes from both conservative care and surgery include stiffness about the ankle joint, broadening of the Achilles tendon causing difficulty wearing shoes (usually worse in surgical groups), calf atrophy, deep vein thrombosis, rerupture, infection, skin necrosis, and Achilles tendon lengthening.(82, 87, 90, 93, 114, 115, 117) (Inglis 76, Nistor 81, Cetti 93, Khan 05, Lapidus 07, Metz 08, Longo 09) Most trials clinical trials of repair of Achilles tendon rupture have inclusion criteria of care starting within 2 weeks of rupture and the applicability of the results is uncertain in the treatment of older ruptures.

1. *Recommendation: Surgery for Treatment of Achilles Tendon Rupture*

**Surgical repair is recommended for treatment of ruptured Achilles tendon.** (The mixed results of the data supporting operative and non-operative care should be discussed with patients when covering treatment options. Discussion should include the numbers needed to treat or harm or likelihood that they will benefit from surgical care versus non-surgical care – 1 in 11, or be harmed by surgical care – 1 in 3), and the equivocal superiority of surgical compared to non-operative treatment.)

*Strength of Evidence – Recommended, Evidence (C)*  
*Level of Confidence – Moderate*

2. *Recommendation: Non-operative Management of Achilles Tendon Rupture with Functional Splinting and Casting*

**Non-operative management with functional splinting and casting is recommended for Achilles tendon rupture. Non-operative management may be particularly selected for those with low physical demands and/or having co-morbidities that may preclude operative treatment.**

*Strength of Evidence – Recommended, Evidence (C)*  
*Level of Confidence – Low*

3. *Recommendation: Early Weight Bearing in Non-operative Treatment for Achilles Tendon Rupture*

**There is no recommendation for or against early weight bearing for non-operatively managed Achilles tendon ruptures.**

*Strength of Evidence – No Recommendation, Insufficient Evidence (I)*  
*Level of Confidence – Low*

### *Rationale for Recommendations*

There are five moderate-quality trials comparing non-operative management with surgical repair for ruptured Achilles tendons.(89-91, 115, 116, 118, 119) (Cetti 93; Möller 01, Moller Scan J Med Sci Sports Med 02; Moller Knee Surg Sports Traumatol Arthrosc 02; Twaddle 07; Metz 07; Metz 08) One trial suggested surgical management was superior to non-operative management for reducing risk of re-rupture,(89, 118) (Möller 01, Möller Scan J Med Sci Sports 02) but did not have an important aspect of care (timing of casting and mobilization) held constant. In the other trials, there appeared to be a non-statistically significant trend towards higher re-rupture rates among the non-operative groups (there were no trials suggesting higher risk of re-rupture in the surgical groups).(90, 115, 116, 119) (Cetti 93; Twaddle 07; Metz 07; Metz 08)

Khan pooled data from three studies into a summary odds ratio and 95% confidence limit derived from the meta-analysis, which showed that non-surgical treatment was likely to result in 3.7 times more reruptures than surgical treatment; however, overall rerupture rates are low enough in surgical and non-surgical reapproximation methods to make 11 operations necessary to avoid one rerupture.(117) (Khan 05) Additionally, simple arithmetic summing of their data allowed calculation of an overall rerupture and infection rates, which are described above. The evidence indicates surgery reduces risk of re-rupture compared to non-operative treatment, but given a low overall rerupture rate, the effect is not dramatic.

One trial found no difference in lost time,(90) (Cetti 93) and two reported less lost time with the surgical group.(89, 91, 115, 118) (Möller 01; Moller Scan J Med Sci Sports 02; Moller Knee Sur Sports Traum 02; Metz 08) A low-quality RCT also documented less lost time in the surgically repaired group.(87) (Nistor 81) One noted time-to-return-to-work favored the subset of population performing light work that received surgery (35.7 days versus 67.2 days), but the advantage was equivocal in sedentary and heavy job classifications. Overall, the studies suggest that persons in jobs that require mobility may benefit from surgical repair.(89, 91, 118) (Möller 01; Moller Scan J Med Sci Sports 02; Moller Knee Sur Sports Traum 02) One author suggested early mobilization is the most important factor in treating ruptured Achilles tendons.(116) (Twaddle 07) Möeller investigated differences in tendon healing based with MRI and ultrasound studies(91) (Möller Knee Surg Sports Traum 02) and found no differences of partial defect, tendon thickness, homogeneity, tendinous edema, peritendinous reaction, or pattern of motion and the type of treatment received.

However, non-operative management appears to be effective in most patients.(89-91, 116, 118) (Cetti 93; Moller 01; Moller Scan J Med Sci Sports 02; Moller Knee Surg Sports Traumatol 02; Twaddle 07) There are few trials on casting and splinting or bracing. One moderate-quality study compared functional splinting with casting and reported higher satisfaction in the bracing compared with casting.(120) (Saleh 92) No differences in re-rupture rates or complications were found. There was a significant difference in dorsiflexion range of motion favoring the splinting group, although the clinical significance of this finding is unknown. The bracing group also self-reported shorter time required to be able to walk comfortably indoors and outdoors. However, this was a small study and was not a randomized crossover trial, which limits the utility to make a recommendation for one method over another. Thus, both methods are recommended as they are non-invasive, have similar long-term efficacy, and are reported as an effective treatment arm in other studies. Use of splinting is now becoming more common, with the primary advantage being patient preference.

One high-quality trial evaluated early weight bearing comparing non-operative immediate weight bearing using an orthosis to the use of a non-weight bearing rigid cast over a 12-week treatment period.(121) (Costa 06) Both groups were placed in the equinus position for 6 weeks followed by reduction of 1.5 inches every 2 weeks until the ankle was in a neutral position at 12 weeks. Evaluations at 3, 6, and 12 months did not demonstrate any significant differences in walking, stair climbing, return to work, return to sport, quality of life scores, or deficits in range of motion or torque. From this single study, it appears early weight bearing using the protocol described did not result in a significant benefit or adverse effect. Therefore, there is no recommendation for immediate weight bearing over rigid immobilization. Early weight bearing was found to provide functional improvement over rigid immobilization after surgical repair

(see Post-Operative Care), but further evidence is needed to make a similar recommendation for non-operative care.

*Evidence for the Use of Non-operative and Surgical Repair for Achilles Tendon Rupture*

There are 7 moderate-quality RCTs (one with two reports) incorporated into this analysis. There is 1 low-quality RCT in Appendix 1.

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
<b>Non-operative Functional Brace vs. Rigid Immobilization</b>						
Saleh 1992  RCT	4.0	N = 40 with acute complete rupture of calcaneal tendon	Rigid cast (8 weeks) vs. functional splint (cast x 3 weeks, then splint x 6-8 weeks Sheffield splint).	Splint vs. cast (3, 6, 12 months): no differences in plantar strength or range of flexion at any period. Dorsiflexion ROM: 7.9 vs. 1.4, 13.2 vs. 3.8, 13.6 vs. 8.6 (all periods p <0.001) favor splint. Time to walk comfortably outdoors (cast vs. splint): 11 weeks vs. 6 weeks (p <0.001); time to walk comfortably indoors 15 weeks vs. 9 weeks (p <0.001); 1 re-rupture in each group.	“Recovery of ankle dorsiflexion is quicker, without overstretching, and return to normal activities is more rapid. It was more popular with patients than a plaster cast. The risk of re-rupture did not appear to be increased.”	No placebo or sham control. Lack of randomization, allocation, baseline comparability details. Lack of observer blinding. Data suggest functional splint superior assessed by patient preference, increased dorsiflexion range of motion. No difference in number that returned to sports.
<b>Achilles Rupture Surgery vs. Non-operative Care</b>						
Metz 2007, 2008  RCT	7.5	N = 83 acute Achilles tendon ruptures	Percutaneous surgery vs. non-operative treatment with immediate full weight bearing.	Mean days for return to work: nonoperative: 108, surgery: 58. Difference of 49 days, 95% CI, 4-94, p <0.05.	“Minimally invasive surgical treatment of acute AT rupture appears to have a lower risk of complications than does nonoperative treatment using	No blinding of assessor. Data suggest advantage in return-to-work time for surgery, although both groups able to bear weight after 1 week. Study not done in U.S.

					functional bracing, although this difference is not statistically significant.”	
Möller 2001  RCT	7.5	N = 112 with acute, complete rupture of Achilles tendon	Plaster immobilization (equinus position neutral for 4 weeks) vs. end-to-end surgical repair with functional orthosis (ROM-Walker brace, 2 weeks equinus cast, 2 weeks 30° equinus brace, 2 weeks 10° equinus, 2 weeks 10° dorsiflexion).	Re-rupture after non-surgical treatment in 11 patients (20.8%), only 1 patient in surgical group (1.7%) (p = 0.0013). VAS quality of life scores favored surgical group for all follow up. VAS treatment results: 8 weeks – surgical: 89.2 (SD 10.3); non surgical: 74.9 (SD 19.1) (p <0.0001); 2 years surgical group: 88.7 (SD 9.0); non surgical group: 70.3 (SD 20.1) (p = 0.0001).	“...surgical treatment followed by early functional rehabilitation is a safe and reliable method of treatment. Conservative management resulted in failure in every fifth patient, and cannot be regarded as acceptable in healthy, active patients under the age of 65.”	First report of study population (see Möller 2002). Data suggest surgery particularly helpful for return to work in light jobs (35.7 days vs. 67.2 days), with no differences between heavy work (102.2 vs. 108.1 days) or sedentary jobs (30.8 vs. 33.2 days).
Möller Scand J Med Sci Sports 2002  RCT	7.5	N = 112 with Achilles tendon rupture	Plaster immobilization (equinus position 4 weeks, neutral 4 weeks) vs. end-to-end surgical repair with functional orthosis (ROM-Walker brace, 2 weeks equinus cast, 2 weeks 30° equinus brace, 2	Re-rupture rates: non-surgical 11/53 (20.8%) vs. 1/59 surgical group (1.7%) p = 0.0013). Plantar flexion: no differences between groups in concentric muscle strength at 6 months, 1 and 5 years; dorsiflexion: no differences; endurance: no difference.	“If re-ruptures are avoided, surgical treatment followed by early functional rehabilitation and non-surgical treatment with a plaster for ATR appear to produce equally good results.”	Study represents 2nd report on same population. No baseline comparison data provided. No blinding. Both groups had significant functional deficits compared to non-injured leg after 2 years.

			weeks 10° equinus, 2 weeks 10° dorsiflexion).			
Möller Knee Surg, Sports Traumatol 2002  RCT	6.0	N = 58 closed injury of tendon substance with injury no older than 7 days	Surgery (end- to-end suture) vs. progressive casting: healing evaluated by MRI and ultrasound.	No statistically significant differences between treatment groups in terms of positive healing findings on ultrasound or MRI at 6 or 12 months.	“Ultrasound (evaluation) performed during the healing after ATR detected no significant difference in the number of positive findings between the treatment groups. MRI findings after 1 year were well correlated with [ultrasound] findings, but no significant correlation was found between clinical parameters and the number of positive radiological findings.”	Intent of study was to describe healing process in terms of ultrasound and MRI studies. Baseline comparability unclear. Findings suggest no advantage to either protocol based on MRI or ultrasound (tendon thickness, tendon glide function, tendon defects).
Twaddle 2007  RCT	6.0	N = 50 acute ruptures of Achilles tendon	Surgery vs. non surgical intervention, both with controlled early motion (10 days cast than orthosis for both groups).	No significant differences in any outcome measures (musculoskeletal functional assessment instrument, dorsiflexion, plantar flexion, calf circumference, reruptures, complications) at measured follow-up at 8 weeks, 12 weeks, 24	“...there was no difference in any of the measured parameters for operatively and nonoperatively treated patients as long as both groups received early, controlled motion as part of their rehabilitation.”	Randomization by coin toss. No blinding. Early motion orthosis did not include weight bearing until 6 weeks.

				weeks or 52 weeks.		
Cetti 1993 RCT	5.5	N = 111 acute ruptures of Achilles tendon	Surgery (end to end suture) + vs. progressive casting (casting 20° equinus for 6 weeks vs. 20° equinus, no weight bearing 4 weeks, neutral cast with 1-cm heel raise 4 weeks, heel raise alone 2 weeks).	Mean sick time (off work) for surgery group 6.2 weeks vs. 8.0 weeks (conservative) (p = NS). Complication rates not different. Rupture rates not significant (5% vs. 15%). Differences in ankle movement/calf atrophy favored surgical group at 12 months; 57.1% surgical group vs. 29.1% returned to level of sports at same level (p <0.05).	“Operative treatment using end to end suture of acute Achilles tendon rupture results in a higher resumption of sports activities at the same level as before the rupture. Major complications were equal in both groups. Operative treatment using end-to-end suture is preferable, while non-operative treatment is an acceptable alternative.”	Study appears to have excluded dropouts and noncompliant subjects as 156 were enrolled. Surgical technique varied. Data suggest benefit from surgery limited to faster return to sport.

### **SURGICAL REPAIR – OPEN AND PERCUTANEOUS METHODS**

Surgical repairs have included two basic approaches – open and percutaneous methods. There are more than 40 open techniques reported.(122) (Wong 02) A number of augmentation techniques for open repair have been described purportedly resulting in strengthened repair and permitting earlier weight bearing after rupture. These include tendon transfers of the flexor hallucis longus, plantaris longus, semitendinosus and peroneus brevis or other methods such as gastrocnemius flap, dermal tissue graft, and fibrin glue.(27, 105, 123-129) (Maffulli 05, Zell 00, Wegrzyn 10, Ibrahim 09, Reddy 09, Hahn 08, Maffulli 08, Nilsson-Helander 08; Hohendorff 09) Percutaneous techniques involve multiple smaller incisions through which the tendon is repaired. There are multiple techniques described,(130-132) (Klein 91, Webb 99, Lim 01) but few quality trials.

#### *1. Recommendation: Open and Percutaneous Operative Approaches*

**Open repair and percutaneous approaches are recommended for patients undergoing operative repair. There is no recommendation of one approach over the other.**

*Strength of Evidence – Recommended, Evidence (C)*

*Level of Confidence – Moderate*

2. *Recommendation: Augmented Surgical Repair for Acute Ruptures*

**Augmented repair is not recommended for acute ruptures unless primary repair is not possible.**

*Strength of Evidence – Not Recommended, Evidence (C)*

*Level of Confidence – Moderate*

3. *Recommendation: Augmented Surgical Repair for Chronic or Neglected Ruptures*

**There is no recommendation for or against the use of augmented repair for chronic or neglected ruptures.**

*Strength of Evidence – No Recommendation, Insufficient Evidence (I)*

*Level of Confidence – Low*

*Rationale for Recommendations*

There are two moderate-quality studies that compare open to a percutaneous approach for tenorrhaphy and both studies do not show clear evidence of superiority of one approach over the other.(132, 133) (Lim 01, Gigante 08) In a moderate- quality trial of 60 repaired tendons, there were no differences found in functional recovery, rerupture or time to return to sports.(132) (Lim 01) However, there were more infections in the open repair group (21% versus 0%). In a second moderate-quality trial of 40 patients, equivocal results were again demonstrated between the two repair techniques, with no differences despite different post-operative immobilization durations.(133) (Gigante 08) Thus, there is currently insufficient evidence to recommend one approach over the other, and both are recommended. Potential advantages for percutaneous repairs include shorter procedure time completed under local anesthesia without a tourniquet,(133) (Gigante 08) cosmetic results, and fewer wound complications. There is one moderate-quality study on suture technique of end-to-end repair which found no difference in a reinforced continuous 6-strand suture technique compared with a simple Mason technique.(134) (Mortensen 92) Thus, there is no recommendation for any particular suture type or technique in end-to-end repairs.

There are two moderate-quality trials that compare open procedure end-to end suture techniques versus augmentation of repair using either a portion of the plantaris tendon or down-turned gastrocnemius fascia flap in patients with acute ruptures.(135, 136) (Aktas 07, Pajala 09) From both trials, no additional advantages were gained from augmentation as measured by functional improvement or reruptures after long-term follow-up. Augmentation presumptively has higher risk of deep tissue infection, deep venous thrombosis, and delayed wound healing as the incision site may cross more poorly vascularized skin.(123, 124, 128) (Maffulli 05, Zell 00, Nilsson-Helander 08) These two trials did not demonstrate significant differences in adverse outcomes. Functional deficits at the tendon donor site may also be of concern,(127, 137) (Richardson 09, Hahn 08) although the trials did not demonstrate these deficits. There is no quality evidence for or against the use of augmentation in repairing chronic or neglected ruptures. Increased tensile strength over suture alone is reported in cadaveric studies.(138-140) (Lee 08, Barber 08, Gebauer 07) Therefore, there is evidence that augmentation repair for acute injury tendon repair is not recommended due to lack of demonstrated benefit. There is insufficient evidence to recommend for or against using augmentation techniques for chronic or neglected ruptures, and there may be surgical situations in which the only option for repair is augmentation. Further studies regarding improvement of function, adverse effects including re-rupture rates, and donor site functional deficits are required.

*Evidence for the Use of Surgical Technique for Achilles Tendon Rupture*

There are 5 moderate-quality RCTs or quasi-randomized controlled trials incorporated into this analysis.

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
------------------------	--------------	-------------	------------------	---------	------------	----------

### Achilles Rupture Surgical Technique

Pajala 2009  RCT	6.5	N = 60 acute Achilles tendon ruptures	End-to-end suture with and without augmentation (gastrocnemius fascia flap).	Twelve month follow-up: No differences in pain, stiffness, calf muscle weakness, ROM, or subjective satisfaction. Both groups 3 re- ruptures.	“...the augmented repair in cases of fresh complete Achilles tendon rupture does not have any advantage over simple end-to-end repair.”	No assessor blinding noted. Data suggest no benefit to augmentation for acute rupture repair.
Gigante 2008  RCT	5.0	N = 40 acute Achilles tendon ruptures	Open vs. percutaneous repair of Achilles rupture.	Operating room time: 47 vs. 24 minutes for percutaneous repair (p <0.01). No differences in calf circumference or ankle ROM. Ankle circumference at 12 months open repair: 24.5 cm (SD 1.5) vs. percutaneous repair: 25.8 (SD 1.1) (p <0.01).	“...both the open and percutaneous technique are safe and effective in repairing the ruptured Achilles tendon, and that both afford nearly total restoration of clinical, US (ultrasound) and isokinetic patterns with the same rehabilitation protocol, despite slight differences in the duration of immobilization.”	Allocation unclear. No baseline characteristics provided. Differences in immobilization duration. Casting 30 days open surgical group vs. 15 days for percutaneous. Data suggest comparable results.
Mortensen 1992  RCT	5.0	N = 57 acute Achilles tendon ruptures	Mason suture technique vs. continuous 6 strand suture technique.	No cases of infection or re- rupture in either group. No difference in metal marker separations of plantar repaired ends or planter flexion strength measured in 3 ankle positions between both groups found.	“[W]e did not find any clinical advantage in using a stronger and more extensive suture technique. Consequently, we recommend a simple suture technique.”	No baseline comparison data. No blinding. Both groups had cast immobilization post-op for 7 weeks. Data suggest comparable efficacy.
Lim 2001  Quasi- RCT	4.5	N = 66 ruptured Achilles tendon s	Percutaneous vs. open repair (both groups receiving post- operative casting for mean of 12.6 weeks).	No differences in recovery duration to return activities of daily living, functional activity, sports at 8, 13, 26 weeks follow-up; 21% of open repairs had infection vs. 0% with percutaneous repair (p <0.05), No difference in re-	“...no difference in the numbers of re- ruptures between open and percutaneous groups, and the rate of injury to the sural nerve occurring during the repair is low, but nevertheless present.”	Randomization based on medical record number (odd/even). No baseline comparison data presented. Sparse details. Data suggest comparable results.

				ruptures (6% vs. 3%).		
Aktas 2007 RCT	4.0	N = 105 acute Achilles tendon ruptures	Single end-to-end with and without augmentation (use of plantaris tendon).	AOFAS hindfoot clinical outcome scores were 96.7 in Group 1 and 98.8 in Group 2. Return to preinjury level of sport activity: 58% Group 1 vs. 89% Group 2.	“Although functional outcomes of both treatment groups were the same, the end-to-end suturing technique provided a safer and more reliable treatment with a low risk of complications in the treatment of acute Achilles’ tendon ruptures compared with the plantaris tendon augmentation technique.”	Allocation and baseline results unclear. No blinding of assessment.

### ACHILLES RUPTURE POST-OPERATIVE CARE

Post-operative management is controversial, with debate over rigid immobilization versus functional bracing, the timing for initiating weight bearing, the optimal initial plantarflexion angle of the foot, the progression of dorsiflexion allowance, and the length of time required in cast or brace.(26, 93, 100, 103, 117, 141) (Wills 86, Khan 05, Jacob 07, Metzl 08, Longo 09, Heckman 09) Prolonged immobilization carries an increased risk of complications including joint stiffness, muscle atrophy, scar adhesion and deep venous thrombosis.(142) (Mortensen 99) Immobilization of the muscle body in a shortened position (equinus) has been demonstrated to produce atrophy within 4 weeks.(143, 144) (Maxwell 92, Rantanen 99)

1. *Recommendation: Early Weight Bearing for Post-operative Rehabilitation of Achilles Tendon Repair*  
**Early weight bearing is strongly recommended as a primary treatment method for post-operative rehabilitation of Achilles tendon ruptures for functional bracing or rigid immobilization.**

*Indications* – All post-operative non-augmented Achilles tendon repairs concomitant with functional bracing or rigid casting.

*Frequency/Duration* – Initiate 0 to 2 weeks post-operative.

*Indications for Discontinuation* – Rerupture, surgical complications, physical ability.

*Strength of Evidence* – **Strongly Recommended, Evidence (A)**

*Level of Confidence* – High

#### *Rationale for Recommendation*

There is one high-quality and two moderate-quality trials comparing early weight bearing post-operatively with non-weight bearing rehabilitation protocols.(121, 145, 146) (Suchak 08; Costa 03; Costa 06) These

studies all report benefits of early weight bearing without increases in adverse effects. The high-quality trial allowed weight bearing beginning at two weeks compared to non-weight bearing plus ROM exercises for 6 weeks and found higher functional and quality of life scores (RAND-36 Scale) at 6 weeks than the controls. Two moderate-quality studies also found immediate weight bearing was well tolerated with no significant differences in complication rates(146) (Costa 03) and resulted in faster recovery times as measured by resumption of normal walking (12.5 versus 18 weeks,  $p = 0.027$ ) and stair climbing (13 versus 22 weeks,  $p = 0.023$ ).(121) (Costa 06) Thus, there is strong evidence that early immobilization is beneficial for short-term functional recovery, may result in increased mobility of the patient with improved quality of life, can be achieved with no incremental cost increase, and has no demonstrated increase in complication rates. There is no evidence that early weight bearing reduces the other risks reported with prolonged immobilization – stiffness in the ankle joint, calf atrophy, DVT and embolism, rerupture, deep infection, or skin necrosis (see Hip and Groin Disorders guideline for DVT prophylaxis).

2. *Recommendation: Functional Bracing for Post-operative Rehabilitation of Achilles Tendon Repair*  
**Functional splinting (bracing) is moderately recommended as a primary treatment method for post-operative care of Achilles tendon ruptures.**

*Indications* – All post-operative Achilles tendon repairs.

*Frequency/Duration* – Apply 0 to 2 weeks post-operative.

*Indications for Discontinuation* – Discomfort, non-compliance, device intolerance.

*Strength of Evidence* – **Moderately Recommended, Evidence (B)**

*Level of Confidence* – Moderate

*Rationale for Recommendation*

There are five moderate-quality trials comparing the effects of early mobilization through functional bracing versus rigid immobilization through casting.(142, 147-150) (Cetti 94, Mortensen 99, Kauranen 02, Kangas 03, Kangas 07) Three of the studies measured short-term outcomes, and all demonstrated a significant positive effect with mobilization. A comparison study of functional casting to rigid casting demonstrated quicker return to normal gait, ability to stand on toes, higher satisfaction in mobile group, and more subjects reporting normal ankle mobility.(147) (Cetti 94) Mean sick leave was reduced (53 versus 20 days,  $p = 0.0009$ ) in the mobile group. A comparison study of functional brace to 8 weeks of rigid cast demonstrated quicker return to work (43 versus 68 days,  $p < 0.05$ ), patient report of excellent results (84% versus 63%,  $p < 0.05$ ), time until sport was resumed (4 versus 7.5 months,  $p < 0.001$ ) and time until pre-injury level was reached (6 versus 9 months,  $p < 0.001$ ).(142) (Mortensen 99) Calf atrophy and other complications were similar in both groups. There were no long-term differences in complications, in the percentage of patients who returned to sports or who reached pre-injury levels of function. Another comparison study of functional bracing to rigid immobilization in neutral position for 6 weeks measured elongation of the repaired tendon.(149) (Kangas 07) The study demonstrated no significant differences in functional outcomes of ankle performance scores or isokinetic muscle strength scores. There was a trend toward less tendon elongation in the functional group, although significance was not reached.

Three quality trials included analysis of long-term benefits of early mobilization through functional splinting/ bracing.(147, 148, 150) (Cetti 94, Kauranen 02, Kangas 03) Functional casting resulted in better plantar flexion strength, percentage who returned to full sports activity, and less elongation of tendon at 1 year.(147) (Cetti 94) However, two trials found no long-term differences in motor function(148) (Kauranen 02) or differences in pain, stiffness, or active range of motion compared with the contralateral ankle or patient satisfaction.(150) (Kangas 03) Thus, there is quality evidence that early motion through functional bracing/splinting provides short-term benefit over rigid casting in quicker return to work, sports, and/or maximum function with no significant difference in the risk of rerupture. There is modest evidence that these benefits diminish over time, such that equivalent outcomes in function will

likely be reached within 6 months to 1 year regardless of treatment. Functional bracing is of little incremental cost and provides higher patient mobility and patient satisfaction. Therefore, functional bracing/splinting is moderately recommended.

*Evidence for the Use of Post-operative Management for Achilles Tendon Rupture*

There are 2 high- and 7 moderate-quality RCTs incorporated into this analysis.

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Costa 2006 RCT	8.0	N = 96 Achilles tendon ruptures	Trial 1: early weight bearing vs. non-weight bearing in 48 operative patients. Trial 2: early weight bearing vs. non-weight bearing in 48 non-operative patients.	Trial 1: return to normal walking; treatment group: 22 weeks, control group: 25 weeks (p = 0.027). Return to normal stair climbing; treatment group: 22 weeks, control: 24 weeks (p = 0.023). Trial 2: return to normal walking (p = 0.765), climbing stairs (p = 0.484), return to sport (p = 0.631), quality of life (p = NS).	The study “[A]dvocates immediate weight-bearing mobilisation for the rehabilitation of all patients with rupture of the tendon Achilles.”	Randomization, allocation, baseline comparability data not reported. Small sample with high dropout although intention to treat analysis reported. 2 trials in article. Two cases of rerupture in the 2 operative weight-bearing groups. Data suggest better results with earlier walking.
Suchak 2008 RCT	8.0	N = 110 Achilles tendon ruptures	Weight bearing vs. non weight bearing 2 weeks after surgery (both groups using same functional brace).	Quality of life RAND-36 scores: physical functioning weight bearing: 61.4 SD 29.4). Non weight bearing 47.6 (SD 34.4) (p = 0.03). Social functioning weight bearing: 72.7 (28.5). Non weight bearing: 60.7 (26.8) (p = 0.03). Vitality weight bearing 69.4 (23.7). Non weight bearing 60.6 (21.1) (p = 0.04). Role-emotional weight bearing 84.6 (32.0); on weight bearing 67.3 (43.1) (p = 0.02).	“The postoperative early weight-bearing protocol provided enhanced quality of life and activity level without an increase in complications in the early postoperative period.”	Surgical repair techniques not uniform. Compliance quantified with sensors in orthotic brace. Results based on questionnaire rather than objective functional outcomes. Data suggest earlier return to weight bearing superior.
Kangas 2007	7.0	N = 50 acute Achilles	Functional brace (braced	Elongation of AT occurred to lesser extent in early	“Achilles tendon elongation was somewhat less in	Data suggest less elongation of Achilles tendon

RCT		s tendon ruptures	neutral and plantar flexion) vs. cast immobilization post-surgical repair.	motion group rather than cast group ( $p = 0.054$ ) at mean 60 weeks. AT elongation correlated significantly with clinical outcome ( $p = -.42$ , $P = 0.17$ , patients with less AT elongation achieving a better clinical outcome.	the early motion group and correlated with the clinical outcome scores. We recommend early functional postoperative treatment after Achilles rupture repair.”	after suture repair correlates with better clinical outcome. But does not show early mobilization significantly reduces elongation over cast group; likely underpowered to detect a difference.
Kangas 2003 RCT	6.5	N = 50 acute Achilles tendon ruptures	Cast immobilization vs. functional brace and full weight bearing (after 3 weeks) after open repair.	At 3 months, difference in isometric strength deficit 25.2% weight bearing group vs. 24.1% cast group ( $p = NS$ ). Pain relief, stiffness, subjective calf muscle weakness, footwear restrictions, and ROM not statistically significant over follow-up period.	“The isokinetic calf muscle strength results were somewhat better in the early motion group, whereas the other outcome results obtained in the two groups of patients were very similar. We recommend early functional postoperative treatment after Achilles rupture repair for athletes and well-motivated patients and for less-motivated patients and nonathletes.”	Author conclusions related to differences within same group over time rather than between group deficit comparisons, which were not significant. Three reruptures; no difference between groups (6%).
Kauranen 2002 RCT	5.5	N = 30 acute Achilles tendon ruptures	Post-op functional treatment vs. early immobilization.	No differences found between groups in reaction time, speed of movement, tapping speed. Lateral coordination value of operated leg higher in plaster cast group than in active brace group 12 weeks after operation; $p < 0.05$ .	“It seems that the recovery of the above mentioned motor performance functions of the leg does not depend on whether the leg is in a plaster cast with the AT in tension or in an active brace during the early postoperative period after AT rupture repair.”	Data limited to motor testing and motor performance, which may not correlate with functional outcomes of recovery studied by other researchers.
Cetti 1993	5.5	N = 111	Surgery (end to end	Mean sick time (off work) for surgery	“Operative treatment using	Study appears to have excluded

RCT		acute Achilles tendon ruptures	suture) plus vs. progressive casting (casting 20° equinus for 6 weeks vs. 20° equinus, no weight bearing 4 weeks, neutral cast with 1-cm heel raise 4 weeks, heel raise alone 2 weeks)	group was 6.2 weeks vs. 8 weeks (conservative) (p = NS). Complication rates not different. Rupture rates were not significant (5% vs. 15%). Differences in ankle movement and calf atrophy favored surgical group at 12 months. 57.1% of surgical group vs. 29.1% returned to level of sports at same level (p <0.05).	end to end suture of acute Achilles tendon rupture results in a higher resumption of sports activities at the same level as before the rupture. Major complications were equal in both groups. Operative treatment using end-to-end suture is preferable, while non-operative treatment is an acceptable alternative.”	dropouts and noncompliant subjects as 156 were enrolled. Surgical technique varied. Data suggest benefit from surgery limited to faster return to sport.
Cetti 1994 RCT	4.5	N = 60 acute Achilles tendon ruptures	Mobile cast (n = 30) vs. below knee rigid cast (n = 30) after operative repair (4-string suture).	60% of rigid cast patients reported discomfort from cast vs. 30% from mobile cast (p = 0.0037); 77% mobile cast found it “excellent,” 20% rigid cast thought same (p <0.00005). Mean sick leave days: 53.4 rigid cast; 20.2 mobile cast (p = 0.0009). No difference in gait, ability to stand on toes at 12 months. Ankle mobility rated better in mobile cast group at 6 and 12 months (p <0.05).	“Operative treatment with a 4-string suture and use of a postoperative mobile cast proved safe and convenient and preferable to treatment with the traditional rigid below-knee cast.”	Allocation and baseline results unclear. Reported results favor early mobilization after suture repair.

Mortensen 1999 RCT	4.5	N = 71 acute Achilles tendon ruptures	Cast x 2 weeks plus 6 weeks modifiable brace vs. equinus position cast x 6 weeks plus 2 weeks neutral cast (both groups after open repair).	Early motion vs. cast 16 months after operative treatment: sick leave in Days 43 (1-103)/68 (2-285); p <0.05, number of patients who returned to sports 22 (73%)/ 22 (76%); p = 1.00, months until sports resumed 4 (2-13)/7.5 (3-22); p <0.001, number who reached pre-injury level 17 (57%)/16 (55%); p = 1, months until preinjury level reached 6 (2.5-13)/9 (6-14); p <0.001.	“Early restricted motion appears to shorten the time needed for rehabilitation. There were no complications related to early motion in these patients. However, early unloaded exercises did not prevent muscle atrophy.”	Allocation, baseline comparability unclear. No observer blinding. Timing of assessment may not have been same. Study suggests early motion advantageous in immediate post-op period, but results same by 16 month average follow-up (mean 16 months, 12-24 month range). Therefore, duration of differences unclear.
Costa 2003 RCT	4.0	N = 28 unilateral ruptures of Achilles tendon	Functional brace (immediate weight bearing) vs. progressive casting for 8 weeks following open end-to-end operative repair.	Time to return to sports (months): early loading: 6.0 (2.0 IQR) Cast: 8.0 (8.0 IQR). (-5.0, 3.5 95% CI for median difference). Flexion deficit degrees: Early loading plantar: 5.0 (3.5 IQR) Dorsal: -5.0 (4.25 IQR). Cast plantar: 5.0 (5.0 IQR) Dorsal 0.0 (0.0 IQR). (95% CI for median difference plantar: -10,0 dorsal: 0, 14) Peak torque deficit (% at 12 months); Early loading concentric: 13.5 (50.8 IQR) Eccentric: -1.5 (27.8 IQR). Cast concentric: 29.0 (23.5 IQR) Eccentric: 41.0 (26.0). (95% CI for median difference concentric: -56, 53 Eccentric -30, 45)	“(I)mmmediate controlled weight-bearing mobilisation after Achilles repair is safe and may produce functional benefits for the patient.”	Randomization, allocation, baseline comparability data not reported. Small sample with high dropout although intention to treat analysis reported. Data suggest shorter duration of functional deficits with earlier weight bearing.

**PHYSICAL OR OCCUPATIONAL THERAPY, EXERCISE AND EDUCATION**

Numerous rehabilitation protocols are described for treating Achilles tendon rupture.(89, 90, 100, 115, 116, 118, 133, 135, 142, 145, 147-150) (Mortensen 99, Kauranen 02, Kangas 03, Kangas 07, Cetti 94, Cetti 03, Aktas 07, Moller 01, Moller Scan J Med Sci Sports 02, Twaddle 07, Metz 08, Gigante 08, Suchak 08) The goals of rehabilitation are to restore function, including ankle range of motion (ROM) in plantar flexion, dorsiflexion, ankle proprioception, and strength of the calf musculature, allowing full return to daily activities, sports, and occupation.

*Recommendation: Exercise and Education for Achilles Tendon Rupture Rehabilitation*

**A primarily home-based rehabilitation program (exercise and education) is recommended for treatment of Achilles tendon rupture.**

*Indications* – All post-operative and conservatively managed Achilles rupture patients.

*Dose/Frequency* – A written rehabilitation program including education and exercises with a provider that usually includes participation in instruction and demonstration of exercises. Additional, occasional periodic measurements of functional recovery progress and provision of instruction of new activities (see Tables 6 and 7 for schedules).

*Frequency/Duration* – Three to 12 visits over the course of recovery of 3 to 6 months.

*Strength of Evidence* – **Recommended, Insufficient Evidence (I)**

*Level of Confidence* – High

*Rationale for Recommendation*

There are no quality trials studying the influence of therapy on outcome after an Achilles tendon rupture. A retrospective study in German found no difference in functional outcomes measures between three groups that received no formal physiotherapy, physiotherapy for 3 to 6 weeks, and physiotherapy for more than 6 weeks. Review of protocols from the reviewed randomized trials regarding operative and non-operative treatment above found formal supervised physiotherapy was provided in only four of the studies.(89, 118, 120, 133) (Saleh 92, Moller 01, Moller Scan J Med Sci Sports 02, Gigante 08) The majority of studies used widely diverse protocols for home exercises dependent on treatment methods. In general, functional rehabilitation can be performed following a written protocol performed sequentially over a 6-month period post injury. One or two initial visits to a physical therapist may be beneficial for instruction on a protocol, followed by periodic visits to measure progress and to provide additional coaching and instruction as new activities are added. A post-operative rehabilitation guideline derived from a well-detailed protocol by Kangas, with evidence based modifications from the reviewed quality trials, is shown in Tables 3 and 4.

**Table 3. Post-Operative Rehabilitation Protocol**

<b>Post-Operative Rehabilitation Routine Protocol</b>							
	0-2 weeks	2-4 weeks	4-6 weeks	6-8 weeks	8-12 weeks	12-16 weeks	16-24 weeks
Foot/Ankle Position	Cast : Neutral (0°); Brace: neutral (0°)	Cast: Neutral (0°); Brace: neutral (0°)	Cast: Neutral (0°); Brace: neutral (0°)	Cast removed at 8 weeks; Brace removed at 6 weeks, 1cm heel raise for 2 to 4 more weeks.	No restriction on range of ankle movement	No restriction on range of ankle movement	No restriction on range of ankle movement

Weight Bearing	No recommendation with crutches on flat surface	Yes, flat surfaces, no tiptoes on stairs	Yes, flat surfaces, no tiptoes on stairs	Yes, flat surfaces, no tiptoes on stairs	Full	Full	Full
Physical Therapy Activities	None	Cast: ROM of toes, knee, hip joints. Isometric contraction of calf muscles. Brace: with leg dangling, active DF to neutral, passive PF	Cast: ROM of toes, knee, hip joints. Isometric contraction of calf muscles. Brace: with leg dangling, active DF to neutral, passive PF	At 8 weeks begin progressive heel raise; begin resistance exercises with tubing.	Begin closed chain exercises, stationary cycling, swimming	Eccentric/concentric exercises. Closed chain exercises, stationary cycling, swimming	Jogging, sports specific activities, running. Full sport at 6 months.

Derived from Kangas 2007, 2003 with modifications from Cetti 1994, Kauranen 2002, Costa 2003, 2006, Twaddle 2007, Metz 2008, Suchak 2008.

**Table 4. Non-Operative Rehabilitation Protocol**

<b>Non-Operative Rehabilitation Routine Protocol</b>							
	<b>0-2 weeks</b>	<b>2-4 weeks</b>	<b>4-6 weeks</b>	<b>6-8 weeks</b>	<b>8-12 weeks</b>	<b>12-16 weeks</b>	<b>16-24 weeks</b>
Foot/Ankle Position	Fixed Equinus (30° PF)	Cast: fixed at 15° plantar flexion at 2 weeks. Brace: allow 15-30° plantar flexion range	Cast: Fixed at neutral Brace: Allow 0°-30° Plantar flexion range	Cast and brace removed at 8 weeks, 1cm heel raise for 2 more weeks.	No restriction on range of ankle movement	No restriction on range of ankle movement	No restriction on range of ankle movement
Weight Bearing	None	No recommendation; with crutches on flat surface	Yes; flat surfaces, no tiptoes on stairs	Yes; flat surfaces, no tiptoes on stairs	Full	Full	Full
Physical Therapy Activities	None	Cast: ROM of toes, knee, hip joints. Isometric contraction of calf muscles. Brace: with leg dangling, active DF to neutral, passive PF	Cast: ROM of toes, knee, hip joints. Isometric contraction of calf muscles. Brace: with leg dangling, active DF to	8 weeks begin progressive heel raise. Begin resistance exercises with tubing.	Begin closed chain exercises, stationary cycling, swimming	Eccentric / concentric exercises. Closed chain exercises, stationary cycling,	Jogging, sports specific activities, running. Full sport at 6 months.

			neutral, passive PF			swimmin g	
--	--	--	------------------------	--	--	--------------	--

Derived from Kangas 2007, 2003 with modifications from Cetti 1994, Kauranen 2002, Costa 2003, 2006, Twaddle 2007, Metz 2008, Suchak 2008.

## DEEP VEIN THROMBOSIS (DVT) PROPHYLAXIS

Thromboembolic events following lower-limb immobilization for musculoskeletal conditions have been reported as a common adverse effect,(151-153) (Kujath 93, Lassen 02, Nilsson-Helander 09) although the greatest reported risks have been among hip and knee arthroplasty and hip fracture patients (see Hip and Groin Disorders guideline). The incidence of symptomatic deep vein thrombosis after surgical treatment of Achilles tendon rupture has been reported to be between 7 and 19%.(82, 152) (Lassen 02, Lapidus 07) Incidence of asymptomatic thromboembolic events based on ultrasound phlebography or color Doppler has been reported to be approximately 34%(82, 153) (Lapidus 07, Nilsson-Helander 09) with no differences reported between surgical or non-operative treatment groups.(153) (Nilsson-Helander 09) Despite the high number of asymptomatic events, few progress to clinically symptomatic venous thrombosis or post-thrombotic syndrome.(154) (Persson 09) There are no widely accepted recommendations for thromboprophylaxis in patients with lower limb injury or surgery.(153) (Nilsson-Helander 09)

### 1. Recommendation: Prophylaxis for Prevention of Deep Venous Thrombosis

**Prophylaxis is recommended for the prevention of deep vein thrombosis.**

*Indications* – Patients with predisposing risks for developing venous thrombosis events. High-risk populations are not well defined currently, and therefore require a high degree of physician and patient judgment. A low threshold for prophylaxis may be appropriate for patients with prior history of thrombotic and thromboembolic events, delayed rehabilitation or ambulation, obesity, diabetes, or other coagulation disorders.

*Strength of Evidence* – **Recommended, Evidence (C)**

*Level of Confidence* – High

### 2. Recommendation: Thrombosis Prophylaxis for Prevention of Deep Venous Thrombosis

**There is no recommendation for or against the use of the most common types of prophylaxis, including warfarin, heparin, low molecular weight heparin, graded compression stockings, aspirin, or Factor Xa to prevent deep vein thrombosis.**

*Strength of Evidence* – **No Recommendation, Insufficient Evidence (I)**

*Level of Confidence* – Low

### Rationale for Recommendations

There is no quality evidence that prophylaxis is beneficial in preventing symptomatic deep vein thrombosis. However, there is one high-quality study that demonstrated a significantly reduced risk of venography diagnosed DVT (asymptomatic events) in patients with immobilized lower limbs treated for fractures or Achilles tendon ruptures,(152) (Lassen 02) although the analysis did not describe prevention of symptomatic DVT. Another high-quality trial of DVT prophylaxis with a different low molecular weight heparin (dalteparin) did not demonstrate a difference in total thromboembolic events as diagnosed by ultrasound phlebography compared with placebo.(82) (Lapidus 07) Furthermore, these two studies

differed in duration of immobilization (6 weeks versus 3 weeks). Asymptomatic venous thrombosis events appear to be common after immobilization for Achilles rupture repair, although the incidence of symptomatic events is much lower, and quality evidence for strategies to prevent symptomatic DVT have not been established. Therefore, there is no recommendation for routine use of prophylaxis for Achilles rupture patients. A low threshold for use of prophylaxis may be indicated in patients with additional risk factors for venous thrombosis, such as previous thromboembolism, visible varicose veins, hypertension, hypercholesterolemia, current use of oral contraceptives, current hormone-replacement therapy, diabetes mellitus, or current smoking(152) (Lassen 02) (see Hip and Groin Disorders guideline for discussion of DVT prophylaxis).

*Evidence for the Use of DVT Prophylaxis for Achilles Tendon Rupture Repair*

There are 2 high-quality RCTs incorporated into this analysis.

Author/Y ear Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Lapidus 2007  RCT	10.0	N = 105 with Achilles tendon rupture	Low molecular weight heparin (5,000 u) vs. saline placebo for post-op DVT prophylaxis	Patients underwent modified Kessler end-to-end suture repair with casting. Incidence of DVT 34% LMWH group, 36% in placebo (p = 0.8). No difference in proximal DVT between groups.	“Our study showed that DVT is common during immobilization after Achilles tendon rupture surgery, and therefore effective thromboprophylaxis is desirable. [T]he daily administration of 5000 U of (low molecular weight heparin) did not affect the incidence of DVT.”	Allocation method unclear. Diagnosis made with ultrasound with majority being asymptomatic. Thus, clinical significance of these findings unclear.
Lassen 2002  RCT	9.0	N = 440 ≥18 years or older undergoing elective hip replacement surgery	Low molecular weight heparin (5000 u) vs. saline placebo for post-surgical DVT prophylaxis.	Reviparin vs. placebo; Thrombosis- 17/189 (9%) vs. 35/188 (19%), OR 0.45 (0.24-0.82). Achilles tendon specific - 3/48 (6%) vs. 6/28 (21%), OR 0.24 (0.27-1.03). Bleeding events (14 vs. 12), major bleeding (2 vs. 1).	“[R]outine use of reviparin for prophylaxis against thrombosis during the period of leg immobilization after fracture of the leg or rupture of the Achilles tendon is beneficial. However, further evaluation is warranted before such treatment can be recommended for routine use.”	Study included lower limb fractures and Achilles rupture patients with bracing and casting mean 7-8 weeks. Intent to treat based on 371 patients. Baseline between group differences in smoking rate. DVT diagnosis made on findings of venography. Data suggest fewer DVTs with treatment.

**TRANSCUTANEOUS ELECTRICAL NERVE STIMULATION (TENS)**

The use of transcutaneous electrical nerve stimulation (TENS) as a method to induce more rapid healing of the surgically repaired tendon has been reported.(155, 156) (Burssens 03, Burssens 05)

*Recommendation: Post-operative TENS for Achilles Tendon Repair*

**There is no recommendation for or against the use of TENS as a post-operative treatment for Achilles tendon rupture.**

*Strength of Evidence – No Recommendation, Insufficient Evidence (I)*

*Level of Confidence – Low*

#### *Rationale for Recommendation*

There are two moderate-quality reports from the same trial population of 20 surgically repaired tendons that describe the use of burst TENS in the post-operative period to stimulate tendon healing.(155, 156) (Burssens 03, Burssens 05) The treatment group received 30-minute TENS treatment sessions 5 times a week in the second and third week post-operatively while the control received sham TENS sessions. The author reported increased numbers of fibroblasts(156) (Burssens 03) and increased collagen production and deposition(155) (Burssens 05) in the TENS group compared with the control. However, no clinical or functional outcomes were provided, making these results of unknown application. Thus, although TENS treatment is non-invasive with few reported adverse effects, there is no defined benefit for promoting the healing process and therefore, there is no recommendation for or against its use.

## ***Ankle Tendinopathies (Other than Achilles Tendinopathy)***

The ankle's tendinous compartments are susceptible to stenosing tenosynovitis, similar to those of the wrist. (Tuite 02; Lynch 90; Wertheimer 95) They may be affected by disease (e.g., rheumatic disorders, diabetes mellitus, and infection) and undergo age-related degenerative changes. Tendon subluxations, dislocations, and tears occur. (Oloff 98) There are no quality trials addressing ankle tendinopathies other than Achilles tendinopathy. Guidance for these ankle-foot tendon disorders is based on analogies to other tendinopathies, particularly of the wrist.

## ***Tenosynovitis (Including Stenosing Tenosynovitis)***

### ***General Approach and Basic Principles***

Stenosing tenosynovitis involves hypertrophy of the retinaculum of the compartment with signs of tenosynovial and retinacular fibrosis usually present. Most cases are thought to be manifestations of a non-inflammatory condition caused by hypertrophy of the retinaculum and parietal layer of the tenosynovium with resulting symptoms of pain on use.

### ***Initial Assessment***

Tendon entrapment generally has a simple presentation. Some occur after acute injury, but most occur without a specific inciting event.

### ***Medical History***

Patients with tendinopathy present with localized ankle pain that is augmented by movement. Occasionally, pain may extend along the affected tendon sheath. Patients rarely have paresthesias unless there is an accompanying swelling or other mechanism to affect an adjacent nerve.

### ***Physical Examination***

The ankle usually appears normal, although there may be visible tendon sheath edema. Edema is more common with inflammatory conditions (e.g., rheumatoid arthritis) or infections. Swelling and crepitus may indicate peritendinitis if there is no inflammatory or infectious disease. Tenderness occurs over the

affected tendon and compartment. Pain in the affected compartment is generally present with provocative maneuvers (e.g., resisted use of the muscle-tendon unit).

### ***Diagnostic Criteria***

Diagnosis of ankle-foot tendinopathy should include a specific tendon or tendon group, and is based on the clinical criteria described in “Physical Examination” in this section.

### ***Work-Relatedness***

As there are no quality epidemiological studies of these disorders, work-relatedness is considerably less clear than for the wrist where work-relatedness is thought to be present in a significant proportion of cases. Systemic diseases are potential causes, including rheumatoid arthritis, other rheumatic disorders, diabetes mellitus, amyloidosis, heredity, and anatomic variants. Direct trauma over the affected compartment is reported in a minority of cases.

### ***Job Analysis***

Job analyses may be useful to identify repeated, forceful use, or localized compression by sharp objects. However, addressing these factors may be more useful for providing relief from activity that provokes discomfort than for determining causation. Footwear should be comfortable and not constrict the affected area of foot and ankle.

### ***Special Studies and Diagnostic and Treatment Considerations***

There are no special tests that are typically performed for compartment tenosynovitis. X-rays are usually not helpful. The threshold for testing for confounding conditions such as diabetes mellitus and hypothyroidism should be low, particularly in the presence of and to prevent other morbidity. Yet, bony deformities may contribute to the tenosynovitis and occult fractures may occur also producing low thresholds for testing in certain circumstances. There are reports of MRI findings including tendinopathy, tendinosis, tenosynovitis, tears, subluxation and entrapment in ankle-foot tendinopathy (Tuite 02; Taljanovic 15; Park 10); however, the utility of MRI has not been demonstrated in quality studies.

### ***Initial Care***

Initial care usually involves limitation of the physical factors thought to be contributing. Walking casts or boots, splints, or braces for compartment tendinoses may be helpful especially in moderate to severe cases. NSAIDs are often prescribed for initial treatment. The efficacy and optimal timing of other treatment, such as corticosteroid and other injections, is unclear.

### ***SPLINTS***

*Recommendation: Walking Boots, Casts, Splints, and Braces for Acute and Subacute Ankle Compartment Tenosynovitis*

**Walking boots, casts, splints, and braces are recommended for treatment of acute and subacute ankle compartment tendinoses.**

*Indications* – Patients with compartment tendinosis.

*Frequency/Duration* – Worn while ambulating.

*Indications for Discontinuation* – Failure to respond or resolution.

*Strength of Evidence* – **Recommended, Insufficient Evidence (I)**

*Level of Confidence* – Low

### ***Rationale for Recommendation***

There are no quality studies evaluating walking boots and splints/braces for compartment tenosynovitis. These are not invasive, have few adverse effects, and are not costly; thus, they are recommended.

### ***Follow-up Visits***

Follow-up visits are generally required every 1 or 2 weeks to evaluate efficacy of interventions until resolution of the condition.

## **Medications**

There are few quality studies on use of medications for this condition, although they are frequently prescribed.

### **NSAIDs**

*Recommendation: NSAIDs for Acute, Subacute, or Chronic Ankle Compartment Tenosynovitis*

**NSAIDs (oral or topical) are recommended to control pain associated with acute, subacute, or chronic ankle compartment tenosynovitis.**

*Indications* – Patients with ankle compartment tendinosis.

*Dose* – Optimal dose is unknown and there are no quality studies comparing different NSAIDs. Regularly scheduled dosing is recommended for acute, significantly symptomatic presentations.

*Indications for Discontinuation* – Failure to respond, development of adverse effects, resolution.

*Strength of Evidence* – **Recommended, Insufficient Evidence (I)**

*Level of Confidence* – Moderate

### *Rationale for Recommendation*

There are no quality studies that address the use of NSAIDs controlling pain associated with ankle compartment tenosynovitis. By analogy, NSAIDs are often used to treat pain associated with wrist compartment tendinosis (Jirattanaphochai 04; Mazieres 05; Piligian 00; Hanlon 99; Idler 90; Steinberg 15; Pantukosit 01) and there is one quality study demonstrating efficacy of a ketoprofen patch versus placebo. (Mazieres 05) As a NSAID patch has been demonstrated to be efficacious compared to placebo for the wrist, it is assumed that other topical forms are also efficacious. NSAIDs are not invasive, have low adverse effects in employed populations, and are low cost, thus they are recommended.

### *Evidence for the Use of NSAIDs for Compartment Tenosynovitis*

There are no quality studies evaluating the use of NSAIDs for compartment tenosynovitis.

## **Physical Methods/Rehabilitation**

### **EXERCISE**

Exercise is not generally indicated acutely and most patients with tendon entrapment do not require an exercise program. For those with residual deficits, particularly post-operatively, a progressive exercise program may be indicated.

### **IONTOPHORESIS**

*Recommendation: Iontophoresis for Acute and Subacute Ankle Compartment Tenosynovitis*

**Iontophoresis treatments using glucocorticosteroids and sometimes NSAIDs are recommended for ankle compartment tenosynovitis.**

*Indications* – Patients with ankle compartment tendinosis. Generally those who either fail to respond adequately to NSAIDs, splints, and activity modifications or decline injection.

*Dose* – Glucocorticosteroid is generally used. However, quality studies of the elbow have documented successful treatment of lateral epicondylalgia with NSAIDs administered via iontophoresis (see Elbow Disorders guideline), thus they appear reasonable for this indication as well.

*Frequency/Duration* – Generally 2-3 appointments to ascertain efficacy; an additional 4-6 appointments may be scheduled if efficacious. If improvements continue at 6 appointments, an additional 4-6 appointments are reasonable.

*Indications for Discontinuation* – Failure to respond, development of adverse effects, resolution.

*Strength of Evidence* – **Recommended, Insufficient Evidence (I)**

*Level of Confidence* – Low

### *Rationale for Recommendation*

There are no quality studies evaluating iontophoresis for ankle compartment tenosynovitis. Iontophoresis is not invasive, has low adverse effects, but is moderate to high cost depending on the number of treatments. Iontophoresis with either a glucocorticoid or NSAID is recommended for select patients who fail to respond to other treatments or who decline injection.

## **OTHER NON-OPERATIVE INTERVENTIONS**

*Recommendation: Other Non-operative Interventions Including Manipulation and Mobilization, Massage, Deep Friction Massage, or Acupuncture for Acute, Subacute, or Chronic Ankle Tenosynovitis*

**There is no recommendation for or against the use of other non-operative interventions (i.e., manipulation and mobilization, massage, deep friction massage, or acupuncture) for the treatment of acute, subacute, or chronic ankle tenosynovitis as other interventions have proven efficacy and are preferentially indicated for initial and subsequent treatment options.**

*Strength of Evidence – No Recommendation, Insufficient Evidence (I)*

*Level of Confidence – Low*

### *Rationale for Recommendation*

There are no quality studies evaluating other non-operative interventions for ankle tenosynovitis. Other treatments have evidence of efficacy for treatment of the wrist and thus they are recommended by analogy.

### **Injections**

#### **GLUCOCORTICOSTEROID INJECTIONS**

While there are no quality studies for treatment of the ankle, glucocorticosteroid injections are frequently used for wrist compartment tendinoses. (Jirarattanaphochai 04; Anderson 91; Lapidus 72; Hanlon 99; Idler 90; Steinberg 15; Pantukosit 01; Richie 03; Avci 02; Peters-Veluthamaningal 09a, 09b; Lane 01; Kosuwon 96) For the wrist, estimates of efficacy in case series and active treatment arms of trials range from 54-100%. (Lapidus 72; Anderson 91; Sakai 02; Zingas 98; Rankin 98; Jeyapalan 09; Lane 01; Witt 91)

*Recommendation: Glucocorticosteroid Injections for Acute, Subacute, or Chronic Ankle Tendinosis*

**Glucocorticosteroid injections are recommended for treatment of acute, subacute, or chronic ankle tendinosis.**

*Indications –* Ankle symptoms of pain over a compartment. Generally at least 1 week of non-invasive treatment to determine if condition will resolve without invasive treatment. It is reasonable to treat cases with an initial injection although there is no quality evidence to support that approach. Failure or suboptimal results with an initial injection result in a need for additional injection(s) in a minority of patients which is (are) usually successful. (Anderson 91; Sakai 02; Peters-Veluthamaningal 09b)

*Dose –* Optimal dose is unknown. Studies in the wrist have utilized methylprednisolone acetate 40mg, (Anderson 91; Goldfarb 07; Witt 91) and triamcinolone acetonide 10mg. (Sakai 02; Peters-Veluthamaningal 09b) An adjuvant injectable anesthetic is typically used. (Anderson 91; Sakai 02; Jirarattanaphochai 04)

*Frequency/Duration –* It is recommended that a single injection be scheduled and the results evaluated to document improvement. (Peters-Veluthamaningal 09b) Failure of a response within 1-2 weeks should result in reanalysis of the diagnosis and consideration of repeat injection. (Peters-Veluthamaningal 09b) Recurrence of symptoms months later should result in consideration of re-injection. (Anderson 91; Lapidus 72) While there is no evidence-based maximum number of injections to treat an episode or over a lifetime, more than 3 injections in a year should be avoided due to tendon weakening and risk of rupture. Recurring injections on a year after year basis should also be similarly avoided.

*Indications for Discontinuation –* If a partial response, consideration should be given to repeating the injection, typically at a modestly higher dose.

*Strength of Evidence – Recommended, Insufficient Evidence (I)*

*Level of Confidence – Moderate*

### *Rationale for Recommendation*

There are no quality studies that address glucocorticosteroid injections for ankle tendinosis. By analogy, there is one moderate-quality study comparing glucocorticosteroid injections with placebo for treatment of de Quervain's stenosing tenosynovitis. (Peters-Veluthamaningal 09b) The trial showed considerable benefits from active treatment that persisted for 12 months and allows for an evidence-based recommendation. Another high-quality trial found no additive benefit of NSAID in addition to injection to prevent recurrence but did not assess reductions in pain immediately after injection thus appears to have no bearing on use of NSAIDs for those purposes. (Jirattanaphochai 04) (A low-quality trial found glucocorticosteroid injection superior to splinting in pregnant and lactating females. (Avci 02)) These injections are minimally invasive, have low adverse effects and are low to moderate cost. Thus, they are recommended to treat ankle tendinosis.

### *Evidence for the Use of Glucocorticosteroid Injections for Ankle Tendinoses*

There are no quality studies evaluating the use of glucocorticosteroid injections for ankle tendinosis.

### **Surgery**

Various open surgical procedures (Cooper 99; Kolettis 96; Michelson 05; Philbin 09; Gluck 10) as well as arthroscopic procedures (Corte-Real 12; Theodoropoulos 09; Monteagudo 15; Hsu 14; Lui 12a,b; Marmotti 12; Vega 11; Ogut 11a,b) have been performed for ankle tendinoses.

### *Recommendation: Surgical Release for Subacute or Chronic Ankle Tenosynovitis*

**There is no recommendation for or against the use of surgical release for patients with subacute or chronic ankle tenosynovitis who fail to respond to injection.** (Lapidus 72)

*Indications* – Ankle tenosynovitis that fails to respond to non-operative interventions generally including at least 2 glucocorticosteroid injections. May be indicated without prior injection(s) if there is a clear contraindication for injections. Tendinous ruptures are often surgically treated.

**Strength of Evidence – No Recommendation, Insufficient Evidence (I)**

*Level of Confidence* – Low

### *Rationale for Recommendation*

There are no quality studies evaluating the use of surgical release for ankle tenosynovitis. It may be a last resort for patients who have failed glucocorticosteroid injection(s) and other non-invasive treatments, but no recommendation is offered. A non-randomized study of 27 patients who underwent arthroscopic release for flexor hallucis longus tenosynovitis found 81% to have returned to the same level of activity prior to the injury. (Corte-Real 12) In another study, 13 female ballet dancers underwent operative release of the flexor hallucis longus tendon due to stenosing tenosynovitis. After a mean follow-up time of six years and six months, the authors found the treatment to be effective. All patients returned to dancing within 5 months, and 11 reached full participation. (Kolettis 96)

### *Evidence for Surgical Release*

There are no quality studies incorporated into this analysis.

*We searched PubMed, Scopus, CINAHL and Cochrane Library without date limits using the following terms: disorder terms: foot, feet, ankles, ankle, foot tendinopathy, ankle tendinopathy, posterior tibial tendinopathy, peroneal tendinopathy, flexor hallucis longus tendinopathy, anterior tibial tendinopathy, anterior tibial tendon, posterior tibial tendon, peroneal tendon, flexor hallucis longus tendon, posterior tibial, anterior tibial, flexor hallucis longus, peroneal, tendinopathy, tendinopathies, tendinitis, tendinitides, tendonitis, tendonitides, tendinosis, tendinoses (we excluded Achilles Tendon and Achilles tendinopathy); RCT terms- controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random\*, randomized, randomization, randomly; systematic reviews terms- systematic, systematic review. In PubMed we found and reviewed 21 articles, and kept 2. In Scopus, we found and reviewed 477 articles, and kept 3. In CINAHL, we found and*

reviewed 12 articles, and kept 0. In Cochrane Library, we found and reviewed 5 articles, and kept 0. We also kept 0 articles from other sources. We included 0 RCT and 0 systematic reviews articles.

## **Plantar Heel Pain (“Plantar Fasciitis”)**

### **General Approach and Basic Principles**

Heel pain is the most common area of pain in the foot. (McMillan 09, Tahririan 12, Thomas 10) Plantar heel pain, known as “plantar fasciitis,” is common.(157, 158) (Furia 07, Barrett 99) Other names for plantar heel pain include painful heel syndrome, heel spur syndrome, runner’s heel, subcalcaneal pain, calcaneodynia, plantar fasciopathy, and calcaneal periostitis.(28, 159) (Roxas 05; Rompe 09) The cumulative incidence of plantar fasciitis is reported as up to 10% of the U.S. population. Plantar heel pain affects active and sedentary adults of all ages.(157, 160, 161) (Furia 07, Cole 05, Riddle 03)

The pathophysiology of posterior-medial plantar heel pain, or “plantar fasciitis,” is unclear and controversial.(162-165) (Bordelon 83; Scherer 91; Schepesis 91; Perelman 95) Degeneration of the heel fat pad, pressure from spurs, bursitis, nerve entrapment, and other pathologies have been offered as explanations.(163-165) (Scherer 91; Schepesis 91; Perelman 95) Histologic findings often demonstrate degeneration without inflammation.(166) (Lemont 03) Several surgical case series that include structural observations or tissue analysis are reported,(164, 167, 168) (Shepsis 91, Przulucki 81, Baxter 84) but the selection of heel pain patients includes only the most recalcitrant cases that choose to resort to surgery; and the only controls are cadaveric. Case selection may be restricted and biased,(169) (Baxter 89) and similar histology is found in cases and cadavers.(167) (Przulucki 81) Calcaneal spurs have been described in association with plantar fasciitis; however, plantar heel pain may exist without the presence of a spur and asymptomatic spurs are common.(170, 171) (Jeswani 09, Irving 06) Thus, spurs are not sufficient or necessary to cause plantar heel pain.(170, 171) (Jeswani 09, Irving 06) In summary, various pathophysiological correlates with heel pain have been postulated, but there is no agreement in the literature on pathophysiology.

Plantar fasciitis is usually marked by pain in the inferior or plantar aspect of the medial heel most noticeable during weight-bearing activities, especially on the first weight-bearing step in the morning or upon standing after periods of sitting or recumbency.(160, 164, 172-174) (Irving 07, Puttaswamaiah 07, Cole 05, Young 01, Schepesis 91) Plantar fasciitis generally responds well to conservative management, with more than 90% of patients resolving over a 6 to 12 month period with non-surgical intervention.(160, 175-177) (Toomey 09, Neufeld 08, Cole 05, Buchbinder 04)

### **Work-Relatedness**

There are no prospective cohort studies reported with measured exposure and health outcomes. There are no retrospective cohort studies or serial cross sectional studies. Data on prolonged standing as a potential risk factor is inconclusive. Upon multivariate analysis, the data from a case-control study, with the exception of body mass index over 30kg/m<sup>2</sup>,(161, 178) (Riddle 03, Riddle 04) failed to show any association between any factor measured, including amount of time standing and plantar fasciitis. Additionally, another case-control study reported conflicting results, failing to demonstrate any association between prolonged standing or weight bearing and plantar fasciitis.(172) (Irving 07) Other criteria used in causal assessment are absent, including dose-response.(179, 180) (Hill 65, Hegmann AMA 08) Thus, there is insufficient evidence to determine if prolonged weight bearing is a risk for plantar fasciitis.

### **Initial Assessment**

Assessment of heel pain should exclude diagnoses that need aggressive or highly restrictive treatment, or involve systemic disease such as Achilles tendon rupture, plantar fascial rupture, systemic metabolic or inflammatory disorders, or calcaneal stress fracture. Additionally, before assigning a diagnosis of plantar fasciitis, plantar calcaneal and retro calcaneal bursitis, posterior tibial or medial calcaneal nerve

entrapment, osseous tumor of the calcaneus, and S1 radiculopathy should also be eliminated.(160, 175-177) (Cole 05, Toomey 09, Neufeld 08, Buchbinder 04) (Some of these diagnoses may be controversial and pose diagnostic difficulties in themselves.) Distinguishing clinical features include location and duration of symptoms.

### **Medical History**

Plantar fasciitis is usually marked pain in the inferior or plantar aspect of either the center or medial heel. Pain may be reported distal towards the arch of the foot. As noted, it is most noticeable during weight-bearing activities, especially the first weight-bearing step of the day or after periods of sitting or recumbency.(160, 164, 172-174) (Cole 05, Irving 07, Puttaswamaiah 07, Schepsis 91, Young 01)

### **Physical Examination**

Examination usually reveals tenderness over the proximal central fascia, particularly near the insertion point at the calcaneal tuberosity. Stretching the plantar fascia by dorsi-flexing the toes may exacerbate the pain.(157) (Furia 07) The calcaneal squeeze test is used to help identify a calcaneal stress fracture.(175) (Toomey 09) Plantar calcaneal bursitis pain can be elicited with palpation of the plantar center of the calcaneus. Additionally, the “windlass test” may be used, which has weight- and non-weight-bearing approaches:

- *Non-weight bearing* – With the patient sitting, the examiner stabilizes the ankle joint in neutral with one hand placed just behind the first metatarsal head then passively dorsiflexes the first metacarpophalangeal (MCP) joint while allowing the interphalangeal joint to plantarflex. Dorsiflexion of the first MTP joint is continued to its end of range or until the patient’s pain is reproduced.
- *Weight bearing* – The patient stands on a step stool and positions the metatarsal heads of the foot to be tested just over the edge of the step. The subject is instructed to place equal weight on both feet. The examiner then passively extends the 1st MTP joint while allowing the interphalangeal joint to flex. Passive extension dorsiflexion of the 1st MTP joint is continued to its end of range or until the patient’s pain is reproduced.

According to DeGarceau, sensitivity and specificity for the windlass test are 0.33 and 0.99, respectively.(181) (DeGarceau 03) Using DeGarceau’s sensitivity and specificity, a person with plantar fasciitis may not have a positive test, but in the absence of a positive windlass test, plantar fasciitis is unlikely.

### **Diagnostic Criteria**

The diagnosis is evident from history and physical examination in most cases. There are no formally established diagnostic criteria. Diagnostic ultrasound or MRI may be used as a diagnostic tool, but no firm diagnostic criteria have been established. Hypoechoogenicity of the plantar fascia on ultrasound, increased signal intensity of the plantar fascia on MRI, and plantar fascial thickness over 4 or 5mm by either method is likely to be abnormal. Plantar fascial thickness has been the subject of several radiographic studies in heel pain, some of which are summarized in Table 8. However, studies comparing subjects with heel pain to those without heel pain are often inadequately controlled and their findings are not conclusive.

**Table 5. Diagnosis of Plantar Fasciitis**

Author/Year	Number of Subjects with Heel Pain (# of Painful Heels)	Plantar Fascial Thickness of Painful Heels (mm±SD)	Number of Controls (# of Heels)	Plantar Fascial Thickness of Controls	Comments
Abdel-Wahab 2008	17 (23)	4.9 ± 1.3	11 (22)	1.7 ± 0.06	Ultrasound, controls not matched

Berkowitz 1991	8 (9)	7.40 ± 1.17 sagittal 7.56 ± 1.01 coronal	5 age- and sex-matched; 5 unmatched	3.22 ± 0.44 sagittal 3.44 ± 0.53 coronal	MRI
Akfirat 2003	25	4.75	15	3.37 mm	Ultrasound
Cardinal 1996	15 (19)	5.2 ± 1.13	15 (11) asymptomatic heels of patients, and 15 asymptomatic persons	2.9 mm ± 0.70 2.6 mm ± 0.48	Ultrasound
Gibbon 1999	190 (297)	5.9 in unilaterally and 6.0 in bilaterally effected subjects	58	3.3mm in completely asymptomatic and 3.6 mm in unaffected side of unilateral subjects	Ultrasound
Kane 2001	28 (23)	5.7 ± 0.3	28 (5)	3.8±0.2	Ultrasound, longitudinal view, asymptomatic heels of patients served as control
Tsai 2000	102 (123)	5.47±1.09 in persons with bilateral heel pain; 5.61±1.19 in those with bilateral heel pain	33	3.83±0.7 in asymptomatic heels of heel- pain patients; 3.19±0.43 in asymptomatic subjects	Ultrasound, demographic characteristics documented included age, BMI, and sex, which were not different between heel pain patients and controls
Vohra 2002	109 (211)	5.35 in symptomatic bands		2.70 in asymptomatic bands	Ultrasound, thickness of lateral and medial bands measured and reported

Grasel considered a database of “1852 MR imaging studies of the ankle,” selected 56 patients, but collected complete data sets on only 25.(182) (Grasel 99) There was no comparison population. The authors’ most-common finding was poorly circumscribed perifascial increase in STIR signal intensity superficial or deep to the plantar fascia (76% and 52%, respectively). Fifty-two percent of subjects had increased interfascial signal intensity, 56% had a bone marrow abnormality, and 25% had thickened plantar fascia. Grasel considered plantar fascia thicker than 5mm as abnormal. Kane stated that “plantar fasciitis was considered present when the plantar fascial thickness was greater than or equal to 4.5mm or when there was more than 1mm difference in plantar fascial thickness between the symptomatic and asymptomatic heels in association with decreased echogenicity and/or loss of definition of the antero-inferior border of the calcaneus.”(183) (Kane 01)

Imaging studies used to determine plantar fascial thickness select subjects from specific settings and are poorly controlled.(182, 184-187) (Abdel-Wahab 08, Berkowitz 91, Akfirat 03, Gibbon 99, Grasel 99) Only

a minority of persons with plantar heel pain may have plantar fascia thicker than 5mm.(182) (Grasel 99) A reliable cutoff separating normally from abnormally thick plantar fascia is not clear. Given the variability of plantar fascial thickness in persons without heel pain, with thickness at the high end of the 95th percentile as much as 4.5mm, assuming a plantar fascial thickness of less than 4.5mm is abnormal is tenuous.

### ***Workplace Intervention***

#### **WORK RESTRICTIONS**

There are no quality trials that include work or activity restrictions as an intervention. In general, avoidance of activities that are thought to exacerbate substantially symptoms such as prolonged walking or running may be beneficial,(174) (Young 01) and no prolonged walking and/or running are work restriction may be specified as activity limitations. More commonly, activities may continue as before the onset of symptoms, but careful attention to stretching prior to weight bearing should be implemented.

### ***Special Studies, Diagnostic and Treatment Considerations***

Imaging plays a limited role in routine clinical practice and is generally reserved for select cases to rule out other causes of heel pain or to establish the diagnosis of plantar fasciitis when it is in doubt.(174-177) (Toomey 09, Neufeld 08, Buchbinder 04, Young 01)

### **X-RAY**

Plain radiographs are utilized for diagnosing plantar fasciitis.

#### *1. Recommendation: Routine Use of X-ray for Diagnosis of Plantar Heel Pain*

**The routine use of x-ray is not recommended for diagnosing plantar fasciitis or plantar heel pain.**

*Strength of Evidence – Not Recommended, Insufficient Evidence (I)*

*Level of Confidence – High*

#### *2. Recommendation: Routine Use of X-ray for Diagnosis of Plantar Heel Pain with Suspected Fracture*

**The use of x-ray is recommended for diagnosing plantar fasciitis or plantar heel pain when fractures are suspected including calcaneal stress fracture, osseous tumors, or non-routine confirmation of diagnosis.**

*Indications – Evaluation of plantar heel pain when calcaneal fracture or osseous tumor is suspected. Plain films should not be obtained solely to identify the presence of heel spurs, as the correlation between heel spurs and diagnosis or prognosis is believed to be poor. Lateral non-weight bearing x-ray focusing on soft tissue changes in plantar fascia thickness and fat reduction may provide diagnostic utility,(188) (Osborne 06) but ultrasound and MRI are considered superior. Plain x-rays are not indicated for routine evaluation of plantar heel pain as management is not altered.*

*Strength of Evidence – Recommended, Insufficient Evidence (I)*

*Level of Confidence – High*

### ***Rationale for Recommendations***

There is no quality evidence evaluating the use of x-ray for the diagnosis of routine plantar heel pain consistent with the clinical diagnosis of plantar fasciitis. Radiography is poor at diagnosing soft-tissue disorders. For confirmation of ruptured fascia, ultrasound or MRI are more effective. X-ray is not invasive, has low adverse effects, and is low cost. X-ray is not recommended for routine evaluations except in cases of trauma or red flags.

### **MRI**

MRI is used to evaluate plantar heel pain.(182, 184, 185, 189, 190) (Abdel-Wahab 08, Grasel 99, Recht 01, Theodorou 00, Berkowitz 91)

*Recommendation: MRI for Diagnosis of Select Patients with Plantar Fasciitis*  
**MRI is recommended for the evaluation of select patients with plantar fasciitis.**

*Indications* – Suspected plantar fascial rupture, avascular necrosis of talar dome, and stress fracture of the talar neck particularly if heel pain is not improving.(182, 184, 185, 189, 190) (Abdel-Wahab 08, Grasel 99, Recht 01, Theodorou 00, Berkowitz 91)

*Strength of Evidence* – **Recommended, Insufficient Evidence (I)**  
*Level of Confidence* – Moderate

#### *Rationale for Recommendation*

There are no quality trials evaluating the use of MRI for the diagnosis of plantar fasciitis. MRI may be useful in the diagnosis of causes of heel pain other than plantar fasciitis, including calcaneal stress fracture, plantar fascia rupture, perifascial fluid, calcaneal spurs, avascular necrosis of talar dome, joint fluid, ganglion cyst, stress fracture of the talar neck,(184, 189) (Abdel-Wahab 08, Recht 01), and osseous tumors.

#### *Evidence for the Use of MRI for Plantar Fasciitis*

There are no quality studies incorporated into this analysis. There is 1 low-quality RCT in Appendix 1.(191) (Maier 00)

#### **SPECT-CT**

SPECT-CT has been used to investigate the diagnosis of chronic heel pain.(192) (Breunung 08)

#### *Recommendation: SPECT-CT for Diagnosis of Plantar Fasciitis*

**The use of SPECT-CT is not recommended for the diagnosis of plantar heel pain.**

*Strength of Evidence* – **Not Recommended, Insufficient Evidence (I)**  
*Level of Confidence* – Low

#### *Rationale for Recommendation*

There is no quality evidence supporting the use of SPECT-CT in investigating heel pain. SPECT-CT imaging for documenting increased metabolic activity is of unclear usefulness as there is no current accepted standard for interpretation of results, nor evidence that it will change outcome, nor is superior to less-expensive imaging methods. SPECT-CT is non-invasive but results in radiation exposure, is high cost, and is of undefined clinical utility. It is unlikely that SPECT-CT would result in changing or enhancing the treatment plan for plantar fasciitis, and is therefore not recommended.

#### **ULTRASOUND**

The use of ultrasound is described for the evaluation of plantar fasciitis by identifying thickened plantar fascia, abnormal echogenicity, plantar fascia edema, and calcaneal spur.(183, 184, 193-198) (Abdel-Wahab 08, Khoury 07, Sabir 05, Vohra 02, Kane 01, Rawool 00, Tsai 00, Cardinal 96)

#### *Recommendation: Ultrasound for Diagnosis of Plantar Fasciitis*

**Ultrasound is recommended for the evaluation of select patients with plantar fasciitis.**

*Indications* – Evaluation of plantar heel pain when clinical diagnosis is uncertain or after no improvement from a course of conservative treatment of 4 to 6 weeks.(175, 176) (Neufeld 08, Toomey 09)

*Strength of Evidence* – **Recommended, Insufficient Evidence (I)**  
*Level of Confidence* – Low

#### *Rationale for Recommendation*

There are no quality trials for the use of ultrasound in diagnosing plantar fasciitis. However, ultrasound is frequently used to confirm suspected plantar fasciitis. Reported ultrasound findings include local thickening of the plantar fascia structure with hypoechoic areas,(183, 194, 195, 197, 198) (Sabir 05, Vohra 02, Kane 01, Tsai 00, Cardinal 96) fluid surrounding the tendon, and adhesions that can be visualized as thickening of the hypoechoic paratenon.(27) (Reddy 09) A threshold for considering plantar fascia thickened is not clear, but of the studies considered, the high end of the 95% confidence intervals for asymptomatic heel-thickness is above 4.5mm, and the low end for symptomatic heels is below 5.0mm. Thus, unless accompanied by a clinical correlation and other ultrasonographic findings, such as decreased echogenicity and/or loss of definition of the antero-inferior border of the calcaneus,(183) (Kane 01) use of plantar fascial thickness alone is not a reliable for diagnosis of plantar fasciitis. In addition to a lack of clear diagnostic criteria, findings on ultrasound are not likely to alter clinical management.

Ultrasound may be most helpful to identify fascial ruptures and plantar calcaneal bursitis. Ultrasound is non-invasive, has low adverse effects, and is of moderate cost. However, ultrasound may be less sensitive than MRI for suspected calcaneal fracture. Therefore, ultrasound is recommended for most cases when the clinical diagnosis is uncertain after a trial of presumptive conservative therapy where there is reasonable suspicion of symptomatic ruptures or plantar calcaneal bursitis. Ultrasound is not the primary diagnostic test for occult pathology or for suspected calcaneal fracture. However, it is recommended for cases of suspected plantar fascial rupture or plantar calcaneal bursitis if symptoms are not resolved after a trial of non-invasive therapy.

### **Initial Care**

Initial management of plantar heel pain is non-invasive. More than 90% of plantar heel pain will resolve with non-invasive measures over a 6- to 12-month period.(160, 175-177) (Toomey 09, Neufeld 08, Cole 05, Buchbinder 04)

### **EDUCATION**

Possibly, the most important non-operative treatment is education – reassuring the patient that 95% of those with plantar fasciitis will have resolution of symptoms in 12 to 18 months.(199) (Davies 99)

*Recommendation: Education for Plantar Fascia Disorders*

**Education is recommended for select patients with acute, subacute, chronic, or post-operative plantar fascia and plantar heel pain.**

*Frequency/Duration* – One or 2 appointments to educate patients about the disorder, effects of activity, unhelpfulness of complete inactivity, prognosis, and to address other questions. These appointments are often combined with detailed instructions in a stretching exercise program. Additional appointments may be needed if education is combined with therapy treatments. Follow-up educational visit(s) for more severe disorders as part of a progression towards normal functional use is sometimes helpful.

*Indications for Discontinuation* – Achievement of education goals or non-compliance.

*Strength of Evidence* – **Recommended, Insufficient Evidence (I)**

*Level of Confidence* – High

### *Rationale for Recommendation*

There are no quality trials evaluating efficacy of specific patient education for treating plantar fascia or heel pain disorders. Yet, education appears essential for optimizing doctor-patient alliance, reliable use of splints and performance of exercises, managing casts, and monitoring for infection and other problems. Some physicians accomplish this in the course of extended patient visits, while others routinely refer patients to a therapist for education. Regardless of the approach, a few appointments for educational purposes are recommended for select patients. The number of appointments needed is usually dependent on the diagnosis, severity of the condition, and co-existing conditions. A prospective series demonstrated

that the addition of a multimedia presentation in the physician's office enhanced patient understanding of plantar fasciitis treatment protocols over surgeon-patient discourse(200) (Beischer 08) and may be considered. Although education is usually incorporated as part of the overall treatment plan, an additional 1 or 2 appointments for purely educational purposes may be helpful midway through a treatment course for the more severely affected patient. Education is low cost and thus is recommended.

*Evidence for the Use of Education for Plantar Fasciitis*

There are no quality trials incorporated into this analysis.

**Medications**

**NON-STEROIDAL ANTI-INFLAMMATORY DRUGS (NSAIDs) AND ACETAMINOPHEN**

NSAIDs and acetaminophen are widely used for treatment of numerous soft-tissue and musculoskeletal injuries including ankle sprains(34) (Duranceau 86) (see other MSD-related guidelines). The mechanism of action for NSAIDs is unclear for typical musculoskeletal disorders that mostly lack traditional markers of inflammation, although some believe the mechanism of efficacy nevertheless involves addressing some component of inflammation.(35) (Jakobsen 89)

*Recommendation: NSAIDs and Acetaminophen for Acute, Subacute, Chronic, or Post-operative Plantar Fasciitis Pain*

**NSAIDs and acetaminophen are recommended for acute, subacute, chronic, or post-operative plantar fasciitis pain.**

*Indications* – Pain associated with acute, subacute, chronic, or post-operative plantar fasciitis.

*Frequency/Dose/Duration* – Frequency and dose per manufacturer's recommendations; may be taken scheduled or as needed. There is no evidence one NSAID is superior to another for treatment of plantar fasciitis or for other musculoskeletal disorders.

*Indications for Discontinuation* – Resolution, intolerance, adverse effects, lack of benefits, or failure to progress over a trial of a few weeks.

*Strength of Evidence* – **Recommended, Insufficient Evidence (I)**

*Level of Confidence* – High

*Rationale for Recommendations*

Acetaminophen is an analgesic and has no substantial anti-inflammatory effect. There is no quality evidence for or against the use of acetaminophen for the treatment of acute or subacute plantar fasciitis. There is one low-quality study comparing the effect of paracetamol with ibuprofen for acute sports injuries, which showed ibuprofen to be superior, although the study had several methodological problems.(36) (Bourne 80) However, there is quality evidence that acetaminophen is modestly superior to placebo for treatment of other musculoskeletal disorders, including low back pain, and has a low adverse effect profile (see Chronic Pain guideline for discussion of acetaminophen use). Acetaminophen is not invasive, has low adverse effects, and is low cost, thus by analogy with other musculoskeletal disorders, it is recommended.

There are no quality trials of NSAID use specific for plantar fasciitis or for treatment of post-operative patients. A low-quality trial concluded Celecoxib may provide modest benefit over placebo, although the sample size was small and lacked methodological details.(201) (Donley 07) However, NSAIDs have been shown to be highly effective for several other musculoskeletal disorders and post-operative conditions. NSAIDs are not invasive, have low adverse effects particularly in employed populations, and are low cost, thus they are recommended.

*Evidence for the Use of NSAIDs and Acetaminophen for Plantar Fasciitis*

There are no quality trials incorporated into this analysis. There are 2 low-quality RCTs in Appendix 1.(36, 201) (Donley 07; Bourne 80)

## **INFLIXIMAB**

Infliximab (Remicade®) has been used for treatment of recalcitrant plantar fasciitis.(202) (Eklund 07)

*Recommendation: Infliximab for Acute, Subacute, or Chronic Plantar Fasciitis*

**Infliximab is not recommended for the treatment of acute, subacute, or chronic plantar fasciitis.**

*Strength of Evidence – Not Recommended, Insufficient Evidence (I)*

*Level of Confidence – Low*

### *Rationale for Recommendation*

Infliximab is a monoclonal antibody that acts as an anti-TNF factor used primarily for treatment of autoimmune disease such as rheumatoid arthritis and Crohn's disease. These medications have been used for treatment of other musculoskeletal disorders (see Chronic Pain and Low Back Disorders guidelines). There is no quality evidence for the use of Infliximab for the treatment of plantar fasciitis. Infliximab is administered as an infusion therapy and is therefore invasive, has a high adverse effect profile, and is high cost with no evidence of efficacy. Therefore, it is not recommended for routine or recalcitrant plantar fascial pain.

### *Evidence for the Use of Infliximab for Plantar Fasciitis*

There are no quality trials incorporated into this analysis.

## **OPIOIDS – Oral, Transdermal, and Parenteral (Includes Tramadol)**

Opioids are sometimes used for musculoskeletal disorders; however, these are rarely used for plantar heel pain other than for limited use in post-operative patients.

### *1. Recommendation: Opioids for Acute, Subacute, or Chronic Plantar Fasciitis Pain*

**The use of opioids for the treatment of acute, subacute, or chronic plantar fasciitis pain is not recommended.**

*Strength of Evidence – Not Recommended, Insufficient Evidence (I)*

*Level of Confidence – High*

### *2. Recommendation: Opioids for Post-operative Plantar Fasciitis*

**Limited use of opioids for a few post-operative days is recommended for select patients with plantar fasciitis.**

*Indications – Post-operative pain management.*

*Frequency/Dose/Duration – Frequency and dose per manufacturer's recommendations; may be taken as scheduled or as needed. Generally suggested to be taken for short courses (a few days), with subsequent weaning to nocturnal use if needed, then discontinued. Duration usually ranges from a few days to up to 2 weeks.*

*Indications for Discontinuation – Sufficient pain management with other methods such as NSAIDs and acetaminophen, resolution of pain, intolerance, adverse effects, lack of benefits, or failure to progress over a couple weeks.*

*Strength of Evidence – Recommended, Insufficient Evidence (I)*

*Level of Confidence – Moderate*

### *Rationale for Recommendations*

There is no quality evidence for the use of opioids for the treatment of acute, subacute, or chronic plantar heel pain. The vast majority of patients with plantar fasciitis generally do not have pain sufficient to merit trialing with the risks of opioids. Patients having such degrees of pain are recommended to have investigations performed for alternative diagnoses as well as psychological issues (see Chronic Pain guideline). Opioids are not invasive, but have very high dropout rates (25 to 80%) and otherwise high rates of adverse effects. They are moderate to high cost depending on duration of treatment. They are not recommended for routine use.

Quality evidence for treatment of post-operative patients with opioids is absent. Some patients may have insufficient pain relief with NSAIDs, thus judicious use of opioids in the immediate post-operative period may be helpful, particularly for nocturnal use. Opioids are recommended for brief select use in post-operative patients with primary use at night to achieve post-operative sleep while not impairing early rehabilitation.

#### *Evidence for the Use of Opioids for Plantar Fasciitis*

There are no quality trials incorporated into this analysis.

### **SYSTEMIC GLUCOCORTICOSTEROIDS**

Oral or intramuscular glucocorticosteroids are occasionally administered for some musculoskeletal disorders, with efficacy believed to be largely through an anti-inflammatory mechanism. However, the use of these medications for plantar heel pain including plantar fasciitis is not reported in quality studies. Injections are reviewed below.

#### *Recommendation: Oral or Intramuscular Glucocorticosteroids for Acute, Subacute, or Chronic Plantar Heel Pain*

**Oral or intramuscular glucocorticosteroids are not recommended for the treatment of acute, subacute, or chronic plantar heel pain.**

*Strength of Evidence – Not Recommended, Insufficient Evidence (I)*

*Level of Confidence – Moderate*

#### *Rationale for Recommendation*

There is no quality evidence for use of these agents for treatment of plantar fasciitis. These medications are either not invasive or minimally invasive, have adverse effects, and are low cost. As evidence is lacking and evidence of efficacy is present for several other treatments, the use of glucocorticosteroids by oral or intramuscular routes is not recommended.

#### *Evidence for the Use of Systemic Glucocorticosteroids for Plantar Heel Pain*

There are no quality trials incorporated into this analysis.

### **VITAMINS**

The use of vitamins including B<sub>6</sub>, C, and E is described for various musculoskeletal disorders as an antioxidant or is hypothesized as a promoter of tendon healing processes.

#### *Recommendation: Vitamins for Treatment or Prevention of Plantar Fasciitis*

**There is no recommendation for or against the short-term use of vitamins for the treatment or prevention of plantar fasciitis.**

*Strength of Evidence – No Recommendation, Insufficient Evidence (I)*

*Level of Confidence – Low*

#### *Rationale for Recommendation*

There are no quality trials evaluating the use of vitamins for treating or preventing plantar fasciitis. Quality evidence increasingly documents lack of efficacy of vitamins for preventive cardiovascular purposes and

increased risks of cancer has been reported, particularly for vitamin A and folate, raising serious questions about the antioxidant theory. Cost may be low, but with either compound formulations or cumulatively, costs may be considerable. Thus, there is no recommendation for or against short-term use of vitamins.

#### *Evidence for the Use of Vitamins for Plantar Fasciitis*

There are no quality trials incorporated into this analysis.

### **Topical Medications**

#### **LIDOCAINE PATCHES**

The use of lidocaine patches has been described for various musculoskeletal disorders and has been reviewed in other guidelines (see Chronic Pain, Elbow Disorders, and Hand, Wrist and Forearm Disorders guidelines).

#### *Recommendation: Lidocaine Patches for Acute, Subacute, Chronic, or Post-operative Plantar Fasciitis*

**There is no recommendation for or against the use of lidocaine patches for the treatment of acute, subacute, chronic, or post-operative plantar fasciitis.**

*Strength of Evidence – No Recommendation, Insufficient Evidence (I)*

*Level of Confidence – Low*

#### *Rationale for Recommendation*

There are no quality trials of lidocaine patch use for plantar fasciitis. As one goal of therapies for plantar heel disorders is pain relief, this may represent a potential treatment on a short-term basis while other concomitant interventions, such as plantar fascia stretching exercises are being performed. However, lidocaine patches may be somewhat difficult to use on weight-bearing surfaces and with shoe wear. Patches are low cost for a short-term trial, but costs accumulate rapidly over time. Adverse effects of systemic absorption of topical anesthetics have prompted an FDA warning. There is no recommendation for or against lidocaine patches for plantar heel pain.

#### *Evidence for the Use of Lidocaine Patch for Plantar Fasciitis*

There are no quality trials incorporated into this analysis.

### **TOPICAL NSAIDs**

Topical NSAIDs are used to deliver medication locally and superficially in musculoskeletal disorders, including plantar heel disorders to reduce pain, swelling, improve range of motion and return to the patient to full functional capacity.(39, 40) (Russell 91, Mason 04)

#### *1. Recommendation: Topical NSAIDs for Acute, Subacute, or Chronic Plantar Fasciitis Pain*

**Topical NSAIDs are recommended for treatment of acute, subacute, or chronic plantar fascial pain syndromes.**

*Indications* – Mild, moderate, or severe plantar fasciitis or in patients with contraindications for oral treatment. There is no evidence of comparative superiority of one topical NSAID versus another.

*Frequency/Duration* – Frequency according to manufacturer’s recommendation. Topical NSAIDs have been used for 1 to 3 weeks.(39) (Russell 91)

*Indications for Discontinuation* – Resolution, intolerance, adverse effects, or lack of benefits.

*Strength of Evidence – Recommended, Insufficient Evidence (I)*

*Level of Confidence – Low*

#### *2. Recommendation: Topical NSAIDs for Post-operative Plantar Fasciitis*

**There is no recommendation for or against the use of topical NSAIDs for post-operative plantar fasciitis.**

*Strength of Evidence – No Recommendation, Insufficient Evidence (I)*  
*Level of Confidence – Low*

*Rationale for Recommendations*

There are no quality trials of topical NSAIDs for treatment of plantar heel pain. Support is derived from evidence that topical NSAIDs may provide benefit to persons with Achilles tendinopathy, in addition to systematic review of RCTs covering multiple musculoskeletal conditions (see Achilles Tendinopathy). A systematic review of RCTs for multiple conditions has suggested effectiveness of topical NSAIDs for treatment of multiple musculoskeletal disorders.(40) (Mason 04) Topical NSAIDs are not invasive, have low adverse effect rates, but may cumulatively be moderate to high cost. They are recommended for treatment of acute, subacute, and chronic plantar fascial or plantar heel pain, particularly in patients who do not tolerate or are poor candidates for oral treatment. Post-operative patients may be reasonable candidates after the incision is well healed.

*Evidence for the Use of Topical NSAIDs for Plantar Fasciitis*

There are no quality trials incorporated into this analysis.

**WHEAT GRASS CREAM**

The use of wheat grass cream has been described for plantar fasciitis. Topical creams containing wheat grass are marketed for skin rejuvenation and healing.

*Recommendation: Wheat Grass Cream for Acute, Subacute, or Chronic Plantar Fasciitis*

**Wheat grass cream is moderately not recommended for treatment of acute, subacute, or chronic plantar fasciitis.**

*Strength of Evidence – Moderately Not Recommended, Evidence (B)*  
*Level of Confidence – Moderate*

*Rationale for Recommendation*

There is one high-quality RCT comparing topical wheat grass cream with placebo that found no differences in efficacy for pain or function.(203) (Young 06) Wheat grass cream is not invasive, has low adverse effects, and is inexpensive. However, it has a lack of efficacy and is therefore not recommended.

*Evidence for the Use of Wheat Grass Cream for Plantar Fasciitis*

There is 1 high-quality RCT incorporated into this analysis.

Author/Y ear Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
<b>Wheatgrass Cream vs. Placebo</b>						
Young 2006 RCT	8.5	N = 80 with chronic plantar fasciitis	Wheatgrass cream vs. placebo cream.	VAS 1st-step pain improved from baseline to 6 weeks (wheatgrass p = 0.013; placebo p = 0.017), but NS between groups. Improvements continued to 12 weeks (wheatgrass p = 0.003; placebo p = 0.017). No changes in calf muscle	“The topical application of wheatgrass cream is no more effective than a placebo cream for the treatment of chronic plantar fasciitis.”	Data suggest lack of efficacy.

				strength and ankle dorsiflexion ROM.		
--	--	--	--	--------------------------------------	--	--

**Devices/Physical Methods**

**CASTING**

The use of a short-leg walking cast has been utilized for the treatment of plantar fasciitis.(204, 205) (Pribut 07, Tisdel 96)

*Recommendation: Casting for Chronic Plantar Fasciitis*

**There is no recommendation for or against the use of casting as a treatment for chronic plantar fasciitis.**

*Strength of Evidence – No Recommendation, Insufficient Evidence (I)*

*Level of Confidence – Low*

*Rationale for Recommendation*

There are no quality trials of immobilization with casting for plantar fasciitis. Mixed efficacy of cast immobilization (1 to 12 weeks) for recalcitrant plantar fasciitis as a last resort treatment prior to surgery is described in a case series report with 42% reporting total satisfaction and 46% reporting dissatisfaction.(205) (Tisdel 96) Casting is non-invasive, but is frequently not well tolerated and may have adverse effects including stiffness, recurrence of pain, venous thromboses, and is of unknown efficacy. The intervention could be high cost if it impaired or precluded performing occupational tasks. Therefore, there is no recommendation for or against the use of casting for chronic and subchronic plantar fascial heel pain.

*Evidence for the Use of Casting for Plantar Fasciitis*

There are no quality trials evaluating the use of casting for plantar fasciitis.

**CRYOTHERAPY/HEAT**

Cryotherapy and heat are commonly used as an initial intervention for analgesia, and cryotherapy in particular is thought by some to reduce inflammation in acute musculoskeletal injuries.

1. *Recommendation: Cryotherapy for Acute, Subacute, Chronic, or Post-operative Plantar Heel Pain*

**Cryotherapy is recommended for treatment of acute, subacute, chronic, or post-operative plantar heel pain.**

*Indications – All patients with plantar heel pain.*

*Frequency/Duration – Approximately 3 to 5 self-applications per day as needed.*

*Indications for Discontinuation – Resolution, adverse effects, non-compliance.*

*Strength of Evidence – Recommended, Insufficient Evidence (I)*

*Level of Confidence – Low*

2. *Recommendation: Heat Therapy for Acute, Subacute, Chronic, or Post-operative Plantar Heel Pain*

**Heat is recommended for treatment of acute, subacute, chronic, or post-operative plantar heel pain.**

*Indications* – All patients with plantar heel pain.

*Frequency/Duration* – Approximately 3 to 5 self-applications per day as needed.

*Indications for Discontinuation* – Resolution, adverse effects, non-compliance.

*Strength of Evidence* – **Recommended, Insufficient Evidence (I)**

*Level of Confidence* – Low

*Rationale for Recommendations*

There are no quality trials for the use of heat or ice therapy. Ice and heat may help particularly with more acute symptoms. These treatments are not invasive, have no or minimal adverse effects, and are not costly; thus they are recommended.

*Evidence for the Use of Cryotherapy and Heat for Plantar Heel Pain*

There are no quality trials incorporated in this analysis.

**Magnets**

Magnets are commonly used as an alternative treatment for musculoskeletal disorders, including heel pain.(206-208) (Winemiller 03, 05; Caselli 97)

*Recommendation: Magnets for Acute, Subacute or Chronic Plantar Heel Pain*

**Magnets are strongly not recommended for the treatment of acute, subacute, or chronic plantar heel pain.**

*Strength of Evidence* – **Strongly Not Recommended, Evidence (A)**

*Level of Confidence* – High

*Rationale for Recommendation*

There are two high-quality placebo controlled trials available for the use of magnets in plantar heel pain disorders.(206, 207) (Winemiller 03; 05) After an 8-week trial, no differences were found in pain scores or in the number reporting improvements.(207) (Winemiller 03) The same researcher also demonstrated in another high-quality trial no effect with magnetic insoles on non-specific foot pain.(206) (Winemiller 05) A low-quality study also found no difference between insoles with and without magnetic foil in 40 heels.(208) (Caselli 97) Magnets have been evaluated in quality studies elsewhere involving the spine and hand and have been uniformly found to be ineffective. Magnets are not invasive, have no adverse effects, and are low cost, but are not recommended for treatment of plantar heel pain.

*Evidence for the Use of Magnets for Plantar Heel Pain*

There are 2 high-quality RCTs incorporated into this analysis. There is 1 low-quality RCT in Appendix 1.

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Winemiller 2005  RCT	9.5	N = 89 health care employees with non- specific foot pain for at least 30 days	Magnetic vs. sham- magnetic cushioned insoles for 8 weeks.	“All better” or “mostly better” at 4 8 weeks sham- magnetic vs. magnetic group: 33% vs. 32%; p = 0.98/ 33% vs. 32%; p = 0.86.	“This study provides convincing evidence that use of static magnets for a total of 8 weeks was not effective in relieving symptoms of nonspecific foot	Heterogeneous inclusion criteria. Non-specific diagnoses. No control for co- interventions. Data suggest lack of efficacy.

					pain in the workplace.”	
Winemiller 2003  RCT	9.0	N = 101 adults with diagnoses of plantar heel pain for at least 30 days	Magnetic vs. sham-magnetic cushioned insoles for non-specific foot pain for 8 weeks.	“All better” or “mostly better” at 8 weeks sham-magnetic vs. magnetic group: 33% vs. 35%; p = 0.78; VAS 4, 8 weeks (placebo vs. magnets) 4.2 vs. 4.4 p = 0.63, 3.9 vs. 3.9 p = 0.94.	“Static bipolar magnets embedded in cushioned shoe insoles do not provide additional benefit for subjective plantar heel pain reduction when compared to nonmagnetic insoles.”	Randomization by drawing insoles from box. Acute pain included in study. Baseline differences in pain characteristics biased positively toward magnetic group. Data suggest lack of efficacy.

### NIGHT SPLINTING

Night splints have been utilized to treat plantar fascial pain.(209-212) (Batt 96, Powell 98, Probe 99, Roos 06) The therapeutic mechanism of night splinting is unclear, but believed to be that stretching of the plantar fascia through dorsiflexion of the foot presumably maintains the length of the plantar fascia, preventing stiffening and contraction that may occur during sleep.(213, 214) (Ryan 95, Evans 01)

*Recommendation: Night Splints for Plantar Heel Pain*

**The use of prefabricated night splints is recommended for subacute or chronic plantar heel pain.**

*Indications* – Subacute or chronic plantar fasciitis requiring temporary pain and stiffness improvement.

*Frequency/Duration* – Nightly for duration of effectiveness (as determined by improvement in symptoms and function while under the care of a health care provider).

*Indications for Discontinuation* – Resolution, adverse effects, intolerance, non-compliance.

**Strength of Evidence – Recommended, Insufficient Evidence (I)**

*Level of Confidence* – Low

#### *Rationale for Recommendation*

There are four moderate-quality trials evaluating efficacy of night splints.(209-212) (Batt 96, Powell 98, Probe 99, Roos 06) One study demonstrated improvement over no treatment after 1 month of treatment for chronic symptoms.(210) (Powell 98) However, this study had baseline differences between groups in the two arms of the study and the same splinting treatment was provided to both groups, with a crossover 1 month apart, limiting the strength of the conclusions. The other studies compared night splints to other conservative measures. One study demonstrated the combination of visco-elastic heel pad, stretching, and NSAIDs resulted in better “cure” rate than night splints, and those that failed night splints were nearly all cured after crossover.(209) (Batt 96) However, further evaluation after cure, which was generally within 13 weeks of use of splints, was not described. Chronicity of symptoms was not provided and exclusion criteria did not preclude acute plantar fascial pain, thus potential confounders were not controlled. Another study found no increased efficacy with the addition of night splints to NSAIDs, stretching, and shoe modifications after 3 months of treatment.(211) (Probe 99) A third study demonstrated no differences between orthoses, anterior night splints, or both interventions combined after 12 weeks of treatment.(212) (Roos 06) A low-quality trial compared custom made orthoses versus

prefabricated orthoses versus night splints for treatment of acute and subacute plantar fascial pain and found no differences between the groups, concluding that all were effective as initial treatments.(215) (Martin 01) Thus, there is insufficient evidence that night splints are beneficial for chronic painful plantar pain. However, night splints are non-invasive, have few adverse effects (if not well tolerated can be discontinued) and are usually low to moderate cost if prefabricated. Thus, night splints are recommended for chronic and subacute plantar fascial heel pain.

*Evidence for the Use of Night Splints for Plantar Heel Pain*

There are 4 moderate-quality RCTs incorporated into this analysis. There is 1 low-quality RCT in Appendix 1.

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Batt 1996  RCT	5.0	N = 40 with plantar fasciitis	Standard treatment of anti- inflammatory medication, Viscoheel softspot heel cushion, and stretching program for gastrocnemius and soleus muscles vs. Tension Night Splint.	Healed: Control 6/17 (35.3%) vs. TNS 16/ 16 (100%). After crossover, 8 of 11 (72.7%) controls asymptomatic after average 13 weeks.	“When used in combination with a visco- elastic heel pad, stretching program and nonsteroidal anti- inflammatory drugs, the TNS is an effective treatment of plantar fasciitis.”	No blinding. Symptom chronicity not provided. Cure rates reported may indicate acute condition as no other studies have reported such efficacy of intervention.
Probe 1999  RCT	5.0	N = 116 with plantar fasciitis	Night splints vs. no splints in groups that received 1 month NSAIDs, Achilles stretching exercises, and shoe recommendations for 3 months.	At 19 months follow-up, 84% experienced improvement of symptoms. No statistical differences between treatment groups (p = 0.95). Improvement rate, defined as decrease of 1 pain grade on 4- point scale in Group 1 was 66% and in Group 2 71% (p = 0.69).	“No statistically significant improvement was seen to a standard nonoperative protocol with the addition of night splinting in this group of patients with symptoms of less than 12 months duration.”	Lack of study details. No additional benefit of using commercial splints in study over other conservative measures (NSAID, Achilles stretching). Study suggests lack of efficacy of night splints.

Powell 1998  RCT	4.5	N = 37 with chronic plantar fasciitis	Group A: splints for 1st month; Group B: for 2nd month. No splints used in either group for final 4 months of study.	Mayo Clinical Scoring System – significant differences found between Groups A and B (p = 0.0001) and between periods (p <0.0001 at 0, 1, 2, and 6 month follow- up visits).	“We demonstrated that dorsiflexion night splints can be an effective treatment in patients with recalcitrant plantar fasciitis.”	Classified as cross-over but appears not true cross-over design, rather treatment delayed for 1- month in control group. Not blinded. Baseline differences. No washout for previous treatments.
Roos 2006  RCT	4.5	N = 43 with plantar fasciitis	Foot orthoses vs. orthoses plus night splints vs. night splints only.	All groups improved significantly in all 5 FAOS subscales across all times (p <0.04). No significant differences in pain among 3 groups at any time.	“Foot orthoses and anterior night splints were effective both short-term and long-term in treating pain from plantar fasciitis.”	No baseline data presented; no blinding. Lack of details on co- interventions, compliance. No statistical differences in interventions. Study likely underpowered.

## ORTHOTICS

Orthotic devices (i.e., heel lifts, pads, heel cups, heel braces) are commonly utilized for plantar fasciitis.(216) (Landorf 06) The mechanism of action is unknown, although it is thought that foot orthoses reduce symptoms by reducing strain in the plantar fascia during standing and ambulation.(216) (Landorf 06)

### 1. Recommendation: Orthotic Devices for Acute, Subacute, or Chronic Plantar Heel Pain

**Orthotic devices are recommended for treatment of acute, subacute, or chronic plantar heel pain.**

*Indications* – All patients with plantar fasciitis.

*Duration/Frequency* – Daily use for 2 to 3 months.

*Indications for Discontinuation* – Resolution, adverse effects, non-compliance.

*Strength of Evidence* – **Recommended, Evidence (C)**

*Level of Confidence* – Low

### 2. Recommendation: Custom Orthoses for Acute, Subacute, or Chronic Plantar Fasciitis

**There is no recommendation for or against the use of custom orthoses for acute, subacute, or chronic plantar fasciitis.**

*Strength of Evidence* – **No Recommendation, Insufficient Evidence (I)**

*Level of Confidence* – Low

3. *Recommendation: Orthoses for Prevention of Plantar Fasciitis or Lower Extremity Disorders*  
**There is no recommendation for or against the use of orthotic devices for the prevention of plantar fasciitis or lower extremity disorders.**

*Strength of Evidence – No Recommendation, Insufficient Evidence (I)*  
*Level of Confidence – Low*

*Rationale for Recommendations*

There is one high-quality trial comparing custom and pre-fabricated orthoses with sham orthoses for treatment efficacy of plantar fasciitis.(216) (Landorf 06) In 136 patients with clinical plantar fasciitis, modest functional improvement at 3 months was demonstrated in both orthoses groups compared to sham, but the comparative improvement at 3 months was within the range of the clinical measuring method (Foot Health Status Questionnaire) ability to detect differences (intraclass correlation coefficients range, 0.74 to 0.92, and Cronbach  $\alpha$ , 0.85 to 0.88), and the statistically significant effect disappeared at 12 months. There were no differences in symptom relief at 3 or 12 months. Thus, there is limited evidence for short-term functional benefit from the use of orthoses and no evidence of long-term benefit. (A low-quality crossover trial of orthoses for symptom relief of metatarsalgia related to rheumatoid arthritis demonstrated pain relief but no improvement in function.(217)) (Mejjad 04)

There is one high-quality and three moderate-quality studies that compared custom-made orthoses to other prefabricated orthoses.(216, 218-220) (Landorf 06, Baldassin 09, Pfeffer 99, Kelly 98) Despite advantages in pressure redistribution achieved with custom orthoses,(220) (Kelly 98) there were no advantages demonstrated in clinical outcomes including symptom relief at 8 weeks from the use of custom orthoses over prefabricated orthoses,(218, 219) (Baldassin 09, Pfeffer 99) or at 3 and 12 months.(216) (Landorf 06) However, patients with unusual foot anatomy may require custom-made orthoses.

One issue with some of the comparison trials is that custom-made and prefabricated orthoses may use different materials.(216, 220) (Landorf 06, Kelly 98) Thus, the comparison is made of both production method and material of the orthotic. In one trial, both custom-made and prefabricated orthoses were made of the same material and showed similar effectiveness.(218) (Baldassin 09) Material characteristics such as elasticity (ratio of force/unit area to fractional change in height) and thicknesses of the orthotics were usually not specified. In comparison with other treatments, orthoses were demonstrated to be equivalent in efficacy to night splints,(212) (Roos 06) supportive shoes,(221) (Chalmers 00) Achilles and plantar stretching exercises,(219) (Pfeffer 99) electrical stimulation(222) (Stratton 09) and in a low-quality study, the airheel device.(223) (Kavros 05)

There is one moderate-quality trial for orthotics and prevention of lower extremity disorders, which did not demonstrate benefit from using orthotics in a military population.(224) (Esterman 05) However, the study had multiple weaknesses, including low compliance making inference difficult to the general population. A low-quality randomized trial found demonstrated benefit in reducing acute leg and foot pain in referees during a tournament from the use of heel cups.(225) (Fauno 93)

Thus, the use of orthotic devices may provide some short-term benefit, but is not likely to result in dramatic improvements over natural healing. These devices are non-invasive, have few adverse effects, and are generally low cost for devices that are not custom-made; therefore, they are recommended. Custom orthoses also appear to have modest efficacy; however, there is no demonstrable improvement compared to other, commercially available orthoses, yet costs are higher. Thus, there is no recommendation for or against custom orthoses. There is insufficient evidence for orthotics for prevention and therefore, there is no recommendation for or against their use.

*Evidence for the Use of Orthoses for Plantar Fasciitis*

There is 1 high- and 7 moderate-quality RCTs incorporated into this analysis. There are 6 low-quality RCTs or crossover trials in Appendix 1.(208, 215, 217, 223, 225, 226) (Martin 01; Caselli 97; Kavros 05, Mejjad 04; Fauno 93; Lynch 98)

Author/Y ear Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
<b>Orthotics vs. Sham/No Treatment</b>						
Landorf 2006  RCT	8.5	N = 136 with plantar fasciitis	Prefabricated orthoses vs. customized orthoses vs. sham orthoses. All had plaster molds of their feet. Sham orthosis fabricated “by molding a 6-mm, soft (120 kg/m <sup>3</sup> ) ethyl vinyl acetate foam over an unmolded cast of the foot.... [in such a way as] to provide minimal structural support for foot. Prefabricated orthosis was 3/4 length, retail mold made from firm-density polyethylene foam sufficiently thick to fill the arch area and prevent the orthosis from flattening.” Custom orthotic made in commercial lab of semirigid polypropylene, had firm foam heel post “designed to provide significant support for the foot and influence the position of the foot relative to the leg.”	ANCOVA adjusted differences between mean of Foot Health Status Questionnaire (95% CI); PF vs. sham, custom vs. sham, PF vs. custom. Pain 3-months: 8.7 (-0.1 to 17.6), 7.4 (-1.4 to 16.2), 1.3 (-7.6 to 10.2); Pain 12 months: 2.2 (-5.6 to 10.0), -0.1 (-7.8 to 7.7), 2.3 (-5.6 to 10.1); Function 3 months: 8.4 (1.0 to 15.8), 7.5(0.3 to 14.7), 0.9 (-6.3 to 8.1); Function 12 months: 5.5(-2.0 to 13.0), 4.3(-3.0 to 11.6), 1.2(-6.1 to 8.5)	“Foot orthoses produce small short-term benefits in function and may also produce small reductions in pain for people with plantar fasciitis, but they do not have long-term beneficial effects compared with a sham device. The customized and prefabricated orthoses... have similar effectiveness...”	Inclusion criteria for pain duration was at least 4 weeks, with mean of 12 months. Data suggest modest function at 3 months over placebo but no differences in pain.
<b>Orthoses: Custom vs. Fabricated</b>						

Pfeffer 1999  RCT	6.5	N = 236 with proximal plantar fasciitis	Silicone heel pad vs. felt insert vs. rubber heel cap vs. custom-made "neutral" orthoses vs. no orthoses. All received AF and PF stretching exercises. Trial at 15 orthopedic foot/ankle centers; personnel at each center underwent instructional video on obtaining molds; orthoses made at single production facility of 1/4 or 3/16 inch [6 to 9 mm] polypropylene.	Percentages improved in each group: 1) silicone insert, 95%; 2) rubber insert, 88%; 3) felt insert, 81%; 4) stretching only, 72%; 5) custom orthosis, 68%. Multivariate analysis of mean pain score changes showed all groups with significant improvement, no significant differences between groups.	"We conclude that, when used in conjunction with a stretching program, a prefabricated shoe insert is more likely to produce improvement in symptoms as part of the initial treatment of proximal plantar fasciitis than a custom polypropylene orthotic device."	Lack of blinding. Data suggest added benefit from orthosis plus stretching program, but percentages of improvement are of uncertain clinical significance as benefit response included the broad category of "all, much, or slightly better." No differences in mean pain scores.
Baldassin 2009  RCT	7.0	N = 142 adults (75% female) with plantar fasciitis, without anatomical alterations in feet	Prefabricated vs. custom foot orthoses for 8 weeks. Both prefabricated and custom orthoses made of ethylene vinyl acetate.	Significant improvement both groups for modified FFI, no difference between them, $p < 0.05$ . Cointerventions used 67% of the time, 40% performed stretching for Achilles tendon and 28% used other cointerventions.	"The low-cost prefabricated and customized foot orthoses, as used in this trial, had similar effectiveness in the treatment of noncomplicated plantar fasciitis after 8 weeks of use."	High dropout (~40%). No compliance data provided. Data suggest no differences in pain relief between prefabricated and custom EVA inserts.
Kelly 1998  RCT	5.0	N = 48 with primary lesser metatarsalgia	Bauerfiend Viscopod orthoses (group 1) vs. Langer Blueline orthoses (group 2) for 8 weeks for lesser metatarsalgia.	Mean reduction in VAS scores $13.6 \pm 23.3$ for Group 1; $15.4 \pm 16.0$ for Group 2. Symptom relief score $22.6 \pm 31.1$ for Group 1; $40.2 \pm 34.7$ for Group 2. Mean reduction of peak forefoot pressure $2.1 \pm 1.7$ kPa in Group 1, $4.4 \pm 1.7$	"The use of stock orthoses we feel is only acceptable providing that they are adjusted appropriately to each individual before being used. We continue to use the Langer Blueline insole because it is	Compliance of 40-56%. May not be applicable to heel pain. Data suggest lack of efficacy.

				kPa in Group 2, p <0.001.	more efficacious (both subjectively and objectively), more economical, and better tolerated by patients.”	
<b>Orthotics vs. Other Therapies</b>						
Chalmer s 2000  RCT	7.5	N = 28 with rheumatoid arthritis referred to therapy	Supportive shoes worn alone vs. supportive shoes worn with soft orthoses vs. supportive shoes worn with semi-rigid orthoses.	Mean pain scores: final adjusted for baseline (mean±SD): Subortholen (2.88±0.44) vs. plastazote (4.27±0.45) vs. shoes (4.79±0.44), p = 0.006. Compared across treatments, change in pain for subortholen significantly different from change for plastazote and shoes alone, p = 0.027. No interventions had a significant effect on MTP joint synovitis or lower extremity function. No significant correlation between pain amount and amount of time intervention was worn.	“[Semi-rigid foot orthoses worn in supportive shoes were shown to be an effective treatment for metatarsalgia secondary to RA...Soft orthoses did not provide significant pain relief and had limited durability. However, they may be clinically useful for clients who cannot tolerate more rigid materials.”	Data suggest no differences in patient preference.
Pfeffer 1999  RCT	6.5	N = 236 with proximal plantar fasciitis	Silicone heel pad vs. felt insert vs. rubber heel cap vs. custom orthoses vs. no orthoses. All groups received AF and PF stretching exercises.	The percentages improved in each group were: 1) silicone insert, 95%; 2) rubber insert, 88%; 3) felt insert, 81%; 4) stretching only, 72%; and 5) custom orthosis, 68%. Multivariate analysis of mean pain score	“We conclude that, when used in conjunction with a stretching program, a prefabricated shoe insert is more likely to produce improvement in symptoms as part of the initial	Lack of blinding. Data suggest added benefit from orthosis plus stretching program. Percentages of improvement are of uncertain clinical significance as benefit

				changes showed all groups with significant improvement, no significant differences between groups.	treatment of proximal plantar fasciitis than a custom polypropylene orthotic device.”	response included broad category of “all, much, or slightly better.” No differences in mean pain scores.
Roos 2006 RCT	4.5	N = 43 with plantar fasciitis	Foot orthoses vs. orthoses plus night splints vs. night splints only.	All groups improved significantly in all 5 FAOS subscales across all times (p <0.04). No significant differences found in pain among 3 groups at any time.	“Foot orthoses and anterior night splints were effective both short-term and long-term in treating pain from plantar fasciitis.”	No baseline data. No blinding. Lack of details on co-interventions, compliance. Study likely underpowered. No statistical differences in interventions.
Stratton 2009 RCT	4.5	N = 26 with plantar fasciitis symptoms ranging 1 week to 5 months	Low frequency electrical stimulation with orthoses and stretching vs. orthoses and stretching.	No intergroup differences in VAS, Activities of Daily Living Subscale of FAAM 4 weeks and 3 months after treatments. Both treatment arms showed statistically significant improvements compared to baseline.	“...the efficacy of using low-frequency electrical stimulation in the management of patients with plantar fasciitis is questionable.”	Study included those with symptoms ranging 1 week to 6 months. Inclusion criteria required athletic activity 5 times a week for >90 minutes limiting general applicability. Randomization and allocation details sparse. Data suggest no added benefit from low frequency electrical stimulation.
<b>Orthotics for Prevention</b>						
Esterman 2005 RCT	4.0	N = 47 Royal Australian Air Force recruits with flexible flat feet embarking on	Orthotics vs. no orthotics for prevention in asymptomatic group.	Results not significant different but those with the orthotics had the least limb pain, the lowest rate of injuries, the best general foot health, and the best quality of life.	“The results of this pilot randomized controlled trial provide some tentative evidence that orthotics may improve lower limb pain and general foot	Pilot study. Study performed on military recruits in basic training who were deemed to have “flat” feet. No blinding. Data suggest

		10-week basic training course			health and decrease injury rates among military recruits with flexible flat feet.”	orthotics may have preventive benefit.
--	--	-------------------------------	--	--	--	--

### SHOCK ABSORBING SHOES

Individually fitted “sports shoes” with shock-absorbing capabilities are utilized for lower extremity pain disorders, including plantar fasciitis.(227, 228) (Torkki 02, Milgrom 92)

*Recommendation: Shock Absorbing Fitted Shoes for Prevention of Plantar Fasciitis*

**There is no recommendation for or against the use of special fitted or shock absorbing shoes for prevention of plantar fasciitis or lower extremity disorders.**

*Strength of Evidence – No Recommendation, Insufficient Evidence (I)*  
*Level of Confidence – Low*

#### *Rationale for Recommendation*

There are two moderate-quality trials for the use of shock absorbing shoes for prevention of plantar heel pain.(227, 228) (Torkki 02, Milgrom 92) A study of 176 newspaper carriers with lower limb overuse disorders randomized to shock absorbing athletic footwear or to continue their own footwear were followed over a 12-month period.(227) (Torkki 02) There was no control for “own footwear,” and there was a large bias favoring the intervention group in which subjects “expected” to improve with the intervention. Regardless, there were no significant differences in outcomes at 3, 6, or 12 months. A study of military recruits randomized to basketball shoes or military boots during basic training demonstrated no benefit in overall incidence of lower extremity disorders, but was effective in reducing arch and plantar pain over a 14-week period.(228) (Milgrom 92) Fitted athletic shoes are non-invasive, have no adverse effects, and are inexpensive considering the duration of use is 6 months to 1 year, although there is no clear benefit to their use. Thus, there is no recommendation for or against the use of fitted shock absorbing shoes. A moderate-quality cross-over study utilized deep soft shoes as an intervention arm for metatarsalgia and demonstrated no improvement within the groups after a 12-week period.(221) (Chalmers 00)

#### *Evidence for the Use of Shock Absorbing Shoes for Plantar Fasciitis*

There are 2 moderate-quality RCTs incorporated in this analysis. There is 1 low-quality RCT in Appendix 1.(229) (Fransen 97)

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Torkki 2002  RCT	6.5	N = 176 lower- limb overuse injuries	Individually adjusted footwear with good shock absorbing properties vs. subjects’ own used footwear (control).	No differences between groups at 3 or 12 months follow-up for lower-limb pain intensity, number of painful days, or ability to work.	“[[I]ndividually fitted shock- absorbing shoes seem to offer only rather small health benefits to subjects exposed to daily walking and having lower-limb overuse injuries.”	Study of newspaper carriers in Finland. Study of lower limb “overuse injury.” No control for other treatments. No analysis by disorder. Those in intervention expected improvement from treatment introducing potential bias for results

						(67% vs. 18%, p <0.001).
Milgrom 1992  RCT	4.0	N = 390 healthy recruits	Basketball shoes vs. marching boots and incidence of "overuse" injuries.	Basketball shoes vs. boots (14 weeks cumulative injuries); Femoral stress fracture (Fx) p = NS, tibial stress Fx p = NS, Metatarsal stress Fx 0 vs. 3.4% p = 0.03. Knee pain = NS, Achilles tendon pain = NS; foot problems 15.5% vs. 29.1 % p = 0.001.	"[M]odified basketball shoes in this study were not effective in lowering overall incidence of overuse injuries in the recruit population. The effect was limited to overuse injuries resulting from vertical impact loads."	Randomization, allocation unclear. No blinding. Study in military population. Data suggest basketball shoes (presumably with greater shock absorption) are superior to marching boots for prevention of foot overuse injuries.

## STRETCHING

Stretching exercises are utilized for the treatment of plantar fasciitis.

*Recommendation: Stretching Exercises for Plantar Fasciitis*

**Stretching exercises of the plantar fascia and Achilles tendon are recommended for treatment of plantar fasciitis.**

*Indications* – Acute, subacute, or chronic plantar fasciitis.

*Frequency/Duration* – Ten-minute stretches 3 times a day; no limit identified for duration.

*Indications for Discontinuation* – Resolution, adverse effects, intolerance, non-compliance.

*Strength of Evidence* – **Recommended, Insufficient Evidence (I)**

*Level of Confidence* – High

### *Rationale for Recommendation*

There is one moderate-quality trial with a 2-year follow-up report comparing plantar fascia stretching with Achilles stretching exercises.(230, 231) (DiGiovanni 03; DiGiovanni 06) Heel pain in patients with chronic plantar pain who failed other conservative measures improved significantly with plantar fascia stretching exercises after 8 weeks of treatment compared with the Achilles stretching group. Stretching improved the subjects' reported pain but did not improve reported function to a statistically-significant level. Those in the Achilles group were crossed over to plantar stretching, and improved significantly over a 2-year period, similar to the first group. There was not a "no treatment" group to compare natural healing. Another moderate-quality trial comparing stretching to calcaneal taping, sham taping, and no treatment over a 1-week period found no benefit from gastrocnemius and plantar fascia stretching.(232) (Hyland 06) However, this study was limited to 1 week of treatment and follow-up. One moderate-quality study used stretching as a treatment arm to compare efficacy of orthotic interventions.(219) (Pfeffer 99) The stretching arm was as beneficial as a felt insert and custom orthosis. Another trial showed no statistically

significant improvements between intervention (Achilles tendon-calf muscle stretching and sham ultrasound) and control (sham ultrasound only) groups after its 2-week period.(233) (Radford 07) Three trials offered a comparison between stretching and no stretching(219, 232, 233) (Hyland 06, Radford 07, Pfeffer 99) without comparative benefit of stretching to the alternative treatment demonstrated in any of the trials. Two of the trials had participants who stretched stretch the plantar fascia(219, 232) (Hyland 06, Pfeffer 99) and one did not.(233) (Radford 07) Stretching is non-invasive, has no adverse effects, is self-administered and is of low cost, but has minimal evidence of efficacy. Given its low risk and cost, stretching is recommended.

*Evidence for the Use of Stretching Exercises for Plantar Fasciitis*

There are 4 moderate-quality RCTs (one with two reports) incorporated into this analysis.

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Pfeffer 1999  RCT	6.5	N = 236 with proximal plantar fasciitis	Silicone insert vs. rubber insert vs. felt insert vs. vs. custom orthosis vs. stretching only. Each group performed Achilles and plantar fascia stretching for approximately 10 minutes, twice a day. Follow-up at 8 weeks.	Percentages improved in each group: 1) silicone insert, 95%; 2) rubber insert, 88%; 3) felt insert, 81%; 4) stretching only, 72%; and 5) custom orthosis, 68%. Multivariate analysis of mean pain score changes showed all groups with significant improvement, no significant differences between groups.	“We conclude that, when used in conjunction with a stretching program, a prefabricated shoe insert is more likely to produce improvement in symptoms as part of the initial treatment of proximal plantar fasciitis than a custom polypropylene orthotic device.”	Lack of blinding. Study suggests added benefit from orthosis plus stretching program. However, percentages of improvement are of unknown clinical significance as benefit response included broad category of “all, much, or slightly better.” No differences in mean pain scores.
DiGiovanni 2003, 2006  RCT	4.5	N = 101 with chronic proximal plantar fasciitis for a duration >10 months	Plantar fascia tissue-stretching program vs. Achilles tendon-stretching (concentric) program; 8-week and 2-year follow-up.	Inclusion criteria was failure of non-operative treatments. Subject-relevant outcome measures all statistically better in positive responses for PF stretching vs. Achilles stretching. Overall better 82.6% vs. 55.6% (p = 0.01), >50%	“After eight weeks of treatment, the group managed with plantar fascial stretching exercises exhibited enhanced outcomes with regard to pain, function, and overall satisfaction compared with those of the	All groups received orthoses and NSAIDs. Baseline differences in duration of symptoms reported, (duration >in PF group, p<0.01) although the mean (years) not provided. Baseline pain scores not provided

				improvement in pain 82.6% vs. 58.3% (p = 0.03). Totally satisfied 91.3% vs. 60% (p = 0.006). At 8 weeks, Achilles group switched to PF stretching. At 2-year follow-up (attrition 40%) PF stretching resulted in improvement of Achilles group; both groups improved with no differences.	group managed with standard Achilles tendon-stretching exercises. This study supports the use of the tissue-specific plantar fascia-stretching protocol as the key component of treatment for chronic plantar fasciitis.”	limiting comparison of change in scores (main outcome). High attrition (28%, 14/50) in Achilles stretching group. Lack of control group for Achilles limits conclusion for group treated with PF stretching at the 2 year follow-up as natural history is not ruled out.
Hyland 2006 RCT	4.5	N = 41 with plantar fasciitis	Stretching (plantar fascia, gastrocnemius) vs. calcaneal taping vs. sham taping vs. no treatment. Durations of symptoms unknown. Treatment effect measured after 1 week.	Stretch vs. taping vs. control vs. sham taping. VAS, PSFS stretching: 6.3±0.8 to 4.6±0.7, 5.6±1.1 to 4.9±1.2; taping: 7.0±0.8 to 2.7±1.8, 4.5±6.2±1.8; control: 6.3±1.3 to 6.2±1.0; sham taping: 6.4±1.2 to 6.0±0.9, 5.3±0.5 to 5.4±0.6; pre- and post-intragroup difference p<0.05; intragroup: taping vs. stretching p <0.06, tape vs. sham and control p <0.001, stretch vs. sham and control p = NS.	“Calcaneal taping was shown to be a more effective tool for the relief of plantar heel pain than stretching, sham taping, or no treatment.”	Randomization and allocation unclear. No blinding. Small sample size. Duration of symptoms at study entry unknown but suspect acute and subacute as previous treatment was a study exclusion criterion. Very short term study of only 1 week.

Radford 2007  RCT	5.5	N = 92 with plantar heel pain >3 months duration	Calf muscle stretching and sham ultrasound vs. sham ultrasound only. Required stretching 5 minutes per day.	No statistically significant differences between groups in first-step pain, foot pain, foot function, general foot health, or functional measures in ROM.	"[A] two-week stretching program provides no statistically significant benefit in 'first-step' pain, foot pain, foot function or general foot health compared to not stretching."	Improvement in both groups occurred, but no between group differences. Short trial duration – only 5 minutes of intervention per day. Results suggest no benefit of calf stretches using wedge technique.
-------------------------	-----	--	---	---	---	---

### TAPING (LOW DYE and CALCANEAL)

Various taping techniques, including Low-Dye and calcaneal taping, have been used for the treatment of plantar fasciitis.(232, 234) (Radford 06; Hyland 06)

#### 1. Recommendation: Heel Taping for Acute or Subacute Plantar Fasciitis or Heel Pain

**The use of heel taping is recommended as a short-term treatment for acute or subacute plantar fasciitis or heel pain.**

*Indications* – Patients with acute or subacute plantar fasciitis without adhesive allergies as a short-term intervention for pain relief.

*Frequency/Duration* – Daily application of tape for 1 to 4 weeks.

*Indications for Discontinuation* – Resolution, adverse effects, non-compliance, completion of 4-week course of treatment.

*Strength of Evidence* – **Recommended, Evidence (C)**

*Level of Confidence* – Low

#### 2. Recommendation: Heel Taping for Chronic Plantar Fasciitis or Heel Pain

**There is no recommendation for or against the use of heel taping for the treatment of chronic plantar fasciitis or heel pain.**

*Strength of Evidence* – **No Recommendation, Insufficient Evidence (I)**

*Level of Confidence* – Low

#### Rationale for Recommendations

One high-quality trial of taping using the Low-Dye technique for plantar heel pain demonstrated modest benefit in “first-step” pain relief over a no-taping control at 1 week of follow-up.(234) (Radford 06) Taping failed to show improvement in other outcome measures however, including overall foot-pain, foot function, and general foot health status. Taping was limited by high adverse events (28%) including taping too tight, new pain, and allergic reaction to the tape. Low-Dye taping is described as an adjunct to other treatment arms in one moderate-quality study,(188) (Osborne 06) but no conclusions regarding its efficacy compared to other interventions or to no treatment can be made. There is one moderate-quality trial comparing calcaneal taping to stretching, sham taping, and no treatment for short-term treatment of plantar heel pain.(232) (Hyland 06) Calcaneal taping was demonstrated to be more effective in pain relief after 1 week of treatment than stretching, sham taping, and control. However, results are limited due to

small sample size and short-term follow-up. Thus, the efficacy of taping is limited to modest short-term pain relief. Taping is non-invasive, is generally limited to short-term use by its potential for skin sensitization and breakdown, and is of moderate cost. Therefore, the use of taping is recommended as a short-term strategy as an adjunct with other non-operative treatments.

#### *Evidence for the Use of Taping for Plantar Fasciitis*

There is 1 high- and 1 moderate-quality RCTs incorporated into this analysis. There is 1 low-quality RCT in Appendix 1.(226) (Lynch 98)

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Radford 2006 RCT	8.0	N = 92 with plantar heel pain	Low-Dye taping with sham ultrasound vs. sham ultrasound. Symptoms >4 weeks. Treatment effect measured over 1 week.	Taping vs. control: (adjusted mean difference 95% CI). First step pain; -12.3 (-22.4 to -2.2) p = 0.017. Foot pain, foot function, general foot health scores all non-significant between groups.	“Low-Dye is effective for the short-term treatment of the common symptoms of “first-step” pain in patients with plantar heel pain.”	Short trial of 1 week. High level of adverse events in taping (28%) due to discomfort, allergic reactions. Data suggest no differences in outcomes measures except first step pain.
Hyland 2006 RCT	4.5	N = 41 with plantar fasciitis	Stretching (plantar fascia, gastrocnemius) vs. calcaneal taping vs. sham taping vs. no treatment. Durations of symptoms unknown. Treatment effect measured after 1 week.	Stretch vs. taping vs. control vs. sham taping; VAS, PSFS stretching: 6.3±0.8 to 4.6±0.7, 5.6±1.1 to 4.9±1.2; taping: 7.0±0.8 to 2.7±1.8, 4.5±6.2±1.8; control: 6.3± 1.3 to 6.2±1.0. Sham taping: 6.4±1.2 to 6.0±0.9, 5.3±0.5 to 5.4±0.6 pre/post intra-group difference p <0.05; intra-group: taping vs. stretching p <0.06, tape vs. sham and control p <0.001, stretch vs. sham and control p = NS.	“Calcaneal taping was shown to be a more effective tool for the relief of plantar heel pain than stretching, sham taping, or no treatment.”	Randomization and allocation unclear. No blinding. Small sample size. Duration of symptoms at study entry unknown but suspect acute and subacute as previous treatment was a study exclusion criteria. Very short term trial and follow-up of only one week limits utility of study for guidance.

#### **ACUPUNCTURE**

Acupuncture is frequently described as an alternative intervention for musculoskeletal disorders. However, there is little information available pertinent to the treatment of plantar fasciitis.

*Recommendation: Acupuncture for Acute, Subacute, or Chronic Plantar Fasciitis*  
**There is no recommendation for or against the use of acupuncture for treatment of acute, subacute, or chronic plantar fasciitis.**

*Strength of Evidence – No Recommendation, Insufficient Evidence (I)*  
*Level of Confidence – Low*

*Rationale for Recommendation*

There are no quality controlled trials of acupuncture of the lower extremity for the treatment of plantar fasciitis. There is one high-quality study comparing the efficacy of acupuncture applied at one of two traditional acupoint sites in the upper extremity for relief of plantar fasciitis and heel pain of 3 months or greater duration.(235) (Zhang 09) Participants received 10 treatments over a 2-week period. There was greater benefit in pain score improvement at 1 month only in the acupoint Daling (PC7) group versus acupoint Hegu (LI 4) group. As this study had no placebo or “no treatment” comparison group, and with the inclusion criteria allowing subacute cases, the effectiveness of acupuncture at either acupoint is not distinguished from natural history. Acupuncture is minimally invasive, has minimal adverse effects, and, depending on numbers of treatments, is moderately costly. There are other interventions with documented efficacy. Therefore, there is no recommendation for or against the use of acupuncture for treatment of plantar fasciitis pending publication of quality trials.

*Evidence for the Use of Acupuncture for Plantar Fasciitis*

There is 1 high-quality RCT incorporated in this analysis.

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Zhang 2009  RCT	8.5	N = 53 with plantar fasciitis	Acupuncture needling of upper extremity at acupoint Daling (PC7) vs. acupoint Hegu (LI 4) in patients with symptoms >3 months; 10 treatments over 2-week period with 6- month follow- up.	Daling (palmar side of forearm, midpoint of wrist crease); Hegu (between 1st and 2nd metacarpal bones) at 1 month: Morning Pain VAS: 22.6±4.0 vs. 12.0± 3.0, p <0.05; overall pain VAS: 20.3±3.7 vs. 9.5±3.6, p <0.05; pressure pain threshold: 145.5±32.9 vs. -15.5±39.4, p <0.05	Study “demonstrates that acupoint PC 7 has a specific effect for treatment of plantar fasciitis, and that the methods of acupuncture treatment is both simple and safe.”	Lack of placebo control limits conclusions on effectiveness of acupuncture vs. natural history. Some bias may be present as study conducted in culture where acupuncture is widely accepted as standard treatment.

**ELECTRICAL STIMULATION**

Low frequency electrical stimulation is described for treatment of plantar fasciitis.(222) (Stratton 09)

*Recommendation: Low Frequency Electrical Stimulation for Acute, Subacute, or Chronic Plantar Fasciitis*

**There is no recommendation for or against the use of low frequency electrical stimulation for acute, subacute, or chronic plantar fasciitis.**

*Strength of Evidence – No Recommendation, Insufficient Evidence (I)*  
*Level of Confidence – Low*

### Rationale for Recommendation

There is one moderate-quality trial that compared the addition of low-frequency electrical stimulation applied once a day for 4 weeks to a protocol that included plantar fascia stretching and prefabricated orthoses.(222) (Stratton 09) There were no differences between the groups, although the sample size was small and included acute, subacute, and chronic subjects. Low-frequency electrical stimulation is not invasive, is moderately costly with the purchase or rental of machine and supplies, and has low adverse effect profile, but appears to provide no benefit compared with orthosis and stretching. Thus, efficacy is unclear and no recommendation for or against its use is made.

### Evidence for the Use of Electrical Stimulation for Plantar Fasciitis

There is 1 moderate-quality RCT incorporated into this analysis.

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Stratton 2009  RCT	4.5	N = 26 with plantar fasciitis	Low frequency electrical stimulation with orthoses and stretching vs. orthoses and stretching.	No intergroup differences in VAS, Activities of Daily Living Subscale of FAAM 4 weeks and 3 months after treatments. Both treatment arms statistically significant improvements compared to baseline.	“The efficacy of using low- frequency electrical stimulation in the management of patients with plantar fasciitis is questionable.”	Study included patients with symptoms of 1 week to 6 months. Inclusion criteria: athletic activity 5 times per week for >90 minutes limiting generalizability. Randomization and allocation details sparse. Data suggest no added benefit from low frequency electrical stimulation.

### EXTRACORPOREAL SHOCKWAVE THERAPY

Shockwave therapy has been utilized for treatment of multiple chronic soft tissue disorders including Achilles tendinopathy, plantar fasciitis, epicondylitis, and calcific rotator cuff tendonitis. The mechanism of action is unknown, but shockwaves are purported to reduce pain and enhance healing.(28) (Rompe 09) Application and delivery of shockwave energy differs among studies. Focused shockwave therapy (fESWT) is the application of energy, whereas radial ESWT (rESWT) applies energy in a much broader tissue field. There have been challenges interpreting studies as the amount of energy delivered, method of focusing shockwaves, treatment frequency, timing, use of anesthetics, and outcomes vary among studies.

In ESWT, energy is imparted to tissue is a succession of usually 1,000 to 4,000 rapidly generated waves. Classification schemes for energy levels of shockwave therapy have been proposed by Mainz and Kassel,(236) (Speed 04) which are summarized in Table 9. Energy is expressed as energy flux density (EFD), or milliJoules passing through an area specified in square millimeters (mJ/mm<sup>2</sup>), and measured in an area close to the center of the wave rather than at its lower-energy periphery.

**Table 6. Classification Schemes for Energy Levels of Shockwave Therapy**

Classification Scheme	Energy Level	Energy Flux Density Range (mJ/mm <sup>2</sup> )
Mainz	Low	0.08-0.27
	Medium	0.28-0.59

	High	>0.60
Kassel	Low	<0.12
	High	>0.12

The total energy delivered during an application of ESWT is a product EFD of each shock, the number of shocks, the area of the energy delivery for each shock (usually on the order of 20mm<sup>2</sup>), and the amount of energy absorbed by the tissue. Thus, a “low energy” application with a high number of shocks may impart more energy than a “high energy” application with a low number of shocks. No classification scheme to address this aspect of ESWT could be found. In lithotripsy, highly-focused shock waves are more effective. What if any bearing the transmission area has on treatment in musculoskeletal disorders is not addressed in the medical literature. Other areas of confusion when seeking an understanding of ESWT are that energy flux density may be reported in different ways and energy is distributed in the shock waves differently at different energy levels. EFD is reported as “total energy flux density (EFD)” or “positive energy flux density (EFD<sub>+</sub>),” the latter being the amount of energy contained in only in the initial, rapid, positive-pressure compression wave (and does not include the longer negative-pressure wave that follows). EFD<sub>+</sub> is always smaller than EFD, and its comparative size may be dependent on EFD and the ESWT device.(237-240) (Ogden 01, Maier 05, Thiel Intl Soc Med Shockwave, Tóth-Kischkat Intl Soc Med Shockwave) Lower-energy EFDs have comparatively small proportions of their total energy in EFD<sub>+</sub> than do higher-energy EFDs.(241) (Kudo 06) EFD and EFD<sub>+</sub> may be recorded as the energy in the portion of the wave with sonic energy twice that of baseline, with pressure over 5 MPa (50 atmospheres), or in a “focal area” of the highest energy of 5mm diameter.(238-240) (Maier 05, Thiel Intl Soc Med Shockwave, Tóth-Kischkat Intl Soc Med Shockwave) The different ways of measuring EFD may result in reporting differences of several-fold.(237, 242) (Ogden 01; Rompe 03) Lastly, the frequency of delivery of shock waves may affect secondary phenomena, such as formation of air bubble in tissue with the low-pressure portion of the energy wave that follows the high-pressure pulse, a phenomenon known as cavitation.

ESWT may induce frank tissue damage and pain at higher energy. One set of authors assert that energy flux levels of more than 0.34mJ/mm<sup>2</sup> require “regional nerve blocks combined with either intravenous sedation or general anesthesia.”(243) (Malay 06) However, in most studies, the authors do not indicate anesthesia was administered. Other than the assertion by Malay,(243) (Malay 06) a threshold for anticipating pain or administering anesthesia is not clear.

*1. Recommendation: Extracorporeal Shockwave Therapy for Chronic Plantar Fasciitis*

**Extracorporeal shockwave therapy (ESWT) is recommended as a treatment for chronic plantar fasciitis in select patients with chronic recalcitrant conditions.**

*Indications* – Chronic plantar heel pain consistent with plantar fasciitis. In most studies of ESWT used for treatment of plantar fasciitis, patients often have at least 6 months of symptoms and fail therapy with active and passive exercises, NSAIDs, and glucocorticosteroid injection(s).(237, 241-249) (Malay 06, Kudo 06, Rompe 03, Theodore 04, Cosentino 01, Mehra 03, Ogden 04, Rompe 02 & 96, Ogden 01) The presence or absence of heel spur does not impact decision for use of ESWT.(246) (Cosentino 01)

*Frequency/Duration* – Treatment protocols vary; 1 to 3 treatment sessions with reported efficacy are 1,500 impulses at 0.22 mJ/mm<sup>2</sup> to 3,800 impulses at 0.36 to 0.64mJ/mm<sup>2</sup>. (237, 241, 243, 245, 249) (Ogden 01, Ogden 04, Theodore 04, Kudo 06, Malay 06) Serial sessions of 1,000 to 2,100 impulses at 0.16 mJ/mm<sup>2</sup> or lower repeated over 3 sessions spaced in weekly or biweekly intervals is also reported.(242, 246, 247) (Rompe 03, Cosentino 01, Mehra 03)

*Indications for Discontinuation* – Resolution, intolerance, non-compliance.

*Strength of Evidence* – **Recommended, Insufficient Evidence (I)**  
*Level of Confidence* – Low

2. *Recommendation: Extracorporeal Shockwave Therapy for Acute or Subacute Plantar Fasciitis*  
**Extracorporeal shockwave therapy (ESWT) is not recommended for treatment of acute or subacute plantar fasciitis.**

*Strength of Evidence – Not Recommended, Insufficient Evidence (I)*  
*Level of Confidence – Moderate*

3. *Recommendation: Ultrasound or Fluoroscopy Guidance for Shockwave Therapy for Plantar Fasciitis*  
**Ultrasound or fluoroscopic guidance is not recommended over application of energy at the point of maximal tenderness for treatment of plantar fasciitis.**

*Strength of Evidence – Not Recommended, Insufficient Evidence (I)*  
*Level of Confidence – Low*

4. *Recommendation: Local Anesthesia with High Shockwave Therapy for Plantar Fasciitis*  
**Local anesthesia is recommended when used in conjunction with high-energy ESWT for the treatment of plantar fasciitis.**

*Strength of Evidence – Recommended, Insufficient Evidence (I)*  
*Level of Confidence - Low*

5. *Recommendation: Local Anesthesia with Low or Medium Shockwave Therapy for Plantar Fasciitis*  
**There is no recommendation for or against the use of local anesthesia when used in conjunction with low- or medium-energy ESWT for the treatment of plantar fasciitis.**

*Strength of Evidence – No Recommendation, Insufficient Evidence (I)*  
*Level of Confidence – Low*

6. *Recommendation: Radial Extracorporeal Shockwave Therapy for Chronic Plantar Fasciitis*  
**There is no recommendation for or against the use of radial ESWT (rESWT) for the treatment of chronic plantar fasciitis.**

*Indications – Same as ESWT (see above).*

*Strength of Evidence – No Recommendation, Insufficient Evidence (I)*  
*Level of Confidence – Low*

7. *Recommendation: Radial Extracorporeal Shockwave Therapy for Acute or Subacute Plantar Fasciitis*  
**Radial ESWT (rESWT) is not recommended for the treatment of acute or subacute plantar fasciitis.**

*Strength of Evidence – Not Recommended, Insufficient Evidence (I)*  
*Level of Confidence – Moderate*

#### *Rationale for Recommendations*

There are multiple quality placebo-controlled trials providing conflicting outcomes for the efficacy of ESWT for the treatment of chronic plantar heel pain. Most of the high-quality studies failed to show superiority of ESWT to placebo(250-254); (Haake 03, Buchbinder 02, Speed 03, Marks 08; Gollwitzer 07) however, there are two high-quality trials(241, 243) (Malay 06, Kudo 06) and seven moderate-quality trials(237, 242, 244-247, 249) (Rompe 03, Theodore 04, Cosentino 01, Mehra 03, Ogden 04, Rompe 96, Ogden 01) that suggested efficacy. Additionally, evidence for intermediate- and long-term harm was lacking.

Interpretation of these results is complicated by the wide variations in amount of energy delivered, treatment frequency, and use of local anesthetics. The optimal EFD for ESWT is unclear, as are the strata for energy flux delivery. Rompe used low energy ( $\sim 0.08\text{mJ/mm}^2$ ), medium energy ( $\sim 0.28\text{mJ/mm}^2$ ), and high energy ( $\sim 0.60\text{mJ/mm}^2$ ), in agreement with the Mainz classification.(254) (Gollwitzer 07) Quality trials have demonstrated low- and high-energy density delivery treatment regimens to be both effective and non-effective. Comparison of outcomes with total energy delivered is also inconsistent, as quality trials demonstrated total energy (EFD multiplied by the number of pulses at that EFD) between  $60\text{mJ/mm}^2$  (244) (Rompe 96) and  $2330\text{mJ/mm}^2$  (241) (Kudo 06) to be both effective and ineffective. This energy range presumes EFD, not EFD+, reported by the study authors. Described protocols consisted of 3 treatment sessions, with varied impulse energy density ( $0.02$  to  $0.33\text{mJ/mm}^2$ ), number of impulses applied (1,500 to 4,000 per session), and spacing of treatment sessions (every third day to every other week). Thus, the optimal energy level of treatment is not well defined. There are three quality studies that demonstrated benefit from a single high-energy treatment session.(237, 243, 245) (Malay 06, Theodore 04, Ogden 01) One trial suggested a dose effect with increased impulses.(255) (Rompe 02)

Benefit of ESWT compared to corticosteroid injection in acute patients was compared.(256) (Porter 05) Both groups improved and no recommendation is made for either as an acute treatment. In comparison to mixed conservative therapies(257) (Greve 09) one moderate-quality trial found no differences in outcomes measures, whereas two moderate-quality trials demonstrated ESWT more effective than serial conservative treatments of NSAIDs, orthotics, physiotherapy, stretching, and cortisone injections.(258-260) (Hammer 02, 03, Wang 06) These studies had multiple weaknesses limiting interpretation of results, but suggest for chronic conditions, ESWT may provide greater benefit than continuing with other non-operative treatments. ESWT may be invasive, particularly at high energy, when it may be performed with an injected anesthetic. Adverse effects from ESWT, particularly high-energy ESWT, may include erythema, pain, numbness, and tingling which are generally transient.(237, 241, 246, 249, 250) (Cosentino 01, Ogden 01, Ogden 04, Haake 03, Kudo 06) ESWT is moderate to high cost depending on numbers of treatments. However, the results of the studies are heterogenous, with more than a quarter of the high-quality studies and all seven moderate-quality studies showing efficacy. Thus, ESWT is recommended for treatment of chronic plantar fasciitis if more conservative measures have failed, particularly as if surgery is being considered.

A high-quality trial comparing radial ESWT (rESWT) with sham demonstrated efficacy in reduction of pain and improved function at 3 months and 1 year.(261) (Gerdesmeyer 08) There are no studies comparing rESWT versus ESWT. Another moderate-quality trial compared perpendicular to tangential application of energy, which demonstrated no difference in outcomes as both groups improved the same.(262) (Tornese 08) The study was missing a control group and therefore no recommendation is made for one technique over the other. Radial ESWT is similar to ESWT in other aspects, adverse effects, and cost. Based on the insufficient evidence of efficacy for ESWT, there is insufficient evidence for recommendation.

The use of ultrasound and fluoroscopy has been described to guide the location for ESWT application. The quality comparison trial found no difference in outcomes using fluoroscopy compared to palpation.(263) (Dorotka 06) Ultrasound was used in three high-quality studies that showed no benefit over sham treatment,(250-252) (Haake 03, Buchbinder 02, Speed 03) but has not been compared without ultrasound in the same study. Therefore, there is insufficient evidence that the use of ultrasound or fluoroscopy guidance provides additional benefit over application of energy at point of maximal tenderness, and is therefore not recommended.

Regarding the use of local anesthesia, a high-quality study compared the effect of local anesthesia block to no block in subjects receiving low-energy ESWT and found local block reduces the positive treatment effect of ESWT, with prolonged benefit at 3 months, suggesting pain associated with ESWT has a treatment effect.(264) (Rompe 05) However, two high-quality studies finding no effect of ESWT did not utilize a local block and still found no effect over placebo.(250, 251) (Haake 03, Buchbinder 02) Thus, there is insufficient evidence for a recommendation for or against the use of local block with low- or

medium-energy ESWT. Local anesthesia is typically used in high-energy ESWT, using the Mainz categorization, to over 0.60mJ/mm<sup>2</sup>, and is recommended for use with high-energy ESWT.

*Evidence for the Use of ESWT for Plantar Fasciitis*

There are 9 high- and 14 moderate-quality RCTs (one with two reports) or quasi-RCTs incorporated into this analysis. There are 2 low-quality studies in the Appendix.(265, 266) (Furia 05, Alvarez 03)

Author/Y ear Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
<b>ESWT vs. Sham</b>						
Haake 2003 RCT	10.0	N = 272 chronic plantar fasciitis with symptoms >6 months and failure of conservative treatment (non-specified)	ESWT vs. sham. Active treatment: 4,000 shocks 0.08 mJ/mm <sup>2</sup> x 3 treatments 2 week intervals; mepivacaine local used. Energy focused on insertion of fascia guided by ultrasound; 12 week at 12-month follow-up period; 320 mJ/mm <sup>2</sup> ; low energy flux.	Primary outcome: success on Roles and Maudsley Scale (score 1-2): 12 weeks – difference in success rates 3.6% (-8.0% to 15.1; p = 0.5927), OR 1.18 (0.675 to 2.07). 12 months: 91 of 113 (81%) ESWT vs. 87 of 115 (76%) placebo p >0.05. No significant effect of ESWT.	“We cannot recommend specific applications of extracorporeal shock wave therapy to be tested in further clinical studies because all major trials, using different shockwave variable and types of lithotripters, showed negative results.”	Blinding of treatment method shown to be effective, 75% (therapy) vs. 65% (placebo) thought they were in treatment group. Local anesthesia with 2ml mepivacaine. Data suggest no benefit from ESWT given parameters.
Buchbinder 2002 RCT	9.5	N = 166 plantar fasciitis with symptoms range 8-900 weeks, mean 36-43 weeks; 12-week follow-up period; Dx of thickened insertion of plantar fascia (>4 mm) by ultrasound required	ESWT vs. sham. Active treatment: 2,000-2,500 shocks of variable energy (0.02-0.33mJ/mm <sup>2</sup> ) dictated by pain tolerance) x 3 weekly treatments. No local used. Energy focused on insertion of fascia guided by ultrasound; ≤825 mJ/mm <sup>2</sup> ; low to medium energy flux.	At 6 and 12 weeks, significant improvements in overall pain in both active group placebo group although no differences between groups (mean±SD): 17.9±30.5 and 19.8±33.7 at 6 weeks (p = .74). 26.3±34.8 and 25.7±34.9 at 12 weeks (p = .99). No significant effect of ESWT.	“We found no evidence to support a beneficial effect on pain, function, and quality of life of ultrasound-guided ESWT over placebo in patients with ultrasound proven plantar fasciitis 6 and 12 weeks following treatment.”	Use of anesthesia not noted. Focus of energy on thickest portion of plantar fascia vs. most tender point. Suggests ESWT provided no benefit given parameters of study at 6 or 12 weeks. Study included subacute and chronic conditions. No long-term follow-up.

Speed 2003 RCT	9.5	N = 88 adults with plantar fasciitis with symptoms >3 months (most failed analgesics, NSAIDs, injections, footwear, and orthotics); 6-month follow-up	ESWT vs. sham. Active treatment: 1,500 shocks of 0.12 mJ/mm <sup>2</sup> x 3 treatment at monthly intervals. No local used. Energy focused on insertion of fascia guided by ultrasound and point of maximal tenderness on treatment application; 180 mJ/mm <sup>2</sup> ; low energy flux.	EWST vs. sham pain VAS (mean): 0/1/2/ 3/6 months: 73.6/ 62.5/51.6/41.4/34.7 vs. 70/63.7/48.1/47.1/29. No significant difference between groups with respect to changes seen in any outcome measures over 6-month period. No significant effect of ESWT.	“There appears to be no treatment effect of moderate dose ESWT in subjects with plantar fasciitis. The improvement shown with placebo may be simply an improvement in symptoms or a true placebo effect.”	Use of anesthesia not noted. Data suggest lack of long term efficacy.
Gollwitzer 2007 RCT	9.0	N = 40 with chronic painful heel syndrome (symptoms >6 months); failed 4 conservative treatments; 12 week follow-up	ESWT vs. sham. Active treatment - 2000 shocks of 0.25 mJ/mm <sup>2</sup> x 3 treatments at weekly intervals. No local used. Energy focused on at point of maximal tenderness; 500mJ/mm <sup>2</sup> ; low energy flux.	Final percent change from baseline in composite heel pain VAS score: 73.2% in the ESWT group vs. 40.5% in placebo group. Between-group difference not statistically significant. No differences in overall success rate. No significant effect of ESWT.	“In conclusion, ESWT with 3 repetitive applications of 2000 impulses of an electromagnetic shockwave device without local anesthesia appeared to be an effective, non-invasive treatment modality for proximal plantar fasciitis. This intervention was associated with negligible side effects.”	Use of anesthesia was not indicated. Mann Whitney effect test to determine clinical significance of observed differences to justify conclusion. None of the clinical outcomes measures reached statistical significance.
Malay 2006 RCT	9.0	N = 172 volunteers with symptoms >6 months, failed 2 pharmaceutical and 2 non-pharmaceutical treatments. VAS > 5 (0-10 scale); 3-	ESWT (115) vs. sham. Control (57) - Active treatment of 3500 impulses in single session (energy variable, total dose not reported). Energy Flux not specified.	Mean VAS change ESWT vs. placebo (1, 2, 3 months): -1.61 vs. 11.27 p = 0.34, -2.30 vs. -1.31 p = 0.26, -2.51 vs. -1.57 p = 0.45. Mean VAS change ESWT vs. placebo at 3 months: Spur absent; -3.67 vs. -2.19 p = 0.12, Spur present; -2.06 vs. -1.99, p =	“All assessments of the reduction of heel pain were found to be statistically significant when compared with placebo in participants who had already failed standard conservative treatments...with a single treatment session without	Study performed by manufacturer for FDA approval of Orthospec device (portable ESWT). Anesthesia not used. Study suggests delayed reduction in pain on assessor and patient report,

		month follow-up period		0.96; Assessment of heel pain (responder vs. non-responder) at Months 1, 2, 3: 35.5% vs. 31.5% p = 0.61, 43.2% vs. 31.5% p = 0.14, 52.7% vs. 28.6% p = 0.003. Intervention subjects receiving higher-energy flux treatment and without heel spurs did better than those with heel spurs and those receiving lower-energy flux. Mixed statistically significant effects and few clinically-significant effects of ESWT.	the use of local anesthetics or systemic analgesics or sedatives.”	but no improvement in function or activity after single treatment session. Effect seems greatest at 3 months. No long-term follow-up to determine if effect lasting.
Kudo 2006 RCT	8.5	N = 114 with plantar fasciitis symptoms >6 months, failed NSAIDs, stretching, and 2 other treatments ; VAS >5 (0-10 scale); 3-month follow-up	ESWT vs. sham. Active treatment 3800 impulses at variable energy (0.36 -0.64 mJ/mm <sup>2</sup> ) in single treatment for total of 1,300 mJ/mm <sup>2</sup> ED <sub>+</sub> or 2330 mJ/mm <sup>2</sup> ED; high energy flux.	Clinical success [No. of subjects (%)] active treatment group vs. placebo: 25/53 (47%) vs. 12/52 (23%); p = 0.0099. Adverse events through 3 months: pain during treatment (% incidence): 79.3 vs. 8.9; p = 0.000. Mixed, mostly non-statistically significant effects and questionable clinically-significant effects of ESWT.	“The results of this study confirm that high-energy ESWT, administered with the Dornier Epos Ultra is a safe and effective treatment for patients who have failed previous conservative nonsurgical treatments for chronic plantar fasciitis.”	Local anesthesia with 5 ml lidocaine. Study suggests EWST provided benefit over placebo.
Marks 2008 RCT	8.5	N = 25 mean symptom duration 28.3 months, failed NSAIDs,	ESWT (16) vs. Sham (9). Active treatment of 500 impulses day 1, 2000 impulses on day 4 and 7 at 0.16 mJ/mm <sup>2</sup> . No report on use	VAS change >50%: ESWT 4/9 vs. sham 9/16 p = 0.44. VAS change overall: p = 0.75 between group mean Roles and	“There appears to be a significant placebo effect with low-energy ESWT in patients with heel pain, and	Randomization by drawing lots. Use of anesthesia not noted. Small sample size. Data suggest no clinically

		corticosteroid injections, physiotherapy; follow-up at 1, 6 months	of local or guidance method; 320 mJ/mm <sup>2</sup> ; low energy flux.	Maudsley Scores: p = 0.22 between group mean. No significant effect of ESWT.	there is also a lack of evidence for its efficacy compared to sham therapy.”	significant effect at 1 or 6 months.
Rompe 2003 RCT	7.5	N = 45 recreational runners with symptoms >12 months, failure of 3 non-operative treatments including NSAIDs, physiotherapy, orthotics; 12-month follow-up	ESWT vs. sham. Active treatment – 2,000 shocks of 0.16 mJ/mm <sup>2</sup> x 3 treatments at weekly intervals. No local used. Energy focused on at point of maximal tenderness; 320 mJ/mm <sup>2</sup> ; low energy flux.	Mean reduction in self-assessment of pain on 1st walking in morning. Initial rating/6 months/1 year treatment vs. sham: 6.9±1.3/2.1±2.0/1.5±1.7 vs. 7.0±1.3/4.7±1.9, 4.4±1.7; p <0.0005 at 6, 12 months. Mean scores on AOFAS Ankle-Hindfoot Scale: 52.7 ±10.0/89.9±8.6/90.4 ±8.3 vs. 49.7±10.1/69.1±20.1, 75.4±17.3; p = 0.0211. Subjective scale results: 4.0±0.0/2.1±0.8/1.9±0.6 vs. 4.0±0.0/3.0±1.0/2.7 ±1.1; p = 0.0445. Statistically significant positive effect of ESWT.	“The results of the current study revealed beneficial effects of low-energy extracorporeal shock wave therapy in long-distance runners with chronic plantar fasciitis. [W]e recommend shock wave therapy to any patient who has had unsuccessful conventional non-operative treatment over a period of at least 6 months, before considering an operative intervention.”	Small sample size. No anesthesia used. Data suggest low energy ESWT showed beneficial vs. placebo in this group of runners over 12 month period.
Theodore 2004 RCT	7.5	N = 150 with plantar fasciitis with symptoms >6 months, failed stretching, failed	ESWT vs. sham. Active treatment 3800 impulses at variable energy (0.36 -0.64 mJ/mm <sup>2</sup> ) in single treatment for total of 1,300 mJ/mm <sup>2</sup> . Local anesthetic was used in	VAS: ESWT vs. sham (0, 5 days, 6 weeks, 3 months): 7.7 vs. 7.7, 5.0 vs. 5.7, 4.6 vs. 5.0, 3.4 vs. 4.1. Mean change from baseline -4.4 vs. -3.6 p = 0.435. Roles & Maudsley	“In conclusion, extracorporeal shock wave therapy has emerged as a safe treatment option for chronic plantar fasciitis. This study demonstrates	Anesthesia through medial calcaneal nerve block with 5 ml of 1% lidocaine. Data suggest single treatment provides some pain relief but minimal functional

		NSAIDs and 2 other therapies; 12-month follow-up	conjunction with ultrasound guidance and modification with pain feedback. Study patients unblinded at 3 months and placebo group was allowed to crossover; 1300 mJ/mm <sup>2</sup> ; medium to high energy flux.	(number reporting improvement from fair/poor to excellent/good at 3 months: 45/73 (63%) vs. 29/73 (40%), p = 0.0327. AOFAS Ankle-Hindfoot, SF-12: no differences. Statistically significant differences between groups noted in 3 months of blinded comparison. Some findings not statistically different and differences in VAS scores between groups less than 1.0. Mixed statistically significant, but positive short-term effect of ESWT, some statistically significant effects of questionable clinical significance.	that electromagnetically generated, high-energy shock waves administered with ultrasound guidance during a single therapeutic session can safely produce clinical improvement by 3 months post treatment.”	improvement at 3 months post single treatment. No long-term results available for control group.
Cosentino 2001 RCT	6.0	N = 60 talalgia associated with heel spur with symptoms >6 months, failure of other non-surgical treatments in past 6 months (non-specific); 3-month follow-up period	ESWT vs. sham. Active treatment 1200 impulses x 6 weekly treatments of 0.03-0.4 mJ/mm <sup>2</sup> . Energy directed to enthesophytosis with ultrasound. No local used. Energy flux not clearly specified, may have been between 36 and 480 mJ/mm <sup>2</sup> . Low to medium energy flux.	No numerical statistics provided. ESWT significant decrease of VAS at rest, walking, after awakening and normal activity (p <0.0001) at treatment end, at 1, 3 months. Control (Group 2) no significant decrease of VAS (p = 0.47) at these points. Enthesitis statistically significantly reduced in grade in intervention and	“Our results confirm the presence and size of bony spurs do not correlate with clinical symptoms and that ESWT can, in our opinion, be considered the best treatment for painful heel with heel spurs, owing to its lack of side effects and because it is repeatable and non-invasive	Randomization, allocation, baseline characteristics not well described. Blinding uncertain. No anesthesia used. Intervention group received variable levels of energy (0.03-0.4mJ/mm <sup>3</sup> ). Suggests ESWT more effective than placebo in pain scores after

				compared to control group. No significant reduction in enthesophytosis size vs. control on x-ray.	treatment without anesthesia.”	treatment, lasting 3 months in patients with chronic plantar heel pain although study weaknesses reduce strength of conclusion.
Mehra 2003 RCT	6.0	N = 47 (23 plantar fasciitis, 24 tennis elbow); mean duration of symptoms 11 months; failure treatments : topical NSAIDs, steroid injection and/or surgery; 3 and 6 month follow-up	ESWT vs. sham. Active treatment – 2000 shocks of 2.5 bars of air pressure x 3 treatments at 2 week intervals. Local injection used. No guidance method reported.	Plantar fasciitis: mean pain score (13 patients ESWT) reduced from 5.9 to 1.9 at 6 months vs. 7.0 to 6.6 in control (no p-value provided); 12 patients (93%) showed significant improvement, 1 patient remained unchanged in treatment group. No improvement noted in control group.	“The mobile lithotripter is an effective form of treatment for tennis elbow and plantar fasciitis but warrants further larger studies.”	Small sample size in PF treatment arm. Study details sparse. No anesthesia used. Data suggest ESWT is effective.
Ogden 2004 RCT	5.5	N = 384 plantar fasciitis (symptom duration not described) ; failure of 2 physical methods or pharmacologic treatments ; 12-month follow-up	ESWT vs. sham. Active treatment of 1500 shocks of variable energy (1400 at 0.22 mJ/mm <sup>2</sup> ) in single session (total 324.25 J). Local block used. Guidance by point of maximal tenderness; 324 mJ/mm <sup>2</sup> ; low energy flux.	ESWT vs. sham: completely successful treatment 3 months after treatment, 67/144 (47%) vs. 42/141 (30%) (p = 0.008). 1 year; 65/67 ESWT maintained successful result. 36/51 (71%) of non-randomized patients had a successful result.	“The application of electrohydraulic high-energy shock waves to the heel is a safe and effective noninvasive method to treat chronic plantar fasciitis, lasting up to and beyond one year.”	FDA clinical trial. Multiple arms (randomized and non-randomized patients) combined in multiple analyses. Study similar to and may be same population as Ogden 2001. “Ankle-block” anesthesia used. Data suggest benefit of ESWT.
Rompe 1996 RCT	5.5	N = 36 with persistent symptoms	ESWT vs. sham. Active treatment – 1000 shocks of 0.06 mJ/mm <sup>2</sup> x	ESWT vs. sham (3, 6 weeks): Night pain % reduction from	“We found a significant decrease of pain and an increase	Small sample size. Randomization, allocation,

		of painful heel. Calcaneal spur, symptoms >12 months, unsuccessful conservative therapy (not specified)	3 treatments at weekly intervals. No local used. Treatment guided by fluoroscopy; 60 mJ/mm <sup>2</sup> ; low energy flux.	baseline; 58.2% vs. 13.6 %, 57.4% vs. 8.1% (p <0.05). Resting pain % reduction from baseline: 75% vs. 36.6% (p <0.05), 79.6% vs.33.8% (p <0.01). Walking ability rated 1 to 5. Increase of 171.4% in Group I after 6 weeks of 178.6%; after 12 weeks 200%; after 24 weeks 185.7%. Sham: 0% (p <0.0001) and 4.8% (p <0.0005) at 3, 6 weeks.	of walking ability compared with a control group. After cross-over had been finished, all but 9 patients had improved -6 had become pain free - after ESWT, but, just as after surgery, the average time to maximum improvement was 6 months.”	baseline comparisons details sparse. No anesthesia was used. Data suggest low energy ESWT appears effective for chronic painful heel.
Ogden 2001 RCT	5.0	N = 302 with MSDs (260 random, 42 non-random) symptoms 6 months to 18 years; failed at least 3 conservative treatments ; 1-year follow up	ESWT vs. sham. Active treatment of 1500 shocks of 18kV power in single session (repeat allowed in some cases). Local block used. Guidance by point of maximal tenderness.	ESWT vs. placebo (0, 12 weeks) VAS: 7.68 vs. 7.87, 3.13 vs. 4.37; Pain Self-assessment: 8.02 vs. 8.14, 3.48 vs. 4.20; Activity self-assessment: 3.49 vs.3.53, 1.72 vs. 1.88. No p-values provided between groups. Author states number of patients improved in all categories was significantly higher than placebo.	“The results suggest that this therapeutic modality should be considered before any surgical options, and even may be preferable to cortisone injection, which has a recognized risk of rupture of the plantar fascia and recurrence of symptoms.”	Study is similar (may be same population as Ogden 2004). Randomization, allocation unclear. Lack of details for compliance, co-interventions; 42 non-randomized patients included for training. Unclear if results are clinically significant but suggest modest clinical global improvement after ESWT.
<b>rESWT vs. Sham</b>						

Gerdesmeyer 2008  RCT	8.5	N = 254 chronic plantar fasciitis with symptoms >6 months, failed 2 pharmaceutical and 2 non-pharmaceutical treatments ; VAS >5 (0-10 scale); follow-up at 3 and 12 months	Radial ESWT (rESWT) vs. sham. Active treatment of 2000 impulses x 3 sessions 2 weeks apart of 0.16 mJ/mm <sup>2</sup> . Energy applied without anesthesia to the spot of greatest tenderness; 320 mJ/mm <sup>2</sup> ; low energy flux.	rESWT vs. placebo (VAS) % change from baseline: 12 weeks; -72.1 vs. -44.7, p = 0.0220, 12 months; -84.8 vs. -43.2, p = 0.0086; overall success heal pain (VAS), (n): 12 weeks ESWT (75) vs. placebo (49), p = 0.0020, 12 months ESWT (78) vs. placebo (51), p = 0.0014. Changes baseline to 12 weeks: SF-36 (%) -44.1 (-37.2±48.42) vs. -23.9 (-19.5±52.13), p = 0.0013; Roles & Maudsley Score excellent or good % - 58.40 vs. 41.5, p = 0.0031; patient global judgment (very satisfied or moderately satisfied) % - 63.16 vs. 46.36, p = 0.0045.	“Radial ESWT demonstrated safety and effectiveness. Radial ESWT can be strongly recommended for patients with therapy-resistant plantar painful heel syndrome.”	No anesthesia used. Study performed by manufacturer for FDA approval of radial ESWT device. Randomization, allocation methods details sparse. Radial ESWT is alternative method of application with expanded energy field as compared to focused energy field of ESWT.
-----------------------------	-----	--	---	---	---	--

**ESWT (Dose, Location, Frequency Studies)**

Rompe 2002  RCT	7.0	N = 112 intractable plantar heel pain with symptoms for 6 to 20 months; failure for at least 6 months of conservative therapy; follow-up 3 and 6 months, 5 years	Three applications of 1000 impulses of low-energy shock waves of 0.08 mJ/mm <sup>2</sup> vs. those of three applications of ten impulses of low-energy shock waves; 80 mJ/mm <sup>2</sup> ; low energy flux.	Scores for subjective variable for Group I vs. Group II: Modified Roles and Maudsley: (Excellent/Good at 6 months) 28/49 vs. 5/48, p<0.0001. Night pain at baseline (N): 31±8 vs. 30±10; p = 0.8681. 6 months: 6±10 vs. 32±9; p <0.0001. After 5 years: 4±8	“In conclusion, the current pilot study revealed dose-related effects of low-energy extracorporeal shock-wave therapy in patients with chronic plantar fasciitis. The therapy with three applications of 1000 impulses appeared to be a useful,	Pilot study. No anesthesia was used. Authors opine the modified Roles and Maudsley scale is not valid for the foot. Data suggest efficacy at 6 month follow-up. Efficacy at 5 years uncertain at 58% of low shock group had undergone surgery.
-----------------------	-----	--	--	---	---	--

				vs. 11±15; p = 0.0015. Resting Pain at baseline: 27±14 vs. 26±14; p = 0.0890. 6 months: 7±10 vs. 25±13; p <0.0001. After 5 years: 4±9 vs. 11±12; p = 0.0033.	noninvasive treatment method with negligible side effects that reduced the necessity for a surgical procedure. Nevertheless, low-energy shock-wave application cannot be recommended as a first-line procedure for chronic heel pain.”	
Dorotka 2006  RCT	6.5	N = 41 with chronic plantar fasciitis (radiologic evidence of heel spur), symptoms >6 months; failed conservative treatment with at least 3 different therapeutic modalities ; follow-up at 6 and 12 weeks	Location of heel spur for ESWT by fluoroscopy vs. patient location for ESWT by maximal point of tenderness; 80 mJ/mm <sup>2</sup> .	Pain at rest (VAS) before ESWT/ 6/ 12 weeks for Group 1 vs. Group 2: 67.0/ 83.8/ 74.6 vs. 67.7/ 104.5/ 119.0. No significant differences noted between Group 1 and 2.	“We found no noticeable differences in the clinical outcome between the groups. However, due to the longer lasting therapy sessions and the burden of additional radiation with fluoroscopy, we recommend patient location as a safe and effective technique for positioning the focus of ESWT in the treatment of plantar fasciitis with a calcaneal spur.”	Both groups showed statistically significant improvement from baseline, although no difference between groups. Treatment protocol 1,000 impulses, lower than many other low energy ESWT studies. Lack of significant difference in localization suggests non-fluoroscopic technique is acceptable, if not preferred.
Tornese 2008  RCT	5.5	N = 51 subjects with history of at least 6 months of heel pain	Group A: perpendicular technique of ESWT vs. Group B: tangential technique of ESWT using 1800 pulses, of which at least 1400 were 0.22	Mayo Clinical Scoring System (mean±SD): initial MCSS Group A (55.2±18.7) vs. Group B (53.5±20), p >0.05; 2 months follow-up MCSS Group A	“No differences in long-term outcome after extracorporeal shock wave therapy were found between the two treatment groups.”	No placebo group for comparison. No anesthesia used. Randomization, allocation details not described. Both groups

			mJ/mm <sup>2</sup> ; ≥308 mJ/mm <sup>2</sup> ; low energy flux.	(83.9±13.7) vs. Group B (80±15.8), p >0.05; 8 months follow-up MCSS - Group A (90±10.5) vs. Group B (90.2±8.7), p >0.05.		improved with no difference between two.
<b>ESWT and Local Anesthesia</b>						
Rompe 2005 RCT	10.0	N = 86 chronic plantar fasciitis, symptoms >6 months; failure of at least 3 conventional therapies for > 6 months (>or = 4weeks of PT and/or heel cord stretching, heel cushions/ orthotic devices, casting/night splints, >or = to 4 weeks course of NSAIDs, at least 2 local steroid injections); follow-up 3 weeks, 3 and 12 months	ESWT without local anesthesia (LA) vs. ESWT with LA. Treatment of 2,000 pulses at 0.09 mJ/mm <sup>2</sup> administered after localization of most-tender point in non-LA group. Anesthesia group received 2,000 pulses at 0.09 mJ/mm <sup>2</sup> ; 0 mJ/mm <sup>2</sup> ; low energy flux.	Mean changes from baseline at 3 weeks, 3 months, and 12 months Group I vs. Group II: 3 month mean change from baseline (95% CI) for Pain at 1st steps [0-10]: 4.7(4.0-5.4) vs. 2.6 (1.9-2.9). Between-group difference (95% CI): 2.1 (1.3-3.0); p <.001. Subjective rating scale [1-4]: 1.9 (1.6-2.1) vs. 1.2 (0.9-1.4). Between-group difference: 0.7 (0.3-1.1); p<.001. 12-month mean change from baseline (95% CI). Between-group difference (95% CI): Pain at first steps [0-10]: 5.0 (4.3-5.7) vs. 2.6 (1.9-3.3), 2.4 (1.4-3.3); p <.001. Subjective rating scale [1-4]: 1.9 (1.6-2.2) vs. 1.2 (0.9-1.5), 0.7 (0.3-1.1); p <.001.	“We conclude that there is a positive treatment effect of repetitive low-energy ESWT as applied at 3-month follow-up in subjects with chronic plantar fasciitis. This positive treatment effect may be reduced by application of a local anesthetic to the painful area prior to low-energy ESWT.” “[A] local anesthetic should not be used for blinding in randomized-controlled trials evaluating the clinical efficacy of repetitive low-energy ESWT for musculoskeletal disorders.”	Anesthesia group received 4 ml mepivacaine injected in the origin of the plantar fascia. Data suggest efficacy of treatment is reduced with concomitant use of local anesthetic. Lack of sham control limits statement for treatment.
<b>ESWT vs. Other Therapies</b>						
Hammer 2002, 2003	6.5	N = 47 chronic proximal plantar	Three sessions of ESWT (3000 shockwaves/session of 0.2	VAS (Mean±SD) score decreased t = 0 to t = 24 weeks (p <0.01)	“ESWT was able to decrease pain and increase the comfortable	ESWT group showed significant improvement

RCT		fasciitis with symptoms 6 to >12 months unsuccessful treatment of at least 6 months consisting of NSAIDs, heel cup, orthoses and/or shoe modifications, local steroid injections and electrotherapy (iontophoresis with diclofenac); follow-up 6, 12, 24 weeks	mJ/mm <sup>2</sup> ) at weekly intervals vs. in the patients of Group 2 treatment was continued for 12 weeks. Group 2 then were crossed-over to ESWT and followed for 2 years; 600 mJ/mm <sup>2</sup> ; low energy flux.	in both groups without significant difference between groups. VAS score at rest baseline/6/12/24 weeks for Group 1: 34.0±27.1/13.8±26.0/11.8±19.8/12.0 ±25.9. Group 2: 43.1 ±26.9/18.8±29.8/10.2±24.4/5.0±20.4. Everyday life Group 1: 78.2±17.5/28.2±31.4/29.0±31.6/22.6 ±33.6. Group 2: 70.4 ±22.2/37.1±32.8/26.0 ±30.1/11.9±23.5	walking time significantly in patients with previous unsuccessful nonsurgical treatment for proximal plantar fasciitis. Up to 80% of the patients experienced a complete or nearly complete pain relief after a follow-up of six months."	over 24 month study. Control group showed no improvement over 12 weeks prior to crossover, where results became similar to ESWT group (no differences at last follow-up.)
Porter 2005 RCT	6.5	N = 132 proximal plantar fasciopathy with symptoms present for at least 6 weeks; follow-up at 3 and 12 months	ESWT 1000 impulses at 0.08mJ/mm <sup>2</sup> x 3 weekly sessions vs. Intralesional corticosteroid injection. Inclusion criteria symptoms of 6 weeks duration; 80 mJ/mm <sup>2</sup> ; low energy density.	VAS pain scores, values for CSI (1.48; 0-7) significantly lower than ESWT (3.69; 0-8), and controls (3.58; 2-5) at 3 months. At 12 months, VAS scores for CSI (0.84; 0-7) and ESWT (0.84; 0-4) both significantly lower than controls (2.42; 1-4). Tenderness values at 3 months significantly higher for CSI (9.42; 7-11) than both ESWT (6.72; 4-11) and controls (7.63; 6-9); p	"Corticosteroid injection is more efficacious and multiple times more cost-effective than ESWT in the treatment of plantar fasciopathy that has been symptomatic for more than 6 weeks."	In this study both ESWT and CSI were used as first line therapy for acute symptoms. Results are therefore limited as no control for natural history of improvement in this disorder. Effects of CSI are short term.

				<0.05 used throughout. Of 64 heels that received CSI, no infections or cases of rupture of plantar fascia.		
Greve 2009 RCT	4.0	N = 32 plantar fascia >4mm thickness on ultrasound ; symptoms ≥3 months; follow-up immediately after treatment and 3 months	ESWT (3,000 impulses at unspecified energy density for 3 weekly sessions vs. physiotherapy (ultrasound 1.2 W/cm2 twice weekly for 5 weeks plus stretching posterior leg; no energy flux specified.	No differences in two groups in parameters of pain duration after treatment, morning pain, pain with gait, use of analgesics.	“The two evaluated treatments were effective for reducing pain and incapacitation among patients with plantar fasciitis for at least three months after treatment.”	Duration of disorder at study entry not specified. No control group. Lack of study details. Study suggests no difference in interventions of ESWT and physiotherapy.
Wang 2006 Quasi-RCT	4.0	N = 149 (168 heels) with chronic plantar fasciitis with symptoms for 6-38 months; follow-up 60-72 months treatment group, 34-64 months control group	ESWT (1500 impulses at 0.32 mJ/mm2 x single treatment) vs. conservative modalities. Outcomes measures reported at 3 to 6 years; 480 mJ/mm <sup>2</sup> ; medium energy flux.	Nearly 25% of ESWT group required second treatment. ESWT vs. Control: Final VAS 0.2 vs. 4.2, p <0.001. Mean function score (out of 30) - 29.6 (18-30) vs. 14.0 (10-17) p <0.001.	“ESWT is a new therapeutic modality that can safely and effectively treat patients with plantar fasciitis, with good long term results.”	Quasi-randomization using odd/even medical chart number. Conservative management group included multiple modalities including NSAIDs, orthotics, PT, stretching, cortisone injection.

## IONTOPHORESIS

Iontophoresis with topical steroids and acetic acid have been used in musculoskeletal disorders, including plantar fasciitis.(267) (Gudeman 97)

*Recommendation: Iontophoresis with Glucocorticosteroid or Acetic Acid for Acute, Subacute, or Chronic Plantar Fasciitis*

**There is no recommendation for or against the use of iontophoresis with glucocorticosteroid or acetic acid for treatment of select patients with acute, subacute, or chronic plantar fasciitis.**

*Strength of Evidence – No Recommendation, Insufficient Evidence (I)*

*Rationale for Recommendation*

There are two moderate-quality placebo-controlled trials for iontophoresis using dexamethasone that provide conflicting results. A study of 40 heels comparing 0.4% dexamethasone with saline and combined with the co-interventions of stretching, exercises, ice, and orthoses demonstrated subjects that received 6 treatments over a 2-week period improved in function and pain scores at treatment end, but differences disappeared at 1-month post-treatment follow-up.(267) (Gudeman 97) Another study comparing dexamethasone to acetic acid and placebo with the co-intervention of Low-Dye taping demonstrated placebo to be more effective than dexamethasone in improving morning pain and worst pain in past 2 days at treatment end, but loss of effect at 4 weeks.(188) (Osborne 06) There was no difference between acetic acid and placebo in pain relief, although the acetic acid group demonstrated improved morning stiffness scores over placebo at 4 weeks. Thus, evidence for efficacy of iontophoresis with glucocorticoid or acetic acid is inconclusive, and at best appears to reflect modest short-term benefit. A treatment series of iontophoresis is non-invasive, has low adverse effect profile, but is of moderate cost. Treatment effects are short-lived after 2-week course. Therefore, no recommendation is made for or against its routine use.

*Evidence for the Use of Iontophoresis for Plantar Fasciitis*

There are 2 moderate-quality RCTs incorporated into this analysis.

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Osborne 2006 RCT	7.5	N = 31 medial calcaneal origin plantar fasciitis	0.4% dexamethasone vs. placebo (0.9% NaCl) vs. or 5% acetic acid. All groups with LowDye taping. 6 treatments over 2-week period. Final outcome at 2-weeks post treatment.	Numerical statistics not provided. Placebo/taping and acetic acid/taping groups significantly better than dexamethasone/taping for morning pain relief and reduction of worst pain in past 2 days at end of treatment. At 2 weeks post-treatment, no difference between groups in pain ratings, although placebo/taping lost all gains from baseline. No difference in functional improvement between dexamethasone/taping and acetic acid/taping at 4 weeks, but significant difference between AA/Taping and placebo/taping (p = 0.031).	“Six treatments of acetic acid iontophoresis combined with taping gave greater relief from stiffness symptoms than, and equivalent relief from pain symptoms to, treatment with dexamethasone/taping. For the best clinical results at four weeks, taping combined with acetic acid is the preferred treatment option compared with taping combined with dexamethasone or saline iontophoresis.”	Co-intervention of stretching (gastrocnemius/ soleus). Small sample size with questionable baseline differences in duration of disease. Data results are of unknown clinical significance.
Gudeman 1997	6.0	N = 40 feet with	Group I: feet treated with	Group II had significantly greater improvement between pre-treatment	“Based on these results, iontophoresis of	Randomization and allocation

RCT		plantar fasciitis	traditional modalities and placebo iontophoresis. Group II: feet received traditional modalities plus iontophoresis with dexamethasone.	and immediate post treatment than Group I; increase of 6.8±5.6 for Group II and 3.0±4.1 for Group I. At 1-month follow-up, no significant difference between groups. Difference in increase (control vs. treatment groups) between pre- and post testing statistically significant (p = 0.022), but difference in increase between pre- and follow-up testing not significant (p = 0.434).	dexamethasone for plantar fasciitis should be considered when more immediate results are needed.”	unclear. Possible baseline difference in outcome measure. Baseline pain scores were mostly of mild severity.
-----	--	-------------------	---	--	---	--

### LOW-LEVEL LASER THERAPY

Low-level laser treatment (LLLT) usually involves laser energy that does not induce significant heating and has been used for treatment of many musculoskeletal disorders.

*Recommendation: Low-level Laser Therapy for Acute, Subacute, or Chronic Plantar Fasciitis*

**There is no recommendation for or against the use of low-level laser therapy for treatment of acute, subacute, or chronic plantar fasciitis.**

*Strength of Evidence – No Recommendation, Insufficient Evidence (I)*  
*Level of Confidence – Low*

#### *Rationale for Recommendation*

There are two moderate-quality studies providing conflicting results for the use of LLLT. A placebo-controlled trial suggested benefits for night pain and daily activity pain, although both groups improved significantly over the 6-week trial period.(268) (Kiritsi 10) The study had several weaknesses that limit conclusions. Another placebo controlled trial demonstrated no differences during or after 12 treatments of LLLT compared to the sham group in 32 patients.(269) (Basford 98) LLLT is not invasive, has low adverse effects, but is high cost, and demonstration of efficacy is conflicting. Further quality studies are needed; therefore no recommendation is made for its use to treat acute, subacute, or chronic plantar fasciitis or heel pain.

#### *Evidence for the Use of Low-level Laser Therapy for Plantar Fasciitis*

There are 2 moderate-quality RCTs incorporated into this analysis.

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Kiritsi 2010 RCT	7.0	N = 30 unilateral plantar fasciitis	904 nm gallium-arsenide (GaAs) laser vs. sham laser, 18 sessions (3 x a week for 6 weeks).	LLLT vs. sham: VAS night rest- 48±9.4 to 21±24.3 vs. 49±9.4 to 38±10.3 p = 0.000 favoring LLLT change; VAS Daily Activities - 67±8.3 to	“We believe that 904 GaAs infrared (IR) laser therapy may contribute to plantar fasciitis healing and pain reduction. At this point, we should	Small sample size with 1/3 of control group withdrawing related to non-treatment reasons. Duration of baseline symptoms unknown, although inclusion

				28±24.4 vs. 67±9.3 to 50±15.9, p = 0.001 favoring LLLT.	state that LLLT warrants further study as a treatment for plantar fasciitis.”	criteria were 6 weeks or longer. No comparison of symptom duration between groups provided. Conclusions therefore limited.
Basford 1998  RCT	6.5	N = 32 plantar fasciitis >1 month duration	30mW .83µm gallium aluminum arsenide (GaAlAs) laser vs. placebo.	No significant differences over study period between groups in terms of pain severity in morning, duration of painful walking on rising, exam, or medication, orthotic use.	“Low-intensity IR laser therapy appears safe but, at least within the parameters of this study, is not beneficial in the treatment of plantar fasciitis.”	Randomization, allocation not described. Possible co-interventions of NSAIDs, orthoses. Data suggest lack of efficacy.

## MANIPULATION

Manipulative therapy is described as an intervention for plantar fasciitis and post-fasciotomy pain.(270-273) (Brantingham 09, Cleland 09, Wyatt 06, Dimou 04)

*Recommendation: Manipulation for Acute, Subacute, Chronic, or Post-operative Plantar Heel Pain*

**There is no recommendation for or against the use of manipulation for treatment of acute, subacute, chronic, or post-operative plantar heel pain.**

*Strength of Evidence – No Recommendation, Insufficient Evidence (I)*

*Level of Confidence – Low*

### *Rationale for Recommendation*

There are no quality trials comparing manipulation to natural history. There is one moderate-quality trial for the use of manipulation techniques compared to orthotics in the treatment of plantar heel pain; however, the study has a small sample size and methodological weaknesses, and was inconclusive.(273) (Dimou 04) A moderate-quality trial comparing mobilization and manipulation with electrical therapies demonstrated modest improvement in functional disability questionnaire scores, but the degree to which each person received manipulation is unclear, and the techniques used were not described, thus making conclusions regarding benefit of manipulation impossible.(271) (Cleland 09) Manipulation is not invasive, is moderately costly, but may have adverse effects, including migration of pain.(272) (Wyatt 06) There is no recommendation for or against manipulation of the ankle and foot joints as there is insufficient quality evidence.

### *Evidence for the Use of Manipulation for Plantar Heel Pain*

There are 2 moderate-quality RCTs incorporated into this analysis.

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
------------------------	--------------	-------------	------------------	---------	------------	----------

Cleland 2009 RCT	5.0	N = 60 age 18 to 60 with chronic plantar heel pain	Manual physical therapy soft tissue mobilization, joint mobilization, manipulation) and ankle eversion exercises (MTEX) (n = 30) vs. electrophysical agents (iontophoresis with dexamethasone, ultrasound, and stretching/strengthening (EPAX) (n = 30); therapies 2 times week for 2 weeks, then once a week for 2 weeks.	EPAX vs. MTEX: 4, 26 weeks; Improvement in Lower Extremity Function Scale (LEFS- 0-80, higher is better): 7.5 vs. 21.0; p = 0.001; 12.9 vs. 22.8, p = 0.027. Improvement on Pain Scale from baseline (0-10) -1.4 vs. -2.9, p = 0.08; -2.8 vs. -3.4, p = 0.39.	“The results of this study provide evidence that MTEX is a superior management approach over an EPAX approach in the management of individuals with plantar heel pain at both the short- and long-term follow-ups. Future studies should examine the contribution of the different components of the exercise and manual physical therapy programs.”	Multiple co-interventions used and lack of details for compliance to exercise/stretching regimens. Significance levels set by minimal clinically important difference for disability scores (9 points on scale). Study suggests both groups improved, but mobilization group demonstrated better disability scores. Actual clinical significance uncertain. Baseline pain scores moderate, and although change in score (improvement) significant at 6 weeks; clinical significance of VAS score of 3 vs. 2 is small.
Dimou 2004 RCT	4.5	N = 20 chronic plantar fasciitis	Manipulation (chiropractic adjustments twice weekly x 4 weeks) plus Achilles stretching (3 sessions daily) vs. orthotics.	Intergroup comparisons: Pain: no differences at Day 1, 1 or 2 months. Heel pain (leisure, work, sports); no differences at any interval.	“With the small sample size and methodological limitations of this trial, no firm conclusions can be drawn...[B]oth treatments appeared useful when used individually.”	Lack of study details. Range of symptom duration was wide (8 weeks to 5 years). Small sample size with low power. Results inconclusive.

## MASSAGE AND SOFT TISSUE MOBILIZATION

Deep tissue massage and soft tissue mobilization are common physiotherapy interventions for plantar fasciitis.

*Recommendation: Massage and Soft Tissue Mobilization for Acute, Subacute, Chronic, or Post-operative Plantar Fasciitis*

**There is no recommendation for or against the use of massage and tendon mobilization for treatment of acute, subacute, chronic, or post-operative plantar fasciitis.**

*Strength of Evidence – No Recommendation, Insufficient Evidence (I)  
Level of Confidence – Low*

### Rationale for Recommendation

There are no quality trials comparing the use of manual therapy with no treatment. A moderate-quality trial comparing soft tissue mobilization, cryotherapy, and gastrocnemius stretching exercises to iontophoresis and ultrasound with exercises demonstrated manual physical therapy to be of greater benefit as measured by functional disability scores than electrical physiotherapy technique.(271) (Cleland 09) However, the magnitude of differences demonstrated was small, and are of uncertain clinical significance. It is possible for patients to self-administer these treatments, although there are no quality studies of self-administration. Massage and soft tissue mobilization are not invasive, have minimal adverse effects, and depending on numbers of treatments are low to moderate cost. As there are other interventions with documented efficacy, there is no recommendation for or against use of these treatments for plantar fasciitis.

### Evidence for the Use of Massage and Soft Tissue Mobilization for Plantar Fasciitis

There is 1 moderate-quality RCT incorporated into this analysis.

Author/Y ear Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Cleland 2009  RCT	5.0	N = 60 age 18 to 60 with chronic plantar heel pain	Manual physical therapy soft tissue mobilization, joint mobilization, manipulation) and ankle eversion exercises (MTEX) (n = 30) vs. electro-physical agents (iontophoresis with dexamethasone , ultrasound, and stretching and strengthening (EPAX) (n = 30); therapies 2 times week for 2 weeks, then once a week for 2 weeks.	EPAX vs. MTEX: 4, 26 weeks; Improvement in Lower Extremity Function Scale (LEFS- 0-80, higher is better): 7.5 vs. 21.0; p = 0.001; 12.9 vs. 22.8, p = 0.027. Improvement on Pain Scale from baseline (0-10) -1.4 vs. -2.9, p = 0.08; -2.8 vs. -3.4, p = 0.39.	“The results of this study provide evidence that MTEX is a superior management approach over an EPAX approach in the management of individuals with plantar heel pain at both the short- and long-term follow-ups. Future studies should examine the contribution of the different components of the exercise and manual physical therapy programs.”	Lack of details for compliance to exercise/stretching regimens and control for co-interventions. Significance levels set by minimal clinically important difference for disability scores (9 points on scale). Data suggest both groups improved, but mobilization group demonstrated better disability scores. Actual clinical significance uncertain. Baseline pain scores moderate, and although change in score (improvement) significant at 6 weeks; clinical significance of VAS score of 3 vs. 2 is small.

### PHONOPHORESIS

Phonophoresis is commonly used in the treatment of musculoskeletal disorders.

*Recommendation: Phonophoresis for Acute, Subacute, Chronic, or Post-operative Plantar Heel Pain*  
**There is no recommendation for or against the use of phonophoresis for treatment of acute, subacute, chronic, or post-operative plantar heel pain.**

*Strength of Evidence – No Recommendation, Insufficient Evidence (I)*  
*Level of Confidence – Low*

*Rationale for Recommendation*

There is no quality evidence evaluating phonophoresis for treatment of patients with chronic plantar heel pain. Phonophoresis is non-invasive, has few adverse effects, and is moderately expensive. There is no recommendation for or against its use for plantar heel pain pending publication of quality trials.

*Evidence for the Use of Phonophoresis for Plantar Heel Pain*

There are no quality trials incorporated into this analysis.

**ULTRASOUND**

Therapeutic ultrasound is used in the treatment of musculoskeletal disorders.

*Recommendation: Therapeutic Ultrasound for Acute, Subacute, Chronic, or Post-operative Plantar Fasciitis*

**Therapeutic ultrasound is not recommended for treatment of acute, subacute, chronic, or post-operative plantar fasciitis.**

*Strength of Evidence – Not Recommended, Evidence (C)*  
*Level of Confidence – Low*

*Rationale for Recommendation*

There is one moderate-quality trial that suggested no difference between therapeutic ultrasound and sham ultrasound after 8 treatments.(274) (Crawford 96) Ultrasound was also used in a treatment arm with iontophoresis, cryotherapy, and stretching and was found to be less beneficial than manual physical therapy.(271) (Cleland 09) Ultrasound is non-invasive, has low adverse effects, is moderate cost depending on numbers of treatments, but has low treatment efficacy and is therefore not recommended.

*Evidence for the Use of Therapeutic Ultrasound for Plantar Fasciitis*

There are 2 moderate-quality RCT incorporated into this analysis.

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Crawford 1996  RCT	6.0	N = 19 with plantar heel pain (26 heels)	Ultrasound vs. placebo (0.5 w/cm <sup>2</sup> , 3 MHz, pulsed for 8 minutes); 8 treatments.	VAS ESWT vs. placebo: 6.7 vs. 7.5, 4.5 vs. 5.6 p >0.05	“Therapeutic ultrasound (at dosage described) is no more effective than placebo in the treatment of plantar heel pain.”	Randomization, allocation methods unclear. Study details sparse. Treatment for 4 weeks. Data suggest no benefit from ultrasound at stated dosage.
Cleland 2009  RCT	5.0	N = 60 age 18 to 60 with chronic	Manual physical therapy soft tissue mobilization, joint	EPAX vs. MTEX: 4, 26 weeks; Improvement in Lower Extremity	“The results of this study provide evidence that MTEX is a superior management	Lack of details for compliance to exercise/stretching regimens and control for co-interventions. Significance levels set

		plantar heel pain	mobilization, manipulation) and ankle eversion exercises (MTEX) (n = 30) vs. electro-physical agents (iontophoresis with dexamethasone, ultrasound, and stretching and strengthening (EPAX) (n = 30); therapies twice a week for 2 weeks, then once a week for 2 weeks.	Function Scale (LEFS-0-80, higher is better): 7.5 vs. 21.0; p = 0.001; 12.9 vs. 22.8, p = 0.027. Improvement on Pain Scale from baseline (0-10) -1.4 vs. -2.9, p = 0.08; -2.8 vs. -3.4, p = 0.39.	approach over an EPAX approach in the management of individuals with plantar heel pain at both the short- and long-term follow-ups. Future studies should examine the contribution of the different components of the exercise and manual physical therapy programs.”	by minimal clinically important difference for disability scores (9 points on scale). Data suggest both groups improved, but mobilization group demonstrated better disability scores. Actual clinical significance uncertain. Baseline pain scores moderate, and although change in score (improvement) significant at 6 weeks; clinical significance of VAS score of 3 vs. 2 is small.
--	--	-------------------	---	---	---	--

## RADIOTHERAPY

Radiation therapy is utilized for the treatment of plantar fasciitis. The mechanism for effect is unknown, although an anti-inflammatory effect is proposed.(275) (Miszczyk 07)

*Recommendation: Low-dose Radiation (Radiotherapy) for Chronic Plantar Heel Pain*

**There is no recommendation for or against the use of radiation therapy for treatment of chronic plantar heel pain.**

*Strength of Evidence – No Recommendation, Insufficient Evidence (I)*

*Level of Confidence – Low*

### *Rationale for Recommendation*

There are no quality placebo-controlled trials for radiation therapy. There is one moderate-quality trial comparing total radiation dose of 3.0 Gy vs. 6.0 Gy, which found no difference between the two groups.(276) (Heyd 07) The authors reported 87.7% of patients in both groups with improvement at 6 months, although nearly half had symptoms less than 6 months duration. A placebo-controlled protocol has been published with results pending until 2012 or later.(277) (Niewald 08) A prospective case series reported 77% success rates in 137 feet at 3 weeks and 24 months in patients with chronic plantar heel pain.(278) (Cavazos 09) Radiation therapy is non-invasive, has a potential adverse effect risk profile from radiation, and is moderately costly. Although potentially promising, further studies are needed, thus there is no recommendation for or against its use for treatment of chronic plantar heel pain.

### *Evidence for the Use of Radiation Therapy for Plantar Heel Pain*

There is 1 moderate-quality RCT incorporated into this analysis.

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
---------------------------	-----------------	----------------	---------------------	---------	------------	----------

Heyd 2007 RCT	5.0	N = 130 with painful heel spurs	Total dose of 3.0 Gy given in 2 weekly fractions of 0.5 Gy (low dose [LD] group) vs. total dose of 6.0 Gy using 2 weekly fractions of 1.0 Gy (high dose [HD] group).	No statistically significant difference between both study groups	“Our prospective study demonstrated an equivalent efficacy of both fractionation schedules. More clinical and experimental trials are needed for evaluation of the minimum effective dose and optimization of the dose-fractionation schedules in anti-inflammatory RT.”	Allocation method unclear. No control for co-interventions noted. No placebo group.
------------------	-----	---------------------------------	--	---	--	---

**Injection Therapies**

**AUTOLOGOUS BLOOD INJECTIONS**

Autologous blood injection into plantar fascia has been described.(279-281) (Kalaci 09, Lee 07, Kiter 06)

*Recommendation: Autologous Blood Injection for Acute, Subacute, or Chronic Plantar Fasciitis*

**Autologous blood injection is not recommended for treatment of acute, subacute, or chronic plantar fasciitis.**

*Strength of Evidence – Not Recommended, Evidence (C)*

*Level of Confidence – Low*

*Rationale for Recommendation*

There are no quality trials comparing autologous blood injection to placebo. Three moderate-quality studies compare autologous blood injection to corticosteroid injection. Two of these studies found autologous blood injection to be less effective than steroid injection(279, 280) (Kalaci 09, Lee 07) while one demonstrated equal efficacy.(281) (Kiter 06) Two of these studies also compared the peppering technique with autologous blood and found no differences between the two treatments.(279, 281) (Kalaci 09, Kiter 06) Adverse effects of autologous blood injection include post-injection pain (53%) lasting up to 10 days and may require analgesia. These injections are moderate cost related to procedure charges of venipuncture and injection. Autologous blood is demonstrated to be less effective than steroid injection, and is of unknown efficacy compared with placebo. Thus, autologous blood injection is not recommended.

*Evidence for the Use of Autologous Blood Injections for Plantar Fasciitis*

There are 3 moderate-quality RCTs incorporated into this analysis.

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
<b>Injection Therapies – Autologous Blood vs. Glucocorticosteroid</b>						
Lee 2007 RCT	5.5	N = 64 with chronic plantar	Autologous blood 1.5mL vs. 20mg triamcinolone acetoneide.	Mean VAS score at 0, 6 weeks, 3 months, 6 months for blood vs. steroid: 7.3±1.8 vs. 6.9±1.7 p = .3; 4.6±2.3 vs. 2.9±2.8 p = 0.011; 4.3±2.7 vs. 2.3±2.6 p = 0.005, 3.6±2.6 vs.	“Intralesional autologous blood injection is efficacious in lowering pain and tenderness in chronic plantar fasciitis,	No placebo. Lack of blinding. Many co-interventions (rest, NSAIDs, stretching, repeat

		fasciitis		2.4±3.0 p = 0.094. Mean tenderness threshold scores at 0, 6 weeks, 3 months, 6 months for blood vs. steroid: 3.1±1.2 vs. 3.7±2.9 p = 0.167; 4.1±1.8 vs. 6.4±3.5 p = 0.003; 5.5±2.7 vs. 7.9±3.2 p = 0.003; 6.5±2.9 vs. 8.6±3.1 p = 0.008. Over 6-month follow-up, significant reduction in pain levels noted in both groups (p < 0.0001).	but corticosteroid is more superior in terms of speed and probably extent of improvement.”	injections). Data suggest steroids more effective in short term for pain relief.
Kalaci 2009 RCT	5.5	N = 100 with plantar fasciitis	Group A: 2mL autologous blood only vs. Group B: anesthetic (2mL lidocaine) combined with peppering vs. Group C: corticosteroid (2mL triamcinolone) only vs. Group D: corticosteroid (2mL triamcinolone) combined with peppering.	Pain in affected heel on a 10 -cm VAS at 6 months (mean ± SD): Group A (3.53±3.06) vs. Group B (3.40±2.88) vs. Group C (1.52±2.14) vs. Group D (0.96±1.24). All improved from baseline (p = 0.000), C+D more effective than A+B (p <0.05). No difference between C+D. Modified roles/Maudsley score at 6 months: Group C, excellent and good 20/25; Group D, excellent and good 22/25, p = 0.24.	“[C]orticosteroid injection with peppering can be used as a first alternative in plantar fasciitis in cases in which other conservative methods failed.”	Data suggest steroids equally effective with and without peppering from presented data. No placebo arm.
Kiter 2006 RCT	5.5	N = 45 with plantar heel pain	Peppering (10-15 injections with local) vs. autologous blood (2mL) vs. methylprednisolone acetate 40mg injection (all allowed up to 3 injections at monthly interval) followed for 6 months.	Peppering vs. autologous blood vs. steroid VAS (0-10): baseline 6.4±1.1 vs. 7.6 ±1.3 vs. 7.28±1.2. VAS: 6 months 2.2±2.2, 2.4±1.8, 2.57±2.9. All intragroup changes p <0.001, intergroup not significant.	“[P]eppering technique and autologous blood injection seem to be good alternatives to corticosteroid injection for the treatment of plantar heel pain, although the mechanism of cure is not completely understood.”	Small sample size for each arm. Randomization by drawing lots. Author states demonstrated improvement in all groups, and therefore equal efficacy of treatment, but no placebo, limiting conclusions.

## BOTULINUM TOXIN A INJECTION

Botulinum Toxin A injection into plantar fascia has been described.(282-284) (Jabbari 08, Placzek 06, Babcock 05; Diaz-Llopis 13) The mechanism of therapeutic effect is unknown, but is thought to have antinociceptive properties and produce relative rest through muscle paresis.(285-288) (Gobel 06, Qerama 06, Richards 07, Ferrante 05) These injections have primarily been used for non-occupational conditions such as cervical dystonia,(289) (Lew 97) strabismus, blepharospasm,(290) (Charles 04) severe primary axillary hyperhidrosis, plantar hyperhidrosis,(291, 292) (Vadoud-Seyed 04; Sevim 02) and spasticity due to cerebral palsy.(293-298) (Graham 08; Galli 07; Rousseaux 07, 08; Burbaud 96; Baricich 08)

1. *Recommendation: Botulinum Toxin A Injection for Select Chronic Plantar Fasciitis*

**Botulinum Toxin A injection is recommended as a treatment for select chronic plantar fasciitis.**

*Indications* – Chronic plantar pain (>6 months) and failure of multiple courses of NSAIDs, stretching exercises, and at least two steroid injections.

*Frequency/Duration* – One injection of 70 units in 2 divided doses; 40 units injected into tender region of heel medial to base of plantar fascia insertion, 30 units in most tender point of arch.(283) (Babcock 05) Alternatively, 1 injection of 50 units into plantar fascia under ultrasound guidance.(299) (Huang 10) The efficacy of repeat injections has not been studied in controlled trials.(283) (Babcock 05)

*Strength of Evidence* – **Recommended, Evidence (C)**

*Level of Confidence* – Low

2. *Recommendation: Botulinum Toxin A Injection for Acute or Subacute Plantar Fasciitis*

**Botulinum Toxin A injection is not recommended for acute or subacute plantar fasciitis.**

*Strength of Evidence* – **Not Recommended, Insufficient Evidence (I)**

*Level of Confidence* – Low

*Rationale for Recommendations*

There are four moderate-quality placebo controlled trials. (283) (Babcock 05; Huang 10; Elizondo-Rodriguez 13; Peterlein 12) A trial conducted in military personnel demonstrated significant pain relief and improved functional scores from a single injection of Botulinum Toxin A (BTX-A) versus saline into the plantar fascia up to 8 weeks post-injection.(283) (Babcock 05) This group was highly mobile (military transfers), and therefore long-term effects were not studied. The study was stopped at the interim analysis due to high therapeutic efficacy found with BTX-A in the short term, which means long-term benefit and harm was not assessed. Another trial demonstrated efficacy over saline after injection of Botulinum Toxin A into the plantar fascia thickening under ultrasound guidance.(299) (Huang 10) Fatalities have been reported from use of Botulinum Toxin A,(300) (Li 05) thus use only with extreme caution. The agent induces muscle weakness and there is concern regarding long-term safety, especially with repeated dosing. Injection of BTX-A is high cost, and has not been studied in acute or subacute populations. It is recommended in highly select patients who have chronic plantar fasciitis and have failed multiple other treatments that have lower adverse effect profiles or are lower cost.

*Evidence for the Use of Botulinum Toxin A Injections for Plantar Fasciitis*

There are 4 moderate-quality RCTs incorporated into this analysis. (Babcock 05; Peterlein 12; Huang 10; Elizondo-Rodriguez 13)

Author/Year or Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
<b>Injection Therapies – Botulinum Toxin A vs. Placebo</b>						

<p>Babcock 2005</p> <p>RCT</p>	<p>6.5</p>	<p>N = 27 (43 feet) with plantar fasciitis</p>	<p>Botulinum toxin A 70 units vs. saline placebo.</p>	<p>Mean P-VAS pain scale score at 0, 3, 8 weeks for BTX-A vs. placebo: 5.1/2.7/1.6 vs. 4.9/4.7/4.4. Mean MFS score: 44/72/81 vs. 46/49/54. Compared with placebo injections, Botulinum toxin A group improved in all measures: Pain VAS (p &lt;0.005), Maryland Foot Score (p = 0.001), Pain relief VAS (p &lt;0.0005), pressure algometry response (p = 0.003).</p>	<p>“Botulinum toxin A injection for plantar fasciitis yields significant improvements in pain relief and overall foot function at both 3 and 8 weeks after treatment.”</p>	<p>Data suggest Botulinum toxin A is effective for plantar fasciitis, although sample size is low, due to significant difference found at mid-study evaluation and subsequent termination of recruitment.</p>
<p>Peterlein 2012</p> <p>RCT</p> <p>No mention of sponsorship, study medication donated by Ipsen Ltd. No COI, CP and RP are members of the research group botulinum toxin of the German Association of Neurology.</p>	<p>6.5</p>	<p>N = 40 with refractory plantar fasciitis for 4+ months and at least 2 previous conservative treatment fails. Median age 51.5 years.</p>	<p>BoNT-A 200 units in 2 mL 0.9% saline solution (n = 20) vs. saline placebo 2 mL (n = 20). Study duration: 18 weeks. Concomitant treatment prescribed for study was continued. Follow-up at baseline week 2, 6, 10, 14, and 18.</p>	<p>There were no significant differences between groups.</p>	<p>“In our study, we showed that fan-shaped local injections with 200 units of BoNT-A (Dysport) on the origin of the plantar fascia may decrease the 6-week pain score (VAS) and 18-week pain intensity, but this was not statistically significant when compared with the placebo group in patients with refractory plantar fasciitis.”</p>	<p>Multicenter study with relatively small N and meaningful dropout. Data do not support treatment.</p>

Huang 2010  RCT	6.0	N = 50 chronic unilateral plantar fasciitis	Botulinum toxin A 50 units vs. saline placebo under ultrasound guidance.	BTX-A vs. placebo 0, 3 weeks, 3 months. VAS (0-10): 5.9/3.4/2.0 for BTX-A group vs. 5.4/5.1/5.2 for placebo, p <0.001. Plantar fascia thickness (mm): 5.5/4.2/3.6mm for BTX-A vs. 5.5/5.6/5.6mm for placebo, p <0.001.	“[T]reatment of unilateral plantar fasciitis with [BTX-A] led to significant pain relief and a reduction in the plantar fascia thickness 3 weeks and 3 months post-injection.”	No details for allocation, drop-out, co-interventions, and baseline chronicity of condition. Data suggest benefit from botulinum toxin A for chronic plantar pain. Ultrasound guidance vs. injection at point of maximal tenderness not addressed.
Elizondo-Rodriguez 2013  RCT  No sponsorship or COI.	4.5	N = 40 with heel pain at insertion of plantar fascia or in anteromedial tuberosity of calcaneus having failed conservative treatment for 3 months. Mean age: Botox Group 41.6 years; Steroid Group 44.5 years.	Group A: botulinum toxin A 250 U (n = 19) vs. Group B: steroid injection, 2% lidocaine 2mL and 8mg dexamethasone 2mL (n = 17) Both groups received stretching exercises and attended 6 visits. Follow-up at 15 days following treatment and at 1, 2, 4, and 6 months.	Mean±SD VAS initial visit/final visit Group A vs. Group B: 7.1±1.75 vs. 7.7±1.32 (NS)/1.1±1.50 vs. 3.8±1.15 (p = 0.0005). Mean±SD Maryland Foot Ankle Score initial visit/final visit: 62.1±9.84 vs. 60.0±11.87 (NS)/94.4±10.64 vs. 79.2±14.96 (p = 0.0001). Mean±SD Foot and Ankle Disability Index score initial/final: 75.4±6.92 vs. 77.0±3.20 (NS)/95.0±7.27 vs. 83.0±6.41 (p = 0.000004). Mean±SD American Orthopaedic Foot	“[A] combination of BTX-A applications into the gastroc-soleus complex and plantar fascia stretching exercises yielded better results for the treatment of plantar fasciitis than intralesional steroids.”	Data suggest Botox may be superior to steroids for treatment of plantar fasciitis. Results are seen early and persisted through the study period.

				and Ankle Society score initial/final: 46.0±14.83 vs. 46.8± 11.2 (NS)/ 93.2±9.31 vs. 74.8±10.29 (p = 0.00000006).		
--	--	--	--	---	--	--

## GLUCOCORTICOSTEROIDS INJECTIONS

Local glucocorticosteroid injections have been used for treatment of plantar fasciitis.(280) (Lee 07)

### 1. Recommendation: Glucocorticosteroid Injections for Chronic Plantar Fasciitis

**Glucocorticosteroid injections are recommended for short-term relief of chronic plantar fasciitis.**

*Indications* – Moderate or severe plantar fasciitis, failed satisfactory management with NSAIDs, stretching, and other exercise.

*Frequency/Duration* – Quality trials have utilized hydrocortisone 25mg, triamcinolone 20mg, betamethasone 5.7mg, and prednisolone acetate 25mg.(256, 279, 301-303) (Blockey 56; Kalaci 09; Crawford 99; Kriss 03; Porter 05) The tenderest point is generally included in the injection. A 2nd injection may be performed if prior results unsatisfactory, the problem is incapacitating, other options have been exhausted, and the patient understands and accepts that rupture is a possible complication and will likely necessitate surgery.

*Indications for Discontinuation* – Resolution, intolerance, adverse effects, or lack of benefits.

**Strength of Evidence – Recommended, Evidence (C)**

*Level of Confidence* – Moderate

### 2. Recommendation: Glucocorticosteroid Injections for Acute or Subacute Plantar Fasciitis

**Glucocorticosteroid injections are not recommended for treatment of acute or subacute plantar fasciitis.**

**Strength of Evidence – Not Recommended, Insufficient Evidence (I)**

*Level of Confidence* – Moderate

### 3. Recommendation: Guidance of Steroid Injection with Ultrasound or Scintigraphy

**Ultrasound or scintigraphy imaging techniques to guide injection are not recommended as there is no added benefit compared with palpation.(304) (Yucel 09)**

**Strength of Evidence – Not Recommended, Evidence (C)**

*Level of Confidence* – Moderate

### Rationale for Recommendations

There are two moderate-quality placebo-controlled trials of steroid injection for plantar fasciitis.(279, 302) (Kalaci 09, Crawford 99) Kalaci compared injection with autologous blood, peppering with lidocaine, and injection or peppering with triamcinolone (dose in milligrams not specified) in 100 chronic plantar fasciitis patients.(279) (Kalaci 09) Both triamcinolone arms provided significantly better pain relief than autologous blood and peppering with lidocaine. It is unlikely that the use of peppering resulted in a treatment effect. A study of 106 patients with chronic plantar pain of 6 months median duration (range 1 to 120 months) had serious analysis reporting flaws, with four study arms, two of which received corticosteroids, two of which did not; two of which received tibial nerve blocks, two of which did not.(302)

(Crawford 99) The authors claimed their subjects had a modest reduction in pain at 1 month after injection of 25mg prednisolone, but the comparison groups were not clear. At 1 month, the tibial nerve block groups did not do as well as the non-tibial nerve block groups, but the matter was not discussed. There was no difference among the groups at 3 or 6 months, suggesting that benefit of steroid injection or drawback of tibial nerve block may be short term. In contrast, the other study demonstrated no short-term benefit at 3 weeks, but did demonstrate a long-term benefit at 6 months post injection.(279) (Kalaci 09) A comparative trial of 22 heels found no significant differences between placebo and steroid. Heels were divided between placebo and 25mg hydrocortisone injection with no significant differences found at short- and long-term follow-up. This study has potential methodological flaws, including duration of plantar pain at initiation.

Two moderate-quality trials compared steroid injection to other treatments.(256, 303) (Kriss 03, Porter 05) Injection of 20mg triamcinolone into the point of maximal tenderness in 76 heels was compared with soft anti-pronatory pad versus both treatments combined.(303) (Kriss 03) The steroid arms showed significant reduction in pain scores over anti-pronatory pad alone with early onset lasting 4 months. There was no statistical analysis presented between the steroid and steroid-pad groups, but a trend towards better scores in the injection alone group was presented. A trial of betamethasone (5.7mg) injected at the point of maximal tenderness demonstrated improved pain scores and tenderness threshold compared with 3 sessions of low-energy extracorporeal shock wave therapy at 3 months. These differences disappeared at the 12-month follow-up.(256) (Porter 05) One trial compared autologous blood injection with glucocorticosteroid injection and found the steroid injection superior.(280) (Lee 07)

A moderate-quality trial compared the use of ultrasound and scintigraphy guidance injection techniques versus palpation and injection at point of maximal tenderness and found no difference between the groups.(304) (Yucel 09) Thus, there is evidence that steroid injection provides short-term symptom relief lasting 4 to 6 months. Injection should be performed at the point of maximal tenderness by palpation rather than with ultrasound or other guidance techniques. Plantar fascia rupture post injection occurs in up to 10% of patients.(305)(Acevedo 98) However, this is likely high as none of the RCTs cited above reported ruptures among subjects in their corticosteroid arms. Ruptures may have long-term sequelae, including longitudinal arch strain, lateral plantar nerve dysfunction, stress fracture, hammer toe deformity, and antalgia.(305, 306) (Acevedo 98, Sellman 94) Physicians and patients should carefully consider the benefits and risks compared to other conservative treatments, including temporizing, prior to glucocorticoid injection. Overall, corticosteroid injections are minimally invasive, are of moderate cost, and are recommended after other non-operative options have been tried for patients who have chronic or recalcitrant plantar fasciitis.

*Evidence for the Use of Injected Glucocorticosteroids for Plantar Fasciitis*

There are 6 moderate-quality RCTs incorporated into this analysis. There is 1 low-quality RCT in the appendix.(226) (Lynch 98)

Author/Y ear Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
<b>Glucocorticosteroid Injection vs. Placebo</b>						
Crawford 1999 RCT	7.5	N = 106 with heel pain	Prednisolone acetate (25mg) plus 1ml of 2% lignocaine vs. 25mg prednisolone acetate plus 1ml of 2% lignocaine given	Mean heel pain scores at baseline/1/3/6 months for local anesthetic alone: 5.5±2.1/4.0±2.9/3.7±3.3/ 3.3±2.7. Corticosteroid plus LA plus tibial nerve	“A steroid injection can provide relief from heel pain in the short term. A single steroid injection does not offer a	Large drop-out rate, 48% at 6 months. Patients allowed to continue co-interventions although analysis controlled for co-

			after a tibial nerve block vs. 2ml of 1% lignocaine hydrochloride vs. 2ml of 1% lignocaine hydrochloride given after a tibial nerve block; 6-month follow-up.	block: 5.5±2.1/4.5±2.6/3.4±2.7/ 2.5±3.2. Corticosteroid and LA: 5.6±2.3/2.9±2.5/ 3.6±2.8/ 2.4±2.6. Local anesthetic plus tibial nerve block: 5.8±2.8/5.3±2.9/ 3.1±2.7/ 0.6±1.1. Outcomes favor steroid at 1 month (p = 0.02).	therapeutic benefit in the long term. There appears to be no increase in patient comfort from anaesthetizing the heel prior to infiltration.”	variates. Statistical methods and analytical approach not specified. Data suggest glucocorticosteroid injection modestly superior to placebo.
Blockey 1956  RCT	6.0	N = 22 heels in 19 with pain in 1 or both heels	Hydrocortisone acetate 25mg injection vs. saline.	Steroid vs. saline group: relief at 1 week: 4/13 vs. 1/9. Relief at 2 months: 6/13 vs. 4/9. No statistical analysis provided but author states not significant.	“Hydrocortisone acetate may be the best substance to inject, but its advantage over saline has not been proved in this series.”	Randomization, allocation methods unclear. Baseline comparisons not provided. All subjects given heel cups. One-hundred percent follow-up although at variable number of months for final visit (6-18 months). Small sample size. Data suggest no benefit from 25mg hydrocortisone, which may have been a suboptimal dosage.
Kalaci 2009  RCT	5.5	N = 100 with plantar fasciitis	Group A: 2mL autologous blood only vs. Group B: anesthetic (2mL of lidocaine) combined with peppering vs. Group C: corticosteroid (2mL of triamcinolone) only vs. Group D: corticosteroid (2 mL of triamcinolone)	Pain in affected heel on a 10cm VAS at 6 months (mean ± SD): Group A (3.53±3.06) vs. Group B (3.40±2.88) vs. Group C (1.52±2.14) vs. Group D (0.96±1.24). All improved from baseline (p = 0.000), C+D more effective than A+B (p <0.05). No difference between C+D.	“[C]orticosteroid injection with peppering can be used as a first alternative in plantar fasciitis in cases in which other conservative methods failed.”	Data suggest steroids appear equally effective with and without peppering from presented data. No placebo arm.

			combined with peppering. Triamcinolone salt and dose not specified. 6-month follow-up.	Modified roles and Maudsley score at 6 months: Group C, excellent and good 20/25; Group D, excellent and good 22/25, $p = 0.24$ .		
--	--	--	--	---	--	--

### Glucocorticosteroid Injection vs. Other Treatments

Porter 2005 RCT	6.5	N = 132 plantar fasciopathy present for at least 6 weeks ; follow-up at 3 and 12 months	Low-energy ESWT vs. intralesional corticosteroid injection. ESWT - 3 applications of 1000 pulses 0.08/mm <sup>2</sup> flux density; Injection of 5.7 mg betamethasone (salt not specified) into maximal tender point.	VAS Scores at 0, 3, 12 months post treatment CSI: 5.47(2-8), 1.48 (0-7), 0.84 (0-7); ESWT: 5.52(3-8), 3.69 (0-8), 0.84 (0-4) $p < 0.05$ at 3 months only favoring CSI TT (tenderness threshold, 0,3,12 months); CSI: 5.3(1-11), 9.42(7-11), 9.6 (7-11); ESWT: 5.2(3-7), 3.69(0-8), 9.54 (5-11); $p > 0.05$ for all measurements	“Once plantar fasciopathy has persisted for more than 6 weeks, intralesional corticosteroid injection is more effective than ESWT within the first 3 months with regard to pain and tenderness, but at 12 month follow-up, there is no difference between the 2 treatments.”	Randomization methods unclear. All had stretching as co-intervention. No true placebo included (compared with non-enrolled subjects). Effects of CSI appear short term. Inclusion criteria for most ESWT studies include failure of conservative treatment. In this case it was 1st line therapy.
--------------------	-----	--	---	---	--	---

Kriss 2003 RCT	4.5	N = 76 unilateral heel pain	Soft anti-pronatory pad vs. steroid injection (20mg triamcinolone hexacetonide) vs. both; 6-month follow-up period.	Mean difference in VAS Week 0, 1, 4, 8, 12, 24 (injection vs. injection plus pad): Baseline: 76.1 vs. 66.3 vs. 71.7 $p = 0.1$ ; Week 1: -51.5 vs. -36.5 vs. -18.4 $p = 0.001$ ; Week 4: -65.3 vs. -49.3 vs. -20.3 $p = 0.001$ ; Week 8: -65.0 vs. -52.1 vs. -30.9 $p = 0.05$ ; Week 24: -63.7 vs. -61.3 vs. -50.6 $p = 0.1$ . Difference in pain relief between 2 steroid groups and pad-only group stayed statistically significant for 4 months.	“Patients had significant and immediate pain relief following injection. This was maintained for the 6-month trial period. Orthoses also alleviate symptoms but within this trial group the benefit is delayed.”	Randomization and baseline comparability unclear. No blinding. Analysis of between steroid groups not presented statistically. Data suggest benefit of injection compared with pad.
-------------------	-----	--------------------------------	---	--	--	---

### Glucocorticosteroid Injection by Palpation vs. Imaging

Yucel 2009 RCT	4.5	N = 35 heels in 27 patients with plantar fasciitis	Palpation guided (pg) 31.4% vs. ultrasound guided (ug) 42.9% vs. scintigraphy guided (sg) 25.7%. Using betamethasone dipropionate 3.215mg; 25-month follow-up.	VAS values – before treatment: ug (5.6±2.5), pg (6.4±2.7), sg (4.9±2.0); after treatment: ug (1.3±1.2), pg (2.2±2.5), sg (0.8±1.0). Plantar fascia, fat pad thickness, fascial echogenicity of groups: thickness before injection (mm): ug 4.2, pg 5.4, sg 3.5; fat pad thickness (mm) before injection: ug 6.9, pg 8.3, sg 8.7. Significant difference between ug and pg for plantar fascia thickness before injection, p = 0.017.	“All three methods were effective in the treatment of plantar fasciitis, and there was no statistically significant difference between these techniques in terms of plantar fascia thickness, fat pad thickness, and VAS value.”	Randomization, allocation methods unclear. Baseline difference in outcome measures (plantar fascia thickness, fat pad thickness). Data suggest no difference between injection techniques. No placebo arm.
-------------------	-----	--	--	---	--	--

### HYPEROSMOLAR DEXTROSE

Injected hyperosmolar dextrose has been used for treatment of plantar fasciitis.(307) (Ryan 09)

*Recommendation: Hyperosmolar Dextrose Injections for Plantar Fasciitis*

**There is no recommendation for or against the use of hyperosmolar dextrose injections for treatment of plantar fasciitis.**

*Strength of Evidence – No Recommendation, Insufficient Evidence (I)*

*Level of Confidence – Low*

#### *Rationale for Recommendation*

There are no quality trials for plantar fascia hyperosmolar dextrose injection. In a case series of 20 consecutive patients treated with sonographically guided injections of hyperosmolar dextrose and lidocaine in patients with plantar fasciitis of 6 months duration, 16 reported good or excellent results with 4 unchanged.(307) (Ryan 09) This intervention has a low risk of adverse effects, is moderately costly as it may require a series of up to 3 injections. However, the clinical efficacy is currently undefined. Ultrasound guidance of injection was also described, although the necessity of this technique is also undefined. Therefore, there is no recommendation for or against the use of hyperosmolar dextrose injection into the plantar fascia.

#### *Evidence for the Use of Hyperosmolar Dextrose for Plantar Fasciitis*

There are no quality trials evaluating the use of hyperosmolar dextrose injections for plantar fasciitis.

### PLATELET RICH PLASMA

Injected platelet rich plasma has been used for treatment of plantar fasciitis.

*Recommendation: Platelet Rich Plasma Injections for Plantar Fasciitis*

**There is no recommendation for or against the use of platelet rich plasma injections for treatment of plantar fasciitis.**

*Strength of Evidence – No Recommendation, Insufficient Evidence (I)*  
*Level of Confidence – Low*

*Rationale for Recommendation*

There are no quality trials for plantar fascia platelet rich plasma (PRP) injection. This intervention consists of obtaining 30 to 60mL of autologous blood, centrifuging, and injecting 3 to 6mL of PRP under ultrasound guidance.(308) (Sampson 08) This procedure reportedly is low risk of adverse effects, is moderately costly, and may require repeat injection. There is a case series report suggesting therapeutic efficacy, which suggests future trials of this intervention are indicated. (A case series report of 9 patients with chronic plantar fasciitis treated with sonographically guided injections of platelet rich plasma demonstrated good or excellent relief at 2 months with continued relief at 12 months.(309)) (Barrett 04) However, the clinical efficacy is currently undefined. Therefore, there is no recommendation for or against the use of platelet rich plasma injection into the plantar fascia.

*Evidence for the Use of Platelet Rich Plasma for Plantar Fasciitis*

There are no quality trials evaluating the use of platelet rich plasma injections for plantar fasciitis.

***Invasive Therapies***

**CRYOSURGERY**

Cryosurgery has been described for treatment of plantar heel pain.(278) (Cavazos 09) This technique involves local application of extreme cold to the plantar fascia percutaneously.

*1. Recommendation: Cryosurgery for Chronic Plantar Heel Pain*

**There is no recommendation for or against the use of cryosurgery for treatment of chronic plantar heel pain.**

*Strength of Evidence – No Recommendation, Insufficient Evidence (I)*  
*Level of Confidence – Low*

*2. Recommendation: Cryosurgery for Acute or Subacute Plantar Heel Pain*

**Cryosurgery is not recommended for treatment of acute or subacute plantar heel pain.**

*Strength of Evidence – Not Recommended, Insufficient Evidence (I)*  
*Level of Confidence – Low*

*Rationale for Recommendations*

There are no quality trials for percutaneous cryosurgery. A prospective case series reported 77% success in 137 feet at 3 weeks and 24 months in patients with chronic plantar heel pain.(278) (Cavazos 09) Cryosurgery is invasive, has an undefined adverse effect risk profile, and is moderately costly. Although potentially promising, further studies are needed, thus there is no recommendation for or against its use to treat plantar heel pain.

*Evidence for the Use of Cryosurgery for Plantar Fasciitis*

There are no quality trials incorporated into this analysis.

**INTRACORPOREAL PNEUMATIC SHOCK THERAPY**

Intracorporeal pneumatic shock therapy (IPST) is applied invasively through a small percutaneously placed lithotripter transducer.(310) (Dogramaci 10)

*Recommendation: Intracorporeal Pneumatic Shockwave Therapy (IPST) for Select Chronic Plantar Fasciitis*

**Intracorporeal pneumatic shock therapy is moderately recommended for treatment of select chronic plantar fasciitis.**

*Indications* – Failure of NSAIDs, injection(s), stretching, other exercises and night splinting; demonstrable heel spur.

*Strength of Evidence* – **Moderately Recommended, Evidence (B)**  
*Level of Confidence* – Moderate

*Rationale for Recommendation*

There is one high-quality placebo-controlled trial performed as a pilot study that suggested pain relief and satisfaction compared with sham treatment in a small population of chronic plantar heel pain and radiographic spur.(310) (Dogramaci 09) Intracorporeal pneumatic shock therapy is invasive, requiring a rigid probe to be directly introduced into the calcaneal spur under fluoroscopic guidance, and is thus costly. This treatment has risk for hematoma, infection, or rupture. Thus, the use of IPST is recommended as an alternative to surgical intervention for recalcitrant plantar fasciitis among those patients who fail other non-operative treatments and have a heel spur.

*Evidence for the Use of Intracorporeal Pneumatic Shock Therapy for Plantar Fasciitis*

There is 1 high-quality RCT incorporated into this analysis.

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Dogramaci 2010  RCT	8.5	N = 50 clinically and radiologically confirmed plantar fasciitis	Intracorporeal pneumatic shock wave (IPST) vs. sham.	VAS ESWT vs. sham (0, 3 weeks, 6 months) 8.92 vs. 9.12, 2.60 vs. 5.04 p = 0.000, 2.04 vs. 7.16 p = 0.000; excellent/good vs. acceptable/poor 92% vs. 24% (p <0.001).	“Pneumatic lithotripter may be used safely and effectively in the treatment of chronic PF as an alternative to SWT devices before considering the surgery.”	Chronic patients assessed at 3, 6 months. No mention of control for co- interventions. Data suggest highly effective treatment in small population. All had radiographic spurs. Further studies needed to generalize for PF without spurs.

**PERCUTANEOUS BONE FENESTRATION**

Percutaneous bone fenestration of the anteromedial aspect of the calcaneus for symptomatic relief has been described.(311) (Hassan 09)

*Recommendation: Percutaneous Calcaneus Fenestration for Chronic Plantar Heel Pain*

**There is no recommendation for or against the use of percutaneous calcaneus fenestration for treatment of chronic plantar heel pain.**

*Strength of Evidence* – **No Recommendation, Insufficient Evidence (I)**  
*Level of Confidence* – Low

*Rationale for Recommendation*

There are no quality trials for percutaneous bone fenestration. A prospective case series of 38 feet reported 100% success rates 12 months post-operatively in patients with chronic plantar heel pain.(278)

(Cavazos 09) Percutaneous bone fenestration is invasive, has an undefined adverse effect risk profile, and is high cost as it is a surgical procedure performed with general or regional anesthesia. Although potentially promising, further studies are needed, and thus there is no recommendation for or against its use.

*Evidence for the Use of Percutaneous Bone Fenestration for Plantar Heel Pain*

There are no quality trials incorporated into this analysis.

## **RADIOFREQUENCY MICROTENOTOMY**

Radiofrequency microtenotomy has been described for treatment of plantar fasciitis. This technique involves application of radiofrequency cautery through 10 to 20 percutaneous sites into the superficial tissue and plantar fascia. The mechanism for healing is unknown.(312) (Weil 08)

*Recommendation: Radiofrequency Microtenotomy for Chronic Plantar Fasciitis*

**There is no recommendation for or against the use of radiofrequency microtenotomy for treatment of chronic plantar fasciitis.**

*Strength of Evidence – No Recommendation, Insufficient Evidence (I)*

*Level of Confidence – Low*

*Rationale for Recommendation*

There are no quality trials evaluating radiofrequency microtenotomy for plantar fasciitis. A small prospective series showed positive benefits.(312) (Weil 08) Radiofrequency microtenotomy is invasive, has an undefined adverse effect risk profile, and is moderately costly. Although potentially promising, further studies are needed, thus there is no recommendation for or against its use.

*Evidence for the Use of Radiofrequency Microtenotomy for Plantar Fasciitis*

There are no quality trials incorporated into this analysis.

### **Surgical Considerations**

Plantar fascia release is performed in 5 to 7% of patients treated for plantar fasciitis(199, 313) (Faraj 02, Davies 99) as a last resort when other therapies have failed. A release is commonly performed with an open or endoscopic approach.

1. *Recommendation: Surgery for Select Chronic Recalcitrant Plantar Fasciitis*

**Surgical release is recommended for select chronic recalcitrant plantar fasciitis. There is no recommendation for any particular procedure or method over another.**

*Indications* – Moderate to severe chronic plantar fasciitis patients who have failed multiple non-surgical treatments and whose condition has lasted at least 6 to 12 months. Patients should generally have failed NSAID(s), plantar fascia stretching, injection(s) and failed or refused other more conservative treatment. Patients should receive pre-operative education regarding expected outcomes.

*Strength of Evidence – Recommended, Insufficient Evidence (I)*

*Level of Confidence – Low*

2. *Recommendation: Surgery for Acute or Subacute Plantar Fasciitis*

**Surgical release is not recommended for treatment of acute or subacute plantar fasciitis.**

*Strength of Evidence – Not Recommended, Insufficient Evidence (I)*

*Level of Confidence – High*

*Rationale for Recommendations*

There are no quality randomized trials that compare sham surgery with surgical release, none that include surgery as a treatment arm for chronic plantar fasciitis, and none that compare efficacy of open versus endoscopic or other procedures. There is a dearth of case series reports of surgical plantar fascia release. Plantar fasciotomy is reported to have a complete pain relief success rate of 44%,(313) (Faraj 02) 50%,(199) (Davies 99) 61%,(314) (Conflitti 04) 68%,(315) (Hogan 04) and 69%.(316) (Jarde 03) Complete satisfaction is also reported between 48%(199) (Davies 99) and 85%.(315) (Hogan 04) Average return to work or daily activities can range from 1.5(314) (Conflitti 04) to 7.85 months.(199) (Davies 99) Patients in the workers' compensation system have reportedly fared worse in satisfaction and lost time than those in non-workers' compensation systems.(317) (Bazaz 07) Fascial release is also associated with many adverse effects, including acute plantar fasciitis, forefoot stress fractures, and calcaneal and cuboid fractures.(318) (Cheung 06) Fascial release greater than 50% of the thickness may result in instability of the plantar arch(319) (Jerosch 04) and result in lateral column pain symptoms.(320) (Brugh 02) There is no quality evidence on the added inclusion of spur excision or release of the abductor digiti quinti nerve with plantar release surgery. Thus, while surgery appears to provide complete relief to about half of patients, it is not without significant risk of complication, expense, and lack of comparison data to other non-surgical interventions.

Therefore, surgery is recommended as an intervention after at least 6 months of other non-operative treatments have been attempted and the patient's symptoms are sufficient to warrant the risks of surgical intervention. Patient education regarding suboptimal expected outcomes is recommended. There is no recommendation for or against procedure type (i.e. open vs. endoscopic) or the adjunct procedures (i.e. spur excision, neurolysis or release of abductor digiti quinti nerve).

#### *Evidence for the Use of Surgery for Plantar Fasciitis*

There are no quality trials incorporated into this analysis.

## **Foot Ulceration**

Foot ulcers that arise out of occupational trauma, burns, infection, or other occupational disease (i.e., occupational peripheral neuropathies) and exposures or from non-occupational origins, such as diabetes mellitus (with or without peripheral neuropathy), vascular insufficiency and non-occupational peripheral neuropathies, may be encountered in an occupational setting. Foot ulcers may be painless; but may be accompanied by pain, burning, or itching; and may be infected. Pressure ulcers develop as a result of pressure, force or friction concentrated on a small area over a bone of the foot. (Landi 03, Tymec 97) Shear (tangential) force may be important. Treatment options for foot ulcerations include local wound care, surgical intervention and topical nerve growth factors. (Landi 03) Pressure-relieving devices are often used. (Tymec 97) Few research studies have investigated the pressure reducing properties of such devices.

### **Initial Assessment**

Assessment of foot ulcer should exclude diagnoses that need aggressive or highly restrictive treatment, or involve inadequately treated underlying disease. The patient should be assessed for cardiovascular disease, diabetes, inflammatory disorders, peripheral neuropathy, systemic and localized infection. The affected foot should be checked for infection or gangrene. Ulcers are graded by the depth with different systems, (Sumpio 00; Bluestein 08) but most commonly with the Wagner grading system: (O'Neal 83)

Grade 0 – No ulcer in a high-risk patient

Grade 1 – Superficial ulcer involving the full skin thickness but not underlying tissues

Grade 2 – Deep ulcer, penetrating down to ligaments and muscle, but no bone involvement or abscess formation

Grade 3 – Deep ulcer with cellulitis or abscess formation, often with osteomyelitis

Grade 4 – Localized gangrene

Grade 5 – Extensive gangrene involving the whole foot

### **Medical History**

A history adequate to exclude uncontrolled comorbidities should be conducted. Ensure that the patient is free of fever and chills, compromise of skin in other areas than the affected foot, and sensory changes.

### **Physical Examination**

The size, depth, and location of and condition of the area surrounding an ulcer should be recorded. Check for exudate, odor, tunneling, undermining, sinus tracts, necrosis or eschar formation, infection, and signs of healing (granulation and epithelialization). Assess the wound margins and areas around the wound, including for induration, and tracking of infection or inflammation. Determine the stage of each ulcer.

Sensation of the foot and bone and joint deformities should be carefully assessed. Evaluation of perfusion of the foot and ankle, including dorsalis pedis and posterior tibial pulses, and of capillary refill is helpful. Footwear should be assessed for good repair, provision of comfort and support, and freedom from protruding, abrasive, or sharp features.

### **Diagnostic Studies**

X-rays are indicated for those with concerns about possible underlying boney involvement, particularly including concerns about osteomyelitis and are **Recommended, Insufficient Evidence (I)**. Bone scans are also indicated for those with further questions of boney involvement, particularly with indeterminate x-rays, and are **Recommended, Insufficient Evidence (I)**. X-rays are indicated for those with questions of osteomyelitis.

## **PATIENT EDUCATION AND INFRARED TEMPERATURE MONITORING**

Patient education has been used to attempt to reduce diabetic foot complications. (Lincoln 08; Donohoe 00; Borges 08; Corbett 03) One trial has used temperature detection for further preventive efforts. (Lavery 07)

### *1. Recommendation: Patient Education for Diabetic Foot Complications*

**Patient education is recommended for prevention of diabetic foot complications.**

*Indications* – Diabetics at risk of foot ulcers and amputations, particularly those with peripheral neuropathy and/or arterial insufficiency.

*Strength of Evidence* – **Recommended, Insufficient Evidence (I)**

*Level of Confidence* – Low

### *2. Recommendation: Infrared Temperature Monitoring for Diabetic Foot Complications*

**Infrared temperature monitoring is recommended for prevention of diabetic foot complications.**

*Indications* – Diabetics at risk of foot ulcers and amputations, particularly those with at least moderately severe peripheral neuropathy and/or arterial insufficiency.

*Strength of Evidence* – **Recommended, Evidence (C)**

*Level of Confidence* – Low

### *Rationale for Recommendations*

One moderate quality trial found no evidence patient education reduced diabetic foot infections or amputations. (Lincoln 08) However, other moderate-quality trials have found that education changes patient behaviors. (Corbett 03; Borges 08) A moderate-quality trial found use of infrared temperature monitoring to be effective in preventing recurrent foot ulcers when added to footwear, diabetic education and regular foot care. (Lavery 07) These interventions are not invasive, have no significant adverse effects, and are low cost; thus they are recommended.

### *Evidence for the Use of Patient Education and Temperature Monitoring*

There are 4 moderate-quality RCTs incorporated into this analysis. (Lavery 07; Lincoln 08; Corbett 03; Borges 08) There is 1 low-quality RCT in the Appendix. (Donohoe 00)

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Lavery 2007  RCT, multicenter trial  Sponsored by the National Institute of Diabetes and Digestive and Kidney Diseases, National Institutes of Health. No mention of COI.	6.0	N = 173 with diabetic foot ulceration. Age range 40 – 80 years.	Standard therapy group: lower extremity evaluation by physician every 8 weeks, an education program about foot complications and self-care practices, and therapeutic insoles and footwear (n = 58) vs Structured foot exam group: standard therapy in addition to training to conduct a structured foot inspection twice a day using a mirror to see bottom of foot (n = 56) vs Enhanced therapy group: digital infrared thermometer to measure and record temperatures on each foot (n = 59). Follow-up for 15 months.	Significant difference in times to develop ulcers (p = 0.011). Enhanced therapy significantly different from both standard therapy (p = 0.0059) and structured foot exam (p = 0.0055). Trend of survival better in enhanced therapy than standard therapy or structured foot exam (p = 0.0107). Decrease in risk of developing foot ulceration in enhanced therapy group (8.5%) vs. standard therapy group (OR 4.48 [95% CI: 1.53–13.14], p = 0.008) and structured foot exam group (4.71 [1.60 – 13.85], p = 0.0061). Enhance therapy group contacted nurse due to foot problems than standard therapy (p = 0.030) or structured foot exam groups (p = 0.026).	“Infrared temperature home monitoring, in serving as an “early warning sign,” appears to be a simple and useful adjunct in the prevention of diabetic foot ulcerations.”	Enhanced therapy group had fewer ulcers than other 2 groups and the other groups were 4 and 5 times more likely to develop ulcers.
Lincoln 2008	6.0	N = 172 with diabetes and recently	Intervention group: education	At 12 months, intervention group followed more	“Even though the intervention	No apparent benefit in one on one

<p>RCT</p> <p>Sponsored by Diabetes UK. No COI.</p>		<p>healed foot ulcers.</p> <p>Mean age 63.5 [12.1] years in the intervention group and 64.9 [10.9] years in control group.</p>	<p>program (n = 87) vs Control group: usual care (n = 85).</p> <p>Follow-up 6 and 12 months.</p>	<p>foot care behaviours vs. control group (median score: 42.0 vs. 38.7, p = 0.03). No significant difference in ulcer incidence at 6 (intervention 30%, control 21%) and 12 months (intervention 41%, control 41%).</p>	<p>was associated with improved foot care behaviour, there was no evidence that this programme of targeted education was associated with clinical benefit in this population when compared with usual care. The usefulness and optimal delivery of education to such a high-risk group requires further evaluation.”</p>	<p>education in prevention of diabetic foot ulcers.</p>
<p>Corbett 2003</p> <p>RCT, prospective</p> <p>Sponsored by the AADE Education and Research Foundation and Carl M. Hansen Foundation/ Intercollegiate College of Nursing. No mention of COI.</p>	<p>4.5</p>	<p>N = 40 with type 2 diabetes.</p> <p>Age range 26 – 91 years.</p>	<p>Educational intervention: foot care education (n = 20) vs Control group (n = 20).</p> <p>Follow-up for 6 and 12 weeks.</p>	<p>At baseline, risk for lower-extremity ulceration was high. Foot risk score 1.88 at baseline, 1.97 at 6 weeks, 1.87 at 12 weeks. At 12 weeks, intervention group had greater foot care knowledge (p = 0.029) and improved self-care practices (p = 0.007) vs. control group. At 12 weeks, intervention group improved significantly in self-efficacy (p = 0.014), reported foot self-care</p>	<p>“A brief, individualized educational intervention about standard foot care topics improved patients' foot care knowledge and self-efficacy as well as reported self-care practices. Incorporating such interventions into routine home care services may enhance the quality of care</p>	<p>Pilot study. Sparse methodology and baseline comparability. Relatively small sample size.</p>

				practices ( $p = 0.003$ ), and foot care knowledge ( $p = 0.007$ ).	and decrease the incidence of lower-extremity complications.”	
Borges 2008  RCT  No mention of sponsorship or COI.	4.0	N = 167 with type 2 diabetes who lived in a predominantly Mexican American community.  Mean age 61.5 (11.4).	Intervention Group: 15-min intervention designed to improve diabetes self-efficacy and foot self-care behaviors (n = 55) vs Risk Assessment Group: 5-min foot risk assessment using a monofilament (the LEAP Abbreviated Diabetes Foot Screen), designed to encourage patients' involvement in assessing their feet (n = 55) vs Control group: Usual care (n = 57).  Follow-up for 1 month.	Significant increase of the foot self-care knowledge score after follow-up within control group ( $p < 0.05$ ). Diabetes self-efficacy scores high at baseline and remained high after follow-up in all groups. There was a significant increase of diabetes self-efficacy score within control group ( $p < 0.05$ ) and risk assessment group ( $p < 0.001$ ). Baseline diabetes self-efficacy correlated with self-reported foot self-care behaviors at baseline ( $p < 0.001$ ) and follow-up ( $p < 0.05$ ). Significant increase of self-reported foot self-care behaviors within intervention group ( $p < 0.01$ ) and control group ( $p < 0.05$ ). Significant difference in observed self-care behavior scores between groups ( $p < 0.05$ ). Applying lotion between toes was	“Recommendations for foot care education to prevent foot pathology indicate that the intervention should be simple, relevant, consistent, and repeated. Brief interventions delivered as patients interact with the health care system offer an opportunity for such interventions. The willingness of patients and emergency department staff to participate in the intervention and follow-up suggests that interventions delivered in this environment are not a burden.”	Significant difference regarding foot self care behaviors between groups at 1 month follow-up suggested that a brief education intervention may lead to increased preventive diabetic behaviors.

				significant difference between groups ( $p < 0.01$ ). Significant difference in item of checking bottom of foot ( $p < 0.05$ ).		
--	--	--	--	---	--	--

## WOUND DRESSINGS

Dressings are widely used in wound care with a vast amount of dressing types available. (Dumville 12, 13; Game 12; Veves 02; Jeffcoate 09; Jacobs 08; Shukrimi 08; Piaggese 10) Types of dressings include basic wound contact dressing (low-adherence dressings), advanced wound dressings (e.g., foams, hydrogel, films), anti-microbial dressings (e.g., honey-impregnated, iodine-impregnated) and special dressing (e.g., protease-modulating matrix dressing) which all vary in cost. (Dumville 13)

*Recommendation: Wound Dressings for Management of Lower Extremity Ulcers*

**Wound dressings are recommended for management of lower extremity ulcers.**

*Indications* – All lower extremity ulcers, usually on a daily basis. There is no convincing evidence of superiority of any particular product. (Jeffcoate 09)

*Strength of Evidence* – **Recommended, Insufficient Evidence (I)**

*Level of Confidence* – Low

### *Rationale for Recommendation*

While there are multiple moderate-quality studies, none compared wound dressings with no wound dressings. One comparative trial found no differences between 3 types of dressings and concluded that the least expensive should then be utilized. (Jeffcoate 09) One high-quality trial of an antimicrobial dressing reported lower bacterial burdens at 4 weeks, but only modest, non-significant reductions in wound size. (Sibbald 12) One moderate-quality trial of dressings of Hydrofiber® with ionic silver or calcium alginate found modestly better healing with silver. (Jude 07) However, another similar trial found no material differences. (Trial 10) Wound dressings are not invasive, generally have relatively low adverse effects, may be costly over time but are recommended. With almost no head-to-head trials for comparison, there is no recommendation for a particular formulation or product.

### *Evidence for the Use of Wound Dressings*

There is 1 high (Sibbald 12) and 4 moderate-quality RCTs (Jeffcoate 09; Jude 07; Trial 10; Piaggese 10) incorporated into this analysis. There are 3 low-quality RCTs in the Appendix. (Veves 02; Jacobs 08; Shukrimi 08)

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
<b>Foams</b>						
Sibbald 2012  RCT  No mention of CO or	8.5	N = 45 with leg and foot ulcers.  Mean±SD age was 55.8±13.13 years.	Polyhexamethylene biguanide (PHMB) foam dressing (n=22) (vs. non-antimicrobial foam (n = 23).	Bacteriology at week 4 (polymicrobial organisms): detected in 5.3% of wounds treated with PHMB foam	“PHMB foam dressing successfully reduced chronic wound pain and bacterial burden.”	Pilot RCT suggesting PHMB significantly decreased wound bacterial burden ( $p =$

Sponsorship			Follow-up 5 weeks.	dressing vs. 33% control foam, p = 0.04).		0.016) at 4 weeks compared to foam alone.
Jeffcoate 2009  RCT  No mention of sponsorship or COI.	7.0	N = 317 with type 1 or type 2 diabetes with a chronic full - thickness foot ulcer, for at least 6 weeks and over age 18 or mean age was 60 years.	N-A or a non-adherent, knitted, viscose filament gauze (n = 106) vs. Inadine or an iodine-impregnated dressing both traditional dressings (n = 108) vs. Aquacel a newer product or hydrocolloid preparation (n = 103).  Follow-up for 24 weeks.	At 12 weeks, incidences of healing for 3 dressings were; N-A/Inadine/and Aquacel; 25.5%/29.6%/and 28.2%.  At week 24, number of ulcers managed in each group; N-A/Inadine/ and Aquacel; 30%/50%/55%. Overall healing rates for 3 dressings were: N-A/Inadine/and Aquacel; 39%/44%/ and 45%.	“As there was no difference in effectiveness, there is no reason why the least costly of the three dressings could not be used more widely across the UK National Health Service, thus generating potentially substantial savings.”	Large sample size. High dropouts. Data suggest no difference in healing rates.
Jude 2007  RCT  E.J. has received speaker's fees, research funding and fees for organizing education from ConvaTec.	6.0	N = 134 with non-ischaemic diabetic foot ulcer resulting from Type 1 or 2 diabetes mellitus or DM, all wounds $\geq 1\text{cm}^2$ . Mean age in AQAg and CA group; $58.9 \pm 1.6$ / and $61.1 \pm 11.4$ .	AQAg, AQUACEL® Hydrofiber® dressing group, with 1.2% ionic silver left in place for up to 7 days (n = 67) vs. CA or Algosteril® calcium alginate dressing group, instructed to moisten it before use on dry wounds and to change daily (n = 67).  Follow-up for 8 weeks.	Healing efficacy; primary end-point, healing speed, similar in AQAg-dressed and CA-dressed wounds; AQAg, (p = 0.993). 21 in AQAg group healed vs 15 in CA during 8 weeks. Wound infection; median time for clinical infection to resolve without recurring for AQAg and CA: 9 days for eight (88.9%) AQAg-resolved infections and 15 days, (p = 0.35) for 10 (76.9%; p = 0.48) CA-resolved infections.	“When added to standard care with appropriate off-loading, AQAg silver dressings were associated with favourable clinical outcomes compared with CA dressings, specifically in ulcer depth reduction and in infected ulcers requiring antibiotic treatment.”	Ulcer depth was significantly decreased in Hydrofiber group compared to CA group (p = 0.04) but other outcome measures did not show statistical significance.

				Safety; Of AQAg patients, 25 (37%) experienced 1 or more adverse events, vs 26 (39%) of CA patients.		
Trial 2010 RCT No mention of sponsorship or COI.	5.5	N = 42 with locally infected chronic wounds, one of which is diabetic foot ulcers. The mean age was 68.9 for women and 66.5 for men.	Askina Calgitrol Ag or test dressing consists of a proprietary ionic silver alginate matrix and an absorbent polyurethane foam layer (n = 20) vs. Algosteril standard silver-free alginate dressing controlled and sustained over 72 hours (n = 22).  Follow-up for 1 and 15 days.	Diabetic foot ulcers in 29% of participants. Chronic wounds: pressure ulcers (57%) or venous or mixed aetiology leg ulcers and diabetic foot ulcers (29%); few acute wounds (14%). Clinical scores of infection decreased significantly in both groups at day 15, 3.8± 2.9 in Askina Calgitrol Ag, (p = 0.001) vs 3.8 ±3.4 in Algosteril group, (p = 0.007). No adverse events recorded during study.	“The regression of local signs of infection, local tolerance, acceptability and usefulness were similar for the two dressings.”	Similar efficacy between groups. Short follow-up. Dissimilar baseline data. Relatively small sample size (n = 42).
Piaggese 2010 RCT Supported by a nonrestricted research grant from Oculus Innovative Sciences, manufacturers of Dermacyn Wound	4.0	N = 40 patients with diabetic ulcers greater than 5 cm <sup>2</sup> area; Mean age was 62.05 years.	Group A treated with daily instillation of Dermacyn Wound Care (DWC) solution in amounts varying from 5-20mL (n = 20) vs. Group B- received same medication with povidone iodine diluted 50% with saline. Followed up weekly for 6 months or until	Healing rate (complete closure) at 6 months: 90% in Group A vs. 55% in group B (p = 0.002). Average healing time 10.5 weeks in Group A vs. 16.5 weeks in Group B (p = 0.007). Duration of antibiotic therapy significantly shorter in Group A vs. Group B; 10.1 weeks vs.	“The data from this study permit the observation that DWC should be considered as part of the integrated therapeutic approach in all the cases of infected DF ulceration, alongside surgery, systemic antibiotics, and revascularization	Data suggest faster healing.

Care. No COI.			complete closure of lesion.	15.8 weeks (p = 0.016).	n when needed.”	
------------------	--	--	--------------------------------	----------------------------	--------------------	--

### **Physical Modalities**

Reduction in localized mechanical compression and/or pressure points is amongst the most common treatment options for foot ulcers.

#### **LOCALIZED MECHANICAL COMPRESSION/PRESSURE**

*Recommendation: Reduced Localized Mechanical Compression/Pressure*

**Reduced Localized Mechanical Compression/Pressure is recommended for foot ulcers.**

*Indications* – All patients with foot ulcerations especially those for which ulceration is not healing. Also recommended for prevention in particularly susceptible patients at high risk of complications (e.g., select workers with diabetes mellitus with peripheral neuropathy; frail elderly with compromised immune, dermatological, vascular systems).

*Strength of Evidence* – **Recommended, Insufficient Evidence (I)**

*Level of Confidence* - High

#### *Rationale for Recommendation*

There are no quality trials on a general approach to reduction in localized mechanical compression or pressure/ force. These interventions include assessing whether there are poorly fitting shoes, and lack of movement producing sustained localized mechanical compression. Yet, approaches to reduce these forces are widely used, assumed to be of major importance, and assumed to have efficacy as localized pressure is generally presumed to be a causal factor. These techniques are not invasive, have low adverse effects, and are generally low cost. They are recommended for treatment of foot ulcerations, as well as prevention in susceptible populations. There are wound care systems but no quality trials to evaluate their efficacy. (Lerman10)

#### *Evidence for the use of Localized Mechanical Compression/Pressure*

There are no quality studies evaluating the use of localized mechanical compression/pressure for foot ulcers.

#### **NEGATIVE PRESSURE (VACUUM) WOUND CARE SYSTEMS**

Negative pressure wound care systems have been used for treatment of chronic leg ulcers. (Eginton 03; Akbari 07; Game 12; Page 04; Lerman 10; Mars 08; Sepulveda 09)

*Recommendation: Negative Pressure (Vacuum) Wound Care Systems*

**Negative Pressure (Vacuum) Wound Care Systems are moderately recommended for the treatment of chronic lower extremity ulcers.**

*Indications* – Chronic, non-healing lower extremity ulcers, including those associated with diabetes mellitus and venous stasis. (Vuerstaek 06)

*Strength of Evidence* – **Moderately Recommended, Evidence (B)**

*Level of Confidence* – Moderate

#### *Rationale for Recommendation*

There are multiple moderate-quality trials suggesting efficacy of negative pressure therapy for chronic leg ulcers, mostly diabetic-related. Two moderate-quality trials suggested improved wound healing with a vacuum-assisted device compared with moist gauze therapy. (Blume 08; Mouës 04) Other moderate-quality trials suggested better wound healing and fewer amputations. (Armstrong 05) (Vuerstaek 06) A trial of -75mmHg vs. -125mmHg found no differences at 4 weeks. (Lavery 14) Another trial found no differences between mechanically and electrically powered devices. (Armstrong 12) There are various wound care systems and no quality comparative controls to suggest one is superior to another. Wound

care systems are not invasive, have low adverse effects, are moderately costly, and with evidence of efficacy are recommended.

*Evidence for the Use of Negative Pressure Therapy (Vacuum Devices)*

There are 6 moderate-quality RCTs incorporated into this analysis. (Blume 08; Armstrong 12; Vuerstaek 06; Lavery 14; Armstrong 05; Moues 04) There is 1 low-quality RCT in the Appendix. (Mars 08)

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Blume 2008  RCT  No mention of sponsorship or COI.	7.0	N = 341 with diabetes a stage 2 or 3 calcaneal, dorsal, or plantar foot ulcer ≥ 2 cm <sup>2</sup> . Mean age of 58 years.	Negative pressure wound NPWT therapy or vacuum-assisted closure (n = 172) vs. Advanced moist wound therapy or AMWT, predominately hydrogels and alginates (n = 169).  Follow-up at 3 and 9 months.	NPWT group significantly greater for complete ulcer closure vs AMWT group; 73/169 [43.2%] vs. 48/166 [28.9%], (p = 0.007). Fewer amputations observed in NPWT group or 4.1% vs AMWT group or 10.2%, (p = 0.035). Home care therapy days to total therapy days for NPWT was 9,471 of 10,579 (89.5%) vs 12,210 of 12,810 (95.3%) for AMWT.	“NPWT appears to be as safe as and more efficacious than AMWT for the treatment of diabetic foot ulcers.”	Total wound closure in NPWT group 43.2% vs. AMWT 28.8% at 112 days.
Armstrong 2012  RCT, multicenter, prospective  Sponsored by Spiracur, Inc. COI, two authors (DGA and WAM) have received research funding from both Spiracur,	6.5	N = 132 with noninfected, nonischemic, nonplantar lower extremity diabetic and venous wounds.  Mean age of 65.0 ± 14.2 in the SNaP and 65.6 ± 15.6 in the VAC group.	The ultraportable mechanically powered Smart Negative Pressure (SNaP) Wound Care System vs Electrically powered Vacuum-Assisted Closure (VAC) Therapy System.  Follow-up for 4, 8, 12, and 16 weeks.	SNaP group demonstrated non-inferiority vs. VAC group at 4, 8, 12, and 16 weeks: -33.08± 68.46 vs. -23.73± 76.51 - 44.62±78.35 vs. -40.7±85.28/-49.52± 78.94 vs. -39.56± 111.13/-52.91 ± 77.40 vs. -42.73±111.13; (p = 0.0030, 0.0130, 0.0051, and 0.0044).	“[T]his study provides prospective, randomized controlled trial evidence that treatment of wounds with a mechanically powered NPWT device results in similar wound healing outcomes as treatment with an electrically powered NPWT device	Similar efficacy between groups at all time points up to 16 weeks. Mean use devices: SNAP 10.2 minutes vs. VAC 18.22 minutes.

Inc. and KCI.					with what appears to be less impact on patient's quality of life."	
Vuerstaek 2006  RCT  Sponsored by the Dutch department of Kinetic Concepts, Inc. (KCI). No COI.	5.5	N = 60 with chronic leg ulcers of >6 months duration. Age for SWC/VAC groups:23 (77)/ 23 (77).	Vacuum-assisted closure (VAC) group applied to wound during preparation stage, permanent negative pressure of 125mmHg exerted (n = 30) vs. Therapy or SWC group, conventional wound care techniques (n = 30).  Follow-up for 12 months.	Treatment by VAC associated with significant faster time to complete healing, HR = 3.2; 95% CI, 1.7 – 6.2, (p < 0.000) and preparation time HR = 2.4; 95% CI, 1.2 – 4.7, (p < 0.01). Secondary outcome: median recurrence rate at month 4 (95% CI, 0.7 – 7.4) after VAC therapy vs. month 2 (95% CI, 0.5 – 3.6) in control group, (p = 0.47).	"V.A.C. therapy should be considered as the treatment of choice for chronic leg ulcers owing to its significant advantages in the time to complete healing and wound bed preparation time compared with conventional wound care."	VAC significantly better in complete wound healing compared to conservative group (median time 29 days vs. 45 days, p = 0.0001).
Lavery 2014  RCT  No mention of Industry Sponsorship  COI, Dr. Lavery has research grants from KCI, Osirus, Health Point, ThermoTek, Integra, GlaxoSmith Kline, ConvaTec, and Innovative Therapies,	5.0	N = 40 with diabetic foot wounds, age 21-90 years, surgical lower extremity wounds, and ankle-brachial indices > 0.70.  Mean±SD age 70.5±7.4 years (75mmHg) and 51.3±12.7 years (125mmHg).	Negative-pressure wound therapy with 75-mmHg continuous pressure with a silicone-covered dressing (75 mmHg) vs. 125mmHg with a polyurethane foam dressing. Both devices changed 3x/week.  Follow up to 4 weeks or until surgical closure.	Mean±SD wound area and volume: 20.10±14.33cm <sup>2</sup> (125mmHg) vs. 34.61±32.92cm <sup>2</sup> (75mmHg), p = 0.08. No differences were found between treatments.	"[T]here was no difference in outcomes in wounds treated with low pressure (75 mmHg) with a silicone-coated interface and high pressure (125 mmHg) with a polyurethane foam interface."	Pilot study. No non-negative pressure group. Small sample size (n = 40). Similar efficacy between groups at 4 weeks.

<p>Inc. He is on speaker's bureau for Shire, KCI, and Innovative Technologies and a consultant/ advisor for Innovative Therapies and PamLab, L.L.C. He has stock ownership in Diabetica Solutions and Prizm Medical and holds patents with Diabetica Solutions.</p>						
<p>Armstrong 2005  RCT  Sponsored by KCI USA. COI, two authors (DGA and LAL) have received research funding from KCI.</p>	<p>5.0</p>	<p>N = 162 patients with diabetic partial foot amputation wounds up to transmetatarsal level and evidence of adequate perfusion. Also corresponding to grade 2 or 3 of the University of Texas Diabetic Foot Wound Classification system.  Mean age 59 (12.8).</p>	<p>Negative pressure wound therapy (NPWT) group (n = 77) received Vacuum-Assisted Closure (VAC) and dressing changes every 48 hours vs. Control group (n = 85) received dressing changes only everyday unless authorized by clinician.  16 week study, follow-ups at day 7, 14, 28, 42, 56, 84, and 112.</p>	<p>Patients within the NPWT group (56%) showed faster healing results than control group (39%). In wound closure 0.1702 (95% asymptotic CI (0.0184-0.322) when comparing NPWT to control group. Complete wound closure higher in NPWT than control group (p = 0.005). Wounds healed by surgical closure higher in NPWT at 40% than control group at 30%. Overall, VAC system helped to reduce risk of second amputation in</p>	<p>"In conclusion, our results indicate that NPWT as delivered through the VAC Therapy System seems to be a safe and effective treatment for complex diabetic foot wounds. Treatment with NPWT resulted in a higher proportion of wounds that healed, faster healing rates, and potentially fewer re-amputations than with standard treatment. Future work should look at the effect of</p>	<p>132/162 patients male. Proportional healing at 12 and 16 weeks similar.  More frequent dressing changes in usual care group (QD vs. Q 48hrs), which may bias in favor of usual care. NPWT group had more complete and faster wound healing vs. conventional treatment at 16 weeks</p>

				NPWT than in control group.	rapid healing on cost efficacy, length of hospital stay, and effectiveness, as well as quality of life.”	and fewer amputations . High dropout rate.
Mouës 2004 RCT  Sponsored in part by Plastic & Reconstructive Surgery Esser foundation, “Vereniging Trustfonds Erasmus University Rotterdam,” and KCI International, Houten, the Netherlands.	4.0	N = 54 with full-thickness wound that could not be closed immediately because of infection, contamination, or chronic character. Mean age for VAC and Conventional group: 47.7±9.6 / and 47.9±17.0.	Vacuum-assisted closure or VAC-therapy included polyurethane foam dressing with pore size of 400–600 mm (n = 29) vs. Treatment by conventional moist gauze therapy two times a day or more (n = 25).  Follow-up for 20 days.	“Ready for surgical therapy” for VAC group 6.00±0.52 days (median±SEM) vs 7.00±0.81 days for conventional moist-treated wounds (p = 0.19). Wound surface reduction area was larger in VAC-treated group vs conservative group, (p < 0.05).	“In conclusion, this study shows a positive effect of vacuum-assisted closure therapy on wound healing, expressed as a significant reduction of wound surface area.”	VAC group showed decrease in wound surface area 3.8±0.5%/day vs. conventional treatment group of 1.7±0.6 percent/day.

## TOTAL CONTACT CASTING

*Recommendation: Total Contact Casting*

**Total Contact Casting is recommended for foot ulcers.**

*Indications* – All patients with non-healing foot ulcerations are potential candidates although the moderate-quality data are all among diabetics.

*Strength of Evidence* – **Recommended, Evidence (C)**

*Level of Confidence* – Low

*Rationale for Recommendation*

Total contact casting produced faster time to healing in a moderate quality trial, (Lavery 14) thus it is recommended.

*Evidence for the Use of Total Contact Casting*

There is 1 moderate-quality RCT incorporated into this analysis. (Lavery 14)

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
---------------------------	-----------------	-------------	---------------------	---------	------------	----------

Lavery 2014 RCT	4.5	N = 73 with diabetes mellitus and grade UT1A or UT2A (University of Texas Ulcer Classification System) forefoot ulcer, no age information presented.	Shear-reducing cast walker (n = 27) vs. healing sandals (HS) with 8-mm Plastazote insole (n = 23) vs. total contact casts, TCCs, (n = 23) 12 week study. Follow-up every 7-10 days.	Mean±SD time to heal (weeks) HS vs. TCC vs. shear walker: 8.9±3.5 vs. 5.4±2.9 vs. 6.7±4.3 (p <0.001 TCC vs. HS). Mean±SD daily steps HS vs. TCC vs. shear walker: 4022±4652 vs. 1447±1310 vs. 1404±1234 (p = 0.014 HS vs. TCC, p = 0.007 HS vs. shear walker). Wounds healed per-protocol analysis HS vs. TCC vs. shear walker: 50.0% vs. 88.9% vs. 40.0% (p = 0.015 TCC vs. HS).	“[P]atients treated with TCCs had the highest proportion of healed wounds and fastest healing time.”	Diabetic population studied. Total contact cast associated with fastest healing time.
--------------------	-----	--	---	---	--	---

## FOOT WAFFLE SUPPORT BRACE

*Recommendation: Foot Waffle Support Brace*

**Foot Waffle Support Brace is not recommended for select patients with foot ulcers.**

*Strength of Evidence – Not Recommended, Insufficient Evidence (I)*

*Level of Confidence – Low*

*Rationale for Recommendation*

There is one low-quality RCT suggesting worse results with a foot waffle support brace compared with pillow support (Tymec 97) to attempt to reduce localized pressure. Foot waffle support braces are low cost, not invasive, but also do not appear effective and thus are not recommended.

*Evidence for the Use of the Foot Waffle Support Brace*

There is 1 low-quality RCT in Appendix 1. (Tymec 97)

### **Medications**

Antibiotics are indicated for most non-healing and/or infected ulcers. The antibiotic selection may require tailoring to anticipated organism(s) and are **Recommended, Insufficient Evidence (I)]** in workers.

### **GROWTH FACTORS (becaplermin, autologous plasma concentrate, topical nerve growth factor, topical basic fibroblast growth factor)**

Growth factors have been used for treatment of chronic ulcers, including platelet-derived Becaplermin, autologous plasma concentrate, topical nerve growth factor, and topical basic fibroblast growth factor, Becaplermin is a cicatrizant, topical gel of platelet-derived growth factor especially used as an adjuvant to wound care for non-healing diabetic neuropathic ulcers. (Bhansali 09, Blume 11; Embil 00; Smiell 99;

Landsman 10; Kirsner 10; Millington 00; Ladin 00; Buchberger 11; Edmonds 00; Mulder 09; Lacci 10; Papanas 10; Sibbald 03; Papanas 07,08; White 09; Hardikar 05)

*1. Recommendation: Becaplermin (Regranex) for Select Non-healing Diabetic Neuropathic Ulcers*  
**Becaplermin is recommended as adjuvant therapy to wound care for select non-healing diabetic neuropathic ulcers.**

*Indications* – Non-healing diabetic neuropathic ulcers that extend at least into the subcutaneous tissue, have adequate blood supply. Should only be used in addition to debridement, pressure relief and infection control.

*Strength of Evidence* – **Recommended, Evidence (C)**

*Level of Confidence* – Low

*2. Recommendation: Autologous-derived Growth Factors for Select Non-healing Diabetic Ulcers*  
**Autologous-derived growth factors are recommended as adjuvant therapy to wound care with collagen and oxidized regenerated cellulose for select non-healing diabetic ulcers.**

*Indications* – Non-healing diabetic neuropathic ulcers of at least 4 weeks duration unresponsive to moist gauze treatment that extend at least into the subcutaneous tissue, have adequate blood supply. (Kakagia 07) Should only be used in addition to a dressing of collagen and oxidized regenerated cellulose, debridement, pressure relief, and infection control.

*Strength of Evidence* – **Recommended, Evidence (C)**

*Level of Confidence* – Low

*3. Recommendation: Topical nerve growth factors for Select non-healing diabetic ulcers*  
**Topical Nerve Growth Factors are recommended for select patients with foot ulcers.**

*Indications* – Foot ulcerations that are: (i) 1-30cm<sup>2</sup> (Landi 03) and (ii) either not healing after approximately 2-3 weeks, or occurring in those with high risk of complications (e.g., advanced diabetes mellitus with peripheral neuropathy; frail elderly with compromised immune, dermatological, vascular systems).

*Strength of Evidence* – **Recommended, Insufficient Evidence (I)**

*Level of Confidence* - Low

*Evidence for the use of Topical Nerve Growth Factors*

There is 1 low-quality RCT in Appendix 1. (Landi 03)

*4. Recommendation: Topical basic fibroblast growth factors for Select non-healing diabetic neuropathic ulcers*

**There is no recommendation for or against topical basic fibroblast growth factor for non-healing diabetic ulcers.**

*Strength of Evidence* – **No Recommendation, Insufficient Evidence (I)**

*Level of Confidence* - Low

*Rationale for Recommendations*

There are trials comparing becaplermin with placebo for adjuvant treatment of diabetic ulcers. (Steed 95, 06, Wiemann 98; Blume 11; Niezgoda 05; d-Hemecourt 98; Bhansali 09) While the trials often have methodological weaknesses, they overall appear to be associated with modestly superior wound healing rates. Becaplermin is non-invasive, has some adverse effects, is labor-intensive and is high cost; however, in select circumstances is recommended as an adjuvant to good ulcer care to speed healing.

There is one moderate-quality trial suggested faster resolution of a diabetic ulcer with a combination of autologous-derived growth factors plus collagen and oxidized regenerated cellulose for select non-healing diabetic neuropathic ulcers. (Kakagia 07) This combination therapy is non-invasive, has some adverse effects, is labor-intensive and is high cost, however, in select circumstances is recommended as an adjuvant to speed healing.

One low-quality randomized controlled trial assessing topical nerve growth factor (TNGF) suggested fairly strong efficacy. (Landi 03) Topical Nerve Growth Factors are not invasive, has adverse effects and is costly, but is recommended for select patients. There is one low quality trial regarding topical basic fibroblast growth factor and thus insufficient evidence for a recommendation.

*Evidence for the Use of Growth Factors*

There are 17 moderate-quality RCTs incorporated into this analysis. (Blume 11; Wieman 98; Niezgod 05; Steed 06; d’Hemecourt 98; Hardikar 05; Bhansali 09; Fernandez-Montequin 09; Uchi 09; Viswanathan 06; Kusumanto 06; Lyons 07b; Fife 07; Brgido 06; Reyzelman 09; Purandare 07; Kakagia 07) There are 7 low-quality RCTs (Steed 95; Landi 03; Huang 14; Akbari 07; Eginton 03; Landsman 10; Richard 95) and 1 other study (Lyons 07) in the Appendix.

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
<b>Becaplermin</b>						
Blume 2011 RCT  No mention of sponsorship. COI: GAM501 and FCG are products in development by Cardium Therapeutics Inc., Lois A. Chandler is an employee of and owns stock options in Cardium Therapeutics, Inc. Robert L. Engler is a Consultant to and owns stock options in Cardium	7.0	N = 129 patients with Wagner Classification Grade 1 cutaneous lower extremity ulcer between 1.5 and 10.0cm <sup>2</sup> ; mean age 56.9 years.	GAM501 Group-Ad5PDGF-B (Becaplermin) combined with Formulated Collagen Gel-Sub group, one treated at week 1, group 2 treated at weeks 1 and 4. Data analysis combined both groups (n = 72) vs. Formulated Collagen Gel (FCG) Group-Sub group, one treated at week one, group two treated at weeks 1 and 4. Data analysis combined both groups (n = 33) vs. Standard of Care (SOC)	No significant difference for ulcer closure incidences between groups 31% in SOC, 45% in FCG and 41% in GAM501 (p >0.05). All groups showed significant increase in cumulative wound healing rates (decrease in radius of ulcer) from week 2 on compared to baseline. FCG showed a significant decrease in radius size vs. SOC from day 1 to week 1; 1.97 mm/week vs. 0.78 mm/week (p <0.05) and from day 1 to week 2; 1.37 vs. 0.63 (p <0.05). GAM501 did not show significant differences compared to SOC.	“We conclude from this exploratory trial that a single application of GAM501 or FCG increases the healing rate of neuropathic DFUs for the first two weeks after treatment; whereas SOC with weekly visits seems to have a much smaller and delayed effect on wound healing rate.”	At 1 week GAM501 and Formulated Collagen Gel improved healing rates vs. standard of care control.

Therapeutics. Barbara K. Sosnowski is a named inventor of an applicable patent and currently an employee of Pfizer. Other authors were principal investigators and have no financial relationship with Cardium Therapeutics.			Group (n = 19).  Follow-up for 12 weeks.			
Wieman 1998  RCT  No mention of sponsorship. COI: T.J.W has served as a member of an advisory group for and has received research support and honoraria for speaking from Johnson & Johnson. TJW, JMS and YS hold stock in Johnson & Johnson.	6.5	N = 382 patients with type 1 or 2 diabetes and chronic low-extremity ulcers; mean age 58 years.	Becaplermin Gel 30 group: 30µg/g of 0.01% Regranex gel (n = 132) vs. Becaplermin Gel 100 group: 100µg/g of 0.01% Regranex gel (n = 123) vs. Placebo Group- Identical to vehicle component of gel with active drug, however it was saline. (n = 127).  Follow-up for 20 weeks.	The 100 group showed a 50% incidence of complete healing at week 20 vs. 35% in placebo (p = 0.007) and 36% in the 30 group (p <0.05). The 100 group also showed a significantly decreased time to achieve complete healing vs. placebo; 86 days vs. 127 days (p = 0.013).	“Becaokernub gel 100 µg/g, in conjunction with good wound care, significantly increased the incidence of complete wound closure and significantly reduced the time to complete closure of chronic diabetic neuropathic ulcers.”	Phase 3 trial suggesting becaplermin 100µg/g associated with better wound healing than placebo or beclaplermin 30µg/g.
Niezgoda 2005	5.5	N = 90 patients with at least 1	OASIS Wound Matrix Group: an acellular	At 12 week follow-up 18 (49%) in OASIS group were	“In this study, OASIS was as effective as	Open label, unblinded. Wound care

<p>RCT</p> <p>No mention of sponsorship or COI.</p>		<p>diabetic foot ulcer; mean age 57.6 years.</p>	<p>biomaterial derived from pig small intestine submucosa in combination with standard care. (n = 50) vs. Regranex Group- Regranex with a secondary dressing and standard care. (n = 48).</p> <p>Follow-up for 12 weeks.</p>	<p>considered healed vs. 10 (28%) patients in Regranex group (p = 0.055). In subgroup analysis, OASIS showed a significantly higher number of healed ulcers vs. Regranex for Plantar Ulcers; 14 (52%) vs. 3 (14%) (p = 0.14) and for Type 2 Diabetes; 12 (63%) vs. 8 (29%) (p = 0.034). There were 17 Complications/Adverse Events in OASIS group vs. 10 in Regranex group (p &gt;0.05).</p>	<p>Regranex Gel in treating full-thickness diabetic foot ulcers and appears to be a viable treatment option for these patients.”</p>	<p>differed between groups. Baseline comparability in DM differed of unclear significance. Substantiation of blinding unclear. Patients followed up to 12 weeks, and given option of cross-over treatment if healing did not occur. Significantly more patients in OASIS group (49%) had type 1 diabetes than in Regranex Gel group (22%) (p = 0.018).</p>
<p>Steed 2006</p> <p>RCT</p> <p>No mention of sponsorship or COI.</p>	<p>5.5</p>	<p>N = 118 with chronic, full-thickness, lower-extremity diabetic neurotrophic ulcers of at least 8 weeks. Pooled from 10 centers. Mean age not provided.</p>	<p>PDGF group- rhPDGF-BB (Becaplermin) gel applied at dose equivalent to 2.2 micrograms until completely healed, or 20 weeks (n = 61) vs. Placebo Gel Group- Saline Gel (n = 57).</p>	<p>Healing rates in gel group vs. placebo group at 6 weeks: 29 (48%) vs. 14 (25%); p = 0.01).</p> <p>Median reduction in wound area gel vs. placebo group: 98.8% vs 82.1%; p = 0.09.</p>	<p>“PDGF applied once daily was effective in healing chronic diabetic neurotrophic foot ulcers when used in conjunction with good wound care.”</p>	<p>High dropout rate. PDGF effective vs. placebo for healing ulcer rate.</p>

<p>d'Hemecourt 1998</p> <p>RCT</p> <p>No mention of sponsorship or COI.</p>	<p>5.0</p>	<p>N = 172 patients with type 1 or 2 diabetes and chronic lower extremity diabetic ulcers. All received sharp debridement of ulcer; mean age 58.3 years.</p>	<p>Wound Care Group- good wound care alone – Sharp debridement of ulcers to remove calluses, fibrin and necrotic tissue (n = 68) vs. NaCMC Group- good wound care plus NaCMC gel (n = 70) vs. Becaplermin Group- 100µg/g of 0.01% Regranex gel plus good wound care (n = 34). Follow-up for 20 weeks.</p>	<p>22% of Patients in the wound care alone group achieved complete wound closure at 20 weeks compared to 36% of NaCMC group and 44% of the Becaplermin group. Mean time to achieve complete closure was 85 days in the Becaplermin group, 98 days in the NaCMC group and &gt;141 days in the wound care group. P-values not given.</p>	<p>“In conclusion, the results presented here demonstrate that treatment with NaCMC gel does not impact wound healing negatively; NaCMC gel may have a beneficial effect on wound healing when compared with good wound care practice alone in patients with chronic diabetic ulcers of the lower extremity.”</p>	<p>High dropout rate. P-values not provided and statistics not clear whether there was a significant relationship or not. Appears to show comparable results.</p>
<p>Hardikar 2005</p>	<p>5.0</p>	<p>N = 111 with type 1 or 2 diabetes mellitus, 18-80 years, &lt;3 full-thickness chronic neuropathic ulcers of at least 4 weeks duration on lower extremity (Stages III-IV). Mean±SD age 54.5±9.9 (placebo group) and 54.7±9.0 years (treatment group).</p>	<p>Placebo gel (n = 58) vs. rhPDGF-based gel (n = 53). Both used 1.5mm layers of gel and covered with moist saline gauze. Dressings changed daily.</p> <p>Follow-up for 20 weeks.</p>	<p>Complete healing (achieving a functional score of 1) reported at end of 10 weeks: 71% (39/55) rhPDGF group vs.31% (18/58) placebo group, p &lt;0.001). At 20 weeks: 85% (47/55) vs. 53% (31/58), p &lt;0.05.</p>	<p>“[T]he efficacy assessed at 10 weeks in the present study showed that rhPDGF-based gel healed a greater percentage of patients and also healed patients faster and caused a greater reduction in the ulcer size than placebo.”</p>	<p>Pragmatic RCT. Treatment administration not standardized. At 10 weeks, (39/55), 71% of rhPDGF had complete ulcer healing compared to (18/51) 31% in the placebo group. At 20 weeks, (47/55) 85% had complete ulcer healing compared to 31/58 (53%) in the</p>

						placebo group.
Bhansali 2009  Prospective RCT  No mention of sponsorship. No COI.	4.5	N = 20 patients with at least one neuropathic plantar ulcer of Wagner's grade $\geq 2$ ; mean age 50.6 years.	Platelet-derived growth factor group (PDGF): A rh-PDGF-BB (Becaplermin) 0.01% Regranex gel (n = 10) vs. Standard Wound Care group (SWC) moist saline used (n = 10).  Follow-up at 30, 60, 90, 120 and 150 days.	Mean duration of healing target ulcers 50.10 days in PDGF group and 86.10 days in SWC group; a 41.8% reduction in favor of PDGF group (p <0.02). Ulcers completely healed by 90 days in PDGF group vs. 120 days in SWC group (p <0.05). Reduction of size of ulcer did not show significant difference between groups.	"In conclusion, the results of this study suggest that within the setting of TCCoff-loaded patients with diabetic neuropathic large plantar ulcers, short-term use of rh-PDGF-BB gel reduced the time to complete healing considerably compared to SWC."	Small sample size (n = 20). Baseline wound size not comparable. Short-term use of PDGF-BB gel associated with increased wound healing vs. SWC by 30 days.
<b>Autologous-derived growth factors</b>						
Uchi 2009  RCT  Supported by Kaken Pharmaceutical Co. Ltd. No mention of COI.	6.5	N=150 with non- ischaemic diabetic ulcers measuring $\leq 900$ mm <sup>2</sup> .	Placebo group (n = 51) vs. 0.001% bFGF group (n = 49) vs. 0.01% bFGF group (n = 50).  Follow-up for 8 weeks.	Area of ulcer decreased by $\geq 75\%$ : 57.5% (27/47) vs. 72.3% (34/47) vs. 82.2% (37/45) in the placebo, 0.001% bFGF and 0.01% bFGF groups, respectively (p = 0.025 between the 0.01% bFGF and placebo groups).	"The findings obtained in this trial showed wound healing accelerating effects of bFGF on diabetic ulcers."	Data suggest a dose-response relationships suggesting potential efficacy.
Fernandez-Montequin 2009  RCT  Sponsored by The Ministry of Public Health of Cuba. C.V.S. and P.A.L.S. are employees of the Centre for Biological Research,	6.5	N = 149 with Wagner's grade 3 or 4 diabetic foot ulcers (DFUs). Age $\geq 18$ years old.	Group I received rhEGF 75 $\mu$ g, 3 times per week (n = 53) vs. Group II received rhEGF 25 $\mu$ g, 3 times per week (n = 48) vs. Group III or placebo administered together with standardized good wound care, 3 times	Ulcer closure occurred in 41 (77.4%), 25 (52.1%) and 27 (56.2%) from I, II and group III, respectively, (p = 0.018).  The granulation tissue covering $\geq 50\%$ of ulcer at 2 weeks; achieved by 19/48 controls vs 44/53 in 75 $\mu$ g group, OR = 7.5; 95% (CI) 2.9-18.9 vs. 34/48 in 25 $\mu$ g	"It was concluded that recombinant human EGF (rhEGF) local injections offer a favourable risk-benefit balance in patients with advanced DFU."	Wagner's 3 or 4. High dropouts. Data suggest efficacy.

.B.A. works at CIGB itself and is author of patent that sustains project. J.I.F.M. is also coauthor.			per week (n = 48).  Follow-up for 3, 6 and 12 months.	group, OR = 3.7, 1.6-8.7.		
Viswanathan 2006  RCT  Sponsored by Bharat Biotech International Limited. No mention of COI.	5.0	N = 60 with target ulcers no less than 2 cm and no more than 50 cm <sup>2</sup> in area. Ages of 18 and 65 years.	Treatment group or rhEGF 30-g tubes twice daily until wound healed or until end of study (n = 30) vs. Placebo tubes water based and did not include active ingredient, twice daily (n = 29). Follow-up for 15 weeks.	90% of ulcers healed in 15 weeks vs. 22 weeks in the control group. Chances of non-healing within 15 weeks 14% in test group and 50% in control.  Those with an ulcer area >6 cm in test group exhibited better healing vs. control (p <0.002).	“This phase III multicenter study established the safety and efficacy of rhEGF formulated gel and found the gel healed diabetic foot ulcers faster than treatment with placebo.”	Phase 3 trial. Study group exhibited quicker healing times compared with placebo.
Kusumanto 2006  RCT  Sponsored by Fornix BioSciences. No mention of COI.	5.0	N = 54 with diabetic foot ulcers and/or rest pain >2 weeks, failure of conventional treatment, serious limb ischemia, type 1 or 2 diabetes; Mean age 68.4 for control group and 68.7 for phVEGF group.	Control group (n = 27) vs. Vascular endothelial growth factor (2000 µg; phVEGF <sub>165</sub> ) treatment group (n = 27).  Both groups received their allocated treatment at baseline and 28 days.  Assessments at baseline, 7, 14, 35, 42, 72 and 100 days.	At final assessment, phVEGF group had significantly higher percentage of hemodynamic improvement and improvement in skin ulcer vs. control group; hemodynamic – 33% vs. 6%, (p = 0.05). Ulcer improvement – 33% vs. 0%, (p = 0.01).	“[W]e did not meet the primary end point of a reduced amputation rate. We did, however, demonstrate that intramuscular injections of the naked plasmid DNA encoding VEGF165 (phVEGF165) significantly improved wound healing and reduced hemodynamic insufficiency compared with placebo. Importantly, in the responders these clinical	Longer ulcer duration in controls (5 vs. 3 months). No difference in amputations . Some data favor growth factor.

					improvements resulted in improved physical functioning (mobility, and daily activities such as washing, dressing, and cleaning) and improved social functioning as detected by the RAND-36 questionnaire for QOL. Therefore “response” as defined in this study seems to be a meaningful notion.”	
Lyons 2007 RCT  Sponsored by Agennix, Inc. and the National Institute of Arthritis and Musculoskeletal and Skin Diseases of the National Institute of Health.	5.0	N = 46 with diabetes mellitus HbA <sub>1c</sub> 6-13%, full thickness diabetic foot ulcer below that ankle that has not reduced in size ≥30% in past 4 weeks with typical treatments, post debridement size between 0.5 to 10 cm <sup>2</sup> , transcutaneous oxygen tension ≥30mm Hg or ankle-brachial index ≥0.7; Mean (±SD) age 58 (±10) for	2.5% Talactoferrin gel group (n = 15) vs. 8.5% Talactoferrin gel group (n = 15) vs. Placebo gel group (n = 16).  Groups instructed to apply gel twice daily to ulcer for 12 weeks alongside typical wound care.  Assessments at baseline, 30 days, 90 days and 180 days.	50% of participants in treatment groups reduced ulcer size ≥75% compared to 25% of participants in placebo group, approaching significance (p = 0.091). No statistically significant differences reported between varying percentages of talactoferrin gel.	“[T]alactoferrin was a safe and well-tolerated treatment of diabetic neuropathic foot ulcers without associated adverse events or laboratory abnormalities. In addition, talactoferrin enhanced the rate of healing in these ulcers. A phase 3 will be required to confirm these results.”	Study Phase 2- same article as above. Small samples. High dropouts. Data suggest no differences in healing during treatments – modest differences appeared later.

		2.5% gel group, 53 ( $\pm 15$ ) for 8.5% gel group and 56 ( $\pm 14$ ) for placebo gel group.				
Fife 2007 RCT  Sponsored by Chrysalis BioTechnology Inc., Galveston, TX, a spinout of UTMB, Galveston. Dr. Carney's research related to this technology are monitored and managed by UTMB Conflicts of Interest Committee.	5.0	N = 60 with diabetic foot ulcers. Median age for the saline placebo, 1, and 10mg groups were 54.7, 59.6, and 53.7.	1 mg Chrysalin® twice weekly for up to 20 weeks or until ulcer reached complete closure, Bandages removed during twice-weekly visits for evaluation (n = 20) vs. 10mg Chrysalin® twice weekly for up to 20 weeks (n = 18) vs. Saline twice weekly for up to 20 weeks (n = 21).  Follow-up for up to 20 weeks.	ITT population, 61% (11/18) of ulcers treated at 10mg dose achieved complete closure vs 52% (11/21) in 1mg dose and 48% (10/21) in saline-treated group.  In PP population, incidence of complete ulcer closure was 57% (8/14) for 10mg dose, 45% (5/11) for 1mg dose and 33% (5/15) in saline placebo. Median time to 80% closure of 32 days for 10mg dose, 47 days for 1mg dose, and 57 days for saline control.	"These results indicate the potential safety and efficacy of Chrysalin® for treatment of diabetic foot ulcers."	Phase 1/2 study report. High dropouts. Data suggest efficacy.
Reyzelman 2009 RCT  Supported by Wright Medical Technology, Inc. (Arlington, TN). Support included compensation to study personnel, providing AM therapy	4.5	N = 86 patients with diabetes and University of Texas (UT) grade 1 or 2 ulcer. Mean Age was 56.3 years.	Study Group- received single application of human acellular dermal regenerative tissue matrix graft (n = 47) vs. Control Group: standard wound care management (n = 39).  Follow-up for 12 weeks.	There was a significantly higher rate of complete ulcer closure in study group compared to control group; 32/46 69.6% vs. 18/39 46.2% (p = 0.0289). No significant difference between groups for time it took to completely heal; 5.7 weeks vs. 6.8 weeks (p >0.05).	"The results of this prospective, randomised, multicentre study indicate that diabetic foot ulcers treated with AM therapy have a two to three times higher probability of healing compared with those with standard of	Data suggest efficacy.

at no charge and statistical analysis. DGA and Orthopaedic Research & Reporting, Ltd received research funding from Wright Medical Technology, Inc.					care management.”	
Brigido 2006  RCT  No mention of sponsorship or COI.	4.5	N = 28 diabetic patients with full-thickness wounds for at least 6 weeks. Mean age for Graftjacket / and Debridement group: 61.43 (7.18) / 66.21 (4.37).	A single application of Graftjacket tissue matrix, plus mineral oil-soaked fluff compression dressing (n = 14) vs. Control treatment of wound gel with gauze dressings (n = 14).  Follow-up for 16 weeks.	12/14 patients treated with Graftjacket were healed by 16 weeks and only 4/14 patients in the control group.  Average time to heal 11.92 weeks and 13.50 weeks for control group.  Final ulcer area / depth / volume and number of ulcers healed in favor of Graftjacket, (p ≤0.001).	“Patients with chronic ulcers of various aetiologies who were treated with Graftjacket, a human acellular regenerative tissue matrix, showed a statistically significant higher percentage of wound closure by week 16 than the patients treated with sharp debridement only.”	Pilot study. Data suggest efficacy.
Kakagia 2007  RCT  No mention of sponsorship or COI.	4.0	N = 54 diabetics with foot ulcers, or soft tissue defects, present >3 months; Mean (±SD) age 58 (±10) for group A, 57 (±12) for group B and 61 (±9) for group C	Promogran only group (n = 18) vs. Autologous growth factors group (n = 18) vs. both Promogran and autologous growth factors group (n = 18).  All groups received treatment for 8 weeks.	Both promogran and autologous growth factors treatment group demonstrated significantly greater reduction in all dimensions of wound compared to other two groups, (p <0.001).	“[W]e have shown that dressing nonhealing diabetic foot ulcers with modulators of the wound environment in combination with the administration of autologous growth factors significantly accelerates the healing rate. It is suggested that	Data suggest combination therapy superior and no differences between individual treatments.

			Assessments at baseline and 8 weeks.		rebalancing of the wound microenvironment by using dressings that inhibit proteases should initiate the repair process and increases the healing potential of autologous growth factors.”	
Purandare 2007  RCT  No mention of sponsorship or COI.	4.0	N = 50 patients with diabetic foot ulcers greater than 4 cm in diameter. Mean age was 56.29 years	Group A: Study drug (Tinospora cordifolia) administered in prepackaged numbered bottles for 1 month (n=25) vs. Group B- Placebo- same timeline with same medical treatment as well (n = 25).  Follow-up for 3 months.	Seventeen patients in study group improved (73.9%) compared to 13 patients in the placebo group (59.1%), this difference was not significant between groups (p = 0.292). There was no significant difference between group A and B for mean change in wound severity score; 14.39 vs. 10.59 (p = 0.149), or change in mean ulcer depth; 2.17 vs. 1.36 (p = 0.096).	“Diabetic patients with foot ulcers on T. cordifolia as an adjuvant therapy showed significantly better final outcome with improvement in wound healing. Reduced debridements and improved phagocytosis were statistically significant, indicating beneficial effects of immunomodulation for ulcer healing.”	Sparse data. Non-significant results.

### GRANULOCYTE COLONY-STIMULATING FACTOR

Granulocyte colony-stimulating factor (GCSF) is a glycoprotein cytokine that stimulates the formation of granulocyte cell colonies in bone marrow. Although expensive, GCSF can be used to improve neutrophil function in those with infected diabetic foot ulcers. (Papanas 07, Edmonds 00; Viswanathan 03; Papanas 07, Cruciani 05, Nelson 06, Peters 12, Nelson 06, Bennett 03, Reed 04) A systematic review of the literature concluded GCSF lacks evidence for its use. (Cruciani 13)

*Recommendation: Granulocyte Colony-Stimulating Factor*

**Granulocyte colony-stimulating factor is recommended for treatment of particularly challenging diabetic foot ulcers.**

*Indications* – At least moderate sized ulcers (0.5-3cm) with neuropathy (Kästenbauer 03), threatening amputations (De Lalla 01) and/or extensive cellulitis. (Gough 97)

*Strength of Evidence* – **Recommended, Insufficient Evidence (I)**  
*Level of Confidence* - Low

*Rationale for Recommendation*

Overall literature is relatively sparse and somewhat conflicting, yet the higher quality studies suggest efficacy. One study suggested C-SCF was associated with faster reductions in pathogens, (Kästenbauer 03) one study found shortened hospital stays (Gough 97) and another found fewer amputations. (De Lalla 01) Yet, another found no reduction in hospital stays. (Yönem 01) While there is somewhat conflicting literature, the higher quality literature suggests efficacy, thus G-CSF is recommended on a highly select basis for treatment of particularly difficult diabetic foot ulcers.

*Evidence for the Use of Granulocyte Colony-stimulating Factor*

There are 4 moderate-quality RCTs incorporated into this analysis. (Kastenbauer 03; Gough 97; DeLalla 01; Yonem 01)

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Kästenbauer 2003  RCT  No mention of sponsorship or COI. Amgen Austria provided funding for Neumann who assisted in monitoring and analyzing the study.	6.5	N = 37 diabetic patients with moderate sized (diameter 0.5 – 3 cm) infected neuropathic (abnormal 10g-monofilament test) foot ulcer of Wagner's grade 2 or 3. Mean age G-CSF 60.8±11.1 years, placebo 58.2±8.1 years.	G-CSF 5µg/kg injected subcutaneously, stopped if neutrophil count >50.000/l and leukocyte count >75.000/l (n = 20) vs. placebo, 0.9% sterile saline injected subcutaneously (n = 17) for a 10 day in-hospital stay. All patients put on bed rest and treated with i.v. antibiotics (clindamycin and ciprofloxacin) until inflammation improved.	Mean±SD leukocyte count (10 <sup>9</sup> xL <sup>-1</sup> ) at day 10: G-CSF 40.8±16.3 vs. placebo 9.3±8.3 (p = 0.00005).	"[A]ntibiotic and non-weight-bearing therapy (bed rest) accelerated the resolution of cellulitis in infected foot ulcers. Additional treatment with G-CSF had no further beneficial effect."	Small sample size. G-CSF associated with pathogen reduction faster than placebo leading to earlier resolution of cellulites.
Gough 1997  RCT  No mention of sponsorship. COI, Gough was supported by a grant from	6.0	N=40 diabetic patients with extensive cellulitis (acute spreading skin infection with involvement of subcutaneous tissues, characterize	G-CSF: initial dose of 5µg/kg daily and then lowered to 2.5µg/kg daily after 2 doses if neutrophil count higher than 25x10 <sup>9</sup> /L and stopped if neutrophil >50x10 <sup>9</sup> /L (n = 20) vs. placebo, saline (n = 20)	Median time to hospital discharge (days): G-CSF 10 vs. placebo 17.5 (p = 0.02). Median time to resolution of cellulitis (days): G-CSF 7 vs. placebo 12 (p = 0.03). Median time to withdrawal of intravenous antibiotics (days):	"This study showed that in diabetic patients with foot infection G-CSF treatment significantly accelerated resolution of cellulitis, shortened hospital stay, and	Small sample size. G-CSF shortened hospital stay, accelerated wound healing (cellulitis), and decreased antibiotics. The mechanism may be

Amgen Ltd, CA, USA.		d by erythema in association with purulent discharge with or without lymphangitis) . Mean age G-CSF 65 years, placebo 66 years.	daily as an injection for 7 days. All patients received 4 antibiotics (ceftazidmine, amoxicillin, flucloxacillin, and metronidazole) intravenously until cellulitis and ulcer discharge resolved. Patients followed until resolution of infection and discharge from hospital.	G-CSF 8.5 vs. placebo 14.5 (p = 0.02). Median time to negative swab culture (days): G-CSF 4 vs. placebo 8 (p = 0.02).	decreased antibiotic requirements. ”	related to increases in neutrophil superoxide production.
De Lalla 2001  RCT  No mention of sponsorship or COI.	4.5	N = 40 adult diabetic patients with limb-threatening infection (full-thickness ulcer, >2cm of cellulitis with or without lymphangitis, bone or joint involvement, and systemic toxicity). Mean age G-CSF 56.6±8.6 years, control group 59.8±9.6 years.	Conventional treatment: local treatment (debridement, daily inspection, cleaning with sterile water, disinfection with povidone iodine, surgical removal of necrotic tissues, and occlusive dressing of foot lesions, oral ciprofloxacin 750mg 2x/day plus clindamycin 300mg 4x/day) plus systemic antibiotic therapy (n = 20) vs. conventional treatment plus systemic antibiotic therapy plus glycosylated recombinant human granulocyte colony-	NS between groups for bacterial species or number of isolates per species. Mean±SD neutrophil counts: G-CSF 25,200±3,500 vs. control 6,500±4,400 cells/mm <sup>3</sup> (p=0.002). Amputations at 9 weeks: G-CSF 3 vs. control 9 (p=0.038)	“[T]he administration of G-CSF for 3 weeks as an adjunctive therapy for limb-threatening diabetic foot infection was associated with a lower rate of amputation within 9 weeks after the commencement of standard treatment.”	Relatively small sample size. Comparable results in, both conventional therapy and G-CSF group. At 6 months the G-CSF group had fewer amputations (3) vs. (9) in the conventional treatment group.

			stimulating factor (G-CSF) subcutaneously 263µg daily for 21 days (n = 20). Assessments weekly first 21 days and every 2 weeks for 6 weeks following. Follow-up for 6 months.			
Yönetim 2001  RCT  No mention of sponsorship or COI.	4.5	N = 30 diabetic patients with pedal cellulitis or Wagner's grade 2 or less lesion on their feet. Mean age G-CSF group 60.3±1.3 years, standard group 61.0±1.4 years.	Standard treatment: local wound care and parenteral antibiotherapy, ciprofloxacin and metronidazole intravenously (n = 15) vs. G-CSF 5µg/kg subcutaneously daily and stopped if neutrophil count >45x10 <sup>9</sup> /l in addition to standard treatment (n = 15). Patients were followed until hospital discharge.	Mean±SD neutrophil count post-treatment: G-CSF group 48700±1000 vs. standard group 4800±300 (p <0.001).	"Although G-CSF improves neutrophil function as well as increasing the absolute numbers, this improvement is not associated with shortening of duration of antibiotic administration, duration of hospital stay or need for amputation in diabetic foot infection"	Small sample size (n = 30), appears to lack efficacy G-CSF increased neutrophil counts but was not associated with decreased antibiotic administration or shortened hospital stays.

### PROSTACYCLIN ANALOGUES (ILOPROST)

Prostacyclin analogues have been used to treat diabetic ulcers. (Sert 08)

*Recommendation: Prostacyclin Analogues (Iloprost) for Diabetic Ulcers*

**There is no recommendation for or against prostacyclin analogues (iloprost) for treatment of diabetic foot ulcers.**

*Strength of Evidence – No Recommendation, Insufficient Evidence (I)*

*Level of Confidence – Low*

*Rationale for Recommendation*

Prostacyclin analogues, including iloprost, have not been studied in quality studies and thus there is no recommendation.

*Evidence for the Use of Prostacyclin Analogues (Iloprost)*

There is 1 low-quality in the Appendix. (Sert 08)

## LOW-MOLECULAR WEIGHT HEPARINS

Low-molecular weight heparins have been used to treat diabetic foot ulcers. (Rullan 08)

*Recommendation: Low Molecular Weight Heparins for Diabetic Foot Ulcers*

**There is no recommendation for or against the use of low molecular weight heparins for treatment of diabetic foot ulcers.**

*Strength of Evidence – No Recommendation, Insufficient Evidence (I)*

*Level of Confidence – Low*

*Rationale for Recommendation*

There is one exploratory trial suggesting potential efficacy. Additional, confirmatory studies are needed before an evidence-based recommendation is made.

*Evidence for Low-Molecular Weight Heparins*

There is 1 exploratory RCT incorporated into this analysis. (Rullan 08)

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Rullan 2008  RCT  Supported by the Primary Health Care Management of Mallorca (Ib-Salut), Carlos III Health Institute (RedIAPP network RD06/0018), Ministry of Health, Public Health Research Fund (FIS) (grant PI: 02/1704) and Laboratorios Farmacéuticos Rovi, S.A., Spain. No COI.	8.0	N = 70 patients with diabetes and with a foot ulcer persisting for >3 months. Mean age 64.5 years.	Bemiparin Group- Administered at 3500 IU/day for first 10 days followed by 2500 IU/day for 3 months (n = 37) vs. Placebo Group: 0.2mL of isotonic saline administered for 3 months (n = 33).  Follow-up for 3 months.	Ulcer improvement rates at 3 months were significantly higher in the Bemiparin group compared to the Placebo group; 26/37 70.3% vs. 15/33 45.5 %, (p = 0.035). There was not a significant difference between the two group for complete healing rates Bemiparin vs. Placebo; 35.1% vs. 33.3% (p=0.874). In the subgroup of Wagner grade II ulcers Bemiparin showed a significantly higher rate of complete healing compared to placebo; 50% vs. 0% (p=0.047).	“[T]his exploratory trial provides a ‘proof of concept’ of the potential usefulness of bemiparin in the treatment of diabetic foot ulcers.”	“Exploratory trial.” Data suggest efficacy.

## COMPLEMENTARY AND ALTERNATIVE MEDICATIONS

Herbal products have been used to treat diabetic foot ulcers. (Leung 08)

*Recommendation: Complementary and Alternative Medications for Diabetic Foot Ulcers*

**There is no recommendation for or against the use of complementary and alternative medications for treatment of diabetic foot ulcers.**

*Strength of Evidence – No Recommendation, Insufficient Evidence (I)*

*Level of Confidence - Low*

*Rationale for Recommendation*

Complementary and alternative medications have not been studied in quality studies and thus there is no recommendation for their use.

*Evidence for the Use of Complementary and Alternative Medications*

There are 3 low-quality RCTs in the Appendix. (Leung 08; Larijani 08; Bahrami 08)

## HYPERBARIC OXYGEN

Hyperbaric oxygen (HBO) has been used to treat diabetic foot ulcers. (Duzgun 08; Löndahl 10; Stoekenbroek 14)

*Recommendation: Hyperbaric Oxygen for Diabetic Foot Ulcers*

**Hyperbaric oxygen therapy is recommended for treatment of diabetic foot ulcers.**

*Indications – Wagner’s 2, 3, 4 foot ulcer(s) of more than 3 months duration. (Löndahl 10)*

*Frequency – HBOT was used in one quality trial; regimen was 100% O<sup>2</sup>, 5min compression, 2.5 atmospheres for 85 min., 5min decompression. Treatments 5 days per week for 8 weeks. May extend to 10 weeks; maximum 40 treatments. (Löndahl 10)*

*Strength of Evidence – Recommended, Evidence (C)*

*Level of Confidence – Low*

*Rationale for Recommendation*

Hyperbaric oxygen therapy has been evaluated in one moderate-quality trial. Data suggest substantially improved rates of healing. (Duzgun 08; Löndahl 10) HBO is not invasive, usually has low adverse effects, and is costly, but it is recommended for treatment of select diabetic foot ulcers.

*Evidence for the Use of Hyperbaric Oxygen*

There is 1 moderate-quality RCT incorporated into this analysis. (Londahl 10) There are 2 low-quality RCTs in the Appendix. (Wang 09; Duzgun 08)

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Löndahl 2010  RCT  Sponsored by Thelma Zoegas Foundation, Region	7.5	N = 94 with grade 2, 3, or 4 Wagner rated ulcers below foot lasting >3 months, diabetes, previous treatment at diabetes foot	HBOT (100% O <sup>2</sup> , 5min compression, 2.5 atmospheres 85 min., 5min decompression) vs. hyperbaric air treatments 5 days/week for 8 weeks. Treatment	Ulcer healing in 25/48 (52%) HBOT vs. 12/42 (29%) in sham group, p = 0.03. Sub analysis of those completing >35 sessions showed HBOT	“...[A]djuvative treatment with HBOT facilitates healing of chronic foot ulcers in selected patients with diabetes.”	Sham hyperbaric air. Data suggest NNT 3-4 to prevent non-healing ulcer with HBO.

Skane Foundation and medical faculty of Lund University. No COI.		clinic <2 months; Mean age 69 for HBOT group; 68 for placebo group.	adjunctive to infection treatment, revascularization, off-loading, metabolic control.	vs. placebo group healing at 1 year: 61% vs. 27%, (p = 0.009).		
--	--	---	---	--	--	--

## EXTRACORPOREAL SHOCK WAVE THERAPY

Extracorporeal shock wave therapy (ESWT) has been used to treat diabetic foot ulcers. (Rullan 08; Sert 08)

*Recommendation: Extracorporeal Shock Wave Therapy for Diabetic Foot Ulcers*

**Extracorporeal Shock Wave Therapy is not recommended for treatment of diabetic foot ulcers.**

*Strength of Evidence – Not Recommended, Evidence (C)*

*Level of Confidence - Low*

### *Rationale for Recommendation*

ESWT has been evaluated in a moderate-quality trial. Data do not show substantially improved rates of healing. ESWT is not invasive, has low adverse effects other than pain, but is costly and without clear evidence of benefit it is not recommended for treatment of diabetic foot ulcers.

### *Evidence for the Use of Extracorporeal Shock Wave Therapy*

There are 3 low-quality RCTs in the Appendix. (Moretti 09; Wang 09; Petrofsky 10)

### **Surgical Procedures**

Surgical debridement has long been used to treat lower extremity ulcers. It is indicated, particularly for devascularized, callus, wound edge tissue and foreign debris (Ottawa 14; Braun 14; Caputo 08) and is **Recommended, Insufficient Evidence (I)** in workers.

## **TISSUE-ENGINEERING TECHNIQUES (including skin sheets, fibroblast-derived dermis and skin grafts)**

Cultured sheets of allogeneic keratinocytes have been used to treat diabetic foot ulcers (You 12; Moustafa 07). Tissue engineered grafts have also been used with products including Graftskin™/Apligraf™, Dermagraft®, and Hyalograft-3D.™ (Falanga 98, Veves 01, Teng 10)

### *1. Recommendation: Tissue-engineered Skin Grafts for Non-healing Diabetic Ulcers*

**Tissue-engineered skin grafts are moderately recommended for highly select non-healing diabetic neuropathic ulcers.**

*Indications* – Non-healing diabetic neuropathic ulcers at least 1cm<sup>2</sup> that extend at least into the subcutaneous tissue, have adequate blood supply and lasting at least 14 days. Should only be used in addition to debridement, pressure relief and infection control. (Edmonds 09; Sams 02)

*Strength of Evidence – Moderately Recommended, Evidence (B)*

*Level of Confidence – Moderate*

### *2. Recommendation: Sheets of Cultured Allogeneic Keratinocytes for Non-healing Diabetic Ulcers*

**Sheets of cultured allogeneic keratinocytes are recommended for select non-healing diabetic ulcers.**

*Indications* – Non-healing diabetic ulcers of at least 1cm<sup>2</sup> size, Wagner 1 or 2, transcutaneous oxygen of at least 40mmHg that have not responded to 6 weeks of treatment. Should only be used in addition to debridement, systemic antibiotic(s), pressure relief, and infection control. (You 12)

**Strength of Evidence – Recommended, Evidence (C)**  
*Level of Confidence – Low*

*Rationale for Recommendations*

Multiple moderate-quality RCTs have evaluated efficacy of tissue engineered skin grafts of various compositions (Edmonds 09; Hanft 02; Sams 02) as adjuncts to wound care, all showing substantially better healing. Tissue grafts are not invasive, have low adverse effects, are costly but are recommended for select ulcers.

One moderate-quality trial found better healing using cultured allogeneic keratinocytes compared to Vaseline gauze (You 12). This is a non-invasive treatment with low adverse effects, high cost but with significant evidence of efficacy and this thus recommended for highly select patients.

*Evidence for the Use of Skin Grafts*

There are 11 moderate-quality RCTs incorporated into this analysis. (Edmonds 09; Hanft 02; Sams 02; You 12; Caravaggi 03; Uccioli 11; Gentzkow 96; Pollak 97; Veves 01; Han 10; Caputo 08) There are 2 low-quality RCTs in the Appendix. (Martson 03; Moustafa 07)

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
<b>Tissue Engineered Skin Grafts</b>						
Edmonds 2009  RCT  No mention of sponsorship. COI: Author has been reimbursed by Organogenesis, Inc., manufacturer of Apligraf Bi-Layered Cell Therapy, Bi-Layered Cell Therapy for attending conferences, and	6.0	N = 82 patients with ulcer of neuropathic origin; mean age 58.7 years.	Apligraf group: Apligraf placed directly on base of target ulcer (n = 40) vs. Control Group-standard therapy, treated with same primary and secondary dressings as apligraf group (n = 42).  Follow-up for 12 weeks.	There were more Apligraf patients who did not have debridement at week 1; (p = 0.001), and after week 4; (p = 0.0273). Shorter wound healing time in Apligraf group compared to control group; (p = 0.059). At 12 week follow-up 51.5% of Apligraf group had complete closure compared to 26.3% in control group (p = 0.049).	“The overall results suggest that Apligraf, in combination with debridement, standard wound care, and offloading, should be considered in treating patients with nonhealing neuropathic diabetic foot ulcers.”	Open label 1:1 prospective study.

received honoraria for providing clinical expertise in meetings with regulatory agencies.						
Hanft 2002  RCT  Sponsored by Advanced Tissue Science, Inc. No mention of COI.	5.0	N = 46 patients with type 1 or 2 diabetes and a plantar foot ulcer on the heel or forefoot; Mean Age; not provided.	HFDD group- application of Dermagraft at baseline and up to 7 additional applications throughout study (n = 24) vs. CT group- Control group with standard dressing application (n = 22). Follow-up for 12 weeks.	28 patients (14 each group) with ulcers of >6 weeks duration. HFDD group significantly greater number of complete wound closure vs. control group; 10 (71.4%) vs. 2 (14.3%) (p = 0.003). Time to complete wound closure significantly faster in HFDD group vs. control (p = 0.004).	“The results of this study suggest that the Dermagraft product is a safe and effective treatment for diabetic foot ulcers that are greater than 6 weeks' duration.”	Wound closure significantly better in HFDD group (71.4% vs. 14.3%, p = 0.003) and time to wound closure was better.
Sams 2002  RCT  Supported by Organogenesis, INC. No mention of COI.	4.0	N= 22 patients diabetes and foot ulcer longer than 2-weeks in duration; mean age 53.6 years.	Graftskin group: graft contoured to ulcer base during surgery (n = 9) vs. Control: aggressive debridement, dressing change 2x/day, custom-made tridensity pressure-relieving footwear (based on ADA recommended treatment for diabetic ulcers (n = 8). Follow-up for 6 months (weekly first 12 weeks).	No statistically significant differences between groups. Graft skin group showed complete healing in 56% of patients at 12 weeks compared to 38% in the control group. There were no significant differences between groups in baseline ulcer history. No significant adverse events were attributable to either treatment group.	“Graftskin application appears to reduce healing time in difficult to heal diabetes-related neuropathic foot ulcers. The ease of application is exceptional. In our study, no serious side effects were associated with Graftskin.”	17 treated due to 5 failing screening process after randomization. Small sample size (n = 17).
<b>Allogeneic keratinocytes vs. vaseline gauze</b>						

<p>You 2012 RCT</p> <p>No mention of COI. Sponsorship, supported by grants from Tego Science (Seoul, Korea).</p>	<p>6.0</p>	<p>N = 59 type 1 or 2 diabetes, foot ulcer &gt;1.0cm<sup>2</sup> that did not exhibit healing for 6 weeks, Wagner grade 1 or 2, and transcutaneous oxygen pressure ≥40mmHg. Mean±SD age 63.5±9.0 years (treatment) and 62.4±9.4 years (control).</p>	<p>Keratinocyte group (n = 27) vs. vaseline gauze (n = 32).</p> <p>Follow-up weekly until wound closure or week 12.</p>	<p>Mean percentages of wound area reduction: 100±0 vs. 85±65% in treatment and control groups, Respectively, p &lt;0.05.</p> <p>Complete wound healing: 85% of keratinocyte-treated group vs. 59% of control group, p&lt;0.05.</p>	<p>“These results indicate that cultured allogeneic keratinocytes may offer a safe and effective treatment for diabetic foot ulcers.”</p>	<p>No ITT analysis conducted. Keratinocyte group achieved 100% ulcer healing compared to control group (59%) at 12 weeks, p &lt;0.005.</p>
<b>Other Skin Graft</b>						
<p>Caravaggi 2003 RCT</p> <p>Supported by a grant from Fidia Advanced Biopolymers. No mention of COI.</p>	<p>5.0</p>	<p>N = 79 patients with diabetic foot ulcer either plantar or dorsal; Mean Age not reported.</p>	<p>Autologous graft treatment: patients received autologous fibroblasts on Gyalograft3D which was grafted onto ulcer (n = 43) vs. Control Group treated with nonadherent paraffin gauze and scheduled for same treatment as graft group (n = 36).</p> <p>Follow-up for 11 weeks.</p>	<p>At final follow-up 65.3% in treatment group showed complete healing vs. 49.6% in control group (p = 0.191). In dorsal subgroup, treatment group showed significantly higher odds ratio (95% CI) for complete healing vs. control; 4.44 (1.09-17.7, p = 0.037). Mean healing time 63 days in treatment group vs. 77 days in control group (p &gt;0.05).</p>	<p>“The results of this clinical study clearly show that the use of total offloading is so important to the tissue repair process in plantar ulcers that the efficacy of fibroblasts on Hyalograft3D and keratinocytes on Laserskin cannot be differentiated from control techniques.”</p>	<p>Open label. Data suggest improved healing in dorsal ulcers compared to standard care.</p>
<p>Uccioli 2011 RCT</p> <p>Supported by Anika Therapeutic</p>	<p>4.0</p>	<p>N = 160 patients with a diabetic ulcer without signs of healing for one month.</p>	<p>Treatment Group- Hyalograft 3D autograft, 2 weeks later, laserskin autograft was applied (n = 80)</p>	<p>No significant difference between treatment and control for ulcer healing at 12 weeks; 19 (24%) vs. 17 (21%) (p =</p>	<p>“[T]he results demonstrate the safety and effectiveness of autologous skin substitutes in the hard-to-</p>	<p>Pragmatic, open study. High dropout rate. Baseline comparability of initial</p>

s srl. No COI.		Mean Age; not reported.	vs. Control Group- nonadherent paraffin gauze with secondary dressing (n = 80).  Follow-up for 12 weeks.	0.85). Mean time to complete healing not significant between groups; 50 vs. 58 days (p = 0.253). A 50% reduction in ulcer area achieved significantly sooner in treatment vs. control; Mean 40 days vs. 50 days (p = 0.018). No significant differences in adverse events between groups.	heal diabetic dorsal foot ulcer population. The results permit the suggestion that such bioengineered substitutes are potentially useful in patients with hard-to-heal diabetic dorsal ulcers”	ulcer size is different between the groups. Data suggest moderate efficacy.
-------------------	--	----------------------------	---	---	--	--

**Dermagraft**

Gentzkow 1996  RCT  No mention of sponsorshi p. COI: GDG and SDI are employed by and hold stock in Advanced Tissue Sciences, Inc. DPS, S JL, JJP, JJR and KSH receive funds from Advanced Tissue Sciences, Inc. for their participatio n as clinical investigatio ns using Dermagraft to treat	5.0	N = 50 patients with Diabetic foot ulcers; Mean Age was 61.4 years.	Group A: One piece of dermagraft applied weekly for a total of 8 pieces (n = 12) vs. Group B- two pieces of Dermagraft applied every 2 weeks for a total of 8 pieces and 4 applications (n = 14) vs. Group C: One piece of Dermagraft applied every 2 weeks for a total of 4 pieces (n = 11) vs. Group D: Control group, conventional therapy and wound-dressing (n=13).  Follow-up for 12 weeks.	Complete closure was significantly higher in group A compared to the control group; a, b, c, d respectively, 50% vs. 21.4% vs. 18.2% vs. 7.7% (p = 0.03 for A vs. D). Median time for complete wound closure was 12 weeks in Group A and >12 weeks in the remaining groups. Median closure time in Group A vs. Group B (p = 0.056). Median time to 50% closure was 2.5 weeks in group A compared with >12 weeks in group D (p = 0.0047).	“This study has provided pilot evidence of effectiveness and has defined which treatment regimen should be used for pivotal studies of dermagraft as an active wound- healing agent for diabetic foot ulcers.”	Significant difference in mean age between groups.  Potential randomizati on failure due to differences in baseline comparabilit y. Control groups depicts duration of ulcers 37 weeks longer than in dermagraft group A and 46 weeks longer than group B and 44 weeks longer than group C.
--	-----	--	--	---	---	---

diabetic foot ulcers.						
Pollak 1997  RCT  No mention of sponsorship or COI.	4.5	N = 281 patients with full-thickness diabetic ulcers of the plantar surface. Mean age was 55.4 years.	Control Group-Standard care with debridement, moist dressings and pressure relief (n = 142) vs. DG Group-Dermagraft added to ulcer with standard treatment (n = 139).  Primary follow-up for 12 weeks, secondary follow-up at 32 weeks.	50.8% of patients in DG group showed complete wound healing at 12 weeks compared to 31.7% (p = 0.006). At week 32, DG group had a significantly higher healing.	“Thus, Dermagraft within the therapeutic range of metabolic activity, used in addition to a well-defined regimen of standard care, has been demonstrated to provide significantly improved healing of diabetic foot ulcers compared to standard care alone.”	At 12 weeks DG-TR group had more healed ulcers than control group (52% vs. 32%, p = 0.006). Time to healing for DG-TR group 13 weeks vs. 28 weeks for control group. At week 32, DG-TR group sustained healing when compared to control group (58% vs. 42%), p = 0.04.
<b>Apligraf</b>						

<p>Veves 2001</p> <p>RCT</p> <p>No mention of sponsorship. COI: A.V. and V.F. are members of the Novartis advisory panel on Apligraf and have received honoraria for speaking arrangements from Novartis AF and Novartis AG, respectively. In addition, Organogenesis provided funds to laboratories of A.V. and V.F. to conduct studies on Apligraf. D.G.A. has accepted honoraria to speak on behalf of Novartis Pharmaceuticals</p>	<p>5.5</p>	<p>N=208 with type 1 or 2 diabetes and full-thickness neuropathic ulcers; mean age 57.1 years.</p>	<p>Graftskin Group: Graftskin applied after debridement directly over ulcer site and trimmed to fit ulcer. Graftskin could be reapplied from weeks 1-4 (n = 112) vs. Control Group-Standard care of American Diabetes Association, with complete dressing changes every week, and 2 secondary dressing changes 2x per day (n = 96).</p> <p>Follow-up at 1, 4 and 12 weeks.</p>	<p>Complete wound healing achieved in 63 (56%) of graftskin-treated patients compared with 36 (38%) control patients (p = 0.0042). Odds ratio (95% CI) of Graftskin compared to control was 2.14 (1.23-3.784). Median time to complete closure 65 days for graftskin which was significantly lower than 90 days in control group (p = 0.0026).</p>	<p>“In summary, in the present study we have shown, in a randomized prospective controlled fashion that weekly application of Graftskin for a maximum of 4 weeks results in a higher healing rate when compared with state-of-the-art currently available standard treatment and is not associated with any significant side effects.”</p>	<p>At 12 weeks, 56% of Graftskin groups achieved complete wound healing vs. 38% control group. There were twice as many amputations in the control group after 12 weeks.</p>
--	------------	--	--	--	--	--

<p>Han 2010</p> <p>RCT</p> <p>Sponsored by a grant of Korean Ministry of Knowledge Economy, Republic of Korea. No mention of COI.</p>	<p>4.5</p>	<p>N = 54 with diabetic foot ulcers &gt;1.0cm<sup>2</sup> that did not display signs of healing for 6 weeks. Mean age for treatment/control group: 6.5 ±7.5/68.4 ± 8.7.</p>	<p>PLA cell treatment wound management and pressure off-loading, were set up to be identical for all (n = 28) vs. Control treatment only fibrinogen 0.3 – 1.0 mL + thrombin 0.3–1.0mL, without cells, applied topically over debrided wounds (n = 26).</p> <p>Follow-up for 8 weeks.</p>	<p>Ulcer sizes of PLA group ranged between 1.2-7.6cm<sup>2</sup> (mean area, 4.3±2.1cm<sup>2</sup>) with wound durations of 6-30 weeks (12.5±5.6 weeks). Ulcer size of control group ranged from 1.4-10.0cm<sup>2</sup> (4.0 ±2.1cm<sup>2</sup>) with wound duration of 6-24 weeks (12.5±5.5 weeks). At 8 weeks, wound healing in 100% PLA cell-treated group and 16 (62%) in control, (p &lt;0.05). Time for complete healing ranged from 17-56 days (mean, 33.8±11.6 days) in PLA cell-treated vs 28-56 days (42.1±9.5 days) in control, (p &lt;0.05).</p>	<p>“In conclusion, uncultured PLA cell autografts stimulate the activity of diabetic fibroblasts and may offer a simple and effective treatment for diabetic ulcers.”</p>	<p>Pilot study. Data suggest potential efficacy.</p>
<p>Caputo 2008</p> <p>RCT</p> <p>Sponsored by Smith &amp; Nephew Inc, Florida. No COI.</p>	<p>4.0</p>	<p>N = 41 with clinical signs of infection in the study ulcer. Mean age (range) 68.0 (33.0 – 95.0).</p>	<p>VERSAJET™ HydroSurgery System (n = 22) vs. Conventional debridement with scalpel plus pulsed lavage (n = 19).</p> <p>Follow-up for 12 weeks.</p>	<p>At baseline median ulcer duration 1.2 months in both groups median surface area of 5.9cm<sup>2</sup> and median area of devitalized tissue of 5.3cm<sup>2</sup> in treatment group/surface area of 3.9cm<sup>2</sup> and devitalized tissue of 3.7cm<sup>2</sup>. Wound closure between patients treated with Versajet vs conventional debridement (p = 0.733). At 12</p>	<p>“[T]he Versajet HydroSurgery system is a quick and effective means of debriding lower extremity ulcers.”</p>	<p>Ulcer size differed at baseline (5.9 v 3.9 cm<sup>2</sup>) but favoring conventional. No difference in wound closure rate. Versajet faster.</p>

				weeks, wounds closed in 52.6% of Versajet group and 47.4% in controls.		
--	--	--	--	--	--	--

## **Wound Care, Subungual Hematoma, Contusions**

See Hand, Wrist, and Forearm guideline.

## **Charcot Joint (Neurogenic Arthropathy)**

Charcot joints are theorized to be caused by either: 1) a neuropathy with loss of position sense and chronic ongoing joint trauma; or 2) an autonomic neuropathy with secondary bone loss. The condition conveys a poor prognosis. (Gazis 04; Sohn 09) While any sensory peripheral neuropathy (e.g., alcoholism, polio, leprosy, syphilis) and some central nervous system conditions such as syringomyelia may cause the condition, the largest cause is diabetes mellitus. (Munson 14; Frykberg 08, 12) The rate or progression is thought to correlate with the duration and severity of the underlying neuropathy, (Nehring 14; Garcia-Alvarez 13; Sohn 09) diabetic nephropathy, (Samann 12) as well as, obesity (Nehring 14; Garcia-Alvarez 13; Stuck 08) which conveys the risk and severity of joint trauma. Genetic factors have been suggested. (Korzon-Burakowska 12) The condition may be associated with some fractures and/or dislocations often due to the insensate foot. (Wukich 11) The onset may be relatively acute over a few weeks, (Game 12) or it may be insidious or both. While any joint may be affected, the most common are the ankle and knee. Work-related causes are extremely rare, but may theoretically include impacts of a toxic neuropathy or spinal cord injury. There are no quality studies to guide treatments, especially for workers, thus all recommendations are consensus-based.

Diagnostic testing usually includes x-rays (Chantelau 06) that are **Recommended, Insufficient Evidence (I)**, *Level of Confidence* – High. MRIs have been shown to provide more information, are hypothesized to improve staging, (Chantelau 06) have not been shown to change management, but may be selectively **Recommended, Insufficient Evidence (I)**, *Level of Confidence* – Low. Medical treatment includes addressing the underlying neuropathy to attempt to reduce systemic impacts and are **Recommended (I)**, *Level of Confidence* – High. Gait training by a therapist is **Recommended, Insufficient Evidence (I)**, *Level of Confidence* – Moderate. Splints, walking braces, orthoses and casts (deSouza 08) should be tailored to the specific cause-condition and are **Recommended, Insufficient Evidence (I)**, *Level of Confidence* – Low. Acetaminophen and/or NSAIDs for pain control are often not needed due to the propensity for the joint to be denervated, but if needed are **Recommended, Insufficient Evidence (I)**, *Level of Confidence* – Low (see Chronic Pain guideline for other neuropathic pain medication options).

Surgical procedures including ostectomy may be performed to address deformities that place the foot at risk of ulceration, which if ulceration occurs increases risk of amputation, (Sohn 10; Larsen 01) and are **Recommended, Insufficient Evidence (I)**, *Level of Confidence – High*. Fractures require treatment that may include open reduction internal fixation and are **Recommended, Insufficient Evidence (I)**, *Level of Confidence – High*. Fusion is also performed for some cases (Rammelt 13; Ahmad 08) and is **Recommended, Insufficient Evidence (I)**, *Level of Confidence – Moderate*. Arthroplasty (total joint replacement) has been traditionally viewed as contraindicated for Charcot joints due to underlying neuropathy that increases the failure rate. Although there are a few case reports suggesting potential success, there are no quality studies and there is no recommendation for arthroplasty for Charcot joints (Babazadeh 10; Bae 09; Parvizi 03; Lee 08) [No **Recommendation, Insufficient Evidence (I)**, *Level of Confidence – Low*].

## **Paronychia**

Paronychia is an inflammatory disorder of the nail folds. They are generally classified as acute and chronic. Acute cases are caused by trauma to the nail folds or cuticle. There are recurrent acute cases. However, chronic paronychia is increasingly thought to be an inflammatory condition of the nail folds that is analogous to eczema. (Tosti 97; Zaias 90)

There are few quality trials of treatment of acute paronychia. If an abscess has formed, the primary treatment is incision in drainage and is **Recommended, Insufficient Evidence (I)**. Systemic antibiotics have been reported as ineffective in a low quality trial (Reyzelman 00). However, they are commonly prescribed and would be widely considered essential with a complicating condition such as diabetes mellitus, signs of systemic infection, or with a surrounding cellulitis. Thus, while antibiotics may not be needed for many cases and there is **No Recommendation, Insufficient Evidence (I)** there also would be a low threshold for prescribing antibiotics.

Warm compresses are **Recommended, Insufficient Evidence (I)** in the acute phase. Topical antibiotics are **Recommended, Insufficient Evidence (I)**. Pain management is generally not needed, but NSAIDs or acetaminophen may be used and are **Recommended, Insufficient Evidence (I)**.

Recurrent acute paronychias are thought to be recurrences of the same problems. These are often treated with surgery, especially en bloc excision of the proximal nail fold and eponychial marsupialization, with or without nail plate removal. (Grover 06) As there are no quality studies, this surgical management is **Recommended, Insufficient Evidence (I)**

Chronic paronychia have been thought to be largely related to fungal infections and thus antifungals were common treatments, both topical and systemic (Wong 84; Barlow 70) and are still **Recommended, Insufficient Evidence (I)**, *Level of Confidence - Low*; however, that treatment option is usually the primary treatment for those thought to mainly have a fungal infection. One moderate-quality trial found superiority of terbinafine compared with itraconazole. (Bräutigam 95) Instead, glucocorticosteroids are now thought to be the primary treatment. Topical glucocorticosteroid creams were found superior to antifungals in one RCT, (Tosti 02) and thus they are **Recommended, Evidence (C)**, *Level of Confidence - Low*. Antifungal and glucocorticosteorid creams have been combined and are **Recommended, Insufficient Evidence (I)**, *Level of Confidence - Low*. Tacrolimus 0.1% ointment has been found superior to steroids (Rigopoulos 09) and is **Recommended, Evidence (C)**, *Level of Confidence – Low*. Topical antibiotics and systemic antibiotics have been used for secondary infections and are **Recommended, Insufficient Evidence (I)**, *Level of Confidence – Low*. The threshold for using an antibiotic in combination with a topical glucocorticosteroid is necessarily low, due to the potential for infectious complications.

Consideration of surgical management is **Recommended, Insufficient Evidence (I)**, *Level of Confidence – Low*, but only for those who fail non-operative measures, particularly including attempts to

manage with glucocorticoids and anti-fungal(s). Surgical interventions include en bloc excision of the proximal nail fold and eponychial marsupialization, with or without nail plate removal. (Grover 06)

## **Foot Drop**

Foot drop is a weakness in the dorsiflexion strength of the affected lower extremity resulting in an abnormal gait pattern. (Everaert 13) Foot drop is most commonly caused by a variety of central and peripheral nervous system disorders, although any disorder affecting muscle strength may cause foot drop. Among these are stroke, central nervous system disorders (e.g., multiple sclerosis), muscular dystrophies, trauma (including surgical damage to nerves), spinal cord compression such as a herniated disc, autoimmune disorders (e.g., polyarteritis nodosa), ruptured anterior tibial tendon, and vascular disorders such as aneurysm. (Hwang 13; Kluding 13; Kottink 08; Bethoux 14, Stewart 08, Pritchett 14) The acute onset of foot drop after ipsilateral leg trauma may be a manifestation of compartment syndrome.

An estimated 20% of all stroke survivors experience foot drop, often a consequence of spastic hemiparesis from stroke. (Wade 87, Bethoux 14) There are many abnormalities associated with the gait cycle in patients with hemiparesis. Foot drop results in an abnormal gait pattern most often because the ankle of the weak side cannot undergo voluntary dorsiflexion. (Everaert 13) Improving gait efficiency is a rehabilitation goal for hemiparetic stroke patients. (Sheffler 06) Addressing gait is important in persons with foot drop regardless of etiology. Other goals include increasing mobility and range of motion. (Bayram 06) One trial found no differences between high and low dose botulinum A in spastic drop foot. (Bayram 06) Another trial found lack of efficacy with an implanted peroneal nerve stimulator. (Kottink 08) A minor proportion of cases of foot drop are considered occupational. Foot drop does not usually arise out of employment, but treatment, fitness for duty, and accommodation issues may be encountered by the occupational physician.

### **Initial Assessment**

Assessment of foot drop should exclude diagnoses that need aggressive or highly restrictive treatment, or involve untreated systemic disease (see above). Acute cases of foot drop are urgencies if not emergencies due to the potential for significant enduring impairments. In the absence of an obvious traumatic cause in an otherwise healthy person, the patient with foot drop should be assessed for cardiovascular and cerebrovascular disease, diabetes, inflammatory disorders, and peripheral neuropathy. The affected leg should be examined thoroughly and, if possible, damaged or diseased nerves, muscles, and blood vessels should be identified. (Sumpio 00; Bluestein 08)

### **Medical History**

A history adequate to exclude uncontrolled comorbidities should be conducted. History of slipping, tripping, and falling should be obtained to assess risk and need for treatment and accommodations. Acute trauma followed by foot drop and lower leg pain may mark compartment syndrome, which is one of the surgical emergent causes of foot drop. The patient should be questioned about problems with balance, fall history, near-fall history, environmental hazards, use of assistive devices, and limitations in ability to stand.

### **Physical Examination**

The back, groin, and legs of a patient with foot drop should be examined for signs of trauma, tumor, and vascular insufficiency. Consider examining strength and sensation of the entire leg, but focus on clues for involved myotomes, dermatomes, and tendons. Pulses throughout the leg should be checked. Palpation for pulsatile masses may reveal aneurysm.

Strength and sensation of the legs should be evaluated. Observation of gait, including use of stairs and ability to maneuver around obstacles may show opportunities for eliminating slip, trip, and fall hazards.

### ***Diagnostic Studies***

Diagnostic studies to determine the cause of foot drop most often include MRI of the brain, (Ricarte 14; Park 13) spinal cord (Breen 94; Mahapatra 03; Takagi 02) and/or MRI of the periphery (Bendszus 03) and electrodiagnostic studies of the peripheral nerves. (Bauer 05; Katirji 99; Pickett 85)

### ***Physical Modalities***

#### **ORTHOTICS**

Orthotics, especially ankle-foot orthotics (AFOs) have been used for treatment of foot drop. (Hausdorff 08)

*Recommendation: Ankle-foot Orthotics for Treatment of Foot Drop*

**Orthotics, especially ankle-foot orthotics (AFOs) are recommended for the treatment of foot drop.**

*Strength of Evidence – Recommended, Insufficient Evidence (I)*

*Level of Confidence - Moderate*

#### *Rationale for Recommendation*

Although there are no quality trials, ankle-foot orthotics for foot drop have been used successfully for many years and thus they are recommended since they facilitate walking ability. Evaluation for orthotics should include evaluation of the footwear that is to be worn by the patient, including the nature of the fore-soles. Fronts of shoes and boots can catch on carpets and low-lying irregular surfaces, and modifications of shoes and boots may mitigate slip, trip, and fall risks posed by footwear.

#### *Evidence for use of Orthotics*

There is 1 low-quality RCT in Appendix 1. (Hausdorff 08)

#### **TAPING**

Taping has been used for treatment of foot drop. (Vicenzino 00)

*Recommendation: Taping for Treatment of Foot Drop*

**There is no recommendation for or against the use of taping for the treatment of foot drop.**

*Strength of Evidence – No Recommendation, Insufficient Evidence (I)*

*Level of Confidence – Low*

#### *Rationale for Recommendation*

There are no quality trials and thus there is no recommendation for or against the use of taping. Generally, braces are used for foot drop.

#### *Evidence for the Use of Taping*

There is 1 low-quality RCT in Appendix 1. (Vicenzino 00)

## ***Tarsal Tunnel Syndrome (TTS)***

### ***General Approach and Basic Principles***

Tarsal tunnel syndrome (TTS) is a relatively infrequent condition defined as an entrapment neuropathy of the tibial nerve or one of its branches from its entry point under the flexor retinaculum below the medial malleolus to the end of its lateral and medial plantar and posterior calcaneal branches, which innervate the base of the foot. Anatomically, the lateral plantar nerve (similar to the ulnar nerve) innervates the 5th and lateral half of the 4th toe, as well as most of the deep muscles of the foot. The medial plantar nerve (similar to the median nerve of the wrist), innervates the great toe, 2nd and 3rd toes, and the medial aspect of the 4th toe. Often compared to carpal tunnel syndrome (CTS) in the literature, the anatomical characteristics of the tunnel and the accompanying tunnel contents are markedly different from the wrist.

The position of the tibial nerve and vessels are relatively fixed in a compartment lying between two tendons, the flexor digitorum longus tendon superiorly and the flexor hallucis longus tendon inferiorly, with the flexor retinaculum forming the roof of the tarsal tunnel. Any excessive fat, mass, adjacent tenosynovitis, flexor retinaculum fibrosis, varicose veins, arthritides, compartment edema or space occupying object can hypothetically result in compression or traction of the tibial nerve.

### ***Work Relatedness***

There are no population-based or other quality epidemiological studies to determine the incidence or prevalence of tarsal tunnel syndrome. There are multiple possible etiologies conjectured for TTS, including trauma or fracture,(321) (Myerson 95) flexor tendon tear,(322) (Mezrow 02) ganglion,(323, 324) (DiStefano 72, Ng 04) accessory muscle,(325) (Cheung 99) venous anomalies or dilatation of the vessels in the neurovascular bundle(326) (Keck 62) and adjacent arthrosis, bone callous or osteophytes.(327) (Linscheid 70) One case-review study suggests idiopathic cases characterized by minimal trauma through normal weight-bearing activities are strongly associated with pes planus and benign joint hypermobility.(328) (Francis 87) Another case report suggests rheumatoid arthritis as a possible etiology, particularly when there is also a report of carpal tunnel syndrome.(329) (Lloyd 70) There are no quality epidemiologic studies for occupational causality of TTS. The available literature and case reports largely did not consider risk by occupation or activity.

### ***Initial Assessment***

TTS is often described as a complex condition difficult to diagnose and treat. This complexity is in part related to similar presentation of plantar and ankle pain as other foot and ankle disorders. In addition, anatomic variation in innervations of the plantar foot by the several nerves may result in variation of sensory and pain patterns, as well as variation in the level of bifurcation of posterior tibial nerve and artery as it traverses through the tunnel.(330) (Bilge 03)

### ***Medical History***

TTS is described by the constellation of symptoms of intermittent tingling, numbness or burning paresthesias in the any of toes and the plantar surface of the foot. Case histories are mostly non-specific to exact dermatomal distribution of symptoms. As both medial and lateral plantar nerves travel in the same tunnel but may bifurcate and have lesions at different levels, impingement could theoretically cause symptoms in either one of the distributions or both distributions. There may also be a sensation of ankle pain, tightness and cramping. There may be a worsening of symptoms throughout the day with prolonged standing or walking, opposite of plantar fasciitis. Pain at night is also common which is similar to median nerve impingement at the carpal tunnel. There may be proximal radiation to the calf and leg with advanced nerve compression.(327, 331-333) (DeLisa 83, Edwards 69, Goodgold 65, Linscheid 70) Similar to CTS patients being asked to complete a hand diagram to locate and rate symptoms, practitioners may ask patients to complete a foot diagram (Foot Wong-Baker Pain FACES Intensity Scale), which may be identify the different branches of the posterior tibial nerve that may be involved. Nerve identification is often useful in pre-treatment and follow-up evaluations.(334) (Gondring 08)

### ***Physical Examination***

Physical findings reported in patients with clinical are minimal and include a Tinel's sign over the tarsal tunnel, local tenderness behind the medial malleolus, altered sensation of the plantar surface, and weakness of foot muscles as evidenced by reduced ability to fan the toes.(327, 335) (Kinoshita 01, Linscheid 70) Evidence of pes planus, ankle trauma or bone deformity, arthritis, gout, edema, or palpable mass may increase the suspicion of TTS and support further diagnostic testing. Injection of the tarsal tunnel with lidocaine that provides pain relief is suggested in the literature, but is non-specific for nerve impingement as other disorders distal to the injection site are likely to similarly respond to an anesthetic nerve block. Inflation of a sphygmomanometer about the thigh to just above venous pressure may increase symptoms of the foot.(327, 336) (Linscheid 70, Lam 67)

One examination maneuver proposed for TTS is the “dorsiflexion-eversion test,” during which the examiner, with the patient seated and non-weight bearing, maximally dorsiflexes the ankle, everts the foot, and extends the toes maintaining the position for 5 to 10 seconds while tapping over the region of the tarsal tunnel to determine if a positive Tinel sign is present or if the patient complains of local nerve tenderness. This test was performed on 50 normal and 37 (44 feet) treated operatively for tarsal tunnel syndrome.(335) (Kinoshita 01) In the normal groups, no signs or symptoms were produced by the test. In the 44 symptomatic feet, the test increased numbness or pain in 36 feet (sensitivity 0.81, specificity 0.99). One issue with this examination maneuver is that there is no reliable standard of comparison. For example, electrophysiological studies, often considered a standard for locating nerve compression, is not reliable in TTS; and finding that persons who are awaiting an operation have discomfort more-easily provoked in the area of the operation than do persons who are not awaiting an operation may be fallacious. Thus, results of the dorsiflexion-eversion test should be interpreted with caution. A differential diagnosis for TTS should include interdigital neuroma, peripheral neuropathy, tenosynovitis, plantar fasciitis, plantar calluses, acute strain of the medial longitudinal arch, and peripheral vascular disease.(329) (Lloyd 70)

### **Diagnostic Criteria**

There are no well-established standard diagnostic criteria for TTS. Clinicians should maintain a high level of suspicion for TTS in patients presenting with pain and paresthesias of the plantar foot that worsen with prolonged standing and walking, or cause interruption of sleep.

### **Special Studies, Diagnostic and Treatment Considerations**

#### **ELECTRODIAGNOSTIC STUDIES**

1. *Recommendation: NCS for Diagnosis and Pre-operative Assessment of TTS Patients*  
**Nerve conduction studies (NCS) are recommended for confirming the diagnosis of entrapment of the tibial nerve at the ankle for cases that do not improve with conservative treatment or if considering surgical release after excluding the possibility of other causes such as polyneuropathy and radiculopathy.**

*Strength of Evidence – Recommended, Insufficient Evidence (I)*  
*Level of Confidence – High*

2. *Recommendation: NCS for Initial Evaluation of TTS Patients*  
**NCS is not recommended for the initial evaluation and most TTS patients as NCS does not change the management of the condition during the first 4 to 6 weeks while conservative therapy is being tried.**

*Strength of Evidence – Not Recommended, Insufficient Evidence (I)*  
*Level of Confidence – High*

3. *Recommendation: EMG for Initial Evaluation, Diagnosis or Pre-operative Assessment of TTS Patients*  
**There is no recommendation for or against the use of EMG for initial evaluation, diagnosis or pre-operative assessment of TTS patients. Electromyography (as distinguished from a nerve conduction study) is not generally recommended as there is no quality evidence demonstrating the utility of EMG in the diagnosis of TTS.**

*Strength of Evidence – No Recommendation, Insufficient Evidence (I)*  
*Level of Confidence – Low*

### *Rationale for Recommendations*

There are no quality trials evaluating the efficacy of electrodiagnostic methods, or how they affect the treatment outcomes of suspected TTS. A review of 317 articles by a task force of the American

Association of Neuromuscular and Electrodiagnostic Medicine (AANEM) on the role of nerve conduction studies (NCS) and electromyography in the diagnosis of tarsal tunnel syndrome found only four studies meeting evidence criteria set by their panel.(337) (Patel 05) The review found nerve conduction studies were abnormal in some patients with suspected tarsal tunnel syndrome, although the study sizes were small in each case. Similar to CTS, sensory conduction was more likely to be abnormal than motor studies. AANEM recommendations for confirming tibial mononeuropathy at the level of the tarsal tunnel in patients with clinically suspected tarsal tunnel syndrome include: 1) tibial motor responses recorded over the abductor hallucis and abductor digiti minimi pedis muscles demonstrating prolonged distal onset latency; 2) medial and lateral plantar mixed NCSs demonstrating prolonged peak latency or slowed conduction velocity across the tarsal tunnel; and 3) medial and lateral plantar sensory NCSs demonstrating slowed conduction velocities across the tarsal tunnel and/or small amplitude or absent responses.

There is no quality evidence demonstrating the utility of needle EMG or surface EMG assessment in the diagnosis of TTS. Although this technique is used by many foot surgeons to confirm the diagnosis of tibial nerve impingement at the ankle, the utility as an early diagnostic test is not well defined. There is no well described benefit of EMG versus NCS or other tests, although by analogy to CTS, a utility for EMG for TTS is doubtful. Analyses of needle EMG by AANEM concluded with no recommendation for the use of EMG in diagnosis of TTS. Therefore, NCS is recommended for diagnosis of entrapment of the tibial nerve at the ankle and for pre-operative assessment, but is not recommended for initial evaluation and most TTS patients. There is also no recommendation for or against the use of EMG for initial evaluation, diagnosis or pre-operative assessment of TTS patients.

## **MRI**

MRI is commonly used to examine musculoskeletal disorders and injuries of the foot and ankle and is increasingly being recognized as the modality of choice for assessment of pathologic conditions.(338) (Rosenberg 00)

### *1. Recommendation: MRI for Diagnosis of TTS*

**MRI is recommended for the diagnosis of select cases of clinically suspected TTS that has failed conservative management or if a mass lesion is suspected.**

*Strength of Evidence – Recommended, Insufficient Evidence (I)*

*Level of Confidence – Low*

### *2. Recommendation: Routine Use of MRI to Diagnose TTS*

**The routine use of MRI is not recommended for the initial evaluation of TTS.**

*Strength of Evidence – Not Recommended, Insufficient Evidence (I)*

*Level of Confidence – High*

### *Rationale of Recommendations*

There are no quality studies evaluating the efficacy of MRI in identifying tarsal tunnel syndrome. However, MRI has taken a much more prominent role in recent years because of superior soft tissue resolution and the ability to noninvasively visualize the osseous structures, cartilage, and soft tissues. High-resolution of the tarsal tunnel allows visualization of the tibial nerve and plantar nerves in nearly their entire length, allowing demonstration of nerve compression by an adjacent structure.(339) (Campbell 06) The reviewed surgical case reports of TTS frequently implicate space occupying lesions impinging the tarsal fibro-osseous tunnel. MRI may have unique ability to visualize the described anomalies such as accessory muscles, venous dilation, ganglion cysts, neurilemoma, posttraumatic fibrosis and tenosynovitis. However, the presence of abnormal MRI findings in the lower legs of asymptomatic persons is unknown, so predictive values of abnormal findings, particularly minor abnormal findings, is unknown. Further, MR imaging demonstrated the presence and extent of impinging

lesions in 17 of 19 patients who underwent surgery.(340) (Finkel 94) MRI is a moderate cost option with few side effects and is non-invasive with a high potential to direct treatment.

## **ULTRASOUND**

Ultrasound has been described for both diagnostic purposes in identifying lesions (ganglion cysts, accessory muscle), as well as guiding interventional therapies (cyst aspiration), and requires a high level of expertise for successful nerve imaging.

### *1. Recommendation: Use of Ultrasound As an Aid to NCS*

**Ultrasound is recommended as an aid to NCS as it may be beneficial to identify suspected space occupying lesions in the tarsal tunnel after failed conservative management, or as an adjunct to guide interventional therapies.**

*Strength of Evidence – Recommended, Insufficient Evidence (I)*

*Level of Confidence – Low*

### *2. Recommendation: Routine use of Diagnostic Ultrasound*

**Ultrasound is not recommended as a routine diagnostic test for TTS.**

*Strength of Evidence – Not Recommended, Insufficient Evidence (I)*

*Level of Confidence – Low*

### *Rational for Recommendations*

There are no quality studies evaluating the efficacy of ultrasound imaging techniques for the initial diagnosis of TTS, or for the use of ultrasound in managing tarsal tunnel treatment courses. Ultrasound as an initial diagnostic test is not well described. There are efforts to correlate nerve size or swelling with other diagnostic criteria, but no quality data exist outlining sensitivity and specificity. Further, there are no comparison studies between MRI and ultrasound for making diagnostic or treatment decisions. The routine use of ultrasound for initial evaluation is therefore not recommended. Ultrasound studies reserved for patients that have failed conservative therapy or as an adjunct to guide interventional therapies however may be useful. When the diagnosis of TTS is highly suspected or confirmed by NCS, diagnostic nerve block, or glucocorticoid injection, the use of ultrasound can provide etiologic details such as inflammation of the nerve, soft tissue swelling, or soft tissue mass lesion.(341-345) (Vijayan 09, Girish 07, Hochman 04, Lee 05, Sofka 01)

### **Initial Care**

In the absence of neuropathic findings (sensory or motor involvement), by inference from other neurological impingement syndromes, 4 to 6 weeks of conservative care before using invasive measures may be reasonable. The commonly prescribed conservative measures are intended to relieve pressure and pain. These include cold, taping, exercises (especially posterior tibial nerve stretching), anti-inflammatory medications, splints, orthotic devices and supportive footwear.

### *1. Recommendation: Rest for Treatment of TTS*

**There is no recommendation for or against the use of rest for the treatment of TTS.**

*Strength of Evidence – No Recommendation, Insufficient Evidence (I)*

*Level of Confidence – Low*

### *2. Recommendation: Self-application of Ice or Heat for Treatment of TTS*

**Self-application of ice or heat is recommended for the treatment of TTS.**

*Strength of Evidence – Recommended, Insufficient Evidence (I)*

*Level of Confidence – Low*

### 3. Recommendation: Taping for Treatment of TTS

**There is no recommendation for or against the use of taping for the treatment of TTS.**

*Strength of Evidence – No Recommendation, Insufficient Evidence (I)*

*Level of Confidence – Low*

#### *Rationale for Recommendations*

There are no quality studies evaluating rest, ice, or taping, for symptomatic relief of TSS. Ankle rest or providing limitations of the affected leg is non-invasive, but can be moderate to high cost over time. Ankle rest may be beneficial for the more symptomatic cases where aggravating factors include constant standing or walking. Ice and heat may help particularly with more acute symptoms, although there is no evidence they help with other nerve impingement syndromes. Systematic reviews and case series reports using taping strategies for TTS were not found in the literature search and over time this intervention may be costly. However, taping may be helpful in the treatment of non-specific heel pain(232) (Hyland 06) (see Heel Pain). Each of these treatments is not invasive and generally has few adverse effects. Self-applications of ice and heat are not costly. Orthotics may be selectively recommended for those with TTS thought to be of biomechanical origin.

#### **Medications**

#### **NON-STEROIDAL ANTI-INFLAMMATORY DRUGS (NSAIDs) AND ACETAMINOPHEN**

*Recommendation: Non-steroidal Anti-inflammatory Drugs (NSAIDs) and Acetaminophen for TTS*

**A trial of acetaminophen or NSAIDs is recommended to treat pain from TTS.**

*Strength of Evidence – Recommended, Insufficient Evidence (I)*

*Level of Confidence – Moderate*

#### *Rationale for Recommendation*

There are no quality studies evaluating the effects of acetaminophen in treating TTS. However, acetaminophen may provide enough mild analgesic relief to allow the patient to exercise or function at a higher level. It is low cost, has few side effects, and is not invasive. There are no quality studies evaluating the effects of NSAIDs in treating TTS. Many of the review articles and case studies reviewed reported beneficial results from the use of NSAIDs. In addition, oral NSAIDs are useful in many soft tissue musculoskeletal conditions. However, NSAIDs have been shown to be ineffective for neuropathic pain including in the treatment of carpal tunnel syndrome (see Hand, Wrist, and Forearm Disorders guideline), so that true impingement of the posterior tibial nerve or its branches in the tarsal tunnel may have low response. Thus, while there is insufficient evidence, NSAIDs are recommended as an initial conservative treatment for tarsal tunnel syndrome particularly for cases where symptoms are thought to be able to be addressed by the NSAID.

#### **SYSTEMIC GLUCOCORTICOSTEROIDS**

Glucocorticosteroids are used to treat CTS and other tendinoses through both oral and injection routes (injections for CTS and other tendinoses).(346-352) (Chang 98, 02, 03; Herskovitz 95; Wong 01; Hui 01, 04) Although these medications are considered to be anti-inflammatory corticosteroids, TTS is generally thought to not have a significant inflammatory condition absent an inflammatory arthropathy or infection, thus a mechanism of action is somewhat unclear.

*Recommendation: Oral Systemic Glucocorticosteroids for Treatment of TTS*

**Oral glucocorticosteroids are recommended for treatment of TTS patients who decline tarsal tunnel injection.**

*Indications – Tarsal tunnel syndrome unresponsive to splinting. Most patients should be injected rather than given oral steroids(352); (Wong 01) however, among those declining injection, oral glucocorticosteroids may be warranted.*

*Frequency/Dose* – It is unclear what dose and duration of treatment is optimal. Inference is made from CTS literature. Two trials used 10 days of treatment with prednisolone acetate 25mg a day.(351, 352) (Wong 01, Hui 01) A third trial used prednisolone 20mg a day for 2 weeks, then 10mg a day for 2 weeks.(347, 353) (Mishra 06; Chang 98) Another used prednisolone 20mg a day for 1 week, then 10mg a day for 1 week.(354) (Chang 95) Another used prednisolone 20mg a day for 2 weeks on one of the treatment arms.(348) (Chang 02) There is some evidence that 2 weeks of treatment is as effective as 4 weeks.(346, 348) (Chang 03; Chang 02) It is recommended that one course (10 to 14 days) of oral glucocorticosteroid be prescribed, rather than repeated courses. Prescriptions of low rather than high doses are recommended to minimize potential for adverse effects.

*Strength of Evidence* – **Recommended, Insufficient Evidence (I)**

*Level of Confidence* – Low

#### *Rationale for Recommendation*

There are no quality studies of glucocorticosteroid use in TTS patients. However, glucocorticosteroids have been used to treat CTS and have been shown to be effective (see Hand, Wrist, and Forearm Disorders Guideline). Oral glucocorticosteroids are not invasive, have relatively few adverse effects for a short course and are low cost.

### **DIURETICS**

Diuretics have been used to treat TTS, in part due to observations of swelling in some patients.

*Recommendation: Diuretics for Routine Treatment of TTS*

**Diuretics are not recommended for routine treatment of TTS.**

*Strength of Evidence* – **Not Recommended, Insufficient Evidence (I)**

*Level of Confidence* – Moderate

#### *Rationale for Recommendation*

There are no quality studies on the use of diuretics for TTS. Most of the medical conditions described as risk factors for TTS do not involve edema or swelling of the lower extremities. In the CTS literature, two quality studies of diuretics for treatment of CTS patients failed to find evidence of efficacy compared with placebo.(347, 355) (Pal 88; Chang 98) Whether they are effective for treatment of patients with TTS accompanied by fluid retention states, such as third trimester pregnancy, has not been determined in quality studies, and use for select cases may be a reasonable intervention. Thus, diuretics are not recommended for routine treatment of CTS patients.

### **OPIOIDS – Oral, Transdermal, and Parenteral (Includes Tramadol)**

Opioids have occasionally been used to treat patients with TTS. These medications have primarily been used for a few nights in the post-surgical timeframe (see Chronic Pain guideline for a detailed discussion).

1. *Recommendation: Opioids for Pain Treatment of TTS in Select Patients*

**Limited use (a few days) of opioids is recommended for select patients who have undergone recent tarsal tunnel release and have large incisions or encountered significant complications and whose pain cannot be managed with other means.**

*Strength of Evidence* – **Recommended, Insufficient Evidence (I)**

*Level of Confidence* – Low

2. *Recommendation: Routine Use of Opioids for Treatment of Pain from TTS*

**The routine use of opioids is not recommended for treatment of patients with pain from TTS.**

*Strength of Evidence – Not Recommended, Insufficient Evidence (I)*  
*Level of Confidence – High*

*Rationale for Recommendations*

There are no quality studies of opioids for treatment of patients with TTS. The vast majority of patients with TTS do not have pain of sufficient intensity to require opioids. Patients having such degrees of pain should generally have investigations performed for alternative diagnoses. Opioids are not invasive, but have very high dropout rates and otherwise high rates of adverse effects. They are moderate to high cost depending on duration of treatment (see Chronic Pain guideline). They are not recommended for routine use. Opioids are recommended for brief, select use in post-operative patients with primary use at night to achieve sleep post-operatively.

*Evidence for the Use of Opioids for TTS*

There are no quality studies evaluating the use of opioids for the treatment of pain from TTS.

**VITAMINS – Including Vitamin B<sub>6</sub> (Pyridoxine)**

Treatment of TTS with pyridoxine (Vitamin B<sub>6</sub>) has been recommended by many providers using an inferred association between pyridoxine deficiencies and peripheral neuropathies and particularly with CTS.(356) (Keniston 97)

*1. Recommendation: Pyridoxine for Treatment of TTS*

**Pyridoxine is not recommended for routine treatment of TTS in patients without vitamin deficiencies.**

*Strength of Evidence – Not Recommended, Insufficient Evidence (I)*  
*Level of Confidence – Moderate*

*2. Recommendation: Use of Other Vitamins for the Treatment of TTS*

**There is no recommendation for or against the use of other vitamins for the treatment of TTS.**

*Strength of Evidence – No Recommendation, Insufficient Evidence (I)*  
*Level of Confidence – Low*

*Rationale for Recommendations*

There are no quality studies for the use of pyridoxine to treat TTS. However, review of this treatment for CTS did not show a clear benefit (see Hand, Wrist, and Forearm Disorders Guideline). While vitamin B<sub>6</sub> is relatively low risk and patients may use it without prescription, available evidence does not support its use for the routine treatment of TTS and thus it is not recommended. It may be a reasonable treatment option for those with presumptive pyridoxine deficiency (e.g., malnutrition, alcoholism, malabsorption, especially jejunal disorders such as sprue, etc.).

**Topical Medications**

**LIDOCAINE PATCHES**

Topical lidocaine patches have been increasingly used to treat numerous pain conditions through transdermal application of topical anesthetic.(357-359) (Nalamachu Med Gen Med 06, Nalamachu J Fam Prac 06; Galer 99)

*Recommendation: Lidocaine Patches for Treatment of TTS*

**Lidocaine patches are recommended for treatment of select cases of TTS.**

*Indications* – Patients with moderate to severe TTS with pain as a central complaint and in whom other treatable causes of the pain have been eliminated. Generally should have previously been treated with likely more efficacious treatment strategies.

*Frequency/Duration* – Usually 3 patches per day; duration of use for chronic, localized pain may be as long as indefinitely, although most of these patients do not require indefinite treatment, as symptoms of TTS usually resolve, improve or require surgery. Caution is warranted regarding widespread use of topical anesthetics for potential systemic effects from widespread administration.

*Indications for Discontinuation* – Resolution, intolerance, adverse effects, lack of benefits, or failure to progress over a trial of at least a couple weeks.

***Strength of Evidence – Recommended, Insufficient Evidence (I)***

*Level of Confidence – Low*

#### *Rationale for Recommendation*

Topical lidocaine has not been evaluated in quality studies of TTS. It has been suggested to improve pain associated with CTS (although the case diagnoses do not appear well substantiated in the available study as pain complaints as an overriding symptom among CTS patients raise concerns about alternate explanations for the symptoms).(358) (Nalamachu J Fam Prac 06) Lidocaine patches are not invasive and have a low adverse effects profile although some patients may experience local reactions such as skin irritation, redness, pain, or sores with use. Patches are also moderately or even high cost over time. While there are other lower cost topical treatments that provide analgesia, including heat, ice, and capsaicin, lidocaine patches may be a reasonable treatment option for pain related to TTS. Patients should be monitored to ensure that they are receiving benefit and to ascertain if there are any untoward local skin changes as a result of use.

#### ***Devices/Physical Methods***

##### **EXERCISE**

*Recommendation: Exercises for Treatment of TTS*

**There is no recommendation for or against the use of exercises for the treatment of TTS.**

***Strength of Evidence – No Recommendation, Insufficient Evidence (I)***

*Level of Confidence – Low*

#### *Rationale for Recommendation*

Exercise regimens for tendon gliding or nerve gliding are prescribed but have not studied for TTS. Similar exercise regimens prescribed for CTS showed unclear benefit and no recommendation is made based on insufficient evidence. Additionally, as many believe physical activity is a risk factor for TTS and CTS, the logic of performing exercises for treatment is somewhat dissonant. Exercise programs are not invasive, have few if any adverse effects, and are low cost if performed independently after receiving initial instructions. However, no recommendation is made because of insufficient evidence.

#### **ANKLE/FOOT SPLINTING**

Splinting of the foot and ankle for tarsal tunnel syndrome has been described briefly in the literature.(360) (Franson 06)

*Recommendation: Nocturnal Splints for Treatment of TTS*

**There is no recommendation for or against the use of a trial of nocturnal splinting for treatment of TTS.**

***Strength of Evidence – No Recommendation, Insufficient Evidence (I)***

*Level of Confidence – Low*

#### *Rationale for Recommendation*

There are no quality studies or reviews found on the benefit of splinting of the foot specifically for TTS. Nocturnal splinting of the wrist in a functionally neutral position has been found to be effective for CTS,

although the mechanism of action is unknown. By inference from the CTS literature, nocturnal paresthesia and pain is also often described with TTS. However, the foot posture is less likely to be highly variable during sleep. Thus, although a trial of dorsal splinting of the foot may be beneficial, there is no recommendation for or against splinting.

### **Magnets**

Treatment of TTS with magnets has been attempted.

*Recommendation: Magnets for Treatment of TTS*

**Magnets are not recommended for the treatment of TTS.**

*Strength of Evidence – Not Recommended, Insufficient Evidence (I)*

*Level of Confidence – High*

#### *Rationale for Recommendation*

Quality evidence in CTS suggests that magnets are not efficacious for treating pain associated with nerve impingement.(361) (Carter 02) There are no quality studies on the use of magnets for TTS. While magnets are not invasive, have no adverse effects, and are low cost, other interventions have been shown to be effective. Thus, magnets are not recommended for treatment of TTS.

### **ORTHOTICS**

Orthotics are commonly recommended by allied practitioners who hypothesize foot alignment disorders as the etiology or strong risk factor for TTS. Orthotics has been used to correct the defects of pronation and pes planus.

*Recommendation: Orthotics for Treatment of TTS*

**There is no recommendation for or against the use of orthotics for the treatment of TTS.**

*Strength of Evidence – No Recommendation, Insufficient Evidence (I)*

*Level of Confidence – Low*

#### *Rationale for Recommendation*

Orthotics are often prescribed to treat underlying alignment disorders (pes planus, valgus hindfoot deformity, varus hindfoot deformity, generalized joint hypermobility) which have been described as a possible etiology for TTS. It is hypothesized that these disorders result in increased strain on the flexor retinaculum, reducing the tarsal tunnel space causing impingement of the nerves.(328) (Francis 87) Orthotics are intended to reduce the stressors on the ligaments and reduce inflammation of the nerve. One case report of 14 patients with TTS and varus heel deformity were treated with lateral heel wedge orthotics.(362) (Radin 83) Eleven of the 14 patients did not respond to orthotics and went on to have surgical release. Another series report of 15 patients with pes planus and valgus hindfoot that were treated with orthotics showed a near 50% cure rate.(328) (Francis 87) Orthotics are non-invasive, have few if any side effects, but can be high cost for customized fitting and materials. Therefore, the lack of evidence of efficacy prevents a recommendation for or against the use of orthotics for TTS.

### **ACUPUNCTURE**

Acupuncture has been used to treat other peripheral nerve impingement syndromes.(363) (Branco 99) There is evidence of efficacy for treatment of chronic spine disorders, although the evidence suggests traditional acupuncture is not superior to other acupuncture methods (see Chronic Pain and Low Back Disorders guidelines).

*Recommendation: Acupuncture for Treatment of TTS*

**There is no recommendation for or against the use of acupuncture for the treatment of TTS.**

*Strength of Evidence – No Recommendation, Insufficient Evidence (I)*

*Level of Confidence – Low*

*Rationale for Recommendation*

There is no quality evidence of efficacy for acupuncture as a treatment for TTS. Acupuncture is minimally invasive, has minimal adverse effects, and is moderately costly. There are other interventions with documented efficacy. Therefore, there is no recommendation for or against use of acupuncture for treatment of TTS.

**MANIPULATION AND MOBILIZATION**

Manipulation and mobilization are two types of manual therapy which have been used for treatment of musculoskeletal disorders.(364, 365) (Tal-Akabi 00; Sucher 94) These include wide arrays of different techniques and schools of thought. Some consider these two interventions to be on a spectrum of velocity and applied force. In general, mobilization involves assisted, low-force, low-velocity movement. Manipulation involves high-force, high-velocity, and low-amplitude action with a focus on moving a target joint (see Chronic Pain and Low Back Disorders guidelines).

*Recommendation: Manipulation and Mobilization of the Distal Lower Extremity for Treatment of TTS*

**Manipulation and mobilization of the distal lower extremity is not recommended for the treatment of TTS.**

*Strength of Evidence – Not Recommended, Insufficient Evidence (I)*

*Level of Confidence – High*

*Rationale for Recommendation*

There are no quality studies of manipulation or mobilization of the lower extremity for the treatment of TTS. By inference from CTS, two quality studies suggested manipulation is ineffective for treatment of CTS.(366, 367) (Davis 98, Burke 07) Manipulation is not invasive, is moderately costly, although it is unlikely to have adverse effects in the distal lower extremity. It is not recommended for treatment of TTS.

**ULTRASOUND**

Ultrasound has been used to treat many MSDs, including CTS.(368-370) (Oztas 98; Bakhtiary 04; Ebenbichler 98)

*Recommendation: Ultrasound for Treatment of TTS*

**There is no recommendation for or against the use of ultrasound for the treatment of TTS.**

*Strength of Evidence – No Recommendation, Insufficient Evidence (I)*

*Level of Confidence – Low*

*Rationale for Recommendation*

There are no quality studies for the use of ultrasound as a treatment for TTS. While there is a recommendation for its use in CTS patients, there is a lack of any case reports or systematic review for this treatment modality in TTS patients. Ultrasound is not invasive, has few adverse effects, but is moderate to high cost depending on the number of treatments (which were high in quality studies).

**IONTOPHORESIS**

Iontophoresis is a drug-delivery system that utilizes electrical current to transdermally deliver glucocorticosteroids or NSAIDs. It is believed to be more efficacious where the dermis and adipose tissue overlying the target tissue is thin which facilitates penetration of the pharmaceutical to the target tissue.

*Recommendation: Iontophoresis for Treatment of TTS*

**There is no recommendation for or against the use of iontophoresis for the treatment of TTS.**

*Strength of Evidence – No Recommendation, Insufficient Evidence (I)*  
*Level of Confidence – Low*

*Rationale for Recommendation*

There are no quality studies of iontophoresis for the treatment of TTS. Iontophoresis with glucocorticosteroid may be a reasonable option for treating patients who decline injection. However, oral glucocorticosteroids have quality evidence of efficacy and may be recommended preferentially as iontophoresis is believed to be less effective than glucocorticosteroid injections. Iontophoresis is not invasive, has low adverse effects, and is of moderate cost. However, other treatments have documented efficacy, and should be used preferentially.

**PHONOPHORESIS**

Phonophoresis involves the use of ultrasound to deliver topically applied drugs, and has been used to treat patients with nerve impingement syndromes.(371) (Aygül 05)

*Recommendation: Phonophoresis for Treatment of TTS*

**There is no recommendation for or against the use of phonophoresis for the treatment of TTS.**

*Strength of Evidence – No Recommendation, Insufficient Evidence (I)*  
*Level of Confidence – Low*

*Rationale for Recommendation*

Phonophoresis has not been examined for the treatment of TTS in quality studies. It is believed to be less effective than glucocorticosteroid injections.(371) (Aygül 05) Phonophoresis is not invasive, has low adverse effects, and is moderately costly. However, other treatments have documented efficacy and should be used preferentially.

*Evidence for the Use of Phonophoresis*

There are no quality studies evaluating phonophoresis for treating TTS patients.

***Injection Therapies***

**GLUCOCORTICOSTEROID INJECTIONS**

*Recommendation: Glucocorticosteroid Injections for TTS*

**Glucocorticosteroid injections are recommended as part of a conservative management strategy for treatment of TTS.**

*Strength of Evidence – Recommended, Insufficient Evidence (I)*  
*Level of Confidence – Moderate*

*Rationale for Recommendation*

There are no quality studies evaluating the effects of corticosteroid injections in treating TTS. Injections are commonly reported as part of conservative therapy and as an additional mode for confirmation of suspected diagnosis of TSS. Corticosteroid injections are useful in other entrapment syndromes, particularly CTS (see Hand, Wrist, and Forearm Disorders guideline), and have been reported helpful for TTS. There are no data on recurrence or long-term benefits. This option is invasive, but low cost and has few side effects. Thus, if a more conservative treatment strategy fails to improve the condition, glucocorticosteroid injections may be useful. There is no quality information on the frequency or number of injections (see CTS in Hand, Wrist, and Forearm Disorders guideline).

**INSULIN INJECTIONS**

Treatment of tarsal tunnel syndrome with insulin injections has been described. Because of the similarities of CTS, tarsal tunnel insulin injections are likely considered by some physicians.

*Recommendation: Insulin Injections for Treatment of TTS*

## **Insulin injections are not recommended for the treatment of TTS.**

*Strength of Evidence – Not Recommended, Insufficient Evidence (I)*  
*Level of Confidence – High*

### *Rationale for Recommendation*

There are no quality studies on TTS patients and the use of insulin injection into the tarsal tunnel. This technique has been described for CTS patients and by inference may have application to TTS. However, this treatment is invasive, requiring 7 weekly injections, may have adverse effects that also require ascertainment, and is moderate to high cost.

## **BOTULINUM INJECTIONS**

Botulinum injections have been used in an attempt to treat TTS and used in CTS patients.(372, 373) (Breuer 06; Tsai 06)

### *Recommendation: Botulinum Injections for Treatment of TTS*

**Botulinum injections are not recommended for the treatment of TTS.**

*Strength of Evidence – Not Recommended, Insufficient Evidence (I)*  
*Level of Confidence – High*

### *Rationale for Recommendation*

There is no quality evidence for the use of botulinum injections in TTS patients. However, there is one quality study which included CTS patients that does not show clear benefit, but did show weakness in two patients lasting a few weeks.(372) (Breuer 06) Botulinum injections are invasive, have adverse effects that include fatalities,(300) (Li 05) and are costly. These injections are not recommended for the management of TTS.

## **Surgical Considerations**

### *Recommendation: Surgical Release for Space Occupying Lesion*

**Surgical release of posterior tibial nerve impingement at the tarsal tunnel is recommended upon failure of conservative treatment and in the presence of space occupying lesion. Surgical release for cases with nonspecific causes are otherwise expected to have mixed results and patients should be counseled regarding potential lack of benefit before consideration of surgery. There is no recommendation for any specific technique as there is a lack of quality evidence.**

*Strength of Evidence – Recommended, Insufficient Evidence (I)*  
*Level of Confidence – Moderate*

### *Rationale for Recommendation*

Surgical intervention is controversial as there are no quality trials comparing surgery with conservative care methods, or any quality studies evaluating the overall efficacy of surgical intervention. Further, although surgical techniques have changed over time, there are no comparison studies of techniques. The majority of TTS cases described in the literature ultimately resulted in surgical release. Case reports and series generally report space occupying lesions are responsible for symptoms in many cases, although there is no data to indicate what percentage of overall TTS. There are few data reported on complications, efficacy of symptom relief, or correction of neurosensory deficits post surgery. Results of a case series (n = 32 feet) of patients undergoing surgical release and followed longitudinally 24 to 118 months found only 44% had good or excellent results with 48% dissatisfied with the results.(374) (Pfeiffer 94) Somewhat similar to CTS, no correlation was found between pre-operative electrodiagnostic results and clinical results (negative versus positive versus not done). The only reliable predictor of favorable result was identification of an anatomic lesion. Another case series (n = 34) comparing patients who had surgery with those who did not, report 50% efficacy of conservative treatment, whereas surgical decompression effectively relieved some symptoms in 79% of cases, although varied by diagnosis. The

authors concluded aggressive treatment is warranted, although the prognosis overall is mixed, and should be preceded by a trial of conservative therapy prior to surgical release.(327) (Linscheid 70) Finally, the author in a case series of 108 ankles (72 patients) surgically released after failure of conservative treatment patients concluded that patients operated on sooner than 12 months after onset of symptoms had significantly higher postoperative scores on the Maryland Foot Score tool at 12 month follow-up than those with longer duration of symptoms, although both groups showed significant improvement in scores compared with preoperative measurements.(375) (Sammarco 03)

### ***Workplace Intervention***

In some cases, it may be desirable to conduct an ergonomic analysis of the activities that may be thought to contribute to the symptoms. Unlike CTS, there are no ergonomic surveys or instruments available for estimating duration of foot intensive activities, repetition rates, or forces as they relate to morbidity. With the lack of detailed measures necessary or useful for understanding risk, redesigning the workstation or recommending organizational and management initiatives is hypothetical. Such situations may also call for referral to certified professional ergonomists or a human factors engineer, either through the patient or the employer.

### **WORK RESTRICTIONS**

Some physicians place work restrictions on patients with TTS, while others do not. There is no quality evidence to suggest that restrictions are required.

*Recommendation: Work Restrictions for Treatment of TTS*

**There is no recommendation for or against the use of work restrictions for the treatment of TTS.**

*Strength of Evidence – No Recommendation, Insufficient Evidence (I)*

*Level of Confidence – Low*

### *Rationale for Recommendation*

There are no quality studies of workplace restrictions. Whether patients improve more quickly with activity limitations has not been shown. Additionally, there is no quality evidence that activities cause or worsen tarsal tunnel syndrome. Restrictions are not invasive, likely have few adverse effects, but may be moderate to high cost depending on length. There is no recommendation for or against workplace activity limitations.

### **RETURN-TO-WORK PROGRAMS**

Return-to-work programs have not been well described among patients with ankle and foot conditions (see Chronic Pain guideline for discussion of principles). By implication from CTS, several studies suggest that job physical demands, lack of job accommodation, and psychosocial conditions are the most important factors in predicting work disability.(376, 377) (Turner 07; Gimeno 05)

*Recommendation: Return-to-Work Programs for Treatment of TTS*

**Return-to-work programs are recommended for patients with TTS particularly those with significant lost time.**

*Strength of Evidence – Recommended, Insufficient Evidence (I)*

*Level of Confidence – Low*

### *Rationale for Recommendation*

There are no quality studies that review the types of return-to work programs typically found in the U.S. These programs are thought to reduce morbidity and improve function. They are not invasive, have minimal potential for adverse effects and are not costly. Return-to-work programs are recommended for management of TTS patients with lost time, and may be helpful for proactive emphases on functional recovery.

There are no quality studies incorporated into this analysis (see Chronic Pain guideline for additional studies).

## Ankle Sprain

### **General Approach and Basic Principles**

Injuries to the ankle are common and are a frequent reason for seeking acute care.(378-382) (McKeon Par I 08, Fong 07, Puffer 00, Birrer 99, Safran Part II 99) The ankle is the second most commonly injured body site after the knee for sports-related injuries, and ankle sprain is the most common ankle injury.(379) (Fong 07; Terada 13) Ankle sprain is common in physically active populations, particularly among those who participate in basketball, soccer, football, or any sports which require participants to jump, land on one foot, and/or make sharp turns.(383-385) (Garrick 89, Lindenfeld 94, Van Den Bekerom 08)

The ankle is a modified hinge joint formed by three bones – the tibia and fibula superiorly, and the talus inferiorly – and stabilized by several ligaments. The ankle is also known as the talocrural joint and primarily allows plantarflexion and dorsiflexion of the foot. The subtalar or talocalcaneal joint is the articulation between the talus and the calcaneus, and allows inversion and eversion. Both the talus and calcaneus articulate with the tarsal bones in the junction between hind and midfoot. There are distinctions between ankle and foot, although both ankle and foot may be injured together, and it may be hard in practice (and in the medical literature), to separate ankle and foot injuries.(21) (Kapandji 87)

The integrity of the ankle is maintained by three groups of ligaments. (Van Den Bekerom 08) Laterally the ligament complex is comprised of the anterior talofibular ligament (ATFL), the calcaneofibular ligament (CFL), and the posterior talofibular ligament (PTFL). Medially, the ankle is stabilized by the deltoid ligament complex. Axially, the ankle mortise is stabilized by ligaments of the syndesmosis and interosseous membrane fibers between the tibia and fibula.(380, 381, 385-387) (Cooke 09, Puffer 00, Birrer 99, Safran Part I 99, Van Den Bekerom 08)

Ankle sprain injuries involve tear of one or more ligaments in any of the three ligament groups. The majority of ankle sprains involve only the lateral ligaments, with approximately 15% involving the medial ankle.(379, 388) (Fong 07, Ferran 06) Most mild and moderate lateral injuries involve the ATFL and CFL, and severe injuries may also involve the PTFL. These injuries usually result from plantarflexion and inversion of the foot with external rotation of the tibia. As the foot twists medially in relation to the lower leg, a progression of tears in a predictable sequence occurs.(380, 381, 387) (Safran Part I 99, Puffer 00, Birrer 99)

The natural course of the lateral ankle sprain is rapid improvement. A systematic review of the natural history of ankle sprains from 31 prospective studies demonstrated rapid decrease in pain and improvement in function over the first 2-weeks post-injury.(389) (van Rijn 08) However, 5 to 33% of patients still reported persistent or residual pain at 1 year. Reports of full recovery 3 years after an ankle sprain varied 36 to 85%. Up to one-third of patients experience subsequent sprain that appears related to severity of the sprain. (van Rijn 08; Pourkazemi 14) As the majority of patients with ankle sprain show significant improvement in the first 2 weeks, the effectiveness of interventions is difficult to judge. However, a significant proportion of persons will continue to have chronic changes from their pre-injury state. Those with recurrent sprain may exhibit ill-defined radiological differences in the talus and decreased ankle stability. (Hiller 11) It is not clear whether the instability is a cause or an effect of recurrent sprain. This group may have a disproportionate influence of the outcomes in treatment studies.

Ten to 20% of patients with acute ankle sprain may develop chronic ankle instability (CAI).(390-393) (Alparslan 08, Baumhauer 02, Cheng 02, Karlsson 96) Chronic ankle instability from lateral ankle

ligament injury may be characterized by recurrent sprains and/or a persisting feeling (for at least 6 months) that the ankle is unstable and will give way. Mechanical testing demonstrates increased laxity of the lateral ankle ligaments in some patients, but many have no objective findings, but still report functional instability related to what is thought to be a proprioception deficit.(394-396) (Gutierrez 09, Hertel 00 & 08) Thus, the sense of instability may be the result of other factors, such as deficits in proprioception preceding or following the sprain. The cause of a proprioception deficit is unknown. A prevailing theory is that an alteration of afferent somatosensory information, reflex responses, and efferent motor measures result from destruction or functional alteration of nerve endings in the soft tissue, cartilage, and joints trauma can occur with ankle sprain trauma.(394-396) (Gutierrez 09, Hertel 00, Hertel 08) There are no quality trials that help identify who is at greater risk for CAI development.

**Work-Relatedness**

The incidence of workplace ankle sprain injuries is not well defined, but is reported in one retrospective study as approximately 3% of work related injuries.(397) (Grimm 99) Acute occupational ankle injuries are related to a specific acute traumatic event – the circumstances of the event determines work-relatedness.

**Initial Assessment**

The physician performing an initial evaluation of a patient with ankle sprain should seek a discrete diagnosis. A careful thorough history is required. The examination generally needs to focus on the bony structures, ligaments, soft tissue, range of motion, and vascular status. Likelihood of fracture is assessed using the Ottawa Ankle and Foot Rules. Other trauma may be present and the examiner should be alert for other injuries that may have been sustained in the incident.

**Table 7. Differential Diagnosis of Acute Ankle Sprain**

Lateral ligament sprain
Medial ligament sprain
Syndesmotic injury
Physeal fractures
Osteochondral fractures
Lateral process fracture of the talus
Posterior process fracture of the talus
Anterior process fracture of the calcaneus
Fracture of the base of the fifth metatarsal
Fracture of the base of the fifth metaphyseal-diaphyseal junction (Jones Fracture)
Peroneal tendon subluxation/dislocation
Malleolar fracture
Calcaneocuboid joint sprain

**Medical History**

The medical history should elicit information to establish the mechanism of injury, severity of forces, and disability immediately following the injury. Red flags, including fracture, should be considered. The examiner should determine if the injury is a result of inversion versus eversion of foot, the position of the foot at the time of injury, and if rotational forces or direct physical trauma was involved. Previous ankle injury should be noted, including duration of symptoms and any residual symptoms at the time of injury. The examiner should seek co-morbidity including osteoporosis, arthritis, movement disorders, diabetes, peripheral vascular disease, seizure disorder and use of seizure medications, and hyperthyroidism as they are risk factors for falls and weakened joints and bones.(381) (Birrerr 99)

**Physical Examination**

A careful observation of the exposed extremity and systematic examination should be performed including observation for soft tissue trauma and laceration or foreign body, edema, and ecchymosis. Edema is non-specific and has not been correlated with severity of injury. However, ankle girth on the injured side of 13 to 15mm greater than on the uninjured side, measured around the medial and lateral malleoli, has been reported to have a positive predictive value for detecting fracture of 83%.(398, 399)

(Clark 95, 96) Ecchymosis indicates more significant trauma. Ecchymosis on the medial aspect of the ankle along the posterior tibial ligament suggests deltoid ligament rupture. Ecchymosis from the ankle extending proximally to the distal lower leg suggests syndesmotic injury. However, ecchymosis may track subcutaneously, can be widespread, and is not a good indicator of the type or location of an injury unless it is focused.

Palpation of bony structures should include the tibia and fibula, the medial and lateral malleoli, mortise, calcaneus, lateral and posterior talus, and the base of fifth metatarsal. Palpation of the ATFL, CFL, PTFL, and deltoid ligament is performed to identify tenderness and/or discontinuity. Palpation of the Achilles tendon is performed to rule out other causes of acute ankle pain. Range-of-motion testing for the ankle includes plantar flexion, and dorsiflexion.

The anterior drawer test is performed to assess the integrity of the ATFL. The maneuver is performed by grasping the heel in one hand and pulling it forward while stabilizing the tibia with the other.(400, 401) (Lindstrand 76, Bahr 97) Optimal results are described using a force of 30 N (about 7 pounds force).(402) (Tohyama 03) Laxity is dependent on joint positioning, with the most laxity and the least stiffness reported when the knee is positioned at 90° of flexion and the ankle at 10° of plantarflexion.(403) (Kovaleski 08) Results are compared with the non-injured ankle, with 8mm or more increased laxity considered a positive test. Sensitivity and specificity of this maneuver are reported to be 73% and 97%.(404) (van Dijk 02) A high correlation with radiographic findings for ligament rupture has also been described.(405) (Nyska 92) Results of objective dynamic testing equipment for testing lateral ligament laxity are mixed and are not reported to provide significant benefit over routine examination in clinical management.(406-408) (de Vries 10, Kerkhoffs 07, Docherty 09)

The talar tilt test assesses the calcaneofibular ligament through inversion of the foot, and the deltoid ligament through eversion. This maneuver is performed by grasping the heel in one hand and the forefoot with the other hand and moving the foot back and forth from eversion (or pronation) to inversion (or supination). Pain and laxity of more than 5 to 10° compared with the uninjured ankle is indicative of ligament injury.(381) (Birrer 99)

Syndesmosis integrity (high ankle sprain) is tested by the side-to-side external rotation test and the squeeze test. The examiner stabilizes the injured leg laterally with one hand, and externally rotates the foot in the horizontal plain. For the squeeze test, the examiner squeezes circumferentially around the syndesmosis. Pain elicited in the anterior ankle with these maneuvers suggests syndesmotic injury or fracture.(409) (Molinari 09) The patient's ability to stand and bear weight is also examined. The ability to take 4 steps on the injured ankle is evaluated as part of the Ottawa Ankle and Foot Rules.

### ***Diagnostic Criteria***

Classification systems for lateral ankle sprain severity are based on physical examination findings and are used to define the extent of ligament injury. According to the West Point Grading System, Grade I sprains are mild, the most common, and require the least amount of treatment and least time to recovery. The anterior talofibular (ATFL) ligaments are stretched but not torn, and there is no significant instability. Grade II sprains are more severe, include a partially torn ATF ligament and may also involve the calcaneofibular ligament (CFL). Grade III sprains are the most severe, resulting in complete rupture of one or more ligaments of ATFL, CFL, and or posterior talofibular ligament (PTFL) resulting in instability of the joint. Most reviewed studies did not indicate specific schema system used for grading injuries, although Gerber(410) (Gerber 98) and Puffer(380) (Puffer 00) summarize the West Point Ankle Sprain Grading System. For the purpose of this section, a Grade I sprain and a mild sprain are synonymous; a Grade II sprain and a moderate sprain are synonymous; and a Grade III sprain and a severe sprain are synonymous.

### ***Workplace Intervention*** **WORK RESTRICTIONS**

Ankle sprain injuries often result in lost time from work and sport. Workplace limitations should be dictated by physical requirements of the job. Physical restrictions may include limited or progressive weight bearing. Walking is encouraged, but may require use of assistive devices. Activities that require sure footing such as working on irregular or inclined surface, climbing, or jumping should be avoided if they are likely to cause significant pain or feeling of instability. Accommodation may be requested for protective footwear or use of ankle-brace, which may impact a patient's ability to drive.

### **Special Studies, Diagnostic and Treatment Considerations**

#### **ARTHROGRAPHY (X-RAY)**

1. *Recommendation: Routine Use of Arthrography in Diagnosis of Acute Ankle Sprain*

**The routine use of arthrography is not recommended for evaluation of acute ankle sprain.**

*Strength of Evidence – Not Recommended, Insufficient Evidence (I)*

*Level of Confidence – Low*

2. *Recommendation: Routine Use of Arthrography in Diagnosis of Subacute or Chronic Ankle Sprain*

**There is no recommendation for or against the routine use of arthrography for evaluation of subacute or chronic ankle sprain.**

*Strength of Evidence – No Recommendation, Insufficient Evidence (I)*

*Level of Confidence – Low*

#### *Rationale for Recommendations*

There are no quality randomized trials evaluating arthrography for ankle sprain. Arthrography was considered the gold standard for identifying ligament and osteochondral defects.(411, 412) (Nilsson 83, Moller-Larsen 88) Arthrography has a specificity and sensitivity of 71 and 96% respectively when compared to surgical findings.(413) (van Dijk 98) Compared with physical examination in the acute setting, arthrography was more sensitive in detecting ligament rupture,(414) (Lähde 88) although another study found delayed physical examination at 48 hours provides information of diagnostic quality that is equal to that of arthrography, and causes less discomfort to the patient.(415) (van Dijk 96) Arthrography is invasive, is associated with adverse effects including risks from dye and post-procedure pain, and is costly. MRI, CT, and ultrasound have essentially replaced plain arthrography in current practice.

#### **X-RAY**

The primary purpose of obtaining radiologic imaging for the acute ankle injury is to evaluate for the presence of ankle or foot fractures. Ankle fracture occurs in approximately 15% of patients with ankle sprain.(416-418) (Brooks 81, Dunlop 86, Lloyd 86) The Ottawa ankle rules (OAR) have become well established as a valuable instrument for primary care physicians in acute care settings for determining appropriate level of concern for excluding fracture without the use of x-ray.(419-424) (Seah 10, van der Wees 10, Agrawal 09, Ivins 06, Atkinson 04, Bachmann 03) A meta-analysis of 27 studies demonstrated a negative likelihood ratio of less than 1.4%, indicating that very few fractures are missed in application of these rules.(423) (Bachmann 03) OAR has been validated to be 100% sensitive.

The Ottawa ankle rules state that x-ray films are indicated only if there is pain in malleolar zone:

1. tenderness along the tip of or the posterior edge of the distal 6 cm of the lateral malleolus of the medial and/or lateral malleolus; and/or
2. an inability to bear weight for 4 steps (2 steps on each leg) without assistance both immediately and in the clinical setting.

The rule also states that x-ray films of the foot are indicated only if there is pain in the mid-foot and there is:

1. tenderness at the base of the fifth metatarsal and/or tenderness over the navicular bone; and/or

2. an inability to bear weight for 4 steps without assistance both immediately and in the clinical setting(425) (Stiell 93) .

1. *Recommendation: Routine Use of X-ray in Assessment of Acute Ankle Sprain*

**There is no recommendation for or against the routine use of x-ray for evaluation of acute ankle sprain when fracture is not suspected.**

*Indications* – Suspicion of fracture (but not in the context of a diagnosis of sprain without an associated fracture) or if the history or physical is clinically suspicious for an injury other than an ankle sprain. The presence of acute edema measured at the malleoli >13 to 15mm compared to uninjured ankle may indicate an occult fracture.

*Views* – Anteroposterior, lateral, and mortise radiographs should be obtained.(426) (Wolfe 01)

*Strength of Evidence* – **No Recommendation, Insufficient Evidence (I)**

*Level of Confidence* – Low

2. *Recommendation: X-ray in Assessment of Acute Ankle Sprain when Fracture Suspected*

**X-ray in the case of ankle sprain is recommended if fracture is likely and the differential diagnosis reflects suspicion of fracture.**

*Indications* – Suspected or encountered fracture (see Fractures section for further guidance).

*Views* – Anteroposterior, lateral, and mortise radiographs should be obtained.(426) (Wolfe 01)

*Strength of Evidence* – **Recommended, Insufficient Evidence (I)**

*Level of Confidence* – High

3. *Recommendation: Routine Stress X-ray for Evaluation of Ligament Rupture in Acute Ankle Sprain*

**Routine use of talar-tilt and anterior drawer stress x-ray is not recommended for evaluation of acute ankle ligament rupture.**

*Strength of Evidence* – **Not Recommended, Insufficient Evidence (I)**

*Level of Confidence* – Moderate

4. *Recommendation: Routine Stress X-ray for Evaluation of Ligament Rupture in Subacute or Chronic Ankle Sprain*

**There is no recommendation for or against the use of talar-tilt and anterior drawer stress x-rays for evaluation of subacute or chronic ankle pain.**

*Strength of Evidence* – **No Recommendation, Insufficient Evidence (I)**

*Level of Confidence* – Low

*Rationale for Recommendations*

There are no quality studies evaluating the diagnostic value of x-ray for ankle sprain. Plain films are not required for the diagnosis of acute ankle sprain as x-ray is poor at diagnosing soft-tissue disorders. The use of plain film x-ray rather is utilized for evaluation of accompanying ankle or foot fracture, orientation of fracture plane(s), and magnitude of the involvement of the articular surfaces, which if present may alter management in favor of surgery. X-ray is indicated based on high clinical suspicion or as guided by the Ottawa ankle and foot rules. There are two quality trials for the use of Ottawa rules, but these do not validate the rules as a tool. A high-quality trial demonstrated that in a busy emergency or urgent care setting, registered nurse triage using the rules did not significantly improve total visit time compared to MD triage, although there was no difference in patient satisfaction. However, the applicability of the study

results is uncertain as it did not compare inter-discipline rater reliability or validate the rules.(427)(Fan 06) A moderate-quality RCT demonstrated that trained nurses are able to apply the rules as well as house officers.(428) (Derksen 05) Ottawa rules appear to be a valuable screening instrument for ordering x-ray in the acute setting. However, an x-ray should also be considered if there is high clinical suspicion based on history and physical or ankle edema that is 13 to 15mm greater than the uninjured side.(398, 399) (Clark 95, Clark 96) X-ray is non-invasive, has low adverse effect profile, but does result in radiation exposure, and is of moderate cost. Therefore, x-ray is recommended for assessment of suspected ankle or foot fracture.

The use of stress x-ray is a widely debated topic.(429) (Lohrer 08) A study comparing the use of stress x-ray with visual confirmation of ATFL integrity demonstrated accuracy of stress plain films to be 53% for acute cases and 91% for chronic cases. This compares to 91% for diagnostic ultrasound and 97% for MRI.(430) (Oae 10) As initial treatment for all acute ankle sprains without fracture is non-operative clinical management does not depend on the degree of instability on stress views.(431) (Frost 99) For cases of chronic ankle instability, anterior drawer and talar tilt stress views are of unknown clinical utility as there is little correlation of measurement with clinical decision making, as there is wide variability in measurements compared with the uninjured ankle.(429, 432) (Lohrer 08, Martin 96) Stress films are non-invasive, but can result in significant patient discomfort, are less accurate than MRI or CT, and have uncertain clinical correlation. They are not recommended in the acute setting. There is insufficient evidence for a recommendation in the evaluation of chronic ligament instability.

*Evidence for the Use of Ottawa Ankle and Foot Rules for Ankle Sprain*

There is 1 moderate-quality RCT incorporated into this analysis.

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
<b>Nursing Assessment</b>						
Derksen 2005 RCT	7.0	N = 106 ankle sprains	Application of Ottawa ankle and foot rules: specialized emergency nurse assessment (SEN) vs. house officer assessment (HO)	SEN group found indication of radiography in 60 (57%) of 106 patients vs. HO 69 (65%), p = 0.10. SEN vs. HO sensitivity of detecting fractures by means of OAR and OFR: 0.93 (CI 0.64-1.00)/0.93 (CI 0.64-1.00), p = 1.00. Specificity: 0.49 (CI 0.38-0.60)/0.39 (CI 0.29-0.50), p = 0.20. OAR and OFR overall results for lateral malleolus k = 0.30, medial malleolus k = 0.50, navicular k = 0.45, metatarsal vs. base k = 0.43.	“Specialized emergency nurses are able to assess ankle and foot injuries in an accurate manner with regard to the detection of acute fractures after a short, inexpensive course.”	Randomized variable order of assessment. All patients assessed by both (quasi-cross over trial). Data suggest trained nurses are able to apply Ottawa rules.

**COMPUTERIZED TOMOGRAPHY (CT)**

CT is used to evaluate ligament, osteochondral injury such as talar dome lesions, fractures, ankle impingement, and other soft-tissue injuries. Both CT and MRI are used for evaluation of syndesmotic injuries.

*1. Recommendation: CT for Assessment of Subacute or Chronic Ankle Sprain*

**CT is recommended for the assessment of select patients with subacute or chronic ankle sprain.**

*Indications* – Patients who have no limited improvement with non-operative therapy after 4 to 6 weeks, persistent pain with weight bearing, or chronic feeling of instability; ankle injuries that involve crepitus, catching or locking, as these symptoms may be associated with a displaced osteochondral fragment.

*Strength of Evidence* – **Recommended, Insufficient Evidence (I)**

*Level of Confidence* – High

2. *Recommendation: CT for Assessment of Acute Ankle Sprain*

**There is no recommendation for or against the use of CT for assessment of patients with acute ankle sprain.**

*Strength of Evidence* – **No Recommendation, Insufficient Evidence (I)**

*Level of Confidence* – Low

*Rationale for Recommendations*

There are no quality trials for use of CT in evaluating ankle sprain. A prospective study demonstrated CT with an accuracy of 91% compared with arthroscopic findings, but only localized the injury to the same location as arthroscopy 63% of the time.(430) (Oae 10) There is insufficient evidence for recommending MRI over CT or visa versa, and the study should be selected based on objective of clinical suspicion.

**MAGNETIC RESONANCE ARTHROGRAPHY (MRA)**

1. *Recommendation: MRA for Assessment of Subacute or Chronic Ankle Sprain*

**There is no recommendation for or against the use of MRA for the assessment of subacute or chronic ankle sprain.**

*Strength of Evidence* – **No Recommendation, Insufficient Evidence (I)**

*Level of Confidence* – Low

2. *Recommendation: MRA for Assessment of Acute Ankle Sprain*

**MRA is not recommended for the assessment of acute ankle sprain.**

*Strength of Evidence* – **Not Recommended, Insufficient Evidence (I)**

*Level of Confidence* – Low

*Rationale for Recommendations*

There is no quality evidence for the use of magnetic resonance arthrography. MRA is generally used for MRI or CT equivocal or difficult lesions.(433) (Naran 08) MRA performed on 60 consecutive patients with ankle sprain revealed bone contusion that did not appear on MRI or plain film.(434) (Pinar 97) However, the incidence and clinical importance of bone bruises associated with ankle sprain is unknown. MRA is invasive, costly, and of uncertain clinical utility. It is not recommended for acute evaluation of ankle sprain.

**MAGNETIC RESONANCE IMAGING (MRI)**

MRI is used to evaluate ligament, osteochondral injury such as talar dome lesions, fractures, ankle impingement, and other soft-tissue injuries.

1. *Recommendation: MRI for Assessment of Subacute or Chronic Ankle Sprain*

**MRI is recommended for the assessment of select patients with subacute or chronic ankle sprain.**

*Indications* – Patients who have no limited improvement with non-operative therapy after 4 to 6 weeks, persistent pain with weight bearing, or chronic feeling of instability; ankle injuries that involve crepitus, catching or locking, as these symptoms may be associated with a displaced osteochondral fragment.

*Strength of Evidence – Recommended, Insufficient Evidence (I)*  
*Level of Confidence – Moderate*

2. *Recommendation: MRI for Assessment of Acute Ankle Sprain*

**There is no recommendation for or against the use of MRI for the assessment of acute ankle sprain.**

*Strength of Evidence – No Recommendation, Insufficient Evidence (I)*  
*Level of Confidence – Low*

*Rationale for Recommendations*

There are no quality randomized trials evaluating the use of MRI in the diagnosis of ankle sprain. A prospective study comparing MRI with visual confirmation of ATFL integrity demonstrated accuracy of 97% for MRI.(430) (Oae 10) In the acute setting however, MRI has not been demonstrated to provide additional benefit in clinical diagnosis or management compared to plain film x-ray.(435, 436) (Nikken 05, Remplik 04) For cases of non-response to non-operative functional treatment in subacute and chronic stages, syndesmotic injuries and for chronic ankle instability, MRI should be considered as an imaging technique.(390, 430, 433, 437, 438) (Oae 10, Alparslan 08, Martin 08, Naran 08, Brown 04) There is insufficient evidence for recommending MRI over CT or visa versa, and the study should be selected based on objective of clinical suspicion.

## **BONE SCANS**

1. *Recommendation: Bone Scans for Assessment of Acute Ankle Sprain*

**Bone scans are recommended for select patients with acute ankle sprain.**

*Indications – Suspected stress fracture, infection, or tumor.*

*Strength of Evidence – Recommended, Insufficient Evidence (I)*  
*Level of Confidence – Low*

2. *Recommendation: Bone Scans for Assessment of Subacute or Chronic Ankle Sprain*

**There is no recommendation for or against the use of bone scans for patients with subacute or chronic ankle sprain.**

*Strength of Evidence – No Recommendation, Insufficient Evidence (I)*  
*Level of Confidence – Low*

*Rationale for Recommendations*

There is no quality evidence for the use of bone scan in investigating ankle pain. Bone scan imaging for stress fracture may be of benefit in highly select patients. A bone scan is non-invasive, but does result in radiation exposure and is of high cost. Therefore there is no recommendation for or against its use.

## **ULTRASOUND**

1. *Recommendation: Ultrasound for Diagnosis of Acute Ankle Sprain*

**Ultrasound is not recommended for evaluation of select patients with acute ankle sprain.**

*Strength of Evidence – Not Recommended, Insufficient Evidence (I)*  
*Level of Confidence – Low*

2. *Recommendation: Ultrasound for Diagnosis of Subacute or Chronic Ankle Sprain*

**There is no recommendation for or against the use of ultrasound for evaluation of patients with subacute or chronic ankle sprain.**

*Strength of Evidence – No Recommendation, Insufficient Evidence (I)*

## *Level of Confidence – Low*

### *Rationale for Recommendations*

There are no quality randomized trials for the use of ultrasound in the diagnosis of ankle sprain. A prospective study demonstrated lower accuracy of ultrasound compared with MRI and CT based on arthroscopic confirmation of surgical findings.(430) (Oae 10) Another comparative study of clinical and ultrasonographic findings found no correlation between usual clinical signs and type of ligament injury.(439) (Gremeaux 09) A prospective study of 110 patients with acute ankle sprain demonstrated that ultrasound detection of talocrural effusion is a sign to consider a sprain as severe.(440) (Guillodo 07) The long-term clinical utility versus routine care is not yet defined. Other studies have demonstrated utility of ultrasound for diagnosis of syndesmotic injury. Ultrasound is non-invasive, has low adverse effects, and is of moderate cost, but as ultrasonographic findings in the acute setting are unlikely to alter management, it is not recommended. Ultrasound for chronic ankle instability or assessment of ankle sprain that has not demonstrated improvement in 4 to 6 weeks may be reasonable, although there is insufficient information to recommend it over CT or MRI.

### **Initial Care**

#### **EDUCATION**

*Recommendation: Education for Effects of Acute, Subacute, Chronic or Post-operative Ankle Sprain Injury*

**Education is recommended for select patients with acute, subacute, chronic, or post-operative ankle sprain injury.**

*Frequency/Duration –* One or 2 appointments to educate patients about the injury, effects of activity, unhelpfulness of complete inactivity, prognosis and addressing other questions. Additional appointments may be needed if education is combined with therapy treatments. Follow-up educational visit(s) for more severe disorders as part of a progression towards normal functional use is sometimes helpful.

*Indications for Discontinuation –* Achievement of education goals or non-compliance

*Strength of Evidence – Recommended, Insufficient Evidence (I)*

*Level of Confidence – Moderate*

### *Rationale for Recommendation*

There are no quality studies specifically evaluating efficacy of patient education for utility or necessity in treatment of ankle sprain. Yet, for many disorders (e.g., criticality of maintaining splinting, cast management, monitoring for complications) education appears essential. Some physicians accomplish this in the course of extended patient visits, while others routinely refer patients to a therapist for education. Regardless of the approach, a few appointments for educational purposes are recommended for select patients. The number of appointments is dependent on the diagnosis, severity of the condition, and co-existing conditions. Although education is usually incorporated as part of the overall treatment plan, an additional 1 or 2 appointments for purely educational purposes may be helpful midway through a treatment course for the more severely affected patient. In addition, education is low cost and thus is recommended.

### *Evidence for the Use of Education for Ankle Sprain*

There are no quality studies incorporated into this analysis.

### **Medications**

#### **NON-STEROIDAL ANTI-INFLAMMATORY DRUGS (NSAIDs) AND ACETAMINOPHEN**

The use of NSAIDs and acetaminophen are well-described interventions for numerous soft-tissue and musculoskeletal injuries, including ankle sprains.

1. *Recommendation: Acetaminophen for Acute, Subacute, or Chronic Ankle Sprain*

**Acetaminophen is moderately recommended for acute, subacute, or chronic ankle sprain.**

*Indications* – Pain associated with acute, subacute, or chronic ankle sprain pain.

*Frequency/Duration* – Frequency and dose per manufacturer’s recommendations; may be taken scheduled or as needed. Providers are cautioned as an FDA advisory committee has recommended reductions in daily doses below prior recommendations of up to 4gm/day.

*Indications for Discontinuation* – Resolution, intolerance, adverse effects, lack of benefits, or failure to progress over a trial of at least a couple of weeks.

**Strength of Evidence – Moderately Recommended, Evidence (B)**

*Level of Confidence* – Moderate

2. *Recommendation: NSAIDs for Acute, Subacute, Chronic, or Post-operative Ankle Sprain*

**NSAIDs are recommended for treatment of acute, subacute, chronic, or post-operative ankle sprain.**

*Indications* – Pain associated with acute ankle sprain; also for subacute, chronic or post-operative management.

*Frequency/Dose/Duration* – Frequency and dose according to manufacturer’s recommendations; may be taken scheduled or as needed. There is no evidence one NSAID is superior to another for treatment of ankle sprain. OTC agents may suffice and may be tried first. There is no evidence for prolonged use, as quality trials demonstrated the greatest benefit within the first 2 weeks.

*Indications for Discontinuation* – Resolution, intolerance, adverse effects, lack of benefits, or failure to progress over a trial of a few weeks.

**Strength of Evidence – Strongly Recommended, Evidence (A) – Acute**

**Recommended, Insufficient Evidence (I) – Subacute, chronic, post-operative**

*Level of Confidence* – High

*Rationale for Recommendations*

Acetaminophen is an analgesic with no significant anti-inflammatory effect. There are no quality placebo-controlled trials that address acetaminophen for ankle sprain. There is one high-quality trial that demonstrated equal efficacy of acetaminophen with over-the-counter (OTC) strength ibuprofen,(441) (Dalton 06) and two moderate-quality trials that found paracetamol equivalent to diclofenac 75mg twice daily for acute mild and moderate ankle sprains.(442) (Kayali 07; Lyrtzis 11) There is quality evidence that NSAIDs are effective (see NSAIDs). There is also quality evidence that acetaminophen is superior to placebo for treatment of other musculoskeletal disorders, including low back pain, and has a low adverse effect profile (see Chronic Pain guideline for discussion of acetaminophen).

There are two high-quality(443, 444) (Ekman 06, Slatyer 97) and six moderate-quality placebo-controlled randomized trials(445-450) (Ekman 02, Sloan Injury 89, Bahamonde 90, Dreiser 93, Goldie 74, Moran 91) evaluating the use of NSAIDs in the treatment of acute ankle sprain. NSAIDs were demonstrated to improve function, pain scores with movement, and/or subjective patient global assessment over placebo in all of these studies except one,(449) (Goldie 74) which only studied the change in swelling as an outcome measure. NSAIDs demonstrated to be more effective than placebo include valdecoxib,(443) (Ekman 06) piroxicam,(444, 447) (Bahamonde 90, Slatyer 97) celecoxib,(445) (Ekman 02) diclofenac,(447, 450) (Moran 91, Bahamonde 90) nimesulide,(448) (Dreiser 93) and ibuprofen.(445, 446, 450) (Ekman 02, Sloan Injury 89, Moran 91)

Four moderate-quality trials utilized reduction in swelling as an outcome measure. Three studies did not demonstrate any reduction in swelling compared with placebo.(447-449) (Bahamonde 90, Dreiser 93, Goldie 74) One study did find benefit as measured on a soft tissue swelling index for immediate versus delayed treatment with ibuprofen.(446) (Sloan Injury 89) Thus, there is insufficient evidence to support the use of NSAIDs to treat swelling in acute ankle sprains.

There is no evidence of the superiority of one NSAID over another for any of the outcomes of analgesia, function, or swelling. There were no differences between celecoxib versus naprosyn(451) (Petrella 04) or diclofenac,(452) (Nadarajah 06) diclofenac versus aspirin,(453) (Duncan 88) oxyphenbutazone versus diflunisal(454) (Adams 78) or clonixin,(455) (Viljakka 83) diflunisal versus flurbiprofen,(456) (Finch 89) sulindac versus ibuprofen,(457) (Hayes 84) or modified dosing schedule of ibuprofen.(458) (McLatchie 85) There were no quality studies that compared placebo to OTC-strength NSAIDs. There are no quality studies in post-operative patients, however, NSAIDs have been shown to be highly effective for several other post-operative conditions and thus are recommended (see Low Back Disorders, Hand, Wrist, and Forearm Disorders, and Hip and Groin Disorders Guidelines). NSAIDs are not invasive, have low adverse effects particularly in employed populations, and are low cost, thus they are recommended. If NSAIDs are used to treat clinically evident or presumed inflammation, they should be administered on a scheduled basis. If NSAIDs are used for analgesia, they should be taken as needed.

#### *Evidence for the Use of Acetaminophen for Ankle Sprain*

There is 1 high- and 1 moderate-quality RCTs incorporated into this analysis.

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Dalton 2006 RCT	8.5	N = 260 Grade I or II lateral ankle sprains	Acetaminophen Extended Release (1,300mg TID vs. ibuprofen 400mg TID) for mild and moderate acute ankle sprain.	No significant differences at 4 or 9 days on outcomes of pain on walking, ability to walk, swelling, bruising, ROM, satisfaction with treatment, negative anterior drawer, time to resume normal activity.	“Acetaminophen extended release 3,900 mg daily was comparable to ibuprofen 1,200 mg daily for treatment of grade I or II lateral ankle sprains. Both treatments were well tolerated.”	Comparison is to OTC strength ibuprofen. Data suggest no difference in benefit for acute mild to moderate ankle sprain.
Kayali 2007 RCT	4.0	N = 100 1st or 2nd degree lateral ankle sprains within 48 hours of admission	Diclofenac sodium 75mg twice a day vs. paracetamol 500mg 3 times a day for 5 days for Grade I and II ankle sprains; follow-up 6 weeks.	Physician global mean assessment diclofenac sodium vs. paracetamol at Day 1, 10, and Week 6: 1.46±0.5 vs. 1.42±0.49, 3.18±0.5 vs. 3.14 ±0.53, 3.76±0.43 vs. 3.72±0.45. ROM initial/last exam: 28.8°±9.3 vs. 30.2°±8.5 p = 0.43, 68.4°±3.1 vs. 67.6°±3.6 p = 0.03. No differences in swelling at any period.	“[D]iclofenac sodium and paracetamol are effective and well tolerated as a short term treatment alternatives for acute ankle injuries.”	No placebo. Lack of randomization, allocation, baseline comparison and blinding details. Data suggest paracetamol is at least equivalent to NSAIDs for analgesia. No placebo arm.

*Evidence for the Use of NSAIDs for Ankle Sprain*

There are 4 high- and 14 moderate-quality RCTs incorporated into this analysis. (Lyrtzis 11) There are 4 low-quality RCTs in Appendix 1.(459-462) (Dupont 87; Fredberg 89; Aghababian 86; Andersson 83)

Author/Y ear Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
<b>NSAIDs vs. Placebo</b>						
Ekman 2006  RCT	9.5	N = 829 acute 1st- or 2nd-degree ankle sprain	Valdecoxib 20mg once daily vs. valdecoxib 20mg twice daily vs. tramadol 50mg 4 times daily vs. placebo for acute mild and moderate ankle sprain.	Valdecoxib 20mg BID vs. valdecoxib 20mg qd vs. tramadol 50mg 4 times vs. placebo. Patient global assessment good/very good: Day 4: no difference, Day 7 (76.4 vs. 67.3 vs. 59.6 vs. 55.5) p <0.001 BID vs. placebo. APS questionnaire: 33.9 vs. 26.6 vs. 20.6 vs. 24.4 (p = 0.009 Day 4). Patient assessment of return to walking with/without pain Day 4 (47.5/44.6/38.4/35.0) p = 0.002; Day 7 (79.4/72.5/ 67.3/63.9) p = 0.001. Tramadol treatment withdrawals due to adverse events vs. valdecoxib treatment (12.2% vs. 3.4%; p = 0.0005). Withdrawal rates due to adverse events similar in valdecoxib and placebo groups (3.4% vs. 2.4%; p = 0.75).	“...valdecoxib 20 mg bid was at least as effective as Tramadol 50 mg 4 times daily and significantly better than placebo...”	Data suggests valdecoxib 20 mg BID superior to placebo and trended towards better than tramadol for acute pain relief at days 4 and 7. Data suggest no difference in tramadol and placebo at day 4, with higher withdrawal rates in tramadol group.

<p>Slatyer 1997</p> <p>RCT</p>	<p>8.5</p>	<p>N = 364 Australian Regular Army recruits with acute ankle sprains sustained during training</p>	<p>Piroxicam 40mg x 2 days, then 20mg x 5 days vs. placebo. 7- day trial with 6 month follow-up. All grades included.</p>	<p>Piroxicam vs. placebo “positive anterior drawer tests” Day 0, 3, 7, and 14 (%): 36/ 38 (<math>\chi^2 =</math> 1.12, p = 0.57), 26/10 (<math>\chi^2 = 16.14</math>, p = 0.001), 15/2 (<math>\chi^2 =</math> 18.00, p = 0.001), 8/1 (<math>\chi^2 = 9.08</math>, p = 0.001). VAS scores better Day 3, 7 (p &lt;0.001). Subjects experiencing difficulty with activities at Day 14, 1 month, 3, and 6: p = 0.0001/ <math>\chi^2 =</math> 50.58, p = 0.0001/ <math>\chi^2 =</math> 88.02, p = 0.0001/ <math>\chi^2 = 64.96</math>. p = 0.0001/ <math>\chi^2 = 16.90</math> favoring piroxicam.</p>	<p>“[N]onsteroidal anti- inflammatory agents should form an integral part of the treatment of acute ankle sprains.”</p>	<p>Military training camp population. Clinical significance of improving positive anterior drawer sign unspecified. Study suggests benefits in pain scores at 2 weeks from NSAID but not in swelling. Suggests long- term benefit in reduction of difficulty with activities (difficulty in walking, running, jogging, forced march)</p>
<p>Ekman 2002</p> <p>RCT</p>	<p>7.5</p>	<p>N = 445 Grade 1 or 2 ankle sprains within 48 hours and moderate to severe ankle pain</p>	<p>Celecoxib 200mg BID vs. ibuprofen 800mg TID vs. placebo, 10-day trial, Grade I, II sprains, treated within 48 hours. Follow-up on Day 11.</p>	<p>Patient global assessment 0-100 scale: celecoxib vs. placebo Day 4, 8, 11: 67 vs. 55 p &lt;0.05, 82 vs. 72 p &lt;0.05, 90 vs. 88 p = NS. Celecoxib vs. ibuprofen no differences between groups. VAS weight bearing 0-100 scale: celecoxib vs. placebo Day 0, 4, 8, 11: 68.5 (14.1) vs. 71.3 (12.1), 35.3 (1.6) vs. 42.4 (1.6) p &lt;0.05, 23.3 (1.8) vs.31.2 (1.8) p &lt;0.05, 15.6 (1.8) vs. 19.9 (1.8) p = NS. Celecoxib vs. ibuprofen no differences between groups. Median return to normal function: celecoxib 5 days vs. ibuprofen 6 days vs. placebo 8 days, p = 0.001 for celecoxib vs. placebo, no difference between celecoxib and ibuprofen.</p>	<p>“In managing acute ankle sprain- in providing pain relief and accelerating recovery, celecoxib 400 mg/day was more effective as the maximum recommende d dose of ibuprofen (2400 mg/day).”</p>	<p>Randomization, allocation methods unclear. Study suggests both NSAIDs provide short-term benefit in weight- bearing pain, patient global assessment, and return to function over placebo acutely. Differences not significant after 1 week. Differences in clinical VAS scores of questionable significance.</p>

Sloan Injury 1989 RCT	5.5	N = 122 acute ankle injuries within 6 hours of injury	Immediate ibuprofen (1,200mg loading, 2,400mg total per day) vs. placebo 1st 48 hours, than same ibuprofen schedule. Uniform background therapy of 20 minutes cooling, compression and elevation given to all patients using cooled ankle.	Immediate vs. delayed soft tissue swelling index: % improvement 49% vs. 37% p <0.01. Severity of injury: no data presented, favored immediate group p = 0.05; range of movement no differences; ability to bear weight no differences	"[I]mmediate medication with high-dose ibuprofen at 2400 mg/day should be considered in the routine treatment of moderate to severe ankle sprains, whether patients."	Patients treated within 6-hours. Study suggests immediate NSAIDs may be beneficial for immediate pain relief and swelling relief judged at 7 days vs. placebo.
Bahamonde 1990 RCT	5.5	N = 93 mild to severe sprained ankles	Diclofenac potassium 50mg TID vs. piroxicam 20mg vs. placebo (7-day trial) for acute ankle sprain (severity not specified, no torn ligaments).	Minimal statistical details provided. Volume of foot: no differences between 3 groups at 7 days. Pain at 2 days: lower VAS for diclofenac vs. placebo (p <0.0001) and piroxicam (p <0.0002). Differences continued to Day 3 vs. placebo, disappeared with piroxicam. Investigators assessment (excellent) higher for diclofenac p = 0.001.	"[D]iclofenac potassium was a good alternative to piroxicam for the treatment of stable (non-surgical) ligamentary injuries of the ankle, with a rapid onset of action and good overall tolerability by the patients."	Lack of randomization, allocation, compliance details. Suggests NSAIDs provide short-term benefit for acute sprains. Possible superiority of diclofenac vs. piroxicam at this dosage although conclusions limited by lack of presented data.
Dreiser 1993 RCT	5.0	N = 60 with symptoms and signs of traumatic distortion of the ankle	Nimesulide 100mg BID vs. placebo for acute ankle sprain.	Nimesulide vs. placebo (0-10) VAS at 0, 4, 8 days. Functional impairment: 2.7 vs. 2.8, 1.7 vs. 2.4 (p <0.01), 0.8 vs. 1.8 (p <0.001); Pain on passive movement: 2.6 vs. 2.7, 1.6 vs. 2.2 (p <0.01), 0.9 vs.	"Nimesulide 100 mg administered twice daily is an effective and safe short term treatment in the management of post-	Lack of randomization, allocation, baseline comparison, blinding details. Only included subjects with slight to moderate pain (>5 on 10 point

				1.7 (p <0.001); Joint swelling: (units not specified) 19.3 vs. 21.8, 12.1 vs. 16.1 p >0.05, 5.7 vs. 5.7 p >0.05.	traumatic joint injuries.”	VAS). Study suggests NSAIDs beneficial for pain relief over 8-day course for mild to moderately painful sprains. Clinical significance likely small.
Goldie 1974 RCT	4.0	N = 30 ankle sprains	Metopyramizol vs. phenylbutazone vs. placebo (dosages and schedule not stated), 7-day trial.	Mean improvement of foot volume: 60% metopyramizol vs. 51% phenylbutazone, vs. 56% placebo.	“The comparison between phenylbutazone and metopyramizol I did not therefore yield any information as to the preferred drug. The fact, however, that the reduction of swelling was the largest in the placebo group, might be an indication that Nature’s own way in repair of tissue injury may be preferable to interference with drugs whose exact effect in the organism still remains unknown.”	Not clear if study was randomized. Sparse methodology details. Study suggests no benefit on ankle swelling. Conclusions limited by lack of methods details.
Moran 1991 RCT	4.0	N = 60 ankle sprains suffering from moderate to severe inflammation	Diclofenac Potassium 50 mg. t.i.d. vs. Ibuprofen 400 mg. t.i.d. vs. placebo for	Severity rating of 0 on Day 7 using 4-point scale: 0-none to 3 wincing and withdrawal) Diclofenac vs. ibuprofen vs. placebo: 12/20 vs.	“[D]iclofenac potassium has been demonstrated to be effective in the treatment of	Lack of randomization, allocation, baseline comparison, blinding details. Ibuprofen group appears to have

		on and tenderness	acute ankle sprain	8/21 vs. 1/19. p = 0.001, p = 0.004 respectively vs. placebo. Pain on passive movement rating of 0: 17/20 vs. 14/21 vs. 7/19 p <0.05 vs. placebo for both.	acute ankle sprains.”	had significant difference in baseline swelling. Data suggest NSAIDs may be superior to placebo for analgesia.
<b>NSAIDs vs. Other Medications</b>						
Petrella 2004 RCT	10.0	N = 397 acute 1st-degree or 2nd-degree ankle sprain	Celecoxib 200mg BID vs. naproxen 500mg BID, 7-day trial for acute Grade I, II sprains.	Mean VAS scores Day 4 and 8: celecoxib = 31.9±1.96/15.0±1.70, naproxen = 29.0±1.91/15.3±1.65. Non-inferiority treatment differences (upper 95% CI) Day 4 (p = 0.1), and Day 8(p = 0.8). Patient global assessment Day 4 and 8 (%): celecoxib = 71%/89%, naproxen = 72%/90%. Celecoxib vs. naproxen AE of dyspepsia p = 0.032.	“Celecoxib is as effective as naproxen in treating acute first-degree or second-degree ankle sprains but causes significantly less dyspepsia.”	No placebo. Study suggests no difference in NSAID efficacy between Cox-2 inhibitor and naproxen.
Ekman 2006 RCT	9.5	N = 829 acute 1st- or 2nd-degree ankle sprain	Valdecoxib 20mg once daily vs. valdecoxib 20mg twice daily vs. Tramadol 50mg 4 times daily vs. placebo for acute mild and moderate ankle sprain.	Valdecoxib 20mg bid vs. valdecoxib 20mg qd vs. tramadol 50mg 4 times vs. placebo. Patient global assessment good/very good: Day 4 no differences, Day 7 (76.4 vs. 67.3 vs. 59.6 vs. 55.5) p <0.001 for BID vs. placebo. APS questionnaire: 33.9 vs. 26.6 vs. 20.6 vs. 24.4 (p = 0.009 Day 4). Patient assessment of return to walking with/without pain Day 4 (47.5/44.6/38.4/35.0) p = 0.002; Day 7 (79.4/72.5/ 67.3/63.9) p = 0.001. Tramadol treatment	“...valdecoxib 20 mg bid was at least as effective as Tramadol 50 mg 4 times daily and significantly better than placebo.”	Data suggest valdecoxib 20mg BID superior to placebo and trended towards better than tramadol for acute pain relief at Days 4 and 7. Data suggest no difference in tramadol and placebo at Day 4, with higher withdrawal rates in tramadol group.

				withdrawals due to adverse events vs. valdecoxib treatment (12.2% vs. 3.4%, p = 0.0005). Withdrawal rates due to adverse events similar in valdecoxib and placebo groups (3.4% vs. 2.4%, p = 0.75).		
Nadarajah 2006 RCT	9.5	N = 370 1st- or 2nd-degree ankle sprain ≤48 hours prior to 1st dose of study medication	Celecoxib 200mg BID vs. diclofenac SR 75mg BID x 3 days for acute Grade I and II sprains.	VAS score on full weight bearing (celecoxib/diclofenac) : Day 4 (182/164) LS mean -0.8; final visit (188/177) LS mean -0.2.	“Celecoxib (400 mg loading, 200 mg bid) was as effective as diclofenac SR (75 mg bid).”	Study did not include a placebo group and allowed co-interventions of RICE, PT. Efficacy trial suggests no difference in two NSAIDs.
Lyrtzis 2011 RCT No COI or sponsorship.	7.0	N = 86 with acute Grade II sprains of the lateral collateral ligaments, age range 18 to 60	Group A, diclofenac, 75mg orally, twice a day, first 10 days (n = 42) Group B, paracetamol, 500mg, orally, 3 times a day (n = 44). All: RICE protocol, ankle bandage, for 10 days, elevation for first 3 days, start walking after 10 days. Follow-up: baseline, days 3 and 10.	Mean score for VAS pain scale: diclofenac vs. paracetamol: baseline/3 <sup>rd</sup> day: 70.2/22.1 vs. 72.5/22.3, p < 0.001; baseline vs. baseline/10 <sup>th</sup> day: 70.2/6.9 vs. 72.5/5.1, p < 0.001.	“[D]iclofenac and paracetamol had the same effect on pain reduction of ankle sprains but more acute ankle edema was present in patients who were treated with diclofenac than in patients who were treated with paracetamol.”	Results suggest comparable efficacy for pain. Paracetamol associate with less swelling at 3 days, but otherwise did not differ.
Finch 1989 RCT	5.5	N = 50 acute ankle sprains or strains	Flurbiprofen 100mg vs. diflunisal 500mg BID x 18 days	Flurbiprofen vs. diflunisal physician assessment mean score changes: (only significant differences	“Flurbiprofen and diflunisal appear to be effective and well-tolerated	No placebo. Lack of randomization, allocation details. No

			for acute ankle sprain <36 hours. All subjects had 7-day plaster cast immobilization.	reported) measured Day 0, 7, 14, 21. Functional capability: Day 7 -1.96/-1.59 gait: Day 7 -1.22/-1.00, Day 14 -1.96/-1.77; Joint swelling: no differences; Ankle discoloration: no differences; Pain on passive motion: Day 7, -2.17/-1.81; Patient assessment mean scores. Pain while walking: no differences; Pain while standing: no differences; p <0.05, p <0.01.	medications for the treatment of acute ankle sprains and strains.”	blinding. Co-intervention of casting for 7 days. Data suggest no differences.
Duncan 1988  RCT	5.0	N = 139 acute sprains and/or strains of knee or ankle	Diclofenac 75mg BID vs. aspirin 1.2g TID for acute ankle, knee injuries (<72 hours) for 3-10 days.	Diclofenac vs. aspirin mean (±SEM) for swelling, limitation of active ROM, pain on active motion: -1.17 (0.12)/-1.45 (0.11), -1.79 (0.11)/-1.88 (0.11), -1.96 (0.10)/-1.82 (0.10). Intragroup improvement from baseline p <0.001. Intergroup differences not significantly different; % returned to sport in 10 days: 83% vs. 82%, p >0.05).	“[D]iclofenac is useful in treating sports-related injuries and may allow an earlier return to playing fitness.”	No placebo. Thirty-percent loss to follow-up/excluded from study. Data suggest no difference between ASA and diclofenac x.
Adams 1978  RCT	4.5	N = 37 acute, minor ligamentous injuries	Diflunisal 500mg twice daily vs. 200mg oxyphenbutazone 3 times daily (3-day trial, double-dummy, acute sprains classified as minor).	Spontaneous pain (rest) completely resolved in all patients by Day 3. Improvement (better/cured) in pain on movement: 16/17 diflunisal vs. 9/14 oxyphenbutazone p <0.01. Overall assessment (patient and physician): no differences at Day 1 or 3.	“[O]n the third day of treatment showed considerable improvement in the presenting symptoms and at this point diflunisal was statistically significantly better than oxyphenbutazone in regard to relief of pain	Time elapsed from injury to entry into study significantly longer in oxybutazone group (median 13 vs. 4 hours). Sparse study details. Results suggest little clinical differences for acute pain relief. Medication off market.

					on movement of the joint.”	
Hayes 1984 RCT	4.5	N = 191 males >18 years old diagnosis of acute unilateral sprains or strains of ankle, hips, shoulders, or knees based on history and physical findings	Sulindac 200mg BID vs. ibuprofen 400mg TID, 4-day treatment.	Outcomes at 4 days: sulindac vs. ibuprofen mean rank for day pain, night, active motion, tenderness, ROM, and swelling: 86.3/91.0, 72.6/77.6, 88.5/87.4, 91.7/ 84.9, 83.2/93.3, 88.7/86.2. No differences reported.	“[S]ulindac has a place in the treatment of acute sprains and strains.”	No placebo. Multiple co-interventions allowed. Data suggest no differences in treatments.
McLathie 1985 RCT	4.5	N = 144 Grade 1 and 2 inversion injuries to ankle sustained in sport	Ibuprofen 600mg QID vs. 1200mg BID vs. placebo for Grade I, II injuries; 7-day trial.	Ibuprofen QID vs. BID vs. placebo: Joint tenderness (0-8 scale): Day 3 no differences between any group. Day 7 VAS 2.44 vs. 2.647 vs. 3.182 (p <0.001). Mean level of training (0-3 scale): Day 3; 1.34 vs. 1.34 vs. 1.23, p <0.01 for ibuprofen vs. placebo. No difference between ibuprofen groups.	“[I]n soft tissue injuries to the lateral ligament complex caused by sporting activity a short course of high dose ibuprofen should be considered.”	Trial conducted in athlete population. Randomization, allocation details sparse. No blinding. Data suggest NSAID superior to placebo although clinical differences appear to be small.
Kayali 2007 RCT	4.0	N = 100 1st or 2nd degree lateral ankle sprains within 48 hours of admission	Diclofenac sodium 75mg twice daily vs. paracetamol 500mg 3 times daily for 5 days for Grade I and II ankle sprains; follow-up for 6 weeks.	Physician global mean assessment for diclofenac sodium vs. paracetamol Day 1, 10, and Week 6: 1.46±0.5 vs. 1.42±0.49, 3.18±0.5 vs. 3.14±0.53, 3.76±0.43 vs. 3.72±0.45. ROM initial and last examination: 28.8°±9.3 vs. 30.2°±8.5 p = 0.43, 68.4°±3.1 vs. 67.6°±3.6 p = 0.03. No differences in swelling at any period.	“[D]iclofenac sodium and paracetamol are effective and well tolerated as a short term treatment alternatives for acute ankle injuries.”	No placebo. Lack of randomization, allocation, baseline comparison and blinding details. Data suggest equivalency.

Viljakka 1983 RCT	4.0	N = 119 ankle sprains	Layer bandage vs. elastic adhesive tape. Oxyphenbutazone 100mg tid vs. clonixin 300mg TID vs. placebo.	No significant differences between layer bandage vs. elastic tape bandage in pain, tenderness, swelling, ROM. Elastic caused more rash, irritation or compression of skin. Examiners estimate of "Good" result: layer bandage (64%) vs. elastic (62%) vs. placebo 50%) vs. oxyphenbutazone (53%) vs. clonixin (84%). No differences between bandage groups. Placebo vs. oxyphenbutazone p >0.05. oxyphenbutazone vs. clonixin p <0.01, placebo vs. clonixin p <0.01.	"The layer bandage proved more stable in the lateral direction than the elastic adhesive tape bandage (p less than 0.001). Clonixin proved useful in controlling swelling and in the authors opinion gave the best clinical results."	Randomization, allocation, baseline comparability, blinding, compliance details sparse. Data suggest clonixin superior to oxyphenbutazone based on physician assessment but is of unclear clinical significance. Clonixin not available in U.S.
----------------------	-----	-----------------------------	--	--	---	---

### OPIOIDS – Oral, Transdermal, and Parenteral (Includes Tramadol)

The use of opioids and Tramadol for analgesic treatment of acute ankle sprain has been described.(443, 459, 463) (Hewitt 07, Ekman 06, Aghababian 86) They are widely used in post-operative settings.

*Recommendation: Opioids for Select Acute or Post-operative Ankle Sprain*

**Limited use of opioids for no more than 1 week is recommended for select patients with severe pain related to acute ankle sprain. Limited use of opioids for no more than 1 week may be indicated for those that have undergone ankle ligament repair surgery or those who encountered surgical complications.**

*Indications* – Highly selective use. Severe pain with acute ankle sprain and post-operative pain management. Generally to be used only with either demonstrated insufficient control of pain with NSAID or severe sprain/post-operative pain.

*Frequency/Dose/Duration* – Frequency and dose per manufacturer’s recommendations; may be taken scheduled or as needed; generally suggested to be taken for short courses of a few days. Total length of treatment usually ranges from a few days for injuries to up to 2 weeks for post-surgical management.

*Indications for Discontinuation* – Sufficient pain management with other methods such as NSAIDs, resolution of pain, intolerance, adverse effects, lack of benefits, or failure to progress over a couple weeks.

*Strength of Evidence* – **Recommended, Evidence (C)** – Acute  
**Recommended, Insufficient Evidence (I)** – Post-operative  
*Level of Confidence* – Low

*Rationale for Recommendation*

There are two high-quality randomized placebo controlled trials that evaluate the use of Tramadol for treatment of ankle sprain.(443, 463) (Hewitt 07, Ekman 06) Tramadol was demonstrated to be as effective as NSAIDs for short-term pain relief,(443) (Ekman) and as effective as hydrocodone with acetaminophen for pain at rest over the first 3 days post-injury.(463) (Hewitt 07). A low-quality trial concluded that codeine with acetaminophen was equivalent to diflunisal for acute ankle sprain analgesia.(459) (Aghababian 86)

The vast majority of patients with ankle sprain generally do not have pain sufficient to require opioids. Patients having such degrees of pain should generally have investigations performed for alternative diagnoses (see Table 11). Opioids (Tramadol) are not invasive, but have very high dropout rates and otherwise high rates of adverse effects. They are moderate to high cost depending on duration of treatment (see Chronic Pain guideline). They are recommended for short-term analgesia if NSAIDs are not tolerated or are insufficient.

Quality evidence for treatment of post-operative patients with opioids is absent. Some patients have insufficient pain relief with NSAIDs, thus judicious use of opioids may be helpful, particularly for nocturnal use. Opioids are recommended for brief select use in post-operative patients primarily at night to achieve post-operative sleep.

*Evidence for the Use of Opioids for Ankle Sprain*

There are 2 high-quality RCTs incorporated into this analysis. There is 1 low-quality RCT in Appendix 1.

Author/Y ear Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Hewitt 2007 RCT	9.5	N = 603 adults with ankle sprain and a diagnosis of partial ligament tear	Tramadol plus acetaminophen (37.5/375) QID vs. hydrocodone plus acetaminophen (7.5/650) qd vs. placebo for acute mild and moderate ankle sprain short term analgesia (5-day follow-up).	Tramadol/APAP vs. hydrocodone/APAP vs. placebo (pain relief score 0-4 scale) Immediate Mean Pain Relief: Tramadol better than placebo at 2, 3, 4 hours. Hydrocodone better than placebo at 1, 2, 3, 4 hours. Differences continued through Day 3. No differences between Tramadol and hydrocodone. Pain scores were at rest, not with movement (scores on 4 point scale). Total adverse events (95% CI): tramadol/acetaminophen 43.2% (36.2-50.2); hydrocodone/acetaminophen 36.5% (29.8-43.1); placebo 19.3% (13.9 -24.7). Discontinuation caused by adverse events: tramadol/acetaminophe	“One or 2 capsules of 37.5 mg tramadol/325 mg acetaminophen and 1 capsule of 7.5 mg hydrocodone/650 mg acetaminophen were well tolerated, had comparable clinical utility, and were more effective than placebo in the management of acute musculoskeletal pain caused by ankle sprain.”	Study limited to short-term analgesia. Pain scores were at rest and not with activity, limiting overall conclusions.

				n 5.2%; hydrocodone/acetaminophen 4.4%; placebo 1.4%. Most common adverse events were somnolence, nausea, dizziness, and vomiting.		
Ekman 2006 RCT	9.5	N = 829 acute 1st- or 2nd-degree ankle sprain	Valdecoxib 20mg once daily vs. valdecoxib 20mg twice daily vs. Tramadol 50mg 4 times daily vs. placebo for acute mild and moderate ankle sprain.	Valdecoxib 20mg BID vs. valdecoxib 20mg qd vs. Tramadol 50mg 4 times vs. placebo. Patient global assessment good/very good: Day 4 no differences, Day 7 (76.4 vs. 67.3 vs. 59.6 vs. 55.5) p <0.001 for BID vs. placebo. APS questionnaire: 33.9 vs. 26.6 vs. 20.6 vs. 24.4 (p = 0.009 Day 4). Patient assessment of return to walking with/without pain Day 4 (47.5/44.6/38.4/35.0) p = 0.002; Day 7 (79.4/72.5/67.3/ 63.9) p = 0.001. Adverse events, any, (%): valdecoxib 20mg BID 33.0% vs. valdecoxib 20mg qd 27.2% vs. tramadol 50mg QID 58.0% vs. placebo 43.1%. Adverse events, severe, (%): valdecoxib 20mg BID 2.1% vs. valdecoxib 20mg qd 1.7% vs. tramadol 50mg QID 7.5% vs. placebo 3.3%. Withdrawals due to adverse events: tramadol 12.2% vs. valdecoxib 3.4% (p = 0.0005); valdecoxib 3.4% vs. placebo 2.4% (p = 0.75). Adverse events included upper GI discomfort, GI-related adverse events, CNS-related adverse events, fatigue,	“Valdecoxib 20 mg bid was at least as effective as Tramadol 50 mg 4 times daily and significantly better than placebo.”	Data suggest valdecoxib 20mg BID superior to placebo and trended towards better than tramadol for acute pain relief at Days 4 and 7. Data suggest no difference in tramadol and placebo at Day 4, with higher withdrawal rates in tramadol group.

				accidental injury, asthenia, impaired concentration, upper respiratory tract infection, pruritus, and rash.		
--	--	--	--	---	--	--

## PROTEOLYTIC ENZYMES

The use of oral proteolytic enzymes such as hydrolase trypsin, endopeptidase bromelain, and flavonoid rutoside is described as a treatment for pain and swelling from ankle sprain.(464-466) (Kerkhoffs 04, Brakenbury 83, Craig 75)

*Recommendation: Proteolytic Enzymes for Acute, Subacute or Chronic Ankle Sprain*

**The use of oral proteolytic enzyme preparations is moderately not recommended for the treatment of acute, subacute, or chronic ankle sprain.**

*Strength of Evidence – Moderately Not Recommended, Evidence (B)*

*Level of Confidence – Moderate*

### *Rationale for Recommendation*

There are two placebo-controlled trials for proteolytic enzymes. A high-quality placebo-controlled trial demonstrated no difference between proteolytic enzymes and placebo in pain score, reduction in swelling, or range of motion measures.(464) (Kerkhoffs 04) A moderate-quality study found no differences in circumference or volume after 5 days of treatment.(466) (Craig 75) A low-quality trial compared enzymes and cast immobilization to placebo, with and without immobilization, with significant difference favoring enzymes, but had multiple methodological weaknesses and was of uncertain clinical significance.(465) (Brakenbury 83) Oral proteolytic enzymes are well tolerated(464) (Kerkhoffs 04) and low cost, but are not efficacious and therefore are not recommended.

### *Evidence for the Use of Proteolytic Enzymes for Ankle Sprain*

There is 1 high- and 1 moderate-quality RCT incorporated into this analysis. There is 1 low-quality RCT in Appendix 1.(465) (Brakenbury 83)

Author/Year Study Type	Score (0-11)	Sample Size	Comparison on Group	Results	Conclusion	Comments
Kerkhoffs 2004 RCT	8.0	N = 692 aged 16-53 years with acute unilateral sprain of the lateral ankle joint	Oral hydrolytic enzymes (various combinations) of phlogenzym, trypsin, bromelain, rutoside) vs. placebo.	Pain reduction at 7 days: Bromelain-trypsin 73.7%, Phlogenzym 60.3%, placebo 73.3%. Ankle swelling reduction: no significant differences found.	“Administration of proteolytic enzymes is no more effective than placebo in patients with an acute lateral ankle sprain treated functionally with a brace.”	All patients treated with functional brace in addition to interventions. Data suggest lack of efficacy.
Craig 1975	4.5	N = 61 soft-tissue	Proteolytic enzymes (chymoral)	Chymoral vs. placebo measurements for volume, horizontal	“[N]o significant improvement in the treated	Allocation, blinding, baseline

RCT		ankle injuries	vs. placebo taken for 5 days after acute ankle sprain.	circumference, diagonal circumference, and diameter: 60±41.608/75.42 ±57.274 (p = 0.2), 1.10±0.8807/1.229±0.9019 (p = 0.4), 0.469±0.3631/0.466±0.2842 (p = 0.9). Percent improved (%): 4.958±3.378/6.374±4.616 (p = 0.2).	series, there would appear to be no economic grounds for the continued use of these enzymes.”	comparability, compliance details sparse or missing. Data suggest lack of efficacy.
-----	--	----------------	--	---	---	---

### STREPTOKINASE/STREPTODORNASE

Oral combination streptokinase/streptodornase has been administered in the treatment of pain and inflammation for a variety of traumatic conditions.(467) (Calandre 91)

*Recommendation: Streptokinase/Streptodornase Preparations for Acute, Subacute, or Chronic Ankle Sprain*

**Oral streptokinase/streptodornase preparations are not recommended for the treatment of acute, subacute, or chronic ankle sprain.**

*Strength of Evidence – Not Recommended, Insufficient Evidence (I)*  
*Level of Confidence – Low*

#### *Rationale for Recommendation*

There is one moderate-quality trial for streptokinase/streptodornase (Varidase) that demonstrated benefit over placebo in the outcomes measures of pain and edema, although clinically the differences are of uncertain significance.(467) (Calandre 91) There is no recent medical literature on the use of this preparation for ankle sprain. This treatment has low reported side effects when used orally, but additional information is otherwise lacking. As the product is not available as an oral agent, there is no recommendation for or against its use.

#### *Evidence for the Use of Streptokinase/Streptodornase for Ankle Sprain*

There is 1 moderate-quality RCT incorporated into this analysis.

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Calandre 1991 RCT	6.5	N = 200 ankle sprains	Streptokinase 10,000 units plus Streptodornase 2500 units, 2 tabs po TID for 8 days vs. placebo (acute sprain, Grade II, III)	SS vs. placebo, Days 4, 8 mean (SE) (0 none, 1 mild, 2 moderate, 3 severe VAS score) Spontaneous pain: 0.41± 0.05 vs. 0.56±0.06 p = NS, 0.04±0.020 vs. 0.19±0.040, p <0.05; Mobilization pain: 1.26±0.06 vs. 1.70± 0.06, p <0.0001, 0.69±0.062 vs. 1.14±0.060, p <0.0001; edema: 1.38±0.072 vs. 1.96 ±0.060,	“Oral (streptokinase +streptodornase) appears as a suitable alternative to NSAIDs because of its efficacy and low incidence of side effects.”	Data suggest SK, SD may modestly reduce edema, pain over placebo. Clinical results however are of uncertain significance.

				p <0.0001, 0.60±0.062 vs. 1.41±0.070, p <0.0001.		
--	--	--	--	---	--	--

## SYSTEMIC GLUCOCORTICOSTEROIDS

Oral or intramuscular glucocorticosteroids are often administered for musculoskeletal complaints with anti-inflammatory mechanism(s) as a rationale for efficacy. However, the use of these medications for ankle sprain is not cited in quality studies. Injections are reviewed below.

*Recommendation: Systemic Glucocorticosteroids for Acute, Subacute, or Chronic Ankle Sprain*  
**The use of oral or IM steroid preparations is not recommended for the treatment of acute, subacute, or chronic ankle sprain.**

*Strength of Evidence – Not Recommended, Insufficient Evidence (I)*  
*Level of Confidence – High*

### *Rationale for Recommendation*

There is no quality evidence for use of these agents for treatment of ankle sprain. As evidence is lacking and evidence of efficacy is present for several other treatments for this condition, the use of glucocorticosteroids by oral or intramuscular routes is generally suggested to be avoided pending publication of quality studies.

*Evidence for the Use of Systemic Glucocorticosteroids for Ankle Sprain*  
 There are no quality trials incorporated into this analysis.

## VITAMINS – Including Vitamin B<sub>6</sub> (Pyridoxine)

The use of vitamins including B<sub>6</sub>, C, and E is not described for the treatment of ankle sprain.

1. *Recommendation: Vitamin Therapy for Treatment of Ankle Sprains*  
**There is no recommendation for or against the use of vitamins as a therapeutic intervention or for prevention of ankle sprain in doses recommended by the U.S. FDA.**

*Strength of Evidence – No Recommendation, Insufficient Evidence (I)*  
*Level of Confidence – Low*

2. *Recommendation: High-dose Vitamin Therapy for Treatment of Ankle Sprains*  
**The use of high doses (exceeding U.S. FDA recommendations) or expensive compounded preparation vitamins is not recommended for prevention of ankle sprain.**

*Strength of Evidence – Not Recommended, Insufficient Evidence (I)*  
*Level of Confidence – High*

### *Rationale for Recommendations*

There are no quality studies for the use of vitamins for purposes of either treatment or prevention of ankle sprain. If bought in standard doses as standard stock item at food and drug stores, vitamins are usually inexpensive. If taken in doses that do not substantially exceed U.S. FDA recommendations, vitamins are safe. However, custom vitamin mixtures or compounds and high doses of vitamins may be expensive and harmful and are not recommended.

*Evidence for the Use of Vitamins for Ankle Sprain*  
 There are no quality trials incorporated in this analysis.

## Topical Medications BENZYLAMINE

Benzydamine (Difflam™) is a non-COX inhibitor anti-inflammatory used topically for oral and vaginal mucositis disorders,(468) (Karavana 09) and has been described for the treatment of ankle sprain.(469) (Elswood 85)

*Recommendation: Benzydamine for Ankle Sprains*

**There is no recommendation for or against the use of benzydamine for the treatment of acute, subacute, or chronic ankle sprain.**

*Strength of Evidence – No Recommendation, Insufficient Evidence (I)*

*Level of Confidence – Low*

*Rationale for Recommendation*

There are no quality trials of benzydamine for the treatment of ankle sprains. A low-quality trial found no benefit of benzydamine over placebo.(469) (Elswood 85) Benzydamine applied topically has few side effects, is inexpensive, but is of unknown efficacy, and therefore there is insufficient evidence to recommend for or against this treatment.

*Evidence for the Use of Benzydamine for Ankle Sprain*

There are no quality trials incorporated into this analysis. There is 1 low-quality RCT in Appendix 1.(469) (Elswood 85)

### **COLD GEL (Menthol/Ethanol Gel)**

Gels that produce a cold feeling (Menthol/Ethanol) – presumably by stimulating cold receptors in the skin – have been used for treatment of ankle sprain.(470, 471) (Airaksinen 03, Matthews 09)

*Recommendation: Cold Gel for Ankle Sprain*

**There is no recommendation for or against the use of medications (gels) that stimulate sensation of cold for treatment of ankle sprain.**

*Strength of Evidence – No Recommendation, Insufficient Evidence (I)*

*Level of Confidence – Low*

*Rationale for Recommendation*

There is one moderate-quality placebo controlled trial for the use of cold gel in minor soft tissue injuries, which included minor ankle sprain as a subset.(470) (Airaksinen 03) The study demonstrated improved pain and subjective rating of functional disability scores in the cold gel group compared with placebo, although the results were likely of small clinical significance. There was no analysis for the ankle sprain subset of subjects. Cold gel has few adverse effects, is non-invasive, and is of low to moderate cost depending on length of use. There is no quality evidence of efficacy for ankle sprain and therefore there is no recommendation for or against its use.

*Evidence for the Use of Cold Gel for Ankle Sprain*

There is 1 high- and 1 moderate-quality RCT incorporated in this analysis.

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
<b>Cold Gel (Menthol/Ethanol)</b>						
Gonzalez de Vega 2013  RCT	9.0	N = 449 with unilateral ankle sprain of the lateral ligaments;	Traumeel ointment (T-O), 2 g (n = 152) vs. Traumeel gel (T-G) (n =150) vs. Diclofenac gel (D-G) (n =	No significant differences between groups for primary outcomes.	“T-O and T-G decreased pain and improved joint function to the same extent as D-G in acute ankle	No placebo, non-inferiority. Multicenter study. Large N. Data suggest comparable efficacy. However, less

		age range 17- 48	147). Administered to ankle 3x/day for 14 days, paracetamol used as rescue medication for pain. Follow- up: baseline, days 4, 7, 14 and 42		sprain, and were well tolerated.”	paracetamol use in diclofenac group (14.6% vs. 19.7%, 20.7%), suggesting potential confounding.
Airaksinen 2003  RCT	6.5	N = 74 sports- related soft tissue injuries	Cold Gel (Ice Power) vs. placebo gel (4 times a day for 14 days) for acute minor injuries (mixed, including ankle).	Cold gel vs. placebo: pain at rest (0-100 VAS): Day 1; 59±15 vs. 59±15, Day 7; 30 ±16 vs. 45±15, Day 14; 14± 13 vs. 26±18, Day 28; 7±12 vs. 13±14, p <0.001 at 1, 2, 4 weeks. Functional disability (0- 100 VAS): Day 1; 63 vs. 62 Day 7; 31 vs. 48 p <0.001.	“[C]old gel caused significantly faster pain relief and significantly faster rehabilitation results after minor soft tissue injuries.”	Heterogeneous injuries included, 23/74 of ankle. Severity of ankle sprain not specified other than minor. Clinical significance of pain and disability differences likely small. Skin temperature not measured (cold) objectively and thus not considered as part of cryotherapy. Data suggest modest efficacy.

### COMFREY (*Symphytum officinale*)

Comfrey extract ointment is used in the U.S. and Europe to treat wounds and as an anti-inflammatory, and has been described for ankle sprains.(472-475) (Bleakley 08, D’Anchise 07, Predel 05, Koll 04) The FDA banned the use of oral comfrey products due to pyrrolizidine alkaloid induced liver toxicity,(476) (Food Drug Admin 01) but topical preparations are available.

*Recommendation: Comfrey Extract for Ankle Sprains*

**There is no recommendation for or against the use of topical comfrey extract for the treatment of ankle sprains.**

*Strength of Evidence – No Recommendation, Insufficient Evidence (I)*

*Level of Confidence – Low*

#### *Rationale for Recommendation*

There is one placebo-controlled moderate-quality study that suggested efficacy in improved analgesia and reduced swelling.(474) (Koll 04) There is one moderate-quality trial with two reports that demonstrated equivalency of comfrey gel to topical diclofenac gel in resting and active motion pain relief after 7 days of treatment.(473, 475) (D’Anchise 07, Predel 05) As there is no ability to control the dose of nutraceutical and similar products, there is no recommendation for or against the use of comfrey to treat acute ankle sprain.

*Evidence for the Use of Comfrey Extract for Ankle Sprain*

There are 3 moderate-quality RCTs incorporated into this analysis.

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Koll 2004  RCT	7.5	N = 143 unilateral acute ankle sprains	Comfrey extract gel vs. placebo (4 times daily application of 2g).	Comfrey vs. placebo, VAS: mean between injured/healthy foot at Day 4, 7; Pain: 2.37 vs. 3.35, p = 0.001, 1.44 vs. 2.85, p = 0.0001; swelling: 1.69 vs. 2.36, p = 0.0011, 1.09 vs. 1.90, p = 0.0001. Patient global efficacy (good/excellent) 61.3% vs. 50%, p = not reported.	“Compared to placebo, comfrey proved clinically and statistically superior concerning reduction of pain, swelling, movement limitation and global efficacy.”	Lack of randomization, allocation, compliance details. Data suggest comfrey root extract superior to placebo gel for treatment of acute ankle sprains.
D’Anchise 2007  RCT	5.5	N = 164 acute unilateral ankle sprains (distortions)	Comfrey extract ointment (Kitta- Salbe®) vs. diclofenac gel (6-cm q.i.d. x 7 days for acute ankle sprain.	Mean difference in tenderness values measured by tonometry of injured vs. contralateral ankle: comfrey extract minus diclofenac measured as AUC 61.1 h* N/cm <sup>2</sup> favoring comfrey extract (95% confidence interval: 19.08; 103.09 h x N/cm <sup>2</sup> ). No differences in VAS for resting, movement pain.	“The re- evaluation of the data showed superiority of the plant based ointment over the diclofenac gel in the treatment of distortions. It is encouraging and impressive to realize that a natural product seems to be an effective and safe alternative to the standard topical treatment with diclofenac.”	Second report of Predel 2005 (consider one study). Data suggest improvements in tenderness, but not in pain with movement or at rest compared with topical NSAID. No control arm.

Predel 2005  RCT	5.5	N = 164 with acute unilateral ankle sprain (distortion)	Comfrey extract ointment (Kitta-Salbe®) vs. diclofenac gel (6-cm QID x 7 days for acute ankle sprain.	Comfrey vs. diclofenac VAS reduction (%) from baseline: Day 7; At rest: 92.01% vs. 84.96% (p >0.05); At motion: 83.2% vs.72.37% (p >0.05); Good/Excellent patient assessment: 84.2% vs. 70.8% p = 0.0111.	“It was confirmatorily shown that Comfrey extract is non-inferior to diclofenac. Moreover, the results of the primary and secondary variables indicate that Comfrey extract may be superior to Diclofenac gel.”	No placebo. Randomization, allocation, compliance details sparse. Suggests comfrey root extract of equal efficacy.
------------------------	-----	---	---	---	---	--

### LIDOCAINE PATCHES

The use of lidocaine patches has been described for various musculoskeletal disorders and has been reviewed in other guidelines (see Chronic Pain, Elbow Disorders, and Hand, Wrist and Forearm Disorders ).

*Recommendation: Lidocaine Patches for Acute, Subacute, or Chronic Ankle Sprain*

**There is no recommendation for or against the use of lidocaine patches for the treatment of acute, subacute, or chronic ankle sprain.**

*Strength of Evidence – No Recommendation, Insufficient Evidence (I)*

*Level of Confidence – Low*

#### *Rationale for Recommendation*

There are no quality trials of lidocaine patch use for ankle sprain. As one goal of therapies for acute ankle sprain is pain relief, this may represent a potential treatment on a short-term basis while other concomitant interventions such as elevation, cryotherapy, and NSAIDs are utilized. Patches are low cost for a short-term trial; however, costs accumulate rapidly over time. Adverse effects of systemic absorption of topical anesthetics have prompted an FDA warning. There is no recommendation for lidocaine patches for ankle sprain.

#### *Evidence for the Use of Lidocaine Patches for Ankle Sprain*

There are no quality trials incorporated into this analysis.

### TOPICAL CREAMS (including MOVELAT)

Movelat is marketed in Europe as an anti-inflammatory gel or cream composed of mucopolysaccharide polysulphuric acid ester with adrenocortical extract and salicylic acid. It has been described for the treatment of ankle sprain.(477, 478) (Frahm 93, Lester 81)

*Recommendation: Movelat for Acute, Subacute, or Chronic Ankle Sprain*

**There is no recommendation for or against the use of topical creams (including Movelat) for the treatment of acute, subacute, or chronic ankle sprain.**

*Strength of Evidence – No Recommendation, Insufficient Evidence (I)*

*Level of Confidence – Low*

### Rationale for Recommendation

There are two moderate-quality placebo-controlled quality trials of Movelat for the treatment of ankle sprains. One trial compared Movelat to placebo for mild and moderate acute sprain controlling for other co-interventions and demonstrated modest analgesic relief of pain at Day 9 only of an 11 day follow-up.(477) (Frahm 93) The other study compared Movelat as an adjunct to physiotherapy, and suggested a benefit of treatment, although an ill-defined scoring system was used and results were not supported by the analysis.(478) (Lester 81) Movelat applied topically has few side effects, is inexpensive, but is of unknown efficacy, and therefore there is insufficient evidence to recommend for or against this treatment.

### Evidence for the Use of Movelat for Ankle Sprain

There are 2 moderate-quality trials incorporated into this analysis.

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Frahm 1993 RCT	6.0	N = 163 acute sprains of the knee or ankle joint	Movelat vs. placebo. 10cm cream BID for acute mild, moderate ankle sprain.	Movelat vs. placebo-mean pain with movement (100mm VAS) Day 2, 4, 9, 11: 57.46 vs. 64.33, p = NS; 41.53 vs. 48.13, p = NS; 24.87 vs. 38.73, p = 0.0065, 21.11 vs. 32.10, p >0.05. No differences in pain at rest, swelling, or physician assessment of efficacy or tolerability.	“Treatment with the active cream lessened the pain on movement by 28% compared with the placebo, a statistically significant difference.”	Double-blinding details sparse. Data suggest topical Movelat cream has limited, if any, analgesic efficacy as only significant Day 9. No differences for pain at rest, edema, or subjective efficacy. Data suggests benefit clinically non-significant.
Lester 1981 RCT	5.5	N = 50 sprained ankles	Movelat vs. placebo.	Scoring system 1-4 (not defined) for movement limitation, swelling, pain, side effects created. Mean cumulative score (higher = better): Movelat gel group 12.1 (±3.8) vs. placebo gel group 9.7(±3.7), p <0.05.	“Movelat Gel as an adjunct to physiotherapy was shown to be superior to placebo gel and physiotherapy in alleviating the signs and symptoms of sprained ankle.”	Randomization, allocation, compliance details sparse. Minimal statistical analyses presented. Data suggest cream may be effective, however, findings not clearly supported by details of analysis.

### TOPICAL NSAIDs

Topical NSAIDs are used to deliver medication locally and superficially in musculoskeletal disorders, including ankle sprain disorders.

#### 1. Recommendation: Topical NSAIDs for Acute Ankle Sprain

**Topical NSAIDs are moderately recommended for the treatment of acute ankle sprain.**

*Indications* – Acute ankle sprain or patients with contraindications for oral treatment or who prefer not to take oral medications. No evidence of comparative superiority of one topical NSAID over another.

*Frequency/Duration* – Frequency per manufacturer’s recommendation. Topical NSAID use has been reported for 1 to 3 weeks.(39) (Russell 91; Predel 12)

*Indications for Discontinuation* – Resolution, intolerance, adverse effects, or lack of benefits.

**Strength of Evidence – Moderately Recommended, Evidence (B)**

*Level of Confidence* – Moderate

2. *Recommendation: Topical NSAIDs for Subacute, Chronic, or Post-operative Ankle Sprain*

**There is no recommendation for or against the use of topical NSAIDs for the treatment of subacute, chronic, or post-operative ankle sprain.**

**Strength of Evidence – No Recommendation, Insufficient Evidence (I)**

*Level of Confidence* – Low

*Rationale for Recommendations*

There are 3 high- and 3 moderate-quality placebo-controlled randomized trials for the use of topical NSAIDs in the treatment of ankle sprain injuries. All 3 high-quality RCTs demonstrated treatment benefit in analgesia and swelling reduction using daily ketoprofen patch,(479) (Mazieres 05) diclofenac gel, (Predel 12) and ketorolac or etofenamate gel used over a 2-week period.(480) (Diebschlag 90) A moderate-quality trial demonstrated no benefit from Piroxicam gel over placebo for ankle sprains,(39) (Russel 91) while a second moderate-quality study found niflumic acid gel to provide benefit in pain and functional improvement in the acute phase of injury.(481) (Dreiser 90) A third moderate-quality study found no treatment effect with flurbiprofen patch until 7 days post injury compared with placebo.(482) (Dreiser 94) There are no trials that demonstrate efficacy of one NSAID over another. One high-quality trial demonstrated increased efficacy in diclofenac gel formulated with lecithin compared to non-lecithin gel, although no placebo arm was included.(483) (Mahler 03) One moderate-quality trial demonstrated equivalent efficacy of NSAID gel with therapeutic ultrasound, although other studies found no benefit from ultrasound (see Physical Methods – Ultrasound).(484) (Oakland 93) Topical NSAIDs are not invasive, have low adverse effect rates, but may cumulatively be moderate to high cost. They are recommended for treatment of acute ankle sprain, particularly in patients who do not tolerate or are poor candidates for oral treatment. Post-operative patients may be reasonable candidates after the incision is well healed.

*Evidence for the Use of Topical NSAIDs for Ankle Sprain*

There are 4 high-quality RCTs (Predel 12) and 4 moderate-quality RCTs incorporated in this analysis.

There is 1 low-quality study in Appendix 1.(485) (Campbell 94)

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
<b>Topical NSAIDs vs. Placebo</b>						
Mazières 2005 RCT	9.0	N = 163 suffering painful (spontaneous pain >or = 50mm on a 0- to 100-mm VAS), benign (Grade I or II), recent (<2 days) ankle sprains as a	Ketoprofen 100mg patch daily vs. placebo patch; 2-week trial for acute Grade I, II.	Ketoprofen vs. placebo Day 3, 7, 14. Spontaneous pain VAS (100mm): 33±19 vs. 40±22 p = 0.0053, 18±17 vs. 28±24 p = 0.007, 9±13 vs. 20±26 p = 0.006. Pain on active motion, VAS (100mm): 37±18 vs. 45± 22, 22±17 vs. 33±24 p = 0.192, 10±14 vs. 22±25 p = 0.0178. Ankle swelling	“This trial suggests that a 3- to 14-day treatment course by once-a-day 100-mg ketoprofen TDS patch is useful in post-traumatic painful soft tissue injuries, the duration	Data suggest modest short-term benefit of ketoprofen patch over placebo for acute injury.

		model of general traumatic soft tissue injuries		(%): 3.9±3.7 vs. 4.0±3.4, p = 0.0476, 2.8±3.5 vs. 3.5±5.0, p = 0.0234, 1.9±2.8 vs. 2.2±3.6, p = 0.0765.	depending on the results obtained, although 7-days seem optimal.”	
Diebschlag 1990  RCT	8.5	N = 37 ankle sprains	Topical Ketorolac tromethamine 2% gel vs. etofenamate gel 5% vs. placebo x 15 days for acute ankle sprain.	Ketorolac vs. placebo: (% mean difference, 95% CI, p-value). Max volume change: -0.72 (-1.16 to -.28, p = 0.002; AUC: -0.84 (-1.17 to -0.51) p = 0.0001; Day 15 volume: -0.82 (-1.02 to -0.61) p = 0.0001. Ketorolac vs. etofenamate (% mean difference, 95% CI, p-value). Max Vol Change -0.02 (-.46 to 0.42) p = 0.92. AUC: 0.13 (-0.20 to 0.46) p = 0.44. Day 15 Volume: 0.13 (-0.08 to 0.33), p = 0.22. VAS pain on movement: no differences between groups Day 2. Lower scores Days 4, 8. Ketorolac lower than placebo at Day 4, 8.	“Overall, this small study shows topical application of ketorolac would seem to show excellent efficacy with few side-effects.”	Small sample size. Data suggest modest short-term benefits of ketorolac gel vs. placebo for ankle swelling. No superiority over etofenamate gel. No other functional outcomes measured.
Dreiser 1994  RCT	6.0	N = 131 outpatients, 18-70 years old, with acute pain in ankle joint caused by post-traumatic sprain	Flurbiprofen patch (40mg) vs. placebo patch twice daily.	Flurbiprofen vs. placebo at Day 0, 3, 7; spontaneous pain VAS: 64.0 vs. 63.3, 30.2 vs. 31.2, p >0.05, 14.0 vs. 17.6, p <0.05. Periarticular edema (cm): 1.93 vs. 1.79, p >0.05, 0.94 vs. 0.87, p >0.05, 0.42 vs. 0.54, p <0.05; overall efficacy (patient rating good/very good Day 7): 75% vs. 62% p = 0.14.	“After 7 days treatment, the 40 mg flurbiprofen patch proved superior to the control in the treatment of acute, uncomplicated ankle sprains with respect to both the subjective symptoms (pain) and the	Sparse details for randomization, allocation, baseline comparability and blinding. Data suggest benefit at 7 days over placebo but no benefit at 3 days. No difference in patient satisfaction.

					objective signs (oedema).”	
Russell 1991 RCT	5.5	N = 200 acute soft tissue injuries (ankle or acromioclavicular sprains, supraspinatus, or Achilles tendinitis)	Piroxicam 0.5% gel 1gm applied QID vs. placebo gel.	Piroxicam vs. placebo: failure to complete study due to lack of efficacy: 6/100 vs. 42/100, p <0.001. Spontaneous pain: improvement from baseline in VAS Days 2-8 in both groups p <0.001, piroxicam significantly better than placebo p = 0.047. In sprain group, differences between placebo not significant.	“[P]iroxicam gel, administered on a q.i.d. basis for a total daily dose of 20 mg, is effective treatment for patients suffering from musculoskeletal injuries (sprains and tendinitis) and is significantly more effective than placebo.”	Mixed MSDs limit conclusions for specific disorders. Study suggests topical NSAID is effective for tendinitis (shoulder) but did not demonstrate VAS difference in sprains.
Dreiser 1990 RCT	5.0	N = 60 recent uncomplicated ankle sprains	Niflumic acid gel 2.5% applied TID vs. placebo gel for 7 days; uncomplicated sprains with moderate-severe pain <3 days from injury.	Niflumic acid vs. placebo: Differences from baseline in VAS, Day 4; 31.9±3.31 vs. 22.35±3.761, p = 0.056. Day 8: 54.1±4.31 vs. 38.95±5.26, p = 0.03. Investigator rating of patient response Day 4: pain on palpation very much improved, much improved 9 vs. 3, p = 0.026. Pain on contraction much improved, improved 21 vs. 9, p = 0.017; functional disability much improved, improved 24 vs. 11, p = 0.002.	“A new 2.5% topical gel formulation of niflumic acid administered 3-times daily in the treatment of simple ankle sprains has been shown to be effective and well tolerated, with a significantly higher proportion of patients in the group treated with niflumic acid gel being healed at the end of the study.”	Randomization, allocation, blinding methods unclear. Compliance uncertain. Results suggest topical niflumic acid superior to placebo.
<b>Topical NSAIDs vs. Other</b>						
Mahler 2003 RCT	8.5	N = 100 mild to moderate post-traumatic injuries (Grade 1 ankle, knee and muscle injuries)	Diclofenac (DHEP with lecithin) vs. DHEP plain gel for acute ankle sprain.	Pain on movement (VAS) for both groups decreased p <0.01. Lecithin decrease in absolute value Day 3, end of treatment: lecithin = -27.4mm/ gel = -16.8 mm/p = 0.025, lecithin = -48.3 mm/gel = -41.3mm/p = 0.036.	“Due to the presence of lecithin in the new gel formulation, DHEP lecithin showed a faster and significantly more marked	No placebo. Data suggest formulation with lecithin is more effective for pain relief in treatment of acute ankle sprains.

				Spontaneous pain (VAS) significant after 3 days: lecithin = - 18.4mm/gel = - 9.9mm/p <0.01. Pain on movement, spontaneous pain on movement significant Day 2 on, p <0.01.	therapeutic effect compared with that of DHEP gel.”	
Predel 2012 RCT	8.0	N = 242 with acute ankle sprains (Grade I and II); age range 18 to 81	DDEA 2.32% TID, (n = 80) vs. DDEA 2.32% BID, 2 tubes (n = 80) vs. placebo (n = 82). All given 3 tubes labeled morning, noon, evening; 1 <sup>st</sup> dose at center, 2g of gel with fingertips on both sides of ankle ~1 min.; rescue med 500mg paracetamol. Follow-up: baseline, and days 2 to 8.	Mean mm ± SD for POM (VAS): DDEA 2.32% tid vs. placebo: day 5: 49.7±21.5 vs. 25.4±14.8, p <0.0001; DDEA 2.32% bid vs. placebo: 49.1±19.3, p <0.0001.	“DDEA 2.32% gel twice daily (applied in the morning and evening) was well tolerated and provided lasting relief from pain, improved function, and reduced symptomatic healing time in un-complicated ankle sprain.”	Three arms to study. Diclofenac decreased pain vs. placebo although increasing from BID to TID showed little or no difference.
Oakland 1993 RCT	5.5	N = 220 acute lateral ankle ligaments injuries	Felbinac gel plus sham ultrasound placebo vs. placebo gel plus ultrasound vs. felbinac plus ultrasound for acute	Changes from baseline in VAS Pain: 21.5mm vs. 19.4mm vs. 16.5mm, p >0.05. Investigator Assessment (% moderate or better response) 84.5% vs. 83.5% vs. 86.5%. Full Weight Bearing: 73% vs. 77% vs. 80%, p >0.05	“[F]elbinac gel has a similar clinical efficacy to ultrasound in the treatment of acute injuries of the lateral ankle ligaments.”	No placebo. Allocation, investigator blinding not described; 52 of 220 dropped out (results carried forward in analysis). Suggests

			ankle sprains (severity not described).			ultrasound and topical NSAID of similar efficacy. No evidence of combined effect.
--	--	--	---	--	--	---

**Devices/Physical Methods**

**CONTRAST BATHS**

The use of cold/hot contrast baths is commonly utilized for the treatment of musculoskeletal injuries, including ankle sprain.(486) (Stanton 09)

*Recommendation: Contrast Bath Therapy for Acute Ankle Sprain*

**There is no recommendation for or against the use of contrast bath for the treatment of acute ankle sprain.**

*Strength of Evidence – No Recommendation, Insufficient Evidence (I)*  
*Level of Confidence – Low*

*Rationale for Recommendation*

There are no quality trials comparing contrast bath with no treatment. There is one moderate-quality trial that included contrast bath as an intervention compared to cryotherapy and heat.(487) (Cote 88) There was less effect on edema compared to cold, but no functional outcomes were measured. A systematic review of contrast baths for musculoskeletal conditions, including ankle/foot disorders, concluded there is no relationship between physiological effects and functional outcomes. Contrast bath treatments are not invasive, have no adverse effects, and are not costly when self-administered, but there is insufficient evidence of their efficacy and therefore no recommendation for or against their use to treat ankle sprain.

*Evidence for the Use of Contrast Bath for Ankle Sprain*

There is 1 moderate-quality trial incorporated in this analysis.

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Cote 1988  RCT	4.0	N = 30 post- acute sprained ankles	Cold bath (50-60°F) vs. heat bath (102-106°F) vs. contrast bath for acute ankle sprain (Grade I, II) swelling applied once daily (20 minutes) on post-injury Days 3, 4, 5. Outcomes measured 1-3 days post-treatment.	Ankle volume change pre- to post-treatment (mL): cold vs. heat vs. contrast mean (SD); Day 1: -1.3 (27.1) vs. 27.4 (25.2) vs. 27.4 (13.6); Day 3: 1.7 (14.2) vs. 28.7 (15.8) vs. 35.3(31.2). Total 3 day change: 3.3 (11.3) vs. 25.3 (19.5) vs. 26.5 (8.2), p <0.05 cold vs. heat, contrast. No difference between heat and contrast.	“[C]old therapy is clearly the most favorable of the three treatments if the therapeutic objective is to minimize edema before rehabilitative exercise during the third, fourth and fifth days post injury for first- and second-degree ankle sprains.”	Small sample size. Details of allocation, baseline comparability missing. Age of injury not specified. Effect of treatment limited to edema as functional improvement and pain measures not included.

## IMMOBILIZATION AND EARLY MOBILIZATION

Immobilization of the ankle to prevent ankle joint movement in dorsiflexion, plantar flexion, inversion, and eversion is commonly used for treatment of acute ankle sprain. Early mobilization with or without devices that provide some initial external ankle support may be called functional treatment,(386) (Cooke 09) and commonly includes the use of tubular bandage, elastic wrap, lace-up boots, strapping, pneumatic or gel semi-rigid ankle brace, or rigid walking boots. Application of some of the devices and guidance in progression may be aided by supervision of allied health providers such as physical therapists (see Physical or Occupational Therapy). Balance training may be implemented during these sessions (see Balance Training).

### 1. Recommendation: Early Mobilization for Acute Ankle Sprain

**Early mobilization is moderately recommended for acute ankle sprains without fracture.**

*Indications* – Acute ankle sprains (severe sprains should undergo no more than 3 weeks of immobilization, splints should be sufficient for immobilization – see Immobilization for further discussion); ankle sprains that are mild or moderate should not undergo immobilization.

*Strength of Evidence* – **Moderately Recommended, Evidence (B)**

*Level of Confidence* – High

### 2. Recommendation: Cast Immobilization for Acute Mild to Moderate Ankle Sprain

**Immobilization by cast is not recommended for patients with acute mild to moderate ankle sprain as splints should be sufficient. Walking boots are recommended for select severe cases of moderate sprains.**

*Strength of Evidence* – **Not Recommended, Insufficient Evidence (I)**

*Level of Confidence* – High

### 3. Recommendation: Cast Immobilization for Severe Ankle Sprain

**There is no recommendation for or against the use of immobilization by cast.**

*Indications* – Severe ankle sprain.

*Frequency/Duration* – Application of a sugar-tong splint for 10 days to 3 weeks after a 48-hour period of elevation and non-weight bearing.

*Strength of Evidence* – **No Recommendation, Insufficient Evidence (I)**

*Level of Confidence* – Low

### Rationale for Recommendations

There are five quality trials that compared early mobilization with cast immobilization (see Table in Immobilization).(386, 488-494) (Cooke 09, Lamb 09, 05, Dettori 94a,b, Beynon 06, Ardevol 02, Eiff 94) There is evidence early mobilization provides short-term benefit in functional improvement, pain, and return to work. There are no trials demonstrating a negative treatment effect long-term for acute, moderate, or severe sprain injuries. Therefore, early mobilization is recommended over immobilization for most patients (see Immobilization for additional discussion).

There are no quality trials for casting of mild ankle sprains. Mild acute sprains are generally self-limited and respond well to early mobilization and other therapies; therefore, casting is not recommended. There are six quality trials that compared casting with early mobilization for moderate and severe acute ankle sprains. The moderate-quality CAST trial,(386, 488, 489) (Cooke 09, Lamb 09, 05) demonstrated below-the-knee casting of moderate and severe sprains for 10 days provided a statistical, but clinically indeterminate, short-term benefit compared with tubular bandage (control) in subjective ratings of pain,

function, and symptoms in the first 12 weeks. There were no differences between casting and bracing however, and by 9 months there were no differences between groups. A moderate-quality study demonstrated short-term improvement in pain, swelling, and range of motion in the early mobilization group compared to casting for moderate and severe sprains, but did not demonstrate any long-term benefit of one over the other.(490, 491) (Dettori 94a,b) Another moderate-quality trial demonstrated casting was less beneficial for moderate (Grade II) sprains, but was equivocal for severe sprains compared with bracing.(492) (Beynon 06) A moderate-quality trial limited to severe ankle sprains demonstrated early mobilization resulted in short-term benefit in swelling, pain, stiffness and early return to sport compared with 3-week casting.(493) (Ardevol 02) There were no long-term differences measured at 12 months. Another moderate-quality trial demonstrated early mobilization after a 48-hour non-weight-bearing period provided subjective improvement in pain perception at 3 weeks, but no differences in improvement of swelling, residual pain, and function compared with casting.(494) (Eiff 94) However, early mobilization resulted in much faster return to full duty. No long-term differences were demonstrated in any of the quality trials.

Casting is non-invasive, but is restrictive of activity, including return to work, impairs driving performance more than bracing,(509) (Tremblay 09) and is associated with risk for deep venous thrombosis.(488) (Lamb 09) Total direct and indirect costs of casting based on the U.K. health care system are similar to the use of Aircast brace and more cost-effective than compression wrap.(386) (Cooke 09) Cast immobilization is therefore not recommended as an alternative to splinting and early mobilization treatment for severe and moderate ankle sprain.

#### *Evidence for the Use of Early Mobilization for Ankle Sprain*

There are 6 moderate-quality RCTs (two with multiple reports) incorporated into this analysis. (Bendahou 14) There are 3 low-quality RCTs in Appendix 1.(147, 499, 500) (Zwipp 92; Cetti 94; Korkala 87)

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Cooke 2009  Lamb 2005, 2009  RCT	7.5	N = 584 16 years and older with acute severe ankle sprain	Tubular bandage vs. below-knee cast (10 days) vs. Aircast vs. Bledsoe boot. Inclusion criteria of inability to bear weight for 3 days as surrogate for Grade II, III sprains. Study is also known as CAST trial.	Tubular bandage results used as control; 4 weeks: below-knee cast better than tubular bandage for FAOS scores on pain, symptoms, activities of daily living scales. No differences between other interventions except Aircast superior for FAOS ADL scores; 12 weeks: casting better than control FAOS pain, ADL, sports, QoL scores; 9 months: no differences between groups in any measure.	“[I]nitially treated [non weight bearing ankle sprains] treated with 2-3 days of elevation, ice and non-weight bearing exercise, had a more rapid resolution of symptoms and return to normal activities in the first 3 months when treated with a below knee cast for 10 days than when treated with tubular bandage.”	Three reports of same study. All evaluations by postal questionnaire. Compliance to protocols unclear. Co-interventions allowed (ice, NSAIDs, walking aids). Loss to follow-up between 23-27% across groups. Although some statistical differences, clinical differences in outcomes between 4 treatment arms small and of

						uncertain significance.
Ardevol 2002  RCT	6.0	N = 140 Grade III ruptures of lateral ankle ligaments	Cast immobilization (3 weeks) vs. functional treatment (strapping with controlled mobilization) for severe ankle sprains.	Functional treatment showed significant benefit over immobilization at 3, 6 months for pain, swelling, and at 3 months only for stiffness and subjective instability. Mean time to return to sport at same activity 70% vs. 36% favoring functional treatment (p < 0.01). No differences at 12 months except for relative reduction in talar tilt, also favored functional group.	"[F]unctional treatment is safe, associated with a more rapid recovery, and particularly suitable in athletic populations."	Both groups received multiple co-interventions with cryotherapy, physical therapy, proprioception training, and NSAIDs. Data suggest functional treatment is beneficial at 3 and 6 months but is equivocal at 12 months.
Beynon 2006  RCT	5.5	N = 212 suffering 1st acute ankle ligament sprain injury (Grades I, II, or III)	Elastic wrap vs. bracing plus elastic wrap vs. casting for 1st time ankle sprains of Grades I, II, and III and excluded fractures.	Outcomes by severity grade and treatment. Grade I sprain: no casting group included. Elastic vs. brace vs. brace plus elastic: Days to return to normal walking 11.16 vs. 10.33 vs. 4.62, p = 0.008; Days to normal stair climbing: 12.05 vs. 11.43 vs. 5.46, p = 0.003. No difference between elastic wrap and Air-Stirrup for return to normal walking (p = 0.84) and stair climbing (p = 0.98). No differences in secondary outcomes (return to full weight bearing, full capability in normal activities, work or athletics. Grade II sprain: no differences between 3 non-casting	"...Air-Stirrup brace combined with an elastic wrap provided earlier return to preinjury function compared with treatment with the Air-stirrup brace alone, elastic wrap alone, or walking cast for 10 days followed by elastic wrap. At 6 months, all treatments produced comparable outcomes in terms of clinical testing, activity level, functional status, and patient satisfaction."	Several co-interventions (PT, RICE). High drop-out rate although ITT analyses. Data suggest brace with wrap superior to other treatments for mild sprains. Casting in Grade II sprains resulted in more days for recovery in multiple outcomes measures, whereas no difference in non-casting methods. Grade III sprains demonstrated equivalency of casting and bracing.

				<p>treatments. Casting had significantly more days to normal walking (24.12 vs. 10.10, p = 0.001) and stair climbing (27.94 vs. 11.72, p = 0.001) than brace plus wrap, and return to full capability in work and athletics vs. elastic wrap. Grade III sprain: no differences any measure between brace and cast.</p>		
<p>Bendahou 2014 RCT</p>	<p>5.0</p>	<p>N=126 with recent ankle sprain without fracture or traumatic injury seen in ER. Mean age compression stockings 31±9 years, placebo 30±8 years.</p>	<p>Compression stockings (Venoflex) applied from tibia tuberosity to base of toes: class II with pressure between 15-20.3mm Hg (n = 61) vs. placebo: noncompressive stockings (n = 65). All patients received standard care consisting of RICE protocol, immobilization with same orthosis for 4-6 weeks, and acetaminophen or tramadol depending on pain severity, and rehabilitation (2-3 sessions per week of strengthening exercises, proprioception</p>	<p>No significant differences between groups.</p>	<p>“Compression stockings failed to significantly modify the time to return to normal painless walking in ankle sprain.”</p>	<p>Baseline of more physical activity in compression group may have biased in favor of that group. Data suggest lack of efficacy of compression stockings.</p>

			exercises, and weight-bearing postures). Follow-up 6-9 days after trauma, 15-30 days after trauma, and 90 days after trauma.			
Dettori 1994 a, b RCT	5.0	N = 64 moderate or severe lateral ankle sprain	Plaster cast immobilization vs. AirCast vs. elastic wrap (all for 2 weeks) for acute moderate and severe sprain. Each group had 3 weeks PT rehab post treatment.	Cast vs. air-stirrup vs. elastic: Median days return to work (full military duty) 32.4 vs. 29.6 vs. 29.4, p = 0.078; ROM, pain, swelling (2 weeks) significant difference favoring early motion groups vs. cast. Differences disappeared at 5 week follow-up. No differences in re-injury rate at 5-weeks. At 1-year, fewer subjective complaints in casting group. No differences in measures of pain, job performance, ADLs, need for bracing.	“Early ankle mobilization reduces swelling and pain, and increases ROM and strength compared to cast immobilization... There are no differences among those sustaining various degrees of ankle injury in subjective or functional complaints after 1 year. Those with severe double ligament tears perform as well as those with single ligament tears independent of the initial treatment.”	Lack of study detail for randomization, allocation, compliance. 3-weeks PT rehab co-intervention. Data suggest short term advantage of early mobilization although results are of uncertain clinical significance. Study also found 44% of those with moderate or severe sprains were still symptomatic at 1-year independent of treatment type.
Eiff 1994 RCT	4.5	N = 138 lateral ankle sprains	Early mobilization (elastic wrap, Air-stirrup) vs. immobilization (sugar-tong plaster splint x 10 days with no weight bearing) for mild and moderate acute ankle sprains.	Early mobilization vs. immobilization: % of patients with residual pain: No differences at 10 days. At 3 weeks, 57% vs. 87%. No differences at 6 weeks or 3,6,12 months; % of patients with residual swelling or improved activity: No differences in swelling or improved activity at any time;	“[I]n first-time lateral ankle sprains, although both immobilization and early mobilization prevent late residual symptoms and ankle instability, early mobilization allows earlier return to work and may be	Sparse study details. Multiple co-interventions. Study suggests few clinically significant differences between immobilization vs. early mobilization after a 48-hour period of non-weight bearing and RICE although early return to

				% return to work full duty: at 10 days 54% vs. 13%. At 3 weeks, no difference. 100% by 3 months.	more comfortable for patients.”	work at full duty demonstrated with early mobilization.
--	--	--	--	--	---------------------------------	---

*Evidence for the Use of Tubular Elastic, Elastic Wrap, or Tape for Ankle Support*

There are 10 moderate-quality RCTs (two with multiple reports) incorporated into this analysis. (Sultan 12) There are 7 low-quality RCTs in Appendix 1.(411, 416, 500-504) (Muwanga 86; Scotece 92; Cetti 84; Korkala 87; Nilsson 83; Brooks 81; Airaksinen 90)

Author/Y ear Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Cooke 2009  Lamb 2005, 2009	7.5	See Evidence Table for the Use of Early Mobilization for Ankle Sprain above.				
Ardevol 2002	6.0	See Evidence Table for the Use of Early Mobilization for Ankle Sprain above.				
Beynon 2006	5.5	See Evidence Table for the Use of Early Mobilization for Ankle Sprain above.				
Sultan 2012  RCT	6.5	N = 36 with ankle sprains sustained within 72 hours of attending a fracture clinic; 18 years or older	Standard treatment, written and verbal information on ankle sprains, advice on RICE (rest, ice, compression, elevation), Tubigrip, worn for 7 weeks (n = 18) vs. Class II elastic stockings, same advice and	Mean (95% CI) for VAS: baseline vs. 4 weeks: Stocking: 65 (56-73) vs. 9 (5-13), p = 0.004; baseline vs. 8 weeks: 65 (56-73) vs. 5 (0-11), p = 0.002; Tubigrip: baseline vs. 4 weeks: 66 (59-73) vs. 21 (11-31), p = 0.004; baseline vs. 8 weeks: 66 (59-73) vs. 18 (10-26), p = 0.002. Mean (95% CI) for AOFAS: stocking vs. Tubigrip: 4 weeks: 94 (84-102) vs. 83 (70-90), p = 0.004; 8	“ES applied early following ankle sprain significantly improved recovery compared with Tubigrip. By 4 weeks, the ES patients experienced less pain, swelling and restriction in ankle movement. The functional outcome and SF12 at 4 and 8 weeks were also better.”	Few baseline characteristics. ES significantly reduced ankle circumference following ankle sprain vs. tubigrip. Recovery time decreased and ankle ROM and movements at both 4 and 8 weeks.

			information, fitted stockings to patient, wear continuously, day/night, for 7 days, wear during day remove at night for 6 weeks until pain free (n = 18). Follow-up: baseline, 4 and 8 weeks.	weeks: 99 (92-105) vs. 88 (78-95), p = 0.002. Mean (95% CI) for SF 12 scores improved with stocking group from 4 to 8 weeks: 112 (109-115) vs. 119 (118-121), p < 0.01.		
O'Hara 1992  RCT	5.5	N = 220 with and without acute ankle injuries	Ankle support (Malleotrain) vs. standard care (rest, tubigrip) for mild and moderate acute sprains.	Support vs. standard: outcomes at 12-14 days; VAS: rest pain 178.5 vs. 235.8 p <0.05; speed of response rest pain: 9.13 vs. 11.38 days, p <0.05. Overall assessment: normal 88% vs. 67%, p <0.001.	"In patients with acute ankle injuries, a Malleotrain ankle support results in more rapid alleviation of symptoms than does Tubigrip and is acceptable to patients."	Data suggest benefit of using ankle support compared to tubigrip. Despite statistical significance of some factors, clinical significance is uncertain.
Dettori 1994 a, b	5.0	See Evidence Table for the Use of Early Mobilization for Ankle Sprain above.				
Boyce 2005  RCT	4.0	N = 50 presenting consecutively within 24 hours a moderate or severe lateral ligament sprain after an ankle inversion injury	Elastic support bandage vs. Aircast ankle brace for acute Grade II, III sprains	Function measured by Karlsson scores: 10 days (35 for elastic vs. 50 for Aircast, p = 0.028) at 1 month (55 for elastic vs. 68 for Aircast, p = 0.029). No significant differences between groups for secondary outcome measures of swelling, pain at 10 days.	"[T]he use of an Aircast ankle brace in the treatment of moderate and severe lateral ligament ankle sprains, presenting within 24 hours of injury, produces a significant improvement in ankle joint function, at both 10 days and one month, compared with standard	Lack of study details. Withdrawal rate >20%. No detail on co-interventions, compliance to treatments. Data suggest use of Aircast provides better functional outcomes but no differences in swelling or pain at 10 days.

					management with an elastic support bandage.”	
Leanders on 1999 RCT	4.0	N = 73 age 15-55 years old with acute Grade II or III ankle sprain, who sought medical care within 24 hours of injury	Air cushioned ankle brace (AirCast) vs. compression bandage for acute Grade II and III ankle sprains.	ROM discrepancy injured vs. uninjured foot decreased at follow-up; still decreased at 10 weeks (p <0.01). ROM in uninjured foot increased at follow-up (p <0.05). Figure-of-eight running times both groups between 2-10 week follow-up improved significantly from baseline (p <0.05), but no differences between groups.	“[T]he methods used in the present study are well suited for further studies of objective modalities of ankle joint function with the possible exception of the joint position sense test.”	Sparse details for randomization methods, baseline comparability, control of cointerventions. Results are of uncertain clinical significance other than noting both groups improved throughout the follow-up period with no difference between interventions.
Viljakka 1983 RCT	4.0	N = 119 with ankle sprains	Layer bandage vs. elastic adhesive tape. Oxyphenbutazone 100mg TID vs. clonixin 300mg. TID vs. placebo. Severity of acute injury not specified.	No significant differences between layer vs. elastic tape bandage in pain, tenderness, swelling, ROM. Elastic caused more rash, irritation, skin compression. Examiner estimate of “good” result: layer bandage (64%) vs. elastic (62%) vs. placebo 50%) vs. oxyphenbutazone (53%) vs. clonixin (84%). No differences between bandage groups. Placebo vs. oxyphenbutazone,	“The layer bandage proved more stable in the lateral direction than the elastic adhesive tape bandage (p less than 0.001). Clonixin proved useful in controlling swelling and in the authors opinion gave the best clinical results.”	Randomization, allocation, baseline comparability, blinding, compliance details sparse. Study suggests clonixin has advantage over oxyphenbutazone based on physician assessment but is of unknown clinical significance. Clonixin not available in U.S.

				p >0.05; oxyphenbutazone vs. clonixin, p <0.01, placebo vs. clonixin, p <0.01.		
Watts 2001 RCT	4.0	N = 400 with acute Grade I or II (mild to moderate) lateral ankle sprains	Double Tubigrip (elastic wrap) vs. no compression wrap for acute Grade I and II sprain.	In DTG group, 81 took pain killers vs. 50 in no-DTG group, p = 0.001; 54 DTG and 48 no-DTG group had to take days off work, p = 0.072. DTG average 3.37 days off work vs. 3.21 days for no-DTG, p = 0.94. Took average 2.65 days for DTG group to walk unaided vs. 2.32 days for no-DTG group, p = 0.23.	“This study suggests that the use of double tubigrip compression bandage in grade 1 and 2 ankle sprains does not shorten recovery time or number of days off work...(and) seems to be associated with an increase in the need for analgesia.”	50% loss to follow-up. No details on co-interventions other than “therapy and analgesia.” No details on compliance to intervention.

#### Evidence for the Use of Ankle Support or Brace for Ankle Sprain

There are 7 moderate-quality RCTs (two with multiple reports) incorporated into this analysis. There are 5 low-quality RCTs in Appendix 1.(499, 501-503, 505) (Zwipp 92; Cetti 84; Wilkerson 93; Scotece 92; Muwanga 86)

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Cooke 2009 Lamb 2005, 2009	7.5	See Evidence Table for the Use of Early Mobilization for Ankle Sprain above.				
Beynon 2006	5.5	See Evidence Table for the Use of Early Mobilization for Ankle Sprain above.				
O'Hara 1992	5.5	See Evidence Table for the Use of Tubular Elastic, Elastic Wrap, or Tape for Ankle Support above.				
Dettori 1994 a, b	5.0	See Evidence Table for the Use of Early Mobilization for Ankle Sprain above.				
Eiff 1994	4.5	See Evidence Table for the Use of Early Mobilization for Ankle Sprain above.				
Boyce 2005	4.0	See Evidence Table for the Use of Tubular Elastic, Elastic Wrap, or Tape for Ankle Support above.				
Leanderson 1999	4.0	See Evidence Table for the Use of Tubular Elastic, Elastic Wrap, or Tape for Ankle Support above.				

#### Evidence for the Use of Walking Boots for Ankle Sprain

There are 2 moderate-quality RCT (with multiple reports) incorporated into this analysis. (Prado 14)

Author/Year	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments

Study Type						
Cooke 2009  Lamb 2005, 2009	7.5	See Evidence Table for the Use of Early Mobilization for Ankle Sprain above.				
Prado 2014  RCT	4.0	N = 104 with severe lateral ankle ligament injuries, average age 32.7, age range 15 to 64, (SD 12.2)	Group A, walking boot first 3 weeks, functional brace for an additional 3 weeks (n = 94) vs. Group B, functional brace only (n = 92). Rehab program: 4 weeks after injury, strengthening and proprioception exercises, limiting ankle inversion and plantarflexion to 10°; follow-up: baseline, 3, and 6 weeks following injury.	Mean ± SD for AOFAS score: Group A vs. Group B: first week after injury: 61±11.2 vs. 67±10.8, p = 0.00003, in favor of Group B. Mean±SD for VAS: Group A vs. Group B: 3 weeks: 1.7±1.2 vs. 1.4±1.2, p = 0.0348, in favor of Group B. Mean±SD for AOFAS score: Group A vs. Group B: 3 weeks: 79.5±9.2 vs. 84.8±8.8, p = 0.00004, in favor of Group B; 6 weeks: 90.5±10.6 vs. 94.3±6.6, p = 0.027, in favor of Group B.	“Conservative treatment of patients with acute, severe, first episode lateral ankle injuries using a functional brace showed slightly better functional results compared to those using a walking boot, as well as a shorter period of work absenteeism. Both treatment protocols allowed for the reestablishment of ankle stability.”	Minimal baseline comparability. Functional brace showed a slight improvement over use of walking boot and faster return to work. Data support immediate use of functional brace over walking boot for 3 weeks.

## HEAT

The use of heat is described for the early treatment of ankle sprain.(487, 506-508) (Thompson 03, Cote 88, Sloan Arc EmMed 89, Hocutt 82)

*Recommendation: Heat for Acute Ankle Sprain*

**There is no recommendation for or against the use of heat for the treatment of acute ankle sprain.**

*Strength of Evidence – No Recommendation, Insufficient Evidence (I)*

*Level of Confidence – Low*

### Rationale for Recommendation

There are no quality trials comparing heat with no treatment. There is one moderate-quality trial that demonstrated heat application resulted in increased edema compared with ice, although no functional differences were found between the groups.(487) (Cote 88) Heat treatments are not invasive, have no adverse effects, and are not costly when self-administered but there is no evidence for efficacy and therefore no recommendation for use in ankle sprain.

### Evidence for the Use of Heat for Ankle Sprain

There is 1 moderate-quality trial incorporated into this analysis.

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Cote 1988  RCT	4.0	N = 30 post- acute sprained ankles	Cold bath (50-60°F) vs. heat bath (102-106°F) vs. contrast bath for acute ankle sprain (Grade I, II) swelling applied once daily (20 mins) on post-injury days 3,4,5. Outcomes measured 1-3 days post treatment.	Ankle volume change pre- to post-treatment (mL): Cold vs. Heat vs. Contrast mean (SD), Day 1: -1.3 (27.1) vs. 27.4 (25.2) vs. 27.4 (13.6), Day 3: 1.7 (14.2) vs. 28.7(15.8) vs. 35.3 (31.2). Total 3 day change: 3.3 (11.3) vs. 25.3 (19.5) vs. 26.5(8.2), p <0.05 cold vs. heat, contrast. No difference between heat and contrast.	"[C]old therapy is clearly the most favorable of the three treatments if the therapeutic objective is to minimize edema before rehabilitative exercise during the third, fourth and fifth days post injury for first- and second-degree ankle sprains."	Small sample size. Details of allocation, baseline comparability missing. Age of injury not specified. Effect of treatment is limited to edema as functional improvement and pain measures were not included.

## IMMOBILIZATION

Immobilization of the ankle to prevent ankle joint movement in plantarflexion, dorsiflexion, inversion, and eversion is commonly used for treatment of acute ankle sprain.

### 1. Recommendation: Cast Immobilization for Acute Mild to Moderate Ankle Sprain

**Immobilization by cast is not recommended for patients with acute mild to moderate ankle sprain as splints should be sufficient.**

*Strength of Evidence – Not Recommended, Insufficient Evidence (I)*

*Level of Confidence – Low*

### 2. Recommendation: Cast Immobilization for Severe Ankle Sprain

**There is no recommendation for or against the use of immobilization by cast for severe ankle sprain as splints should be sufficient.**

*Indications – Severe ankle sprain.*

*Frequency/Duration – Ten days to 3 weeks sugar-tong splint applied after a 48-hour period of elevation and non-weight bearing.*

*Strength of Evidence – No Recommendation, Insufficient Evidence (I)*

*Rationale for Recommendations*

There are no quality trials for casting of mild ankle sprains. Mild acute sprains are generally self-limited and respond well to early mobilization and other therapies; therefore, casting is not recommended. There are six quality trials that compared casting with early mobilization for moderate and severe acute ankle sprains. The moderate-quality CAST trial,(386, 488, 489) (Cooke 09, Lamb 09, 05) demonstrated below-the-knee casting of moderate and severe sprains for 10 days provided a statistical but clinically indeterminate short-term benefit compared with tubular bandage (control) in subjective ratings of pain, function, and symptoms in the first 12 weeks. There were no differences between casting and bracing however, and by 9 months there were no differences between groups. A moderate-quality study demonstrated short-term improvement in pain, swelling, and range of motion in the early mobilization group compared to casting for moderate and severe sprains, but did not demonstrate any long-term benefit of one over the other.(490, 491) (Dettori 94a,b) Another moderate-quality trial demonstrated casting was less beneficial for moderate (Grade II) sprains, but was equivocal for severe sprains compared with bracing.(492) (Beynon 06) A moderate-quality trial limited to severe ankle sprains demonstrated early mobilization resulted in short-term benefit in swelling, pain, stiffness and early return to sport compared with 3-week casting.(493) (Ardevol 02) There were no long-term differences measured at 12 months. Another moderate-quality trial demonstrated early mobilization after a 48-hour non-weight-bearing period provided subjective improvement in pain perception at 3 weeks but no differences in improvement of swelling, residual pain, and function compared with casting.(494) (Eiff 94) However, early mobilization resulted in much faster return to full duty. No long-term differences were demonstrated in any of the quality trials.

Casting is non-invasive, but is restrictive of activity, including return to work, impairs driving performance more than bracing,(509) (Tremblay 09) and is associated with risk for deep venous thrombosis.(488) (Lamb 09) Total direct and indirect costs of casting based on the U.K. health care system are similar to the use of Aircast brace, and were more cost-effective than compression wrap.(386) (Cooke 09) Cast immobilization is therefore not recommended as an alternative to splinting and early mobilization treatment for severe and moderate ankle sprain.

*Evidence for the Use of Casting for Ankle Sprain*

There are 6 moderate-quality RCTs or crossover trials (two with multiple reports) incorporated into this analysis. There are 5 low-quality RCTs in Appendix 1.(499-501, 510, 511) (Zwipp 92; Cetti 84; Korkala 87; van den Hoogenband 84; Gronmark 80)

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
<b>Immobilization vs. Early Mobilization</b>						
Tremblay 2009  Crossover Trial	7.5	N = 48 healthy volunteers	Braking performance in walking cast vs. Aircast Walker vs. running shoe (control).	Adjusted mean total braking time (seconds): running shoe vs. walking cast vs. Aircast Walker undistracted; 0.604±0.051 vs. 0.636±0.60 vs. 0.639±0.05, p <0.05 vs. control. Distracted, 0.680±0.059 vs. 0.700±0.067 vs. 0.712±0.063, p <0.05 vs. control, p <0.05 vs. walking cast.	“[W]earing a walking cast or a removable Aircast Walker on the right lower limb increases the emergency braking time during simulated driving.”	Data suggest reduced reaction times in emergency braking with and without distractions although findings were linked to lab situation in health subjects. Applicability to

						injured patients uncertain.
Cooke 2009	7.5	See Evidence Table for the Use of Early Mobilization for Ankle Sprain above.				
Lamb 2005, 2009						
Ardevol 2002	6.0	See Evidence Table for the Use of Early Mobilization for Ankle Sprain above.				
Beynnon 2006	5.5	See Evidence Table for the Use of Early Mobilization for Ankle Sprain above.				
Dettori 1994 a, b	5.0	See Evidence Table for the Use of Early Mobilization for Ankle Sprain above.				
Eiff 1994	4.5	See Evidence Table for the Use of Early Mobilization for Ankle Sprain above.				

### REST, ICE, COMPRESSION, ELEVATION (RICE) AND BRACES

The therapies of rest, elevation of the lower extremity, application of ice (cryotherapy) and compression wrap/tape are commonly used as initial interventions for analgesia and reduction of edema and inflammation associated with acute ankle sprain injuries. Practices for resting the ankle include non-weight bearing, using crutches, rest and immobilization using a cast for up to 2 weeks.(489, 492, 497, 512) (Bleakley 10, Lamb 05, Boyce 05, Beynnon 06)

#### 1. *Recommendation: Immediate Non-weight Bearing (Rest) for Acute Ankle Sprain*

**Rest or non-weight bearing is recommended as an initial intervention for acute ankle sprain for patients unable to tolerate weight.**

*Indications* – Acute mild, moderate, and severe ankle sprain patients who are unable to tolerate weight bearing. A short period of up to 48-hours may be prescribed based on tolerance and ability to bear weight. Early mobilization is recommended.

*Frequency/Duration* – Up to 48 hours of non-weight bearing; early mobilization, progressive weight bearing as tolerated, addition of home therapeutic exercises.

*Indications for Discontinuation* – Resolution, ability to tolerate weight.

*Strength of Evidence* – **Recommended, Insufficient Evidence (I)**

*Level of Confidence* - Low

#### 2. *Recommendation: Cryotherapy for Acute Ankle Sprain*

**Cryotherapy is recommended for treatment of acute ankle sprains.**

*Indications* – Acute ankle sprain.

*Frequency/Duration* – Self-application for 10 to 20 minutes every 2 hours for up to 3 days as needed(513) (Bleakley 06); may be applied over compression or casting materials.(514) (Okcu 06)

*Indications for Discontinuation* – Resolution, adverse effects, non-compliance.

*Strength of Evidence* – **Recommended, Insufficient Evidence (I)**

*Level of Confidence* - Low

3. *Recommendation: Compression Therapy for Acute Ankle Sprain*  
**There is no recommendation for or against the use of compression therapy (i.e., tape, elastic wrap, tubular elastic, or pneumatic compression devices) for acute ankle sprains.**

*Strength of Evidence – No Recommendation, Insufficient Evidence (I)*  
*Level of Confidence - Low*

4. *Recommendation: Tubigrip for Acute Ankle Sprain*  
**Tubigrip is not recommended for acute ankle sprains. (Sultan 12)**

*Strength of Evidence – Not Recommended, Evidence (C)*  
*Level of Confidence – Low*

5. *Recommendation: Tape, Elastic Wrap or Tubular Elastic for Acute Ankle Sprain*  
**There is no recommendation for or against the use of non-rigid support therapies (i.e., tape, elastic wrap, or tubular elastic) for acute ankle sprains.**

*Strength of Evidence – No Recommendation, Insufficient Evidence (I)*  
*Level of Confidence - Low*

6. *Recommendation: Ankle Brace (Orthosis) for Acute Ankle Sprain*  
**The use of semi-rigid pneumatic or gel ankle brace supports for treatment for acute ankle sprain is recommended, with optional use as needed by the patient for mild and moderate sprains.**

*Strength of Evidence – Recommended, Insufficient Evidence (I)*  
*Level of Confidence - Low*

7. *Recommendation: Walking Boot for Acute Ankle Sprain*  
**Walking boots are not recommended for treatment of acute ankle sprains. (Prado 14)**

*Strength of Evidence – Not Recommended, Evidence (C)*  
*Level of Confidence - Moderate*

8. *Recommendation: Intermittent Elevation for Acute Ankle Sprain*  
**The use of intermittent elevation is recommended for controlling edema of acute ankle sprains.**

*Indications – Acute ankle sprain that manifest significant edema.*

*Indications for Discontinuation – Resolution, adverse effects, non-compliance.*

*Strength of Evidence – Recommended, Insufficient Evidence (I)*  
*Level of Confidence - Low*

9. *Recommendation: High-voltage pulsed current for Acute Ankle Sprain*  
**There is no recommendation for or against high-voltage pulsed current for acute ankle sprains.**

*Strength of Evidence – No Recommendation, Insufficient Evidence (I)*  
*Level of Confidence - Low*

### *Rationale for Recommendations*

There are no quality trials comparing the effectiveness of using all RICE therapies concurrently with a control of no RICE therapy. RICE is frequently described as a co-intervention in numerous comparative trials. One moderate-quality trial that demonstrated the addition of therapeutic exercises to RICE resulted in improved short-term function with reduction in pain compared to RICE alone, although there were no differences in return to work, walking, or sports.(512, 515) (Bleakley 07, 10) Another moderate-quality trial demonstrated passive manipulation added to RICE protocol demonstrated improved dorsiflexion with reduction in pain compared to RICE alone, although there were no differences in return to work, walking, or return to sport.(516) (Green 01) There are no quality trials comparing immediate rest (non-weight bearing) to continued weight bearing. A moderate-quality trial demonstrated early mobilization through weight bearing with the assistance of ankle supports or compression wraps after a 48-hour non-weight-bearing period demonstrated improved return to full duty compared with immobilization(494) (Eiff 94) (see Functional Treatment – Mobilization). Therefore, there is no evidence that rest is of benefit if weight bearing is tolerated in the immediate post-injury period.

A moderate-quality trial comparing a single 30-minute application of ice therapy to sham therapy demonstrated no significant benefit at 7 days.(507) (Sloan Arc Em Med 89) However, there were no short-term outcome measures included and all subjects had NSAIDs and compression wrap. There is one moderate-quality study comparing continuous versus intermittent application of cold therapy that found two intermittent 10-minute intervals with a 10-minute break between applications every 2 hours for 3 days superior to 20-minute continuous application at same 2-hour intervals as measured by subjective pain with activity at 7 days.(513) (Bleakley 06) However, there were no differences in function, swelling, or pain at rest. Cold therapy has been demonstrated to be more effective in reducing edema than heat or contrast bath(487) (Cote 88) and compression.(446) (Sloan Injury 89) A low-quality study found no additional benefit from cold therapy or elastic tape when used with air-stirrup.(505) (Wilkerson 93) The use of cold therapy applied directly over elastic wrap as well as plaster and synthetic casting material has been demonstrated to effectively reduce skin temperature,(514) (Okcu 06) suggesting that application can be made regardless of immobilization or compression. There is no evidence that the use of ice hastens return to work or function.(517) (Hubbard 04) Cryotherapy is non-invasive, has low adverse effects when used for short periods or if precautions are taken to avoid freezing of soft tissues, is of low to high cost dependent on purchase or rental of equipment,(518) (Stöckle 97) and is recommended.

There is one moderate-quality study comparing compression using elastic wrap to no treatment for mild and moderate acute sprains that did not demonstrate significant benefit of compression wrap.(495) (Watts 01) Three moderate-quality trials demonstrated compression wrap (e.g., bandage, elastic wrap, tubigrip) to be less effective than ankle braces(386, 488, 489, 496, 497) (Lamb 05, 09, Cooke 09, O'Hara 92, Boyce 05) while two trials found no difference between these treatments.(492, 498) (Beynnon 06, Leanderson 99) However, one trial demonstrated the combination of compression wrap with ankle brace (Aircast) to be more effective than either treatment alone for mild (Grade I) sprains.(492) (Beynnon 06) A moderate-quality trial found no difference in tape versus compression wrap.(455) (Viljakka 83) A moderate-quality trial found no long-term differences between casting or semi-rigid immobilization.(490, 491) (Dettori 94 a,b) Compression wraps and a pneumatic compression device were found to be less effective than elevation in reducing acute edema.(519) (Rucinski 91) Compression wraps may provide additional benefit when used in conjunction with ankle braces.

One moderate-quality trial compared non-orthosis ankle support to no treatment, which demonstrated tubular elastic (Tubigrip®) provided no therapeutic benefit for mild and moderate sprains.(495) (Watts 01) Three moderate-quality trials demonstrated elastic support (e.g. bandage, elastic wrap, tubigrip) to be less effective than ankle braces,(386, 488, 489, 496, 497) (Lamb 05, 09, Cooke 09, O'Hara 92, Boyce 05) while three trials found no difference between these treatments.(490-492, 498) (Beynnon 06, Leanderson 99, Dettori 94a,b) One trial did find the combination of compression wrap with ankle brace (Aircast) to be more effective than either treatment alone for mild (Grade I) sprains.(492) (Beynnon 06) Functional strapping (taping) was demonstrated to provide short-term benefits in pain, swelling, stiffness, and feeling of instability for severe sprains compared with casting,(493) (Ardevol 02) but no long-term

benefit was demonstrated. A moderate-quality trial found no difference in tape versus elastic wrap.(455) (Viljakka 83) A moderate-quality trial found no long-term differences between elastic wrap support and casting or semi-rigid immobilization.(490, 491) (Dettori 94 a,b) Taping, tubular elastic, and elastic bandage wrap for support are non-invasive, are generally of low to moderate cost, and have low adverse effects, but are of no therapeutic benefit for mild sprains and appear to be less effective than more rigid support for severe sprains. Therefore, there is insufficient evidence to recommend their routine use.

There are no quality-controlled trials comparing the use of ankle bracing to a “no treatment” group. There are six moderate-quality trials that compared ankle braces to other functional treatments. Three moderate-quality trials demonstrated ankle braces to be more effective than elastic support,(386, 488, 489, 496, 497) (Cooke 09, Lamb 05, 09, O’Hara 92, Boyce 05) while three moderate quality studies found no differences between ankle brace and elastic wrap for moderate and severe sprains.(490-492, 498) (Beynnon 06, Leanderson 99, Dettori 94a,b) There are three moderate-quality studies for ankle brace versus cast immobilization demonstrating benefit of brace over cast immobilization(386, 490, 491, 497) (Cooke 09, Boyce 05, Dettori 94 a,b) Combined ankle brace with elastic wrap was found to be beneficial over immobilization.(492, 494) (Beynnon 06, Eiff 94) Ankle orthoses are non-invasive, are of moderate cost, and the quality evidence is mixed. There are no differences found in sprain recurrence between the different types of ankle supports used for early mobilization. It appears that mobilization is the most important factor; however, insofar as ankle braces and supports may aid and encourage increased mobilization, ankle braces and supports that allow some movement are recommended.

One moderate-quality trial found a walking boot was inferior to a functional brace as part of a treatment program for severe lateral ankle injuries. (Prado 14) There is another moderate-quality study with three reports that included a walking boot as an intervention arm.(386, 488, 489) (Cooke 09, Lamb 09, 05) There were no short- or long-term benefits demonstrated compared with other functional and immobilization techniques. The walking boot was demonstrated to have the highest costs (direct, indirect) compared with casting, tubular bandage, or Aircast. Therefore, use of a walking boot for uncomplicated ankle sprains is not recommended. One moderate-quality sham-controlled trial found mostly negative results from use of compression stockings for treatment of ankle sprain. (Bendahou 14)

There is one moderate-quality study that demonstrated elevation is more effective in reducing edema after a single 30-minute treatment session than elevation used in conjunction with compression wrap or pneumatic brace, suggesting there is no added benefit for additional therapies in the immediate post-treatment period.(519) (Rucinski 91) However, these results are of uncertain short-term clinical significance. The significance of changes in edema in the post-sprain recovery period is of undefined clinical significance, as little correlation is described in available trials.(446, 497, 512, 515) (Bleakley 07, 10, Sloan Injury 89, Boyce 05) A prospective case series found no relationships between ankle-foot edema and ankle function in the acute phase of ankle sprain injury.(520) (Man 05)

Despite the general acceptance of RICE or the individual therapies of RICE for acute ankle sprain, there is a lack of quality evidence for efficacy. A primary rationale for these modalities is to reduce edema. However, there was little correlation demonstrated in the available studies in reduction of edema as an indicator for functional or pain improvement.(446, 497, 512, 515) (Bleakley 07,10, Sloan Injury 89, Boyce 05) These treatments are not invasive, generally have few adverse effects, and are not costly when self-administered. Rest, ice, and elevation are therefore recommended. There is insufficient evidence for recommendation of compression.

*Evidence for the Use of RICE for Ankle Sprain*

There are 2 moderate-quality RCTs (one with two reports) incorporated into this analysis.

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
<b>Combined RICE Therapies</b>						
Bleakley 2007, 2010	7.0	N = 101 acute	PRICE vs. PRICE plus	Treatment effect: control vs.	“[I]ncorporating therapeutic	Compliance <80%, >20%

RCT		Grade 1 or 2 ankle sprain	early therapeutic exercises. Intermittent cryotherapy protocol: 10 minute ice, 10 minute rest (control) or 10 minute exercises (intervention) then 10 minutes cryotherapy, 3 times a day, 1 week). Both groups received exercise protocol after Week 1: 30-minute session once a week, 4 weeks) for Grade I and II sprains; 16 week follow-up.	exercise. Difference in lower extremity function score: Week 1; 5.28 (0.31-10.26) p = 0.008. Week 2; 4.92 (0.27-9.57) p = 0.0083. No difference after Week 2. Pain at rest, pain with activity, and swelling: no differences any interval. Re-injury rate 16 weeks 2/50 vs. 2/51. Physical activity: Time (hours/day) 1st week, control vs. exercise; walking-1.2 (0.9-1.4) vs. 1.6(1.3-1.9) p = 0.029. Step sitting, standing, p >0.05.	exercises during the first week after ankle sprain resulted in significant improvements in short term ankle function compared with a standard functional intervention.”	dropout in exercise group. Data suggest addition of therapeutic exercises to protection, RICE protocols provides short term functional benefit as measured on subjective lower extremity functional scale and in time spent walking. No difference in other outcomes measures.
Green 2001 RCT	6.5	N = 41 acute ankle inversion sprains <72 hours and no other injury to the lower limb	RICE vs. passive accessory joint mobilization + RICE for acute sprain.	At 4th treatment session, 68% of treatment group and 3 subjects from control released as attained full ROM in dorsiflexion, p <0.01. For dorsiflexion ROM, experimental group improved 10.9° (SEM = 1.9°) and control 5.8° (SEM = 1.1°). Stride speed increased more within 1st and 3rd treatment sessions for experimental group, p <0.05.	“Addition of talocrural mobilization to the RICE protocol in the management of ankle inversion injuries necessitated fewer treatments to achieve pain-free dorsiflexion and to improve stride speed more than RICE alone.”	Baseline differences in number of recurrent sprains (higher in experimental group). Despite outcome improvements in dorsiflexion, does not appear to be a statistically significant difference in lost work days or return to work, sports, or normal walking. Thus, improved dorsiflexion ROM as an outcome measure is of

				Experiment group returned to work 6 days after injury, and the control group patients returned to work 5.3 days after injury.		unknown clinical importance.
--	--	--	--	---	--	------------------------------

*Evidence for the Use of Immediate Post-injury Rest for Ankle Sprain*

There is 1 moderate-quality RCT incorporated into this analysis.

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Eiff 1994	4.5	See Evidence Table for the Use of Early Mobilization for Ankle Sprain above.				

*Evidence for the Use of Ice/Cryotherapy for Ankle Sprain*

There are 6 moderate-quality RCTs incorporated into this analysis. (Sandoval 10) There are 4 low-quality RCTs in Appendix 1.(505, 518, 521, 522) (Stockle 97; Michlovitz 88; Wilkerson 93; Laba 89)

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Bleakley 2006  RCT	7.5	N = 89 mild/moderate acute ankle sprains	Cryotherapy (20 minutes continuous application every 2 hours repeated vs. 10 minutes continuous application, 10 minute break, 10 minutes application, repeated q 2 hours) up to 72 hours; 6 week follow-up.	Subjective measures of function, swelling, and pain at rest improved significantly for both groups. No intergroup differences with exception of more pain relief with activity during Week 1 in intermittent group, although there were baseline differences between groups.	“The application of an intermittent cryotherapy protocol after mild or moderate ankle sprain significantly reduced the level of subjective pain on activity, one week after the injury, compared with a standard protocol. There was no significant difference in terms of function, swelling, or pain at rest.”	No placebo or sham. Baseline differences in pain at rest favoring intermittent (less pain) group was nearly significant p = 0.08 which weakens conclusion.

Okcu 2006 RCT	7.0	N = 44 healthy subjects (Group A) and subjects with Grade III inversion type acute ankle sprain (Group B)	Skin temperature measurement after cryotherapy: Robert Jones bandage vs. elastic bandage vs. plaster cast vs. synthetic cast.	All groups had significant temperature reduction after use of ice packs regardless of material. Average time to reach minimum temperature was 48 minutes (RJB), 42 min (elastic), 30 minutes (Plaster) and 38 minutes (synthetic cast). Time to cooling significantly faster in casting groups compared with RJB.	"A bandage or cast does not prevent measurable skin temperature lowering by frozen ice packs both in normal and swollen ankles."	Randomization variable was not treatment but immobilization technique. All subjects received ice packs and skin temperature was measured by thermistor. No differences found. Data suggest that cryotherapy results in skin temperature cooling regardless of material over injury.
Sloan Injury 1989 RCT	5.5	N = 122 acute ankle injuries within 6 hours of injury	Immediate ibuprofen (1200mg loading, 2400mg total per day) vs. placebo 1st 48 hours, than same ibuprofen schedule. A uniform background therapy of 20 minutes cooling, compression and elevation was given to all patients using cooled anklet.	Immediate vs. delayed soft tissue swelling index: % improvement 49% vs. 37% p <0.01. Severity of injury: no data presented, favored immediate group p = 0.05; range of movement no differences; ability to bear weight no differences	"[I]mmediate medication with high-dose ibuprofen at 2400 mg/day should be considered in the routine treatment of moderate to severe ankle sprains, whether patients."	Patients treated within 6-hours. Data suggest immediate NSAIDs may be beneficial for immediate pain relief and swelling relief judged at 7 days vs. placebo.
Sloan Arch Emerg Med 1989 RCT	5.0	N = 143 ankle sprains within 24 hours of injury	Cryotherapy vs. sham cryotherapy (both with NSAIDs, elastic wrap).	At Day 7, improvement in swelling by 46% of cold therapy group and 40% of dummy therapy, p = 0.07; also, 88% of cold therapy group had improved by 2-4 scale points compared to 79% of dummy therapy, p = 0.15. Weight	"[A] single 30-minute period of treatment in the accident and emergency department cannot be justified, though advice to paramedics, sports trainers and patients themselves to	Lack of randomization, allocation, baseline comparability details. All patients had NSAIDs, elastic wrap. Data suggest no benefit of single 30 minute cold treatment vs.

				bearing, 36% of cold therapy group and 29% of dummy therapy showed improvements by 3-4 scale units, $p = 0.64$ .	give and continue cold and compression is probably important.”	placebo at 1 week.
Cote 1988 RCT	4.0	N = 30 post-acute sprained ankles	Cold (50-60°F) vs. heat bath (102-106°F) vs. contrast bath for acute ankle sprain (Grade I, II) swelling applied once daily (20 minutes) post-injury Days 3, 4, 5. Outcomes measured 1-3 days post-treatment.	Ankle volume change pre- to post-treatment (mL): cold vs. heat vs. contrast mean (SD); Day 1: -1.3 (27.1) vs. 27.4(25.2) vs. 27.4 (13.6); Day 3: 1.7 (14.2) vs. 28.7 (15.8) vs. 35.3 (31.2). Total 3 day change: 3.3 (11.3) vs. 25.3 (19.5) vs. 26.5(8.2) $p < 0.05$ cold vs. heat, contrast. No difference between heat and contrast.	“[C]old therapy is clearly the most favorable of the three treatments if the therapeutic objective is to minimize edema before rehabilitative exercise during the third, fourth and fifth days post injury for first- and second-degree ankle sprains.”	Small sample size. Details of allocation, baseline comparability missing. Age of injury not specified. Effect of treatment limited to edema as functional improvement; pain measures not included.
Sandoval 2010 RCT	4.5	N = 28 participants with lateral ankle sprain; age range 18 to 26 (21±2.5 years)	Control group (CG), convention treatment (cryotherapy) only (n = 10) vs. HVPC(+) (high-voltage pulsed current), conventional treatment and HVPC, using active electrodes with positive polarity (n = 8) vs. HVPC(-), conventional treatment and HVPC, using active electrodes with negative polarity (n = 10). Follow-up: baseline, final assessment at completion.	Mean ± SD for ROM: CG vs. HVPC(+) vs. HVPC(-): first: -13±8.2 vs. -2±9.5 vs. -6±5.5, $p = 0.03$ .	“The results showed no significant differences between groups. However, they suggest a possible contribution of HVPC(-) to the acceleration of recovery during the initial healing phase of ankle sprain in humans.”	Small groups. No significant differences in 3 groups but HVPC- trended towards improved recovery time. Possible underpowering.

*Evidence for the Use of Compression Bandage, Wrap, or Tape for Ankle Sprain*

There are 11 moderate-quality RCTs (one with three reports) incorporated into this analysis. (Lardenoye 12; Sultan 12) There are 7 low-quality RCTs in Appendix 1.(411, 416, 500-504) (Muwanga 86; Scotece 92; Cetti 84; Korkala 87; Nilsson 83; Brooks 81; Airaksinen 90)

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Cooke 2009  Lamb 2005, 2009	7.5	See Evidence Table for the Use of Early Mobilization for Ankle Sprain above.				
Beynon 2006	5.5	See Evidence Table for the Use of Early Mobilization for Ankle Sprain above.				
O'Hara 1992	5.5	See Evidence Table for the Use of Tubular Elastic, Elastic Wrap, or Tape for Ankle Support above.				
Dettori 1994 a, b	5.0	See Evidence Table for the Use of Early Mobilization for Ankle Sprain above.				
Lardenoye 2012  RCT	5.0	N = 70 with grade II or III ankle sprain; mean age for tape 30 years, mean age for brace 29.8 years	Tape group; first layer of latex free, adhesive, bandage to protect skin; 2nd layer of 2.5cm non-elastic strapping tape used for support; 3rd layer of elastoplasts 6cm broad, elastic used for fixation (n = 35) vs. semi-rigid brace with air cushions to inflate and stabilize ligaments preventing twisting (n = 35). Follow-up: baseline, 2, 4, 8, and 12 weeks.	No statistically significant differences were seen between both groups for the primary outcome.	"In summary this study shows that treatment of acute lateral ankle sprain with a semi-rigid brace leads to less complications and a higher patient satisfaction than treatment with tape. In line with previous studies there is no difference regarding functional outcome and pain. Therefore using a semi-rigid brace should be considered for treatment of acute ankle sprains."	Semi-rigid brace is better than taping for patient comfort in ankle sprain but no significant differences between 2 groups and a high dropout rate.

Rucinski 1991 RCT	4.5	N = 30 post-acute (>24 hours post-injury) 1st- and 2nd-degree sprained ankles	Elastic (Ace) wrap plus elevation vs. pneumatic compression device plus elevation vs. elevation (all 30 minute treatment sessions).	In volume measurements post treatment, the control (elevation) is only group with reduced measurement from baseline $p < 0.01$ .	“The results of this study suggest that for the post acute phase of a sprained ankle, elevation alone is superior to elastic wrapping and intermittent compression.”	Small sample size. Exclusion criteria: those needing “cast immobilization” may bias generalizability. Suggests after single session, elevation most effective for controlling edema, but no short to long-term conclusions.
Boyce 2005 RCT	4.0	N = 50 presented consecutively within 24 hours moderate or severe lateral ligament sprain after an ankle inversion injury	Elastic support bandage vs. Aircast ankle brace for acute Grade II, III sprains.	Function measured by Karlsson scores: 10 days (35 for elastic vs. 50 for Aircast, $p = 0.028$ ) at 1 month (55 for elastic vs. 68 for Aircast, $p = 0.029$ ). No significant differences between groups for secondary outcome measures of swelling, pain at 10 days.	“[T]he use of an Aircast ankle brace in the treatment of moderate and severe lateral ligament ankle sprains, presenting within 24 hours of injury, produces a significant improvement in ankle joint function, at both 10 days and one month, compared with standard management with an elastic support bandage.”	Lack of details. Withdrawal rate >20%. No detail on co-interventions, compliance to treatments. Data suggest Aircast provides better functional outcomes but no differences in swelling or pain at 10 days.
Leanders on 1999 RCT	4.0	N = 73 age 15-55 with acute Grade II or III ankle sprain, who sought medical care	Air cushioned ankle brace (Aircast) vs. compression bandage for acute Grade II and III ankle sprains.	ROM discrepancy in injured vs. uninjured foot decreased at follow-up; still decreased at 10 weeks ( $p < 0.01$ ). ROM uninjured foot increased at follow-up. Figure-of-eight running times for both groups between 2-10 week follow-up improved	“[T]he methods used in the present study are well suited for further studies of objective modalities of ankle joint function with the possible exception of the joint position sense test.”	Sparse details for randomization, baseline comparability, control of co-interventions. Results of uncertain clinical significance other than noting both groups

				significantly from baseline, but no differences between groups.		improved through follow-up: no difference between interventions.
Viljakka 1983 RCT	4.0	N = 119 ankle sprains	Layer bandage vs. elastic adhesive tape. Oxyphenbutazone 100mg TID vs. clonixin 300mg. TID vs. placebo. Severity of acute injury not specified.	No significant differences between layer vs. elastic tape bandage in pain, tenderness, swelling, ROM. Elastic: more rash, irritation or skin compression. Examiner estimate of "good" result: Layer bandage (64%) vs. elastic (62%) vs. placebo (50%) vs. oxyphenbutazone (53%) vs. clonixin (84%). No differences between bandage groups. Placebo vs. oxyphenbutazone, $p > 0.05$ . Oxyphenbutazone vs. clonixin, $p < 0.01$ , placebo vs. clonixin, $p < 0.01$ .	"The layer bandage proved more stable in the lateral direction than the elastic adhesive tape bandage ( $p$ less than 0.001). Clonixin proved useful in controlling swelling and in the authors opinion gave the best clinical results."	Randomization, allocation, baseline comparability, blinding, compliance details sparse. Data suggest clonixin has advantage over oxyphenbutazone based on physician assessment but is of unknown clinical significance. Clonixin is not available in U.S.
Watts 2001 RCT	4.0	N = 400 acute Grade 1 or 2 (mild to moderate) lateral ankle sprains	Double Tubigrip (elastic wrap) vs. No compression wrap for acute Grade I and II sprain.	81 patients in DTG group and 50 in no-DTG group took pain killers, $p = 0.001$ . 54 of DTG group, 48 of no-DTG group had to take days off work, $p = 0.072$ . DTG group took average of 3.37 days off compared to 3.21 days for no-DTG group, $p = 0.94$ . Took average 2.65 days for DTG group to walk unaided vs. 2.32 days for no-	"This study suggests that the use of double tubigrip compression bandage in grade 1 and 2 ankle sprains does not shorten recovery time or number of days off work....(and) seems to be associated with an increase in the need for analgesia."	Loss of 50% to follow-up. No details on co-interventions other than "therapy and analgesia." No details on compliance to intervention.

				DTG group, p = 0.23.		
Sultan 2012  RCT	6.5	N= 36 aged 18 years or over with ankle sprains sustained within 72 hours.  Mean age (range): stocking group 34 (20-59). Tubigrip group 30 (21-57).	Tubigrip (n = 18) vs. class II below knee elastic stockings (ESs, Medi UK Ltd.) (n = 18) worn until patient pain-free and fully mobile.  Follow-up at 4 weeks.	At 4 weeks: ES reduced mean ankle circumference to 22 (22-23) cm and calf circumference to 38 (37-39) cm compared with no change in either ankle or calf circumference using Tubigrip, p<0.05.	“Elastic compression improves recovery following ankle sprain.”	Few baseline data. Data suggest elastic stockings superior to tubigrip for ROM and edema.

*Evidence for the Use of Elevation for Ankle Sprain*

There is 1 moderate-quality RCT incorporated into this analysis.

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Rucinski 1991	4.5	See Evidence Table for the Use of Compression Bandage, Wrap, or Tape for Ankle Sprain above.				

*Evidence for the Use of Ankle Brace Support (Pneumatic/Gel) for Ankle Sprain*

There are 9 moderate-quality RCTs (one with multiple reports) incorporated into this analysis.

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
<b>Ankle Brace Support (Pneumatic/Gel)</b>						
Cooke 2009	7.5	See Evidence Table for the Use of Compression Bandage, Wrap, or Tape for Ankle Sprain above.				
Lamb						

2005, 2009		
Ardevol 2002	6.0	See Evidence Table for the Use of Early Mobilization for Ankle Sprain above.
Beynon 2006	5.5	See Evidence Table for the Use of Compression Bandage, Wrap, or Tape for Ankle Sprain above.
O'Hara 1992	5.5	See Evidence Table for the Use of Compression Bandage, Wrap, or Tape for Ankle Sprain above.
Dettori 1994 a, b	5.0	See Evidence Table for the Use of Compression Bandage, Wrap, or Tape for Ankle Sprain above.
Eiff 1994	4.5	See Evidence Table for Immediate Post-injury Rest for Ankle Sprain above.
Rucinski 1991	4.5	See Evidence Table for the Use of Compression Bandage, Wrap, or Tape for Ankle Sprain above.
Boyce 2005	4.0	See Evidence Table for the Use of Compression Bandage, Wrap, or Tape for Ankle Sprain above.
Leander son 1999	4.0	See Evidence Table for the Use of Compression Bandage, Wrap, or Tape for Ankle Sprain above.

### **Magnets**

Magnets are commonly used as an alternative treatment for musculoskeletal disorders.

*Recommendation: Magnets for Acute, Subacute, or Chronic Ankle Sprain*

**There is no recommendation for or against the use of magnets for treatment of acute, subacute, or chronic ankle sprain.**

*Strength of Evidence – No Recommendation, Insufficient Evidence (I)*

*Level of Confidence - Low*

#### *Rationale for Recommendation*

There are no quality trials available for the use of magnets in the treatment of ankle sprain. Magnets have been evaluated in quality studies elsewhere involving the spine and hand and have been found to be ineffective. Magnets are not invasive, have no adverse effects, and are low cost, but are of unknown efficacy for sprains and therefore there is no recommendation for or against their use in the treatment of ankle sprain.

#### *Evidence for the Use of Magnets for Ankle Sprain*

There are no quality RCTs incorporated in this analysis.

### **DIATHERMY**

Diathermy is frequently described as an alternative intervention for musculoskeletal disorders, including the treatment of ankle sprains.(522-528) (Seiger 06, Pennington 93, Micholvitz 88, McGill 88, Barker 85, Pasila 78, Wilson 72)

*Recommendation: Diathermy for Acute, Subacute, or Chronic Ankle Sprain*

**Diathermy is not recommended for the treatment of acute, subacute, or chronic ankle sprain.**

*Strength of Evidence – Moderately Not Recommended, Evidence (B) – Acute*

**Not Recommended, Insufficient Evidence (I) – Subacute, chronic**

*Level of Confidence - Moderate*

*Rationale for Recommendation*

There are five placebo-controlled high and moderate-quality trials for diathermy in the treatment of acute ankle sprain. A high-quality(523) (Barker 85) and two moderate-quality trials(524, 525) (McGill 88, Pasila 78) demonstrated no benefit in pain, swelling, or functional recovery from a series of three diathermy treatments for acute ankle sprains of mild and moderate severity. There are two moderate-quality trials that reported benefit of diathermy. In a military population, a single session demonstrated reduction in swelling and pain measured immediately after the treatment was applied.(526) (Pennington 93) However, no long-term results were presented and there were baseline differences in the outcomes measures. Another trial utilizing 3 treatment sessions reported improvement in pain, swelling, and function, although the described statistical methods cause the results to be of uncertain clinical significance.(528) (Wilson 72) There is one moderate-quality study comparing the addition of diathermy to RICE, which demonstrated no additional benefit in reduction of pain or improvement of function. Therefore, while diathermy treatments are not invasive and have low complication rates, they are moderate to high cost depending on numbers of treatments, lacking evidence of efficacy and are not recommended.

*Evidence for the Use of Diathermy for Ankle Sprain*

There are 2 high- and 3 moderate-quality RCTs or quasi-RCTs incorporated into this analysis.

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Barker 1985  RCT	8.5	N = 82 mild ankle sprains	Diathermy vs. sham diathermy for acute ankle sprain (3 sessions, 45 minutes on consecutive days). Severity not specified, exclusion criteria: no fracture.	Outcomes measured at 1, 2, 3, 8, 15 days. ROM: No differences at any time. Volume: No differences at any time. Pain scores: No differences at any time. Gait Scores: no differences any time.	“All the quantitative measurements carried out in this trial have failed to show a statistically significant difference between the active and control groups.”	Data suggest no short-term benefit from diathermy for mild ankle sprain with the stated protocol.
McGill 1988  RCT	8.0	N = 31 age 16-60 with lateral ligament sprain of ankle within 48 hours	Pulsed diathermy (3 daily 15 minute sessions) vs. placebo for acute Grade II sprains.	Diathermy vs. placebo (mean, SD): pain score 2.37±1.19 vs. 2.34±1.47. Number analgesics/day - 0.44 ± 0.51 vs. 0.29± 0.55. Time to weight bearing; 3.78±3.2 vs. 2.88±1.5. All differences not significant.	“No significant differences in terms of pain, swelling, or time to full weight-bearing have been shown.”	Small sample size. Placebo group had proportionately more females. Data suggest no benefit over placebo.

Pennington 1993  RCT	6.5	N = 50 Grade I and II (no gross instability) sprained ankles	Diathermy vs. sham diathermy for acute mild and moderate ankle sprain (1 treatment session of 70 minutes).	Ankle edema (cc of water displacement) Placebo: 1,152±216 to 1,141±213. Diapulse: 1,295±255 to 1,251±255; mean difference: Placebo vs. Diapulse 11 vs. 44, p <0.01. Subjective improvement: 8/25 vs. 16/25 favoring diathermy. No p-value given.	“[N]on-thermal pulsed, electromagnetic energy as delivered by Diapulse can be used to decrease swelling and pain in the acutely sprained ankle. This can be important in a population which is required to wear restrictive footwear and is expected to return to continued active training as rapidly as possible.”	Study purpose for short-term effect of diathermy in a military population. Minimal baseline comparability with heterogeneity in mean outcome measure of swelling. Data suggest benefit immediately after treatment with diathermy but duration and long- term benefit is uncertain.
Pasila 1978  RCT	5.0	N = 321 recent ligamentous injuries of ankle and foot	Diapulse vs. curapuls vs. placebo for acute mild and moderate sprains. 20 minute treatment on 3 consecutive days. Diapulse 38W/sec, curapuls 40W/sec. Outcomes measured at Day 3.	No differences abduction, adduction, strength of forefoot. No differences recovery of impaired weight-bearing (heel, toe). Significant difference in mean change of limp 1.0 (diapulse) vs. 0.7 (placebo). Limp measured 0-3 scale, 0-no limp, 1-hardly noticeable, 2- noticeable, 3- crutches. No clinical significant differences.	“[L]ittle significant difference between recovery in the placebo group of patients and in those given shortwave treatment by either of the two devices used.”	Randomization by drawing lots. No blinding noted although it is possible patients blinded. Data suggest no short term clinical benefit from diathermy.
Wilson 1972	4.5	N = 40 with inversion injury of	Diapulse vs. placebo diapulse (1	Diapulse vs. placebo (at 3 days from	“High- frequency electrical	Quasi- randomization (treatment

Quasi-RCT		ankle during preceding 36 hours	hour treatment for 3 days) for acute mild and moderate sprains. Outcomes measured at 3 days.	baseline): Improvement of swelling – sum of scores all subjects (0-4 VAS) 38 to 14 (63.2%) vs. 38 to 26 (31.6%); Improvement of Pain: sum of scores for all subjects (0-4 VAS) 43 to 11 (74.4%) vs. 37 to 25 (32.4%); Improvement of disability (0-4 VAS): 46 to 6 (86.9%) vs. 41 to 23 (43.9%).	treatment has a biological effect in recently-injured soft tissues. This is particularly noticeable in the reduction of pain and also disability.”	machine randomized not subject). Allocation unclear. Author states statistical significance but results not reported and are of uncertain clinical significance as sum of all subjects were used rather than average improvement per subject.
-----------	--	---------------------------------	--	--	--	---

## ELECTRICAL STIMULATION

Low frequency and high-voltage pulsed electrical stimulation are described for ankle sprain.

1. *Recommendation: Low Frequency Electrical Stimulation for Acute, Subacute, or Chronic Ankle Sprain*

**Low frequency electrical stimulation as a therapeutic measure is not recommended for acute, subacute, or chronic ankle sprain.**

*Strength of Evidence – Not Recommended, Evidence (C)*

*Level of Confidence - Low*

2. *Recommendation: High-voltage Pulsed Electrical Stimulation for Acute, Subacute, or Chronic Ankle Sprain*

**High-voltage pulsed stimulation as a therapeutic measure is not recommended for acute, subacute, or chronic ankle sprain.**

*Strength of Evidence – Not Recommended, Insufficient Evidence (I)*

*Level of Confidence - Low*

### *Rationale for Recommendations*

One moderate-quality trial compared low frequency electrical stimulation to sham stimulation and demonstrated no beneficial treatment effect over placebo.(529) (Man 07) There are no quality trials for high-voltage pulsed stimulation. A low-quality trial demonstrated no benefit over RICE therapy for high-voltage pulsed stimulation.(522) (Michlovitz 88) Low frequency electrical stimulation is non-invasive, is moderately costly with the purchase or rental of machine and supplies, and has low adverse effect profile, but is of no demonstrated efficacy and therefore is not recommended.

### *Evidence for the Use of Electrical Stimulation for Ankle Sprain*

There is 1 moderate-quality RCT incorporated into this analysis. There is 1 low-quality RCT in Appendix 1.

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Man 2007  RCT	4.5	N = 34 subjects recovering from ankle sprain	Neuromuscular electrical stimulation (NMES) vs. sub-motor NMES sham NMES	No significant differences among groups for adapted Hughston Clinic Subjective Rating Scale for Ankle Disorders scores between 1st and 3rd sessions, ankle volume or girth differences.	"...no differences were found between the NMES and submotor or sham ES groups in ankle-foot volumes in the early period after ankle sprain."	Baseline differences existed in outcomes measure of ankle girth. Lack of randomization, allocation details. Small sample size, low power. Data suggest lack of efficacy.

## IONTOPHORESIS

Iontophoresis with topical steroids and acetic acid have been used to treat musculoskeletal disorders.

*Recommendation: Iontophoresis for Acute, Subacute, or Chronic Ankle Sprain*

**There is no recommendation for or against the use of iontophoresis for treatment of acute, subacute, or chronic ankle sprain.**

*Strength of Evidence – No Recommendation, Insufficient Evidence (I)*

*Level of Confidence - Low*

### *Rationale for Recommendation*

There is no quality evidence evaluating iontophoresis for treatment of patients with ankle sprain. A treatment series of iontophoresis is non-invasive, has low adverse effect profile, but is of moderate cost. Therefore, there is no recommendation for or against routine use pending publication of quality trials.

### *Evidence for the Use of Iontophoresis for Ankle Sprain*

There are no quality trials incorporated into this analysis.

## LOW-LEVEL LASER THERAPY

Low-level laser therapy (LLLT) is a treatment described for acute ankle sprain.

*Recommendation: Low-Level Laser Therapy for Acute, Subacute, or Chronic Ankle Sprain*

**Low-level laser therapy is not recommended for treatment of acute, subacute, or chronic ankle sprain.**

*Strength of Evidence – Moderately Not Recommended, Evidence (B) – Acute*

**Not Recommended, Insufficient Evidence (I) – Subacute, chronic**

*Level of Confidence - Moderate*

### *Rationale for Recommendation*

There is one high-quality(530) (de Bie 98) and one moderate-quality placebo-controlled trial(531) (Stergioulas 04) for the use of LLLT in treating acute ankle sprain. A high-quality trial found no benefit in short- and long-term outcome measures from LLLT for acute ankle sprain. Rather, the sham intervention arm demonstrated higher functional scores and fewer lost days from work than the intervention arms. There were no differences in pain scores between the groups.(530) (de Bie 98) A moderate-quality study demonstrated reduction in ankle volume in the LLLT group compared to baseline for acute sprain, but there was no comparison between the intervention and sham and no-treatment groups.(531) (Stergioulas 04) Thus, the clinical significance of this finding is not defined. LLLT is not invasive, has low adverse

effects, but is high cost, and has no demonstrated efficacy. Further quality studies are needed; therefore, LLLT is not recommended for ankle sprain.

*Evidence for the Use of Low-level Laser Therapy for Ankle Sprain*

There is 1 high- and 1 moderate-quality RCT incorporated into this analysis.

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
de Bie 1998 RCT	9.5	N = 217 acute lateral ankle sprains	Low-level laser therapy (5J/cm <sup>2</sup> and 0.5J/cm <sup>2</sup> ) vs. sham laser therapy, 12 treatments over 4 weeks for acute mild, moderate, and severe ankle sprain. Each of 3 groups received bracing and therapeutic exercises.	Perceived pain Day 5 (mean±SD) (low dose/high dose/sham): (2.8± 2.2/2.9±2.1/3.3±2.4) p = 0.6; Day 10 (2.0±2.0/2.1±1.9/1.7±1.9) p = 0.48; Day 14 (1.6±1.9/1.7±1.7/ 1.4±1.7) p = 0.42; Day 28 (0.6±1/0.8±1.2/0.4±1) p = 0.14. Function score Day 5 (25.1±15/24.7±15.1/ 25.7±114.8) p = 0.92; Day 10 (42.2±16.1/44.1±14.9/49.9±15.9) p = 0.01; Day 14 (56.3±16.1/56.0 ±15.7/60.0±17.1) p = 0.03. Sick leave; 12.5±11.1/11.2±10.0/7.8± 9.2, p = 0.02. Outcome measures 1 year follow-up (mean ±SD/low/high/placebo): (13.1±12.3/11.5± 10.7/7.8±9.3) p = 0.013.	“Laser treatment is not effective in the treatment of ankle sprains. On the basis of this trial, therapists should reconsider the use of laser therapy in the treatment of ankle sprains.”	Co-interventions of elastic wrap, bracing, home exercises. No added benefit from laser therapy at low or high energy compared with sham. Treatment groups had significantly more absence days away from work and lower functional outcomes in first 4 weeks. Data suggest lack of efficacy.
Stergioulas 2004 RCT	5.0	N = 47 soccer players with 2nd degree ankle sprains	RICE vs. RICE and placebo laser vs. RICE and LLLT (820nm, 40mW at 16 hz) twice daily x 3 days for acute moderate grade ankle sprains.	Largest volume change in laser group: 40.3±2.4ml decreased after 24 hours (p <0.01), 56.4±3.1ml after 48 hours (p <0.002), 65.1±4.4ml after 72 hours (p <0.001).	“LLLT combined with RICE can reduce edema in second-degree ankle sprains.”	Although significant difference from baseline in volumetric measurement of edema reduction in LLLT group, no intergroup statistical analysis provided. Thus, unknown if LLLT provided benefit over placebo or RICE related to edema. Results limited to 72-

						hours post-treatment. Significance of edema reduction is of unknown clinical significance.
--	--	--	--	--	--	--

## PHONOPHORESIS

Phonophoresis is commonly used to treat musculoskeletal disorders.

*Recommendation: Phonophoresis for Acute, Subacute, or Chronic Ankle Sprain*

**There is no recommendation for or against the use of phonophoresis for treatment of acute, subacute, or chronic ankle sprain.**

*Strength of Evidence – No Recommendation, Insufficient Evidence (I)*  
*Level of Confidence - Low*

### *Rationale for Recommendation*

There is no quality evidence evaluating phonophoresis for treatment of patients with ankle sprain. Phonophoresis is non-invasive, has few adverse effects, and is moderately expensive. There is no recommendation pending publication of quality trials.

### *Evidence for the Use of Phonophoresis for Ankle Sprain*

There are no quality studies incorporated into this analysis.

## ULTRASOUND

Therapeutic ultrasound is used in a wide variety of musculoskeletal disorders, including ankle sprains to relieve pain, reduce swelling, and improve joint function.(532-534) (Zammit 05, van der Windt 02, Nyanzi 99)

*Recommendation: Therapeutic Ultrasound for Acute, Subacute, or Chronic Ankle Sprain*

**Therapeutic ultrasound is not recommended for the treatment of acute, subacute, or chronic ankle sprain.**

*Strength of Evidence – Moderately Not Recommended, Evidence (B) – Acute*  
**Not Recommended, Insufficient Evidence (I) – Subacute, chronic**  
*Level of Confidence - Moderate*

### *Rationale for Recommendation*

There are three moderate-quality placebo-controlled trials that demonstrated no clinical benefit from therapeutic ultrasound compared with sham ultrasound after 3 to 8 sessions as measured by pain, swelling, or functional improvement.(532, 533, 535) (Nyanzi 99, Zammit 05, Williamson 86) A low-quality trial demonstrated ultrasound plus ice to be more effective than elastoplast wrap in pain relief and functional recovery.(536) (Makuloluwe 77) There is one moderate-quality trial that demonstrated similar improvements in the ultrasound group compared with topical NSAIDs, although there was no control arm, so natural history for improvement cannot be excluded.(484) (Oakland 93) Ultrasound is non-invasive, has low adverse effects, is of moderate cost depending on numbers of treatments, but has low treatment efficacy and is therefore not recommended.

### *Evidence for the Use of Therapeutic Ultrasound for Ankle Sprain*

There are 4 moderate-quality RCTs incorporated into this analysis. There is 1 low-quality study in Appendix 1.

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Nyanzi 1999  RCT	6.5	N = 58 ankle injuries	Ultrasound vs. sham ultrasound; 3 10-minute sessions on consecutive days. Energy 0.25 W cm <sup>-2</sup> , 1:4 mark ratio at 3Mhz. Follow-up 2 weeks post last session. Acute sprains, severity not described.	Placebo vs. ultrasound: VAS (0-10cm): No differences any day (1-14). Intragroup placebo improved 4.8 to 0.7cm p <0.0001, ultrasound 4.9 to 0.9cm p <0.0001. Ankle swelling: No intergroup differences at any interval. Both groups improved significantly from baseline. No differences between dorsiflexion, plantar flexion, and weight bearing ability.	“[This study has shown that at the dose and duration used, ultrasound therapy offers no benefits over sham ultrasound (placebo) in the management of lateral ligament sprains of the ankle joint.”	Study blinded to patient and researcher applying treatment. Allocation not described. Few baseline variables presented for comparison. Suggests ultrasound treatment does not provide therapeutic effect for acute ankle sprain. Grade of sprain uncertain, although all subjects eligible after fracture ruled out by radiograph.
Oakland 1993  RCT	5.5	N = 220 acute injuries of lateral ankle ligaments	Felbinac gel plus sham ultrasound placebo vs. placebo gel plus ultrasound vs. felbinac plus ultrasound for acute ankle sprains (severity not described).	Changes from baseline in VAS Pain: 21.5mm vs. 19.4mm vs. 16.5mm, p >0.05. Investigator Assessment (% moderate or better response) 84.5% vs. 83.5% vs. 86.5%; Full Weight bearing: 73% vs. 77% vs. 80%, p >0.05	“[F]elbinac gel has a similar clinical efficacy to ultrasound in the treatment of acute injuries of the lateral ankle ligaments.”	Allocation, blinding of investigator not described; 52 of 220 dropped out although results carried forward in analysis. Study suggests ultrasound and topical NSAID of similar efficacy. No evidence of combined effect. No control arm.
Zammit 2005  RCT	5.0	N = 34 acute lateral ligament sprains of ankle joint	Ultrasound vs. sham ultrasound vs. control. All groups received elastic wrap (tubigrip), exercise, and ice; 6 sessions of ultrasound over 2 weeks,	Ultrasound vs. sham vs. control: Mean changes at 22 days. Pain (VAS cm): 3.9/4.0/4.2, p >0.05; Swelling reduction (cm): 1.0/1.3/1.2, p >0.05; Plantar flexion: 10°/5.2°/5/5°, p >0.05;	“At the does and duration used in this study, ultrasound is not effective in the management of acute lateral ligament sprains of the ankle joint,	Randomization, allocation, baseline comparability details sparse. Data suggest no added benefit of ultrasound therapy to mild and moderate acute ankle sprains over placebo

			energy 0.25Wcm <sup>2</sup> for 10 minutes, sessions 4-6 increased to 0.5Wcm <sup>2</sup> . Acute Grade I and II sprains.	Dorsiflexion: 4.7°/4.6°/8.8°, p >0.05.	with respect to the following outcomes: pain, swelling, range of motion during dorsiflexion and plantar flexion, and postural stability.”	combined plus conservative measures of exercise, elastic wrap. Use of these modalities limits ability to differentiate effect of natural history.
Williamson 1986  RCT	4.0	N = 154 age 12-65 with history of inversion injury to lateral ligament of ankle	Ultrasound vs. sham ultrasound for acute mild and moderate ankle sprains. Treatment every other day until reaching end point of 0-1 on a 15 point scale for pain and degree of limitation.	No significant difference between groups for time spent on crutches or time taken off work. Both groups reached the end points at the same rate.	“Ultrasound treatment by the method used... does not hasten recovery after a lateral ligament sprain of the ankle.”	Lack of randomization, allocation, baseline comparability, compliance details. High withdrawal rate. No additive effect of ultrasound to other methods demonstrated.

## ACUPUNCTURE

Acupuncture is described as an alternative intervention for musculoskeletal disorders.(537-540) (Fong 09, Zhang 90, Mou 87, Paris 83)

*Recommendation: Acupuncture for Acute, Subacute, or Chronic Ankle Sprain*

**There is no recommendation for or against the use of acupuncture for treatment of acute, subacute, or chronic ankle sprain.**

*Strength of Evidence – No Recommendation, Insufficient Evidence (I)*

*Level of Confidence - Low*

### *Rationale for Recommendation*

There are no quality trials of acupuncture for the treatment of ankle sprain. Acupuncture is minimally invasive, has minimal adverse effects, and, depending on numbers of treatments, is moderately costly. Other interventions have documented efficacy. Pending publication of quality studies, there is no recommendation for or against use of acupuncture for treatment of ankle sprain.

### *Evidence for the Use of Acupuncture for Ankle Sprain*

There are no quality RCTs incorporated into this analysis.

## BIOFEEDBACK

See prevention and therapy/rehabilitation for a discussion of proprioception and balance training techniques.

## HYPERBARIC OXYGEN

Hyperbaric oxygen is described for the treatment of musculoskeletal injuries and ankle sprain.(472, 541-543) (Bleakley 08, Bennett 05, Kanhai 03, Borromeo 97)

*Recommendation: Hyperbaric Oxygen Therapy for Acute, Subacute, or Chronic Ankle Sprain*  
**Hyperbaric oxygen therapy is not recommended for treatment of acute, subacute, or chronic ankle sprain.**

*Strength of Evidence – Not Recommended, Evidence (C) – Acute*  
**Not Recommended, Insufficient Evidence (I) – Subacute, chronic**  
*Level of Confidence - Low*

*Rationale for Recommendation*

There is one moderate-quality placebo controlled trial for hyperbaric oxygen therapy that failed to demonstrate any beneficial treatment effect from 2.0 atmospheres pressure as measured 72 hours post-treatment.(542) Hyperbaric oxygen is non-invasive, is of moderate to high cost dependent on treatment facility and number of treatments, and has low risk for adverse effects, but has no demonstrated efficacy and is therefore not recommended.

*Evidence for the Use of Hyperbaric Oxygen for Ankle Sprain*

There is 1 moderate-quality RCT incorporated in this analysis.

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Borromeo 1997 RCT	6.0	N = 32 acute ankle sprains	Hyperbaric oxygen therapy 2 atmospheres absolute pressure vs. air 1.1 atmosphere absolute pressure treatment.	Regression analysis for oxygen vs. air, age, severity, time to initial treatment after injury: p = 0.152, p = 0.010, p = 0.0001, p = 0.995. Both groups significant reduction in pain during treatment (p <0.05): SEM for HBO = 0.19, SEM for air = 0.14.	“Analysis of objective measures of ankle function showed no difference between the subjects exposed to air and those exposed to HBO. Only two factors, subject age and initial severity of injury, affected time to recovery.”	Multiple co-interventions (NSAID, RICE, splinting, elastic wrap, PT). Small sample size. Data suggest no additional benefit for acute injury treated within 72 hours.

**MANIPULATION AND MOBILIZATION**

Manipulation and mobilization therapy is described as a therapeutic intervention for ankle sprain.(516, 544-550) (Kohne 07, Lopez-Rodriguez 07, Vicenzino 06, Eisenhart 03, Collins 04, Coetzer 01, Green 01, Pellow 01)

1. *Recommendation: Manipulation or Mobilization for Acute or Subacute Ankle Sprain*  
**There is no recommendation for or against the use of manipulation or mobilization for the treatment of acute or subacute ankle sprain.**

*Strength of Evidence – No Recommendation, Insufficient Evidence (I)*  
*Level of Confidence - Moderate*

2. *Recommendation: Manipulation or Mobilization for Chronic Recurrent Ankle Sprain*  
**There is no recommendation for or against the use of manipulation or mobilization for the treatment of chronic recurrent ankle sprain.**

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Vicenzino 2006  Crossover Trial	8.0	N = 16 recurrent lateral ankle sprains	Mobilization with movement (MWM): weight bearing vs. non-weight bearing vs. no treatment in those with history of recurrent ankle sprain (no active conditions).	Weight bearing vs. non-weight bearing vs. control: % improvement of posterior talar glide; 55% vs. 50% vs. 17%, p = 0.003 for both MWM techniques vs. control.	“[T]he application of the MWM treatment techniques improved posterior talar glide and talocrural dorsiflexion immediately after application in subjects with chronic recurrent lateral ankle sprain. [T]here appears to be little difference in treatment effect between the 2 MWM techniques.”	Crossover trial. Reported double-blinding, but not feasible subject or intervention could be blinded. Results of uncertain clinical significance as no report of long-term outcomes regarding recurrence of sprain.
Truyols-Dominguez 2013  RCT	7.0	N = 50 with unilateral inversion ankle sprain; mean age for comparison group: 32, mean age for experimental group: 33.	Comparison group, manipulation/mobilization only (n = 25) vs. Experimental group, myofascial manual therapy and manipulation/mobilization intervention (n = 25). Both groups: ankle and foot non-thrust mobilization and thrust manipulation, general exercises, and instruction to elevate	Combined treatment group had greater improvement on each functional score domain. No p-values to report.	“This study provides evidence that, in the treatment of individuals’ post-inversion ankle sprain, the addition of myofascial therapy to a plan of care consisting of thrust and nonthrust manipulation and exercise may further improve outcomes compared to a plan of care solely consisting of thrust and nonthrust manipulation and exercise. However, though statistically significant, the difference in improvement in the primary outcome between groups was not greater than what would be considered a minimal clinically important difference. Future studies	Addition of myofascial techniques to thrust and non-thrust manipulations in treatment of acute ankle sprain associated with greater improvement of function and less pain at 4 weeks and at 1 month follow-up. However, differences modest.

			and ice the ankle. Follow-up: baseline, post intervention, and 1-month		should examine the long-term effects of these interventions in this population.”	
Collins 2004  Crossover Trial	6.5	N = 16 subacute Grade II lateral ankle sprains	Mobilization with movement vs. placebo mobilization vs. no-treatment (single sessions).	Mean±SD for dorsiflexion (mm) MWM vs. placebo vs. control: Pre: 57.27 (p 0.017) ± 41.00 vs. 60.17± 38.49 vs. 58.29±32.67. Post: 68.93± 45.44 (p 0.017) vs. 62.07± 38.97 vs. 56.42± 33.48.	“Mulligan’s dorsiflexion mobilization with movement technique significantly increases talocrural dorsiflexion initially after application in subacute ankle sprains.”	Excluded for sample size. Randomized variable was treatment order. No long-term results; results of unknown clinical significance.
Green 2001  RCT	6.5	N = 41 acute ankle inversion sprains <72 hours and no other injury to lower limb	RICE vs. passive accessory joint mobilization plus RICE for acute ankle sprain (max 6 treatment sessions, once every other day).	Manipulation vs. control: attained full ROM after 4 sessions: 68% vs. 16%, p <0.01. Dorsiflexion ROM improvement: 10.9° (SEM = 1.9°) vs. 5.8° (SEM = 1.1°) after 1st treatment. Stride speed increased more within 1st and 3rd treatment sessions for experimental group, p <0.05. Return to work: 5.3 vs. 6 days.	“Addition of talocrural mobilization to the RICE protocol in the management of ankle inversion injuries necessitated fewer treatments to achieve pain-free dorsiflexion and to improve stride speed more than RICE alone.”	Baseline differences in number of recurrent sprains (higher in experimental group). Despite outcome improvements in dorsiflexion, does not appear statistically significant in lost work days or return to work, sports, normal walking. Thus, improved dorsiflexion ROM as an outcome measure of unknown clinical importance.
Yeo 2011  Experimental Trial	5.5	N= 13 with unilateral acute and	Maitland’s passive accessory mobilization of the talus on distal tibia and fibular	Ankle dorsiflexion index: increase of 9.6mm following treatment condition (p = 0.000), significant between treatment and manual contact	“[A]ccessory mobilisation of the ankle joint using the anteriore posterior glide technique produced an immediate and rapid onset hypoalgesic	Experimental design. No intermediate or longer term outcomes of meaningful clinical efficacy reported.

		subacute ankle supination injury (2-10 weeks). Mean age 29.5 years. Acute and subacute ankle sprains (2-10 weeks)	(manual application of repetitive gentle oscillation of talus for 1 min, repeated 3 times) vs. manual contact control (hand contact on ankle) vs. no contact control. 3 study sessions scheduled at least 48 hours apart where all patients received the 3 conditions. Assessments immediately after each intervention.	control (p = 0.000) and no contact control (p = 0.000). Pressure pain threshold: increased 17.76% after treatment (p = 0.000), significant between treatment and manual contact control (p = 0.000) and no contact control (p = 0.002). Pain VAS scores: NS (p = 0.369). Ankle functional scores: NS (p = 0.475).	effect and an improvement in ankle dorsiflexion range of motion in subjects with an ankle supination injury.”	
Cosby 2011 RCT	4.5	N = 17 with acute lateral ankle sprain (Grade I and II); mean age 19.7	Treatment group, physical therapist guided 30 second grade III AP talocrural joint mobilizations, one mobilization/second vs. Control group, not treatment, no physical contact	Mean±SD for dorsiflexion ROM: control vs. treatment: baseline: 7.36±6.38 vs. 6.49±6.43, p = 0.04; 24-hour: 9.94±4.0 vs. 8.82±7.29, p = 0.04. FADI-ADL (foot and ankle disability index-activities of daily living) control vs. treatment: baseline: 72.76±18.7 vs. 62.29±17.63, p = 0.004, 24-hour: 82.09±9.99 vs. 75.85±15.15, p = 0.004. FADI pain:	“A single bout of AP talocrural joint mobilizations may not have an immediate effect on ankle dorsiflexion ROM, posterior talar translation, or self-reported function; however, they may have an immediate effect on pain perception in individuals with an acute lateral ankle sprain.”	Small N with few baseline characteristics. No significant decrease in pain perception between 2 groups at 24 hours. No significant followup to afford assessment of utility.

		6±1.35	with physician. All participants : dorsiflexion ROM, posterior talar translation using a portable ankle arthrometer, and self-reported function. Follow-ups: baseline, immediate post-treatment, and 24-hour follow-up.	baseline: 81.25±14.94 vs. 72.22±10.87, p = 0.03, 24-hour: 80.47±7.04 vs. 84.03±14.36, p = 0.03.		
--	--	--------	---	---	--	--

*Strength of Evidence – No Recommendation, Insufficient Evidence (I)*  
*Level of Confidence - Low*

*Rationale for Recommendations*

There is one moderate-quality trial that compared the addition of passive talocrural joint mobilization to a RICE protocol for acute ankle sprain.(516) (Green 01) The mobilization group demonstrated improvement in dorsiflexion range of motion. However, there is no correlation of improvement to other outcomes such as lost workdays, return to work, or return to sports or normal walking measures, making this finding of uncertain clinical significance. Another moderate-quality trial comparing a single session of mobilization plus movement with “no treatment” for subacute ankle sprain demonstrated immediate improvement of talocrural dorsiflexion.(545) (Collins 04) There were no other long-term or clinical outcomes reported, making the clinical significance of improved dorsiflexion and the intervention of unknown benefit. A high-quality cross-over trial comparing mobilization plus movement with “no treatment with or no weight bearing” also demonstrated improved talocrural movement, but conclusions of clinical utility are again limited.(550) (Vicenzino 06) An experimental trial of single intervention found limited evidence of potential efficacy, but no intermediate or long-term results. (Yeo 11) A moderate-quality trial found minimal additive benefit of myofascial techniques to manipulation/mobilization. (Truyols-Dominguez 13) Manipulation is not invasive, is moderately costly, but may have adverse effects. There is no recommendation for or against manipulation of the ankle and foot joints for acute, subacute, or chronic ankle sprain as there is an absence of quality evidence.

*Evidence for the Use of Manipulation and Mobilization for Ankle Sprain*

There is 1 high- and 5 moderate-quality RCTs or crossover trials incorporated into this analysis. (Truyols-Dominguez 13; Yeo 11; Cosby 11) There are 5 low-quality RCTs in Appendix 1.(544, 546-549) (Eisenhart 03; Pellow 01; Coetzer 01; Kohne 07; Lopez-Rodriguez 07)

**Prevention**

Multiple strategies for prevention of first time ankle injury as well as recurrence are reported, including use of ankle supports, balance training, footwear, and orthotics.

## ANKLE SUPPORT

*Recommendation: Ankle Support (Brace, Tape) for Prevention of Ankle Injury*

**The use of ankle support (brace, tape) is recommended for the prevention of ankle injury.**

*Strength of Evidence* – **Recommended, Evidence (C)** – Initial injury

**Recommended, Insufficient Evidence (I)** – Recurrent injury

*Level of Confidence* - Moderate

### *Rationale for Recommendation*

There are two controlled moderate-quality trials that compare the incidence of ankle sprain injuries in healthy military populations using an ankle brace compared to “no brace” for intramural basketball participation(551) (Sitler 94) and paratrooper training.(552) (Amoroso 98) Both studies demonstrated a lower incidence of ankle sprain in the brace group. Another moderate-quality trial compared bracing to taping for the prevention of sprain during a high school football season and found no difference between groups.(553) (Mickel 06) However, there was no control group to determine efficacy of prevention. There are two low-quality studies of high school athletes also suggesting preventive value of a lace-up brace. (McGuine 11; McGuine 12) There are no quality trials for the use of ankle supports to prevent recurrent injury, but by inference, they may provide additional protection to persons with feelings of instability or who are involved in activities that are at high risk for ankle inversion. Ankle supports are non-invasive, have low adverse effects, and may be of moderate to high cost, particularly for daily taping or use of multiple braces over a season.

### *Evidence for the Use of Ankle Support (Brace, Tape) for Prevention of Ankle Sprain*

There are 3 moderate-quality RCTs incorporated in this analysis. There are 3 low-quality RCTs in Appendix 1.(554) (Stasinopoulos 04; McGuine 11; McGuine 12)

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Amoroso 1998 RCT	6.0	N = 777 U.S. Army Airborne School volunteers	Outside boot ankle brace (Aircast) vs. no additional support in parachute jump training in military population	Brace vs. control: Ankle inversion injuries 7/376 (3.79% vs. 1/369 (0.55%) p-0.04. No differences in ankle fractures, syndesmosis sprains, knee or leg sprains/strains.	“Inversion ankle sprains during parachute training can be significantly reduced by using an outside-the-boot ankle brace, with no increase in risk for other injuries.”	Randomization based on odd/even military numbers. No baseline comparisons. Compliance not stated but inferred in this military population.
Mickel 2006 RCT	5.0	N = 93 ankle sprains in high school football players during a single season	Bracing (semi-rigid airport brace) vs. taping for prevention of sprain in high school football league.	There was 0.83 ankle sprains per 1,000 exposures for brace group and 0.77 sprains per 1,000 exposures in tape group, p >0.05.	“Both of these prophylactic measures were well tolerated by the players, and the incidence of lateral ankle injuries was equal in both groups, whereas the cost to implement	Allocation, baseline details sparse. Study may not have been powered to detect differences. Cost discussion compares retail taping costs to

					these measures was higher in the taping group.”	wholesale device costs.
Sitler 1994  RCT	5.0	N = 1,601 U.S. Military Academy cadets with no pre-participation, clinical, functional, or radiographic evidence of ankle instability	Ankle stabilizer (Aircast) vs. no ankle stabilizer in healthy military recruits intramural basketball program.	Total number of ankle injuries for 2 years: ankle stabilizer 11, control 35, p <0.05. For contact injuries, those who wore ankle stabilizers had fewer ankle injuries compared to controls, p <0.01. The incidence of knee injury not significant between the 2 groups.	“The total number of ankle injuries as well as the number of single and combined anterior talofibular and calcaneofibular ligament injuries were significantly reduced with ankle stabilizer use. No significant difference existed between the ankle stabilizer and control groups in the frequency of knee injuries.”	Randomization, allocation methods not described. Overall incidence lower with brace group. Study completed in young military population

## BALANCE TRAINING

*Recommendation: Balance/Proprioception Training for Prevention of Ankle Injury*

**Balance/proprioception training is recommended for prevention of initial and recurrent ankle injury.**

*Strength of Evidence – Recommended, Evidence (C)*

*Level of Confidence - Low*

There are two moderate-quality controlled trials that demonstrated benefit in reducing foot or ankle sprain injury after proprioception and balance training in healthy populations compared to control of no training.(555, 556) (Emery 07, McGuine 06) Ankle sprain injuries were significantly reduced in high school athletes over the course of a season in the group that used a wobble board in training during the season.(556) (McGuine 06) A moderate-quality trial demonstrated home-based proprioception training to be effective in reducing recurrent ankle sprains compared with routine physiotherapy alone.(557, 558) (Hupperets 08, 09) A moderate-quality trial compared postural control techniques using either an internal focus of attention or an external focus of attention during training.(559) (Rotem-Lehrer 07) There were no differences between the techniques, and no recommendation for one technique is made over another. A low-quality trial compared training technique with proprioception and orthosis with no demonstrated differences.(554) (Stasinopoulos 04) Balance training is of low cost for exercises, and wobble boards can be inexpensive.(556) (McGuine 06) It is not clear which populations would benefit most from this training. Further studies in working populations are needed. Ankle support is low to moderate costs and has low adverse profile, and is recommended for short-term use.

*Evidence for the Use of Balance Training/Proprioception for Prevention of Ankle Sprain*

There are 4 moderate-quality RCTs (one with two reports) incorporated into this analysis. There are 8 low-quality RCTs (one with 2 reports) in Appendix 1.(554, 560-567) (Coughlan 07; Engebretsen 08; Mohammadi 07; Verhagen 04; Verhagen Br J Sports Med 05; Verhagen Clin Biomech 05; Wedderkopp 99; Melnyk 09; Stasinopoulos 04)

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Emery 2007  RCT	6.0	N = 920 high school basketball players	Wobble board training plus warm-up exercises vs. warm-up exercises in high school basketball league.	Control vs. training player exposure hours, number of injuries, injury rate/1000 hour, relative risk, 95% CI, statistically significant. All injury: 34955/39369, 141/130, 4.03 (3.4-4.76)/3.3 (2.76-3.92), 1/0.8, 0.57-1.11, p = 0.18. All acute injury: 34955/3969, 134/109, 3.83 (3.21-4.54)/2.77 (2.27-3.34), 1/0.71, 0.5-0.99, p = 0.047. Lower extremity injury: 34955/39369, 111/106, 3.18 (2.61-3.82)/2.69 (2.2-3.26), 1/0.83, 0.57-1.19, p = 0.3. Ankle injury: 34955/39369, 76/62, 2.46 (1.97-3.04)/1.57 (1.21-2.02), 1/0.71, 0.45-1.13, p = 0.15.	“A basketball-specific balance training program was effective in reducing acute-onset injuries in high school basketball. There was also a clinically relevant trend found with respect to the reduction of all, lower-extremity, and ankle sprain injury.”	Randomization conducted by team rather than individual. Compliance less than 60%. No significant effect on ankle sprains but data suggest reduced acute injuries.
McGuine 2006  RCT	5.5	N = 765 high school soccer and basketball players	Balance training (wobble board) vs. control for high school basketball and soccer players.	“Taking part in the intervention program significantly reduced the risk of an ankle sprain (risk ratio, 0.56; 95% CI, 0.33-0.95; p = 0.033).”	“[B]alance training program, implemented throughout a sports season, will reduce the rate of ankle sprains by 39% in high school basketball and soccer players.”	Subjects randomized as whole team. Method not described. No blinding of assessors. Suggests balance training program beneficial in reducing sprains.
Hupperts 2008, 2009  RCT	5.0	N = 522 active participants in sports with a lateral ankle sprain up to 2 months prior to	Home-based 8-week proprioceptive training (3 sessions/week plus routine physiotherapy) vs. routine physiother	Effect of proprioceptive training program regression analysis showed lower recurrences of ankle sprain in intervention vs. control (0.63/95%CI = 0.45-0.88). Effect of non-medically treated athletes' regression showed lower recurrence of ankle sprains in intervention vs. control. Self reported	“The use of a proprioceptive training programme after usual care of an ankle sprain is effective for the prevention of self reported recurrences. This proprioceptive training was	No blinding, Low compliance rates (23% fully compliant, 29% partially). Data suggest home based training for proprioception may be beneficial in preventing

		inclusion	study for prevention of recurrent sprain; 1-year follow-up.	recurrences of ankle sprain (0.45, 0.28-0.72). Recurrences leading to loss of sports time (0.47, 0.23-0.96).	specifically beneficial in athletes whose original sprain was not medically treated.”	recurrent ankle sprain.
Rotem-Lehrer 2007 RCT	5.0	N = 36 male volunteers with Grade 1 or 2 ankle sprains	Internal focus of attention (IFA) during postural control training vs. external focus (EFA) during postural control training.	Stability scores: overall/anterior posterior stability/medial lateral stability; pretraining, post-training, change score: IFA mean±SD for (95%): 13.5±4.1/11.9±5.5/-1.59 (-3.13 to -0.05), 8.3±3.2/6.8±3.2/-1.43 (-3.13 to 0.28), 10.3±4.2/ 9.6±5.1/-0.69 (-1.99 to 0.61). EFA: 15.7±3.3/10.2±3.5/-5.45 (-6.62 to -3.97), 10.1±3.4/6.0±2.0/-4.14 (-5.75 to -2.54), 11.5±2.6/8.2±3.4/ -3.36 (-4.88 to -1.84).	“[E]xternal focus of attention is advantageous for the transfer of learning of a postural control task following an ankle injury.”	Randomization, allocation details sparse. Blinding described but not of intervention or assessment. Results do not include injury recurrence or improvement and are thus of limited significance.

## ORTHOTICS (FOOT)

Orthotic devices for the foot are used for prevention of ankle sprain or recurrent ankle sprain.(568-571) (Sesma 08, MacLean 04, Richie 07, Finestone 04)

*Recommendation: Foot Orthotics for Prevention of Ankle Injury*

**There is no recommendation for or against the use of foot orthotics for the prevention of ankle injury.**

**Strength of Evidence – No Recommendation, Insufficient Evidence (I)**  
*Level of Confidence - Low*

### *Rationale for Recommendation*

There are no quality trials comparing the use of foot orthoses with “no use” for the prevention of ankle sprain. A low-quality study demonstrated no differences in injury prevention with the use of heel cup inserts.(225) (Fauno 93) There is one moderate-quality trial with two separate trials that compared custom soft orthotics with soft prefabricated orthotics, and custom semi-rigid orthotics with pre-fabricated semi-rigid orthotics.(568) (Finestone 04) There were no differences in incidence of injury between the groups. With the lack of a control group, prophylactic value of using orthotics is not defined. These devices are non-invasive, have few adverse effects, and are generally low cost for devices that are not custom-made. There is insufficient evidence for or against the use of foot orthotics for prevention of initial or recurrent ankle sprain.

### *Evidence for the Use of Foot Orthotics for Prevention of Ankle Injury*

There is 1 moderate-quality RCT incorporated into this analysis. There is 1 low-quality RCT in Appendix 1.

Author/Y ear Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Finestone 2004  RCT	4.0	N = 451 male infantry recruits	Trial 1: (n = 451) custom soft orthoses vs. soft prefabricated orthoses; Trial 2: (n = 423) semirigid biomechanical orthoses vs. semirigid prefabricated orthoses. Use in military training 14-week program.	Injury incidence (%): custom soft vs. soft prefabricated vs. semirigid biomechanical vs. semirigid prefabricated: Stress fracture 9.1 vs. 8.9 vs. 9.7 vs. 9.1; Ankle sprain 9.9 vs. 10.7 vs. 9.3 vs. 8.0; Foot problems: 17.4 vs. 19.6 vs. 14 vs. 20.1. No differences between groups in any disorder.	"[F]indings suggest that if a foot orthosis is being dispensed as prophylaxis for overuse injuries in an active, healthy population, there is little justification for prescribing semirigid biomechanical orthoses. Their cost is high compared to other types of orthoses, without an advantage in comfort or a reduction in stress fractures, ankle sprains, and foot problems."	Reported as single trial, but groups randomized separately. Prevention study in military population. Reported as subject blinded, but true blinding not described. Data suggest no effect of orthotic type in injury prevention. No control group.

## FOOTWEAR

Various types of work shoes, boots, and athletic shoes are used to prevent initial and recurrent ankle sprains.(572-581) (Knapik 10a,b, 09, Fraley 09, Curtis 08, Perry 08, Fong 08, 07, Chiu 07, Mangan 06)

*Recommendation: Special Shoes for Prevention of Ankle Sprain or Recurrent Ankle Sprain*

**Appropriate activity specific footwear is recommended for the prevention of ankle sprain or recurrent ankle sprain. There is no recommendation for the use of one type of shoe over another for prevention of ankle sprain or lower extremity disorders.**

*Strength of Evidence – Recommended, Insufficient Evidence (I)*

*Level of Confidence - Low*

### *Rationale for Recommendation*

There are two moderate-quality trials comparing the use of different running shoe types matched to foot arch (plantar shape) in military basic training settings, which did not demonstrate benefit in reducing injury or sprain.(577, 579) (Knapik 10a,b) The application of these studies in the military is that no effort is needed to match shoe type with foot arch type. The practical applications in the working population are unclear. There is one moderate-quality trial that compared the use of high- and low-top basketball shoes in an athletic league.(582) (Barrett 93) There were no differences in incidence of injury between the groups over a 2-month college intramural season. There are myriad shoe types that are designed for workplace hazard or athletic event. The use or misuse of shoe type plausibly may result in injury when used improperly or for the wrong purpose. These devices are non-invasive, have few adverse effects, and are generally moderate cost for devices that are not custom designed. There is insufficient evidence for or against the use of one type of footwear over another as long as it is being used for the designed purpose.

### *Evidence for the Use of Foot Wear for Ankle Sprain*

There are 3 moderate-quality RCTs incorporated into this analysis.

Author/Y ear	Score	Sample Size	Comparison Group	Results	Conclusion	Comments
--------------	-------	-------------	------------------	---------	------------	----------

Study Type	(0-11)					
Knapik 2010 RCT	5.5	N = 1,411 Marine Corps recruits	Motion control shoes for low arch-motion vs. cushion shoe for high arch vs. stability (control) running shoes; 12-week basic training (Marines).	Hazard ratio (men) intervention/control; Low arch: 0.91 (0.40-2.07) p = .82; High arch: 1.05 (0.53-2.10) p = .89; hazard ratio (women) intervention/control: Low arch: 0.74 (0.31-1.76) p = .49; High arch: 1.11 (0.62-2.00) p = .72	“This prospective study demonstrated that assigning shoes based on the shape of the plantar foot surface had little influence on injuries even after considering other injury risk factors.”	Lack of compliance, co-intervention details. Compliance assumed high (military training/shoe assignment tracked). Results suggest fitting shoe type to perceived plantar shape provides no additional benefit in preventing injuries, including sprains.
Knapik 2010 RCT	4.5	N = 2,702 U.S. Air Force Basic Military Training (BMT) recruits	Motion control shoes for low arch-motion vs. cushion shoe for high arch vs. stability (control) running shoes; 12-week basic training.	Training-related Injury Index: hazard ratio (men) intervention/control 1.17 (0.95-1.45) p = .14; Training-related Injury Index: hazard ratio (women) intervention/control 1.26 (0.96-1.65) p = .09	“This prospective study demonstrated that assigning running shoes based on the shape of the plantar surface had little influence on the injury risk in BMT even after controlling for other injury risk factors.”	Lack of compliance, co-intervention details. Compliance assumed high (military training/shoe assignment tracked). Results suggest fitting shoe type to perceived plantar shape provides no additional benefit in preventing injuries, including sprains.
Barrett 1993 RCT	4.0	N = 622 college intramural basketball all players	High-top shoes vs. low-top vs. high top with inflatable air chambers for prevention of ankle sprain.	Injury rates per 10,000 player minutes, 95% CI (high-top air chamber vs. low-top vs. high-top): 2.69 (0.6-6.8) vs. 4.06 (1.2-10.3) vs. 4.8 (2.0- 9.8).	“The major finding of this study was that there was no difference between high- and low-top basketball shoes in the prevention of ankle sprains.”	Allocation method, compliance unclear. Results suggest no difference after 2 months in college intramural population with shoe types.

## STRETCHING/STRENGTHENING EXERCISES

*Recommendation: Stretching/Strengthening Exercises for Prevention of Ankle Injury*

**There is no recommendation for or against the use of stretching or strengthening exercises for the prevention of initial or recurrent ankle injury.**

*Strength of Evidence – No Recommendation, Insufficient Evidence (I)*

*Level of Confidence - Low*

*Rationale for Recommendation*

There are no quality trials for the use of stretching/strengthening exercises for the prevention of ankle injury. Stretching or strengthening exercises are of low cost, have no adverse effects, but are of unknown efficacy, and therefore have no recommendation pending quality trials.

#### *Evidence for the Use of Stretching/Strengthening Exercises for Prevention of Ankle Injury*

There are no quality RCTs incorporated into this analysis. There are 4 low-quality RCTs in Appendix 1.(562, 583-585) (Pope 00; Puls 07; Ekstrand 83; Mohammadi 07)

### **PHYSICAL OR OCCUPATIONAL THERAPY**

Rehabilitation and therapy that includes using exercise, stretching and strengthening, proprioception and postural training techniques is frequently used for the treatment of acute and subacute ankle sprain to improve strength and function of the joint and to reduce ankle instability.

#### 1. *Recommendation: Therapy for Acute, Subacute, or Chronic Ankle Sprain*

**Therapy is recommended for select patients with acute, subacute, or chronic ankle sprain.**

*Indications* – Acute, subacute, or chronic ankle sprain.

*Frequency/Duration* – Self-directed, home-based exercise and stretching program is recommended for ankle sprain. Most patients with acute sprains need no therapy. Supervised programs of 1 or 2 therapy sessions may be indicated for patients who require initial supervision; education; need motivation or help in overcoming fear avoidance; have significant impairments or functional limitations; or need to return to a high level of activity. Up to 12 appointments may be needed for chronic sprains, persistent ankle instability or for acute severe sprains. Follow-up educational visit(s) for more severe disorders as part of a progression towards normal functional use is sometimes helpful.

*Indications for Discontinuation* – Achievement of rehabilitation goals or non-compliance.

*Strength of Evidence* – **Recommended, Insufficient Evidence (I)**

*Level of Confidence* - Moderate

#### 2. *Recommendation: Therapy for Chronic Ankle Instability (CAI)*

**Therapy is recommended for treatment of chronic ankle instability.**

*Strength of Evidence* – **Recommended, Insufficient Evidence (I)**

*Level of Confidence* - Moderate

#### *Rationale for Recommendations*

There is no quality assessment of the efficacy of exercises for treatment of ankle sprain/instability as the available literature has significant methodological flaws. The two highest quality studies conflict regarding a partial assessment of the utility of supervised exercises. (Van Rijn 09, 07; Cleland 13) One moderate-quality trial compared supervised physical therapy (balance exercises, walking, running, jumping) to home-based exercises.(586, 587) (Van Rijn 09, 07) Subjects in the home-based program reported less than 20% compliance, essentially allowing for comparison of a no treatment control to supervised physical therapy. For mild and moderate ankle sprains, there were no differences in outcomes at any interval. An analysis of benefit by sprain severity demonstrated a modest benefit from supervised physical therapy for those with severe sprains measured at 4 weeks in the outcomes of pain while walking on hard and rough surfaces, and the feeling of instability while walking on rough surface. However, the prevalence of these reported symptoms in the population was small, making the findings of little or no clinical significance.(586) (Van Rijn 09) Another moderate-quality trial compared early rehabilitation with physical therapy (defined as therapeutic exercises that included muscle strengthening, neuromuscular training, and sports specific functional exercises) to standard RICE therapy (no physical therapy) for mild and moderate acute ankle sprain.(512, 515) (Bleakley 10, 07) The study demonstrated

benefit as measured in subjective functional scores over the first 2 weeks of injury, but found no differences in pain, swelling, re-injury rate or physical activity. A low-quality trial demonstrated no differences between ankle-heel stretching protocols and natural history.(588) (Youdas 09) A low-quality trial demonstrated reduced sprain recurrence with use of wobble-board post-acute injury.(589) (Wester 96) A low-quality study demonstrated balance training with an external focus of attention improved postural sway.(590) (Laufer 07) Another low-quality trial demonstrated no benefit from use of imagery rehearsal.(591) (Christakou 07) Two other moderate-quality trials comparing supervised physical therapy to home based exercises found no differences in short-term outcomes measures.(592, 593) (Bassett 07, Holme 99) Re-injury rates were reported lower in the supervised physical therapy group at 1 year.(593) (Holme 99)

The natural history of ankle sprain is improvement. Therefore, supervised therapy is not recommended for all patients with ankle sprain. A few appointments for educational purposes for patients with severe injury are recommended. The numbers of appointments are dependent on the degree of debility, with 1 or 2 educational appointments appropriate for most affected patients. Patients with severe debility or those unable to return to work may necessitate 8 to 12 appointments that particularly emphasize progressive strengthening exercises. Additionally, while routine use may be of limited benefit, those patients who have muscle weakness or other debilities may also derive benefit from therapy including self-training exercises, particularly if unable to return to work. Therefore, therapy is recommended for select patients.

There are two moderate-quality trials for chronic ankle instability comparing rehabilitation techniques including exercises(594) (Hale 07) and intense training using a bi-directional bicycle pedal,(595) (Hoiness 03) with both studies demonstrated benefit in postural sway measures. Low-quality trials have demonstrated improvement in postural sway in subjects with chronic ankle instability from interventions of balance and control exercises,(596) (Bernier 98) elastic resistance exercises,(597) (Han 09) stochastic coordination training, (Ross 07) proprioception and strength training,(598) (Powers 04) and Dura-disc and mini-trampoline training.(599) (Kidgell 07) None of these studies demonstrated clinical correlation of improved postural sway with reduced subjective or objective findings.

There are no quality studies that have demonstrated improved postural sway outcomes result in improved clinical outcomes, such as recurrence of injury. Rehabilitation techniques are non-invasive, have low adverse effects, and are of moderate to high cost dependent on the duration and frequency of treatment sessions. Rehabilitation techniques are numerous, and there are no quality comparison trials to determine what techniques produce the highest benefit in postural sway improvement. Because the quality evidence is currently limited to improved postural balance, but lacking in evidence of other clinical improvements,(600) (McKeon Part II 08) the use of physical rehabilitation methods is a consensus recommendation prior to surgical intervention.

controlled trial. *Br J Gen Pract.* 2007;57: 793-800. Reproduced with permission from the Royal College of General Practitioners.

#### *Evidence for the Use of Therapy for Ankle Sprain/Instability*

There are 6 moderate-quality RCTs (two with two reports) incorporated into this analysis. (Cleland 13; Ismail 10) There are 9 low-quality RCTs in Appendix 1.(416, 588-591, 601) (Christakou 07; Laufer 07; Youdas 09; Chaiwanichsiri 05; Wester 96; Brooks 81; Kim 14; Collado 10; Asimenia 13)

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Van Rijn 2009, 2007 RCT	7.5	N = 107 adults with acute	Physical therapy (PT) plus conventional care vs.	Outcomes after 3, 12 months follow-up (conventional/PT) AR%: re-sprain 3 months (14/10) -	“Usual care combined with supervised exercises compared with	Of those in home exercise group, 82% reported rarely or never doing

		lateral ankle sprain	conventional care only (education, home exercises, early weight bearing, tape, brace). Intervention group: 9 sessions of supervised PT consisting of individualized program of balance exercises, walking, running, and jumping. Home exercise program not defined.	4.2(-21.5 to 13.1%); re-sprain 12 months (16/13) 2.5 (-16.8 to 22.0%); reported instability 3 months (34/32) 1.2 (-17.4 to 19.7); instability 12 months (30/26) 3.5 (-22.9 to 15.8%); tested instability 3 months (26/18) - 11.5 (-32.6 to 9.5); full treatment appreciation 3 months (32/40) 22.8 (7.0 to 38.7%). Mild/moderate vs. severe sprain subgroups: pain (walking on flat) 2.2 vs. 1.3%, OR 1.1 (0.1-2.0); pain (walking on rough) 2.5 vs. 2.3%, OR 1.7 (0.6-2.9); stability (walking on rough) 2.6 vs. 2.1%, OR 1.8 (0.6-2.9). No differences sprain recurrence between groups.	usual care alone at 3 months and 1-year follow-up after an acute lateral ankle sprain did not indicate clinically meaningful differences in the occurrence of re-sprains or in subjective recovery in patients consulting a GP or the emergency department. The results of (2009) study only partially support the recommendations regarding the use of the ankle function score in the Acute Ankle Injury guideline of the Royal Dutch Society of Physiotherapists.”	home exercises, essentially making this a study of supervised PT vs. “usual care,” with no clinical benefit demonstrated by supervised PT. The 2009 study presented analysis for subset of severe ankle sprains in cohort and demonstrated modest statistical benefit but unknown clinical benefit at 4 weeks, and no differences in any measure at 8 weeks or beyond.
Cleland 2013 RCT	7.5	N = 74 with inversion ankle sprain; mean age for home exercise program: 33.2, mean age for manual therapy and exercise	Manual Therapy & Exercise (MTEX), mobilizing and strengthening, standing and functional exercises; seen by physical therapist (PT) twice weekly for 8 sessions (n = 37) vs. Home Exercise Program (HEP), manipulations of joints, home exercises, strengthening and balancing	Mean percent score for FAAM activities of daily living (ADL): MTEX vs. HEP: 4 weeks: 85% vs. 70%, p <0.05; 6 months: 95% vs. 85%, p <0.05. Mean percent score for FAAM sports: MTEX vs. HEP: 4 weeks: 75% vs. 65%, p <0.05; 6 months: 90% vs. 85%, p <0.05. Mean (95 CI) for FAAM ADL: Between group differences: baseline to 4 weeks: 11.7 (7.4 to 16.1), p <0.001 (in	“The results suggest that an MTEX approach is superior to an HEP in the treatment of inversion ankle sprains.”	Good baseline comparability. Both groups had pain improvement from treatment with Manual therapy and exercise group having slightly better results for pain relief and function at 4 weeks and also 6 months vs. HEP group. However, as the intervention group had both active supervision of exercise as well as manual

		se: 37.1	exercises; seen by PT for 4 sessions 1 per week (n = 37). Both treatments lasted 30 minutes, advice to stay active, and education on ice, compression and elevation. Follow-up: baseline, 4 weeks and 6 months.	favor of MTEX); baseline to 6 months: 6.2 (0.98 to 11.5), p = 0.02 (in favor of MTEX). FAAM sports: baseline to 4 weeks: 13.3 (8.0 to 18.6), p <0.001 (in favor of MTEX), baseline to 6 months: 7.2 (2.6 to 11.8), p = 0.002 (in favor of MTEX).		therapy, what was responsible for the modest differences is unclear.
Bleakley 2007, 2010  RCT	7.0	N = 101 acute Grade I or II ankle sprains	PRICE vs. PRICE plus early therapeutic exercises. Intermittent cryotherapy protocol: 10 minutes ice, 10 minutes rest (control) or 10 minutes exercises (intervention) then 10 minutes cryotherapy 3 times a day for 1 week. Both received exercise protocol after Week 1 for 30 minutes once a week, 4 weeks for Grade I and II sprains; 16 week follow-up.	Treatment effect: control vs. exercise; Difference in lower extremity function score: Week 1; 5.28 (0.31-10.26) p = 0.008. Week 2; 4.92 (0.27-9.57) p = 0.0083. No difference after Week 2. Pain at rest, pain with activity, swelling: all no differences at any interval. Reinjury rate at 16 weeks 2/50 vs. 2/51. Physical activity: Time (hours/day) spent first week, control vs. exercise; Walking-1.2(0.9-1.4) vs. 1.6(1.3-1.9) p = 0.029. Step sitting, standing p >0.05.	“[I]ncorporating therapeutic exercises during the first week after ankle sprain resulted in significant improvements in short term ankle function compared with a standard functional intervention.”	Compliance <80%, >20% dropout in exercise group. Data suggest addition of therapeutic exercises to protection, RICE protocols provides short term functional benefit as measured on subjective lower extremity functional scale and in time spent walking. There was no difference in other outcomes measures.
Bassett 2007  RCT	6.0	N = 47 acute ankle sprains	Home PT vs. clinic based management.	Post-PT scores (mean±SD/ clinic/home): LLTQ recreational activity subscale (12.00±10.10/ 8.18±7.24) p >0.05; LLTQ ADL	“Home based physical therapy intervention plus adherence enhancing adjuncts is a safe and viable option for patients with	No control group of PT vs. no PT. Wide inclusion criteria (all but non-English speakers eligible). Data suggest home

				<p>subscale (2.32±3.60/1.82±3.58) p &gt;0.05; motor activity scale (5.14±1.28/5.73±1.08) p &gt;0.05. Appointments (mean±SD/clinic/home): attended (7.64±4.54/4.55±1.78) p = 0.005; recommended (8.44±4.12/4.68±1.78) p = 0.001; completed physical therapy intervention (15/21) p = 0.004.</p>	<p>ankle sprains, and physical therapists should contemplate using it with patients who have problems attending regular clinic appointments.”</p>	<p>PT for acute ankle sprain as effective as structured/supervised PT with higher compliance to regimen.</p>
<p>Holme 1999 RCT</p>	4.0	<p>N = 92 ankle sprain injuries obtained during sports activity</p>	<p>Supervised PT vs. education and home exercises.</p>	<p>Side-by-side percent differences similar in both groups for all variables, p &gt;0.05. Re-injury data 12 months after injury: yes = 2 in training group, 11 in control group (p &lt;0.05).</p>	<p>“Six weeks after an ankle injury a side-to-side difference in isometric ankle strength and postural control was demonstrated, which appeared to normalize after 4 months, with or without supervised physical therapy. Supervised rehabilitation may reduce the number of re-injuries, and therefore play a role in injury prevention.”</p>	<p>Baseline difference possibly suggesting randomization failure; 30% lost to follow-up. Measured values of uninjured side not constant over study. Appeared to improve in both groups. No between-group comparisons provided as discussion limited to comparison of injured to uninjured ankle.</p>
<p>Ismail 2010 RCT</p>	4.0	<p>N = 36 athletes with lateral ankle sprain referred to physical therapy</p>	<p>Plyometric group, exercise program of jumping and hopping different directions with or without barrier, with single or double leg; 2</p>	<p>Mean±SD for functional tests: plyometric vs. resistive: post-test: climbing downstairs (sec): 13.7±2.6 vs. 16.6±2.3, p = 0.01; raising on heel (times): 47.7±3.5 vs. 38.58±4.4, p = 0.00; raising on toes (times):</p>	<p>“Plyometrics were more effective than resistive exercises in improving functional performance of athletes after lateral ankle sprain.”</p>	<p>Small N, large dropout rate. Plyometrics better than resistive exercises for increased function of lateral ankle sprains in athletes.</p>

		clinic; mean age for plyometric group 25.4±4.3, mean age for resistive group 27.1±4.4	days/week (n = 19) vs. Resistive group, manual exercise for dorsiflexion, plantarflexion, eversion, and inversion; 3 to 5 seconds for 10 reps; heel and toe rise, towel curl, and marble pick up (10 reps each), 2 days/week (n = 17) 6-week study with no other follow-up.	46.1±4.4 vs. 41.5±6.6, p = 0.01; single-limb stance (sec): 65.9±6.4 vs. 56.7±3.9, p = 0.00.		
--	--	---	---	---	--	--

*Evidence for the Use of Rehabilitation for Chronic Ankle Instability*

There are 2 moderate-quality RCTs incorporated into this analysis. There are 5 low-quality studies in Appendix 1.(596-599, 602) (Han 09; Ross 07; Bernier 98; Kidgell 07; Powers 04)

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Hoiness 2003 RCT	6.5	N = 20 recurrent ankle sprains and positive stress x-ray films	Bi-directional bicycle pedal vs. regular (unicycle) pedal in 6 week high intensity training program.	Test group improved performance to 80% maximum level after training, 72.5% before. The control group improved from 56.1% or 67.8%. Figure 8 running (seconds before/after): test group (12.41/12.17) p = 0.003 vs. control group (12.22/12.11) p = 0.078. Eversion torque (before/after): all ankles 60°s <sup>-1</sup> (22.75/2.35) p = 0.037; unstable ankles 60°s <sup>-1</sup> (22.50/25.50) p = 0.154; stable ankles 60°s <sup>-1</sup> (23.00/25.20) p = 0.182.	“Short-term high-intensity training with a bi-directional pedal improves ankle performance and may be an option in the treatment of recurrent ankle sprains.”	Bi-directional pedal tilts 20° sideways during loaded cycles. Small sample size. Results of uncertain clinical significance in general population (test group 0.2 seconds faster running on 40 meter figure 8 track). No significant difference in Karlsson functional scores, figure of 8 running times, or eversion torque angles despite intragroup improvements in intervention group.

Hale 2007 RCT	4.5	N = 48 with unilateral chronic ankle instability (CAI)	Chronic ankle instability (CAI) rehab vs. CAI control vs. healthy group.	CAI groups showed increase in COPV when evaluating eyes closed (p = 0.034) and eyes open (p = 0.029) when standing on involved limb vs. uninvolved limb. CAI rehab and control could reach further standing on uninvolved limb: posteromedial reach p = 0.047, posterolateral reach p = 0.007, lateral reach p = 0.025. The CAI rehab group showed improvement for the FADI-Sport change scores vs. CAI control (p = 0.009), and healthy (p <0.0005).	“[P]ostural control and functional limitations exist in individuals with CAI. In addition, rehabilitation appears to improve these functional limitations. Finally, there is evidence to suggest the SEBT may be a good functional measure to monitor change after rehabilitation for CAI.”	Sparse study details for randomization, allocation, baseline comparability. Data suggest rehab regimen may improve postural deficits although it is not clear from this study if findings correlate to improved function and reduced recurrence of ankle injury.
------------------	-----	--	--	---	---	--

### ***Injection Therapies***

#### **AUTOLOGOUS BLOOD INJECTIONS**

Autologous blood injection is described as a treatment for several tendon or fasciopathy conditions (see Plantar Fasciitis, Achilles Tendinopathy, Lateral Epicondylitis) although is not described in the literature for the treatment of ankle sprain. Autologous blood injection is advertised on Internet to the public as a treatment for ankle sprain.

*Recommendation: Autologous Blood Injection for Acute, Subacute, or Chronic Ankle Sprain*

**There is no recommendation for or against the use of autologous blood injection as a treatment for acute, subacute, or chronic ankle sprain.**

***Strength of Evidence – No Recommendation, Insufficient Evidence (I)***

*Level of Confidence - Low*

#### ***Rationale for Recommendation***

There are no quality randomized trials for the use of autologous blood injection for the treatment of acute, subacute, or chronic ankle sprain. Adverse effects of autologous blood injection for plantar fasciopathy exist and include post-injection pain (53%) that may last up to 10 days and may require analgesia. These injections are of moderate cost related to procedure charges of venipuncture and injection, but are unknown efficacy. Thus, there is no recommendation for or against the use of autologous blood injection.

#### ***Evidence for the Use of Autologous Blood Injections for Ankle Sprain***

There are no quality trials incorporated into this analysis.

#### **GLUCOCORTICOSTEROID INJECTIONS**

Injected glucocorticosteroids have been used for treatment of ankle sprain.(411) (Nilsson 83)

*Recommendation: Glucocorticosteroid Injections for Acute, Subacute, or Chronic Ankle Sprain*

**There is no recommendation for or against the use of glucocorticosteroid injection for routine treatment of acute, subacute, or chronic ankle sprain.**

*Strength of Evidence – No Recommendation, Insufficient Evidence (I)*  
*Level of Confidence - Low*

*Rationale for Recommendation*

There are no quality trials regarding glucocorticosteroid injection of ankle sprain. A low-quality trial found reduced skin temperature after local steroid injection compared to non-injected group, although there were no clinically significant differences.(411) (Nilsson 83) Recommendations for local injection of glucocorticosteroid in musculoskeletal conditions (i.e. epicondylalgia, plantar fasciitis, and shoulder impingement) are limited to focal pathology. There is no description found for injection of ankle ligaments. Injections are minimally invasive, are of moderate cost, with no evidence of efficacy, and have a potential risk for further ligament weakening. Therefore, there is no recommendation for or against the use of steroid injection for the treatment of ankle sprain.

*Evidence for the Use of Injected Glucocorticosteroids for Ankle Sprain*

There are no quality trials incorporated into this analysis. There is 1 low-quality study in Appendix 1.(411) (Nilsson 83)

**HYALURONIC ACID INJECTIONS**

Periarticular injection of hyaluronic acid is described as a treatment of ankle sprain.(603, 604) (Petrella 09, 07) (See Knee Disorders and Hip and Groin Disorders guidelines for review of this subject for inferred treatment of ankle/foot osteoarthritis.)

*Recommendation: Hyaluronic Acid Injections for Acute, Subacute, or Chronic Ankle Sprain*

**There is no recommendation for or against the use of hyaluronic acid injection for the treatment of acute, subacute, or chronic ankle sprains.**

*Strength of Evidence – No Recommendation, Insufficient Evidence (I)*  
*Level of Confidence - Low*

*Rationale for Recommendation*

There is one moderate-quality trial with two reports that compared periarticular injection of hyaluronic acid to placebo.(603, 604) (Petrella 09, 07) The study demonstrated benefit in total change in pain scores from baseline for weight bearing and walking over 90-day period. However, it was unclear if there was significant difference in pain scores at each interval, as baseline scores were not presented. Patient satisfaction scores were favorable to injection at 4 and 8 days. Hyaluronic acid injection is mildly invasive, is of moderate cost related to the procedure, has low incidence of adverse events,(603, 604) (Petrella 09, 07) but is of uncertain clinical significance; therefore, there is no recommendation for or against its use.

*Evidence for the Use of Hyaluronic Acid for Ankle Sprain*

There is 1 moderate-quality RCT (with two reports) incorporated into this analysis.

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Petrella 2007, 2009  RCT	7.0	N = 158 competitive athletes with acute Grade I or II lateral ankle sprains	Periarticular hyaluronic acid injection 1.2mL vs. saline placebo injection (both groups with RICE).	HA vs. PL at Day 4, 8, 30, 90, 712. HA more reduction in VAS from baseline for weight bearing and walking.	“HA treatment for acute sprain was highly satisfactory in the short term and	Blinding, allocation methods unclear. Lack of baseline data. Previous articles on methods were

			Injection site at anterior talofibular ligament in delivering medication in AP, medial, lateral directions. Acute Grade I, II sprains treated <48 hours.	No differences in patient global assessment. Increased patient satisfaction Day 4, 8. Baseline scores not presented so total change significantly different but uncertain if actual data different.	the long term versus placebo. This was associated with reduced pain and more rapid return to sport, with few associated adverse events.”	unclear. Suggests hyaluronic acid injection results in clinical improvement in total pain reduction over placebo with long-lasting effect. Reported results may be of small clinical significance.
--	--	--	--	---	--	--

### PLATELET RICH PLASMA INJECTIONS

Injected platelet rich plasma used for the treatment of chronic ankle sprain is widely advertised by a myriad of providers found via Internet search, but is not described in the medical literature.

*Recommendation: Platelet Rich Plasma Injections for Acute, Subacute, or Chronic Ankle Sprain*

**There is no recommendation for or against the use of platelet rich plasma injection for the treatment of acute, subacute, or chronic ankle sprains.**

*Strength of Evidence – No Recommendation, Insufficient Evidence (I)*

*Level of Confidence - Low*

#### *Rationale for Recommendation*

There are no quality trials for ankle sprain platelet rich plasma (PRP) injection. This intervention consists of obtaining 30 to 60cc of autologous blood, centrifuging, and injecting 3 to 6cc of PRP. This procedure reportedly is low risk for adverse effects, moderately costly, and may require repeat injection. The clinical efficacy is currently undefined. Therefore, there is no recommendation for or against the use of PRP injection for ankle sprain.

#### *Evidence for the Use of Platelet Rich Plasma for Ankle Sprain*

There are no quality trials incorporated into this analysis.

#### **Surgical Considerations**

Lateral ligament repair has been described for acute ankle injury since 1955.(605) (Clark 65) There are a number of procedures described, including direct ligament repair and various types of ligament reconstructions using a variety of tendon grafts.(105, 391, 392, 606-613) (Tourné 10, Mahajan 09, Corte-Real 09, Maffulli 08, Muijs 08, Kerkhoffs 07, Ajis 06, Aydogan 06, Boyer 06, Schmidt 05, Baumhauer 02, Cheng 02) Osteochondral defect (OCD) lesions may also occur in conjunction among patients with lateral ligament instability and some may perform drilling of the lesion on the talar dome at the same time as the lateral ligament reconstruction.

#### *1. Recommendation: Surgery for Treatment of Acute or Subacute Ankle Ligament Tear*

**Surgical repair is not recommended for routine lateral ligament tear associated with acute or subacute ankle sprain.**

*Strength of Evidence – Not Recommended, Insufficient Evidence (I)*

*Level of Confidence - Low*

## 2. Recommendation: Surgery for Treatment of Chronic Ankle Instability (CAI)

### **Ligament reconstruction is recommended for select cases of chronic ankle instability.**

*Indications* – Chronic ankle instability of at least 6-months duration, lateral ankle ligament laxity, and failure of non-operative therapies including therapy and use of ankle orthosis.

*Strength of Evidence* – **Recommended, Insufficient Evidence (I)**

*Level of Confidence* - Moderate

#### *Rationale for Recommendations*

There are six moderate-quality trials that compared operative repair with non-operative management of acute rupture of the lateral ligaments. No quality clinically important evidence has been demonstrated to recommend initial surgical repair over non-operative care. Three of the quality-trials compared surgery to functional treatment.(614-617) (Povacz 98, Pijnenburg 03, Freeman 65a,b; Pihlajamaki 10) Seven low-quality trials compared surgical repair to functional treatment with all finding no clinically significant long-term differences. Two studies suggest limited benefit of operative intervention(511) (Gronmark 80) as measured by percentage of subjects symptomless at long-term follow-up, and number with fear of giving way.(500) (Korkala 87) Four trials suggest limited benefit of functional treatment as measured by higher percentage of subjects symptomless,(412) (Moller-Larsen 88) increased range-of-motion short-term(499, 618) (Sommer 89, Zwipp 92) and faster return to sport.(619) (Specchulli 01) One trial found no differences in any outcome measure.(510) (van den Hoogenband 84) There were no differences in objective long-term functional outcomes demonstrated between the treatment groups. Subjectively, one study found functional treatment to result in patients becoming symptomless sooner than the surgical group,(616, 617) (Freeman 65 a,b) but another study has reported the functional group had a higher incidence of feeling ankle instability,(614) (Pijnenburg 03) although no differences in sprain recurrence were demonstrated. One study found less reinjury in the surgical repair group, but more osteoarthrosis after surgery. (Pihlajamaki 10) Patients in a functional group using an ankle orthosis (Aircast) returned to work significantly faster than the operative group (1.6 weeks versus 7.0 weeks,  $p < 0.001$ ). (615) (Povacz 98)

There are two quality trials that compared cast immobilization with operative repair,(616, 617, 620) (Evans 84, Freeman 65a,b) and seven low-quality trials that compared surgical repair to cast immobilization. Five studies demonstrated no differences between the two treatment types.(412, 499, 510, 605, 621) (Moeller-Larsen 88, Zwipp 92, Niedermann 81, van den Hoogenband 84, Clark 65) Two studies suggest limited benefit of operative intervention(511) (Gronmark 80) as measured by percentage of subjects symptomless at long-term follow-up, and number with fear of giving way.(500) (Korkala 87) There were no long-term differences between the groups demonstrated in either study. Cast mobilization resulted in fewer reports of residual instability than operative repair.(620) (Evans 84) Surgical repair is invasive, high cost, results in more lost-time from work, and has higher risk of adverse events than non-operative treatment. There is insufficient evidence that operative repair of ankle ligament ruptures provides significant long-term clinical benefit compared with non-operative care, and is therefore not recommended as an initial treatment for acute lateral ligament rupture of the ankle. Persistent functional instability of a chronic nature may be considered for ligament reconstruction. There are no quality-trials for repair of chronic ankle instability.

#### *Evidence for the use of Surgical Intervention for Chronic Ankle Instability*

There are no quality RCTs incorporated into this analysis.

#### *Evidence for the Use of Acute Surgical Repair for Ankle Ligament Tear*

There are 6 moderate-quality RCTs (one with two reports) incorporated into this analysis. (Pihlajamaki 10) There are 9 low-quality RCTs in Appendix 1.(412, 499, 500, 510, 511, 605, 618, 619, 621) (Moeller-Larsen 88; Specchiulli 01; Sommer 89; Zwipp 92; Korkala 87; Niedermann 81; van den Hoogenband 84; Gronmark 80; Clark 65)

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
<b>Surgery vs. Non-operative Care</b>						
Pijnenburg 2003  Quasi-RCT	6.0	N = 370 adults 18 to 45 years with painful ankle caused by an indirect supination injury	Surgical repair vs. functional treatment of lateral ligament rupture. Functional treatment either non-weight bearing cast for 5 days followed by elastic wrap or taping.	Operative vs. functional (%), Residual pain: 16 vs. 25, p <0.05, Giving way: 20% vs. 32%, p <0.016, Recurrent sprains: 22 vs. 34, p <0.022. Score of excellent and good: 86% vs. 74% (no P provided).	“We found operative treatment led to better results at the short and long term follow-up. We believe that operative treatment for lateral ligament ruptures can be adopted in selected cases when higher functional demands are required. If operative treatment is rejected or not available, taping is a good alternative.”	Quasi-randomization (odd-even week of enrollment to study). Allocation not concealed. Study demonstrates mixed results as patient report of residual pain, recurrent sprains higher in conservative group, but no difference in subjective satisfaction with treatment.
Povacz 1998  RCT	6.0	N = 167 adults with isolated injury of ankle fibular collateral ligaments	Surgery plus cast for 6 weeks vs. ankle orthosis (6 weeks) using Aircast.	Pain at 2-year follow-up: Surgery vs. Aircast mild (29% vs. 21%), severe (3% vs. 3%), none (68% vs. 77%). Overall results were not significantly different. Time to resume normal work activities (7.0 weeks vs. 1.6 weeks, p <0.0001).	“We recommend non-operative treatment of a sprain of the ankle in young adults, including those who are involved in athletic activities.”	No difference in clinical outcome at 2 years for this particular injury. Patients returned to work earlier with nonoperative treatment.
Pihlajamaki 2010  RCT	5.5	N = 51 with an acute Grade-III lateral ligament rupture of ankle, age	Surgical; ligament repair, talofibular ligament, anterior talofibular and calcaneofibular ligaments (n = 25) vs.	No significant differences to report between two groups in any outcome measure. All patients in both groups recovered preinjury activity level and reported they could walk and run normally.	“These findings indicate that, in terms of recovery of the preinjury activity level, the long-term results of surgical treatment of acute lateral ligament rupture of the ankle correspond with those of	Surgical vs. functional treatment of acute ankle ruptures have similar outcomes although surgical patients showed more degenerative cartilage

		range 18-26 (mean, 20.4)	Functional; functional light-weight orthotic device for 3 weeks; allowed dorsiflexion and plantar flexion, but resisted inversion and eversion of ankle (n = 26). After care: anti-inflammatory medication and crutches, mobilization and muscle strengthening exercises supervised by physiotherapist.		functional treatment. Although surgery appeared to decrease the prevalence of reinjury of the lateral ligaments, there may be an increased risk for the subsequent development of osteoarthritis.”	changes post-surgery via MRI.
Evans 1984 RCT	5.0	N = 100 acute ruptures of ankle lateral ligaments	Suture repair plus cast (3 weeks) plus PT vs. cast plus PT.	Comparisons at 3 months and 2 years after injury. Operative repair vs. plaster cast only: Giving way only; 13 vs. 4. Recurrent sprains only; 13 vs. 11. Giving way and recurrent sprains 3 vs. 4.	“[E]arly mobilisation with the protection of a cast brace may achieve equal functional results with the advantage of earlier recovery.”	Randomization, allocation details missing. Study demonstrated similar outcomes in both groups with higher symptomatic instability at 2 years in surgical group.
Jeong 2010 RCT No mention of sponsorship. No COI.	4.5	N = 100 with diabetic foot ulcers on various locations, type 1 or 2 diabetes	Treatment group receiving blood bank platelet concentrate (ABO- and Rh-compatible) (n = 52) vs. Control group (n =	Mean ( $\pm$ SD) time for complete ulcer healing significantly lower in the treatment group versus the control group; 7.0( $\pm$ 1.9) weeks vs. 9.1 ( $\pm$ 2.2) weeks, (p<0.05). Degrees of wound shrinkage significantly lower in	“Although further investigations are needed to determine the ultimate value of the blood bankplatelet concentrate allograft, the present study demonstrates that this method may	Data suggest efficacy.

		s, and no signs of healing for a month; Mean ( $\pm$ SD) age 64.5 ( $\pm$ 8.1) for treatment group and 63.8 ( $\pm$ 6.4) for control group.	48). Both groups received 25ml or 12.5ml for 1st application and 25ml or 12.5ml 3-4 days post-op alongside standard wound care. Assessments at baseline and 12 weeks.	treatment group versus the control; 96.3 ( $\pm$ 7.8) vs. 81.6 ( $\pm$ 19.7), ( $p < 0.05$ ).	be used to treat diabetic foot ulcers. The use of a blood bank platelet concentrate may provide a simple, safe, and effective means of treating diabetic foot ulcers.”	
Freeman 1965a, b RCT	4.0	N = 45 ankle sprains (46 ankles)	Ligament repair and immobilization vs. cast immobilization 6 weeks vs. strapping (tape) and mobilization.	Report of instability at 1 year (mobilization, immobilization, suture repair) 5/12 (41%) vs. 7/17 (41%) vs. 6/16 (37.5%). Average time to symptomless ankle: mobilization 12 weeks vs. 22 to 26 weeks after immobilization (with or without suture repair).	“Mobilisation may be the treatment of choice for most, perhaps all, ruptures of the lateral ligament of the ankle.”	Lack of randomization, allocation, baseline comparability method details. Data suggest quicker resolution of symptoms in mobilization group and no difference in subjective outcomes at 1 year.

## POST-OPERATIVE MANAGEMENT

Immobilization or early motion and therapy are described as frequent post-operative management techniques.

*Recommendation: Post-operative Management of Ankle Instability*

**Short-term cast immobilization with early mobilization and therapy are recommended for ankle instability.**

*Strength of Evidence – Recommended, Insufficient Evidence (I)*

*Level of Confidence - Moderate*

### *Rationale for Recommendation*

There are two moderate-quality trials that compared early mobilization and physical therapy with 6-weeks cast immobilization for post-operative management for ligament reconstruction.(622, 623) (Karlsson 95, 99) There were no long-term differences between the groups, although results may be limited due to the sample sizes of each study. The early mobilization group demonstrated better range of motion at 6-

weeks, although there were no differences in patient subjective functional scores. A pooled analysis of these two studies found the functional group had a statistically significant earlier return to work and sport than the casting group.(624) (de Vries 06) Thus, there is insufficient evidence to recommend one treatment over the other, and both are recommended according to informed preference of patient and provider.

*Evidence for the Use of Post-operative Management for Ankle Instability*

There are 2 moderate-quality RCTs incorporated in this analysis.

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Karlsson 1999 RCT	5.0	N = 30 chronic lateral ligament instability of the ankle	Post-ligament reconstruction: plaster cast x 6 weeks vs. cast x 7-10 days followed by Aircast (early mobilization) with early motion training. Subjects failed 3 months physiotherapy prior to study.	Cast vs. early motion: Functional results excellent or good (%) - 12/15 vs. 14/15, p >0.05; Sick leave 7 vs. 6 weeks (p >0.05).	“Early mobilization after ankle ligament surgery for chronic ligamentous instability should be preferred to postoperative immobilization.”	Randomization, allocation, baseline comparability details sparse. Study demonstrates early mobilization may have better functional outcomes at 3 months and faster return to sport but no differences in long-term outcomes.
Karlsson 1995 RCT	4.0	N = 40 chronic lateral instability of the ankle	Post-ligament reconstruction: plaster cast vs. walking boot (6 weeks) with early motion training. Subjects failed 3-months physiotherapy prior to study.	Cast vs. early motion: functional results excellent or good (%) - 80% vs. 95%, p >0.05; dorsiflexion at 6 weeks: 5.4 vs. 15.2 (p <0.001), plantar flexion 16.2 vs. 38.5 (p <0.001). Both ROM measures at 2 years not different.	“Early range of motion training in an ankle joint brace is a safe method after anatomical reconstruction of the ankle ligaments in patients with chronic instability. The method allows the patients to return earlier to work and sports activities with preserved mechanical stability.”	Lack of study details including randomization method, allocation, baseline comparability, compliance, and timing of assessments. No significant differences on long term follow-up but early ROM may result in quicker return to work and sports.

## **Mid-tarsus Pain and Sprains**

Mid-tarsus or mid-foot pain and sprains frequently involve any of the ligaments of the mid-foot. A primary diagnostic focus is to eliminate the diagnosis of midfoot fracture (see also Midfoot fracture section). Metatarsalgia is included in this category as is metatarsophalangeal joint sprain. However, metatarsalgia is a broad categorization of forefoot pain that also includes numerous other conditions (e.g., Morton's neuroma). It is widely viewed as related to gait mechanics, anatomical variations, deformities and other largely non-occupational conditions (Espinosa JAAOS 2010; Espinosa Foot Ankle Intl 08) and aside from Morton's neuroma will not be addressed further.

- As there is almost no quality literature on these sprains, and none in typical working populations, most treatment recommendations are by analogy to ankle sprains and should be considered "Insufficient Evidence" recommendations (e.g., NSAID, ice). However, diagnostic and therapeutic approaches differ considerably, especially for Lisfranc injuries.
- Lisfranc injuries involve the tarsometatarsal joint(s) particularly at the bases of the first and second metatarsals. These are often complex injuries that can involve various combinations of the ligaments in the midfoot. Analogous injuries can occur to the other tarsometatarsal joints, are less common, are associated with a greater extent of injury, and may be progressive and sequential injuries. These injuries range in severity from mild sprains to dislocation/fractures (see detailed Lisfranc fractures in Midfoot fracture section below). Lisfranc injuries result from events such as falling from height, stepping in a hole, stepping off a curb, sporting events, and pushing on a brake during a motor vehicle accident. (Burroughs AFP 98; Granata 10; Myerson 08) While many of these injuries are sports and avocationally-related, some of these injuries are occupational.
- Midfoot pain should be carefully sought and located. Impaired weight-bearing is typical. The combination of midfoot pain, impaired weight bearing while in the context of an inciting event are usual characteristics. (Burroughs AFP 98) Swelling and tenderness over the midfoot is common. Perhaps the most common provocative maneuver on examination is to passively pronate and abduct the forefoot to assess tarsometatarsal complex stability.
- Weight-bearing x-rays (AP and lateral views with/without obliques; often bilateral for comparative purposes) are **Recommended, Insufficient Evidence (I), Level of Confidence – High**, and are often normal in mild injuries (grade 1 sprains), generally abnormal in moderate (grade 2), but are always abnormal in severe injuries (grade 3). (Granata 10)
- CT scans are helpful in uncertain cases and in select pre-operative cases and are **Recommended, Insufficient Evidence (I), Level of Confidence – Moderate**. (Myerson 08; Granata 10)
- For mild to moderate cases without diastasis, immobilization in a short-leg walking boot or cast for 4-6 weeks is **Recommended, Insufficient Evidence (I), Level of Confidence – Moderate**, (Nunley 02; Burroughs AFP 98; Granata 10; Myerson 08) with repeat x-rays and evaluation for stability at 2 weeks. (Myerson 08)
- Some prefer to treat with complete non-weight bearing status due to the disability that may ensue in unsuccessfully treated cases, and is a reasonable option.

Surgery is **Recommended, Insufficient Evidence (I), Level of Confidence – Moderate**, for all severe cases, unstable injuries, and those with significant diastasis [e.g., >2mm (Myerson 08)]. Other than one quality study suggesting inferiority of ORIF, (Henning 09) there are no other quality comparative trials for the more common operative techniques (screw fixation vs. arthrodesis vs. ligament reconstruction). There is not quality evidence to preferentially support immediate (24-48 hour surgery post-injury), however some surgeons prefer this often with percutaneous fixation techniques, while others opt to wait approximately one week for swelling to subside. It is helpful to coordinate with the surgeon regarding these preferences. Post-operative, non-weight bearing status is usually maintained for 8-12 weeks.

## **Foot Neuroma (Morton's Neuroma)**

Morton's neuroma is a common neuralgia affecting the web spaces of the toes, typically the third toe. (Thompson 01, Thomson 04) The pain of Morton's Neuroma may be debilitating in cases where patients have difficulty walking or applying pressure on their foot out of fear of pain. The neuroma is associated with a pathology of the plantar digital nerve as it divides at the base of the toes to supply the sides of the toes. (Thompson 11) The prevalence of nerve thickening in an asymptomatic population was 54%. (Symeonidis 12) The cause remains unclear and there are no established occupational causative factors. Histologic examination of intraoperative specimens and imaging shows neuronal thickening (Pace 10; Sharp 03; Reed 73; Scotti 57) and degenerative changes. (Giakoumis 13) There are many different treatments that have been used for Morton's neuroma such as NSAIDs, corticosteroid injections, ablative procedures, and surgery. (Schreiber 11; Thomson 04)

### **Medical History**

A history consistent with Morton's neuroma is that of pain, sometimes radiating, between two rays of the forefoot. The discomfort is often provoked or worsened with compression and weight-bearing activity.

### **Physical Examination**

The feet should undergo a standard evaluation. Morton's neuroma is marked by tenderness between adjacent metatarsal heads and provocation with compression of the affected forefoot. Mulder's click, defined as a painful click palpated between the metatarsal heads when the forefoot is compressed, is pathognomonic for Morton's neuroma. There may be widening and fullness of the toe interspace due to the mass effect of the neuroma.

### **Diagnostic Studies**

A careful history and physical examination is considered the most important diagnostic approach and in most cases, generally needs no further diagnostic testing. (Mahadevan 14; Claassen 14) Other testing that has been used includes MRI, ultrasound and digital nerve testing, (Mahadevan 14; Claassen 14; Pardal-Fernandez 14) however, there is no evidence these are effective and there is no recommendation for or against routine use of imaging studies.

### **Physical Modalities**

#### **SHOE WEAR**

Improved footwear is commonly used for treating Morton's neuroma.

*Recommendation: Changes in Footwear for Treatment of Morton's Neuroma*

**Footwear changes are recommended for treatment of Morton's Neuroma.**

*Indications* – Essentially all patients should be advised to wear stiff-soled, wide toe box shoes with a low heel and soft insert.

*Strength of Evidence* – **Recommended, Insufficient Evidence (I)**

*Level of Confidence* - Low

#### *Rationale for Recommendation*

There are no quality studies showing demonstrable success, however, changes in shoe wear have long been used, are non-invasive and appear to have some clinical efficacy, thus, an attempt at changing footwear is recommended.

### **ORTHOTICS**

Orthotics are commonly used for treating Morton's neuroma.

*1. Recommendation: Orthotics for Treatment of Morton's Neuroma*

**Orthotics are recommended for treatment of Morton's Neuroma.**

*Strength of Evidence – Recommended, Insufficient Evidence (I)*  
*Level of Confidence - Low*

**2. Recommendation: Metatarsal Pads for Treatment of Morton’s Neuroma**  
**Metatarsal pads are recommended for treatment of Morton’s Neuroma.**

*Strength of Evidence – Recommended, Insufficient Evidence (I)*  
*Level of Confidence - Low*

*Rationale for Recommendation*

There are no quality studies showing demonstrable success, although one trial suggested no difference between a supination vs. pronation orthosis. (Kilmartin 94) However, orthotics have long been used, are non-invasive and appear to have some clinical efficacy, thus, an attempt at an orthosis or a metatarsal pad is recommended.

*Evidence for use of Orthotics*

There is 1 moderate-quality RCT incorporated into this analysis. (Kilmartin 94)

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Kilmartin 1994  RCT	4.5	N = 23 with unilateral pain in 3rd/4th metatarsal space which was irritated by exercise and relieved by rest. Mean age of participants was 43.	Supination Orthoses group (n = 10) vs. Pronation Orthoses group (n = 11). Patients followed up at 4, 8, 12 and 52 weeks.	At final follow-up, 5 patients in each group reported their symptoms were better than at baseline. Results not significant between groups for any measurement. Alternative treatment necessary for a number of patients (52% of participants) who were not helped at all by orthoses upon discharge from study.	“While this study has not demonstrated that compressed felt orthoses have any significant effect on Morton’s neuroma, it does show that preventing subtalar joint pronation produces no significant benefit.”	High dropout rate and small N with subjective measurements of patient responses. Pronation did not appear to be superior to supination.

**Topical Medications**  
**LIDOCAINE PATCHES**

Topical lidocaine patches have been increasingly used to treat numerous pain conditions through transdermal application of topical anesthetic. (Nalamachu 06a, b; Galer 99)

*Recommendation: Lidocaine for Treatment of Morton’s Neuroma*

**There is no recommendation for or against the use of lidocaine for treatment of Morton’s Neuroma.**

*Strength of Evidence –No Recommendation, Insufficient Evidence (I)*  
*Level of Confidence - Low*

*Rationale for Recommendation*

There are no quality trials and thus there is no recommendation for or against the use of lidocaine.

*Evidence for the use of Lidocaine*

There is 1 low-quality RCT in Appendix 1. (Quiding 13)

**MANIPULATION AND MOBILIZATION**

Manipulation and mobilization are two types of manual therapy which have been used for treatment of musculoskeletal disorders. (Tal-Akabi 00; Sucher 94) These include wide arrays of different techniques and schools of thought. Some consider these two interventions to be on a spectrum of velocity and applied force. In general, mobilization involves assisted, low-force, low-velocity movement. Manipulation involves high-force, high-velocity, and low-amplitude action with a focus on moving a target joint (see Chronic Pain and Low Back Disorders guidelines).

*Recommendation: Manipulation or Mobilization of the Distal Lower Extremity for Treatment of Morton’s Neuroma*

**There is no recommendation for or against the use of manipulation or mobilization of the distal lower extremity for treatment of Morton’s Neuroma.**

*Strength of Evidence – No Recommendation, Insufficient Evidence (I)*  
*Level of Confidence - Low*

*Rationale for Recommendation*

There are no sham-controlled, quality studies addressing efficacy of manipulation and mobilization for treatment of Morton’s neuroma and thus there is no recommendation.

*Evidence for the use of Manipulation and Mobilization*

There is 1 moderate-quality RCT incorporated into this analysis. (Govender 07)

Author/Y ear Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Govender 2007  RCT	4.5	N = 40 patients with diagnosed Morton’s neuroma.	Group A: Placebo (de-tuned ultrasound) (n = 20) vs. Group B: Manipulative care-mobilized to remove palpated inter-metatarsal and midtarsal restrictions. Manipulation delivered to any areas of restriction found within ankle and foot joints (n = 20). Each group received 6 treatments over 3 weeks. Data obtained at 1 <sup>st</sup> , 3 <sup>rd</sup>	NRS-101 showed Group B to have statistically significant improvement in perceived pain vs. Group A at 6 weeks (final visit). Mean scores: 25.4 and 40.7 (p = 0.03). Pain pressure threshold and pressure tolerance levels significantly improved Group B vs. Group A. 25.6 vs. 19.1 for pain pressure (p = 0.02) and 36.0 vs. 28.5 for pressure	“These findings suggest the possibility of shortterm relief and efficacy for manipulation and mobilization in the treatment of Morton’s neuroma, but they must be confirmed by future well-designed, high-quality, and methodologically improved randomized clinical trials.”	Small numbers, baseline comparability weak, non-blinded observer and questionnaire not specific to Morton’s Neuroma. No clear sham group, rather control is

			and final treatment visits.	tolerance (p = 0.02).		detuned US.
--	--	--	-----------------------------	-----------------------	--	-------------

## EXTRACORPOREAL SHOCKWAVE THERAPY

Shockwave therapy has been utilized for treatment of Morton’s neuroma. (Fridman 09) The mechanism of action is unknown, but shockwaves are purported to reduce pain and enhance healing. (Rompe 09)

*Recommendation: Extracorporeal Shockwave Therapy*

**There is no recommendation for or against the use of extracorporeal shockwave therapy for Morton’s Neuroma.**

*Strength of Evidence – No Recommendation, Insufficient Evidence (I)*  
*Level of Confidence - Low*

*Rationale for Recommendation*

There is only one pilot study identified with some trending but statistically negative results that may be underpowered. (Fridman 09) Thus there is need for full trials prior to a possible evidence-based recommendation and there is no recommendation for or against the use of extracorporeal shockwave therapy for Morton’s Neuroma.

*Evidence for the Use of Extracorporeal Shockwave Therapy for Morton’s Neuroma*

There is 1 moderate-quality RCT incorporated into this analysis. (Fridman 09)

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Fridman 2009 RCT	5.5	N = 25 with Morton’s neuroma confirmed clinically and by ultrasound.	Active group treated with OSSATron device using 2,000 pulses at 21 kV directed inferior to neuroma (n = 13) vs. Sham Group: 5mL of bupivacaine hydrochloride but no shockwave therapy (n = 12). Follow-up at 1, 6, and 12 weeks post-treatment.	Active group had significant difference from baseline VAS pain after 12 weeks. (p<0.0001). Sham group had no differences from baseline (p=0.1218). 69% (9) of ESWT vs 40% (4) of sham achieved VAS 3 or less. No difference between groups.	“Owing to the success with this procedure (no complications and no post-treatment disability), we continue to offer extracorporeal shockwave therapy as an alternative to surgical excision for Morton’s neuroma.”	Pilot study, small numbers. Data suggest EST may be better than sham for Morton’s Neuroma, but data suggest underpowering. Reproduction in full trial needed.

## GLUCOCORTICOSTEROID INJECTIONS

Glucocorticoids have been used to treat Morton’s Neuroma and some evidence has suggested better results with smaller neuromas. (Makki 12)

*Recommendation: Glucocorticosteroid Injections for Morton’s Neuroma*

**Glucocorticosteroid injections are recommended for Morton’s Neuroma.**

*Indications* - select cases where pain and/or debility are significant and changing shoe wear, and/or orthotics fail to sufficiently control symptoms.

**Strength of Evidence – Recommended, Evidence (C)**  
**Level of Confidence - Low**

*Rationale for Recommendation*

There is one moderate-quality trial suggesting efficacy of a glucocorticoid injection at 3 months compared with placebo. Long-term results are unclear, and may well not be present. Still, up to 3 injections to attempt to reduce symptoms is a reasonable intervention to try before surgery. Ongoing injections are not recommended.

*Evidence for the use of Glucocorticosteroid Injections*

There is 1 moderate-quality RCT incorporated into this analysis. (Thomson 13)

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Thomson 2013  RCT	4.5	N = 131 patients who had a clinical diagnosis of Morton's neuroma.	Corticosteroid and anesthetic group (1mL methylprednisolone [40mg] and 1mL 2% lignocaine) (n = 64) vs. Anesthetic alone group (2 mL 1% lignocaine) (n = 67). Patients assessed at 1, 3 and 12 months via questionnaire.	Steroid group reported significantly higher FHT scores compared to control group (mean (SD)) at 1 month 61.1 (22.6) vs. 49.8 (25.4) (p = 0.002), and at 3 months, 64.7 (22.0) vs. 50.9 (27.2) (p = 0.002). Results significantly lower for MFPDS pain score (walking pain) for steroid group compared to control at 1 month 31.4 (20.3) vs. 42.0 (20.9) (p = 0.002) and at 3 months 30.5 (21.5) vs. 41.9 (26.3) (p= 0.004).	"The groups also differed significantly in this measure at one month after injection, and improvements with corticosteroid injection (significant and nonsignificant) were observed for measures of pain, function, and patient global assessment of general health at one and three months after injection."	Methylprednisolone better than control at 3 months.

**SCLEROSANT, INCLUDING ALCOHOL INJECTIONS**

Sclerosant injections including using alcohol have been used to treat Morton's Neuroma. (Gurdezi 13; Rengachary 83; Hyer 11; Espinosa 11; Thomson 04; Musson 12; Mozena 07; Hughes 07)

*Recommendation: Sclerosant Injections for Morton's Neuroma*

**Sclerosant and alcohol injections are not recommended for Morton's Neuroma.**

**Strength of Evidence – Not Recommended, Insufficient Evidence (I)**  
**Level of Confidence - Low**

*Rationale for Recommendation*

There are no quality trials of sclerosing agents including alcohol. Case series have variously suggested efficacy and lack of efficacy, thus considering the intervention is destructive of tissue, it is not recommended.

### **Surgical Considerations**

Ablative procedures (Gurdezi 13; Chuter 13) and surgical excision is a commonly performed procedure. (Kasperek 13; Jain 13)

#### *1. Recommendation: Nerve Ablation for Morton's Neuroma*

#### **Nerve Ablation is recommended for Morton's Neuroma.**

*Indications* - select cases where pain and/or debility are significant and changing shoe wear, orthotics and glucocorticoid injection(s) fail to sufficiently control symptoms.

*Strength of Evidence* –**Recommended, Insufficient Evidence (I)**

*Level of Confidence* - Low

#### *2. Recommendation: Surgical Excision for Morton's Neuroma*

#### **Surgical excision and/or decompression is recommended for Morton's Neuroma.**

*Indications* - select cases where pain and/or debility are significant and changing shoe wear, orthotics and glucocorticoid injection(s) fail to sufficiently control symptoms.

*Strength of Evidence* –**Recommended, Insufficient Evidence (I)**

*Level of Confidence* - Moderate

#### *Rationale for Recommendations*

There are no quality sham-controlled trials for any ablative or surgical procedures. There are no comparative trials with non-operative treatments. The only trials compare operative approaches. (Akermark 13; Colgrove 00; Nashi 97) Procedural results thus are unclear, although case series report successful treatments. Ablative procedures or surgery are recommended in select cases where pain and/or debility are significant and changing shoe wear, orthotics and glucocorticoid injection(s) fail to sufficiently control symptoms.

#### *Evidence of the Use of Surgery*

There are 3 moderate-quality RCTs incorporated into this analysis. (Akermark 13; Colgrove 00; Nashi 97)

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Colgrove 2000  RCT	5.5	N = 44 patients with foot neuromas. Average age of participants was 49 in resection group and 46 in transposition group.	Resection procedure (R Group) (n = 22) vs. Transposition procedure (T Group) (n = 22). Follow-up via phone call 1, 3, 6, 12, 36-48 months to measure pain, 0-100 (0=no pain and 100-max pain)	Preoperative pain levels were 78 (T Group) vs. 77 (R Group). At 1 month is was 22 vs. 19, at 6 months 11 vs. 8, at 12 months 4 vs. 6 respectively. These results were not found to be significant. At final follow up (36-48 months) pain level was 2 (T Group) vs. 9 (R Group). This	“Excellent results can be obtained by performing either a resection or a transposition of the ION, but this review indicates that a long term asymptomatic result is more likely to be achieved by the use of the	Transposition compared with resection showed better long-term results. Question baseline comparability as assessed from patient report and

				difference at final follow up was significant (p = 0.02)	transposition procedure.”	not standardized.
Akermark 2013  Prospective RCT	4.5	N = 76 patients with a typical history and clinical diagnosis of primary Morton’s Neuroma for at least 4 months.	Plantar Incisions (n = 35) vs. Dorsal Incisions (n = 41). Patients’ follow-up at 3 months, 12 months and 33-34 months.	There was a significant reduction of VAS pain score compared with baseline in both groups at all follow-up periods. (p<0.001). There was no significant difference between groups at any follow-up for VAS scores. Restrictions in daily activities were reduced 77% in the plantar group and 67% in the dorsal group. These results were significant compared to baseline for both groups (p<0.001), with no significant difference between groups. There were 5 complications in the plantar group 6 in the dorsal group.	“This study showed that pain during daily activities was equally significantly reduced in both groups at all postoperative follow-ups, with clinically good results in the plantar and dorsal groups. Results from this and other studies confirm the results from our earlier published retrospective study on Morton’s neuroma, that there is a difference in the types of complications between the 2 approaches.	No significant differences in plantar versus dorsal techniques at 34 weeks.
Nashi 1997  RCT	4.5	N = 52 patients with Morton’s neuroma. Mean age among participants (44 female and 8 male) was 53 years.	Dorsal approach group (n = 26) vs. Plantar approach group (n = 26).  Average follow-up was 3.1 years and minimum follow-up time was one year.	In first 2 weeks after operation, 8 patients in dorsal group able to fully bear weight compared to 0 patients in plantar group. Average return to work time after surgery was 22 days in dorsal group with 37 days in plantar group. In dorsal group. 80% of	“The results of our study would appear to favour the dorsal approach because of the shorter in-patient period, earlier weight-bearing, a shorter time taken to return to work, a less painful scar and greater	Dorsal better than plantar approach for earlier hospital discharge and return to work. Far more females in study questioning baseline comparability.

				patients reported good or satisfied compared to 65% in plantar group.	patient satisfaction.”	
--	--	--	--	---	------------------------	--

## ***Bunions / Hallux Valgus***

Hallux valgus (“bunion”) is a lateral deviation of the great toe at the metatarsophalangeal joint with respect to the midline of the body, generally defined as over 14.5 degrees; and occurring in most cases with medial deviation of the first metatarsal. (Magee 06; Dykyj 89; Ferrari, 09) Causes include genetics, restrictive footwear, trauma, and neuromuscular disorders. There are no established occupational causative factors. Treatments include nonoperative (avoid tight-fitting or high-heeled shoes, wear wide-toes footwear, and shoe inserts) and operational (distal soft tissue procedures, first metatarsal osteotomies, proximal phalanx osteotomies, fusion, and resection arthroplasties) options. (Hecht 14, Wülker 12)

### ***Medical History***

A history consistent with hallux valgus is that of pain with lateral or valgus deviation of the distal great toe.

### ***Physical Examination***

The feet should show valgus deviation of the great toe beyond the first metatarsophalangeal joint.

### ***Diagnostic Studies***

A careful history and physical examination is considered the most important diagnostic approach and in most cases, generally needs no further diagnostic testing for preliminary treatment. However, x-rays are commonly needed to evaluate alternate conditions such as osteoarthritis, gout and degenerative joint disease. Also, x-rays are useful for measuring angles and surgical planning and are **Recommended, Insufficient Evidence (I)**].

### ***Physical Modalities***

#### **ORTHOTICS**

Orthotics have been used for treatment of hallux valgus. (Torkki 01; Ferrari 04; Hawke 08)

#### *Recommendation: Orthotics for Treatment of Hallux Valgus*

#### **Orthotics are recommended for treatment of Hallux Valgus.**

*Indications* – Insufficient control or management by changing shoe wear. May be needed without changing shoe wear among those with prescribed footwear (e.g., specified safety shoes). Use of orthoses for hallux valgus should generally be limited to 1 of 2 conditions: 1) There should be demonstrable hyperpronation or radiographic evidence of hyperpronation with a talar flexion angle of 30 degrees or more on a standing study; or 2) there should be pain localized to the plantar aspect of the hallux metatarsal head with or without bunion pathology.

*Strength of Evidence* – **Recommended, Evidence (C)**

*Level of Confidence* - Low

#### *Rationale for Recommendation*

There is one moderate quality trial that found custom orthotics were superior to no treatment over 6 months. However, they were inferior to surgery at both 6- and 12-months. (Torkki 01) Thus, orthotics are recommended for those with symptoms insufficiently controlled by changing footwear when possible. A custom made splint in Iran has also been trialed. (Mirzashahi 12) A pragmatic comparative trial found no difference between manual manipulative treatment and a night splint at one month although better

outcomes were reported with manual therapy at one month and sustainability was not reported. (du Plessis 11)

*Evidence for use of Orthotics*

There are 2 moderate-quality RCTs incorporated into this analysis. (Torkki 01; DuPlessis 11)

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Torkki 2001 RCT	7.5	N = 211 patients with mild or moderate hallux valgus deformation (painful bunion with hallux valgus angle $\leq 35^\circ$ intermetatarsal angle $\leq 15^\circ$ . Mean age surgery $48 \pm 10$ years, orthosis $49 \pm 10$ years, control $47 \pm 9$ years.	Surgery, chevron procedure followed by abduction splint for 6 weeks (n = 71) vs. functional foot orthosis, negative cast technique (n = 69) vs. control, no surgery or foot orthotics (n = 69). Follow-up at 6 months and 1 year after randomization.	Differences in adjusted group means (95% CI) at 6 months: pain in last 6 months (NS between groups); intensity of foot pain, surgery vs. control -20 (-28 to -12), orthosis vs. control -14 (-22 to -6), surgery vs. orthosis (NS); ability to work, significant in surgery vs. orthosis -1 (-9 to -7). Differences in adjusted group means (95% CI) at 12 months: pain in last 6 months surgery vs. control -22 (-42 to -1), orthosis vs. control (NS), surgery vs. orthosis -34 (-55 to -14); intensity of foot pain, surgery vs. control -19 (-28 to -10), orthosis vs. control (NS), surgery vs. orthosis -14 (-22 to -5); ability to work (NS between groups).	"[T]he chevron operation is an effective treatment for patients who have a mild to moderate hallux valgus deformity and bunion pain while walking as their main symptom."	Mild or moderate cases studied and studied worst foot. Data suggest surgery superior to orthosis. Orthosis minimally superior to no treatment at 6 months but not at 12 months.
Du Plessis 2011 RCT	6.0	N = 30 participants with symptomatic hallux (ces)	Experimental group: Brantingham protocol: Mobilization,	No significant differences between groups at 1-week follow-up. At 1 month	"This exploratory trial has demonstrated that a structured	Pragmatic trial. Small sample size. Baseline

		with pain and disability being $\geq 30\%$ on VAS pain scale and disability scale respectively; mean age 42.	Mobilization with HVLA, Post-treatment cold therapy and Mobilization of other foot and ankle joints as indicated (n = 15) vs. Control Group: Night splint which holds big toe in corrected position (n = 15).  Follow-up at 1 week and 1 month.	follow-up there significant difference between experimental group vs. control group for Pain scores; 1.2 vs. 17.7 ( $p < 0.01$ ) and for Foot function scores (FFI); 2.3 vs. 33.4 ( $p < 0.01$ ). Both groups showed statistically significant improvements in both outcome measures at the final follow up.	protocol of MMT (the Brantingham protocol) is possibly as effective as standard care (night splint) in the short-term (3 weeks) for symptomatic mild to moderate HAV. At the 1-month follow-up the MMT maintains its treatment effect without further treatment, but the night splint does not."	comparability unclear. Suggests MMT is comparable to night splint at 1 week but after that MMT sustained outcomes up to 1 month for mild to moderate HAV.
--	--	--	---	--	--	---

## ULTRASOUND THERAPY

Low intensity ultrasound has been used postoperatively to treat bunions (hallux valgus). (Zacherl 09)

*Recommendation: Low Intensity Ultrasound*

**Low intensity ultrasound is not recommended for postoperative osteotomy hallux valgus treatment.**

*Strength of Evidence – Not Recommended, Evidence (C)*

*Level of Confidence - Low*

*Rationale for Recommendation*

One trial suggests a lack of post-operative efficacy and thus low intensity ultrasound is not recommended for treatment of patients having undergone osteotomy for hallux valgus. (Zacherl 09)

*Evidence for the Use of Ultrasound*

There is 1 moderate-quality RCT incorporated into this analysis. (Zacherl 09)

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Zacherl 2009  RCT	6.5	N = 44 participants (52 feet) with mild to moderate hallux valgus deformity; Mean age 53 years.	Verum Group- Daily transcutaneous low intensity pulsed ultrasound (LIPUS) (n = 26 feet) vs. Placebo Group- sham ultrasound	No significant difference between groups for the metatarsophalangeal-interphalangeal scale ( $p = 0.57$ ). Also, no significant difference for	"Despite potential impact of LIPUS on bone formation, we found no evidence of an influence on outcome 6 weeks and 1	LIPUS not associated with improvement in outcomes at 6 weeks or 1 year after chevron osteotomy.

			device (n = 26 feet)  Follow-up at 6 weeks and 1 year.	treatment satisfaction between groups. VAS pain scale did not show significant improvement at final follow-up (p = 0.80) nor did ROM in metatarsophalangeal joint (p = 0.36).	year after chevron osteotomy for correction of hallux valgus deformity.”	
--	--	--	--	---	--	--

## MANIPULATION AND MOBILIZATION

Manipulation and mobilization has been used to treat hallux valgus. (du Plessis 11)

*Recommendation: Manipulation or Mobilization for Treatment of Hallux Valgus*

**There is no recommendation for or against the use of manipulation or mobilization for treatment of hallux valgus.**

*Strength of Evidence – No Recommendation, Insufficient Evidence (I)*  
*Level of Confidence - Low*

### *Rationale for Recommendation*

There are no sham-controlled studies. A pragmatic comparative trial found no difference between manual manipulative treatment and a night splint at 1 week, although better outcomes were reported at 1 month and sustainability was not reported. (du Plessis 11) Thus, there is no recommendation.

### *Evidence for the use of Manipulation and Mobilization*

There is 1 moderate-quality RCT incorporated into this analysis. (DuPlessis 11)

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Du Plessis 2011  RCT	6.0	N = 30 participants with symptomatic hallux (ces) with pain and disability being ≥ 30% on the VAS pain scale and disability scale respectively; Mean Age was 42 years.	Experimental group: Brantingham protocol: Mobilization, Mobilization with HVLA, Post-treatment cold therapy and Mobilization of other foot and ankle joints as indicated (n = 15) vs. Control Group: Night split which holds the big toe in a	There were no significant differences between the two groups at 1-week follow-up. At the 1 month follow-up there was a significant difference between the experimental group vs. control group for Pain scores; 1.2 vs. 17.7 (p <0.01) and for Foot function scores (FFI); 2.3 vs.	“This exploratory trial has demonstrated that a structured protocol of MMT (the Brantingham protocol) is possibly as effective as standard care (night splint) in the short-term (3 weeks) for symptomatic mild to moderate HAV. At the 1-month	Pragmatic trial. Small sample size. Baseline comparability unclear. Suggests MMT is comparable to night splint at 1 week but after that MMT sustained outcomes up to 1 month for

			corrected position (n = 15),  Follow-up at 1 week and 1 month	33.4 (p <0.01). Both groups showed statistically significant improvements in both outcome measures at final follow up.	follow-up the MMT maintains its treatment effect without further treatment, but the night splint does not.”	mild to moderate HAV.
--	--	--	---	--	---	-----------------------

**Surgical Considerations**

Surgical procedures are generally attempted for moderate to severe hallux valgus. These procedures include distal soft tissue procedures, first metatarsal osteotomies, proximal phalanx osteotomies, fusion, and resection arthroplasties) options. (Hecht 14, Wülker 12)

*Recommendation: Surgery for Hallux Valgus*

**Surgery is recommended for Hallux Valgus.**

*Indications* – Select cases of mostly moderate hallux valgus where pain and/or debility are significant and changing shoe wear and orthotics fail to sufficiently control symptoms. However, some evidence suggests better outcomes with milder cases and those cases should have pain clearly localized to the bunion prominence while also demonstrating inadequate relief with shoe wear adjustments. (Deenik 08)

**Strength of Evidence –Recommended, Evidence (C)**

*Level of Confidence - Low*

*Rationale for Recommendation*

There is one moderate quality trial comparing surgery (chevron procedure) with orthosis with no treatment and found the best results with surgery. (Torkki 01) There are no other quality sham-controlled trials or comparative trials with non-operative treatments. There are many comparative trials comparing operative approaches. (Pentikainen 15, 12; Glazebrook 14; Matricali 14; Park 13a,b; Faber 13; Windhagen 13; Giannini 13; Radwan 12; Klos 11; Deenik 08, 07; Saro 07; Easley 96; Resch 94; Klosok 93) The moderate quality comparative study reported osteotomy was superior to either orthotics or no treatment. Thus, surgery is recommended where non-operative approaches are insufficient.

*Evidence of the Use of Surgery*

There is 1 moderate-quality RCT incorporated into this analysis. (Torkki 01)

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Torkki 2001  RCT	7.5	N = 211 patients with mild or moderate hallux	Surgery, chevron procedure followed by abduction splint	Differences in adjusted group means (95% CI) at 6 months: pain in last 6 months (NS between	“[T]he chevron operation is an effective treatment for	Mild or moderate cases studied and studied

		<p>valgus deformation (painful bunion with hallux valgus angle <math>\leq 35^\circ</math> intermetatarsal angle <math>\leq 15^\circ</math>. Mean age surgery <math>48 \pm 10</math> years, orthosis <math>49 \pm 10</math> years, control <math>47 \pm 9</math> years.</p>	<p>for 6 weeks (n = 71) vs. functional foot orthosis, negative cast technique (n = 69) vs. control, no surgery or foot orthotics (n = 69). Follow-up at 6 months and 1 year after randomization.</p>	<p>groups); intensity of foot pain, surgery vs. control -20 (-28 to -12), orthosis vs. control -14 (-22 to -6), surgery vs. orthosis (NS); ability to work, significant in surgery vs. orthosis -1 (-9 to -7). Differences in adjusted group means (95% CI) at 12 months: pain in last 6 months surgery vs. control -22 (-42 to -1), orthosis vs. control (NS), surgery vs. orthosis -34 (-55 to -14); intensity of foot pain, surgery vs. control -19 (-28 to -10), orthosis vs. control (NS), surgery vs. orthosis -14 (-22 to -5); ability to work (NS between groups).</p>	<p>patients who have a mild to moderate hallux valgus deformity and bunion pain while walking as their main symptom.”</p>	<p>worst foot. Data suggest surgery superior to orthosis. Orthosis minimally superior to no treatment at 6 months but not at 12 months.</p>
--	--	--	--	--	---	---

## Hammer Toe

Hammer toe syndromes normally occur in the sagittal plane. (Schrier 09) The metatarsophalangeal joint is dorsiflexed, while the proximal interphalangeal joint is plantarflexed. (Schuberth 99, Witt 12) Hammer toe mostly affects the second toe. Risk factors are not defined in quality epidemiological studies, but theorized to include biomechanical dysfunction, hereditary factors, high-heeled or poor fitting shoes, and trauma.

A trial of a splint in Thailand suggested modestly better results. (Chadchavalpanichaya 12) There are no quality trials to guide evidence-based treatment recommendations. Non-operative treatments include footwear modifications to improve toe box/room, padding, corticosteroid injections, and orthoses (Thomas 09) are **Recommended Insufficient Evidence (I)**, *Level of Confidence – Low*.

There are various surgical procedures used (arthroplasty, flexor tendon transfer, flexor tenotomy, extensor tendon lengthening and metatarsophalangeal joint capsulotomy, fusion, and diaphysectomy) interventions. (Schuberth 99, Thomas 09; Shirzad 11; Witt 12; Klammer 12; Veljkovic 14; Errichiello 12) Yet, there are no quality studies compared with no treatment or non-surgical options. There is one comparative study of operative treatments. (Klammer 12) Thus, surgery is **Recommended, Insufficient Evidence (I)**, *Level of Confidence – Low* for hammer toes with insufficient results from non-operative treatment.

# Ankle and Foot Fractures

## **General Approach and Basic Principles**

Fractures of the foot and ankle are common injuries among the adult population. The incidence of ankle fractures has been estimated to be 107 to 184 per 100,000 person years,(625) (Lin 09) and accounts for approximately 9% of all fractures.(626) (Court-Brown 06) Causes of ankle and foot fractures include falls, twisting injuries, motor vehicle accidents, and sports related injuries.(627-629) (Jensen 98, French 00, Syed 04) In the occupational setting, there is little in the literature regarding the most common types of fractures, recovery and rehabilitation schedules, and workplace limitations.(630) (Campbell 02) Distal lower extremity, ankle, and foot fractures covered in this section include those of the distal tibia and fibula, the malleoli, talus, calcaneus, navicular, metatarsals, and phalanges; and Lisfranc fractures. Syndesmotic and osteochondral injury are also considered.

## **Ankle Fractures**

Most ankle fractures are produced by abnormal motion of the talus, which either pushes off, or, by means of ligamentous attachments, pulls off an alveolus.(631) (Wilson 00) There are multiple classification systems for describing fracture around the ankle and distal lower extremity although most practitioners now refer to the AO/Weber system and the Lauge-Hansen system. The AO/Weber classification system describes the location and type of fracture by the level of fibular fracture relative to the syndesmosis or plafond. (The plafond is the inferior surface of the tibia and fibula – literally, the “base plate.”) According to this system, a Type A fracture is below the level of syndesmosis, Type B fracture is at the level of syndesmosis, and Type C fracture is above the syndesmosis. Type A is most commonly caused by internal rotation and adduction. Type B commonly results from external rotation, and is associated with or without tibiofibular ligament Type C are commonly from adduction (C-1), causing mediolateral oblique break above a ruptured tibiofibular ligament. Type C-2 results from abduction and external rotation, producing more extensive interosseous rupture and more extensive fracture high on the fibular. Type C injuries can also be associated with deltoid ligament rupture.(631-634) (Wilson 00, Michelson 03, 07, Daffner 94)

The Lauge-Hansen classification system is described as a tool to predict the mechanism and injury pattern of ankle fractures based on the position of the foot and the deforming force at the time of injury and on the x-ray findings.(635-638) (Gardner 06, Shariff 06, Heim 02, Arimoto 80) These patterns include supination-external rotation, pronation external rotation, and supination adduction.

Both of these classification systems are noted to have significant shortfalls and therefore are used as guides rather than absolute rules in determining management course. Isolated medial malleolar fractures and pilon fracture do not fit into the Weber classification system. Further, the Weber Classification has not been found to be an accurate predictor of complex bimalleolar and trimalleolar fractures, and the Lauge-Hansen classification prediction model has been demonstrated to have significant discrepancies of predicted injury with actual injury.(633, 635, 636, 639-641) (Michelson 07, Gardner 06, Shariff 06, Madeley 04, Kennedy 98, Nielsen 90)

Ultimately, the outcome of ankle and foot fractures is dependent on proper identification of mechanism of injury and restoration of ankle function through accurate realignment of normal articulations, and stable reconstruction of the syndesmosis and joint surface.(642-645) (Park 09, Gehr 04, Mandracchia 99, Mandi 06) Stability of the ankle injury is assessed by the integrity of the “ring” around the ankle joint, consisting of the syndesmosis, lateral malleolus, medial malleolus, and stabilizing ligaments. A disruption in one place along the ring is generally considered stable, whereas integrity compromise in two locations is unstable and may result in dislocation and poor outcome if not managed appropriately. In general, undisplaced or minimally displaced injuries are treated non-operatively, whereas displaced or unstable injuries are treated operatively.(625, 646) (Lin 09, Gross 98) Complications of ankle and foot fractures include decreased range of motion, post-traumatic osteoarthritis, pain, persistent pain despite hardware

removal, progressive talar instability, and malunions with concomitant syndesmotic widening.(437, 625, 647-650) (Chu 09, Lin 09, Brown 04, Makwana 01, Salai 00, Rowley 86)

### ***Distal Tibia and Fibula Fractures***

Tibial fractures usually result from injuries associated with rotation and high force, and therefore isolated fractures of the distal tibia metaphysis are uncommon. Tibial fractures involving the tibial plafond result from low or high-energy injuries, and can be described with either classification scheme or as a pilon fracture.

Pilon fractures of the tibia result from a high-energy injury such as a fall from heights or motor vehicle accident. The resultant high-energy forces are transmitted axially, causing the talus to impact the tibial articular surface, resulting in fracture of the distal tibia.(629) (Syed 04) Pilon fractures are often associated with other fractures of the fibula and malleolar fractures, as well as syndesmotic disruption, resulting in challenging orthopedic management scenarios. (651)(Wyrsh 96) Intra-articular tibial fractures may result in posttraumatic osteoarthritis and decreased ankle function.(629, 652) (Marsh 06, Syed 04) The fractures may be simple or comminuted. As fractures of the ankle resulting from axial force may appear deceptively-simple if only limited x-ray views are obtained, multiple x-ray views of the ankle or a CT scan should be obtained in the context of a fracture resulting from high-axial-force.

### ***Fibula Fracture***

Fractures of the fibula are commonly caused by eversion injuries with ankle sprain, and may be in isolation or associated with tibia fractures. The Maisonneuve fracture, considered to be one of the most unstable ankle injuries,(653) (Charopoulos 10) occurs when an external rotational force is applied to the fixed foot. The course of damaged tissue runs from the tibia, fractured at the ankle, up through the interosseous membrane and ends with a fracture of the proximal third of the fibula, and may result in unstable syndesmosis and bony avulsion or disruption of the syndesmotic ligaments.(654-656) (Millen 09, Madhusudhan 08, Duchesneau 95)

### ***Malleolar Fractures***

Malleolar fractures have varied presentations, ranging from isolated fibular fracture with no displacement to trimalleolar fracture with dislocation and vascular compromise.(644) (Mandracchia 99) Isolated lateral malleolar fractures usually result from supination-external rotation (SER) injury and may include deltoid ligament rupture.(657) (Weber 10) Isolated medial malleolar fractures may appear stable initially but have a tendency to displace.(630) (Campbell 02) Stress fractures of the medial malleolus and distal fibula are rare but may occur.(658) (Sherbondy 06) Posterior malleolar fractures are often missed and are highly variable.(659) (Haraguchi 06)

A displaced fracture of only one malleolus is associated with ligamentous injury of either the syndesmotic ligament, deltoid ligament complex, or both.(631) (Wilson 00) A single break in the “ring” is usually stable, allowing for conservative treatment.(631, 660) (Wilson 00, Richter 99)

### ***Hind Foot Fractures***

#### ***Talus Fracture***

The talus is a small, irregularly shaped bone whose surface area is covered 60 to 70% with articular cartilage. It transfers vertical weight bearing forces to horizontal support structures of the foot through major articulations with the heel and ankle.(661) (Early 08) Because of its key position, diagnosis and treatment of talus fractures is critical for foot and ankle function. Fracture of the talus may involve the head, neck, body, or lateral process (snowboarder fracture). Half of all talus fractures are of the neck, which are extra-articular.(661) (Early 08) Complications of talus fractures include infection, malunion, posttraumatic arthritis, osteonecrosis, and talar collapse. Avascular necrosis is the most clinically significant complication.(662) (Rush 09) Osteochondral injuries occur where bone and cartilaginous fragments separate from the dome of the talus. These should be suspected when chronic pain, stiffness, weakness or instability continues for weeks to months following ankle trauma.(644, 663) (Judd 02,

Mandracchia 99) Physical findings may include effusion, pain, crepitus, pain with palpation of the corresponding ankle gutter, pain or limited motion of the ankle joint.(664) (Chaney 01)

### ***Calcaneus Fracture***

The Calcaneus is the most frequently fractured tarsal bone and accounts for 60% of all tarsal bone fractures. Calcaneus fractures account for 1 to 2% of all fractures in adults, and often occur in industrial workers most typically jumping or falling from heights or involved in motor vehicle accidents.(665-670) (Knight 06, Kingwell 04, Ibrahim 07, Guyer 85, Dooley 04, Buzzard 03) The majority of calcaneus fractures occur in falls from a height of 6 feet or greater.(671) (Mitchell 09) Displaced intraarticular fractures account for 60 to 75% of the total calcaneal fractures. Approximately 8 to 10% of all displaced intra-articular calcaneal fractures are bilateral.(665, 666, 668, 672, 673) (Born 97, Ibrahim 07, Daftary 05, Dooley 04, Buzzard 03) These fractures typically occur due to axial loading in men 30 to 60 years of age and usually have a poor outcome.(671, 673, 674) (Daftary 05, Howard 03, Mitchell 09) The percentage of calcaneal fracture that occurs while at work has been estimated to be 36 to 50%.(666) (Dooley 04)

### ***Midfoot Fractures***

#### ***Navicular Fractures***

There are three types of fractures of the navicular including avulsion, tuberosity, and body fractures. Fractures of the body are more severe as they are related to disruption of the talonavicular and cuneonavicular joints.(675) (Karasick 94)

#### ***Tarsal Metatarsal Fractures***

Injuries to the tarsal metatarsal complex includes injury to all of the bones and joints directly or indirectly involved in a tarsometatarsal fracture-dislocation, including cuneiforms, cuboid, and navicular.(676) (Myerson 99) Fracture and dislocation of the base of the metatarsals-tarsal joint is also known as a Lisfranc injury, and is usually a result of stepping into a hole, twisting the foot or from a fall from height. Frequent cause of Lisfranc injury is when the patient has their foot on the brake and is involved in a car accident.

#### ***Metatarsal Fractures***

Metatarsal fractures are usually the result of inversion injury, fall from height or dropping an object on the forefoot.(675, 677, 678) (Cakir 10, Hatch 07, Karasick 94) Risk factors for poor outcomes include displacement greater than 2mm, high body mass index, female gender, and diabetes.(677) (Cakir 10)

#### ***Fifth Metatarsal Injuries***

Fifth metatarsal injuries are the most common foot fracture. Fifth metatarsal fractures are characterized by where they occur relative to the tuberosity. Avulsion fractures of the tuberosity are the most common fractures of the proximal 5th metatarsal. They occur after forced inversion with the foot and ankle in plantar flexion.(679) (Strayer 99) Metatarsal head fractures are rare; they often have a history of direct trauma.(680) (Prokuski 97)

#### ***Jones Fracture***

Fractures at the metaphyseal-diaphyseal border are known as a Jones fracture. They are often associated with both eversion and inversion ankle injuries. Stress fractures typically occur in the diaphysis of the metatarsal.

#### ***Phalangeal Fractures***

Injuries to the toes are usually secondary to stubbing injuries and direct blows from crush injuries.(675) (Karasick 94)

#### ***Stress Fractures***

Stress fractures are thought to occur from overuse with excessive and repetitive muscular forces being applied to the bone. The two most common areas for stress fractures are the calcaneus and metatarsals.(675) (Karasick 94) Stress fractures of the medial malleolus and distal fibula also are

reported but are infrequent.(658, 681-683) (Sherbondy 06, Chen 06, Wilder 04, Weinfeld 97) These appear to be caused by combination of muscular forces and axial loading. Stress fractures may also occur in the navicular bone.(681-685) (de Clercq 08, Jones 06, Chen 06, Wilder 04, Weinfeld 97)

### ***Work-Relatedness***

The incidence of workplace ankle fracture injuries is not well defined. Acute occupational ankle fractures are related to a specific traumatic event. The circumstances of the event determine work-relatedness.

### ***Initial Assessment***

It is important that clinicians understand the basic anatomy of the ankle and foot in order to assess injuries. The physician performing an initial evaluation of a patient with ankle injury should seek to identify conditions that require immediate treatment.(686) (Larsen 02) It is best to have a systematic approach to assessing a patient with ankle/foot injuries. Conditions that require immediate attention include open fracture, vascular compromise, compartment syndrome, and joint dislocation.

### ***Medical History***

The physician should attempt to obtain detailed information on mechanism of injury, symptoms, previous injury, and pertinent past medical history. The mechanism of injury includes defining forces associated with the injury. Symptoms and the progress of symptoms over time should be documented, including pain at initial injury, ability to continue work activities, and pain quality over time.(687) (Wardrope 98)

Ankle fractures are most often caused eversion and inversion of the ankle. Rupture of the distal tibiofibular syndesmosis frequently occurs in association with external rotation ankle injuries and may give a history of pain in the high ankle.(688) (Moore 06) Calcaneus fractures are most often associated with falls from heights or motor vehicle crashes.(665) (Buzzard 03) The patient will have significant pain in the foot/ankle with a history of a high impact injury. Because of axial transmission of force, these patients should be evaluated for spinal and visceral injuries. Tarsal fractures occur with both inversion and eversion type injuries and are characterized by pain in the hind and mid foot.(680) (Prokuski 97) Distal phalanx fractures are associated with a crush injury or perpendicular shearing force injury to the toe. The history of stress fractures often includes increased physical activity or increase in intensity of activity preceding symptoms.(658, 681-683) (Sherbondy 06, Chen 06, Wilder 04, Weinfeld 97) Navicular stress fracture and metatarsal stress fractures present as insidious onset of midfoot pain or forefoot pain with weight bearing.(680, 685) (Jones 06, Prokuski 97)

### ***Physical Examination***

A careful observation of the exposed extremity and systematic examination should be performed, including observation for soft tissue trauma, laceration, foreign body, edema, ecchymosis, deformity, and open fracture. Palpation of bony structures should include the length of the tibia and fibula, the medial and lateral malleoli, mortise syndesmosis, anterior calcaneus, lateral and posterior talus and the base of fifth metatarsal. Range-of-motion testing includes plantar flexion, and dorsiflexion. Pain in the heel of the foot may signify calcaneal fracture. The calcaneal squeeze test will elicit pain.

### ***Workplace Intervention***

#### **Work Restrictions**

Distal lower extremity, ankle, tarsal, and foot fractures will most often result in limited or non-weight bearing for a period of time. Management of edema for some fractures, particularly hindfoot and midfoot fractures, may require prolonged elevation of the injured leg. Casting, walking boot, or external hardware can impair ability to drive, walk, perform prolonged standing, climb stairs, work at heights, climb ladders, and other similar safety sensitive activities. The length of time of restrictions depends on the fracture, intervention, and healing rate of the patient, but can last from several weeks to several months.

### ***Initial Care***

The initial treatment of foot and ankle fractures is dictated by injury type (displaced or stable, open or closed) and by concomitant soft tissue injury.(630) (Campbell 02) Closed, stable injuries are generally

treated non-operatively. Open fractures require emergent debridement and antibiotic prophylaxis. Closed unstable fractures generally require operative management. Management should be initiated for severe swelling, compartment syndrome, and skin integrity breakdown from fracture blisters.

### ***Special Studies and Diagnostic and Treatment Considerations***

#### **X-RAY**

*Recommendation: X-ray for Suspected Acute Ankle Fractures*

**X-ray is recommended for suspected acute ankle fractures as a first-line study.**

*Indications* – Suspicion of fracture; Ottawa rules to determine likelihood of acute fracture. Presence of acute ankle edema greater than 13 to 15mm compared to uninjured ankle may indicate occult fracture.

*Views* – Anteroposterior, lateral, and mortise radiographs should be obtained.(426, 689) (Scott 10, Wolfe 01)

*Strength of Evidence* – **Recommended, Insufficient Evidence (I)**

*Level of Confidence* - High

#### *Rationale for Recommendation*

There are no quality studies comparing x-ray to clinical examination for evaluation of suspected fracture. However, x-ray is the recommended initial imaging study for suspected fracture. For ankle and foot sprain injuries, the Ottawa Ankle Rules are widely used as a screening tool to predict the absence of fracture (see Ankle Sprain for further discussion). X-ray is recommended for all acute fractures as an initial diagnostic study.

#### *Evidence for the Use of X-ray for Evaluation of Ankle Fractures*

There are no quality studies incorporated into this analysis.

#### **MRI**

*Recommendation: MRI for Distal Lower Extremity and Ankle Fractures*

**MRI is recommended for investigation of distal lower extremity and ankle fractures.**

*Indications* – For acute or subacute fracture to evaluate soft tissue/ligament trauma in complex displaced or comminuted, or if stability of fracture is uncertain and MRI will guide management decision.

*Strength of Evidence* – **Recommended, Insufficient Evidence (I)**

*Level of Confidence* - Moderate

#### *Rationale for Recommendation*

There is no quality evidence that MRI is superior to radiographs for the initial detection of ankle fractures and should not be used as a first-line imaging technique. Upon confirmation of displaced, comminuted, or unstable fracture, MRI may be an important diagnostic technique for the evaluation of suspected injuries of soft tissues related to distal fibular, tibial, and malleolar fractures, such as to the syndesmotic ankle ligament complex, extensor tendons, deltoid ligament, or tibial nerve.(690) (Koval 07) MRI is recommended for these select circumstances.

#### *Evidence for the Use of MRI for Evaluation of Ankle Fractures*

There are no quality studies incorporated into this analysis.

#### **CT**

*Recommendation: CT for Diagnosis and Classification of Ankle Fractures*

**CT is recommended for investigation of distal lower extremity and ankle fractures.**

*Indications* – Suspected occult and complex ankle fractures; to gain greater clarity of fracture displacement, articular involvement, and subluxation of affected joints.(691-693) (Catalano 04; Harness 06, Katz 01) If intraarticular displacement is considered, then axial views are recommended in addition to any coronal views.(694) (Ogawa 09)

*Strength of Evidence* – **Recommended, Insufficient Evidence (I)**  
*Level of Confidence* - Moderate

#### *Rationale for Recommendation*

There are no quality diagnostic studies for use of CT in distal lower extremity and ankle fractures. CT should be considered when x-ray images are negative, but on the basis of physical findings, an occult fracture is strongly suspected. CT may also be useful for evaluation of complex comminuted fractures, providing superior depiction of distal tibial articular surface involvement, fragment positioning, and diagnosis of subluxations.(691, 692) (Catalano 04; Harness 06) The value of CT has been demonstrated – a 2001 study showed the use of CT scanning for evaluation of articular step off and gaping, comminution, and treatment influenced observers to change treatment plans developed from radiographs and resulted in increased interobserver reliability in the proposed management of these injuries.(693) (Katz 01) Thus, the use of CT imaging is recommended.

#### *Evidence for the Use of CT for Evaluation of Ankle Fractures*

There are no quality studies incorporated into this analysis.

## **ULTRASOUND**

*Recommendation: Ultrasound Imaging for Diagnosing Ankle Fracture*

**Ultrasound imaging is recommended for evaluation of soft-tissue injury associated with select displaced fractures or suspected malleolar stress fractures.**

*Indications* – Evaluation of soft-tissue injury associated with select displaced fractures to assess stability of fracture, particularly of the deltoid ligaments with medial and bimalleolar fractures,(695) (Chen 08) assessment of interosseous membrane injury associated with Weber type B and C ankle fractures,(696) (Christodoulou 95) and in detection of suspected occult or stress fractures. Also used for suspected stress fracture of the distal tibia.(697, 698) (Wang 99, Delacerda 81)

*Strength of Evidence* – **Recommended, Insufficient Evidence (I)**  
*Level of Confidence* - Low

#### *Rationale for Recommendation*

There are no quality trials evaluating the use of ultrasound for evaluation of ankle fractures. The sensitivity and specificity for diagnosis of the rupture of the interosseous membrane is reported at 88 and 94% compared with intraoperative findings.(696) (Christodoulou 95) There is no report of sensitivity and specificity for other disorders found. Ultrasound imaging may be a useful adjuvant to clinical assessment of patients with regards to selection for further radiological examination,(695) (Chen 08) and is therefore recommended in select patients.

#### *Evidence for the Use of Ultrasound for Evaluation of Ankle Fractures*

There are no quality studies incorporated into this analysis.

#### **Follow-up Visits**

No quality evidence exists for specific follow-up care of ankle fractures outside of identified recommendations listed in this section. Changes in ankle girth should be monitored for reduction in swelling after the immediate injury. Changes in tissue volume may necessitate re-casting or device adjustments. The fracture should be monitored for reduction failure with subsequent radiographic studies.

## Medications

### ANTIBIOTIC PROPHYLAXIS

*Recommendation: Pre-operative Antibiotic Prophylaxis for Ankle Fractures*

**Pre-operative antibiotic prophylaxis is recommended for closed or open ankle fracture surgery.**

*Strength of Evidence – Recommended, Insufficient Evidence (I)*

*Level of Confidence – Moderate*

#### *Rationale for Recommendation*

There is one high-quality trial comparing multi-dose pre-operative intravenous cephalotin with placebo for closed ankle fractures that demonstrated no differences in post-operative infections or other outcomes; however, it is likely underpowered.(699) (Paiement 94) A systematic review of antibiotic prophylaxis for any long bone surgery with single-dose antibiotic prophylaxis demonstrated significantly reduced deep surgical site infection (risk ratio 0.40, 95% CI 0.24 to 0.67), superficial surgical site infections, urinary infections, and respiratory tract infections.(700) (Gillespie 10) However, no advantage to multi-dose antibiotic prophylaxis was reported. Single-dose prophylaxis is reported to be more cost effective than multi-dose regimens.(701) (Slobogean 10) Antibiotics are minimally invasive, have low adverse effects, are low to moderate cost, and in large studies prevent risk of infection. Thus, they are recommended.

#### *Evidence for the Use of Antibiotic Prophylaxis for Ankle Fractures*

There is 1 high-quality RCT incorporated in this analysis.

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Paiement 1994  RCT	9.0	N = 122 isolated closed ankle fractures undergoing ORIF	Cephalotin 1g (n = 60) vs. placebo (n = 62) IV every 6 hours for 24 hours.	Functional outcome at 1 year comparable, no pain or limp, and return to work and other activities not statistically different between groups; 1 deep tissue infection in placebo group.	“This series of ORIF of 122 patients with closed ankle fracture shows that the infection rate after such a clean orthopaedic procedure is relatively low, approximately 3%. Therefore, cephalotin prophylaxis does not seem justified in this patient population.”	Intra-operative IV antibiotics did not result in any significant different outcome in terms of infection, return to work or pain in patients undergoing ORIF with an isolated closed ankle fracture. Appears likely underpowered.

### **CALCITONIN (Prophylaxis for Post-Fracture Osteopenia)**

Post-operative osteopenia is hypothesized to interfere with healing and recovery of fracture. Post-operatively, 20 to 50% loss of bone mineral density and increased osteoclastic activity has been reported.(702) (Petersen 98)

*Recommendation: Use of Nasal Spray Calcitonin for Post-fracture Osteopenia*

**The use of nasal spray calcitonin is not recommended for prophylaxis of post-fracture osteopenia.**

*Strength of Evidence – Not Recommended, Evidence (C)*

*Level of Confidence - Low*

### Rationale for Recommendation

A moderate-quality trial demonstrated nasal calcitonin obtained from salmon compared with placebo did not result in significant differences in bone mineralization 3 months after surgery.(702) (Petersen 98) Nasal salmon calcitonin is non-invasive, has few adverse effects, but is of high cost, and has not shown to be effective in preventing post-operative osteopenia; therefore, nasal calcitonin is not recommended.

### Evidence for the Use of Calcitonin Prophylaxis for Post-fracture Osteopenia

There is 1 moderate-quality RCT incorporated in this analysis.

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Peterse n 1998 RCT	6.5	N = 24 ankle fractures requiring ORIF	Nasal salmon calcitonin 200 IU once daily for 12 weeks vs. placebo.	Bone mineralization at 3 months: placebo lost 14%, sCT 2.1% (NS) in injured leg. Uninjured: placebo lost 2.2%, sCT gained 8.6% at 1.5 months (p = 0.07).	“200 IU of nasal salmon calcitonin given daily could not inhibit the development of posttraumatic osteopenia in the injured legs, following ankle fractures, but a statistically significant effect was observed in the healthy legs.”	No mention of co-interventions or compliance with medication on daily basis. Small numbers; drop outs after 3 months make changes seen not able to reach statistical significant in injured leg. Data suggest no benefit for osteopenia prophylaxis.

### DVT PROPHYLAXIS

See discussion of DVT prophylaxis in the Achilles tendon rupture section.

### NON-STEROIDAL ANTI-INFLAMMATORY DRUGS (NSAIDs) AND ACETAMINOPHEN

*Recommendation: NSAIDs and Acetaminophen for Acute Ankle Fracture Analgesia*

**NSAIDs and acetaminophen are recommended for analgesia of pain associated with fracture.**

*Indications* – Pain due to ankle fracture.

*Frequency/Duration* – Scheduled dosage rather than as needed is generally preferable.

*Indications for Discontinuation* – Resolution of pain, lack of efficacy, development of adverse effects, particularly gastrointestinal effects.

*Strength of Evidence* – **Recommended, Insufficient Evidence (I)**

*Level of Confidence* - High

### Rationale for Recommendation

There is no quality evidence regarding the use of NSAIDs or acetaminophen to control pain associated with ankle fractures. However, these medications are thought to be effective for control of swelling and pain in the initial stages of injury, are not invasive, have low adverse effects, and are low cost, thus they are recommended. There is no quality evidence that selective COX-2 inhibiting NSAIDs have a negative effect on bone fracture union or functional recovery(703) (Boursinos 09) as concerns of NSAIDs causing delayed recovery come from an early case report of indomethacin use.(704) (Sudmann 76)

### Evidence for the Use of NSAIDs and Acetaminophen for Foot and Ankle Fractures

There are no quality studies incorporated into this analysis.

## OPIOIDS

*Recommendation: Limited Use of Opioids for Acute and Post-operative Pain Management*

**Limited use of opioids for acute and post-operative pain management is recommended as adjunctive therapy to more effective treatments.**

*Indications* – For acute injury and post-operative pain management, a brief prescription of opioids as adjuncts to more efficacious treatments (especially NSAIDs, acetaminophen, elevation, splinting) is often required, especially nocturnally.

*Frequency/Duration* – Prescribed as needed throughout the day, then later only at night, before weaning off completely.

*Indications for Discontinuation* – Resolution of pain, improvement to the point of not requiring these medications, intolerance or adverse effects, non-compliance, surreptitious medication use, or use beyond 2 to 3 weeks for less extensive procedures.

*Strength of Evidence* – **Recommended, Insufficient Evidence (I)**

*Level of Confidence* - Low

### *Rationale for Recommendation*

There is no quality evidence for the use of opioids for the treatment of pain associated with acute fracture. Opioids are not invasive, but have adverse effects. They are moderate to high cost depending on duration of treatment (see Chronic Pain guideline). Quality evidence for treatment of post-operative patients with opioids is absent. Some patients have insufficient pain relief with NSAIDs, thus judicious use of opioids may be helpful, particularly for nocturnal use. Opioids are recommended for brief, select use in post-operative patients with primary use at night to achieve sleep post-operatively.

### *Evidence for the Use of Opioids for Foot and Ankle Fractures*

There are no quality studies incorporated into this analysis.

## TETANUS IMMUNIZATION

*Recommendation: Tetanus Immunization Status for Open Fractures*

**For open fractures, it is recommended that tetanus immunization status to be updated as necessary.**

*Indications* – Wounds that are not clean if more than 5 years have elapsed since last tetanus immunization.(705) (CDC 09)

*Strength of Evidence* – **Recommended, Insufficient Evidence (I)**

*Level of Confidence* - High

### *Rationale for Recommendation*

There are no quality studies of tetanus immunization updating for these fractures. However, these immunizations are widely used and believed to have been successful on a population basis in reducing risk of tetanus over many decades. Tetanus immunizations are minimally invasive, have low adverse effects and are low cost. As the adverse effects of not immunizing may be fatal, tetanus immunization updating for open wounds is recommended. Wounds that are not clean or burns should require immunization if more than 5 years since last immunization, rather than 10 years.(705) (CDC 09) Patients without a completed immunization series of 3 injections should receive tetanus immune globulin along with immunization.

### *Evidence for the Use of Tetanus Immunization for Open Foot and Ankle Fractures*

There are no quality studies incorporated into this analysis.

## Initial Care

### NON-OPERATIVE REDUCTION ANALGESIA

Patients generally require analgesia for closed reduction procedures. There are a number of common techniques described, including conscious sedation with opioids and benzodiazepines, hematoma block, local or regional anesthetic blocks, intraarticular block, and general anesthesia.(649, 706-709) (White 08, Furia 97, Alioto 95, Brink 96, Rowley 86)

*Recommendation: Analgesia for Non-operative Reduction Ankle Fractures*

**Adequate analgesia is recommended for performing non-operative closed reduction of ankle fractures.**

*Strength of Evidence – Recommended, Evidence (C) – Conscious sedation, intraarticular block  
Recommended, Insufficient Evidence (I) – Hematoma block, general anesthesia*

*Level of Confidence - Moderate*

#### *Rationale for Recommendation*

There are no quality trials evaluating reduction without analgesia. There is one quality trial that compared intraarticular block to conscious sedation for closed reduction of ankle fractures that demonstrated both techniques were effective in providing analgesia with no differences between the groups.(706) (White 08) There are no quality trials for other techniques. A non-randomized study reported similar efficacy of hematoma block with conscious sedation.(707) (Furia 97) There is insufficient evidence to recommend one technique over another, and all are recommended. Appropriate technique should be based on factors of physician experience and preference, patient history of intolerance to medications or level of anxiety, and availability of equipment and supplies.

#### *Evidence for the Use of Non-operative Reduction Analgesia for Ankle Fractures*

There is 1 moderate-quality RCT incorporated into this analysis.

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
White 2008  RCT	7.0	N = 42 closed, displaced ankle fracture requiring non- operative manipulation reduction	Conscious sedation vs. intraarticular block (12mL lidocaine) for reduction maneuver, application of splint.	Conscious sedation vs. block: 2/21 vs.6/21 required repeat analgesia, p = 0.15. No differences in duration, difficulty of performing procedure; both methods effective in reducing pain from baseline (p <0.001, p<0.0002), no differences between groups.	“Compared with conscious sedation, an intra-articular lidocaine block provides a similar degree of analgesia and sufficient analgesia to achieve successful closed reduction of an ankle fracture- dislocation with minimal medical risks. It is a safe and reasonable alternative to conscious sedation.”	Small sample size. Suggests conscious sedation and hematoma block effective in providing analgesia for ankle fracture reduction.

## Fracture Care

### Malleolar Ankle Fractures

Management of non-displaced and stable fractures has traditionally been non-operative with good results. There is continued debate regarding treatment for particular fractures types that are not clearly stable or unstable.(710) (Kosuge 10) Non-union of the distal fibula fracture is rare(711) (McGonagle 10) lending support to a trial of conservative management for non-displaced and stable displaced fractures. Reduction failure or delayed union may require surgical intervention. Posterior malleolar fractures are often missed and are highly variable.(659) (Haraguchi 06) A systematic review found no consensus on fragment size and surgical indication, and concluded that restoration of medial and lateral constraints of the ankle play the major role in development of post-traumatic osteoarthritis.(712) (van den Bekerom 09) A case series with 13-year follow-up demonstrated fixation for fractures less than 25% of posterior malleolus may not be indicated, as both groups had similar outcomes.(713) (De Vries 05)

1. *Recommendation: Immobilization for Non-displaced Ankle Fractures*

**Non-operative management is recommended for the treatment of non-displaced and reduced stable ankle fractures.**

*Indications* – Non-displaced distal fibula, lateral malleolar, or Pilon fractures; select non-displaced medial malleolar fracture.

*Immobilization Method* – Cast or rigid orthotics.(709, 714) (Brink 96, Stuart 89)

*Strength of Evidence* – **Recommended, Insufficient Evidence (I)**

*Level of Confidence* - High

2. *Recommendation: Immobilization and Reduction for Closed Displaced Ankle Fractures*

**Closed reduction and immobilization is recommended for select non-comminuted closed displaced ankle fractures.**

*Indications* – Non-comminuted closed displaced ankle fractures with post-reduction displacement less than 2 to 3mm and less than 25% posterior malleolus articular surface involvement.(649, 709, 715, 716) (Joukainen 07, Rowley 86, Brink 96, Bauer 85) Generally lateral malleolar Weber A & B or Modified Lauge-Hansen severity class 1 or 2 are considered for reduction.(648, 709, 717) (Makwana 01, Phillips 85, Brink 96)

*Strength of Evidence* – **Recommended, Insufficient Evidence (I)**

*Level of Confidence* - High

3. *Recommendation: Operative Fixation for Closed Displaced Ankle Fractures*

**Operative fixation is recommended for unstable closed displaced ankle fractures.**

*Indications* – Generally severe lateral fracture with medial malleolar involvement.(648, 709, 717) (Makwana 01, Phillips 85, Brink 96) Comminuted closed displaced ankle fractures with post-reduction displacement more than 2 to 3mm and more than 25% posterior malleolus articular surface involvement(649, 709, 715, 716) (Joukainen 07, Rowley 86, Brink 96, Bauer 85); patients 55 years of age or older.(648, 717) (Makwana 01, Phillips 85)

*Strength of Evidence* – **Recommended, Evidence (C)**

*Level of Confidence* - High

*Rationale for Recommendations*

There are no quality trials comparing non-operative with operative treatment for initially non-displaced or minimally displaced fractures. There are three moderate-quality trials that compare operative to non-operative treatment for displaced fractures after closed reduction.(648, 716, 717) (Phillips 85, Makwana 01, Bauer 85) A moderate-quality trial that compared operative to non-operative treatment of displaced stable fractures found similar outcomes in fixation time (6 weeks), similar union rates, and same sick-

leave duration.(716) (Bauer 85) Long-term outcomes were also similar in development of arthrosis, function, and residual pain. However, the study results may be biased as significant crossover occurred after randomization as non-reducible fractures were treated operatively, but considered in the non-operative group analysis. Another moderate-quality trial comparing non-operative to open reduction and internal fixation (ORIF) care in severe ankle fractures demonstrated higher scores on the author's measurement scale for the ORIF group.(717) (Phillips 85) A moderate-quality trial demonstrated better functional outcome and range of motion at long-term follow up with ORIF for fractures that were satisfactorily reduced under general anesthesia.(648) (Makwana 01) However, there were no differences in patient satisfaction. The types of ankle fractures were otherwise not clear. The study results suggested persons over 55 years old benefit from ORIF. A low-quality trial demonstrated better functional results in non-operative group with early weight-bearing compared with ORIF.(649) (Rowley 86) Another low-quality trial of cast with early weight bearing was demonstrated to have higher functional scores than ORIF group in an elderly population.(650) (Salai 00)

A systematic review of more than 57,000 patients who had undergone ankle surgery with ORIF of lateral malleolar, bimalleolar, or trimalleolar ankle fracture demonstrated low short-term complication rates for pulmonary embolism (0.34%), mortality (1.07%), wound infection (1.44%), amputation (0.16%), and revision of ORIF (0.82%). Open injury, diabetes, and peripheral vascular disease were strong predictors of post-operative complications.(718) (SooHoo 09) Other adverse effects reported from ORIF include malunion, nonunion, syndesmotic widening, degenerative changes, and septic arthritis.(719) (Ng 09) Thus, non-operative management is recommended in select patients with non-severe fractures with minimal displacement after closed reduction. Operative fixation is recommended for patients with severe fractures, non-satisfactory closed reduction, unstable fracture, or aged 55 or greater. There are two moderate-quality trials comparing rigid immobilization with Aircast immobilization for lateral malleolar fractures that demonstrated similar functional and return to work outcomes, and both are recommended.(709, 714) (Brink 96, Stuart 89)

*Evidence for the Management of Malleolar Ankle Fractures*

There are 5 moderate-quality RCTs incorporated in this analysis. There are 2 low-quality RCTs in Appendix 1.

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
<b>Non-operative Management</b>						
Bauer 1985  RCT	5.5	N = 111 intra-articular malleolar fractures (Weber types A, B, C) with stable syndesmosis	Closed reduction with cast immobilization vs. ORIF and Cast immobilization. Weeks 0-6, non-weight bearing, Cast removed at 6 weeks, full weight bearing at 9-12 weeks.	Cast vs. ORIF: hospitalization (days): 5.0 (0-19) vs. 9.5 (2-33); Cast treatment (weeks): 6.2 (4-16) vs. 6.6 (2.5-10); Sick leave (weeks): 14 (3-63) vs. 14 (4-49); full ROM (weeks): 12 (9-15) vs. 9 (6-12), p <0.01. No difference in degree of arthrosis operative vs.	"[T]he initial results indicated a more favorable early course in the patients randomized to surgery. At follow-up examination, however, patients randomized to closed reduction had long-term results comparable to those randomized to operation."	After randomization, 10 not treated according to protocol received other treatment (8 in non-operative had ORIF). Results suggest similar outcomes for operative vs. non-operative treatment. Loss of reduction in 8 patients subsequently needing ORIF suggests follow-up necessary when

				non-operative long term.		treating non-operatively.
Brink 1996 RCT	5.5	N = 66 stable lateral malleolar fractures. Supination-inversion Stage II	Aircast air-stirrup, with full weight bearing vs. DonJoy ROM Walker Brace, full weight bearing.	At 4 weeks 11/33 (34%) of Air and 4/33 (13%) able to do unlimited activity (p <0.05). Average time for return to work 6 weeks in both groups. No differences remained at 12 weeks.	"[B]oth dynamic braces provided good pain relief at 4 weeks, allowed return to work at 6 weeks, and resulted in healing at 12 weeks. The Aircast was found to be easier to use and more comfortable, but the R.O.M-Walker gave greater pain relief, increased range of motion, and earlier return of ambulation."	No blinding, no mention of co-interventions or lack thereof. Either brace appears sufficient; return to work equal in both groups. No clinical difference at 12 weeks between groups. Aircast cost \$40 and ROM-Walker cost \$110. For cost benefit Aircast seems better choice as they both returned to work on average at 6 weeks. However, pain control may dictate use of ROM-Walker in some patients.
Stuart 1989 RCT	4.0	N = 40 lateral Malleolar fractures, type II	Below-knee walking plaster and crutches (Group A) vs. pneumatic air stirrup and crutches (Group B) for 4-6 weeks.	Air cast group: Comfort at 24 hours better (p <0.05); swelling at 7 days better (p <0.00001). No difference in time to union. Arc of motion better (p <0.0001).	"We advocate the use of the Aircast pneumatic air stirrup in the cost-effective management of stable ankle fractures."	Lack of study details. Improvements not well correlated with long-term clinical or functional outcomes. Cost benefit showed similar overall costs; slightly more in air cast group. In Type II lateral malleolar fractures air cast appears superior.
<b>Non-operative vs. Operative Management</b>						
Phillips 1985 RCT	5.0	N = 138 closed severe ankle fracture (Grade-4 supination-inversion-external rotation or	All underwent closed reduction. If satisfactory, closed treatment vs. ORIF. Unsatisfactory closed reduction:	For patients with initial satisfactorily closed reduction, ORIF had better outcomes in ROM. Gait better if a medial malleolar fracture (p <0.05). For	"In patients with severe fracture of the ankle that had been satisfactorily reduced initially by closed manipulation, open reduction and internal fixation performed according to ASID	Poor compliance with follow-up. No blinding. Measurement scale more weighted by subjective than objective measures. Validity of scoring system unknown. Study

		pronation external rotation)	trial of reduction under general anesthesia, randomized to ORIF vs. or ASIF technique.	closed reduction: no difference between ORIF and ASIF. Better alignment by x-ray after surgery had better clinical outcome in both groups (p <0.01).	guidelines gave significantly better results, as measured by our 150-point scoring system, than did closed treatment. Patients with a medial malleolar fracture and patients who were more than fifty years old both had less favorable results after closed treatment. The difference in the talocrural angle between the injured and normal sides was the only statistically significant radiographic indicator of a good prognosis.”	suggests for severe ankle fractures, ORIF may be better option, particularly with medial malleolar fractures and in persons older than 55.
Makwana 2001 RCT	4.0	N = 47 displaced ankle fractures requiring reduction in patients age 55 and older	Acceptable post-reduction then closed treatment (CT) (below-knee plaster cast, elevation 48 hours, protected weight bearing 6 weeks, then full weight bearing) vs. ORIF: post-op below-knee cast, leg elevated 48 hours, then protected weight bearing. Full weight bearing at 6 weeks.	Hospital stay: CT: 2.6 days, ORIF: 6.7 (p = 0.01). Immediate reduction: CT: 57%, ORIF 86% (p = 0.03). Loss of reduction: CT: 8/21 (38%), ORIF: 0/22 (p = 0.003). CRPS: CT: 0/21, ORIF 2/22 (11%).	“We recommend treating displaced ankle fractures in patients over the age of 55 years by open reduction and internal fixation.”	No blinding, no mention of co-interventions, follow up ranged from 15-42 months. More smokers in the closed group. Study suggests in age group 55 and older ORIF has fewer treatment failures and better functional outcomes.

## Tibial Shaft Fractures (Diaphyseal)

### 1. Recommendation: Operative Fixation for Tibial Shaft Fracture (Closed, Diaphyseal)

**Operative fixation is recommended for definitive management of displaced tibial shaft fracture.**

*Indications* – Displaced, comminuted distal tibial shaft fracture.

*Strength of Evidence* – **Recommended, Evidence (C)**

*Level of Confidence* - High

### 2. Recommendation: Cast Immobilization for Tibial Shaft Fractures (Closed, Diaphyseal)

**There is no recommendation for or against non-operative management of tibial shaft fractures.**

*Strength of Evidence* – **No Recommendation, Insufficient Evidence (I)**

*Level of Confidence* - Low

#### Rationale for Recommendations

There is one moderate-quality trial comparing management of tibial shaft fracture using operative fixation using intramedullary nail to plaster cast. The plaster cast group was separated into those whose fractures were not displaced and a cast alone would suffice, and those whose fracture was displaced and underwent internal fixation using cerclage or screw in addition to the plaster cast.(720) (Karlalani 00) The study demonstrated significantly reduced time to fracture union time and weight bearing for the group without the cast. The cast-only and cast-with-minimal internal-fixation groups both demonstrated 50% failure requiring ORIF for non-union. As the intramedullary nail appears to result in quicker healing time and return to activity, it is recommended. This study indicates that patients should be counseled on the likelihood of knee pain long-term (44% of subjects). Casting may be an alternative for some patients, but with counseling that nearly half may need surgical intervention for delayed union.

There are no quality trials of one type of surgical fixation compared with another. A low-quality trial demonstrated plates to provide faster healing time compared with intramedullary nail.(721) (Fernandes 06) Described techniques include use of an intramedullary nail, external fixators, or plates and screws, and there is no recommendation of one over another, with use based on surgeon preference.(720-722) (Karlalani 00, Keating 97, Fernandes 06) There appears to be no advantage to minimal fixation with screw or cerclage compared with casting.(720) (Karlalani 00)

#### Evidence for the Management of Tibial Shaft Fractures

There is 1 moderate-quality RCT incorporated in this analysis. There is 1 low-quality RCT in Appendix 1.

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Karlalani 2000  RCT	4.5	N = 53 unilateral displaced and closed or Grade 1 open tibial shaft fractures	Intramedullary nail (Group I, n = 27) vs. cast only (Group IIa, n = 12) vs. cast plus additional minimal internal fixation	Mean time to union (mean±SD): Group IIa (25 weeks ±11), Group 2b (26 weeks ±8.3) 95% CI: -4.9- 17.6; Group II (a and b) (25 weeks ±9.4) Group I	“Delayed union, malunion, and restricted range of motion at the ankle joint were common complications when these fractures were treated with a	Large portion crossed over as 14/26 (53.8%) in cast group required ORIF, making comparison groups nonhomogeneous. Data suggest cast only may not be appropriate for

			(Group IIb, n = 14).	(19 weeks $\pm$ 8.2) 95% CI: 2.5-12; 6 patients in Group I and 16 in Group II had delayed union, p = 0.005.	cast. We recommend intramedullary nailing for these fractures.”	specific fracture types as >50% required ORIF.
--	--	--	----------------------	---	---	--

**Distal Tibial Extra-articular Fractures**

1. *Recommendation: Operative Fixation for Distal Tibial Extra-articular Fractures*

**Operative fixation (i.e., fracture plating, intramedullary nail) is recommended for distal extra-articular tibial fractures in select patients.**

*Indications* – Open fractures, initial shortening >15mm, angular deformity after initial manipulation >5° in any plane.(723) (Zelle 06)

*Strength of Evidence* – **Recommended, Insufficient Evidence (I)**

*Level of Confidence* - Low

2. *Recommendation: Cast Immobilization for Distal Tibial Extra-articular Fractures*

**Non-operative management is recommended in select circumstances for distal extra-articular tibial fractures.**

*Indications* – Closed simple fractures with initial shortening <15mm, angular deformity after initial manipulation <5° in any plane.(723) (Zelle 06)

*Strength of Evidence* – **Recommended, Insufficient Evidence (I)**

*Level of Confidence* - Moderate

*Rationale for Recommendations*

There are no quality trials comparing operative to non-operative treatment for distal extra-articular tibia fracture. A systematic review of 1,125 fractures demonstrated a low non-union rate for immobilization of 1.3 vs. 5.5% for intramedullary nailing, although there were more open fractures in the nailing group.(723) (Zelle 06) There is one moderate-quality trial comparing the use of intramedullary nail with percutaneous locking compression plates,(724) (Guo 10) and another moderate-quality trial comparing intramedullary nail with fracture plate and screws.(725) (Im 05) There were no significant differences in functional outcomes between these interventions. Intramedullary nail was demonstrated to have few superficial infections and less angulation than plates and screws,(725) (Im 05) and shorter operating time and radiation exposure than percutaneous compression plate.(724) (Guo 10) However, there is no quality evidence that one technique is superior to the other and no recommendation is made regarding technique.

*Evidence for the Management of Tibial Extra-articular Fractures*

There are 2 moderate-quality RCTs incorporated into this analysis.

Author/Year Study Type	Score (0-11)	Sample Size	Comparison on Groups	Results	Conclusion	Comments
Im 2005	6.0	N = 78 distal metaphys	Closed intramedullary nailing.	Duration of operation: N = 72 minutes, PS = 89 minutes (p = 0.02).	“[L]ocked intramedullary nails have an	Suggests benefit of intramedullary

RCT		real fractures of tibia undergoing operative treatment	(N) vs. ORIF with plates and screws (PS).	Radiological union: N = 18 weeks, PS = 20 weeks (p = 0.89). Infections: N = 1 superficial infections, PS = 6 superficial, 1 deep (p = 0.03). Average angulation: N = 2.8°, PS = 0.9° (p = 0.01). Ankle dorsiflexion: N = 14°, PS = 7° (p = 0.001). Olerud Molander score: N = 88.5%, PS = 88.2% (p = 0.71).	advantage in restoration of motion and reduce wound problems, and anatomic plate and screws can restore alignment better than intramedullary nails.”	nailing in less angulation. No differences in radiological union, and Olerud Molander scores, suggesting both methods similar in functional outcomes. More infections with plates and screws.
Guo 2010 RCT	5.0	N = 111 distal closed metaphyseal fractures, non-intraarticular	Intramedullary nail (IMN) vs. percutaneous locking compression plating (LCP).	IMN vs. LCP: Time to union (weeks) 17.7 vs. 17.6, p .0.05; AOFAS at 1 year, 86. vs. 83.9, p >0.05; Percent wanting hardware removed 84.1% vs. 92.7%, p >0.05; Operative time (minutes) 81.2 vs. 97.9, p <0.001; radiation use (minutes) 21.2 vs. 3.0, p <0.001.	“[B]oth a closed IMN and LCP with MIPO can be used safely to treat OTA type 42-A distal metaphyseal fractures of the tibia. Closed nailing has the advantage of shortened operating and radiation time and ease of removal of hardware.”	Randomization, allocation details sparse, 85/111 completed study. Results suggest no differences in techniques for functional outcomes.

### Tibial Plafond (Pilon) Fractures

#### 1. Recommendation: Non-operative Management of Tibial Plafond and Pilon Fractures

**Non-operative management for tibial plafond fractures is recommended in select patients.**

*Indications* – Non-displaced, non-comminuted, stable fracture; ability to obtain acceptable fracture alignment with closed reduction.

*Strength of Evidence* – **Recommended, Insufficient Evidence (I)**

*Level of Confidence* - High

#### 2. Recommendation: Operative Management of Tibial Plafond and Pilon Fractures

**Operative management for tibial plafond fractures is recommended in select patients.**

*Indications* – Displaced, comminuted, or inability to obtain acceptable fracture alignment with closed reduction.

*Strength of Evidence* – **Recommended, Insufficient Evidence (I)**

*Level of Confidence* - High

#### Rationale for Recommendations

Distal lower leg fractures that impinge on the articular surface with the talus are known as plafond fractures. As these fractures are often caused by axial forces driving the talus into the lower leg, they are often called “pilon” (hammer) fractures. In this section, the term “plafond fracture” will be used. There are no quality trials for operative fixation of tibial plafond fractures. A low-quality trial compared ORIF of tibial plafond fractures with external fixation with and without limited internal fixation and found no radiographic difference at 15 weeks follow-up, but did demonstrate higher wound complication rate in the ORIF group leading to 3 amputation surgeries.(651) (Wyrsh 96) These fractures are noted to have high complication rates from surgical reduction and fixation.(652) (Marsh 06) Numerous internal and external fixation techniques are described, but there is no recommendation for one method over others.(138, 726-732) (Evans 10, Wang 10, Lee 08, Gardner 08, Dunbar 08, Bozkurt 08, Ruland 08, Papadokostakis 08)

#### *Evidence for the Management of Tibial Plafond and Pilon Fractures*

There are no quality studies incorporated into this analysis. There is 1 low-quality RCT in Appendix 1.

### **Syndesmotic Ruptures**

Operative treatment of unstable syndesmotic injury to restore the tibiofibular relationship using several types of fixation techniques, including screws, Kirschner wires, sutures, and bioabsorbable implants is described.(688, 733-737) (Soin 09, Moore 06, Kaukonen 05, Missbach-Kroll 03, Thordarson 01, Kennedy 00)

#### 1. *Recommendation: Operative Fixation for Syndesmotic Ruptures*

**Operative fixation is recommended for unstable syndesmotic rupture.**

*Indications* – Closed ankle fractures with unstable syndesmosis, AO fracture type C and/or pathologic widening of more than 2mm of the syndesmosis at intra-operative testing.(738) (Hoiness 04)

*Strength of Evidence* – **Recommended, Insufficient Evidence (I)**

*Level of Confidence* - High

#### 2. *Recommendation: Non-operative Management of Syndesmotic Injuries*

**Non-operative management is recommended for stable syndesmotic injury.**

*Indications* – Absence of other destabilizing injury including ankle fracture or deltoid ligament injury.(739, 740) (Zalavras 07, Lin 06)

*Strength of Evidence* – **Recommended, Insufficient Evidence (I)**

*Level of Confidence* - High

#### *Rationale for Recommendations*

There are no quality trials for non-operative management of syndesmotic injuries. There is opinion that not all ankle syndesmotic injuries lead to ankle instability, and may not need repair in the absence of other destabilizing injury.(739, 740) (Zalavras 07, Lin 06) Fixation is required in the presence of fracture.(739) (Zalavras 07) Thus, non-operative management is recommended for select patients. Operative repair is recommended for non-stable injuries, which include most syndesmotic rupture with concurrent fractures or deltoid ligament injury. There is one moderate-quality trial comparing tri-cortical screw fixation with quadri-cortical screw fixation that demonstrated no significant long-term differences, although tri-cortical fixation was demonstrated to achieve earlier partial weight bearing and less pain at 3 months follow-up.(738) (Hoiness 04) A low-quality trial comparing tri-cortical screw fixation with quadri-cortical screw fixation demonstrated no significant long-term differences.(688) (Moore 06) There are two moderate-quality trials comparing bioabsorbable screws with metallic screws for syndesmotic repair that demonstrated no differences in outcomes other than that those with metallic screws were more likely to have reoperation for screw removal.(733, 741) (Kaukonen 05, Thordarson 01) A study of outcomes with retained compared to removed screws and broken screws demonstrated no clinical differences, calling into question the need for removal of screws.(742) (Hamid 09) There are no other trials comparing use of

other fixation techniques. Thus, there is insufficient quality evidence for recommendation of one fixation technique over another. Both metallic and bioabsorbable screws appear to provide effective treatment.

*Evidence for the Treatment of Syndesmotic Injury*

There are 3 moderate-quality RCTs incorporated into this analysis. There is 1 low-quality RCT in Appendix 1.

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Høiness 2004  RCT	7.0	N = 64 closed ankle fractures with unstable syndesmosis. AO fracture type B and/or C	Tricortical fixation with two 3.5mm screws through 1 cortex of tibia after 2-3 days, 2-5kg weight bearing for 6 weeks. (TC) vs. Quadricortical fixation with 1 4.5mm screw through both tibial cortices. No weight bearing for 8-12 weeks (QC).	Olerud-Molander functional scores: TC-77, QC 66 (p = 0.025) at 3 months, at 1 year (NS). Pain: TC<QC (p = 0.017) at 3 months, at 1 year (NS). Dorsiflexion: No difference. No loss of fixation in any patient; 2 in TC had to have screws removed.	“[T]ricortical screw fixation of a ruptured syndesmosis is adequate and improves early function compared with the traditional transsyndesmotic fixation with bicortical holds in the tibia.”	No blinding, mention of co-interventions, return to work or ADLs considered outside Olerud Molander score. Suggests tricortical screws for ruptured syndesmosis repair may provide early functional benefit through earlier mobilization by earlier partial weight bearing status. No long-term advantages demonstrated.
Thordarson 2001  RCT	6.0	N = 32 pronation lateral rotation fractures requiring fibular fixation of syndesmosis	PLA (polylactide) syndesmosis screw vs. fibular plate fixation. Stainless steel syndesmosis screw requiring removal of screw on average at 13.4 weeks post-op.	All uncomplicated healing of fibular fractures without loss of function. No evidence of displacement or osteolysis or sterile effusion. No wound complications from original surgery. All	“PLA syndesmotic screw is an attractive [option] to avoid the subsequent morbidity for the removal of the stainless steel screw.”	No blinding, average age PLA group 34.7, in stainless steel 24.2. Study suggests both equally effective for syndesmotic stabilization with major benefit of eliminating need for

				satisfied with surgery. No difference in subjective complaints, pain, walking tolerance. Average ROM: PLA 10° dorsiflexion, 38° plantarflexion. Stainless steel: 8° in dorsiflexion, 45° in plantarflexion.		hardware removal.
Kaukonen 2005 RCT	5.0	N = 40 lateral malleolar fracture with disrupted syndesmosis requiring screw placement	Metallic screws (n = 18) vs. syndesmotic (bioabsorbable) polylevolactic acid screw (n = 20).	Mean operative time decreased in metallic screw group by 15 minutes (p = -0.033). No difference in active ROM, return to sport activity, subjective measures.	"[P]LLA screws may be reliably used in the fixation of syndesmotic ruptures without compromises in the incidence of local postoperative complications."	No blinding or co-interventions noted. PLLA screws did not have increased adverse reactions, and had similar clinical outcomes as metallic screw. Study suggests both methods as effective, with advantage of PLA screws not requiring removal.

### Fibular Fractures

*Recommendation: Operative Fixation for Displaced Distal Fibula Fractures*

**Operative fixation is recommended for displaced distal fibula fracture.**

*Indications* – Distal fibula shaft fracture, unsatisfactory closed reduction.

*Strength of Evidence* – **Recommended, Insufficient Evidence (I)**

*Level of Confidence* - High

#### *Rationale for Recommendation*

There are no quality trials comparing conservative management of distal fibular shaft fracture with operative care. There is one quality trial that compared rod with plate fixation that demonstrated faster

return to full weight bearing.(743) (Pritchett 93) However, these results are limited as the study was conducted in an elderly population and may not be applicable to the working population. Thus, operative fixation is recommended for displaced, unstable distal fibular fractures. There is insufficient quality evidence for recommendation of one technique over another.

#### *Evidence for the Operative Management of Fibular Shaft Fractures*

There is 1 moderate-quality RCT incorporated in this analysis.

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Groups	Results	Conclusion	Comments
Pritchett 1993  RCT	4.0	N = 50 unstable fibular fractures in elderly patients, supination- eversion Stage IV	Rush rods (n = 25) vs. AO plates (n = 25).	Rush Rod: 88% good or fair functional results. Full weight bearing was possible 6 weeks earlier. AO Plate: 76% had good or fair functional results. 2 deep infections and 2 non-unions resulting in 2 ankle fusions.	“The load sharing nature of the fixation allows early weight bearing, which is beneficial for many patients. Also, patients may return to their preoperative status (and hence, home) more rapidly with intramedullary fixation.”	Lack of details. Intramedullary rod has potential to decrease morbidity with earlier weight bearing on fractured ankle. Reported less morbidity with rod vs. AO plate.

#### **Arthroscopy with ORIF of Distal Fibular Fractures**

Distal fibular fractures treated surgically can result in residual pain and disability despite satisfactory reduction(737) (Thordarson 01) that has been attributed to untreated intraarticular injuries.(744) (Takao 04)

*Recommendation: Use of Arthroscopy Assisted ORIF for Distal Fibular Fractures*

**There is no recommendation for or against the use of arthroscopy-assisted ORIF for distal fibular fractures.**

**Strength of Evidence – No Recommendation, Insufficient Evidence (I)**

*Level of Confidence - Low*

#### *Rationale for Recommendation*

There are no quality trials for arthroscopic-assisted ORIF compared with ORIF alone for the treatment of distal fibular fractures. Two low-quality trials demonstrated conflicting reports for arthroscopic-assisted ORIF. One trial demonstrated better clinical AOFAS scores in the arthroscopic-assisted ORIF group, as patients were diagnosed and treated for osteochondral lesions, and talofibular ligament disruptions.(744) (Takao 04) The other study found no differences in outcomes.(737) (Thordarson 01) Arthroscopy may improve detection of osteochondral deficits and ligament rupture; however, functional outcomes from chondroplasty or ligament repair in addition to ORIF are unknown. There is insufficient evidence to recommend for or against this technique.

#### *Evidence for the Use of Arthroscopy Evaluation during Distal Tibia Fracture Fixation ORIF*

There are no quality RCTs incorporated into this analysis. There are 2 low-quality RCTs in Appendix 1.(737, 744) (Takao 04; Thordarson 01)

#### **Deltoid Ligament Repair with ORIF of Lateral Ankle Fracture**

Repair of the deltoid ligament associated with ankle fracture is described.(745) (Stromsoe 95)

*Recommendation: Deltoid Ligament Repair Concurrent with ORIF for Unstable Ankle Fractures*  
**Performing repair of torn deltoid ligament in association with ORIF for ankle fracture is not recommended.**

*Strength of Recommendation – Not Recommended, Insufficient Evidence (I)*  
*Level of Confidence - Moderate*

*Rationale for Recommendation*

There is one moderate-quality trial-comparing repair of rupture deltoid ligament with no repair in patients undergoing ORIF for unstable ankle fractures of lateral malleolus that demonstrated no significant differences in outcomes at short- or long-term follow-up (17 months).(745) (Stromsoe 95) The study suggests surgical repair of a ruptured deltoid ligament is not currently recommended as it can add to surgical time without evidence of clinical benefit, although there may be circumstances outside of the trial criteria of Weber B and C lateral malleolar fractures that warrant repair. The use of weight-bearing radiographs is reported to be an effective, pain-free, and reliable method to exclude the need for operative repair of isolated lateral malleolar fractures with possible deltoid injury.(657) (Weber 10) There is insufficient evidence for recommendation of deltoid repair associated with ankle fracture.

*Evidence for the Repair of Deltoid Ligament with Lateral Ankle Fracture Fixation*

There is 1 moderate-quality RCT incorporated in this analysis.

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Stromsoe 1995 RCT	4.5	N = 50 Weber type-B or C with ruptured deltoid ligament; plaster slab 2-3 days, mobilization allowed on crutches with full weight bearing at or after 6 weeks.	No repair of deltoid ligament with ORIF vs. repair of deltoid ligament with ORIF.	Mean average operation time 75 minutes for suture group vs. 95 for ligament repair group. Mean hospital stay 6 days; absence from work 7 weeks. No difference in symptoms and clinical findings at review. All radiographs showed normal healing.	“[R]uptured deltoid ligament can be left unexplored without any effect either on early mobilisation or on the long-term result.”	Assessor blinded at 17-month follow-up visit. Many details sparse. Difference in age between 2 groups. Study suggests repair of deltoid ligament in Weber type B or C fractures may not change clinical outcome.

**OPERATIVE PROCEDURES AND FIXATORS**

There are many RCTs evaluating various fixator products for ankle fractures, including rods, plates, and metallic and bioabsorbable materials.(715, 733, 738, 747, 748) (Høiness 04; Joukainen 07; Rokkanen 85; Kaukonen 05)

*Recommendation: Operative Procedures and Fixators*

**There is no recommendation for or against the use of a specific operative product.**

*Strength of Evidence – No Recommendation, Insufficient Evidence (I)*  
*Level of Confidence - Low*

*Rationale for Recommendation*

A majority of the studies failed to find one approach superior to another and some provide conflicting results. Additionally, the variability of the types of fractures provides additional uncertainty regarding optimal intervention(s). Thus, there is no recommendation for or against the use of a specific product.

*Evidence for the Use of Operative Procedures and Fixators for Ankle Surgery*

There are 4 moderate-quality RCTs incorporated into this analysis. There are 8 low-quality RCTs in Appendix 1.(688, 741, 744, 747, 749-752) (Dijkema 93; Kankare 96; Takao 04; Bucholz 94; Ahl 94; Moore 06; Kankare 95; Thordarson 01)

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Høiness 2004 RCT	7.0	N = 64 closed ankle fractures and unstable syndesmosis; AO fracture type B and/or C	Tricortical fixation with 2 3.5mm screws through 1 cortex of tibia after 2-3 days, 2-5kg weight bearing for 6 weeks. (TC) vs. Quadricortical fixation with 1 4.5mm screw through both tibial cortices. No weight bearing 8-12 weeks (QC).	Olerud-Molander functional scores: TC- 77, QC 66 (p = 0.025) at 3 months, at 1 year (NS). Pain: TC<QC (p = 0.017) at 3 months, at 1 year (NS). Dorsiflexion: No difference; no loss of fixation in any patient; 2 in TC had to have screws removed.	“[T]ricortical screw fixation of a ruptured syndesmosis is adequate and improves early function compared with the traditional transsyndesmototic fixation with bicortical holds in the tibia.”	No blinding, no mention of co-interventions. No return to work or ADLs outside of Olerud Molander score. Suggests tricortical screws for ruptured syndesmosis repair may provide early functional benefit through earlier mobilization by earlier partial weight bearing status. However, no long-term advantage reported.
Joukainen 2007 RCT	5.5	N = 62 displaced ankle fractures needing operative treatment. Weber B or C	Bioabsorbable screws for fixation: SR-PLA70 screws (retains strength for 24 weeks vs. SR-PLLA screws (retains strength for 36 weeks).	Only difference in sick days: SR-PLA70 60, SR-PLLA 65 (p = 0.02). Operating time, at one year: ROM, pain, x-rays, Olerud-Molander score no statistical difference. No difference in return to sports or syndesmototic ossification.	“Both SR-PLA70 and SR-PLLA screw implants exhibited good biocompatibility.”	No blinding and no information on co-interventions. Suggests SR-PLA70 and SR-PLLA bioabsorbable screws have similar outcomes. Lack of comparison group limits conclusion regarding method vs. other fixation methods.
Rokkane 1985 RCT	5.0	N = 44 displaced ankle fractures	Metallic implants (n = 22) vs. biodegradable implants (n = 22).	Mean operating time 34 minutes in metallic group and 42 minutes in biodegradable group; 1/22 (4.5%) had a non-anatomic	“[T]he biodegradable fixation method is advantageous because the removal procedure	Lack of study details Suggests equivalency of biodegradable implants with metal implants in outcomes measures.

				reduction. Mean number of sick days equal between groups. No difference in “outcome” measures.	associated with metallic implants is avoided.”	
Kaukone n 2005 RCT	5.0	N = 40 lateral malleolar fractures with disrupted syndesmosis requiring screw placement	Metallic screws (n = 18) vs. syndesmotic (bioabsorbable) polylevolactic acid screw (n = 20).	Mean operative time was decreased in metallic screw group by 15 minutes (p = .033). No difference in active ROM, return to sport activity, subjective measures.	“[P]LLA screws may be reliably used in the fixation of syndesmotic ruptures without compromises in the incidence of local postoperative complications.”	No blinding or co-interventions. PLLA screws did not have increased adverse reactions; had similar clinical outcomes as metallic screw. Suggests both methods as effective; advantage of PLA screws no removal required.

**Physical Methods/Rehabilitation**  
**POST OPERATIVE CARE DRESSING**

*Recommendation: Post-operative Care Dressing for Ankle Surgery*

**There is no recommendation for or against the use of post-operative dressing for ankle surgery.**

*Strength of Evidence – No Recommendation, Insufficient Evidence (I)*

*Level of Confidence - Low*

*Rationale for Recommendation*

There is no quality evidence evaluating the post-operative use of dressings to manage ankle fractures. There is one low-quality trial that compared immobilization with back slab to wool and crepe bandage immediately post-operation that demonstrated no differences between the two groups.(753) (Reed 98) The use of post-operative dressings is non-invasive, has no adverse effects, and is low cost. There is no recommendation for dressing type.

*Evidence for the Use of Post-Operative Dressings for Ankle Surgery*

There are no quality studies. There is 1 low-quality RCT in Appendix 1.(753) (Reed 98)

**CAST IMMOBILIZATION**

*Recommendation: Cast Immobilization for Ankle Fractures*

**Cast immobilization is moderately recommended for the management of ankle fractures.**

*Indications – All ankle fractures.*

*Frequency/Duration – Immobilization generally for 6 to 8 weeks.(754-762) (Dogra 99, Franke 08, Hedstrom 94, Ahl 86, Lehtonen 03, Tropp 95 Honigmann 07, Van Laarhoven 96, Ahl 89)*

*Strength of Evidence – Moderately Recommended, Evidence (B)*

*Level of Confidence - High*

### *Rationale for Recommendation*

There are nine moderate-quality trials that compared cast immobilization to other methods, including orthosis, removable cast, and splint with and without early motion and early weight-bearing that demonstrated equivocal results.(754-762) (Dogra 99, Franke 08, Hedstrom 94, Ahl 86, Lehtonen 03, Tropp 95 Honigmann 07, Van Laarhoven 96, Ahl 89) Cast immobilization is recommended for all patients and the use is dependent on physician and patient preference.

## **EARLY MOBILIZATION**

*Recommendation: Early Mobilization for Ankle Fractures*

**Early mobilization is moderately recommended in the management of post-operative and stable non-operative ankle fractures.**

*Indications* – Stabilized malleolar fractures with or without surgery and closed ankle fractures with adequate fixation and stabilization.

*Frequency/Duration* – Early mobilization can be started within 1 to 3 days post-operatively.(754-756, 763, 764) (Dogra 99, Franke 08, Lehtonen 03, Egol 00, Sondenaa 86)

*Strength of Evidence* – **Moderately Recommended, Evidence (B)**

*Level of Confidence* - Moderate

### *Rationale for Recommendation*

There are 10 moderate-quality trials comparing early motion/mobilization with cast immobilization post operatively.(754-758, 760, 763-767) (Dogra 99, Franke 08, Hedstrom 94, Vioreanu 06; Vioreanu 07, DiStasio 94, Ahl 86, Lehtonen 03, Egol 00, Sondenaa 86, Tropp 95) Four of the studies demonstrated near-term benefit in pain, swelling, functional improvement, and early return to work,(763-766) (Vioreanu 07, DiStasio 94, Egol 00, Sondenaa 86) while the other six studies demonstrated equivocal outcomes.(754-758, 760) (Dogra 99, Franke 08, Hedstrom 94, Ahl 86, Lehtonen 03, Tropp 95) One of these equivocal studies included early motion for only the first 2 weeks post-operatively, and then the group was immobilized for 4 weeks.(754) (Dogra 99) Pertaining to adverse effects of early motion, one study demonstrated an increase in superficial wound infections(755) (Lehtonen 03) and another reported infections although power was insufficient for significance.(766) (Vioreanu 07) There were no reports of increased non-union or delayed union from early mobilization. Of these nine studies, early weight-bearing was included as a co-intervention in four of the trials. In the six studies where early weight-bearing was not allowed,(754, 760, 763-766) (Dogra 99, Vioreanu 07, DiStasio 94, Egol 00, Sondenaa 86, Tropp 95) early motion alone provided positive benefit in four studies. (763-766) (Vioreanu 07, DiStasio 94, Egol 00, Sondenaa 86) There is one trial that compared early weight-bearing with and without early motion that demonstrated no significant differences.(757) (Hedstrom 94) A low-quality trial of early mobilization in tibial plafond fracture with external fixators demonstrated no benefit over no mobilization.(652) (Marsh 06) Thus, there is quality evidence that early motion in the immediate post-operative may provide additional benefit in early return to work and functional recovery, and has few adverse effects other than higher risk for superficial wound infection. Therefore, early mobilization is recommended for most patients with stable or repaired malleolar ankle fracture.

## **EARLY WEIGHT-BEARING**

*Recommendation: Early Post-operative Weight-bearing for Ankle Fractures*

**Early weight-bearing of operatively fixated ankle fractures postoperatively is moderately recommended.**

*Indications* – Stabilized malleolar fractures with or without surgery and closed ankle fractures with adequate fixation and stabilization.

*Strength of Evidence* – **Moderately Recommended, Evidence (B)**

*Level of Confidence* - Moderate

### Rationale for Recommendation

There are seven moderate-quality trials comparing early weight-bearing (prior to 6 weeks post ORIF) to delayed weight bearing.(755-759, 761, 762) (Honigmann 07, Van Laarhoven 96, Franke 08, Hedstrom 94, Ahl 89, Ahl 86, Lehtonen 03) One trial demonstrated better functional results and earlier return to work with early weight-bearing using an orthosis.(756) (Franke 08) The remaining trials demonstrated equivocal results with no increase in dislocation or other deficit. There is also one low-quality trial that demonstrated the advantage of early weight-bearing over non-weight bearing.(768) (Ahl 93) Another low-quality trial found no difference in complications or healing between early mobilization, early weight-bearing, and cast immobilization with no weight bearing.(769, 770) (Finsen 89a; 89b) Described methods for rehabilitation include full weight-bearing using a functional vacuum stabilized orthosis immediately post-operative,(757) (Hedstrom 94) at 2 weeks,(761) (Honigman 07) or with graduated weight-bearing beginning with 20kg weight bearing on Day 2.(756) (Franke 08) Other methods include weight bearing with walking cast on post-operative Day 1,(757-759, 762) (Van Laarhoven, 96, Hedstrom 94, Ahl 86, Ahl 89) or graduated weight-bearing in cast at 2 weeks with full weight-bearing at 4 weeks.(755) (Lehtonen 03) Athletes that underwent ORIF followed by early motion and early weight-bearing were able to return to their pre-injury level of competition within 2 to 4 months with minimal residual complaints or deficits.(771, 772) (Jelinek 09, Porter 08) Early weight-bearing therefore may provide improvement in functional recovery short-term, does not appear to result in increased adverse events, is of low incremental cost difference, and is therefore recommended.

### Evidence for the Use of Immobilization, Early Mobilization, Early Weight-bearing for Ankle Fractures

There are 13 moderate-quality RCTs (one with two reports) incorporated in this analysis. There are 4 low-quality RCTs (one with two reports) in Appendix 1.(652, 768-770, 773) (Finsen 89a; Finsen 89b; Ahl 93; Fitzgerald 94; Marsh 06)

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Dogra 1999 RCT	7.0	N = 52 bi-malleolar ankle fractures requiring surgery	Early mobilization (EM) started 24 hours post-op: 10 minutes dorsiflexion and plantarflexion 4 times a day for 2 weeks. Then, below-knee plaster cast applied until Week 6 with partial weight-bearing vs. 6 weeks of plaster cast (IM).	At 3 months: average pain and Olerud score not different. ROM Plantar mean loss: EM = 12.31 degrees, IM = 12.69 (p = 0.83). Symmetrical gait: EM = 20/26 (77%); IM = 6/26 (23%) (p = 0.0001).	“We have demonstrated in our study that ankle remobilisation in the first 2 weeks after surgery does not make a difference to the early outcome at 12 weeks.”	Lack of details for co-interventions and compliance with exercises or weight-bearing status. Suggests 2 weeks of early mobilization followed by 4 weeks of immobilization post-op for bi-malleolar fractures does not have a large clinical benefit at 12 weeks.

Honigmann 2007 RCT	6.5	N = 45 Weber A or B isolated malleolar fracture post-ORIF	Vacuum stabilized orthosis with full weight bearing after 2 weeks and walking without crutches at 3 weeks if able vs. partial weight bearing of 15kg for 6 weeks.	At discharge and 6 weeks, no difference between groups for ability to partially bear weight. Control group favored for mean difference of plantar flexion of 2.5° (p = 0.05) and inversion of 10° (p = 0.02) after 6 weeks.	“We observed that patients receiving surgical treatment for malleolar fractures of the types Weber A and B experienced no adverse events when being treated with a functional orthosis.”	No blinding/lack of details on compliance with weight-bearing and co-interventions. Early mobilization appears to trend for earlier return to work with a mean of 37 days in orthosis group compared to 53 days in control (p = 0.79).
Van Laarhoven 1996 RCT	6.0	N = 81 ankle fractures AO A, B, and C managed by ORIF	Post-op management with weight bearing in a below-knee walking plaster cast vs. non-weight bearing with crutches.	Walking plaster group had small difference for subjective ankle score and linear analogue score compares to non-weight bearing, p = 0.03 and p = 0.02. AO type B and type C had no difference. No difference between groups at 12 months.	“Early application of a walking plaster did not result in an increased rate of complications such as wound dehiscence, superficial wound infection, arthritis, osteitis or secondary dislocation.”	No blinding or discussion of compliance with weight bearing vs. non-weight bearing. No clinical difference at 12 months, thus benefits of early ambulation should not be discounted for fear of complications in ankle fractures AO types A, B and C.
Franke 2008 RCT	6.0	N = 27 Weber B fractures status post ORIF	Dynamic vacuum orthotic applied for 6 weeks post-op to allow movement of 10-0-10° of upper ankle joint movement. Allowed 20kg weight bearing post-op Day 2, full weight bearing post-op Day 15 (O) vs. circular cast with dorsal window cut out to allow dorsal	Olerud Molander score 10 weeks: O = 95; C = 75 (p = 0.02). ROM in plantar flexion at 6 weeks: O>C (p = 0.005). Pain 10 weeks: C>O (p = 0.004). Wound healing complications: O = 2/14 (14%), C = 1/13 (8%). Return to work: O = 52 days (10-87), C = 76 days (45-95) (p = 0.02). Time spent by medical staff to treat O group, 3-4 times less than C	“The orthosis is the prerequisite for early return to work. Its application not only reduces the working time required by medical personnel but it is also likely to save on expenditure for treatment, aftercare and rehabilitation.”	No blinding, no mention of co-interventions or pain medication use. Orthosis does appear to provide benefit for return to work and activities. Wound complication rate similar between two groups.

			extension of talocrural joint; 6 weeks immobilization (C).	group. Cost: O = 381 E, C = 419 E.		
Hedstrom 1994 RCT	5.0	N = 53 dislocated lateral malleolar fractures >2mm requiring ORIF	Post-op protocol of orthosis with active ankle movement and weight bearing vs. walking cast with no ankle movement.	Linear analogue scale results better for orthosis patients at 3-month follow-up examinations, p = 0.02.	"[I]n this prospective randomized study it is not possible to show any clinical advantages by active ankle movements."	No blinding, lack of study details. Baseline difference in classification levels between groups with 5 supination eversion III in cast group and 2 in orthosis group. Suggests no difference in early ankle mobilization compared with cast.
Vioreanu 2007, 2006 RCT	5.0	N = 66 closed Weber A, B, C post ORIF; posterior splint until suture removed (10-14 days) and non-weight bearing	Early mobilization (EM) at 2 weeks vs. immobilization. Both non-weight bearing until Week 6. Early motion group performed exercises 3 times a day for 10 minutes, active and passive ROM with PT.	Return to work: EM-67 days, LM-95 days. (p <0.05). No difference in SF-36 at 6 months; 3 post-op infections in EM. EM had better ROM at 6 weeks (p <0.05). No difference in swelling at 6 weeks. EM had less muscle wasting (p <0.005) at 6 weeks.	"[E]arly motion is consistently beneficial for all outcomes, including pain relief, range of motion, swelling, and return to work."	No blinding. Data suggest early mobilization is associated with earlier return to work and less muscle wasting.
Ahl 1989 RCT	4.5	N = 99 dislocated lateral or bi-malleolar fracture (lateral and medial malleoli) with verified rupture of anterior	Early weight-bearing group: starting 1st postoperative day. Below-knee cast for 7 weeks vs. late weight bearing group: 4th or 5th post-op week. Below-knee cast for 7 weeks.	No differences at 18-months between 2 groups for healing, arthrosis, roentgenographic stereophotogram metric analysis. No negative consequences in 14 patients with ruptured deltoid ligament that was not repaired.	"Early weight bearing does not result in fracture dislocation. No tendency to redislocation was revealed, supporting the opinion that a repair of the deltoid ligament is unnecessary."	Lack of blinding, No mention of co-interventions. Suggests no long-term consequences from early mobilization after surgical fixation. Also suggests no consequence of not repairing deltoid ligament although sample only included 14

		tibiofibular ligament				with ruptured ligament.
DiStasio 1994 RCT	4.5	N = 61 active duty military patients with isolated closed ankle fractures	Six weeks of removable orthosis, starting PT 1 week post-op, 6 weeks non-weight bearing vs. 6 weeks short leg cast, starting PT at 6 weeks; 6 weeks non-weight bearing.	At 3 months post-op, short-leg cast group had lower scores compared to removable orthosis (p = 0.0001). Difference remained at 6 months (p = 0.0027). No difference in strength at 3 months, no difference in swelling at 3 months, no difference in functional testing at 3 months.	“The use of a removable orthosis for six weeks is advocated, with the patient non-weightbearing and following a formal physical therapy program emphasizing edema control, early motion, and strengthening.”	Exact details of fracture and surgery lacking in study. Return to full duty was not different, but study done in military population. 6 weeks of removable orthosis and early physical therapy appears to have subjective benefit.
Ahl 1986 RCT	4.5	N = 46 dislocated fractures of fibula with pre-op verified ruptures of anterior tibiofibular ligament	Early weight bearing from 1st post-op day (n = 24) vs. late weight bearing from 4th post-op week (n = 22). Both groups had below-knee cast for 7 weeks.	All fractures healed “properly.” No infections. No significant difference in swelling, circumference of ankle or calf, or range of motion at 3 or 6 months.	“[W]ith the use of this operative technique, using a minimum amount of osteosynthesis devices, an exact reconstruction of the ankle mortise can, as a rule, be achieved with sufficient stability to allow immediate postoperative weight bearing in a walking cast.”	Lack of details. No functional outcomes measured to see if early mobilization affected ADLs or return to work. Early weight bearing in stable lateral malleolus fractures without demonstrable adverse events.
Lehtonen	4.5	N = 100 unstable	Early mobilization in	All fractures healed well. No	“In conclusion, the results of	No blinding, no mention of co-

2003 RCT		and/or displaced Weber Type A or B with ORIF and casting for 6 weeks, non-weight bearing for 2 weeks, then partial weight bearing to 4 weeks, then full weight bearing at 6 weeks	Aircast. Daily ROM exercises immediately post-operatively vs. immobilization group in below-knee cast for 2 weeks. Then in weight-bearing fiberglass cast until 6 weeks.	difference in ankle swelling, atrophy of calf muscles, laxity of ankle joint, active ROM (NS). Overall complications rates between the cast group (16%) and the brace group (66%) was significant ( $p = 0.0005$ ) with the majority of the increased complications in the brace group being wound infections.	this study show that the postoperative treatment of ankle fractures can be accomplished equally effectively both with use of a plaster cast and with a functional brace. The risk of postoperative wound complications associated with this treatment approach is considerably increased compared with that after conventional cast treatment.”	interventions or compliance with program. Mobilization began immediately post-op which may have contributed to increased wound complication rate seen in study.
Egol 2000 RCT	4.0	N = 60 unstable fractures requiring ORIF; Weber B fractures; all in plaster splint 2-3 days after surgery then randomized into groups (both groups non-weight bearing at least 6 weeks)	Function removable brace with early movement (active and passive exercises of ankle and subtalar joint by PT then at home 3x/day) vs. immobilization postoperatively in below the knee cast. PT after 6 weeks.	All fractures clinically united at 6 weeks and radiographically united at 12 weeks. Early mobilization group had higher functional scores (0-100) at all follow up visits but only significant at 6 weeks 56.5 vs. 52.4 ( $p = 0.03$ ). Return to work: Early mobilization mean days 53.8, immobilization 106.5 ( $p = 0.007$ ).	“We recommend the use of functional bracing and early exercises after operative treatment of fractures of the ankle.”	Study excluded workers’ compensation claims. No blinding, lack of study details on compliance with exercises, co-interventions, and randomization process. No mention of type of work in each group for RTW analyses. Suggests faster return to work with functional bracing and early mobilization with no increase in adverse events.
Sonden aa 1986 RCT	4.0	N = 43 ankle fractures requiring surgery	Primary mobilization group: plaster cast for 3 days. Full weight-	At 6 weeks, ROM greater in primary mobilization group ( $p < 0.01$ ). Swelling decreased in	“Plaster immobilization after ankle fracture results in a minor	Lack of study details. Compliance uncertain. Early mobilization

			bearing at 6 weeks vs. Immobilization group: plaster cast for 6 week with no weight bearing.	mobilization at 12 weeks (p <0.05). Pain less in mobilization group at 6, 12, 18 weeks follow-up; equal 1 year follow-up.	increase in morbidity. If the patient is cooperative and fixation of the fracture stable, an early mobilization (1 week) is preferable.”	appears to increase ROM, decrease pain and swelling in stable fractures.
Tropp 1995  RCT	4.0	N = 30 Weber B or C ankle fractures requiring ORIF	Double-hinged brace (received program for self training or mobility, muscular strength, and function immediately post-op) vs. plaster cast (post-op for 6 weeks, full weight bearing allowed with crutches for 2-4 weeks, then same self-training program at 6 weeks.	At 6 weeks 6/15 (40%) in brace group vs. 1/15 (7%) in cast group showed failure of syndesmotomic staples. No correlation in displacement or fracture healing. No difference in ankle scores or ROM improvement compared to uninjured ankle at 12 months. No difference Olerud function scores. ROM: dorsiflexion better in brace group at 1 year (p <.05), no correlation with functional outcomes at 12 months.	“We conclude that the double-hinged brace is appreciated by the bearer. Higher ROM was noted in the brace group, but the obvious advantage of the brace is subjective to the bearer. There is a higher expense for the brace than for the plaster cast. Long-term results of brace and case treatment are comparable.”	No blinding, no mention of co-interventions, no baseline characteristics provided. No mention of compliance with exercise program in either group or compliance with weight bearing status. Suggests earlier mobilization does not appear to increase adverse events after Weber B or C ankle fractures.

## Edema Management

### PNEUMATIC COMPRESSION

*Recommendation: Pneumatic Compression for Treatment of Ankle and Foot Edema*

**Use of pneumatic compression of foot and ankle to reduce swelling is recommended for patients with significant post-operative edema.**

*Indications* – Excessive swelling after ankle fractures surgery.

*Strength of Evidence* – **Recommended, Evidence (C)**

*Level of Confidence* - Low

#### *Rationale for Recommendation*

There are three moderate-quality trials comparing pneumatic compression or cold compression devices with a regimen of ice, splint, and elevation for managing edema in the peri-operative period that demonstrated effective reduction in swelling.(774-776) (Thordarson 97, Mora 02, Caschman 04) These devices are noninvasive, have no significant adverse effects, and are moderately costly when used in a

hospital setting. They are recommended for patients who have significant peri-operative edema. There is no quantified definition of “significant edema” found in the quality trials, and therefore clinical judgement of appreciable edema is warranted.

*Evidence for the Use of Pneumatic Compression for Edema Management*

There are 3 moderate-quality RCTs incorporated into this analysis.

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Thordarson 1997 RCT	6.0	N = 30 Weber B and C ankle fractures	Pneumatic pedal compression device pre-operatively vs. posterior splint, ice, elevation before surgery.	Compression group: change in volume Day 1-2: -88ml (p = 0.027), Day 1-3: -31ml (p = 0.049). Control group: change in volume Day 1-2: +33ml, Day 1-3: +32ml.	“Pneumatic pedal compression device resulted in a significant decrease in preoperative edema after ankle fractures compared with a control group.”	No baseline characteristics provided. No blinding. Suggests compression device is effective in reducing pre-operative edema in ankle fracture patients.
Caschman 2004 RCT	5.5	N = 64 closed unilateral fractures unable to be operated on immediately secondary to edema but in need of surgery	Pneumatic compression in cast device (AVI) (n = 27) vs. elevation (control) pre-op (n = 27). Compression continuous until time of surgery and without elevation.	AVI vs. Elevation: mean final pre-op swelling (mm±SD): control (24.0± 16.6) vs. AVI (13.1±13.2), p = 0.030. A-V bladder: 3/27 (11%) had soft-tissue complications. 2/27 (7%) had blisters. Limb elevation: 12/27 (44%) had soft-tissue complications; 7/27 (26%) skin blisters, 2/27 (7%) post-op DVT. A-V bladder group went to surgery on average 3.5 days earlier than limb elevation group (not significant).	“[T]he A-V impulse in-cast system is of value in reducing preoperative swelling following ankle fracture, and this is associated with a reduction in delay of surgery and overall morbidity.”	Suggests pneumatic compression superior to elevation alone for reducing edema pre-operatively and complications associated with fracture blister.

Mora 2002  RCT	5.5	N = 24 closed ankle fractures that required ORIF; Weber A, B, C and medial malleolar fractures	Pulsatile cold compression (PCC) device applied to ankle, on bed rest with foot elevated vs. posterior molded splint, bed rest with elevation (C).	Circumferential decrease in cm: 24 hours = PCC-0.5, C-0.1 (p <0.001). 48 hours = PCC-0.9, C-0.4 (p <0.001). 72 hours = PCC-1.2, C-0.5 (p = 0.009). All patients had mean satisfaction score of 4 (1-4).	“The Cryo/Cuff compression dressing and AutoChill system significantly decreased edema in ankle fractures before surgery compared to splintage and elevation alone.”	No blinding or mention of co-interventions. All patients 3 days post-injury when randomized. Pump system cost \$150. Clinical outcome measures (shorter operative time, functional outcomes after surgery, wound infection) not reported.
----------------------	-----	--	--	---	--	---

## INTERFERENTIAL THERAPY

*Recommendation: Interferential Therapy for Treatment of Ankle Edema*

**Interferential therapy for the treatment of post-operative swelling following ORIF for displaced malleolar fracture is moderately not recommended.**

*Strength of Evidence – Moderately Not Recommended, Evidence (B)*

*Level of Confidence - Moderate*

### *Rational for Recommendation*

There is one high-quality trial comparing interferential current therapy with sham before and after ankle surgery that demonstrated no difference in foot or ankle volumetric measures.(777) (Christie 90) Interferential therapy is non-invasive, has no side effects, is of moderate cost, but is of low efficacy and therefore is not recommended for use to control peri-operative ankle and foot swelling.

### *Evidence for the Use of Interferential Current Therapy for Post-operative Edema Management*

There is 1 high-quality RCT incorporated into this analysis.

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Christie 1990  RCT	8.0	N = 24 receiving open reduction and internal fixation	Interferential therapy (electrotherapy) 20 minutes a day before casting and after surgery (2-4 days) vs. placebo.	Foot/ankle volumetric changes: no difference (p >0.05), no trend seen.	“The results of this double-blind study do not support the use of interferential therapy in the treatment of oedema.”	Interferential therapy does not appear effective.

## **Physical Methods**

### **ELECTRICAL STIMULATION**

The use of percutaneous electrical stimulation to prevent muscle atrophy has been described.(778) (Hernandez 06)

*Recommendation: Electrical Stimulation for Prevention of Muscle Atrophy*

**There is no recommendation for or against the use of electrical stimulation for prevention of muscle atrophy in ankle and foot fracture management.**

*Strength of Evidence – No Recommendation, Insufficient Evidence (I)*

*Level of Confidence - Low*

*Rationale for Recommendation*

There are no quality trials for the use of electric stimulation of ankle or foot fractures. There is a low-quality trial of electrical stimulation added to post-operative ORIF for ankle fracture failed to reach statistical significance for any outcomes compared with no stimulation.(778) (Hernandez 06) It has not demonstrated clinical benefit in distal upper extremity fractures.(779) (Wahlstrom 84) This treatment can be invasive with implantable direct current electrodes or can be non-invasive, generally have low adverse effects, but may be costly depending on the frequency and type of treatments. There is no recommendation for the use of electrical stimulation devices for ankle and foot fractures.

*Evidence for the Use of Electrical Stimulation for Ankle and Foot Fractures*

There are no quality studies incorporated into this analysis. There is 1 low quality RCT in Appendix 1.

**PHYSICAL OR OCCUPATIONAL THERAPY**

*1. Recommendation: Therapy for Patients with Functional Debilities after Cast Removal*

**Referral of patients with functional debilities or inability to return to work for therapy after cast removal for ankle fractures is recommended.**

*Strength of Evidence – Recommended, Insufficient Evidence (I)*

*Level of Confidence - Moderate*

*2. Recommendation: Manual Therapy as Part of a Post-ankle Fracture Rehabilitation Program*

**Manual therapy is not recommended as part of an active post-ankle fracture rehabilitation program.**

*Strength of Evidence – Not Recommended, Evidence (C)*

*Level of Confidence - Low*

*3. Recommendation: Passive Stretching for Contractures after Immobilization of Ankle Fractures*

**Passive stretching is moderately not recommended for contractures after immobilization of ankle fractures.**

*Strength of Evidence – Moderately Not Recommended, Evidence (B)*

*Level of Confidence - Moderate*

*Rationale for Recommendations*

There is one moderate-quality trial of supervised physical therapy compared to usual care that demonstrated subjective and objective improvement in the supervised therapy group in persons under age 40.(780)(Nilsson 09) However, no benefit was found when not adjusted for age group and treatment effect. The study may have been underpowered, but the observed effect was likely of small clinical benefit. A high-quality trial comparing exercises alone, exercise with short-duration passive stretches, and exercise with long-duration passive stretches demonstrated no differences among groups when considering outcomes of passive dorsiflexion, pain, return to usual work, or participation in sports and leisure activities.(781) (Moseley 05) A moderate-quality study comparing physical therapy with and without manual therapy after cast removal demonstrated no differences in outcomes after 4 weeks.(782) (Lin 08) There is also a low-quality study comparing exercises with and without manual therapy for 3 weeks that reported increased active range of motion in the manual therapy group.(783) (Wilson 91)

Some patients, such as the young or athletic, may recover quickly and not gain much from therapy. Other patients may benefit from formal therapy after removal of a cast or splint to address disabilities. A few appointments for educational purposes for select patients are recommended. The number of appointments is dependent on the degree of debility, with 1 or 2 educational appointments appropriate for mildly affected patients. Patients with severe debility or those unable to return to work may benefit from 8 to 12 appointments that include assignment of and guidance with progressive stretching and strengthening exercises.

*Evidence for the Use of Therapy for Ankle Fractures*

There are 2 high-quality and 1 moderate-quality RCTs incorporated with this analysis. There is 1 low-quality RCT in Appendix 1.(783)

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Moseley 2005 RCT	8.5	N = 150 plantarflexion contracture patients after ankle cast immobilization for fracture	Exercises plus short-duration passive stretch: 6 minutes a day broken into 12, 30-second stretches vs. exercises plus long-duration stretch: 30 minutes a day vs. exercises; 4 week home-based program. Up to 5 PT visits after cast removal. Included exercises for mobility, strengthening, stepping, weight bearing, balancing.	No difference in main outcomes measures of passive dorsiflexion with knee bent and straight or Lower extremity functional scale. At 4 weeks, long-duration group felt more ready to return to sports and leisure activities (p = 0.03) but not at 3 months.	“The addition of a program of passive stretches confers no benefit over exercise alone for the treatment of plantarflexion contracture after cast immobilization for ankle fracture.”	Exercise program details sparse. No benefit found from passive stretching of either duration in addition to a 4 week exercise program for plantarflexion contractures after casting. Suggests treatment emphasis should be on exercise compliance not stretching.
Lin 2008 RCT	8.0	N = 94 isolated ankle fractures: able to weight bear or partial-weight bear and referred to PT with some residual pain	PT and manual therapy with anterior-posterior joint mobilization over talus. Seen twice a week for 4 weeks for MT, maybe longer for PT vs. PT; twice a week for 1st week, then once a week for	No significant difference in primary outcomes of activity modifications or quality of life between groups. Control group had increase return to sports and activities over MT at 12 weeks. Fracture severity did not influence outcomes.	“When provided in addition to a physiotherapy programme, manual therapy did not enhance outcome in adults after ankle fracture.”	No blinding of participant or therapist, but assessor was blinded. No mention of co-interventions. Manual therapy added costs but not any other benefits over PT in patients after ankle fractures with or without surgical fixation.

			at least 4 more weeks.	Experimental group incurred an increase cost on average of \$200.00AU more.		
Nilsson 2009 RCT	6.0	N = 110 post-op ankle fracture fixations	Supervised PT 12-week program vs. usual care (education on home exercises, PT if ordered by MD).	Training vs. control; average PT visits: 17 vs. 7 (p <0.001). Olerud Molander Score: no differences when unadjusted. For <age 40; 78.1 vs. 65.5 at 6 mos, 86.5 vs. 72.8 at 12 mos, p = 0.028. SF-36 Physical Health: no differences; SF-36 Mental Health (MCS): no differences.	“The training model used in this study showed superior results compared to usual care regarding subjectively scored function and muscle strength in the plantar flexors and dorsiflexors in patients under the age of 40. However, only three out of nine outcome measures showed a difference.”	Co-interventions allowed (usual care). Compliance with supervised program uncertain. Reported results only showed positive effect for 3 variables after adjustment for age group and treatment effect. No differences otherwise. Results appear likely of small clinical significance.

## ULTRASOUND

*Recommendation: Ultrasound to Stimulate Bone Healing for Ankle and Foot Fractures*

**Ultrasound is moderately not recommended for ankle and foot fracture management.**

*Strength of Evidence – Moderately Not Recommended, Evidence (B)*

*Level of Confidence - Moderate*

### *Rationale for Recommendation*

There is one high-quality trial for the use of ultrasound stimulation of ankle or foot fractures.(784) (Handolin 05) Ultrasound applied daily for 20 minutes compared to sham demonstrated no additional benefit in healing of lateral malleolar fractures fixed with bioabsorbable screw. Ultrasound stimulation is non-invasive, is of moderate to high cost depending on frequency and duration of treatment, and has low adverse effects. It is not recommended for routine use to promote bone healing.

### *Evidence for the Use of Ultrasound Stimulation for Ankle and Foot Fractures*

There is 1 high-quality RCT incorporated into this analysis.

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
------------------------	--------------	-------------	------------------	---------	------------	----------

Handolin 2005  RCT	9.0	N = 16 dislocated lateral malleolar fractures fixed with 1 bioabsorbable poly-L-lactide screw	Ultrasound machine daily for 20 minutes applied by patient at home vs. sham ultrasound daily for 20 minutes applied by patient at home.	All fractures fully healed. No foreign body reactions documented . No difference in Olerud-Molander scores.	“In conclusion, the six-week low-intensity ultrasound therapy had no effect on radiological bone morphology, bone mineral density or clinical outcome in bioabsorbable screw-fixed lateral malleolar fractures 10 months after the injury.”	Small numbers. No mention of specific co-interventions. Sparse baseline characteristics presented. Suggests ultrasound of no benefit for fracture healing.
--------------------------	-----	--	---	---	---	--

### HYPERBARIC OXYGEN

The use of hyperbaric oxygen has been described for treatment of foot and ankle fractures including non-union, prophylaxis of avascular necrosis, and soft-tissue injury.(785-788) (Mei-Dan 08, Butler 06, Karamitros 06, Greensmith 04)

*Recommendation: Hyperbaric Oxygen for the Management of Ankle or Foot Fractures*

**There is no recommendation for or against the use of hyperbaric oxygen for management of ankle or foot fractures.**

*Strength of Evidence – No Recommendation, Insufficient Evidence (I)*

*Level of Confidence - Low*

#### *Rationale for Recommendation*

There are no quality trials for the use of hyperbaric oxygen to treat ankle or foot fractures. Hyperbaric oxygen is non-invasive and generally safe, although it is high cost. It has been recommended for crush injuries of the upper extremity, although no quality evidence is available for the lower extremity. Therefore, there is no recommendation for the use of hyperbaric oxygen for routine patients for bone healing or prevention of avascular necrosis. In select patients with moderate to severe crush injuries or compartment syndrome, hyperbaric oxygen may be indicated as risks of these conditions are outweighed by potential benefits.

#### *Evidence for the Use of Hyperbaric Oxygen for Ankle and Foot Fractures*

There are no quality studies incorporated into this analysis.

### HYPNOSIS

*Recommendation: Hypnosis to Promote Healing of Ankle and Foot Fractures*

**There is no recommendation for or against the use of hypnosis for the management ankle or foot fractures.**

*Strength of Evidence – No Recommendation, Insufficient Evidence (I)*

*Level of Confidence - Low*

#### *Rationale for Recommendation*

There is one moderate-quality trial of hypnosis for promotion of fracture healing compared to a no-hypnosis group that demonstrated no significant differences as it was underpowered.(789) (Ginandes 99) Hypnosis is non-invasive, has low adverse effects, but is costly with multiple therapist visits. There is insufficient evidence for recommending hypnosis.

#### *Evidence for the Use of Hypnosis for Ankle and Foot Fractures*

There is 1 moderate-quality RCT incorporated into this analysis.

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Ginandes 1999  RCT	4.5	N = 11 acute non- displaced lateral malleolar fractures	Six visits of hypnosis with therapist and daily hypnosis tapes for fracture healing vs. regular care.	At 12 weeks, both groups had normal healing as expected (mean±SEM): fracture line controls (13.7±1.31), fracture line hypnosis (11.6±2.06), fracture edge controls (12.5±1.65), fracture edge hypnosis (11.6±1.96). Self reported VAS lower in hypnosis group Week 1, p = 0.15, Week 3, p = 0.013, and Weeks 6 and 12. Week 9, hypnosis group regained more mobility to injured ankle compared to controls, p = 0.24. Hypnosis group better gait going down stairs Week 6, p = 0.24.	“Despite a small sample size and limited statistical power, these data suggest that hypnosis may be capable of enhancing both anatomical and functional fracture healing.”	Lack of study details. Small sample size. Results suggest no benefit from hypnosis in improving fracture healing.

## Hindfoot Fractures (Calcaneus, Talus)

### Special Studies, Diagnostic and Treatment Considerations

#### X-RAY

*Recommendation: X-ray for Suspected Acute Hindfoot Fractures*

**X-ray is recommended as a first-line study for suspected hindfoot fractures.**

*Indications* – Suspicion of fracture.

*Views* – Calcaneus: AP, lateral, and calcaneal view; Talus: AP, lateral, mortise, Broden views (45° internal oblique) and Canale views (talar neck).(670, 790-792) (Knight 06, Furlong 04, Berlett 01, Thordarson 96)

*Strength of Evidence* – **Moderately Recommended, Evidence (B)** – Calcaneus  
**Recommended, Insufficient Evidence (I)** – Talus

*Level of Confidence* - High

#### *Rationale for Recommendation*

There are two quality diagnostic studies for the use of x-ray for calcaneus fractures.(670, 793) (Knight 06, Ebraheim 96) A case-control diagnostic study demonstrated emergency department physicians were able to detect 97.5% of calcaneus fractures on lateral x-ray compared with CT confirmed diagnosis. Blinded radiologists reading the same films were 99.5% accurate compared with CT diagnosis.(670) (Knight 06) Another diagnostic study demonstrated x-ray to reveal more detail on articular depression

and severity of rotational displacement of calcaneus fracture fragments than coronal CT.(793) (Ebraheim 96) Talus fractures are often difficult to see on x-ray, particularly of the lateral process. A 45° internal oblique view is beneficial. If clinically suspected in the setting of negative radiographs, follow-up radiographs may be helpful; after approximately 7 days there will be resorption at the fracture line, which will then be more easily visible.(790) (Furlong 04) Thus, x-ray should be the first diagnostic test for suspected hindfoot fracture and is recommended.

*Evidence for the Use of X-ray for Hindfoot Fractures*

There is 1 high- and 1 moderate-quality study incorporated into this analysis.

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Knight 2006  Diagnostic Comparison Study	8.0	N = 133 calcaneal fractures (CT diagnosis, x-ray comparisons) vs. case controls	CT-verified calcaneal fractures, then standard mediolateral foot and ankle projections used on the lateral foot or ankle radiographs vs. Negative lateral x-rays for evidence of calcaneal fractures.	Emergency physicians 97.9% accurate in diagnosing calcaneus fractures based on reviewing plain films without assistance from angles (97%-99%). K value when measured against gold standard was 0.96 (0.94-0.98). Radiologist had sensitivity of 98.5% and specificity of 100%. Bohler's angle had intraclass correlation of 0.84 (0.79-0.87). CAG intraclass correlation 0.52 (0.43-0.60).	"BA is somewhat helpful and the CAG is not useful in diagnosing calcareous fractures in the ED."	Trial randomized order of x-ray reading (case vs. control) by MD. Lateral x-rays appear to have acceptable specificity and sensitivity for diagnosing calcaneal fractures in acute trauma patients compared with CT. Use of angles did not add significant improvement in diagnosis.
Ebraheim 1996  Diagnostic Comparison Study	7.0	N = 35 lateral x-rays, coronal CT scans and intra-operative findings in calcaneal fractures	All patients had lateral x-rays, coronal CT, and surgery.	Good correlation between lateral x-rays and coronal CT images in 26/35 patients. In the other 9 there was evidence of articular depression and incongruity in lateral x-ray but not CT.	"The present study emphasizes that coronal CT images often fail to accurately reveal the articular depression and severity of rotational displacement of calcaneal fracture fragments."	Imaging findings verified intra-operatively on all 35 patients. Study suggests coronal CT may underestimate severity of posterior talocalcaneal fractures.

## MRI

### 1. Recommendation: MRI for Suspected Acute Hindfoot Fractures

**MRI is recommended for suspected acute occult fracture of the talus and calcaneus.**

*Indications* – Generally reserved for suspicion of occult fracture of the talus neck or lateral process.(790) (Furlong 04) Patients whose plain images indicate osteochondral lesion and those who remain symptomatic after 6 weeks should undergo evaluation with MRI.(794-797) (Pettine 87, Flick 85, Alexander 80, Canale 80)

*Strength of Evidence* – **Recommended, Insufficient Evidence (I)**

*Level of Confidence* - Moderate

### 2. Recommendation: MRI for Follow-up Evaluation of Non-acute Calcaneus Fracture

**MRI is recommended for calcaneus fractures for identification of complications in the non-acute fracture patient.**

*Indications* – Non-acute fracture patient with persistent pain more than 4 months after injury.(798) (Zeiss 91)

*Strength of Evidence* – **Recommended, Evidence (C)**

*Level of Confidence* - Moderate

#### *Rationale for Recommendations*

There is no quality evidence that MRI is superior to radiographs for the initial detection of hindfoot fractures and should not be generally used as a first-line test. MRI may be an important diagnostic technique for the evaluation of suspected injuries of the talar neck and lateral process. MRI is used for suspected occult fracture, as some talus fractures are not apparent on radiographs. MRI is also indicated for evaluation of avascular necrosis. For calcaneus fracture, there is one moderate-quality diagnostic study that compared MRI and CT findings of intra-articular calcaneus fractures with x-ray.(798) (Zeiss 91) MRI was demonstrated to be suboptimal for acute and subacute calcaneal injury compared to CT, but was more effective at diagnosis of soft tissue and avascular necrosis in patients with prolonged symptoms. Results of this study are limited by its small sample size of 29. In general, MRI is suboptimal compared with CT scan for calcaneus injury.

#### *Evidence for the Use of MRI for Hindfoot Fractures*

There is 1 moderate-quality study incorporated in this analysis.

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Zeiss 1991  Diagnostic Comparison Study	5.5	N = 29 cadavers, calcaneal fracture patients, and healthy volunteers	Use of MRI for identifying both bone and soft tissue injury in calcaneal fracture.	Difficult to interpret MRI scans in fracture patients up to 4 months after injury. After 2 years with continued symptoms MRI useful in identifying possible problems in	“The usefulness of MRI evaluation of calcaneal fractures in acute and subacute evaluation will most likely be very limited to occasions where CT does not clearly define tendon displacement or when avascular necrosis or osteomyelitis is a concern. It could be	Data suggest MRI not helpful in acute or subacute calcaneal fracture or soft tissue injury evaluation. Can be helpful in chronic pain patient in identifying

				both bone and soft tissue.	more helpful in evaluation of persistent pain complicating healed fractures.”	possible pain generating issues.
--	--	--	--	----------------------------	---	----------------------------------

## BONE SCAN

Bone scans are utilized to diagnose occult calcaneus fractures and stress fractures of the calcaneus which are a result of compression forces exerted by the pull of the triceps surae muscle and the plantar fascia.(672) (Born 97)

*Recommendation: Bone Scanning for Calcaneus Fracture*

**Bone scans are recommended for diagnosis of occult and stress fractures in select patients.**

*Strength of Evidence – Recommended, Insufficient Evidence (I)*

*Level of Confidence - High*

### *Rationale for Recommendation*

There are no quality studies on bone scanning and bone scans are not required for evaluation of the majority of patients with calcaneus fractures. A bone scan may be reasonable for those with high clinical suspicion but with negative x-ray and CT scan. Technetium scanning may be positive for occult or stress fracture within 6 to 72 hours of the onset of pain.(672) (Born 97)

*Evidence for the Use of Bone Scanning for Hindfoot Fractures*

There are no quality studies incorporated into this analysis.

## CT IMAGING

*Recommendation: CT for Diagnosis and Classification of Hindfoot Fractures*

**CT is recommended for investigation of hindfoot fractures.**

*Indications –* CT is recommended for occult and complex distal extremity, ankle, and foot fractures to gain greater clarity of fracture displacement, articular involvement, and subluxation of affected joints.(691-693) (Catalano 04; Harness 06, Katz 01) If intraarticular displacement is considered, then axial views are recommended in addition to any coronal views.(694) (Ogawa 09) CT is indicated for evaluation of suspected subtalar joint fractures.(672, 799) (Born 97, Haygood 97)

*Views –* Coronal and axial.(793) (Ebraheim 96)

*Strength of Evidence – Recommended, Evidence (C)*

*Level of Confidence - High*

### *Rationale for Recommendation*

A moderate-quality retrospective diagnostic study demonstrated CT to be superior to lateral x-ray in detecting articular displacement when coronal and axial images are obtained.(793) (Ebraheim 96) The same study suggests sagittal reconstruction for rotational abnormalities of the posterior facet should be considered for appropriate patients. CT scans are considered the gold standard(673, 694, 800, 801) (Ogawa 09, Daftary 05, Koval 93, Gilmer 86) and are used in several quality trials for diagnosing and characterizing calcaneus fractures.(669, 670, 674, 792, 802-805) (Knight 06, Howard 03, Buckley 02, Kingwell 04, Johal 09, Thordarson 96, Parmar 93, Longino 01) For other hindfoot fractures, CT should be considered when x-ray images are negative, but on the basis of physical findings an occult fracture is strongly suspected. CT may also be useful for evaluation of complex comminuted fractures, providing superior depiction of distal tibial articular surface involvement, fragment positioning, and diagnosis of subluxations.(691, 692) (Catalano 04; Harness 06) The value of CT has been demonstrated – its use for

evaluation of articular step off and gaping, comminution, and treatment has influenced observers to change treatment plans developed from radiographs and resulted in increased interobserver reliability in the proposed management of these injuries.(693) (Katz 01) Thus, the use of CT imaging is recommended.

#### *Evidence for the Use of CT for Hindfoot Fractures*

There is 1 moderate-quality study incorporated into this analysis.

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Ebraheim 1996  Diagnostic Comparison Study	7.0	N = 35 calcaneal fractures (lateral x-rays, coronal CT scans and intraoperative findings)	All had lateral x-rays, coronal CT, and surgery.	Good correlation between lateral x-rays and coronal CT images in 26/35 patients. In other 9, evidence of articular depression and incongruity in lateral x-ray, but not CT.	“The present study emphasizes that coronal CT images often fail to accurately reveal the articular depression and severity of rotational displacement of calcaneal fracture fragments.”	Imaging findings verified intra-operatively on all 35 patients. Study suggests coronal CT may underestimate severity of posterior talocalcaneal fractures.

#### ***Follow-up Visits – Imaging***

For talus fracture, if clinically suspected in the setting of negative radiographs, follow-up radiographs may be helpful; after approximately 7 days there will be resorption at the fracture line, which will then be visible more easily.(790) (Furlong 04) Follow-up radiography at 6 to 8 weeks for confirmed talus fracture, looking for the Hawkins sign, a radiographic subchondral radiolucent band in the talar dome. This sign, visible in the anterior-posterior view, is indicative of viability at 6 to 8 weeks post-fracture indicating that avascular necrosis is unlikely to develop.(806, 807) (Tezval 07, Schulze 02)

#### ***Medications***

See ankle fracture section.

#### ***Initial Care***

##### **Talus Fractures**

Because of its key position, diagnosis and treatment of talus fractures is critical for foot and ankle function. Referral to specialist is indicated for all injuries due to the high potential for poor outcomes. Management includes evaluating the fracture closely with CT before deciding on conservative treatment. Non-displaced, non-rotated talar neck fractures can be treated with short-leg, non weight-bearing cast in neutral position for 6 to 12 weeks or until there is radiographic evidence that union has been achieved, followed by weight bearing in walker boot for 1 to 2 more months.(791) (Berlet 01)

##### ***1. Recommendation: Non-operative Management of Non-displaced Talar Fractures***

**There is no recommendation for or against non-operative management of non-displaced talar fractures (head, neck, body).**

*Strength of Evidence – No Recommendation, Insufficient Evidence (I)*

*Level of Confidence - Low*

##### ***2. Recommendation: Operative Management of Displaced Talar Fractures***

**Operative management is recommended for all displaced talar fractures (head, neck, body, lateral process).**

*Indications* – All non-displaced, non-reducible fractures. Referral to specialist is indicated for all injuries due to the high potential for poor outcomes of these injuries. Emergent referral for talar neck fractures.(791) (Berlet 01)

*Management* – Post operative non-weight bearing casting for 6 to 12 weeks, changing every 3 weeks to evaluate soft tissue healing. Serial radiographs. Once union is apparent, non-weight bearing for another 4 to 8 weeks; if AVN of talar body is present, ensure protected weight bearing to prevent collapse of talar dome.(661, 791) (Early 08, Berlet 01)

*Strength of Evidence* – **Recommended, Insufficient Evidence (I)**  
*Level of Confidence* - High

#### *Rationale for Recommendations*

There are no quality trials for talar head, neck, body, or lateral process fractures. Because of the key role the talus plays in locomotion, and the risk for significant disability and complication with these fractures, most are managed aggressively with open reduction and internal fixation.(664, 791, 808) (Berlet 01, Thordarson 01, Chaney 01) Referral to specialists for most, if not all, talus fractures is recommended.

#### *Evidence for the Management of Talar Fractures*

There are no quality studies incorporated into this analysis.

### **Osteochondral Lesions of the Talus**

Osteochondral lesions occur where bone and cartilaginous fragments separate from the dome of the talus.(664) (Chaney 01) Non-injury ischemic events have also been reported to cause these lesions.(794) (Alexander 80)

1. *Recommendation: Non-operative Management of Osteochondral Lesions of the Talus*  
**Non-operative management of osteochondral lesions of the talus is recommended for select patients.**

*Indications* – A non-operative approach is indicated for initial management of lateral lesions that radiographically appear to be a compression lesion with no visible fragment or there is a fragment but it is still attached. Medial lesions may also include nondisplaced fragment without attachment.(809, 810) (Gobbi 06, Ferkel 90)

*Management* – Cast or brace immobilization and protected weight-bearing for 6 to 12 weeks, followed by increasing pain-free range-of-motion exercises and strengthening.

*Strength of Evidence* – **Recommended, Insufficient Evidence (I)**  
*Level of Confidence* - Moderate

2. *Recommendation: Operative Intervention for Osteochondral Lesions of the Talus*  
**Operative intervention for osteochondral lesions of the talus is recommended for after an initial course of conservative management. Microfracture and osteochondral autograft are recommended.**

*Indications* – Based on CT classification, (Ferkel 90) open articular surface lesion with underlying undisplaced fragment, undisplaced lesion with lucency, displaced fragment, anterior and lateral osteochondral lesions of the talus.(809, 810) (Gobbi 06, Ferkel 90)

*Strength of Evidence* – **Recommended, Insufficient Evidence (I)**  
*Level of Confidence* - High

### Rationale for Recommendations

There are no moderate- or high-quality trials comparing conservative management with operative repair. A systematic review of 32 lesser quality studies describing clinical outcomes reported a 45% success rate with non-operative treatment.(811) (ToI 00) There is no quality evidence that a trial of conservative therapy adversely affects surgery performed after conservative therapy has failed.(794, 796) (Flick 85, Alexander 80) Therefore, a trial of conservative management is recommended initially. There are no quality trials regarding duration of conservative treatment, method of immobilization, weight-bearing status, use of NSAIDS, or the role of therapy. A trial of protected weight bearing for 6 to 12 weeks is reasonable.(812) (McGahan 10) There is one moderate-quality trial that compared three different surgical interventions for the treatment of osteochondral lesions of the talus.(809) (Gobbi 06) Chondroplasty, microfracture, and osteochondral autograft transplantation were all demonstrated to improve intragroup post-operative AOFAS and SANE scores from pre-operative baseline ( $p < 0.001$ ), with no significant difference between groups. There are no studies that compare these procedures with conservative management. Therefore, there is no recommendation for one procedure over another. Surgical treatment of Stage III and IV lesions yields good early results in 63% to 88% of patients.(794-797) (Pettine 87, Flick 85, Alexander 80, Canale 80)

### Evidence for the Use of Operative Management for Osteochondral Lesions

There is 1 moderate-quality RCT incorporated into this analysis.

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Gobbi 2006  RCT	4.0	N = 32 osteochondral lesions of talus: Ferkel class 2b, 3 or 4	Chondroplasty (CP) vs. microfracture (MF) vs. osteochondral autograft transplantation (OAT).	No difference in Ankle-Hindfoot scale at 6 or 12 months. No difference in SANE scores at final follow-up. Pain less for CP group compared to MF and OAT at 24 hours post-op ( $p < 0.001$ ).	“On the basis of AHS and SANE ratings, no differences can be seen between chondroplasty, micro fracture, or OAT for patients with osteochondral lesions of the talus.”	No blinding or mention of co-interventions or compliance with aftercare. No significant differences at 6 or 12 month follow-up between 3 groups. All 3 methods appear effective therapeutic options with similar outcomes. However, chondroplasty shown ineffective in knee.

### Calcaneus Injuries

Both non-surgical and surgical interventions are described to help regain anatomical reduction and alignment.(804, 813, 814) (Longino 01, Marx 08, Makki 10) The majority of calcaneus fractures extend into the subtalar joint.(680) (Prokuski 97) Calcaneocuboid joint injuries should be considered in the presence of calcaneus fracture.(815) (Kinner 10) Calcaneus fractures are often complicated by significant swelling secondary to soft tissue injury that may require delay in operative fixation and result in significant complications including fracture blister formation.(630, 816) (Thordarson 99, Campbell 02) Clinical outcomes appear to be associated with restoration of Böhler’s angle.(666, 802, 813, 817) (Makki 10, Rammelt 10, Dooley 04, Buckley 02)

#### 1. Recommendation: Cast Immobilization for Select Calcaneus Fractures

**Non-operative cast immobilization is recommended for select calcaneus fractures.**

*Indications* – Non-displaced fracture, displaced extra-articular, displaced intra-articular.

*Strength of Evidence – Recommended, Insufficient Evidence (I)*  
*Level of Confidence - High*

2. *Recommendation: Operative Management for Select Calcaneus Fractures*  
**Operative management is recommended for select calcaneus fractures.**

*Indications – Displaced, non-reducible extra-articular fractures, displaced intra-articular fractures.*

*Strength of Evidence – Recommended, Insufficient Evidence (I)*  
*Level of Confidence - High*

*Rationale for Recommendations*

There are two moderate-quality trials that compared operative management (ORIF) to non-operative cast immobilization of non-reduced displaced intra-articular calcaneus fractures.(792, 802) (Buckley 02, Thordarson 96) A low-quality prospective trial with 15-year follow-up demonstrated no significant benefit from surgery for non-displaced calcaneus fractures over non-operative care.(668, 805) (Parmar 93, Ibrahim 07) There are two additional reports from the original trial and are considered as one trial in this analysis.(674, 818) (Howard 03, O'Brien 04) The study, which included 424 fractures with intraarticular displacement greater than 2mm, demonstrated no differences in functional and pain assessment scores between groups. Upon stratification, females, patients not receiving workers' compensation, younger males, patients with a higher Böhler angle, patients with a lighter workload, and those with a single simple displaced intra-articular calcaneus fracture were demonstrated to have better results after operative treatment than after non-operative treatment. A second report demonstrated ORIF patients are more likely to develop complications, but workers' compensation patients developed a high incidence of complications regardless of the management strategy chosen.(674) (Howard 03) The third report demonstrated similar effect on subjective gait scores as the original report, with no differences between the non-stratified groups, but improved scores after stratification in the classifications of young males, non-workers' compensation, moderate workload before injury, and restoration of the Böhler angle to above 0 degrees.(818) (O'Brien 04) The second moderate-quality trial of 30 patients demonstrated surgical fixation results in lower pain scores and higher functional scores at 12 months. Thus, there is conflicting evidence for management recommendations, and both are recommended as treatment alternatives. Additional quality studies are needed.

There is evidence for consideration of non-operative management in workers' compensation patients.(802) (Buckley 02) Both operative and non-operative management have considerable potential for adverse effects, including secondary late fusion, compartment syndrome and fasciotomy, DVT and pulmonary embolism, and late-term arthrodesis. Surgical intervention also may result in superficial and deep infection, malposition of fixation, and hardware removal,(674, 805, 819) (Howard 03, Parmar 93, Radnay 09) and this should be taken into consideration when determining management technique. There is no quality evidence for costs of operative compared with non-operative care, although an economic study evaluated both direct and indirect costs, reporting operative management costs \$19,000 CAN less per patient than non-operative management because of reduced lost time from work.(820) (Brauer 05) There is no quality evidence for one operative technique over another.

*Evidence for the Management of Calcaneal Fractures*

There are 4 moderate-quality RCTs incorporated in this analysis. There are 2 low-quality RCTs in Appendix 1.(668, 805) (Parmar 93; Ibrahim 07)

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
<b>Non-operative vs. Operative Care</b>						
Buckley 2002 RCT	5.5	N = 424 displaced intra-articular	Non-operative treatment involved no	Outcomes after non-operative treatment not different for	"Without stratification of groups, the functional results	No blinding noted. Operative management

		calcaneal fractures	attempt at closed reduction, treated with ice, elevation, and rest vs. ORIF.	those after operative treatment. SF-36 score was non-op: 64.7 vs. ORIF: 68.7 (p = 0.13). VAS score: non-op:64.3, ORIF 68.6 (p = 0.12). Patients not in workers' comp and managed operatively had significantly higher satisfaction scores (p = 0.001).	after nonoperative care of displaced intra-articular calcaneal fractures were equivalent to those after operative care. However, careful stratification of the patient population and clinical outcome information distinguishes certain features that support surgical care for displaced intra-articular calcaneal fractures. Statistical analysis demonstrated that women, patients who were not receiving workers' compensation, younger males, patients with a higher Böhler angle, patients with a lighter workload, and those with a single, simple displaced intra-articular calcaneal fracture have better results after operative treatment than after nonoperative treatment."	trended towards better outcomes in subsets of study. Post-hoc analyses suggests good anatomic reduction provides a positive effect on outcomes. Data suggest no difference in general population between treatments, but ORIF may be superior to non-operative management in specific populations.
Howard 2003 RCT	5.5	N = 424 displaced intra-articular	Non-operative treatment (NOP). Pain	ORIF had more clinical complications than NOP. NOP	"Outcome scores in this study tend to support ORIF for	Second report of Buckley 2002. No blinding, large

		calcaneal fractures with disruption of posterior facet >2mm	management, RICE, non-weight bearing. PT and full weight bearing at 6 weeks vs. ORIF, lateral approach. Full weight bearing and PT at 6 weeks.	42.218 (19%) had complications that led to surgery; 2/218 (0.01%) had late compartment syndrome. 37/218 (16%) had secondary late fusion. 1/218 developed CRPS. ORIF: 11/206 (0.5%) deep wound infections. 2/206 developed PE. 4/206 had compartment syndrome.	calcaneal fractures. ORIF patients are more likely to develop complications, however. Certain patient populations have a high incidence of complications regardless of the management strategy chosen (WCB patients, Sanders type IV patients)."	drop out rate, no mention of co-interventions. Suggests non-operative management of displaced intra-articular calcaneal fractures with disruption of posterior facet >2mm has fewer complications than ORIF.
O'Brien 2004  RCT	5.5	N = 319 patients with 351 displaced intra-articular calcaneal fractures	Non-operative management vs. ORIF measuring gait satisfaction scores at 2-8 years.	No difference in SF-36 scores between groups at 2 to 8 years follow-up (p = 0.22). Age <30 with ORIF = improvement in gait scores compared to non-op (p = 0.02). Quality of fracture reduction no different between groups. Bohler angle in non-op group of >15° compared to <0° had better gait scores (p = 0.00).	"[P]ersonal gait satisfaction scores were not significantly affected by treatment method in patients with DIACF at 2-8 years follow up. However, gait scores were better in patients treated with ORIF if they were younger than 30 years of age, had no worker's comp claims, had jobs requiring a moderate workload before injury and had restoration of Bohler angle to above 0 degrees."	Third report of same population (see Buckley 2002). Post-hoc analyses suggests restoration of Bohler angle is predictive of function. Data also suggests those with workers' comp claims have worse outcomes regardless of treatment type for this injury.

Thordarson 1996  RCT	4.0	N = 30 displaced intra-articular calcareous fractures Sanders Type II or III	Non-operative management with early mobilization and delayed weight bearing at 8 weeks vs. ORIF with early mobilization and delayed weight bearing.	Pain on extremes of motion in 25% of ORIF and 100% in non-operative group. Average functional score of 86.7 in ORIF group vs. 55.0 in non-operative group. (p <0.0001).	“Our study demonstrated markedly superior results with operative treatment of fractures versus non-operative treatment.	Follow-up 14 months for non-operative group, 17 months for ORIF. Significantly greater recovery after displaced intra-articular calcareous fractures Sanders Type II and III with ORIF compared to non-operative treatment with pain and functional scores.
----------------------------	-----	--	---	---	---	---

### Edema Management

Calcaneus fractures are often complicated by a varying degree of edema after injury because of the traumatic nature of the mechanism. Edema may result in delay of surgical intervention, fracture blister formation, and compartment syndrome.(630, 665, 816) (Buzzard 03, Campbell 02, Thordarson 99)

### PNEUMATIC COMPRESSION DEVICE

*Recommendation: Use of Pneumatic Compression Device for Treatment of Calcaneus Fractures*

**Use of pneumatic compression of foot to reduce swelling is recommended for patients with significant edema after closed calcaneus fractures.**

*Indications* – Patients with excessive swelling after closed displaced calcaneus fractures who are surgical candidates. Use in non-operative patients to reduce risk of other complications.

*Frequency/Duration* – Pedal compression device used continuously until swelling subsides sufficiently to allow for surgery or to manage non-operatively.(816) (Thordarson 99)

*Indications for Discontinuation* – Achievement of desired swelling reduction, intolerance because of pain or discomfort.

**Strength of Evidence – Recommended, Evidence (C)**

*Level of Confidence - Low*

#### *Rationale for Recommendation*

There is one moderate-quality trial comparing intermittent pneumatic pedal compression device after closed displaced calcaneus fractures compared to compression dressing and elevation.(816) (Thordarson 99) Compared to baseline, volumetric decrease was significantly greater in the pedal pneumatic compression group (p = 0.02). Faster resolution of pre-operative swelling allows earlier surgery and may reduce risk of developing fracture blister, but quality evidence is lacking for improvement of functional outcomes. There is a retrospective study of intermittent pneumatic compression for calcaneus fracture patients that reported decreased swelling and compartment pressures associated with calcaneus fractures.(821) (Myerson 00) Thus, pneumatic compression for

edema management is recommended for management of acute calcaneus fracture management in select patients. There is no definition of significant edema found in the quality trials. Clinical judgement is therefore warranted.

*Evidence for the Management of Edema Associated with Calcaneal Fractures*

There is 1 moderate-quality RCT incorporated into this analysis.

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Thordarson 1999 RCT	6.0	N = 28 closed dislocated intra-articular calcaneal fractures	Intermittent pedal compression device, posterior splint, and leg elevation. Started 24 hours after injury. Compression 3 x cycles/minutes full time until surgery vs. compression dressing, posterior splint, and elevation.	All patients tolerated foot pump without need of ankle nerve block. Volumetric measurements: Day 1-2: Pump = -40mm, control = +76mm (p = 0.02); Day 1-3: pump = -96mm, control = +37mm (p = 0.02).	“In summary, we found that using a foot pump prior to surgery resulted in a significant decrease in preoperative edema in patients after an intraarticular calcaneus fracture in comparison with those in the control group.”	No blinding or mention of baseline characteristics. Pedal pump appears beneficial in reducing post injury pre-op swelling in displaced intra-articular calcaneal fractures.

**DIATHERMY**

Pulsed short-wave diathermy is described for management of edema associated with calcaneal fracture.(665) (Buzzard 03)

*Recommendation: Diathermy for Management of Edema Associated with Calcaneus Fracture*

**There is no recommendation for or against the use of diathermy for management of edema associated with calcaneus fractures.**

*Strength of Evidence – No Recommendation, Insufficient Evidence (I)  
Level of Confidence - Low*

*Rationale for Recommendation*

There are no quality trials for the use of diathermy for edema management of calcaneus fracture. There is no evidence that diathermy is more effective than elevation and ice, but it is more costly. There is no recommendation for the use of diathermy for edema management.

*Evidence for the Use of Diathermy for Edema Control*

There are no quality studies incorporated into this analysis.

**BONE GRAFT AND FILLERS**

Bone grafts and other materials are used to provide mechanical strength and increase stimulation for fracture healing in calcaneus fractures with fracture depression bone deficit.(803, 804, 822) (Johal 09, Dickson 02, Longino 01)

*Recommendation: Treatment of Cancellous Bone Defect with Displaced Intra-Articular Calcaneus Fractures*

**There is no recommendation for or against the use of calcium phosphate paste or bone graft for treatment of displaced intra-articular fracture defects.**

*Strength of Evidence – No Recommendation, Insufficient Evidence (I)*  
*Level of Confidence - Low*

*Rationale for Recommendation*

There are no quality trials comparing functional outcomes after use of bone graft, bone cement, or calcium phosphate paste to correct bone defects during fixation of displaced intraarticular calcaneus fracture. A low-quality trial demonstrated less calcaneal collapse measured by Böhler angle with the use of calcium phosphate paste, although clinical outcomes were no different.(803) (Johal 09) Another low-quality trial demonstrated equivalency of bone cement to bone graft, although there was no comparison to a non-treatment group.(822) (Dickson 02) A cohort study comparing bone grafting to no grafting in displaced intraarticular calcaneus fractures found no objective radiographic or functional benefit from the use of bone graft.(804) (Longino 01)

There are few adverse effects from the use of bone cement or other synthetic products, but bone graft can result in a harvest surgical site with associated complications. This treatment is of moderate to high costs related to material and procedure costs, but is of unknown efficacy. There is no recommendation for the use of bone graft, bone cement, or calcium phosphate paste to fill displaced intraarticular calcaneus defects.

*Evidence for the Use of Bone Graft and Fillers for Calcaneal Fracture Defect*

There are no quality studies incorporated into this analysis. There are 2 low-quality trials in Appendix 1.(803, 822) (Johal 09; Dickson 02)

**ORTHOTICS**

The use of foot orthotics for prevention of lower extremity disorders is considered elsewhere in this guideline (see Plantar Fasciitis). There is **No Recommendation, Insufficient Evidence (I)**, for or against the use of orthotics and special shoes to prevent stress fractures and overuse injuries.

**Physical Methods/Rehabilitation**

There are no quality trials for physical methods and rehabilitation of hindfoot fracture (see Ankle Fracture section).

**Forefoot and Midfoot Fractures (Tarsal, Metatarsal, Phalangeal)**

**Special Studies and Diagnostic and Treatment Considerations**

**X-RAY**

*Recommendation: X-ray for Suspected Acute Forefoot or Midfoot Fractures*

**X-ray is recommended as a first-line study for suspected forefoot or midfoot fractures.**

*Indications* – Suspicion of all forefoot and midfoot fractures.

*Views* – AP, lateral, and oblique.

*Strength of Evidence – Recommended, Insufficient Evidence (I)*  
*Level of Confidence - High*

*Rationale for Recommendation*

There are no quality trials for the use of x-ray for forefoot or midfoot fractures. However, x-ray assists in identifying fractures, orientation of fracture plane(s), magnitude of the involvement of the interphalangeal and metatarsal phalangeal joints, which if large enough may alter management in favor of surgery (see below). If fracture is clinically suspected in the setting of negative radiographs, follow-up radiographs

may be helpful; after approximately 7 days there will be resorption at the fracture line, which will then be visible. X-ray is non-invasive, is lower cost than MRI or CT, and is recommended.

*Evidence for the Use of X-ray for Suspected Tarsal, Metatarsal, or Phalangeal Fractures*

There are no quality trials incorporated in this analysis.

## **MRI**

*Recommendation: MRI for Suspected Acute Forefoot and Midfoot Fractures*

**MRI is recommended for suspected occult and stress fracture in select patients.**

*Indications* – Generally reserved for suspicion of occult or stress fracture of the fore- or midfoot, however, CT is viewed as superior by some. (Myerson 08)

*Strength of Evidence* – **Recommended, Insufficient Evidence (I)**

*Level of Confidence* - Moderate

*Rationale for Recommendation*

There is no quality evidence for the use of MRI for detecting forefoot or midfoot fractures. MRI should not be used as a first-line test. MRI may be an important diagnostic technique for the evaluation of suspected injuries of the navicular, tarsometatarsal joint (Lisfranc injury) and for early diagnosis of suspected stress fracture. MRI is also used for suspected occult fracture and for evaluation of avascular necrosis.

*Evidence for the Use of MRI for Suspected Tarsal Metatarsal and Phalangeal Fractures*

There are no quality studies incorporated into this analysis.

## **BONE SCAN**

Bone scans are utilized to diagnose occult and stress fractures of the navicular and metatarsals.

*Recommendation: Bone Scanning for Forefoot and Midfoot Fractures*

**Bone scans are recommended for diagnosis of occult and stress fractures in select patients.**

*Indications* – Generally reserved for suspicion of occult fracture of the tarsal and metatarsal bones, however, CT is viewed as superior by some. (Myerson 08)

*Strength of Evidence* – **Recommended, Insufficient Evidence (I)**

*Level of Confidence* - Moderate

*Rationale for Recommendation*

There are no quality studies on bone scanning and bone scans are not required for evaluation of the majority of patients with forefoot and midfoot fractures. A bone scan may be reasonable for patients with high clinical suspicion but negative x-ray or CT scan. Technetium scanning may be positive for occult or stress fracture within 6 to 72 hours of pain onset.(672) (Born 97) MRI has become more widely used for early detection of stress fractures than bone scan.

*Evidence for the Use of Bone Scan for Suspected Tarsal, Metatarsal, or Phalangeal Fractures*

There are no quality studies incorporated into this analysis.

## **CT IMAGING**

*Recommendation: CT for Diagnosis and Classification of Forefoot and Midfoot Fractures*

**CT is recommended for investigation of forefoot and midfoot fractures.**

*Indications* – Evaluation of displaced or comminuted fracture of the tarsal and metatarsal bones to gain greater clarity of fracture displacement, articular involvement, and subluxation of affected joints. Generally, this is a second-line diagnostic tool after x-rays. (Myerson 08)

*Strength of Evidence – Recommended, Insufficient Evidence (I)*  
*Level of Confidence - Moderate*

*Rationale for Recommendation*

There is no quality evidence for the use of CT for detection of forefoot and midfoot fractures. CT should not be used as a first-line test. CT may be an important diagnostic technique to gain greater clarity of fracture displacement, articular involvement, and subluxation of affected joints, and is recommended for select patients.

*Evidence for the Use of CT for Suspected Tarsal Metatarsal and Phalangeal Fractures*

There are no quality studies incorporated into this analysis.

**Initial Care**

Initial management should include treatment of soft tissue injuries and pain control following completion of physical examination. Regional anesthesia may be administered to complete diagnostic assessment (passive range of motion, rotational alignment) and to perform closed reduction of the fracture, although not until neurovascular examination is documented. There are no quality trials for forefoot block techniques (see Metacarpal Fractures in Hand, Wrist, and Forearm Disorders guideline).

**Medications**

**NON-STEROIDAL ANTI-INFLAMMATORY DRUGS (NSAIDs) AND ACETAMINOPHEN**

*Recommendation: NSAIDs or Acetaminophen for Phalangeal or Metatarsal Fractures*

**NSAIDs or acetaminophen are recommended to control pain from phalangeal or metatarsal fractures.**

*Indications* – Pain due to phalangeal or metatarsal fracture.

*Frequency/Duration* – Scheduled dosage rather than as needed is generally preferable.

*Indications for Discontinuation* – Resolution of pain, lack of efficacy, development of adverse effects particularly gastrointestinal.

*Strength of Evidence – Recommended, Insufficient Evidence (I)*  
*Level of Confidence - High*

*Rationale for Recommendation*

While there is no quality evidence, these medications are thought to be effective for control of swelling (NSAIDs) and pain in the initial stages of injury, are not invasive, have low adverse effects, are low cost, and thus are recommended. While there have been some concerns regarding delayed fracture healing, other studies have suggested no delayed bone healing (see Ankle Fractures). These concerns appear outweighed by pain management concerns.

**Tarsal-Metatarsal Joint (Lisfranc) Injury**

**IMMOBILIZATION AND SURGERY**

1. *Recommendation: Non-operative Management for Non-displaced Tarsal-Metatarsal Injury (Lisfranc)*  
**Non-operative management of non-displaced tarsal-metatarsal injury (Lisfranc) is recommended for select patients.**

*Indications* – Fracture/joint dislocation displacement <2mm.

*Management* – Non-weight bearing cast for 6 weeks.

*Strength of Evidence – Recommended, Insufficient Evidence (I)*  
*Level of Confidence - Moderate*

2. *Recommendation: Operative Management for Displaced Tarsal-Metatarsal Injury (Lisfranc)*  
**Operative management is recommended for an unstable tarsal-metatarsal injury (Lisfranc).**

*Indications* –Fracture joint displacement with joint dislocation >2 mm.(676) (Myerson 99)

*Management* – Operative fixation with K-wire or screws, or primary arthrodesis; non-weight bearing for 6 to 12 weeks and edema management (see Ankle and Calcaneus Fractures).(630, 676, 678, 823) (Henning 09, Hatch 07, Campbell 02, Myerson 99) Toe-touch weight-bearing in walking boot for 8 weeks. May take 4 to 5 months to heal; therapy may be started. Removal of hardware prior to full activities.(676) (Myerson 99)

*Strength of Evidence – Recommended, Insufficient Evidence (I)*  
*Level of Confidence - Moderate*

*Rationale for Recommendations*

There are no quality trials comparing non-operative treatment to fixation, bone screws, or plates for tarsal-metatarsal joint injuries. There is one moderate-quality trial comparing primary arthrodesis to primary ORIF that demonstrated no functional differences, but the study was discontinued secondary to higher number of secondary surgeries for hardware removal.(823) (Henning 09) It is unclear if removal was due to protocol or from symptomatic concerns. Twenty-two percent of eligible patients were enrolled in the study. Therefore, there is insufficient evidence to recommend primary arthrodesis as the initial procedure over primary ORIF. There are no quality studies defining acceptable limits of displacement for non-operative management, determining the ideal splint time or duration of internal or external fixation, making comparisons of fixation techniques or defining ideal post-operative rehabilitation protocols. Immobilization or fixation technique is therefore dictated by the physical and radiographic findings.

*Evidence for the Management of Lisfranc Injuries*

There is 1 moderate-quality RCT incorporated into this analysis.

Author/Y ear Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Henning 2009  RCT	5.0	N = 40 Lisfranc injuries, <3 months duration	Primary arthrodesis (PA) vs. ORIF	Study discontinued after 40 patients (planned for 60) secondary to hardware removal rates and secondary surgery (79 vs. 17%) favoring arthrodesis. No differences in functional outcomes, clinical assessments or patient satisfaction.	“PA resulted in a statistically significant decrease in the number of follow up surgeries compared to [primary] ORIF if hardware removal is routinely performed. If performed properly, patients are satisfied with either technique.”	Small sample size. Baseline differences suggest potential randomization failure. Loss to follow-up 20%.

**Metatarsal Shaft Fractures**  
**IMMOBILIZATION AND SURGERY**

1. *Recommendation: Non-Operative Management for Non-displaced Metatarsal Fractures*  
**Non-operative management is recommended for non-displaced metatarsal fractures.**

*Indications* –Non-displaced shaft fractures or with up to 3 to 4mm displacement in dorsal or plantar

direction, angulation less than 10° dorsally.(677, 678) (Cakir 10, Hatch 07)

*Management* – Edema management with bulky dressing, elevation, splint if needed. Firm supportive shoe or fracture shoe with progressive weight bearing. Pain intolerance warrants short leg-walking cast for 2 to 3 weeks.(678) (Hatch 07) Repeat films at 1 week and 6 weeks.

*Strength of Evidence* – **Recommended, Insufficient Evidence (I)**

*Level of Confidence* - High

## 2. Recommendation: Operative Management for Displaced Metatarsal Shaft Fractures

**Operative management is recommended for displaced metatarsal shaft fractures.**

*Indications* – Multiple metatarsals fractured if displaced; shaft fracture near metatarsal head.(678) (Hatch 07)

*Management* – Percutaneous pinning or internal fixation with screws, plates; non-weight bearing 4 to 6 weeks. Progressive weight-bearing over next 4 to 6 weeks in fracture shoe/boot or walking cast. Full weight-bearing in shoes/stiff soled shoe after radiographic evidence of union.(630) (Campbell 02)

*Strength of Evidence* – **Recommended, Insufficient Evidence (I)**

*Level of Confidence* - High

### *Rationale for Recommendations*

There are no quality studies comparing non-operative treatment, fixation, bone screws, or plates for metatarsal fractures. There also are no quality studies defining acceptable limits of displacement for non-operative management, determining the ideal splint time or duration of internal or external fixation, making comparisons of fixation techniques or defining ideal post-operative rehabilitation protocols. Immobilization or fixation technique is therefore dictated by the physical and radiographic findings.

### *Evidence for the Management of Metatarsal Fractures*

There are no quality studies incorporated into this analysis.

## **Proximal Fifth Metatarsal Fractures**

### **IMMOBILIZATION AND SURGERY**

Fractures of the proximal fifth metatarsal should be managed differently than other metatarsal injuries.

## 1. Recommendation: Non-operative Management for Proximal Fifth Metatarsal Fractures

**Non-operative management of fifth metatarsal fractures (including Jones and Avulsion) is recommended for select patients.**

*Indications* – Avulsion of tuberosity: non-displaced, <1 to 2mm step-off on articular surface or less than 30% of articular surface with cuboid(678, 679, 824); (Zwitser 10, Hatch 07, Strayer 99) Jones Fracture: patient/provider preference.

*Management* – Avulsion of tuberosity: edema management with bulky dressing, elevation, splint if needed; firm supportive shoe or fracture shoe with progressive weight bearing. Pain intolerance warrants short-leg walking cast for 2 to 3 weeks.(678, 679) (Hatch 07, Strayer 99) Repeat films at 1 and 6 weeks. Jones Fracture: non-weight-bearing short-leg cast immobilization for 6 to 8 weeks, followed by hard-sole shoe or walking cast until union.(825) (Mologne 05)

*Strength of Evidence* – **Recommended, Insufficient Evidence (I)**

*Level of Confidence* - High

## 2. Recommendation: Operative Management for Displaced Metatarsal Shaft Fractures

**Operative management for fifth metatarsal fractures (Jones, Avulsion) is recommended for select patients.**

*Indications* – Avulsion of tuberosity: displaced >1 to 2mm step-off on the articular surface or more than 30% of articular surface with cuboid(678, 679, 824); (Zwitser 10, Hatch 07, Strayer 99) Jones Fracture: patient/ provider preference.

*Management* – Avulsion of tuberosity: similar to other metatarsal shaft fractures treated operatively. Jones Fracture: non-weight bearing Jones splint for 2 weeks, followed by weight bearing in hard-sole shoe as tolerated.(825) (Mologne 05)

**Strength of Evidence – Recommended, Insufficient Evidence (I)**

*Level of Confidence* - Moderate

*Rationale for Recommendations*

There are no quality studies comparing non-operative treatment, fixation, bone screws, or plates for avulsion fractures. A low-quality trial demonstrated Jones dressing resulted in faster return to activity than cast immobilization for avulsion fractures.(826) (Wiener 97) There also are no quality studies defining acceptable limits of displacement for non-operative management, determining the ideal splint time or duration of internal or external fixation, making comparisons of fixation techniques or defining ideal post-operative rehabilitation protocols. Immobilization or fixation technique is therefore dictated by the physical and radiographic findings.

There is one quality trial for operative management compared with cast immobilization of Jones fractures that demonstrated shorter times to union and return to activity with screw fixation. The procedure is invasive with associated surgical risks and is high cost compared to conservative management. Conservative management may result in non-union.(676, 825, 826) (Wiener 97, Mologne 05, Myerson 99) There is insufficient evidence for recommending one treatment over another, and should therefore be managed based on physician and patient preference.

*Evidence for the Management of Proximal Fifth Metatarsal Injuries*

There is 1 moderate-quality RCT incorporated into this analysis. There is 1 low-quality RCT in Appendix 1.(826) (Wiener 97)

Author/Y ear Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
<b>Metatarsal Fracture (Jones) – Operative Management</b>						
Mologne 2005  RCT	6.0	N = 37 acute Jones fractures	Cast immobilization vs. intramedullary screw fixation. Non-weight bearing cast 8 weeks, followed by walking cast or hard shoe until union. Post-op non-weight bearing with bulky Jones splint for 2 weeks.	8 of 18 (44%) in cast group had treatment failures vs. 1/19 (5.3%). Mean time to clinical union 7.5 weeks (surgery) vs. 14.5 weeks (cast), p <0.001. Mean time to running and jumping sports (weeks) 8.0 vs. 15.0 (cast), p <0.001	“Early surgical treatment results in a shorter time to clinical union and allows patients to return to sports and activities of daily living faster than with cast treatment.”	Lack of details for allocation, blinding. No loss to follow-up. Suggests surgical fixation of acute Jones fracture provides fewer treatment failures and quicker time to healing and functional recovery.

## **Phalangeal Fractures**

### **IMMOBILIZATION AND SURGERY**

#### *1. Recommendation: Immobilization for Distal, Middle, or Proximal Phalanx Fractures*

**Immobilization is recommended for treatment of select patients with distal, middle, or proximal phalanx fractures.**

*Indications* – Closed, non-displaced or stable after reduction, involves less than 25% of articular surface.(827) (Hatch 03) No established guides to the degree of acceptability of displacement, angulation, or rotation.

*Management* – Closed reduction after digital or hematoma block; obtain post-reduction film, repeat at 1 and 6 weeks; splint toe with buddy tape to adjacent toe until non-tender (3 to 4 weeks). Additional immobilization with a post-operative shoe or cast-boot should be considered.

*Strength of Evidence* – **Recommended, Insufficient Evidence (I)**

*Level of Confidence* - High

#### *2. Recommendation: Operative Management for Distal, Middle, or Proximal Phalanx Fractures*

**Operative management is recommended for treatment of select patients with distal, middle, or proximal phalanx fractures.**

*Indications* – Displaced fractures of great toe with poor reduction, unable to hold reduction with tape splinting.

*Management* – Fixation with pins, K-wire.

*Strength of Evidence* – **Recommended, Insufficient Evidence (I)**

*Level of Confidence* - High

#### *Rationale for Recommendations*

There are no quality studies for non-operative treatment, percutaneous fixation, bone screws, or plates for phalangeal fractures. There also are no quality studies defining acceptable limits of displacement for non-operative management, determining the ideal splint time or duration of internal or external fixation, making comparisons of fixation techniques or defining ideal post-operative rehabilitation impractical. Immobilization or fixation technique is therefore dictated by the physical and radiographic findings. It is generally limited to displaced fractures of the great toe or multiple toe fractures (see Phalangeal Fractures in Hand, Wrist, and Forearm Disorders guideline for analogous injury management).

#### *Evidence for the Management of Phalangeal Fractures*

There are no quality studies incorporated into this analysis.

## **Stress Fractures**

Stress fractures are thought to be caused by repetitive loading to the bone rather than a discrete event. The etiology is thought to be related to intrinsic factors resulting in bone weakness such as rheumatoid arthritis, osteoporosis, or long-term corticosteroid use. Extrinsic factors that may contribute to stress fracture include vigorous athletic training regimens, and suboptimal footwear and nutritional status.(828) (Gehrmann 06) History of stress fractures often includes increased physical activity or increase in intensity of activity preceding symptoms.(658, 681-683) (Sherbondy 06, Chen 06, Wilder 04, Weinfeld 97) Navicular stress fracture presents as insidious onset of midfoot pain. They are often slow to be diagnosed.(685) (Jones 06) There may be tenderness over the dorsal aspect of the navicular bone in navicular stress fractures or over a metatarsal bone in metatarsal stress fractures. Diagnostic imaging includes x-ray which generally requires 2 to 4 weeks for a stress fracture to show up, MRI, and radionuclide bone scan.(658, 681, 829) (Sherbondy 06, Chen 06, Muthukumar 05)

## IMMOBILIZATION AND SURGERY

Conservative and surgical management strategies are described for stress fractures of the lower extremity.(681, 684, 828, 830-834) (Brockwell 09, Mann 09, de Clercq 08, Chen 06, Gehrman 06, Fetzer 06, Coris 03, Haverstock 01) Stress fractures of the 2nd to 4th metatarsal or calcaneus are at low risk of non-union with conservative treatment.(828) (Gehrman 06)

### 1. *Recommendation: Non-operative Management for Lower Extremity Stress Fractures*

**Non-operative management is recommended for low risk lower extremity stress fractures.**

*Indications* – Non-displaced stress fractures.

*Management* – All non-displaced stress fractures can be treated conservatively initially. Metatarsal: weight bearing with short leg cast, cast boot, or stiff soled shoe for 6 to 8 weeks. Calcaneus: activity restriction, heel-pad inserts, protected weight bearing. Fifth metatarsal: non-weight bearing for 6 to 8 weeks, same as Jones Fracture (see Fifth Metatarsal Fractures).(828) (Gehrman 06) Non-weight bearing may be required for up to 20 weeks in extreme cases.(675) (Karasick 94) Navicular: non-weight bearing cast until fracture is healed (6 weeks) but may require up to 8 months to return to full activity.

*Strength of Evidence* – **Recommended, Insufficient Evidence (I)**

*Level of Confidence* - High

### 2. *Recommendation: Operative Management for Lower Extremity Stress Fractures*

**There is no recommendation for or against the use of operative management of lower extremity stress fractures in select patients.**

*Strength of Evidence* – **No Recommendation, Insufficient Evidence (I)**

*Level of Confidence* - Low

### *Rationale for Recommendations*

There are no quality trials available for lower extremity stress fractures. Stress fractures are reported to respond well to activity restriction in most instances. Activity restriction is therefore recommended. Stress fractures that do not respond or that are displaced are treated operatively with fixation with and without graft. Athletes or persons that desire quicker return to activity often go straight to surgical intervention for stress fractures that are high-risk for non-union. Some high-risk fractures for non-union include talus, navicular, and fifth metatarsal.(681-685, 828) (de Clercq 08, Gehrman 06, Jones 06, Chen 06, Wilder 04, Weinfeld 97)There is insufficient evidence for recommendation of operative management.

### *Evidence for the Management of Stress Fractures*

There are no quality studies incorporated into this analysis.

## APPENDIX: Low-quality Randomized Controlled Trials and Non-randomized Studies

The following low-quality randomized controlled studies (RCTs) and other non-randomized studies were reviewed by the Evidence-based Practice Ankle and Foot Panel to be all inclusive, but were not relied upon for purpose of developing this document's guidance on treatments because they were not of high quality due to one or more errors (e.g., lack of defined methodology, incomplete database searches, selective use of the studies and inadequate or incorrect interpretation of the studies' results, etc.), which may render the conclusions invalid. ACOEM's Methodology requires that only moderate- to high-quality literature be used in making recommendations.(835) (Harris JOEM 08)

### FOOT ULCERATIONS

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
<b>Patient Education</b>						
Donohoe 2000  RCT  No mention of sponsorship or COI.	3.5	N = 1939 with diabetes.  Age range 18.7 -95.8 years in intervention group and 18.0 -93.6 years in the control group.	Intervention group: explanatory practice visits and foot care education (n = 981) vs. Control group (n = 958).  Follow-up for 6 months.	There was a significantly greater change of attitude about foot care in intervention group (p = 0.01). Intervention group had better attitudes towards personal foot care by 2.5% vs. 0.2% decrease in control group (p = 0.027). Small improvement in knowledge score within intervention group with mean percentage change of 1.1 (p = 0.015) and 1.3 in control group (p = 0.002).	"Provision of integrated care arrangements for the diabetic foot has a positive impact on primary care staffs' knowledge and patients' attitudes resulting in an increased number of appropriate referrals to acute specialist services."	Pragmatic RCT. Health care professionals. Knowledge of diabetic footcare improved in intervention group (p <0.001).
<b>Wound Dressings</b>						

<p>Veves 2002</p> <p>RCT</p> <p>Sponsored by Johnson &amp; Johnson Wound Management.</p>	<p>3.5</p>	<p>N = 276 diabetics with a foot ulcer &gt;30 days, rating grade 1 to 2 on Wagner scale and area ≥1cm; Mean age 58.3 years for both groups.</p>	<p>Promogran Group (n = 138) vs. Moistened gauze control Group (n = 138).</p> <p>Assessments at baseline and 12 weeks.</p>	<p>No significant results of improvement reported for Promogran group versus moistened gauze control group.</p>	<p>“[W]e have shown that Promogran, a wound dressing consisting of collagen and oxidized regenerated cellulose, was as effective as moistened gauze in promoting wound healing in diabetic foot ulcers,…”</p>	<p>Data suggest mostly comparable results. Sparse methodology.</p>
<p>Jacobs 2008</p> <p>RCT</p> <p>No mention of sponsorship or COI.</p>	<p>3.0</p>	<p>N= 40 diabetic patients with Wagner grade 1 or 2 ulcers. Mean age was not provided.</p>	<p>Bensal HP group- Benzoic Acid 6%, Salicylic acid 3% and extract from Q rubra, 3%. Application daily every 12 hours (n=20) vs. SSC Group- Silver Sulfadiazine cream. Application every 12 hours daily (n=20).</p> <p>Follow-up for 6 weeks.</p>	<p>At 6 week follow-up wound diameter decreased in both groups; difference approached significance for Bensal HP vs. SSC group; 72.5% reduction vs. 54.7% (p = 0.059). Reductions significant in both groups compared to baseline (p = 0.016). Effect size of Bensal HP was 2.06 vs. 1.03 in SSC group.</p>	<p>“In this tightly controlled and random study, Bensal HP not only served as an adequate adjunct to generally accepted wound care, but also convincingly outperformed SSC used in the control.”</p>	<p>Blinding only mentioned without details. Sparse baseline comparability details.</p>
<p>Shukrimi 2008</p> <p>RCT</p> <p>No mention of sponsorship or COI.</p>	<p>1.5</p>	<p>N= 30 with Wagner's grade-II diabetic foot ulcers.</p> <p>Mean age: 52.1 years.</p>	<p>Honey dressing group (pH of 6.5, glucose 321mmol/l and specific gravity of 1.003) vs. standard dressing group (iodine solution 10%).</p>	<p>Mean healing time in standard dressing group vs. Honey group: 15.4 days (range 9-36 days) vs. 14.4 days (range</p>	<p>“Honey dressing is a safe alternative dressing for Wagner grade-II diabetic foot ulcers.”</p>	<p>Sparse methodological and sample size.</p>

				7-26 days); p<0.005		
<b>Negative Pressure Therapy (Vacuum) Wound Care Systems</b>						
Mars 2008  RCT  No mention of sponsorship or COI.	3.0	N = 60 with non-ischemic diabetic foot ulcers, type 1 or 2 diabetes mellitus; Mean ( $\pm$ SD) age 51.5 ( $\pm$ 7.6) for treatment group and 55.3 ( $\pm$ 9.0) for control group	Compressed air massage group receiving 15-20 minutes of treatment (1 bar; 100kPa pressure) daily 5x a week until healed or administered skin graft (n = 30) vs. Control group (n = 30).  Both groups received standard wound care for their ulcers.	Mean ( $\pm$ SD) time of ulcer healing in days significantly greater in air massage group versus control group: Air massage – 58.1 ( $\pm$ 22.3) vs. control – 82.7 ( $\pm$ 30.7), (p = 0.001). No significant results reported between groups for Wagner grade and ulcer size, Wagner size and time to healing and ulcer size and time to healing.	“Compressed air therapy can be viewed as a variant of pneumatic compression. It appears to be a safe and simple treatment modality, which, when added to standard medical and surgical management of infected diabetic ulcers, enhances ulcer healing. Further studies with this treatment modality are warranted”	Sparse descriptive data. Data suggest faster healing.
<b>Foot Waffle Support Brace</b>						
Tymec 1997  RCT	1.5	N=52 patients within age range 27 to 90 years (M=66.6, SD=16.5)	Pillow positioned under both legs from below knee to Achilles tendon region, leaving heels suspended above (Pillow group) vs. Foot waffle placed on each leg (Foot waffle group)  Patient’s position order supine then right lateral tilt	Both groups Odds Ratio of 4.38 with interface pressure >0mm Hg 4 times often with foot waffle than pillow. Significant difference between groups in skin changes (p = 0.036). Difference between groups in mean length of survival;	“[T]he results of this study did not support the use of the previously designed foot waffle for continuous heel elevation.”	Data suggest use of foot waffle device led to earlier development of foot ulcers although both groups ultimately developed foot ulcers.

			or right lateral tilt then supine.	pillow group vs. foot waffle (13 vs. 10 days)		
<b>Growth Factors</b>						
<b>Becaplermin</b>						
Steed 1995  RCT  No mention of sponsorship or COI.	3.0	N = 118 with chronic, full-thickness, lower-extremity diabetic neurotrophic ulcers of at least 8 weeks'; Mean Age was 60.8 years.	PDGF group-rhPDGF-BB (Becaplermin) gel applied at dose equivalent to 2.2 micrograms until completely healed, or 20 weeks (n = 61) vs. Placebo Gel Group-Saline Gel (n = 57).  Follow-up for 20 weeks	At 20 weeks, 29 (48%) of patients treated with PDGF showed complete wound healing (functional assessment score of 1) compared with 14 (25%) of placebo group (p = 0.01). From day 68 to end of trial a difference of 30-40 days in time to complete wound healing observed in favor of PDGF group (p = 0.01).	"...demonstrated that repeated, once-daily, topical application of rhPDGF-BB is safe and stimulates rapid healing of chronic, full-thickness neurotrophic ulcers of the lower extremity in patients with diabetes mellitus.	Sparse study design details. Wound healing in experimental group was 2x vs. placebo.
<b>Topical nerve growth factor (TNGF)</b>						
Landi 2003  RCT	3.0	N = 38 patients with pressure ulcers on foot. Mean age of participants was 80.3 years.	2.5 S murine nerve growth factor used (topical nerve growth factor treatment, n=18) vs. (topical conventional treatment, n = 18). Balanced salt solution used as placebo and dropped on lesion in similar way	Mean area ( $\pm$ SD) of ulcers between groups after 6 weeks treatment; treatment group vs. controls (274 $\pm$ 329 mm <sup>2</sup> vs. 526 $\pm$ 334 mm <sup>2</sup> ) p = 0.022. Reduction in ulcer area	"Topical application of nerve growth factor may be an effective therapy for patients with severe pressure ulcers."	1 patient from treatment group died and another from control group lost to follow-up. Topical treatment with NGF appears effective for treatment of foot pressure ulcers

			with topical nerve growth factor solution. Both groups received same daily local care, NS irrigation, debriding enzymes, and opaque hydrocolloid occlusive barriers. Assessment at 6 weeks.	after adjustment for potential confounders; treatment vs. control group (6.5±0.3mm <sup>2</sup> vs. 5.9±0.3 mm <sup>2</sup> ) p <0.001		
Huang 2014  RCT  Sponsored by the Jinan City 2009 Technology Development Program. No mention of COI.	2.5	N = 60 with refractory chronic skin ulcers, which persisted for >1 month. Aged between 20 and 75 years with an average age of 50.6.	Group A or rhGM-CSF paste covered by alginate dressing (n = 20) vs Group B or rhGM-CSF only, applied to wounds (n = 20) vs Group C or Conventional vaseline dressing gauze applied (n = 20). Follow-up for 21 days.	Healing: highest healing rate of 56% for group A vs group C and B had a healing rate of 21 and 34%, respectively. Group showed significantly reduced pain vs groups B and C, (p <0.05).	“[T]he combined application of alginate dressing and rhGM-CSF for the treatment of refractory chronic skin ulcers demonstrated significant advantages.”	Non-specific to diabetic ulcers. Sparse methods and baseline data combination of alginate and rhGM-CSF promoted faster wound healing compared to rhGM-CSF or conventional therapy.
Akbari 2007  RCT  No sponsorship or COI.	3.0	N = 18 patients with diabetic foot ulcers corresponding to grade 2 of University of Texas Diabetic Foot Wound Classification system.  Mean Age 58.2 ± 8.07 Experimental group and 57.6 ± 8.02 Control group.	Experimental group (n = 9) received Vacuum-Compression Therapy (VCT) and conventional therapy vs. Control group (n = 9) received conventional therapy only.  12 sessions during 3 weeks, follow-up not clarified.	After 10 VCT sessions or conventional therapy sessions, surface area of foot ulcer diminished. Experimental showed a larger improvements in reduced surface area than control group. It is also believed that the VCT systems using negative pressure	“Our results showed that VCT with conventional therapy more effectively healed diabetic foot ulcers than conventional therapy alone. VCT effectively prompted capillary filling and therefore helped patients with arterial circulation problems.	VCT administered 1 hour a day, 4 times a week for 10 sessions. Statistical data appear to be missing from the article. Small sample size (n = 18). Sparse methodology and comparable results.

				helps to improve oxygenation to tissues affected by vascular insufficiency and diabetes.	Thus, for wound healing and limb preservation, we recommend VCT, in addition to conventional therapy, for patients with diabetic foot ulcers and nonhealing wounds.”	
Eginton 2003  RCT, prospective	3.0	N = 10 diabetics with significant soft tissue defects of the foot.	Vacuum Assisted Closure device™ (VAC) Vs Conventional moist dressings. At enrollment, patients assigned to receive 1 treatment for first 2 weeks, after which they switched to other treatment for remaining 2 weeks.  Follow-up for 2 and 4 weeks.	At 4 weeks, wound depth significantly changed from examination ( $3.1 \pm 0.9$ ) to termination ( $1.2 \pm 0.3$ ); ( $p < 0.05$ ). At 2 weeks, VAC therapy significantly reduced wound depth ( $-49 \pm 11.1$ vs. $-7.7 \pm 5.2$ ) and volume ( $-59 \pm 9.7$ vs. $-0.1 \pm 14.7$ ) of wound vs. moist dressing ( $p < 0.05$ and $p < 0.005$ ).	“[The] data from a small group of diabetic patients with large foot wounds demonstrate that negative-pressure wound dressings decrease wound depth and volume more effectively than moist gauze dressings over the first 4 weeks of therapy. We believe that this will ultimately result in more rapid complete wound healing and prevention of wound complications so frequently encountered in this population.”	High dropout rate and small sample size. Crossover design.

<p>Landsman 2010</p> <p>RCT</p> <p>Sponsored by Soluble Systems LLC. COI: Dr. Landsman is a paid consultant for Soluble Systems LLC.</p>	<p>3.5</p>	<p>N= 32 wounds (number of patients not specified) with forefoot or midfoot ulcer of Wagner Grade 1 or 2. Mean Age; 57.2 years.</p>	<p>TheraGauze (TG) group- treated with standard wound debridement as needed and dressing changes every other day with TheraGauze applied to wound surface (n = 16 wounds) vs. TheraGauze + Becaplermin (TG + B) Group- Same treatment as TG group, with the extra treatment of becaplermin (Regranex 0.01%) daily (n = 16 wounds). Weekly follow-up to Week 12, then bi-weekly to Week 20.</p>	<p>Main outcome was percentage of wounds that achieved complete closure and rate of closure: 46.2% of wounds in both groups achieved closure at 12 weeks and 69.2% in TG+B group vs. 61.5% in TG group at 20 weeks (p &gt;0.05). Rate closure higher during first 4 weeks compared to last 16. Average rate closure 0.37 cm<sup>2</sup>/week in TG group vs. 0.41 cm<sup>2</sup>/week in TG +B group (p = 0.34).</p>	<p>“In conclusion, we believe that this study illustrates that wounds are more likely to close and to close more quickly with regulation of moisture across the wound bed. Smart dressings that provide precise regulation of the wound environment will be expanded in the future as new applications that take advantage of this unique technology are explored.”</p>	<p>Comparable results in both groups suggesting becaplermin does not increase wound healing.</p>
<p>Richard 1995</p> <p>RCT</p> <p>Sponsorship, supported by Farmitalia Caro Erba Laboratory, Milano, Italy.</p> <p>No mention of COI.</p>	<p>3.5</p>	<p>N = 17 suffering from chronic neuropathic ulcer of the plantar surface of foot. Typical neuropathic ulcer of Wagner grade I-III, more than 0.5 cm in the largest diameter.</p> <p>Mean age 61.9±10.0 years in treatment group.</p>	<p>bFGF vs. placebo applied daily for 6 weeks, then twice a week for 12 weeks.</p>	<p>Weekly reduction in ulcer perimeter and area was identical in both groups, as was rate of linear advance from entry to 6th week of treatment (bFGF: 0.053±0.048 mm vs. placebo: 0.116±1.129 mm): same result</p>	<p>“Topical application of bFGF has no advantage over placebo for healing chronic neuropathic diabetic ulcer of the foot. Because diabetes causes significant wound-healing defects, we hypothesized that using a single growth</p>	<p>Small sample size (n = 17). Sparse methodological details.</p>

				obtained at 11th week.	factor might be insufficient to accelerate wound closure of diabetic ulcers.”	
<b>Autologous-derived Growth Factor</b>						
Lyons 2007  Dose-escalation study  Sponsored by Agennix, Inc. and the National Institute of Arthritis and Musculoskeletal and Skin Diseases of the National Institute of Health.	N/A	N = 9 with diabetes mellitus with an HbA <sub>1c</sub> from 6% to 13%, full thickness diabetic foot ulcer below that ankle that has not reduced in size ≥30% in past 4 weeks with typical treatments, post debridement size between .5-10 cm <sup>2</sup> , transcutaneous oxygen tension ≥30 mm Hg or ankle-brachial index ≥0.7; Mean (±SD) age 57 (±6) for 1% gel group, 54 (±7) for 2.5% gel group and 52 (±11) for 8.5% gel group.	1% Talactoferrin gel group (n=3) vs. 2.5% Talactoferrin gel group (n=3) vs. 8.5% Talactoferrin gel group (n=3).  Groups instructed to apply gel twice daily to ulcer for 30 days alongside typical wound care.  Assessments at baseline, weekly during treatment, weekly for 1 month after final treatment, and semimonthly for 3 months after final treatment.	No p-value statistics reported for this phase of the study. 2.5% and 8.5% talactoferrin selected for use in phase 2.	“[T]alactoferrin was a safe and well-tolerated treatment of diabetic neuropathic foot ulcers without associated adverse events or laboratory abnormalities. In addition, talactoferrin enhanced the rate of healing in these ulcers. A phase 3 will be required to confirm these results.”	Study Phase 1- same article as below.
<b>Prostacyclin Analogues (Iloprost)</b>						
Sert 2008  RCT  No mention of COI or Sponsorship.	2.5	N = 60 with type 2 diabetic patients (61.8 ± 9.7 years, mean ±SD) with diabetic foot ulcer and peripheral arterial occlusive disease, stage	Group I: iloprost infusion (0.5-2 ng/kg/min for 6 h) for 10 consecutive days. (n = 30) vs. Group II: (n=30) treated same except iloprost	Group I patients showed improvement in endothelial functions at 10th and 30th day (p = 0.002) in respect to group II.	“Ten-day iloprost infusion therapy to patients with diabetic foot ulcers seems to be efficient in the improvement of endothelial	Sparse details.

		III or more by Wagner classification. Plus 15 healthy controls.	treatment constituting a patient control group.  30 day follow-up.		function, but, despite our positive clinical observation, this improvement does not affect the outcome of the amputation rates at 30 days follow up period.”	
<b>Complementary and Alternative Medications</b>						
Leung 2008  RCT  Sponsored by the University Grants Council of Hong Kong.	2.5	N = 80 with chronic foot ulcers, type 2 diabetes; Mean ( $\pm$ SD) age 66.3 ( $\pm$ 12.6) for herbal group and 68.5 ( $\pm$ 11.1) for placebo group	Herbal treatment group receiving a mixture of 12 herbs given 2x daily in a drink (n = 40) vs. Placebo control group (n=40).  Both groups received typical antidiabetic treatment.  Assessments at baseline, 1 week, 2, 3, and 4 weeks.	No statistically significant p-value results reported for limb salvage or healing of ulcers.	“[T]his study further supports the efficacy of the herbal supplement. The treatment group showed superiority over the placebo group in terms of: limb salvage, appearance of granulation tissue, and overall assessment of wound healing. Importantly, the study further supported the safety of the herbal formulation.”	Article methods note inclusion is Type 2 DM, but table has some Type 1 enrolled. Sparse methods. Baseline differences in gangrenous tissue (none in 18% herbal vs. 35% placebo) concerning for randomization failure.
Larijani 2008  RCT  Supported by ParsRoos Co. No mention of COI.	2.0	N= 25 patients with diabetic foot ulcers; Mean Age was 53.6 years.	Semelil Group- Intravenous administration of ANGIPARS 4 mL daily for 28 days (n = 16) vs. Conventional Therapy included betadine bath,	Significant decrease in ulcer surface area for Semelil vs. Conventional Therapy; 64% reductions vs. 25% reduction (p = 0.015).	“This herbal extract by intravenous route in combination with conventional therapy is more effective than conventional	Small sample size. Differing group sizes with only 9 controls reported.

			antibiotic therapy, wound debridement. (n = 9).  Follow-up for 4 weeks.	Treatment group showed decrease in wound size compared to baseline (479.93 mm <sup>2</sup> to 198.93 mm <sup>2</sup> , (p<0.001)). No significant decrease in area in control group (p = 0.076).	therapy by itself probably without side effect. However, further studies are required in the future to confirm these results in larger population.”	
Bahrami 2008  RCT  No mention of sponsorship or COI.	1.0	N = 21 with diabetic foot ulcers. Age range from 18 to 75 years.	Group 1 received 100mg of oral ANGI <sup>PARS</sup> ™ twice a day for 6 weeks, plus conservative treatment (n = 6) vs. Group 2 received ANGI <sup>PARS</sup> ™ gel 3% added to oral form of same product and not conventional therapies (n = 6) vs. Group 3 or control, only conventional therapies performed (n = 9). Follow-up for 6 weeks.	Foot ulcer surface areas decreased from 375.00± 118.14 mm <sup>2</sup> to 41.67±32.70 mm <sup>2</sup> in group 1, (p = 0.040); and from 916.67±228.64 mm <sup>2</sup> to 137.50± 41.71mm <sup>2</sup> in group 2 (p = 0.010). In group 3, ulcer surface areas reduced from 766.22±320.17 to 689.11±329.07, (p = 0.076).	“[I]n diabetic foot ulcers, either treatment with oral ANGI <sup>PARS</sup> ™ capsules (100mg) twice a day or combination therapy with oral and topical forms, in conjunction with good wound care significantly increased the incidence of complete wound closure.”	Phase 3 trial. Small sample size (21), and unequal group sizes. Baseline differences (ulcer surface area 375 vs. 917 vs. 766), concerning for randomization failure.
<b>Hyperbaric Oxygen</b>						
Wang 2009  RCT  Sponsorship, supported by National Science Council (95-2314-B-182A-081), Tissue	3.5	N =72 with chronic diabetic foot ulcers.  Mean±SD age was 58.6±12.6 years (ESWT); 63.4±10.3 years.	ESWT group received 300 100/cm <sup>2</sup> impulses of shockwave at 0.11 mJ/cm <sup>2</sup> energy flux density every 2 weeks for 6 weeks vs. hyperbaric oxygen therapy (HBO) group received	Completely healed in 31%, improved in 58%, and unchanged in 11% for the ESWT group vs. 22% completely healed, 50% improved, and 28% unchanged	“ESWT appears to be more effective than HBO in chronic diabetic foot ulcers”	Quasi-randomized (date of treatment). HBO administered by a “mask” in a chamber.

Regeneration Technologies, and National Health Research Institute (NHRI-EX96-9423EP). No mention of COI.			HBO daily for 20 treatments via mask.	for HBO group.		
Duzgun 2008  RCT  No sponsorship or COI.	2.5	N = 100 with foot wound that had been present for at least 4 weeks despite appropriate local and systemic wound care.	Standard therapy (ST) administered 2 sessions per day, followed by 1 session on following day (n = 50) vs ST combined with HBOT standard therapy supplemented by hyperbaric oxygen treatments (n = 50).  Follow-up for 4 to 5 months.	No patients in ST group who healed without surgery vs 33 (66%) of patients in group receiving HBOT healed without surgery. Healing ST vs HBOT; (Ulcer grade 2)/(Ulcer grade 3)/and (Ulcer grade 4): (0 vs 6) / (0 vs 13) / and (0 vs 14).	“In conclusion, this study showed that the use of HBOT in the treatment of diabetic foot ulcers statistically significantly improved the prevalence of healing in foot ulcers of diabetic patients.”	Multiple baseline differences concerning for randomization failure. Data suggest better results with HBO.
<b>Extracorporeal Shockwave Therapy</b>						
Moretti 2009  RCT  No COI. No mention of Sponsorship.	3.5	N = 30 with neuropathic diabetic foot ulcers.  Mean±SD age: 56.8±7.5 years.	Standard care and shock wave therapy. Other group treated with standard care.  Follow-up over 20 weeks.	Complete wound closure ESWT-treated vs. control: 53.33% vs. 33.33%. Healing times: 60.8 vs. 82.2; p <0.001.	“[ESWT] may be a useful adjunct in the management of diabetic foot ulceration.”	Details sparse.

Wang 2009 RCT  Sponsorship, supported by National Science Council (95-2314-B-182A-081), Tissue Regeneration Technologies, and National Health Research Institute (NHRI-EX96-9423EP). No mention of COI.	3.5	N = 72 with chronic diabetic foot ulcers.  Mean±SD age 58.6±12.6 years (ESWT); 63.4±10.3 years.	ESWT group received 300 100/cm <sup>2</sup> impulses of shockwave at 0.11 mJ/cm <sup>2</sup> energy flux density every 2 wk for 6 wk vs. hyperbaric oxygen therapy (HBO) group received HBO daily for 20 treatments via mask.	Completely healed in 31%, improved in 58%, and unchanged in 11% for the ESWT group vs. 22% completely healed, 50% improved, and 28% unchanged for the HBO group.	“ESWT appears to be more effective than HBO in chronic diabetic foot ulcers”	Quasi-randomized (date of treatment). HBO administered by a “mask” in a chamber.
<b>Electrical Stimulation</b>						
Petrofsky 2010 RCT  No COI. No mention of Sponsorship.	1.0	N = 20 non-healing diabetic foot ulcers (mean duration 38.9±23.7 months).  Mean±SD age: 48.4±14.6 years	Local dry heat (37°C; n = 10) vs. local dry heat + ES (n = 10) three times a week for 4 weeks.	Average wound area and volume decreased in ES + heat group: 68.4±28.6% and 69.3 ± 27.1%, respectively (both p<0.05), over the 1-month period.	“Local dry heat and ES work well together to heal chronic diabetic foot wounds; however, local heat would appear to be a relevant part of this therapy because ES alone has produced little healing in previous studies.”	Sparse details. Attempted to study additive benefit of Electrical stimulation over dry heat alone.
<b>Skin Grafts</b>						
<b>Dermagraft</b>						
Martson 2003 RCT	3.5	N= 314 patients with diabetes with a foot ulcer of at	Dermagraft Group: Dermagraft application	There were 245 patients with chronic ulcers (>6	“In conclusion, Dermagraft has been	Some dissimilar baseline comparability

<p>Supported by a research grant from Advanced Tissue Sciences, Inc. and Smith and Nephew, Inc. COI- W.A.M. is on speaker's bureau for Smith and Nephew, Inc., and has received honoraria and travel support for lectures and travel programs from Smith and Nephew, Inc. J.H. has received consulting fees for lectures and program sponsorship from Advanced Tissue Sciences, holds stock in ATIS, and has been a paid speaker for Smith and Nephew, Inc.</p>		<p>least 2 weeks duration. Mean Age was 55.7 years</p>	<p>with standard wound dressings (n = 163) vs. Control Group: Standard wound dressings (n = 151).  Follow-up for 12 weeks.</p>	<p>weeks duration). 39 (30%) of patients in dermagraft group had completely healed at 12 weeks compared to 21 (18%) in control group (p = 0.023). The dermagraft group had a significantly faster time to complete wound closure than the control group (p=0.04). No significant differences in the number of adverse events between groups.</p>	<p>shown in this multicenter, prospective randomized study to be safe and effective for the treatment of chronic diabetic foot ulcers.”</p>	<p>data. Adverse events similar between groups. Dermagraft group had more complete ulcer healing at 12% compared to control group (30% vs. 18%, p = 0.023).</p>
<p><b>Apligraf</b></p>						

<p>Moustafa 2007</p> <p>RCT</p> <p>No mention of sponsorship. Dr. Manar Moustafa and Dr. Anthony Bullock were employed by the University of Sheffield through a grant obtained from CellTran Limited, Ms. Zoe Ince and Dr. David B Haddow are employees of Celltran and Professor Sheila MacNeil is a Founder Director of CellTran and R&amp;D Director of CellTran.</p>	<p>3.5</p>	<p>N= 16 patients (21 Ulcers) with diabetic ulcers. Mean age was 52.4 years.</p>	<p>Active Group- received up to 12 active dressings (n = 8) vs. Placebo Group: initially received 6 placebo dressings followed up by up to 12 active dressings (n = 8).</p> <p>Follow-up for 12 weeks.</p>	<p>Ultimately, 12 patients each with 1 ulcer index were analyzed (7 active, 5 placebo). In the placebo group 1/5 ulcers completely healed and 4/7 in the active group. During follow-up, 3 of 4 completely healed ulcers in the active group recurred. Ulcer size reduction after treatment was greater in active group compared to the placebo group, however, these differences were not significant (p &gt;0.05).</p>	<p>Repeated regular applications of the patient's keratinocytes, delivered on the carrier dressing, initiated wound healing in ulcers resistant to conventional therapy, with 19 out of 21 ulcers responding.</p>	<p>Partial cross-over. High dropouts.</p>
--	------------	--	--	--	---	---

**FOOT DROP**

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
<b>Orthotics</b>						
<p>Hausdorff 2008</p> <p>RCT</p>	<p>1.0</p>	<p>N = 24 with chronic hemiparesis whose walking</p>	<p>Subjects walked for 6 minutes while wearing force-</p>	<p>Gait asymmetry index instantly improved by</p>	<p>“The studied neuroprostheses enhances gait and</p>	<p>Neuroprostheses appeared to improve gait and stability in</p>

		was impaired by foot drop, with mean age $54.0 \pm 5.2$ .	sensitive insoles, once with and once without the neuroprostheses. Neuroprostheses were conducted after using the device for 4 and 8 weeks.  Follow-up for a total of 8 weeks.	28% or from $0.58 \pm 0.30$ to $0.42 \pm 0.22$ ) and by 45% (to $0.32 \pm 0.20$ ; $p \pm 0.001$ , after 8 weeks. Stride time variability decreased by 23% immediately (from $5.7 \pm 2.9\%$ to $4.4 \pm 1.3\%$ ) and by 33% (to $3.8 \pm 1.4\%$ ; $p < 0.002$ ) after 8 weeks.	improves dynamic stability in chronic hemiparetic patients, supporting the idea that this is a viable treatment option in the rehabilitation of patients with foot drop.”	patients with foot drop but study elements were sparse and omitted many details.
--	--	---	--	--	---	--

### Taping

Vicenzino 2000  RCT Cross-over	1.0	N = 14 with an increase in vertical navicular height of at least 10mm when foot was moved from relaxed calcaneal stance to subtalar neutral, mean age $23.8 \pm 3.5$ .	LowDye taping, temporary felt orthotics, consisting of a spur and mini-stirrups, and adding calcaneal slings and reverse sixes which are anchored one third up leg and all subjects have participated in fitness activities (10 and 20 minutes). In control condition, subjects did not have tape or orthotics applied.  Follow-up of exercise challenge (0, 10, and 20 minutes of	Exercise challenge effect on each treatment technique: with tape, there was a significant reduction in mean percentage change in mean vertical navicular height from 19.0%-5.9% over first 10-minute period, but not over second 10-minute period (5.9%-3.5%). Tape and orthotic treatments produced approximately a 19% and 14% increase in vertical navicular height.	“Antipronation tape and temporary orthotics help to control excessive foot pronation initially after application and following exercise.”	Crossover study with small N and few details on methodology.
---	-----	--	--	---	---	--

			controlled jogging).			
--	--	--	----------------------	--	--	--

### MORTON'S NEUROMA

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
<b>Lidocaine Patches</b>						
Quiding 2013  RCT	3.0	N=27 patients with Morton neuroma for at least 3 months confirmed by MRI.	2mL Placebo vs. 1mg/mL lidocaine vs. 10mg/mL lidocaine. Patients had 3 visits each. At each visit, a patient randomly assigned to one of three treatments and then immediately tested with QST assessments and a step-up test.	Mean QST assessment value calculated for affected and non-affected foot. Difference between feet not significant for any group (p >0.10). Lidocaine (10mg/mL) showed significant effects compared to placebo for QST for 3 measurements, CDT measurement (p = 0.039), MDT measurement (p = 0.009) and wind up (p = 0.016). Mean pain intensity following injection was 4.1 after placebo, 2.0 after 1 mg/mL lidocaine and 1.2 after 10mg/mL lidocaine. Difference between placebo and lidocaine (1mg/mL) and lidocaine (10mg/mL) significant. (p <0.001).	“The present results may therefore suggest that lidocaine is relatively more effective on heat pain in damaged tissue and, although results were seen in only 3 patients, could be effective in patients with heat hyperalgesia, ie, in patients with pain resulting from sensitized heat nociceptors.”	Crossover study with small N and minimal baseline characteristics. Some data suggest possible efficacy.

### ACHILLES TENDINOPATHY

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments

Exercise vs. Exercise						
Niesen-Vertommen 1992 RCT	2.5	N = 17 athletic patients, chronic Achilles tendinitis	Eccentric vs. concentric exercise regimens daily for 12 weeks.	No differences in return-to activity ratings. Differences favoring eccentric in pain ratings 3.0 vs. 4.7 at 12 weeks.	“The subjective symptoms of pain with Achilles tendonitis were better controlled in the eccentric exercise group than in the concentric group.”	Small sample size. Lack of study details.
NSAIDs						
Bourne 1980 RCT	3.5	N = 60 acute sports injuries	Ibuprofen (1,600 mg) vs. paracetamol (3,600 mg) daily.	Days to return to sport in 1-5 days: Ibuprofen 14/28, paracetamol 5/27, (p <0.05).	“[I]f ibuprofen is given within two days of injury return to sporting activity is hastened, and our results support those of Muckle (1974).”	Sparse study details.
Orthotic Devices						
Lowdon 1984 RCT	2.5	N = 33 age 11-51 years with unilateral Achilles tendinitis	Sorbothane heel pads for 2 months (n = 11) vs. soft sponge rubber pads of “Molefoam” (n = 10) vs. no pads (n = 12). All received 5 consecutive daily 5 minute ultrasound treatments.	All groups with improvement at 10 days and 2 months.	“Patients treated with ultrasound and exercises alone (group III) revealed the most significant improvement in the clinical findings, as characterized by a reduction in both swelling and tenderness.”	All groups with ultrasound and exercise therapy. Data suggest possible randomization failure. Small sample size for 3 comparison groups. “No heel pad group” significantly shorter duration of symptoms. Outcomes measures were gain parameters that may have little clinical significance.

### ACHILLES TENDON RUPTURE

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
<b>Achilles Rupture Surgery vs. Non-operative Care</b>						

Nistor 1981	3.5	N = 105 closed acute ruptures of Achillis tendon	Surgery (end to end suture) vs. progressive casting.	“Absence from work varied depending on work. It averaged thirteen weeks (0-30) in surgically treated groups and nine weeks (0-44) in non- surgically treated groups (P <0.05).” No differences in plantar flexion strength or increases in tendon size.	“Results of both surgical and non- surgical treatment of acute ruptures of the tendo Achilles were good, and they confirmed the results reported previously. There were only minor differences in the groups, but the period of morbidity was shorter, the complaints were fewer, and no hospital stay was needed in the conservatively treated patients. ...The treatment of choice should be non-surgical.”	Quasi randomized (odd-even day). No blinding of assessment. Casting group was quicker to return to work, although also had higher re- rupture rate (8% vs. 4%).
----------------	-----	--	--	--	---	---

### PLANTAR FASCIITIS

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
<b>MRI</b>						
Maier 2000  RCT	2.5	N = 43 patients (48 heels) with chronic courses of plantar fasciitis	MRI with a high field system vs. MRI with a low field system.	While thickness of plantar aponeurosis, soft tissue signal intensity changes, and soft tissue contrast medium uptake did not correlate with clinical outcome, presence of a calcaneal bone marrow edema highly predictive for satisfactory outcome (positive predictive value 0.94, sensitivity 0.89, specificity 0.8).	“This study indicates that in patients with chronic plantar fasciitis, the presence of calcaneal bone marrow edema on pretherapeutic MRI is a good predictive variable for a satisfactory clinical outcome of ESWA.”	No non-MRI control group.
<b>NSAIDs</b>						
Bourne 1980	3.5	See NSAIDs in Evidence Table for Achilles Tendinopathy above.				

Donley 2007	2.5	N = 29 with plantar fasciitis	NSAID (celecoxib 200mg q day) vs. placebo.	NSAID vs. Placebo (1, 2, 6 months); Pain (VAS improvement): 2.55 vs. 1.47, 3.73 vs. 2.97, 6.06 vs. 4.85, all p >0.05; Disability (VAS improvement): 1.92 vs. 0.88, 2.71 vs. 2.42, 4.96 vs. 3.81, all p >0.05.	"...the use of an NSAID may increase pain relief and decrease disability in patients with plantar fasciitis when used with a conservative treatment regimen."	Small sample size. Co- interventions (heel cup, stretching, and night splints) allowed. Details of randomization sparse. Baseline differences in outcome measures. No statistical differences in outcomes measures at 1, 2, 6 months.
----------------	-----	--	--	---	---	---

### Glucocorticosteroid Injections

Lynch 1998  RCT	3.0	N = 103 with plantar fasciitis	Group 1 (n = 35) steroid injection 0.5ml dexamethas one plus 2 300mg capsules of etodolac a day vs. Group 2 (n = 33) viscoelastic heel cup plus acetaminop hen vs. Group 3 (n = 35) LowDye taping plus custom orthoses.	High treatment failures in injection group (23%) and heel cup (42%). Final outcome of "excellent" or "fair" vs. "poor." Injection group 33% (9 of 27) Heel cup group 30% (7 of 23) vs. 70% (19 of 27) of orthoses group (p = 0.005).	"The results of this study show that mechanical control of the foot with taping and orthoses is more effective than either anti- inflammatory therapy with NSAIDs in combination with injections or accommodative therapy with heel cups in the conservative treatment of plantar fasciitis."	Lack of study details. No blinding. Lack of control for co- interventions. Randomization and allocation unclear.
--------------------------	-----	--	--	--	---	--

### Magnets

Caselli 1997  RCT	2.5	N = 40 with medial plantar calcane al heel pain	PPT/Rx Firm Molded Insole with magnetic foil vs. PPT/Rx Firm Molded Insole with no magnetic foil.	No significant difference between number of patients reporting improvement in each group (chi-squared = 1.22; p = NS). No significant difference in improvement made by magnetic foil group vs. PPT/Rx	"Approximately 58% of patients using the PPT/Rx Firm Molded Insole with magnetic foil for 4 weeks and 60% of patients using the PPT/Rx Firm Molded Insole alone for the same period reported	Lack of method details. Unclear if this was an RCT.
----------------------------	-----	---	--	--	--	--

				Firm Molded Insole group as measured by percentage difference in mean scores on foot function index.	improvement in foot function as measured by the foot function index. The magnetic foil offered no advantage over the insole.”	
<b>Orthoses</b>						
Martin 2001 RCT	3.5	N = 255 plantar heel tenderness, history of pain on rising in morning or after rest, no history of trauma to heel within previous 3 months	Custom-made orthoses vs. OTC arch supports vs. tension night splints.	No statistically significant differences among treatment groups in overall effectiveness during 12 weeks of treatment for plantar fasciitis. Overall success rate of treatment in present study lower than rates in studies in which multiple modalities used.	“Mechanical control of the foot is a successful method of treating plantar fasciitis. Custom-made orthoses, over-the-counter arch supports, and tension night splints are all effective as initial treatments for plantar fasciitis. Patients in the present study demonstrated the best compliance with the use of custom-made orthoses, which may indicate that orthoses provide the best long-term results.”	No blinding. High drop-out rate; 12 week study.
Kavros 2005 RCT	3.0	N = 50 plantar fasciitis of 4 weeks duration but less than 12 weeks	AirHeel device vs. prefabricated orthoses.	Changes from baseline to week 12 (VAS pain scores); AirHeel vs. 1st Step: -25.8 vs. -21.1 p = 0.075.	“Patients with a higher initial pain score seemed to respond better initially to the AirHeel (p = 0.015) than the 1st Step insert (p = 0.035).”	Intervention provided for acute phase of condition that has natural history of improvement in 90% of cases. No placebo for comparison to natural history. Co-intervention of plantar fascia stretching exercises.
Lynch 1998	3.0	See Glucocorticosteroid Injections above.				
Caselli 1997	2.5	See Magnets above.				

Mejjad 2004  Crossover Trial	5.0	N = 16 metatarsalgia due to rheumatoid arthritis	Orthotics vs. no orthotics.	Mean VAS scores lower for orthotic group (42.06±15.87 mm for gait without orthotics vs. 18.87±12.09mm for gait with orthotics), p = 0.008. No difference between right and left side for spatiotemporal variable values between groups.	“[W]earing foot orthoses provided significant pain relief, but was not sufficient to improve gait in RA patients with metatarsalgia due to forefoot involvement. Limiting pain is the main reason why foot orthoses have been widely recommended, but has not fully addressed the problem of gait in RA patients.”	Population was RA patients with metatarsalgia. Orthotic use resulted in less pain (metatarsalgia) related to RA. Study was excluded in the evidence table as it is a study of purely RA patients and no clear relationship with workers.
Fauno 1993  Quasi-RCT	3.5	N = 121 soccer referees	Shock absorbing heel cup (SAH) vs. no heel cup in asymptomatic population.	Lower incidences of soreness in back, calf, and Achilles tendon for group wearing SAH compared to control group on days 2, 3, and 4, p <0.05.	“The occurrence of achillodynia, calf muscle soreness and back pain can be reduced by the use of shock absorbing heel insoles when used during a period of extreme strenuous activity. Other problems, however, like ankle, knee and thigh soreness were not improved by the use of SAH.”	Study performed in sports referee group at 5-day soccer tournament. Pseudo-randomization (allocation by date born in month). High loss to follow-up (30/121).

**Shock Absorbing Shoes**

Fransen 1997  RCT	N/A	N = 30 with rheumatoid arthritis (RA) reporting chronic foot pain	Footwear vs. no footwear for 2 months.	Footwear group showed improvement on all measured variables. Control group showed slight deterioration for all variables except NWB pain. Footwear group improved for all gait variables.	“These data suggest that off-the-shelf orthopedic footwear is beneficial for people with RA even when subjects were unselected on basis of age, sex, disease duration, or disability as measured by the Stanford Health Assessment Questionnaire.”	Excluded, study of RA patients only.
-------------------------	-----	---	--	---	--	--------------------------------------

**Taping**

Lynch 1998	3.0	See Glucocorticosteroid Injections above.				
Extracorporeal Shockwave Therapy						
Furia 2005 RCT	2.0	N = 53 chronic plantar fasciitis	Single treatment vs. multiple treatments of ESWT	Mean pre-treatment VAS entire group 9.2±0.7; 4 weeks after treatment VAS score decreased to 3.4±1.9; after 12 weeks decreased to 2.4±1.8. Difference between pre-treatment, 12 week post-treatment VAS scores statistically significant (p <.05).	“The results of the current study revealed beneficial effects of extracorporeal shock wave therapy in patients with chronic plantar fasciitis.”	Treatment appeared effective in all groups but sample size too small for between group comparisons.
Alvarez 2003 RCT-Mixed	Excluded		ESWT vs. sham			Results included pooling of randomized and non-randomized subjects from combined studies. No conclusions specific to randomized population provided. Appears similar if not same population as Ogden 2004. Study is excluded.

### ANKLE SPRAINS

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
NSAIDs						
Dupont 1987 RCT	3.5	N = 67 acute ankle sprains, varying degree of severity	Ibuprofen 600mg, 4 times daily vs. placebo.	Ibuprofen vs. placebo VAS 0-4 (day 4, 8); Rest: 0.3 vs. 0.2, 0.2 vs. 0.2; Jumping: 0.7 vs. 1.0, 0.5 vs. 0.5; Walking: 1.8 vs. 1.9. 1.2 vs. 1.3.	“Although there were trends indicating a superiority of effectiveness in the treatment group, the differences between groups were not statistically significant.”	Study not clear if it is a randomized trial. Allocation unclear. Reported no differences between placebo and ibuprofen group.

Fredberg 1989  RCT	3.0	N = 68 acute ankle joint injuries presented to casualty ward	Ibuprofen 600mg, 4 times daily vs. placebo for 4-6 days.	No difference in swelling reduction, number of patients taking additional analgesics (5/47 vs. 9/53).	“No difference between relief of pain and reduction of swelling was demonstrated. We cannot recommend routine treatment with ibuprofen for acute ankle joint injuries.”	Drop outs (14) replaced by new patients. No data on compliance. Multiple co- interventions. Study suggests no difference between placebo and ibuprofen.
Aghababian 1986  RCT	2.5	N = 40 mild to moderate pain associated with Grade 2 ankle sprain	Diflunisal (1000mg loading, 500mg BID/TID) vs. codeine with acetaminophen (30/300 1 or 2 q 4 hours).	Severity of pain for diflunisal vs. acetaminophen at base line (%): none = 0/0, mild = 0/0, moderate = 100/100, severe = 0/0. After treatment: none = 21/28.5, mild = 73.7/62, moderate = 5.3/9.5, severe = 0/0. “In a global assessment of efficacy and tolerability, 17(89%) of 19 patients rated diflunisal as very good or excellent, whereas only nine (43%) of 21 patients rated acetaminophen with codeine similarly.”	“[D]iflunisal and the combination of acetaminophen with codeine are equally effective in relieving moderate pain associated with grade 2 ankle sprain.”	Lack of study details regarding randomization, allocation, blinding, compliance. No statistical analyses of results provided.
Andersson 1983  RCT	2.5	N = 100 sprained ankles	Ibuprofen 800mg TID (compression vs. ace bandage) x 10 days vs. placebo (compression vs. ace) 2- week trial for acute sprain (injury extent non- defined).	No differences in swelling improvement between 4 groups found. No differences in pain at rest, walking, or tenderness. Minimal statistical analysis presented.	“Neither Ibuprofen nor high quality bandaging had a significant effect on the swelling, pain or tenderness.”	Lack of randomization, allocation, baseline comparison, cointerventions and blinding details. Suggests no benefit from ibuprofen or elastic/compression bandages.
<b>Opioids</b>						

Aghababian 1986	2.5	See NSAIDs above.				
<b>Proteolytic Enzymes</b>						
Brakenbury 1983 RCT	3.0	N = 400 males who attended ER within 24 hours of sprain	Proteolytic enzymes plus plaster cast vs. placebo plus plaster vs. enzymes plus Tubigrip vs. placebo plus Tubigrip.	Day 7, bruising significant difference favor placebo/Tubigrip vs. enzymes/Tubigrip (p <0.01). Day 14, improvement in placebo/Tubigrip (89%) and placebo/ plaster (67%). Day 7, edema difference in favor of Tubigrip vs. plaster (p <0.05 in favor of placebo/ Tubigrip). No differences in between groups in dorsiflexion or plantar flexion.	“[T]hose who received a plaster cast and enzymes recovered faster than those in a cast alone. In addition, the power of dorsiflexion recovered faster in the Tubigrip group in those who received oral proteolytic enzymes.”	Lack of study details regarding randomization, allocation, blinding, compliance. High drop-out rate (148/400). Results suggest little clinical significance between these treatments.
<b>Benzydamine</b>						
Elswood 1985 Quasi-RCT	2.0	N = 86 presenting to accident and ER with ankle sprains	Tubigrip vs. benzydamine vs. placebo.	Mean scores for time from presentation Tubigrip vs. placebo vs. benzydamine at 0, 2, 9 days: 7.9/8.8/8.4, 5.2/5.9/5.7, 2.6/2.4/ 2.45. Mean scores for improvement days 0-2, SEM: 2.71/2.93/2.7, 0.53/0.51/0.33. All made similar progress.	“[I]nitial treatment of ankle sprains should include compressive support and rest followed by early active use of the joint. This topical agent appears to offer no advantage in the initial treatment of ankle sprains.”	Quasi-randomization (odd/even birth year), then randomized tubes of topical treatment. High loss to follow-up (34/86). Suggests no treatment effect from benzydamine for acute ankle sprains.
<b>Topical NSAIDs</b>						
Campbell 1994 RCT	3.5	N = 100 to ER with acute ankle sprain	Ibuprofen cream 5% applied QID vs. placebo cream, 7-14 day trial, likely Grade	Ibuprofen cream vs. placebo; significant difference in mean VAS score and walking ability Days 2 and 3 only.	“[T]he use of topical ibuprofen is associated with a statistically significant reduction in pain over the first 48 hours of treatment following	Results are of uncertain significance as 49% of randomized patients did not complete study and were not

			I, II acute sprains.		an acute ankle sprain.”	included in the analysis.
<b>Glucocorticosteroid Injections</b>						
Nilsson 1983  RCT	2.5	N = 178 injury to lateral ankle ligaments only, occurred within last 6 hours, patients 15-67 years of age	Elastic wrap (I) vs. elastic wrap plus cold pack, rubber pad (II) vs. elastic wrap, cold, rubber pad plus hydrocortisone local injection 4mg (III).	Injury severity determined by arthrography. Temperature: no ligament rupture, mean temperature less in Group III than I and II (p <0.005). No difference Day 7. With ligament rupture: Day 1 and 3 no difference I vs. II. I vs. III found lower temperature in III at Day 1, 7 (p <0.05). Pain: All without ligament rupture had more rapid pain relief after Day 1. With ruptures, I more pain than II and III after Day 1 (p <0.05, p <0.001).	“[A]nkle sprains should be treated conservatively with local cooling, anti-inflammatory medication and elastic wrapping regardless of the severity of the injury.”	Randomization, allocation, baseline comparability, blinding details not described. Timing of assessments variable for long term follow-up (3-6 months). Multiple cointerventions (PT in groups II and III) make comparisons difficult for individual treatment recommendations.
<b>Early Mobilization</b>						
Zwipp 1992  RCT	3.5	N = 200 rupture ankle ligaments	Surgery plus cast immobilization vs. surgery plus functional orthosis vs. cast immobilization vs. functional orthosis.	At 3 months, better ROM in primary functional group. No differences in subjective outcomes. At 12 months, no differences regarding joint stability, ROM, recurrence of injury, limitations, instability.	“[A]s a result of the trial, the only remaining surgical indications would seem to be dislocations of the foot and ankle, ankle ligament rupture with additional intra-articular pathology, and second-stage injuries or re-ruptures.”	Possible confounding cointerventions including NSAIDs, PT. Minimal statistical analysis provided.

Cetti 1984  RCT	3.0	N = 130 ruptur ed fibular ankle ligame nts	Below-knee walking plaster for 6 weeks vs. mobile Pliton-80 bandage.	Positive “modified” Romberg test for plaster and pliton (Week 8/24): 30/17, 16/8. Intermittent pain and swelling of ankle for plaster and pliton (Week 8/24): 24/8, 6/4.	“[R]ecommend the mobile Pliton-80 bandage as the treatment of ruptures to the fibular ankle ligaments.”	Randomization, allocation, baseline comparability, blinding, co- intervention details sparse. Differences between two treatments not statistically significant.
Korkala 1987  RCT	2.5	N = 150 recent tears of lateral ligame nt of ankle	Bandaging (1-4 weeks) vs. plaster cast of 4 weeks (weight bearing at 1 week) vs. operative repair of ligament plus plaster cast of 4 weeks for severe acute first time ankle sprain.	No significant differences at 2- years in sprain recurrences, number of subjects reporting decrease in sporting activities, tenderness, or talar tilt on radiographs. “Fear of giving way” more common in non- operative treatments (52.8% bandage, 32% cast vs. 9% operative). total chi square = 15.36 > 13.816 = $\chi^2$ .001 (df = 2). Good/ excellent results based on age (15-40 and 41-50): total chi square = 8.75 > 6.635 = $\chi^2$ .01 (df = 1). Significant difference in favor of younger group. No differences in interventions between age groups.	“Patients over 40 should be treated conservatively, since the capacity for ligamentous regeneration appears significantly less good than that of young people. Severe ankle sprains in patients under 40 should be preferably be treated by operation.”	Lack of study details. Only follow-up reported is at 2-years. Thus, unknown whether any short-term benefits. Suggests no significant differences at 2 years. Results limited to non- athletic populations.
<b>Tubular Elastic, Elastic Wrap, and Tape</b>						

Muwanga 1986 RCT	3.5	N = 156 with acute ankle injuries	Tubigrip vs. strapping vs. Velcro strap (Nottingham Ankle support).	Tubigrip vs. strapping vs. Nottingham; support able to bear weight (%): 40 vs. 62 vs. 67. P value and ROM data not reported. Nottingham > both Tubigrip and strapping p = 0.001174. Feeling of confidence: data not reported, Nottingham > both Tubigrip and strapping p = 0.02.	“The Nottingham Ankle Support was a convenient, economical and effective method of treatment of a common condition. It allowed a greater range of movement at early follow-up than Tubigrip and eversion strapping.”	Sparse details for randomization, allocation, cointerventions, compliance. Suggests Velcro strap support resulted in improved ROM and feeling of stability at 10 days.
Scotece 1992 RCT	3.5	N = 184 healthy soldiers with acute Grade I or Grade II ankle sprain	Taping (unchanged 3 days) vs. gel cast x 3 days vs. taping (changed each day x 3 days).	3-day strap vs. 3-day gel cast vs. daily strap return to duty Day 3 (military) 24/54 vs. 20/59 vs. 36/54. No grade II sprains returned by Day 3.	“[A] treatment protocol of daily ankle strapping plus standard physical therapy modalities/exercise was more effective than a single ankle strapping and a gel-O-cast wrap...for Grade I and II ankle sprains.”	Sparse study details. No baseline comparisons. Multiple cointerventions with PT and modalities. Some subjects had treatment repeated at end of 3-days for initial failure.
Cetti 1984	3.0	See Evidence Table for Early Mobilization above.				
Korkala 1987	2.5	See Evidence Table for Early Mobilization above.				
Nilsson 1983	2.5	See Evidence Table for Glucocorticosteroid Injections above.				
Brooks 1981 RCT	1.5	N = 104 inversion injuries seen during a 10-week period at regional accident unit	No support vs. physiotherapy vs. double Tubigrip support vs. immobilized.	Days off work: days at clinic (no support/physiotherapy/double Tubigrip support/immobilized), 5.1: 23.6/6.0:21.4/7.5 :21.5/41.0:25.0.	“[M]obilisation, with early physiotherapy or even without, offers the most rapid return to functional activity.”	Lack of study details; 241 entered trial with high drop-out or exclusion. Not clear how many randomized.

Airaksinen 1990 RCT	1.0	N = 44 acute ankle sprains	Elastic bandage vs. elastic bandage plus intermittent pneumatic compression (compression 30 minutes a day, 5 days).	Results section did not include measurement data. After 5 IPC sessions, edema volume 33 mL (IPC) vs. 80 mL (control), p <0.001. Pain, ROM scores not presented but reported to be significantly improved in IPC group.	“Elastic bandage with IPC treatment is effective in decreasing edema, relieving pain, and increasing ankle joint motion after ankle sprains. All these factors improve limb function and lead to good results in the rehabilitation of ankle sprains.”	Lack of study details (randomization, allocation, baseline comparability, no blinding, compliance, co-interventions, follow-up). Suggests intermittent compression results in greater reduction of edema/improved ROM.
<b>Ankle Support/Brace</b>						
Muwanga 1986	3.5	See Tubular Elastic, Elastic Wrap, and Tape above.				
Scotece 1992	3.5	See Tubular Elastic, Elastic Wrap, and Tape above.				
Zwipp 1992	3.5	See Early Mobilization above.				
Cetti 1984	3.0	See Early Mobilization above.				
McGuine 2012 RCT, cluster	3.0	N = 2081 high school football players	Laced-up Ankle brace, Don-Joy Ankle Stabilizing Brace; team-organized conditioning session, practice, competition until season is completed (n = 993) vs. Control, no intervention (n = 1088).	“The incidence of the acute ankle injury per 1000 exposures was significantly lower for the braced group compared to the control group: 0.48 vs. 1.12, p = 0.003.” Injury rate (95% CI) for acute ankle injury without a previous history of ankle injury: control vs. braced; 0.91 (0.64, 1.28) vs. 0.40 (0.20, 0.81), p = 0.010; with a history of ankle injury: 2.91 (1.92, 4.41) vs. 1.05 (0.53, 2.09), p = 0.004.	“Players who used lace-up ankle braces had a lower incidence of acute ankle injuries but no difference in the incidence of acute knee or other lower extremity injuries. Braces did not reduce the severity of ankle, knee or other lower extremity injuries.”	Cluster randomization. Laceup braces associated with lower number of ankle injuries vs. placebo but ankle injury severity same between 2 groups.
McGuine 2011	2.0	N = 1460	Lace-up ankle brace,	“The overall incidence of	“Use of lace-up ankle braces	Cluster randomization

RCT		male and female basketball players	McDavid Ultraviolet 195; team-organized conditioning session, practice, competition until season is completed (n = 740) vs. Control, no intervention (n = 720).	acute ankle injury was lower in the braced group (0.47; 95% CI: 0.30, 0.74) than in the control group (1.41; 95% CI: 1.05, 1.89). The incidence of first-event acute ankle injury was lower in the braced group (0.83; 95% CI: 0.37, 1.84) than in the control group (1.79; 95% CI: 0.98, 3.27), $p < 0.001$ , in favor of the braced group.”	reduced the incidence but not the severity of acute ankle injuries in male and female high school basketball athletes both with and without a previous history of an ankle injury.”	Baseline comparability limited with self-reported questionnaire.
Wilkerson 1993 RCT	1.5	N = 34 Grade 2 inversion sprains	Elastic tape plus Air-stirrup vs. Air-stirrup plus room temp cooling device vs. Air-stirrup plus ice.	F-ratio calculated (ANOVA) for evaluation of significant difference among treatment methods not significant $p = 0.055$ .	“Subjects who receive focal compression to the soft tissues around the periphery of the fibular malleolus... recover higher function than ...uniform external compression. Application of cold with greater frequency and longer duration than typical...does not appear to increase the rate of recovery.”	Quasi-randomization (date of injury with predetermined allocation). Lack of other methodological details. Follow-up period not specified. Study likely underpowered to detect any differences.
<b>Casting</b>						
Zwipp 1992	3.5	See Evidence Table for Early Mobilization above.				
Cetti 1984	3.0	See Evidence Table for Early Mobilization above.				
Korkala 1987	2.5	See Evidence Table for Early Mobilization above.				

van den Hoogenb and 1984  RCT	2.5	N = 150 acute ankle sprain injury	Surgical repair vs. cast immobilization (5 weeks) vs. tape bandage (elastic) x 4 weeks for proven lateral ligament tears	Surgical vs. cast vs. tape: Resumption of work activities (weeks): 9.7 vs. 6.8 vs. 2.5 ( no p values given); Return to sports at 12 weeks: 35.7% vs. 47.4% vs. 81.4%	“The results...clearly showed the collective advantages of early mobilization with a Coumans-bandage. The long term results, as indicated by the one year follow-up, showed no significant differences and were completely normal in all three treatment groups.”	Lack of details for randomization, allocation, cointerventions, compliance. Suggests short-term benefit of functional treatment over surgical repair. No differences long term.
Gronmar k 1980  RCT	2.0	N = 95 rupture of lateral ligaments of ankle	Ligament repair and immobilization vs. cast immobilization 6 weeks vs. strapping (tape) and mobilization.	Results at follow-up (4-34 months range): Operation vs. strapping vs. cast: % free of symptoms 97% vs. 77% vs. 67%. (No p values given.)	“Young, physically active people, particularly active sportsmen and women, are recommended for primary suture combined with splinting in a plaster cast for at least 6 weeks. Strapping is preferred if conservative treatment is indicated.”	Lack of methodological details. Follow-up times not same for each subject. Follow-up by postal questionnaire in proportion of subjects vs. clinical exam. No statistical analyses limits conclusions.
<b>Cryotherapy</b>						
Stöckle 1997  RCT	3.0	N = 60 foot or ankle trauma	Continuous cryotherapy vs. intermittent compression vs. cold packs 4 times daily for pre and post-operative edema.	Percent of swelling compared with admission-lower percent is better (Int. Compression/continuous cooling/ice packs): Preoperative Ankle at 24 hours-42% vs. 64% vs. 82%; Post-operative ankle at 24 hours - 64% vs. 73% vs. 80%; Post-operative ankle at 4 days - 37% vs. 36% vs. 62%	“It could be shown that both continuous cryotherapy and intermittent impulse compression therapy lead to faster reduction of swelling compared with standard cool pack therapy.”	Lack of details. Pre-, post-op cooling provided, but not all subjects received both (<50%) despite randomization. No statistical analyses. Included heterogeneous disorders limiting conclusions. Suggests advantage of both treatments compared with standard ice pack application. Equipment costs moderate to high for rental or purchase.

Michlovitz 1988 RCT	2.0	N = 30 young adults with Grade I or II lateral ankle sprains	Ice pack (30 minutes) vs. high voltage pulsed stimulation at 28 or 80 pulses per sec (pps). For grade I, II ankle sprain. All groups had ice, elevation, rest.	Ice and high voltage pulsed stimulation at 28 and 80pps tend to produce decrease in foot and ankle volume, increase in ROM in dorsiflexion, decrease in pain. No significant differences among groups in any measured parameters.	"HPVS did not further enhance the effects of ice, compression, and elevation."	Lack of study details for allocation, baseline comparability. Suggests no benefit from high voltage pulsed stimulation.
Wilkinson 1993	1.5	See Evidence Table for Ankle Support/Brace above.				
Laba 1989 RCT	1.0	N = 30 acute ankle sprain (no other associated condition) referred to physiotherapy	Ice vs. no ice (all subjects received ultrasound, exercises, ankle support) for moderate acute ankle sprain.	Rate of recovery (days) ice vs. no ice; Group 3 (able to stand without pain, pain with stairs or walking 10 steps): 4.6 vs. 3.0 days; Group 4 (unable to bear weight): 7.3 vs. 10.2 days	"This clinical trial reveals no significant differences between subjects with ankle sprain injuries who received ice therapy as part of a standard treatment programme and those that did not."	Randomization via coin toss. Duration of study, time of outcomes measurement, and frequency of interventions not described. Lack of overall details.
<b>Electrical Stimulation</b>						
Michlovitz 1988	2.0	See Evidence Table for Cryotherapy above.				
<b>Ultrasound</b>						
Makuloluwe 1977 RCT	2.0	N = 80 mild or moderate ankle sprains	Immobilization with elastoplast vs. ultrasound and ice	Ultrasound vs. elastoplast recovery at Week 1, 2: 46.2%/26.6%, 86.4%/58.6%. P-values not provided.	"[T]he use of ice packs and ultrasound relieved the pain, swelling and loss of function more than in patients immobilized with elastoplast."	Lack of study details. No statistical analyses. Ultrasound group also had ice pack treatment. No definition of "recovery" as an outcome measure.
<b>Manipulation and Mobilization</b>						
Coetzer 2001	3.5	N = 30 acute Grade	Chiropractic manipulation of subtalar,	No differences at 2 weeks or 6 weeks in NRS-	"As there was no statistically significant	Lack of study details. Partial blinding of

RCT		I, II sprains	talocrural joints (6 sessions for 2 weeks) vs. piroxicam 40mg x 2 days, then 20mg a day, 5 days.	101 questionnaire, McGill Pain questionnaire, Athletic Limitation Questionnaire, algometer or goniometer measurements.	difference found between the two treatment protocols, except for the number of fixations found at the ankle joint, it is suggested that these treatment protocols were equally effective.”	observer (not on all outcomes). Co-interventions of ice, crepe bandage. Suggests no difference in treatment outcomes, although no control group limits conclusions vs. natural history.
Pellow 2001 RCT	3.5	N = 30 subacute and chronic Grade I and Grade II ankle inversion sprains	Ankle mortise separation adjustment vs. placebo group for 8 treatment sessions over 4 weeks.	Although both groups showed improvement, statistically significant differences in favor of the adjustment group were noted with respect to reduction in pain, increased ankle range of motion, and ankle function.	“This study appears to indicate that the mortise separation adjustment may be superior to detuned ultrasound therapy in the management of subacute and chronic grade I and grade II inversion ankle sprains.”	Methodology details sparse, 6 subjects excluded after inclusion of convenience sample. States placebo single-blind study, but blinding or placebo use unclear. Comparison: manipulation to detuned ultrasound. No placebo of “manipulation.”
Eisenhart 2003 RCT	3.0	N = 55 with unilateral ankle sprains	Osteopathic manipulative treatment (single treatment) vs. control. Both groups received RICE, NSAIDs.	Mean±SD VAS score for treatment group vs. control group: 3.15± 1.4 vs. 3.5±2.8; p = 0.61. ROM (degrees): 42.5±14.4 vs. 39.0± 15.4.	“Data clearly demonstrate that a single session of OMT in the ED can have a significant effect in the management of acute ankle injuries.”	Sparse details. Does not demonstrate clear benefit of manipulation at 1 week from single treatment except ROM. No difference in pain or edema.
Köhne 2007 RCT	3.0	N = 30 recent sprain in chronic recurrent ankle sprain patients	Manipulation (6 sessions over 4-week period) vs. single manipulation (talocrural manipulation).	“Subjects in multiple manipulation treatment arm demonstrated statistically significant improvement in 2 measures of proprioception as well as ROM in dorsiflexion.”	“[M]anual manipulation of the ankle is an effective treatment for chronic ankle sprains...It is suggested that careful manipulative therapy in conjunction with exercise may offer effective therapy for recurrent ankle sprain.”	Lack of study details. Single blinding claimed of control group although blinding not of treatment. Results are of unknown clinical significance.

Lopez-Rodriguez 2007 RCT	3.0	N = 52 field hockey players with Grade II ankle sprain	Manipulation (2 techniques) vs. placebo technique; single treatment, immediate follow-up results.	“Intergroup comparison revealed statistically significant differences in the increase in percentage of posterior load on the manipulated foot, percentage of bilateral posterior load, percentage of anterior load on the manipulated foot, and percentage of bilateral anterior load.”	“The application of caudal talocrural joint manipulation redistributed foot load in our sample of athletic individuals with grade II ankle sprain.”	Lack of study details. Patients received both intervention and placebo, although order and washout not clear. Placebo questionable as subjects presumably could discriminate between manipulation and simply holding foot with same manipulation grip. Results of no clinical significance.
<b>Ankle Support for Prevention</b>						
Stasinopoulos 2004 RCT	2.0	N = 52 female volleyball players with ankle sprains	Technical training (land, takeoff technique) vs. proprioception vs. orthosis (ankle stirrup).	Ankle sprain recurrence during season (training vs. proprioception vs. orthosis): 2/18 (12%) vs. 3/17 (18%) vs. 6/17 (35%). No statistical analysis presented.	“All three preventive strategies were effective in athletes who had suffered ankle sprain once or twice only during their career.”	Lack of study details. No compliance data for each intervention limits results. No statistical analyses presented.
<b>Balance/Proprioception Training</b>						
Coughlan 2007 RCT	3.5	N = 20 from active athletic population	Four week neuromuscular training program (proprioception, conditioning, strength) vs. no exercise group.	No significant differences in ankle joint position or velocity of postural control ( $p > 0.05$ ).	“The mechanisms by which neuromuscular training improves function in normal subjects and those with functional ankle instability do not appear to result in measurable changes in gait kinematics.”	Randomization performed on matched pairs of healthy subjects (no previous injury). Results are of unknown clinical significance.
Engelbrecht 2008 RCT	3.0	N = 508 male soccer players with history of previous	Identified athletes at high risk for injury (previous injury). Intervention group (ankle,	Injury incidence (intervention vs. control) ankle: 10/102 (10%) vs. 14/107 (13%), RR 0.9 (0.5-1.3) $p = 0.21$ . Knee, hamstring, groin (all have	“Although we were able to identify players with an increased injury risk through a comprehensive questionnaire, there was no effect of the targeted	Randomization, allocation methods not described. No blinding. Cointerventions not controlled (shoes, orthotics, etc.). Low

		us injury or reduced function in ankle, knee, hamstring or groin	knee, groin training programs with wobble board, balance pad, other exercises 3 times a week for 10 weeks, then once a week during season) vs. no additional exercises.	incidence ratio with $p > 0.05$ . Compliance with protocol 27.5% for ankle intervention.	intervention on injury risk.”	compliance rates (20-30%) lessen significance.
Mohammadi 2007  RCT	3.0	N = 80 male soccer players with previous ankle inversion sprain	Proprioception training (ankle disk) vs. evetor muscle strength training vs. orthosis (Aircast stirrup) vs. no treatment control for prevention of recurrent ankle sprain.	Number of incidence (injuries/1000 players), relative risk of injury (95% CI), and percent sprained. Proprioception: 0.13/0.003-0.93/5%. Strength: 0.5/0.11-1.87/20%. Orthosis: 0.25/0.03-1.25/10%. Control: 3.33/0.12-1.91/40%.	“Proprioceptive training, compared with no intervention, was an effective strategy to reduce the rate of ankle sprains among male soccer players who suffered ankle sprain.”	Lack of details on randomization, allocation, baseline comparability, blinding, compliance, co-interventions. Small sample, power may have been insufficient as incidence lower in orthosis group although $p = 0.06$ . Duration of regimens not indicated.
Verhagen 2004, Verhagen Br J Sports Med 2005  Cluster-RCT	3.0	N = 1,127 volley ball players (4 regions, 116 teams)	Normal training routines vs. addition of balance board training. Randomized by 4 geographic regions, all regional teams assigned to control or	Control group, 0.9 incidences of ankle injuries per 1000 hours, 95% CI of 0.6-1.2. In intervention group, 0.5 incidences of ankle injuries per 1000 hours, 95% CI 0.3-0.6. No differences between groups for total, training, match injury incidence. Costs	“[P]roprioceptive balance board program was effective in preventing recurrence of ankle sprains. However, there seemed to be an increase in recurrence of overuse knee injuries. Positive effects of the balance board programme could	Single study with two reports. Cluster randomization. Lack of study details. Studies suggest balance board training may reduce recurrent ankle sprains, but increases risk of knee injury in those that have had previous knee injury.

			intervention).	per player: \$93.87 vs. \$47.09 (control)	only be achieved at certain costs.”	
Verhagen Clin Biomech 2005  RCT	3.0	N = 30 volleyball players	Balance program (14 exercises with balance board) vs. no balance program for 5.5 weeks.	Outcome measure is center of pressure (CoP) excursions measured by sway platform. No differences in any sway measures with and without eyes closed at end of training.	“The 5 1/2 week balance training programme applied in this study did not reduce CoP excursion in a general population of non-injured and previously injured subjects.”	Lack of randomization, allocation, compliance details. Small sample size. Non-randomized comparison group included. Results are of unknown clinical significance as outcome measure is surrogate for ankle instability but did not measure injury.
Wedderkopp 1999  Cluster-RCT	3.0	N = 237 young female players in European handball (22 teams)	Ankle disk 10-15 minutes all practice sessions with 2 or more functional activities for all major muscle groups vs. usual practice in healthy subjects.	More ankle and finger sprains in control group compared to intervention, p <0.05.	“[T]he intervention programme used in this study had a significant effect on the number of injuries and the injury incidence in young female European Handball players.”	Cluster randomization by team vs. individual player; included multiple injury outcomes. For ankle: 23 injuries in control vs. 6 in intervention, p <0.01. Effect cannot be made attributable to intervention in this study design.
Melnyk 2009  RCT	2.0	N = 26 healthy subjects	Whole body vibration training x 4 weeks vs. no training.	No differences in latencies and reflex activity in both long peroneal and tibialis muscles in response to ankle sprain simulation or ankle inversion motion.	“...it is unlikely that 4-weeks of whole body vibration training has beneficial effects on ankle joint stability in the case of an ankle inversion motion.”	Lack of study details. Results are of unknown clinical significance as the subject population had no orthopedic injuries and outcomes measures did not include incidence of injury post training.
Stasinopoulos 2004	2.0	See Ankle Support for Prevention above.				
<b>Foot Orthotics for Prevention</b>						

Fauno 1993	3.0	See Evidence Table for Plantar Fasciitis (Orthoses) above.				
<b>Stretching/Strengthening Exercises</b>						
Pope 2000  Cluster-RCT	3.5	N = 1,589 male army recruits (39 platoons)	Stretching vs. no stretching for prevention of ankle sprain.	1538 recruits, 170 (11%) transferred to officer training before end of training. Incidence of lower-limb injury: 3.5 per 1,000 training days. Hazard ratio .95 (95% CI .77-1.18). Ligament sprain, ankle joint: control vs. stretch; 27 vs. 19 out of 175 and 158.	“[P]reexercise muscle stretching does not produce a clinically worthwhile reduction in the risk of lower-limb injury. Injury risk is strongly associated with age and 20mSRT scores. This suggests that fitness may be a modifiable risk factor for injury.”	Cluster randomization as subjected assigned to platoon by surname. Platoons then randomized although method unclear. Lack of study details. Ankle specific analysis not presented.
Puls 2007  RCT	3.5	N = 30 healthy subjects	No training vs. Thera-band training 3 times a week vs. Thera-band 5 times a week for 6 weeks.	Primary outcome of postural control measured on force plate. There were no differences related to intervention.	“[F]ound no significant improvements in static postural control among healthy individuals related to a specific Thera-band training regiment after six weeks of training regardless if the exercises were performed three or five times per week.”	Sparse study details. No compliance to training data presented. Study suggests Thera-band training provides no benefit to healthy population. Results are of uncertain clinical significance.
Ekstrand 1983  RCT	1.5	N = 180 male soccer players	Warm-up exercise program (passing soccer ball, flexibility stretches, cool down) vs. control.	Prophylactic program vs. nonobservance prophylactic program vs. control number of injuries: Strains 5/1/23, lower leg injuries (traumatic) 0/0/3, lower leg injuries (overuse) 1/0/7, ankle sprain in players with history of previous strain 0/2/9 (p <0.05), reinjuries 0/0/13,	“[T]he proposed prophylactic program, including close supervision and correction by doctors and physiotherapists, significantly reduces soccer injuries.”	Sparse study details. Intervention appears to have reduced injury and ankle sprains.

				knee sprains with ALRI 0/0/3, injuries due to fouls 1/0/6, injuries at training camp 1/0/8, injuries connected with prophylactic program 8/3/72, other injuries 12/0/21, total 20/3/93.		
Mohammadi 2007	3.0	See Balance/Proprioception Training above.				
<b>Physical or Occupational Therapy</b>						
<b>Acute and Subacute</b>						
Christakou 2007  RCT	3.5	N = 20 athletes who sustained Grade II acute ankle sprains	Imagery rehearsal and physical therapy vs. physical therapy.	Total (heel and toe) risings between imagery rehearsal vs. control: 19.00±2.11 vs. 14.50±4.38, p <0.0167. No differences heel or toe raising individually or in single-leg hop, stairs or balance measures.	“Results revealed significant differences only in the variable of muscular endurance. This study partly supports the contribution of imagery to the functional rehabilitation of grade II ankle sprain.”	Sparse study details for compliance, baseline comparability. Both groups with extensive PT (12 sessions over 4 week period). Study results suggest mental imagery techniques is of little benefit.
Laufer 2007  RCT	3.5	N = 40 volunteers referred to treatment within 4 months after Grade 1 or 2 ankle sprain; no concurrent impairment	Balance training: external attention focus vs. internal attention focus: 4 sessions	Outcomes after 4 sessions of training measured on stability index: EFA group experienced significant decrease in Overall Stability Index (OSI) p = 0.030.	“[E]xternal focus of attention is advantageous for the learning of a postural control task following an ankle injury.”	Military population. Lack of study details. Results are of unknown clinical significance.

Youdas 2009  RCT	3.5	N = 27 acute inversion sprains	Ankle-heel stretch to improve dorsiflexion in mild and moderate ankle sprains: Group 1: 30 second stretch vs. Group 2: 1 minute stretch vs. Group 3: 2 minute stretch	Active ankle dorsiflexion ROM: Mean improvement at 6 weeks (Group 1 vs. 2 vs. 3)- 16°±5°, 19°±6, 18°±9°, p >0.05 for intergroup differences.	“We were unable to demonstrate a significant group effect. Therefore, we are unable to recommend with confidence that after an inversion ankle sprain subjects perform a minimum of 3 daily static heel-cord stretches each of 30 seconds duration.”	Lack of study details. Study demonstrated all subjects improved with no differences in groups.
Chaiwanic hsiri 2005  RCT	3.0	N = 40 male athletes with Grade 2 ankle sprain	Star- excursion balance training plus PT vs. PT for moderate acute sprains. PT included heat, ultrasound, ROM exercises, strengthening and stretching exercises. Balance training 3 supervised sessions a week for 4 weeks.	Balance training vs. control. Single leg stance time (SLST): eyes closed: 11.76+6.25 to 18.10+8.99 p >0.05, vs. 14.65+18.43 to 39.91+22.51, p = 0.002. Eyes closed SLST: 58.68+38.99 to 72.39 +31.47 p >0.05 vs. 74.82+73.49 to 162.98 +108.5, p <0.007. No between-group comparisons provided. Sprain recurrence (3 month follow-up): 1/15 vs. 2/17.	“The 4 weeks program of Star Excursion Balance training is more effective in improving functional stability of the sprained ankle than the conventional therapy program.”	Lack of study details. Clinical significance of single leg stance test is uncertain. Appears to include baseline differences in outcomes measures (SLST, recurrence of injury). No differences in sprain recurrence.
Wester 1996  Quasi- RCT	2.5	N = 61 primary ankle sprains	Wobble board + RICE vs. RICE	6/24 vs. 13/24 patients had recurrent sprains, p <0.05. After 1, 6, and 12 weeks, no significant difference between groups for edema.	“Wobble board training for a period of 12 weeks, beginning 1 week after the ankle sprain, was effective in reducing the number of recurrent distortions and in preventing functional instability of the ankle in patients with	Quasi- randomization. Sparse study details.

					primary ankle sprain. No difference in edema or hematoma seen during recovery period (1, 6, 12 weeks).”	
Asimeria 2013 RCT	2.0	N= 30 with unstable ankles; ages ranged 20 to 22 (20.58±0.64)	Land group, rehab program on land (n = 15) vs. Aquatic group, rehab program in swimming pool (n = 15). Both groups: static (total stability, anterior-posterior, and medial and lateral indices computed) and dynamic balance test with Biodex Stability System (6 wks, 3x/wk); 20 min training program (45 secs/exercise, 15 secs rest). Follow up: pre- and post-training.	Mean ± SD for Balance Assessments: land vs. aquatic: injured: post-training: total stability index: 4.41±1.7 vs. 4.36±1.4, p < 0.01; anterior-posterior index: 3.76±1.4 vs. 3.23±1.3, p < 0.01; medial-lateral index: 3.41±0.9 vs. 3.12±1.1, p < 0.01.	“The findings of this study advocate the use of balance exercise program for rehabilitation of college-aged individuals with functional ankle instability. The results demonstrated that individuals with a previous ankle sprain experienced balance deficits. A balance training program performed on balance boards increased the balance ability of the participants. The performance of balance exercises can take place in either a pool or land environment, with the same positive effect.”	Baseline data sparse, N relatively small. Study of hypothesis that prior ankle sprain led to functional defects and balance problems, then tested that those may benefit from balance training program. However, differences modest between groups and no assessment of preventive and/or major functional gain.
Kim 2014 RCT	1.5	N = 30 with ankle sprains	Control Group (Group A) (n = 10) vs. Muscle strengthening exercise group (Group B); plantar	Mean ± SD for muscle strengthening: Group A vs. Group B vs. Group C: plantar flexion: 45.8±21.6 vs. 75.2±26.4 vs. 71.6±26.3, p <	“Applying combined muscle strengthening and proprioceptive exercises to those who have functional ankle instability is more effective than applying only	Three arms but poorly described and small N. Combination muscle strengthening and proprioceptive exercises to patients with ankle instability

			flexion, dorsiflexion, inversion and eversion, 10 minutes using TheraBands (n = 10) vs. Combined muscle strengthening and proprioceptive exercises group (Group C); same exercises as group B then proprioceptive exercises, marching in place for 50 seconds, 4 sets for 10 minutes (n = 10).	0.05; dorsiflexion: 18.4±7.3 vs. 27.5±9.5 vs. 30.7±5.4, p < 0.05; inversion: 17.8±5.5 vs. 28.7±6.6 vs. 26.2±8.9, p < 0.05; eversion: 10.2±2.2 vs. 14.3±1.9 vs. 14.7±3.0, p < 0.05.	muscle strengthening exercises.”	more effective than muscle strengthening exercises alone.
Brooks 1981 RCT	1.5	N = 104 inversion injuries during a 10-week period at regional accident unit	No support vs. physiotherapy vs. double Tubigrip support vs. immobilized	Days off work: days at clinic (no support/physiotherapy/double Tubigrip support/immobilized), 5.1:23.6/6.0:21.4/7.5:21.5/41.0:25.0.	“[M]obilisation, with early physiotherapy or even without, offers the most rapid return to functional activity.”	Lack of study details; 241 entered trial. High drop-out or exclusion rate(s). Not clear how many randomized.
Collado 2010 RCT	1.0	N = 28 with ankle sprains; mean age in eccentric group: 25.1,	Concentric reinforcement (CG), foot inverted and everted, 10 reps, 2 min. rest period, proprioceptive rehabilitation	Mean ± SD for peak torques: CG vs. EG: concentric mode: 29.11±11.8 vs. 38.6±16, p = 0.01, eccentric mode: 35.7±17.5 vs. 45.8±20.3, p	“After the eccentric reinforcement in the EG group, the muscle strength was significantly greater during concentric movements. Eccentric rehabilitation	Placebo group, few baseline characteristics to compare. Eccentric reinforcement in EG group had greater strength during concentric movements.

		mean age for concentric group: 23.3, mean age for control group: 24.4	n on Freeman plate (n = 9) vs. Eccentric reinforcement (EG), foot blocked in eversion position, physiotherapist grasped lateral part of patient's forefoot, push inwards, patient resisting inversion movement, returning to the first position; 5 series of 10 reps with 2 min rest period (n = 9) vs. Control group, healthy volunteers, no treatment (n = 10). Four-week study with no follow-ups.	= 0.01. Strength deficits for injured side vs. healthy side: concentric: CG vs. EG: -28% vs. 19%, p = 0.01; eccentric: -41% vs. 1.6%, p = 0.03.	therefore restored the strength of the injured eversion muscles. These results show the value of this method, especially as the weakness of these muscles after sprains is one of the main risk factors contributing to instability and the recurrence of sprains."	
<b>Chronic Ankle Instability</b>						
Han 2009 RCT	3.5	N = 40 (20 with chronic ankle instability, 20 healthy subjects)	Exercise CAI vs. exercise healthy normal vs. control CAI vs. control healthy normal.	Post training (change over the first 4 weeks): Treatment t = -5.51/ p = 0.001, ankle sprain history CAI vs. healthy normal t = -2.76/ p = 0.010.	"Balance was improved after 4 weeks of elastic resistance exercise in subjects with and without a history of lateral ankle sprains. Balance improvements persisted 4 weeks following the treatment cessation."	Recruitment method of subjects is vague with healthy and previously injured young adults as study population. Sparse methodological details. Results of unknown clinical significance.

Ross 2007  RCT	3.0	N = 30 functional ankle instability	Conventional coordination training (CCT) vs. stochastic resonance coordination training (SCT) vs. control (no training). Programs 6 weeks.	Center of pressure as outcomes measure: control vs. CCT - no pre or post-test differences. SCT group had less posttest COP than post-test pooled mean of control and CCT groups.	“[C]oordination training alone did not result in significantly better postural stability than subjects who did not participate in coordination training at posttest. Coordination training with SR stimulation enhanced postural stability.”	Randomization, allocation, compliance details sparse. Only portion of subjects blinded. Results are of unknown clinical significance.
Bernier 1998  RCT	2.5	N = 48 functional instability of ankle	Control (no treatment) vs. electrical stimulation sham treatment (peroneus longus and brevis) vs. 6 weeks of balance and coordination training.	Maximum inversion test showed passive position sense better than active position sense, $p < 0.05$ , for joint position sense. No differences between groups for sway index. Modified equilibrium score anterior/posterior: condition $F(1, 42) = 56.64$ , $p < 0.001$ ; eyes, $F(1, 42) = 1118.18$ , $p < 0.001$ , $F(2, 42) = 5.19$ , $p < 0.01$ . Modified equilibrium score medial/lateral: condition $F(1, 42) = 89.2$ , $p < 0.001$ ; eyes $F(1, 42) = 1212.81$ , $p < 0.001$ , $F(2, 42) = 6.90$ , $p < 0.003$ .	“[P]ostural sway can be improved in subjects with functional instability of the ankle following 6 weeks of coordination and balance training.”	Lack of study details (randomization, allocation, baseline comparability, no blinding, and compliance). Study results of improving postural sway is of uncertain clinical significance as no injury recurrence data provided.
Kidgell 2007  RCT	2.5	N = 20 athletes with functional ankle instability	Dura disc training vs. mini-trampoline training vs. control (routine daily)	Postural Sway (pretest vs. post-test) in mm. Control: $36.9 \pm 9.9$ vs. $36.7 \pm 8.2$ ; Mini-tramp: $56.8 \pm 20.5$ vs. $33.3 \pm 8.5$ , $p$	“[R]esults indicate that not only is the mini-trampoline an effective tool for improving balance after LAS, but it is equally as effective as the dura disc.”	Lack of randomization, allocation, co-intervention, compliance details. Small sample size with non-randomized

			activities) in subjects with hx of ankle inversion injury and ankle instability with injury in past 2 years. Balance training program 6 weeks.	= 0.003. Dura Disc: 41.3±2.6 vs. 27.2±4.8 p = 0.003.		comparison group included. Results are of unknown clinical significance as outcome measure is surrogate for ankle instability but did not measure injury.
Powers 2004 RCT	1.5	N = 38 self-reported unilateral functional ankle instability	Strength vs. proprioception vs. proprioception plus strength vs. control (3 sessions a week for 6 weeks).	No differences in muscle fatigue measures or static balance measures.	“Strength training, proprioception training, and the combination of the 2 failed to improve postural-stability characteristics in a group of subjects with functional ankle instability.”	Lack of study details (randomization, allocation, baseline comparability, no blinding, compliance, co-interventions, follow-up).
<b>Surgical Repair</b>						
Møeller-Larsen 1988 RCT	3.5	N = 200 arthrographically verified rupture of 1 or both lateral ankle ligaments	Surgery vs. cast immobilization vs. tape (non-elastic) for 5 weeks, Grade II, III acute sprains.	Tendency of patients treated with tape to start to work earlier than other 2 groups, difference not significant; no differences in talar tilt. Report ankles asymptomatic: 21/34 vs. 20/29 vs. 34/40, p <0.005 favoring tape.	“Patients treated with tape had fewer symptoms, fewer complaints when running, and more ankles recovered to the preinjury state. Therefore, in lateral ankle ligament rupture, tape bandages seem preferable.”	Lack of details for randomization, allocation, baseline comparability, compliance. All sprains were confirmed by arthrography. Suggests benefit of non-elastic tape for faster recovery than surgery.
Specchiulli 2001 Quasi-RCT	3.5	N = 100 Grade III injuries of lateral ankle ligament	Surgical repair vs. conservative care (taping x 40 days)	Surgical vs. taping: Ankle Hind-foot Scale (100 point scale): 79+16 vs. 82+11 p >0.05. Return to sports: 10 vs. 7 weeks, p <0.05. Ankle swelling: no differences at any time.	“[I]n the short term, surgical treatment does not show any advantage over functional treatment. Therefore, nonsurgical treatment is recommended for grade III ankle ligament tears.”	Quasi-randomization (odd/even birth year), Many details sparse. Compliance, drop-out rate unknown. Results suggest no difference in functional outcomes although taping

						resulted in faster return to sports.
Sommer 1989 RCT	3.5	N = 80 recent ruptures of fibular ligament	Surgery plus cast for 3 weeks vs. functional (strapping for 2 weeks)	Surgery vs. functional: Restriction in ROM at 6 weeks: 22/36 vs. 0/27. Restriction in ROM at 1-year: both groups full movement and normal stability.	“The comparably good results of functional and operative treatments reported by others are confirmed by our study.”	Sparse study details. Grade of sprains likely moderate and severe, but not specified. No statistical analysis.
Zwipp 1992	3.5	See Early Mobilization above.				
Korkala 1987	2.5	See Early Mobilization above.				
Niederma nn 1981 RCT	2.5	N = 444 acute ankle sprains	Surgery plus cast for 5 weeks vs. cast for 5 weeks; randomized portion likely moderate and severe sprains.	Outcomes measures: strapping (non-randomized Grade I) vs. plaster vs. operation. No differences in return to sport, functional recovery, pain when walking. Good Results: 76% plaster vs. 81% operative (p = NS).	“[T]here was no statistically significant difference between the results of conservative and operative treatment of rupture of the lateral ligaments of the ankle.”	Sparse study details. Only 209/444 randomized. Results did not clearly indicate if randomized portion considered separately. High drop-out rate at 1-year follow-up (37%). No differences in treatment in any major indicator.
van den Hoogenb and 1984	2.5	See Casting above.				
Gronmar k 1980	2.0	See Casting above.				
Clark 1965 RCT	1.5	N = 24 with injuries of the lateral ligaments of ankle	Surgical repair vs. cast immobilization.	Surgical vs. cast: Average return to full duty (weeks): 12 vs. 8, p not specified. Excellent results (time measured	“In terms of function...there was no difference between the two groups. Surgical treatment, however, is	Timing of outcome measures unclear. Duration of conservative group immobilization not defined. Operative

				not indicated) 9/12 vs. 9/12	associated with a greater morbidity.”	group received PT. Suggests outcomes similar in functional measures. Earlier return to work in cast group.
--	--	--	--	---------------------------------	--	--

## ANKLE FRACTURES

Author/Y ear Study Type	Score (0- 11)	Sample Size	Comparis on Group	Results	Conclusion	Comments
<b>Tibia Shaft Fractures – Operative Management</b>						
Fernande s 2006  RCT	3.0	N = 45 with closed multi- fragment ed tibial diaphyse al fractures AO classificat ion type B or C	Nonreamed interlockin g intramedul lary nails (n = 23) vs. bridging plates (n = 22).	No infections. Healing time for nails group was 20.3 weeks, for plates 16.0 weeks (p = 0.019). No differences in mobility.	“[T]he healing times were significantly shorter in patients undergoing surgery with the bridging plate technique, and the functional results were not different among patients of both groups.”	No blinding; overall lack of details. Healing times appear shorter in plate vs. nails for closed multi-fragmented diaphyseal fractures. Lack of co-interventions, weight-bearing status, compliance, physical therapies make drawing conclusion difficult.
<b>Operative Care – Plafond</b>						
Wyrsc h 1996  RCT	3.5	N = 39 with intra- articular fracture of the tibial plafond	Open reduction and internal fixation (n = 18) vs. external fixation and limited internal fixation (n = 20).	No statistical differences in radiographic or functional results measured by clinical scores between groups; 15 operative complications in 7/19 ORIF group; 4 in 4/20 external fixation with or without limited internal fixation. Follow- up on average 39 months after injury.	“[L]imited internal fixation combined with use of an external fixator is an equally effective and safer method of treatment for most fractures of the tibial plafond.”	Lack of study details in paper resulted in lower score. In tibial plafond fractures class I-III limited internal fixation with external fixation appears to have fewer complications with similar outcomes when compared to ORIF.
<b>Syndesmosis Injury Operative Technique</b>						
Moore 2006	3.0	N = 127 unstable	Fixation of syndesmo	Hardware failure: 3 = 5/59 (8%); 4	“[E]ither three or four cortices of	Lack of study details. No

RCT		malleolar fractures with fluoroscopically confirmed tibiofibular instability	sis, with 3.5mm screws through 3 cortices. Non-weight bearing 6-10 weeks (n = 59) vs. fixation of syndesmosis, with 3.5mm screws through 4 cortices. Non-weight bearing 6-10 weeks (n = 61).	= 4/61 (7%). Loss of reduction: 3 = 3/59 (5%); 4 = 0/61 (0%). Screw removal: 3 = 4/59 (7%); 4 = 4/61 (7%). All 3 patients in 3 cortical fixation group who needed screw removals because of pain non-compliant with weight-bearing restrictions, intoxicated at time of surgery, and smokers.	fixation are sufficient to stabilize the syndesmosis during healing.”	blinding, no mention of co-interventions. Suggests no significant differences in technique, but 4 cortices may be a better choice in patients who are likely to be non-compliant.
-----	--	--	--	---	---	---

### Malleolar Ankle Fracture Management

Rowley 1986 RCT	3.5	N = 42 with displaced ankle fractures requiring reduction (Presumably AO B and C level of fracture)	Closed reduction and long leg plaster cast 6 weeks with early weight bearing encouraged vs. ORIF using AO technique. Below-knee plaster cast 6 weeks with early weight bearing.	At 20 weeks from injury more of the closed reduction group regained normal movements and foot position.	“[I]f a good reduction can be achieved and maintained then closed treatment is as good as operative treatment in the short term and, indeed, seemed to result in a quicker return to normal gait.”	No blinding, lack of details on co-interventions and baseline characteristics.
Salai 2000 RCT	1.5	N = 84 elderly patients with displaced closed tri-malleolar ankle	Conservative therapy including short leg cast and mobilization vs. open	Total ankle scores: 91.37±8.96 for non-operative group vs. 75.22±14.38 for operative group, p = 0.001.	“[C]onsideration of a non-operative approach to the treatment of well-reduced ankle fractures in the elderly.”	Randomization method uncertain. Overall lack of study details. Generalizability may be limited to elderly population.

		fractures with manipulation under anesthesia for reduction	reduction surgery.			
Ankle Fracture Operative Management: Procedures and Fixators						
Dijkema 1993 RCT	3.5	N = 43 closed non-comminuted fractures of lateral and/or medial malleolus and dislocations	ORIF with biofix implants vs. ORIF with metal implants.	Patients with biodegradable rods scored an average of 94.5 point on Olerud's scale compared to 90.4 points scored for patients with the stainless steel implants. Biofix patients scored 89% compared to 84% for AO/ASIF patients on the linear analogue scale.	"Patients treated with the biodegradable material reported slightly less pain during the follow-up period and were found to have a slightly better function of the ankle joint... Biofix biodegradable implants can be used for the internal fixation of a limited number of fracture dislocations of the ankle joint (i.e., noncomminuted simple fractures in nonosteoporotic patients)."	Lack of study details. No blinding, no details on control of co-interventions. Suggests bioabsorbable rods have similar outcomes as metal implants.
Kankare 1996 RCT	3.5	N = 37 displaced malleolar fractures aged 65 and older	Self-reinforced polyglycolide rods and screws (n = 16) vs. metallic screws and plates (n = 19)	Re-displacement occurred in 1/16 (6%) in biodegradable group. Exact reduction obtained in 15/16 (94%) biodegradable group and 16/19 (84%) metallic group.	"It seems that displaced malleolar fractures can be treated successfully also in elderly people using totally biodegradable self-reinforced polyglycolide rods and screws when comminution does not require plate fixation."	Lack of study details. Suggests biodegradable implants achieved similar outcomes to metallic screws and plates in elderly patients with displaced malleolar fractures.

Takao 2004  RCT	3.5	N = 72 Weber type B distal fibular fractures surgically repaired	Arthro- scopically assisted open reduction and internal fixations (AORIF) (n = 41) vs. open reduction and internal fixation (ORIF) (n = 31).	AORIF: 30/41 (73.2%) had osteochondral lesions, 33/41(80.5%) had tibiofibular ligament disruption, 6/41 (14.6%) had no combined disorder found. Ankle Hind-Foot score: AORIF 91.0, ORIF 87.5 (p = 0.0106).	“In the treatment of distal fibular fractures, precisely diagnosing and treating the combined intra- articular disorders is important for gaining satisfactory clinical results.”	No blinding, minimal baseline characteristics included. No mention of co- interventions. At 1 year follow-up, AORIF patients appear to have better scores on Ankle Hind-Foot score. No increase in adverse events reported with AORIF over just ORIF.
Bucholz 1994  RCT	3.5	N = 155 closed displaced medial malleolar fractures	Polyactid e (bioabsorb able) screws vs. stainless- steel screws (control group).	No significant difference between groups for ability to walk, p = 0.95, run, p = 0.14, jump, p = 0.27, or climb stairs, p = 0.13. At 1 year, average ankle score: 83 points for study group, 79 for control, p = 0.13.	“[P]olyactide screws are a safe and effective alternative to stainless-steel screws for the fixation of displaced medial malleolar fractures.”	No blinding, no allocation concealment, follow-up timing was variable. Study suggests PLA screws are as effective as stainless-steel without increased adverse events in medial malleolar fixation.
Ahl 1994  RCT	3.0	N = 32 supinatio n eversion fractures	Fixation with biodegrad able polyglycoli c acid rods or screws vs. metal wires, staples, and pins.	Residual displacement after operative treatment lateral malleolus rod: 0/15 poor; screw 0/17 poor; nondegenerative 0/13 poor. Medial mall: rod 0/3 poor; screw 0/7 poor; nondegenerative 0/13 poor. Tibialis posterior: rod 1/7 (14%) poor; screw 1/7 (14%) poor; non- degenerative 3/18 (17%) poor.	“Nondegradable fixation is easier to handle, gives better fracture stability, can be used in more severe fractures.”	Lack of study details. Suggests no significant differences in clinical outcomes and choice of fixation hardware should be based on surgeon preference.

Kankare 1995 RCT	3.0	N = 29 closed displaced malleolar fx in alcoholics	Self-reinforced dyless polyglycolide (PGA) screws (Biofix) vs. metallic AO implants.	Difference in redisplacements significant between groups, 8/16 for PGA and 1/13 for metallic AO, p = 0.04. Wound infections: 4 superficial, 1 deep all in PGA group 5/16 (31%).	"The significantly higher rate of failures in the PGA group noted during the study caused us to discontinue it."	Large difference in post-operative hospital days between groups, PGA was 5.6 and metallic 3.8. There was a large dropout rate. Study suggests PGA was inferior to metallic implants.
Moore 2006	3.0	See Syndesmosis Injury Operative Technique above.				
Thordarson 2001 RCT	2.5	N = 19 with SER or PER fractures with intact medial malleolus ; no evidence of intra-articular pathology	Open plate fixation with arthroscopic visualization of joint vs. open plate fixation.	8/9 patients who had arthroscopy had evidence of articular damage to the dome of the talus. No difference in SF-36 scores or objective clinical findings between groups.	"Most patients who underwent arthroscopic examination of the ankle joint were found to have a variable degree of articular cartilage damage at the dome of the talus...with no significant difference noted between groups in subjective or objective outcomes."	Lack of study details. Does not appear to be clinically beneficial results from arthroscopic investigation of ankle joint in addition to open reduction and plate fixation in SER or PER fractures with an intact medial malleolus.
<b>Post Operative Care – Dressings</b>						
Reed 1998 RCT	4.5	N = 54 undergoing open reduction and internal fixation	Immobilization with backslab (n = 28) vs. wool and crepe bandage (n = 26) for 1 day for post-op pain management.	Significant difference between groups for closet angle to plantigrade patient could achieve 1st day of physiotherapy, 25.0° for backslab group, 48.3° for wool and crepe group, p = 0.04.	"[E]ither a backslab or wool and crepe bandages may be applied after internal fixation of ankle fractures, depending upon the surgeon's preference."	Abstract with lack of details results in low-quality study. Study suggests no difference in post-op management of ORIF ankle fracture between back slab or crepe bandage.
<b>Calcaneal Fractures: Operative Care – Cancellous Bone Defect Filling</b>						
Johal 2009 RCT	3.5	N = 47 displaced intra-articular calcaneal fractures closed	ORIF with a bioabsorbable calcium phosphate paste to	No difference between groups Bohler angles at 6 weeks and 3 months. At 6 months Bohler angle collapse	"The results of this study show that use of bioabsorbable calcium phosphate paste leads to less calcaneal collapse	No blinding or mention of co-interventions. Drop-out rate >20%. Bioabsorbable group and less

			fill voids vs. ORIF.	was: BSM: 5.6 degrees, ORIF: 9.1 degrees (p = 0.03). At one year BSM: 6.2 degrees, ORIF: 10.4 degrees (p = 0.05). No difference in SF-36, general health, limb specific function, pain.	after operative management once weight bearing is begun. We suggest the use of a bioresorbable calcium phosphate paste to fill the cancellous bone defect and augment ORIF.”	collapse of Bohler angle at 6 months and greater than 1 year. No clinical outcome differences noted at any times. Clinical correlation of findings warrant further study to see if any clinical benefits occur with less collapse of Bohler angle.
Dickson 2002  RCT	3.0	N = 38 acute closed Type I fractures of radius, humerus, ulna, femur, tibia, or calcaneal, traumatic void requiring grafting	Grafting material: BoneSource (BS) mineral product vs. Autograft (AG) from iliac crest or other location.	All fractures healed by 12 months follow-up. Maintenance of reduction observed in BS: 10/12 (83%), AG 10/15 (67%). Pain over fracture site resolved at 6 months: BS: 10/13 (77%), AG 9/16 (56%). (NS).	“Data from this demonstrate that BoneSource was both safe and effective as a bone void filler. The BoneSource showed equal or better maintenance of reduction than the autograft group.”	Small numbers, no blinding, no co-interventions, no mention of compliance with surgical after care. Study did not include control of no grafting. Suggests no difference in bone graft materials.
<b>Post-Operative Rehabilitation: Immobilization, Early Mobilization, Early Weight Bearing</b>						
Finsen 1989a; 1989b  RCT	3.5	N = 57 displaced ankle fractures including the lateral malleolus. Weber A, B, C. Treated operatively. All casts removed after 6 weeks	Cast for 3 days, then no cast. Non-weight bearing. (A) Early motion with daily flexion, extension, inversion, eversion exercises vs. (B) Non-weight bearing plaster cast for 6 weeks vs. (C) plaster walking	Report 1: No significant difference in bone mineral content between 3 different treatment groups. Report 2: No complications with fracture healing in any of the groups. No difference in mean ROM of ankle. Weeks lost from work: A) 9.5, B) 13.8, C) 12.9 (NS). Participants encouraged to bear as much	“It appears that the amount of early weight bearing and active exercises after ankle fracture obtainable in clinical practice does not modify the degree of post-traumatic osteopenia. [T]he three postoperative regimens did not discernibly influence the clinical outcome, the risk of complications, or the delay in returning to work.”	No mention of compliance with exercises or weight bearing status measured. Data suggest no differences in post-fracture osteopenia. No functional differences from each protocol.

			cast first 6 weeks.	weight as possible).		
Ahl 1993 RCT	3.0	N = 40 dislocated bi- or tri-malleolar fractures	Early weight bearing after 1 week of non-weight bearing in an orthosis vs. late weight bearing using dorsal splint.	Orthosis group had better dorsal flexion at 3 and 6 months, p <0.05 and better plantar flexion at 3 months, p <0.05 compared with dorsal splint group.	“When comparing the 4 postoperative regimes, only small differences between the groups were found. As early postoperative weight bearing considerably facilitates rehabilitation it is to be recommended.”	Two different results included. Compliance with motion exercises or weight bearing status not noted. No increases in complications for early weight bearing at 18 months follow-up. Suggests no long-term differences from each protocol.
Fitzgerald 1994 RCT	1.5	N = 27 ankle fractures, type not described but all treated non-operatively	Immobilization in plaster for 6 weeks (n = 10) vs. plaster immobilization along with compression stocking for 6 weeks (n = 10) vs. immediate mobilization (n = 7).	Difference in limb circumference between control limb and fractured one less for stocking group vs. immobilization alone at 12 weeks (1.03±0.72 cms vs. 0.37±0.46 cms), p <0.004, and 18 weeks (1.15±0.72cms vs. 0.45 ±0.30cms), p <0.03. Reduction in limb swelling not seen in early mobilization group. Circumference at 5cm and 10cm from lateral malleolus decreased in compression stocking group only at 12 and 18 weeks.	“[L]imb swelling may subside more rapidly in the immobilised fractured limb if a compression stocking is applied while the limb is in plaster.”	Lack of details. Compression stocking while in a plaster cast may decrease overall calf swelling.

Marsh 2006  RCT	1.5	N = 55 tibial plafond fractures with external and minimal internal fixation	Mobilizatio n (MG) home exercises, non- weight bearing, 10 reps 3 times a day. Passive dorsiflexio n with active plantarflex ion vs. 8- 12 weeks external fixation without any mobilizatio n. (NMG).	In 31 patients who had follow- up after 2 years, no difference detected. NMG averaged 11.7 weeks in a fixator MG 15.5 weeks (p = 0.008).	“These results indicate that treatment protocols that use long periods of cross-joint external fixation that immobilizes the ankle as definitive treatment result in similar patient outcomes compared to otherwise identical treatment protocols that incorporate and use an articulated hinged for ankle motion.”	No blinding noted. Unable to reliably record compliance with home mobilization exercises. Study likely underpowered.
<b>Post-Operative Care – Physical Therapy</b>						
Wilson 1991  RCT	3.5	N = 10 ankle fracture treated operativel y or conserva tively with immobili zation in cast for 6 weeks	Exercise plus manual therapy 3 times a week for 5 weeks vs. exercise only 3 times a week for 5 weeks	MT group: 5/5 at Week 5 had full dorsiflexion. 4/5 had full plantarflexion. Control group: 1/5 at Week 5 had full dorsiflexion. 2/5 had full plantarflexion.	“The results of this small pilot study suggest that the use of manual therapy techniques and exercise used in the mobilisation of fractured ankles post-cast immobilisation is more effective than the traditional physiotherapy approach of mobilising exercises alone.”	Small sample size. At baseline, manual therapy group had a higher functional score compared to exercise-only group. Very small numbers. Lack of reporting on compliance to protocol. No baseline explanation of conservative vs. surgery for fracture management between groups.
<b>Post-Operative Care – Electrical Stimulation</b>						
Hernand ez 2006  RCT	1.5	N = 24 closed ankle fractures requiring surgery	Cast plus percutane ous electrical stimulatio n (Myospare ) for 6 weeks vs.	No adverse effects from Myospare reported. Reported trend (p >0.05) toward improvement in calf diameter as well as in dorsiflexion and	“The use of the Myospare device under a cast in patients after surgical fixation of ankle fractures has been demonstrated as feasible and safe. In this pilot study a	Abstract description only. Sparse details.

			cast for 6 weeks.	plantarflexion in Myospare group.	trend toward enhanced recovery was apparent in the treatment group.”	
<b>Calcaneal Fractures – Non-operative vs. Operative Care</b>						
Parmar 1993  Quasi-RCT	3.5	N = 80 non-displaced calcaneal fractures (included but not randomized) and displaced intra-articular calcaneal fractures	Non-operative (elevation for 5-7 day with mobilization, than non-weight bearing cast for 6-8 weeks vs. ORIF with post-op cast and non-weight bearing for 6-8 weeks.	Displaced fractures: increased pain scores on VAS correlated with significant delays in return to employment (p <0.002), return to full recreational activities (p <0.01), and reduced patient satisfaction (p <0.000002)	“[O]perative treatment of this joint is not likely to improve outcome.”	Quasi-randomization (birth-year odd/even). Lack of detail on how many included in each group. No blinding or post-op compliance noted. Suggests non-displaced fractures superior to displaced fractures, regardless of treatment. In patients with displaced fractures, no significant differences in outcomes between surgery and cast.
Ibrahim 2007  RCT	2.5	N = 46 with displaced intra-articular calcaneal fractures (15 year study follow-up)	Conservative treatment (C) of elevation for 5-7 days, movement as able, cast with non-weight bearing for 6-8 weeks vs. ORIF lateral approach. (Op) Plaster cast for 6 weeks,	AOFAS hindfoot score: C = 78.5, Op = 70.0 (p = 0.11). AOFAS foot function index: C = 24.4, Op = 26.9 (p = 0.66). Calcaneal fracture score: C = 70.1, Op = 63.5 (p = 0.41). Bohler’s angle: C = 10.4° Op = 16.9° (p = 0.07). Height of calcaneus: C = 37.2 mm, Op = 38.2mm (p = 0.57). Grade of OA in subtalar joint: (p = 0.54).	“At a mean follow-up of 15 years, we have shown no difference between conservative or operative patients using both functional and radiological outcomes.”	Follow up of Parmar 93 study; 50% participation from original participants. No mention of interval injury, therapy or concurrent treatment of participants in study. Study did not find any clinical evidence of difference between operative and non-operative treatment of displaced intra-articular calcaneal

			non-weight bearing 6-8 weeks.			fractures at 15 years follow-up.
<b>Metatarsal Fracture (Avulsion) – Operative Management</b>						
Wiener 1997  Quasi-RCT	3.0	N = 89 with avulsion fracture of 5th metatarsal (excluded Jones fractures)	Short leg cast vs. Jones Fracture soft dressing.	Cast vs. dressing: Average time to union (days) 43 vs. 45, p = ns. Average time return to pre-injury level activity (days): 46 vs. 33, p<0.05. Modified Foot score 86 vs. 92, p = NS.	“The Jones dressing proves to be an effective, non-debilitating treatment modality for avulsion fractures of the base of the fifth metatarsal. It allows patients an earlier return to full activity than when treated in a short leg cast, without the risk of compromising clinical or radiographic healing.”	Quasi-randomization by even/odd day of injury presented. Baseline comparability details sparse. Loss to follow-up 35%. Study suggests no dressing for avulsion fracture may lead to quicker return to activity.

## References

1. Statistics UDoLBoL. Table R21. Number of nonfatal occupational injuries and illnesses involving days away from work by part of body and selected events or exposures leading to injury or illness. *Injuries, Illnesses, and Fatalities*. 2005; Available at: <http://www.bls.gov/iif/oshwc/osh/case/ostb1677.pdf>.
2. US Department of Labor Bureau of Labor Statistics. Table R19. Number of nonfatal occupational injuries and illnesses involving days away from work by part of body and selected natures of injury or illness. *Injuries, Illnesses, and Fatalities*. 2004; Available at: <http://www.bls.gov/iif/oshwc/osh/case/ostb1529.pdf>.
3. US Department of Labor Bureau of Labor Statistics. Table R21. Number of nonfatal occupational injuries and illnesses involving days away from work by part of body and selected events or exposures leading to injury or illness. *Injuries, Illnesses, and Fatalities*. 2004; Available at: <http://www.bls.gov/iif/oshwc/osh/case/ostb1531.pdf>.

4. US Department of Labor Bureau of Labor Statistics. Table R19. Number of nonfatal occupational injuries and illnesses involving days away from work by part of body and selected natures of injury or illness. *Injuries, Illnesses, and Fatalities*. 2005; Available at: <http://www.bls.gov/iif/oshwc/osh/case/ostb1675.pdf>.
5. Texas Department of Insurance Workers' Compensation Research Group. Medical Cost Trends in the Texas Workers' Compensation System. 2004.
6. Texas Department of Insurance Workers' Compensation Research Group. Medical Cost and Quality of Care Trends in the Texas Workers' Compensation System. 2004.
7. Thomas C, ed/. *Taber's Cyclopedic Medical Dictionary, 15th Edition*. Philadelphia, PA: FA Davis Company; 1985.
8. Magee S. *Orthopedic Physical Diagnosis, 4th Edition*. Philadelphia, PA: Elsevier; 2006.
9. Dykyj D. Pathologic anatomy of hallux abducto valgus. *Clin Podiatr Med Surg*. 1989;6(1):1-15.
10. Gilkeson G. Mediators of inflammation, tissue destruction, and repair. In: Kippel J, ed. *Primer on Rheumatic Diseases, 11th Edition*. Atlanta, GA: Arthritis Foundation; 1997.
11. Greene W. *Essentials of Musculoskeletal Care, 2nd Edition*. Rosemont, IL: American Academy of Orthopaedic Surgeons; 2001.
12. Richardson E. Neurogenic disorders: painful heel: etiology. In: Crenshaw A, ed. *Campbell's Operative Orthopaedics, 8th Edition*. Boston, MA: Mosby Year Book; 1992.
13. Khan KM, Cook JL, Taunton JE, Bonar F. Overuse tendinosis, not tendinitis part 1: a new paradigm for a difficult clinical problem. *Phys Sportsmed*. 2000;28(5):38-48.
14. Hellmann D. Arthritis and musculoskeletal disorders: degenerative and crystal-induced arthritis: crystal deposition arthritis: gouty arthritis. In: Tierney L, McPhee S, Papadakis M, eds. *Current Medical Diagnoses and Treatment, 34th Edition*. Norwalk, CT: Appleton and Lange; 1995:699-702.
15. Evans JD. Subcutaneous rupture of the tendon of peroneus longus. Report of a case. *J bone Joint Surg BR*. 1966;48(3):507-9.
16. Houry NJ, el-Khoury GY, Saltzman CL, Brandser EA. Rupture of the anterior tibial tendon: diagnosis by MR imaging. *AJR Am J Roentgenol*. 1996;167(2):351-4.
17. Rosenberg ZS, Cheung Y, Jahss MH, Noto AM, Norman A, Leeds NE. Rupture of posterior tibial tendon: CT and MR imaging with surgical correlation. *Radiology*. 1988;169(1):229-35.
18. Rosenberg ZS, Jahss MH, Noto AM, et al. Rupture of the posterior tibial tendon: CT and surgical findings. *Radiology*. 1988;167(2):489-93.
19. Marcus RE, Pfister ME. The enigmatic diagnosis of posterior tibialis tendon rupture. *Iowa Orthop J*. 1993;13171-7.
20. Karasick D, Schweitzer ME. Tear of the posterior tibial tendon causing asymmetric flatfoot: radiologic findings. *AJR Am J Roentgenol*. 1993;161(6):1237-40.
21. Kapandji A. *Physiology of the Joints, 6th Edition - Volume 2 Lower Limb*. New York: Churchill Livingstone; 1987.
22. Tan SC, Chan O. Achilles and patellar tendinopathy: current understanding of pathophysiology and management. *Disabil Rehabil*. 2008;30(20-22):1608-15.
23. Magnussen RA, Dunn WR, Thomson AB. Nonoperative treatment of midportion Achilles tendinopathy: a systematic review. *Clin J Sport Med*. 2009;19(1):54-64.
24. Maffulli N, Khan KM, Puddu G. Overuse tendon conditions: time to change a confusing terminology. *Arthroscopy*. 1998;14(8):840-3.
25. Mafi N, Lorentzon R, Alfredson H. Superior short-term results with eccentric calf muscle training compared to concentric training in a randomized prospective multicenter study on patients with chronic Achilles tendinosis. *Knee Surg Sports Traumatol Arthrosc*. 2001;9(1):42-7.
26. Heckman DS, Gluck GS, Parekh SG. Tendon disorders of the foot and ankle, part 2: achilles tendon disorders. *Am J Sports Med*. 2009;37(6):1223-34.
27. Reddy SS, Pedowitz DI, Parekh SG, Omar IM, Wapner KL. Surgical treatment for chronic disease and disorders of the achilles tendon. *J Am Acad Orthop Surg*. 2009;17(1):3-14.
28. Rompe JD, Furia J, Maffulli N. Eccentric loading versus eccentric loading plus shock-wave treatment for midportion achilles tendinopathy: a randomized controlled trial. *Am J Sports Med*. 2009;37(3):463-70.

29. Furia JP. High-energy extracorporeal shock wave therapy as a treatment for insertional Achilles tendinopathy. *Am J Sports Med.* 2006;34(5):733-40.
30. Rompe JD, Furia JP, Maffulli N. Mid-portion Achilles tendinopathy--current options for treatment. *Disabil Rehabil.* 2008;30(20-22):1666-76.
31. Astrom M, Westlin N. No effect of piroxicam on achilles tendinopathy. A randomized study of 70 patients. *Acta Orthop Scand.* 1992;63(6):631-4.
32. Knobloch K. The role of tendon microcirculation in Achilles and patellar tendinopathy. *J Orthop Surg Res.* 2008;318.
33. Tan G, Sabb B, Kadakia AR. Non-surgical management of Achilles ruptures. *Foot Ankle Clin.* 2009;14(4):675-84.
34. Duranceau JA, Lacoste P, Bourgooin J, Phillips R. Double-blind comparison of ketoprofen and placebo in the treatment of sprains and strains. *Clin Ther.* 1986;8(2):187-95.
35. Jakobsen T, Petersen L, Christiansen S, et al. Tenoxicam vs placebo in the treatment of tendinitis, periostitis, and sprains. *Curr Ther Res.* 1989;45(2):213-20.
36. Bourne MS. The effect on healing of analgesic and anti-inflammatory therapy. *Br J Sports Med.* 1980;14(1):26.
37. Jakobsen T, Petersen L, Christiansen S, et al. Double-blind comparative study of tenoxicam, piroxicam, and placebo in acute soft-tissue injuries. *Curr Ther Res.* 1988;44(4):516-27.
38. Sundqvist H, Forsskahl B, Kvist M. A promising novel therapy for Achilles peritendinitis: double-blind comparison of glycosaminoglycan polysulfate and high-dose indomethacin. *Int J Sports Med.* 1987;8(4):298-303.
39. Russell AL. Piroxicam 0.5% topical gel compared to placebo in the treatment of acute soft tissue injuries: a double-blind study comparing efficacy and safety. *Clin Invest Med.* 1991;14(1):35-43.
40. Mason L, Moore RA, Edwards JE, Derry S, McQuay HJ. Topical NSAIDs for chronic musculoskeletal pain: systematic review and meta-analysis. *BMC Musculoskelet Disord.* 2004;528.
41. Auclair J, Georges M, Grapton X, et al. A double-blind controlled multi-center study of percutaneous niflumic acid gel and placebo in the treatment of achilles heel tendinitis. *Curr Ther Res.* 1989;46782-8.
42. Paoloni JA, Appleyard RC, Nelson J, Murrell GA. Topical glyceryl trinitrate treatment of chronic noninsertional achilles tendinopathy. A randomized, double-blind, placebo-controlled trial. *J Bone Joint Surg Am.* 2004;86-A(5):916-22.
43. Paoloni JA, Murrell GA. Three-year followup study of topical glyceryl trinitrate treatment of chronic noninsertional Achilles tendinopathy. *Foot Ankle Int.* 2007;28(10):1064-8.
44. Rees JD, Maffulli N, Cook J. Management of tendinopathy. *Am J Sports Med.* 2009;37(9):1855-67.
45. Knobloch K, Schreibermueller L, Longo UG, Vogt PM. Eccentric exercises for the management of tendinopathy of the main body of the Achilles tendon with or without the AirHeel Brace. A randomized controlled trial. A: effects on pain and microcirculation. *Disabil Rehabil.* 2008;30(20-22):1685-91.
46. Silbernagel KG, Thomee R, Thomee P, Karlsson J. Eccentric overload training for patients with chronic Achilles tendon pain--a randomised controlled study with reliability testing of the evaluation methods. *Scand J Med Sci Sports.* 2001;11(4):197-206.
47. Rompe JD, Furia J, Weil L, Maffulli N. Shock wave therapy for chronic plantar fasciopathy. *Br Med Bull.* 2007;81-82183-208.
48. Silbernagel KG, Thomee R, Eriksson BI, Karlsson J. Continued sports activity, using a pain-monitoring model, during rehabilitation in patients with Achilles tendinopathy: a randomized controlled study. *Am J Sports Med.* 2007;35(6):897-906.
49. Niesen-Vertommen SL TJ, Clement DB, Mosher RE. . The effect of eccentric versus concentric exercise in the management of Achilles tendonitis. *Clin J Sport Med.* 1992;2(2):109-13.
50. Rompe JD, Furia J, Maffulli N. Eccentric loading compared with shock wave treatment for chronic insertional achilles tendinopathy. A randomized, controlled trial. *J Bone Joint Surg Am.* 2008;90(1):52-61.
51. Robinson J, Cook J, Purdam C, et al. The VISA-A questionnaire: a valid and reliable index of the clinical severity of Achilles tendinopathy. *Br J Sports Med.* 2001;35335-41.
52. Morelli V, James E. Achilles tendonopathy and tendon rupture: conservative versus surgical management. *Prim Care.* 2004;31(4):1039-54, x.

53. Knobloch K, Grasmann R, Spies M, Vogt PM. Midportion achilles tendon microcirculation after intermittent combined cryotherapy and compression compared with cryotherapy alone: a randomized trial. *Am J Sports Med.* 2008;36(11):2128-38.
54. Knobloch K, Grasmann R, Spies M, Vogt PM. Intermittent KoldBlue cryotherapy of 3x10 min changes mid-portion Achilles tendon microcirculation. *Br J Sports Med.* 2007;41(6):e4.
55. Mayer F, Hirschmuller A, Muller S, Schuberth M, Baur H. Effects of short-term treatment strategies over 4 weeks in Achilles tendinopathy. *Br J Sports Med.* 2007;41(7):e6.
56. Roos EM, Engstrom M, Lagerquist A, Soderberg B. Clinical improvement after 6 weeks of eccentric exercise in patients with mid-portion Achilles tendinopathy -- a randomized trial with 1-year follow-up. *Scand J Med Sci Sports.* 2004;14(5):286-95.
57. de Vos RJ, Weir A, Visser RJ, de Winter T, Tol JL. The additional value of a night splint to eccentric exercises in chronic midportion Achilles tendinopathy: a randomised controlled trial. *Br J Sports Med.* 2007;41(7):e5.
58. Lowdon A, Bader DL, Mowat AG. The effect of heel pads on the treatment of Achilles tendinitis: a double blind trial. *Am J Sports Med.* 1984;12(6):431-5.
59. Petersen W, Welp R, Rosenbaum D. Chronic Achilles tendinopathy: a prospective randomized study comparing the therapeutic effect of eccentric training, the AirHeel brace, and a combination of both. *Am J Sports Med.* 2007;35(10):1659-67.
60. Knobloch K, Schreibmueller L, Longo UG, Vogt PM. Eccentric exercises for the management of tendinopathy of the main body of the Achilles tendon with or without an AirHeel Brace. A randomized controlled trial. B: Effects of compliance. *Disabil Rehabil.* 2008;30(20-22):1692-6.
61. Rompe JD. Repetitive low-energy shock wave treatment is effective for chronic symptomatic plantar fasciitis. *Knee Surg Sports Traumatol Arthrosc.* 2007;15(1):107; author reply 8.
62. Rasmussen S, Christensen M, Mathiesen I, Simonson O. Shockwave therapy for chronic Achilles tendinopathy: a double-blind, randomized clinical trial of efficacy. *Acta Orthop.* 2008;79(2):249-56.
63. Costa ML, Shepstone L, Donell ST, Thomas TL. Shock wave therapy for chronic Achilles tendon pain: a randomized placebo-controlled trial. *Clin Orthop Relat Res.* 2005;440:199-204.
64. Chester R, Costa ML, Shepstone L, Cooper A, Donell ST. Eccentric calf muscle training compared with therapeutic ultrasound for chronic Achilles tendon pain--a pilot study. *Man Ther.* 2008;13(6):484-91.
65. Neeter C, Thomee R, Silbernagel KG, Thomee P, Karlsson J. Iontophoresis with or without dexamethazone in the treatment of acute Achilles tendon pain. *Scand J Med Sci Sports.* 2003;13(6):376-82.
66. Fitz-Ritson D. Lasers and their therapeutic applications in chiropractic. *Journal of the Canadian Chiropractic Association.* 2001;45(1):26-34.
67. Stergioulas A, Stergioula M, Aarskog R, Lopes-Martins RA, Bjordal JM. Effects of Low-Level Laser Therapy and Eccentric Exercises in the Treatment of Recreational Athletes With Chronic Achilles Tendinopathy. *Am J Sports Med.* 2008;36(5).
68. Fredberg U, Bolvig L, Pfeiffer-Jensen M, Clemmensen D, Jakobsen BW, Stengaard-Pedersen K. Ultrasonography as a tool for diagnosis, guidance of local steroid injection and, together with pressure algometry, monitoring of the treatment of athletes with chronic jumper's knee and Achilles tendinitis: a randomized, double-blind, placebo-controlled study. *Scand J Rheumatol.* 2004;33(2):94-101.
69. DaCruz DJ, Geeson M, Allen MJ, Phair I. Achilles paratendonitis: an evaluation of steroid injection. *Br J Sports Med.* 1988;22(2):64-5.
70. de Vos RJ, Weir A, van Schie HT, et al. Platelet-rich plasma injection for chronic Achilles tendinopathy: a randomized controlled trial. *Jama.* 2010;303(2):144-9.
71. Mello ML, de Campos Vidal B. Experimental tendon repair: glycosaminoglycan arrangement in newly synthesized collagen fibers. *Cell Mol Biol (Noisy-le-grand).* 2003;49(4):579-85.
72. Larsen AI, Egffjord M, Jelsdorff HM. Low-dose heparin in the treatment of calcaneal peritendinitis. *Scand J Rheumatol.* 1987;16(1):47-51.
73. Pforringer W, Pfister A, Kuntz G. The treatment of Achilles paratendinitis: Results of a double-blind, placebo-controlled study with a deproteinized hemodialysate. *Clin J Sport Med.* 1994;4(2):92-9.
74. Yelland MJ, Sweeting KR, Lyftogt JA, Ng SK, Scuffham PA, Evans KA. Prolotherapy injections and eccentric loading exercises for painful Achilles tendinosis: a randomised trial. *Br J Sports Med.* 2010.

75. Alfredson H, Ohberg L. Sclerosing injections to areas of neo-vascularisation reduce pain in chronic Achilles tendinopathy: a double-blind randomised controlled trial. *Knee Surg Sports Traumatol Arthrosc.* 2005;13(4):338-44.
76. Willberg L, Sunding K, Ohberg L, Forssblad M, Fahlstrom M, Alfredson H. Sclerosing injections to treat midportion Achilles tendinosis: a randomised controlled study evaluating two different concentrations of Polidocanol. *Knee Surg Sports Traumatol Arthrosc.* 2008;16(9):859-64.
77. Brown R, Orchard J, Kinchington M, Hooper A, Nalder G. Aprotinin in the management of Achilles tendinopathy: a randomised controlled trial. *Br J Sports Med.* 2006;40(3):275-9.
78. Chan O, O'Dowd D, Padhiar N, et al. High volume image guided injections in chronic Achilles tendinopathy. *Disabil Rehabil.* 2008;30(20-22):1697-708.
79. Paavola M, Kannus P, Jarvinen TA, Khan K, Jozsa L, Jarvinen M. Achilles tendinopathy. *J Bone Joint Surg Am.* 2002;84-A(11):2062-76.
80. Maffulli N, Waterston SW, Squair J, Reaper J, Douglas AS. Changing incidence of Achilles tendon rupture in Scotland: a 15-year study. *Clin J Sport Med.* 1999;9(3):157-60.
81. Levi N. The incidence of Achilles tendon rupture in Copenhagen. *Injury.* 1997;28(4):311-3.
82. Lapidus LJ, Rosfors S, Ponzer S, et al. Prolonged thromboprophylaxis with dalteparin after surgical treatment of achilles tendon rupture: a randomized, placebo-controlled study. *J Orthop Trauma.* 2007;21(1):52-7.
83. Houshian S, Tscherning T, Riegels-Nielsen P. The epidemiology of Achilles tendon rupture in a Danish county. *Injury.* 1998;29(9):651-4.
84. Suchak AA, Bostick G, Reid D, Blitz S, Jomha N. The incidence of Achilles tendon ruptures in Edmonton, Canada. *Foot Ankle Int.* 2005;26(11):932-6.
85. Clayton RA, Court-Brown CM. The epidemiology of musculoskeletal tendinous and ligamentous injuries. *Injury.* 2008;39(12):1338-44.
86. Carden DG, Noble J, Chalmers J, Lunn P, Ellis J. Rupture of the calcaneal tendon. The early and late management. *J bone Joint Surg BR.* 1987;69(3):416-20.
87. Nistor L. Surgical and non-surgical treatment of Achilles Tendon rupture. A prospective randomized study. *J Bone Joint Surg Am.* 1981;63(3):394-9.
88. Leppilahti J, Orava S. Total Achilles tendon rupture. A review. *Sports Med.* 1998;25(2):79-100.
89. Moller M, Movin T, Granhed H, Lind K, Faxen E, Karlsson J. Acute rupture of tendon Achillis. A prospective randomised study of comparison between surgical and non-surgical treatment. *J bone Joint Surg BR.* 2001;83(6):843-8.
90. Cetti R, Christensen SE, Ejsted R, Jensen NM, Jorgensen U. Operative versus nonoperative treatment of Achilles tendon rupture. A prospective randomized study and review of the literature. *Am J Sports Med.* 1993;21(6):791-9.
91. Moller M, Kalebo P, Tidebrant G, Movin T, Karlsson J. The ultrasonographic appearance of the ruptured Achilles tendon during healing: a longitudinal evaluation of surgical and nonsurgical treatment, with comparisons to MRI appearance. *Knee Surg Sports Traumatol Arthrosc.* 2002;10(1):49-56.
92. Rees JD, Wilson AM, Wolman RL. Current concepts in the management of tendon disorders. *Rheumatology (Oxford).* 2006;45(5):508-21.
93. Longo UG, Ronga M, Maffulli N. Acute ruptures of the achilles tendon. *Sports Med Arthrosc.* 2009;17(2):127-38.
94. Carr AJ, Norris SH. The blood supply of the calcaneal tendon. *J bone Joint Surg BR.* 1989;71(1):100-1.
95. Kannus P, Jozsa L. Histopathological changes preceding spontaneous rupture of a tendon. A controlled study of 891 patients. *J Bone Joint Surg Am.* 1991;73(10):1507-25.
96. Ahmed IM, Lagopoulos M, McConnell P, Soames RW, Sefton GK. Blood supply of the Achilles tendon. *J Orthop Res.* 1998;16(5):591-6.
97. Chen TM, Rozen WM, Pan WR, Ashton MW, Richardson MD, Taylor GI. The arterial anatomy of the Achilles tendon: anatomical study and clinical implications. *Clin Anat.* 2009;22(3):377-85.
98. Sode J, Obel N, Hallas J, Lassen A. Use of fluoroquinolone and risk of Achilles tendon rupture: a population-based cohort study. *Eur J Clin Pharmacol.* 2007;63(5):499-503.
99. Corrao G, Zambon A, Bertu L, et al. Evidence of tendinitis provoked by fluoroquinolone treatment: a case-control study. *Drug Saf.* 2006;29(10):889-96.

100. Metzl JA, Ahmad CS, Levine WN. The ruptured Achilles tendon: operative and non-operative treatment options. *Curr Rev Musculoskelet Med*. 2008;1(2):161-4.
101. Deangelis JP, Wilson KM, Cox CL, Diamond AB, Thomson AB. Achilles tendon rupture in athletes. *J Surg Orthop Adv*. 2009;18(3):115-21.
102. Cary DV. How to diagnose and manage an acute Achilles tendon rupture. *JAAPA*. 2009;22(8):39-43.
103. Jacob KM, Paterson R. Surgical repair followed by functional rehabilitation for acute and chronic achilles tendon injuries: excellent functional results, patient satisfaction and no reruptures. *ANZ J Surg*. 2007;77(4):287-91.
104. Thompson TC, Doherty JH. Spontaneous rupture of tendon of Achilles: a new clinical diagnostic test. *J Trauma*. 1962;2:126-9.
105. Maffulli N, Ferran NA. Management of acute and chronic ankle instability. *J Am Acad Orthop Surg*. 2008;16(10):608-15.
106. Gerster JC, Baud CA, Lagier R, Boussina I, Fallet GH. Tendon calcifications in chondrocalcinosis. A clinical, radiologic, histologic, and crystallographic study. *Arthritis Rheum*. 1977;20(2):717-22.
107. Wick MC, Rieger M. Images in clinical medicine. Rupture of a calcified Achilles' tendon. *N Engl J Med*. 2008;358(24):2618.
108. Lui TH. Fixation of tendo Achilles avulsion fracture. *Foot Ankle Surg*. 2009;15(2):58-61.
109. Margetic P, Miklic D, Rakic-Ersek V, Doko Z, Lubina ZI, Brkljacic B. Comparison of ultrasonographic and intraoperative findings in Achilles tendon rupture. *Coll Antropol*. 2007;31(1):279-84.
110. Paavola M, Paakkala T, Kannus P, Jarvinen M. Ultrasonography in the differential diagnosis of Achilles tendon injuries and related disorders. A comparison between pre-operative ultrasonography and surgical findings. *Acta radiol*. 1998;39(6):612-9.
111. Almekinders LC, Temple JD. Etiology, diagnosis, and treatment of tendonitis: an analysis of the literature. *Med Sci Sports Exerc*. 1998;30(8):1183-90.
112. Hall AJ, Logan JE, Toblin RL, et al. Patterns of abuse among unintentional pharmaceutical overdose fatalities. *Jama*. 2008;300(22):2613-20.
113. Centers for Disease Control and Prevention. Alcohol and Other Drug Use Among Victims of Motor-Vehicle Crashes - West Virginia, 2004-2005. *MMWR*. 2006;55(48):1293-6.
114. Inglis AE, Scott WN, Sculco TP, Patterson AH. Ruptures of the tendo achillis. An objective assessment of surgical and non-surgical treatment. *J Bone Joint Surg Am*. 1976;58(7):990-3.
115. Metz R, Verleisdonk EJ, van der Heijden GJ, et al. Acute Achilles tendon rupture: minimally invasive surgery versus nonoperative treatment with immediate full weightbearing--a randomized controlled trial. *Am J Sports Med*. 2008;36(9):1688-94.
116. Twaddle BC, Poon P. Early motion for Achilles tendon ruptures: is surgery important? A randomized, prospective study. *Am J Sports Med*. 2007;35(12):2033-8.
117. Khan RJ, Fick D, Keogh A, Crawford J, Brammar T, Parker M. Treatment of acute achilles tendon ruptures. A meta-analysis of randomized, controlled trials. *J Bone Joint Surg Am*. 2005;87(10):2202-10.
118. Moller M, Lind K, Movin T, Karlsson J. Calf muscle function after Achilles tendon rupture. A prospective, randomised study comparing surgical and non-surgical treatment. *Scand J Med Sci Sports*. 2002;12(1):9-16.
119. Metz R, Kerkhoffs GM, Verleisdonk EJ, van der Heijden GJ. Acute Achilles tendon rupture: minimally invasive surgery versus non operative treatment, with immediate full weight bearing. Design of a randomized controlled trial. *BMC Musculoskelet Disord*. 2007;8:108.
120. Saleh M, Marshall PD, Senior R, MacFarlane A. The Sheffield splint for controlled early mobilisation after rupture of the calcaneal tendon. A prospective, randomised comparison with plaster treatment. *J bone Joint Surg BR*. 1992;74(2):206-9.
121. Costa ML, MacMillan K, Halliday D, et al. Randomised controlled trials of immediate weight-bearing mobilisation for rupture of the tendo Achillis. *J bone Joint Surg BR*. 2006;88(1):69-77.
122. Wong J, Barrass V, Maffulli N. Quantitative review of operative and nonoperative management of achilles tendon ruptures. *Am J Sports Med*. 2002;30(4):565-75.
123. Maffulli N. Augmented repair of acute Achilles tendon ruptures using gastrocnemius-soleus fascia. *Int Orthop*. 2005;29(2):134.

124. Zell RA, Santoro VM. Augmented repair of acute Achilles tendon ruptures. *Foot Ankle Int.* 2000;21(6):469-74.
125. Wegrzyn J, Luciani JF, Philippot R, Brunet-Guedj E, Moyon B, Besse JL. Chronic Achilles tendon rupture reconstruction using a modified flexor hallucis longus transfer. *Int Orthop.* 2010;34(8):1187-92.
126. Ibrahim SA. Surgical treatment of chronic Achilles tendon rupture. *J Foot Ankle Surg.* 2009;48(3):340-6.
127. Hahn F, Meyer P, Maiwald C, Zanetti M, Vienne P. Treatment of chronic achilles tendinopathy and ruptures with flexor hallucis tendon transfer: clinical outcome and MRI findings. *Foot Ankle Int.* 2008;29(8):794-802.
128. Nilsson-Helander K, Sward L, Silbernagel KG, Thomee R, Eriksson BI, Karlsson J. A new surgical method to treat chronic ruptures and reruptures of the Achilles tendon. *Knee Surg Sports Traumatol Arthrosc.* 2008;16(6):614-20.
129. Hohendorff B, Siepen W, Staub L. Treatment of acute Achilles tendon rupture: fibrin glue versus fibrin glue augmented with the plantaris longus tendon. *J Foot Ankle Surg.* 2009;48(4):439-46.
130. Klein W, Lang DM, Saleh M. The use of the Ma-Griffith technique for percutaneous repair of fresh ruptured tendo Achillis. *Chir Organi Mov.* 1991;76(3):223-8.
131. Webb JM, Bannister GC. Percutaneous repair of the ruptured tendo Achillis. *J bone Joint Surg BR.* 1999;81(5):877-80.
132. Lim J, Dalal R, Waseem M. Percutaneous vs. open repair of the ruptured Achilles tendon--a prospective randomized controlled study. *Foot Ankle Int.* 2001;22(7):559-68.
133. Gigante A, Moschini A, Verdenelli A, Del Torto M, Ulisse S, de Palma L. Open versus percutaneous repair in the treatment of acute Achilles tendon rupture: a randomized prospective study. *Knee Surg Sports Traumatol Arthrosc.* 2008;16(2):204-9.
134. Mortensen NH, Saether J, Steinke MS, Staehr H, Mikkelsen SS. Separation of tendon ends after Achilles tendon repair: a prospective, randomized, multicenter study. *Orthopedics.* 1992;15(8):899-903.
135. Aktas S, Kocaoglu B, Nalbantoglu U, Seyhan M, Guven O. End-to-end versus augmented repair in the treatment of acute Achilles tendon ruptures. *J Foot Ankle Surg.* 2007;46(5):336-40.
136. Pajala A, Kangas J, Siira P, Ohtonen P, Leppilahti J. Augmented compared with nonaugmented surgical repair of a fresh total Achilles tendon rupture. A prospective randomized study. *J Bone Joint Surg Am.* 2009;91(5):1092-100.
137. Richardson DR, Willers J, Cohen BE, Davis WH, Jones CP, Anderson RB. Evaluation of the hallux morbidity of single-incision flexor hallucis longus tendon transfer. *Foot Ankle Int.* 2009;30(7):627-30.
138. Lee T, Blitz NM, Rush SM. Percutaneous contoured locking plate fixation of the pilon fracture: surgical technique. *J Foot Ankle Surg.* 2008;47(6):598-602.
139. Barber FA, McGarry JE, Herbert MA, Anderson RB. A biomechanical study of Achilles tendon repair augmentation using GraftJacket matrix. *Foot Ankle Int.* 2008;29(3):329-33.
140. Gebauer M, Beil FT, Beckmann J, et al. Mechanical evaluation of different techniques for Achilles tendon repair. *Arch Orthop Trauma Surg.* 2007;127(9):795-9.
141. Wills CA, Washburn S, Caiozzo V, Prietto CA. Achilles tendon rupture. A review of the literature comparing surgical versus nonsurgical treatment. *Clin Orthop Relat Res.* 1986(207):156-63.
142. Mortensen HM, Skov O, Jensen PE. Early motion of the ankle after operative treatment of a rupture of the Achilles tendon. A prospective, randomized clinical and radiographic study. *J Bone Joint Surg Am.* 1999;81(7):983-90.
143. Maxwell LC, Enwemeka CS. Immobilization-induced muscle atrophy is not reversed by lengthening the muscle. *Anat Rec.* 1992;234(1):55-61.
144. Rantanen J, Hurme T, Kalimo H. Calf muscle atrophy and Achilles tendon healing following experimental tendon division and surgery in rats. Comparison of postoperative immobilization of the muscle-tendon complex in relaxed and tensioned positions. *Scand J Med Sci Sports.* 1999;9(1):57-61.
145. Suchak AA, Bostick GP, Beaupre LA, Durand DC, Jomha NM. The influence of early weight-bearing compared with non-weight-bearing after surgical repair of the Achilles tendon. *J Bone Joint Surg Am.* 2008;90(9):1876-83.
146. Costa ML, Shepstone L, Darrach C, Marshall T, Donell ST. Immediate full-weight-bearing mobilisation for repaired Achilles tendon ruptures: a pilot study. *Injury.* 2003;34(11):874-6.

147. Cetti R, Henriksen LO, Jacobsen KS. A new treatment of ruptured Achilles tendons. A prospective randomized study. *Clin Orthop Relat Res*. 1994(308):155-65.
148. Kauranen K, Kangas J, Leppilahti J. Recovering motor performance of the foot after Achilles rupture repair: a randomized clinical study about early functional treatment vs. early immobilization of Achilles tendon in tension. *Foot Ankle Int*. 2002;23(7):600-5.
149. Kangas J, Pajala A, Ohtonen P, Leppilahti J. Achilles tendon elongation after rupture repair: a randomized comparison of 2 postoperative regimens. *Am J Sports Med*. 2007;35(1):59-64.
150. Kangas J, Pajala A, Siira P, Hamalainen M, Leppilahti J. Early functional treatment versus early immobilization in tension of the musculotendinous unit after Achilles rupture repair: a prospective, randomized, clinical study. *J Trauma*. 2003;54(6):1171-80; discussion 80-1.
151. Kujath P, Spannagel U, Habscheid W. Incidence and prophylaxis of deep venous thrombosis in outpatients with injury of the lower limb. *Haemostasis*. 1993;23 Suppl 120-6.
152. Lassen MR, Borris LC, Nakov RL. Use of the low-molecular-weight heparin reviparin to prevent deep-vein thrombosis after leg injury requiring immobilization. *N Engl J Med*. 2002;347(10):726-30.
153. Nilsson-Helander K, Thurin A, Karlsson J, Eriksson BI. High incidence of deep venous thrombosis after Achilles tendon rupture: a prospective study. *Knee Surg Sports Traumatol Arthrosc*. 2009;17(10):1234-8.
154. Persson LM, Lapidus LJ, Larfars G, Rosfors S. Asymptomatic deep venous thrombosis is associated with a low risk of post-thrombotic syndrome. *Eur J Vasc Endovasc Surg*. 2009;38(2):229-33.
155. Burssens P, Forsyth R, Steyaert A, Van Ovest E, Praet M, Verdonk R. Influence of burst TENS stimulation on collagen formation after Achilles tendon suture in man. A histological evaluation with Movat's pentachrome stain. *Acta Orthop Belg*. 2005;71(3):342-6.
156. Burssens P, Forsyth R, Steyaert A, Van Ovest E, Praet M, Verdonk R. Influence of burst TENS stimulation on the healing of Achilles tendon suture in man. *Acta Orthop Belg*. 2003;69(6):528-32.
157. Furia J, Rompe J. Extracorporeal shock wave therapy in the treatment of chronic plantar fasciitis and Achilles tendinopathy. *Curr Opin Orthop*. 2007;18102-11.
158. Barrett SJ, O'Malley R. Plantar fasciitis and other causes of heel pain. *Am Fam Physician*. 1999;59(8):2200-6.
159. Roxas M. Plantar fasciitis: diagnosis and therapeutic considerations. *Altern Med Rev*. 2005;10(2):83-93.
160. Cole C, Seto C, Gazewood J. Plantar fasciitis: evidence-based review of diagnosis and therapy. *Am Fam Physician*. 2005;72(11):2237-42.
161. Riddle DL, Pulisic M, Pidcoe P, Johnson RE. Risk factors for Plantar fasciitis: a matched case-control study. *J Bone Joint Surg Am*. 2003;85-A(5):872-7.
162. Bordelon RL. Subcalcaneal pain. A method of evaluation and plan for treatment. *Clin Orthop Relat Res*. 1983(177):49-53.
163. Scherer PR. Heel spur syndrome. Pathomechanics and nonsurgical treatment. Biomechanics Graduate Research Group for 1988. *J Am Podiatr Med Assoc*. 1991;81(2):68-72.
164. Schepsis AA, Leach RE, Gorzyca J. Plantar fasciitis. Etiology, treatment, surgical results, and review of the literature. *Clin Orthop Relat Res*. 1991(266):185-96.
165. Perelman GK, Figura MA, Sandberg NS. The medial instep plantar fasciotomy. *J Foot Ankle Surg*. 1995;34(5):447-57; discussion 509-10.
166. Lemont H, Ammirati KM, Usen N. Plantar fasciitis: a degenerative process (fasciosis) without inflammation. *J Am Podiatr Med Assoc*. 2003;93(3):234-7.
167. Przulucki H, Jones CL. Entrapment neuropathy of muscle branch of lateral plantar nerve: a cause of heel pain. *J Am Podiatry Assoc*. 1981;71(3):119-24.
168. Baxter DE, Thigpen CM. Heel pain--operative results. *Foot Ankle*. 1984;5(1):16-25.
169. Baxter DE, Pfeffer GB, Thigpen M. Chronic heel pain. Treatment rationale. *Orthop Clin North Am*. 1989;20(4):563-9.
170. Jeswani T, Morlese J, McNally EG. Getting to the heel of the problem: plantar fascia lesions. *Clin Radiol*. 2009;64(9):931-9.
171. Irving DB, Cook JL, Menz HB. Factors associated with chronic plantar heel pain: a systematic review. *J Sci Med Sport*. 2006;9(1-2):11-22; discussion 3-4.

172. Irving DB, Cook JL, Young MA, Menz HB. Obesity and pronated foot type may increase the risk of chronic plantar heel pain: a matched case-control study. *BMC Musculoskelet Disord*. 2007;841.
173. Puttaswamaiah R, Chandran P. Degenerative plantar fasciitis: A review of current concepts. *The Foot*. 2007;173-9.
174. Young CC, Rutherford DS, Niedfeldt MW. Treatment of plantar fasciitis. *Am Fam Physician*. 2001;63(3):467-74, 77-8.
175. Toomey EP. Plantar heel pain. *Foot Ankle Clin*. 2009;14(2):229-45.
176. Neufeld SK, Cerrato R. Plantar fasciitis: evaluation and treatment. *J Am Acad Orthop Surg*. 2008;16(6):338-46.
177. Buchbinder R. Clinical practice. Plantar fasciitis. *N Engl J Med*. 2004;350(21):2159-66.
178. Riddle DL, Pulisic M, Sparrow K. Impact of demographic and impairment-related variables on disability associated with plantar fasciitis. *Foot Ankle Int*. 2004;25(5):311-7.
179. Hill A. The environment and disease: association or causation. . *Proc R Soc Med*. 1965;58295-300.
180. Hegmann K, Oostema S. Chapter 3. Causal associations and determination of work-relatedness. In: Melhorn J, Ackermann W, III, eds. *Guides to the Evaluation of Disease and Injury Causation*. Chicago, Ill: AMA Press; 2008.
181. DeGarceau D, Dean D, Requejo S, Thordarson D. The association between diagnosis of plantar fasciitis and windlass test results. *Foot Ankle Int*. 2003;24251-5.
182. Grasel RP, Schweitzer ME, Kovalovich AM, et al. MR imaging of plantar fasciitis: edema, tears, and occult marrow abnormalities correlated with outcome. *AJR Am J Roentgenol*. 1999;173(3):699-701.
183. Kane D, Greaney T, Shanahan M, et al. The role of ultrasonography in the diagnosis and management of idiopathic plantar fasciitis. *Rheumatology (Oxford)*. 2001;40(9):1002-8.
184. Abdel-Wahab N, Fathi S, Al-Emadi S, Mahdi S. High resolution ultrasonographic diagnosis of plantar fasciitis: a correlation of ultrasound and magnetic resonance imaging. *Int J Rhem Dis*. 2008;11279-86.
185. Berkowitz JF, Kier R, Rudicel S. Plantar fasciitis: MR imaging. *Radiology*. 1991;179(3):665-7.
186. Akfirat M, Sen C, Gunes T. Ultrasonographic appearance of the plantar fasciitis. *Clin Imaging*. 2003;27(5):353-7.
187. Gibbon WW, Long G. Ultrasound of the plantar aponeurosis (fascia). *Skeletal Radiol*. 1999;28(1):21-6.
188. Osborne HR, Allison GT. Treatment of plantar fasciitis by LowDye taping and iontophoresis: short term results of a double blinded, randomised, placebo controlled clinical trial of dexamethasone and acetic acid. *Br J Sports Med*. 2006;40(6):545-9; discussion 9.
189. Recht MP, Donley BG. Magnetic resonance imaging of the foot and ankle. *J Am Acad Orthop Surg*. 2001;9(3):187-99.
190. Theodorou DJ, Theodorou SJ, Kakitsubata Y, et al. Plantar fasciitis and fascial rupture: MR imaging findings in 26 patients supplemented with anatomic data in cadavers. *Radiographics*. 2000;20 Spec NoS181-97.
191. Maier M, Steinborn M, Schmitz C, et al. Extracorporeal shock wave application for chronic plantar fasciitis associated with heel spurs: prediction of outcome by magnetic resonance imaging. *J Rheumatol*. 2000;27(10):2455-62.
192. Breunung N, Barwick T, Fernando R, et al. Additional benefit of SPECT-CT in investigating heel pain. *Clin Nucl Med*. 2008;33(10):705-6.
193. Khoury V, Guillin R, Dhanju J, Cardinal E. Ultrasound of ankle and foot: overuse and sports injuries. *Semin Musculoskelet Radiol*. 2007;11(2):149-61.
194. Sabir N, Demirlenk S, Yagci B, Karabulut N, Cubukcu S. Clinical utility of sonography in diagnosing plantar fasciitis. *J Ultrasound Med*. 2005;24(8):1041-8.
195. Vohra PK, Kincaid BR, Japour CJ, Sobel E. Ultrasonographic evaluation of plantar fascia bands. A retrospective study of 211 symptomatic feet. *J Am Podiatr Med Assoc*. 2002;92(8):444-9.
196. Rawool NM, Nazarian LN. Ultrasound of the ankle and foot. *Semin Ultrasound CT MR*. 2000;21(3):275-84.
197. Tsai WC, Chiu MF, Wang CL, Tang FT, Wong MK. Ultrasound evaluation of plantar fasciitis. *Scand J Rheumatol*. 2000;29(4):255-9.

198. Cardinal E, Chhem RK, Beauregard CG, Aubin B, Pelletier M. Plantar fasciitis: sonographic evaluation. *Radiology*. 1996;201(1):257-9.
199. Davies MS, Weiss GA, Saxby TS. Plantar fasciitis: how successful is surgical intervention? *Foot Ankle Int*. 1999;20(12):803-7.
200. Beischer AD, Clarke A, de Steiger RN, Donnan L, Ibuki A, Unglik R. The practical application of multimedia technology to facilitate the education and treatment of patients with plantar fasciitis: a pilot study. *Foot Ankle Spec*. 2008;1(1):30-8.
201. Donley BG, Moore T, Sferra J, Gozdanovic J, Smith R. The efficacy of oral nonsteroidal anti-inflammatory medication (NSAID) in the treatment of plantar fasciitis: a randomized, prospective, placebo-controlled study. *Foot Ankle Int*. 2007;28(1):20-3.
202. Eklund KK, Numminen K, Uusitalo T, Leirisalo-Repo M. Treatment of refractory plantar fasciitis with infliximab. *Scand J Rheumatol*. 2007;36(3):233-4.
203. Young MA, Cook JL, Webster KE. The effect of topical wheatgrass cream on chronic plantar fasciitis: a randomized, double-blind, placebo-controlled trial. *Complement Ther Med*. 2006;14(1):3-9.
204. Pribut SM. Current approaches to the management of plantar heel pain syndrome, including the role of injectable corticosteroids. *J Am Podiatr Med Assoc*. 2007;97(1):68-74.
205. Tisdell CL, Harper MC. Chronic plantar heel pain: treatment with a short leg walking cast. *Foot Ankle Int*. 1996;17(1):41-2.
206. Winemiller MH, Billow RG, Laskowski ER, Harmsen WS. Effect of magnetic vs sham-magnetic insoles on nonspecific foot pain in the workplace: a randomized, double-blind, placebo-controlled trial. *Mayo Clin Proc*. 2005;80(9):1138-45.
207. Winemiller MH, Billow RG, Laskowski ER, Harmsen WS. Effect of magnetic vs sham-magnetic insoles on plantar heel pain: a randomized controlled trial. *Jama*. 2003;290(11):1474-8.
208. Caselli MA, Clark N, Lazarus S, Velez Z, Venegas L. Evaluation of magnetic foil and PPT Insoles in the treatment of heel pain. *J Am Podiatr Med Assoc*. 1997;87(1):11-6.
209. Batt ME, Tanji JL, Skattum N. Plantar fasciitis: a prospective randomized clinical trial of the tension night splint. *Clin J Sport Med*. 1996;6(3):158-62.
210. Powell M, Post WR, Keener J, Wearden S. Effective treatment of chronic plantar fasciitis with dorsiflexion night splints: a crossover prospective randomized outcome study. *Foot Ankle Int*. 1998;19(1):10-8.
211. Probe RA, Baca M, Adams R, Preece C. Night splint treatment for plantar fasciitis. A prospective randomized study. *Clin Orthop Relat Res*. 1999(368):190-5.
212. Roos E, Engstrom M, Soderberg B. Foot orthoses for the treatment of plantar fasciitis. *Foot Ankle Int*. 2006;27(8):606-11.
213. Ryan J. Use of posterior night splints in the treatment of plantar fasciitis. *Am Fam Physician*. 1995;52(3):891-8, 901-2.
214. Evans A. Podiatric medical applications of posterior night stretch splinting. *J Am Podiatr Med Assoc*. 2001;91(7):356-60.
215. Martin JE, Hosch JC, Goforth WP, Murff RT, Lynch DM, Odom RD. Mechanical treatment of plantar fasciitis. A prospective study. *J Am Podiatr Med Assoc*. 2001;91(2):55-62.
216. Landorf KB, Keenan AM, Herbert RD. Effectiveness of foot orthoses to treat plantar fasciitis: a randomized trial. *Arch Intern Med*. 2006;166(12):1305-10.
217. Mejjad O, Vittecoq O, Pouplin S, Grassin-Delyle L, Weber J, Le Loët X. Foot orthotics decrease pain but do not improve gait in rheumatoid arthritis patients. *Joint Bone Spine*. 2004;71(6):542-5.
218. Baldassin V, Gomes CR, Beraldo PS. Effectiveness of prefabricated and customized foot orthoses made from low-cost foam for noncomplicated plantar fasciitis: a randomized controlled trial. *Arch Phys Med Rehabil*. 2009;90(4):701-6.
219. Pfeffer G, Bacchetti P, Deland J, et al. Comparison of custom and prefabricated orthoses in the initial treatment of proximal plantar fasciitis. *Foot Ankle Int*. 1999;20(4):214-21.
220. Kelly A, Winson I. Use of ready-made insoles in the treatment of lesser metatarsalgia: a prospective randomized controlled trial. *Foot Ankle Int*. 1998;19(4):217-20.
221. Chalmers AC, Busby C, Goyert J, Porter B, Schulzer M. Metatarsalgia and rheumatoid arthritis--a randomized, single blind, sequential trial comparing 2 types of foot orthoses and supportive shoes. *J Rheumatol*. 2000;27(7):1643-7.

222. Stratton M, McPoil TG, Cornwall MW, Patrick K. Use of low-frequency electrical stimulation for the treatment of plantar fasciitis. *J Am Podiatr Med Assoc.* 2009;99(6):481-8.
223. Kavros SJ. The efficacy of a pneumatic compression device in the treatment of plantar fasciitis. *J Appl Biomech.* 2005;21(4):404-13.
224. Esterman A, Pilotto L. Foot shape and its effect on functioning in Royal Australian Air Force recruits. Part 2: Pilot, randomized, controlled trial of orthotics in recruits with flat feet. *Mil Med.* 2005;170(7):629-33.
225. Fauno P, Kalund S, Andreasen I, Jorgensen U. Soreness in lower extremities and back is reduced by use of shock absorbing heel inserts. *Int J Sports Med.* 1993;14(5):288-90.
226. Lynch DM, Goforth WP, Martin JE, Odom RD, Preece CK, Kotter MW. Conservative treatment of plantar fasciitis. A prospective study. *J Am Podiatr Med Assoc.* 1998;88(8):375-80.
227. Torkki M, Malmivaara A, Reivonen N, Seitsalo S, Laippalo P, Hoikka V. Individually fitted sports shoes for overuse injuries among newspaper carriers. *Scand J Work Environ Health.* 2002;28(3):176-83.
228. Milgrom C, Finestone A, Shlamkovitch N, et al. Prevention of overuse injuries of the foot by improved shoe shock attenuation. A randomized prospective study. *Clin Orthop Relat Res.* 1992(281):189-92.
229. Fransen M, Edmonds J. Off-the-shelf orthopedic footwear for people with rheumatoid arthritis. *Arthritis Care Res.* 1997;10(4):250-6.
230. DiGiovanni BF, Nawoczenski DA, Lintal ME, et al. Tissue-specific plantar fascia-stretching exercise enhances outcomes in patients with chronic heel pain. A prospective, randomized study. *J Bone Joint Surg Am.* 2003;85-A(7):1270-7.
231. DiGiovanni BF, Nawoczenski DA, Malay DP, et al. Plantar fascia-specific stretching exercise improves outcomes in patients with chronic plantar fasciitis. A prospective clinical trial with two-year follow-up. *J Bone Joint Surg Am.* 2006;88(8):1775-81.
232. Hyland MR, Webber-Gaffney A, Cohen L, Lichtman PT. Randomized controlled trial of calcaneal taping, sham taping, and plantar fascia stretching for the short-term management of plantar heel pain. *J Orthop Sports Phys Ther.* 2006;36(6):364-71.
233. Radford JA, Landorf KB, Buchbinder R, Cook C. Effectiveness of calf muscle stretching for the short-term treatment of plantar heel pain: a randomised trial. *BMC Musculoskelet Disord.* 2007;836.
234. Radford JA, Landorf KB, Buchbinder R, Cook C. Effectiveness of low-Dye taping for the short-term treatment of plantar heel pain: a randomised trial. *BMC Musculoskelet Disord.* 2006;764.
235. Zhang SP, Yip TP, Li QS. Acupuncture treatment for plantar fasciitis: a randomized controlled trial with six months follow-up. *Evid Based Complement Alternat Med.* 2009.
236. Speed CA. Extracorporeal shock-wave therapy in the management of chronic soft-tissue conditions. *J bone Joint Surg BR.* 2004;86(2):165-71.
237. Ogden JA, Alvarez R, Levitt R, Cross GL, Marlow M. Shock wave therapy for chronic proximal plantar fasciitis. *Clin Orthop Relat Res.* 2001(387):47-59.
238. Maier M, Tischer T, Gerdesmeyer L. ESWT in orthopedics. In: Chaussy C, Haupt G, Jocham D, Köhrmann K, Wilbert D, eds. *Therapeutic Energy Application in Urology: Standards and Recent Developments.* New York: Thieme; 2005:144-53.
239. Thiel M, Nieswand M, Dörffel M. *Shockwave overview: history and principles* International Society for Medical Shockwave Treatment.
240. Tóth-Kischkat A. *Shockwave overview: principles - basic physics and definition of physical parameters:* International Society for Medical Shockwave Treatment.
241. Kudo P, Dainty K, Clarfield M, Coughlin L, Lavoie P, Lebrun C. Randomized, placebo-controlled, double-blind clinical trial evaluating the treatment of plantar fasciitis with an extracorporeal shockwave therapy (ESWT) device: a North American confirmatory study. *J Orthop Res.* 2006;24(2):115-23.
242. Rompe JD, Decking J, Schoellner C, Nafe B. Shock wave application for chronic plantar fasciitis in running athletes. A prospective, randomized, placebo-controlled trial. *Am J Sports Med.* 2003;31(2):268-75.
243. Malay DS, Pressman MM, Assili A, et al. Extracorporeal shockwave therapy versus placebo for the treatment of chronic proximal plantar fasciitis: results of a randomized, placebo-controlled, double-blinded, multicenter intervention trial. *J Foot Ankle Surg.* 2006;45(4):196-210.

244. Rompe JD, Hopf C, Nafe B, Burger R. Low-energy extracorporeal shock wave therapy for painful heel: a prospective controlled single-blind study. *Arch Orthop Trauma Surg.* 1996;115(2):75-9.
245. Theodore GH, Buch M, Amendola A, Bachmann C, Fleming LL, Zingas C. Extracorporeal shock wave therapy for the treatment of plantar fasciitis. *Foot Ankle Int.* 2004;25(5):290-7.
246. Cosentino R, Falsetti P, Manca S, et al. Efficacy of extracorporeal shock wave treatment in calcaneal enthesophytosis. *Ann Rheum Dis.* 2001;60(11):1064-7.
247. Mehra A, Zaman T, Jenkin AI. The use of a mobile lithotripter in the treatment of tennis elbow and plantar fasciitis. *Surgeon.* 2003;1(5):290-2.
248. Rompe JD, Buch M, Gerdesmeyer L, et al. Musculoskeletal shock wave therapy--current database of clinical research. *Z Orthop Ihre Grenzgeb.* 2002;140(3):267-74.
249. Ogden JA. Extracorporeal shock wave therapy for plantar fasciitis: randomised controlled multicentre trial. *Br J Sports Med.* 2004;38(4):382.
250. Haake M, Buch M, Schoellner C, et al. Extracorporeal shock wave therapy for plantar fasciitis: randomised controlled multicentre trial. *Bmj.* 2003;327(7406):75.
251. Buchbinder R, Ptasznik R, Gordon J, Buchanan J, Prabakaran V, Forbes A. Ultrasound-guided extracorporeal shock wave therapy for plantar fasciitis: a randomized controlled trial. *Jama.* 2002;288(11):1364-72.
252. Speed CA, Nichols D, Wies J, et al. Extracorporeal shock wave therapy for plantar fasciitis. A double blind randomised controlled trial. *J Orthop Res.* 2003;21(5):937-40.
253. Marks W, Jackiewicz A, Witkowski Z, Kot J, Deja W, Lasek J. Extracorporeal shock-wave therapy (ESWT) with a new-generation pneumatic device in the treatment of heel pain. A double blind randomised controlled trial. *Acta Orthop Belg.* 2008;74(1):98-101.
254. Gollwitzer H, Diehl P, von Korff A, Rahlfs VW, Gerdesmeyer L. Extracorporeal shock wave therapy for chronic painful heel syndrome: a prospective, double blind, randomized trial assessing the efficacy of a new electromagnetic shock wave device. *J Foot Ankle Surg.* 2007;46(5):348-57.
255. Rompe JD, Schoellner C, Nafe B. Evaluation of low-energy extracorporeal shock-wave application for treatment of chronic plantar fasciitis. *J Bone Joint Surg Am.* 2002;84-A(3):335-41.
256. Porter MD, Shadbolt B. Intralesional corticosteroid injection versus extracorporeal shock wave therapy for plantar fasciopathy. *Clin J Sport Med.* 2005;15(3):119-24.
257. Greve JM, Grecco MV, Santos-Silva PR. Comparison of radial shockwaves and conventional physiotherapy for treating plantar fasciitis. *Clinics (Sao Paulo).* 2009;64(2):97-103.
258. Hammer DS, Rupp S, Kreutz A, Pape D, Kohn D, Seil R. Extracorporeal shockwave therapy (ESWT) in patients with chronic proximal plantar fasciitis. *Foot Ankle Int.* 2002;23(4):309-13.
259. Hammer DS, Adam F, Kreutz A, Kohn D, Seil R. Extracorporeal shock wave therapy (ESWT) in patients with chronic proximal plantar fasciitis: a 2-year follow-up. *Foot Ankle Int.* 2003;24(11):823-8.
260. Wang CJ, Wang FS, Yang KD, Weng LH, Ko JY. Long-term results of extracorporeal shockwave treatment for plantar fasciitis. *Am J Sports Med.* 2006;34(4):592-6.
261. Gerdesmeyer L, Frey C, Vester J, et al. Radial extracorporeal shock wave therapy is safe and effective in the treatment of chronic recalcitrant plantar fasciitis: results of a confirmatory randomized placebo-controlled multicenter study. *Am J Sports Med.* 2008;36(11):2100-9.
262. Tornese D, Mattei E, Lucchesi G, Bandi M, Ricci G, Melegati G. Comparison of two extracorporeal shock wave therapy techniques for the treatment of painful subcalcaneal spur. A randomized controlled study. *Clin Rehabil.* 2008;22(9):780-7.
263. Dorotka R, Sabeti M, Jimenez-Boj E, Goll A, Schubert S, Trieb K. Location modalities for focused extracorporeal shock wave application in the treatment of chronic plantar fasciitis. *Foot Ankle Int.* 2006;27(11):943-7.
264. Rompe JD. Shock-wave therapy for plantar fasciitis. *J Bone Joint Surg Am.* 2005;87(3):681-2; author reply 2-3.
265. Furia JP. The safety and efficacy of high energy extracorporeal shock wave therapy in active, moderately active, and sedentary patients with chronic plantar fasciitis. *Orthopedics.* 2005;28(7):685-92.
266. Alvarez R, Ogden J, Jaakkola J, Cross G. Symptom duration of plantar fasciitis and the effectiveness of Orthotripsy. *Foot Ankle Int.* 2003;24(12):916-21.

267. Gudeman SD, Eisele SA, Heidt RS, Jr., Colosimo AJ, Stroupe AL. Treatment of plantar fasciitis by iontophoresis of 0.4% dexamethasone. A randomized, double-blind, placebo-controlled study. *Am J Sports Med.* 1997;25(3):312-6.
268. Kiritsi O, Tsitas K, Malliaropoulos N, Mikroulis G. Ultrasonographic evaluation of plantar fasciitis after low-level laser therapy: results of a double-blind, randomized, placebo-controlled trial. *Lasers Med Sci.* 2010;25(2):275-81.
269. Basford JR, Malanga GA, Krause DA, Harmsen WS. A randomized controlled evaluation of low-intensity laser therapy: plantar fasciitis. *Arch Phys Med Rehabil.* 1998;79(3):249-54.
270. Brantingham JW, Globe G, Pollard H, Hicks M, Korporaal C, Hoskins W. Manipulative therapy for lower extremity conditions: expansion of literature review. *J Manipulative Physiol Ther.* 2009;32(1):53-71.
271. Cleland JA, Abbott JH, Kidd MO, et al. Manual physical therapy and exercise versus electrophysical agents and exercise in the management of plantar heel pain: a multicenter randomized clinical trial. *J Orthop Sports Phys Ther.* 2009;39(8):573-85.
272. Wyatt LH. Conservative chiropractic management of recalcitrant foot pain after fasciotomy: a retrospective case review. *J Manipulative Physiol Ther.* 2006;29(5):398-402.
273. Dimou E, Brantingham J, Wood T. A randomized, controlled trial (with blinded observer) of chiropractic manipulation and Achilles stretching vs. orthotics for the treatment of plantar fasciitis. *J Am Chiropractic Assoc.* 2004;41(9):32-42.
274. Crawford F, Snaith M. How effective is therapeutic ultrasound in the treatment of heel pain? *Ann Rheum Dis.* 1996;55(4):265-7.
275. Miszczyk L, Jochymek B, Wozniak G. Retrospective evaluation of radiotherapy in plantar fasciitis. *Br J Radiol.* 2007;80(958):829-34.
276. Heyd R, Tselis N, Ackermann H, Roddiger SJ, Zamboglou N. Radiation therapy for painful heel spurs: results of a prospective randomized study. *Strahlenther Onkol.* 2007;183(1):3-9.
277. Niewald M, Seegenschmiedt MH, Micke O, Graber S. Randomized multicenter trial on the effect of radiotherapy for plantar Fasciitis (painful heel spur) using very low doses--a study protocol. *Radiat Oncol.* 2008;327.
278. Cavazos GJ, Khan KH, D'Antoni AV, Harkless LB, Lopez D. Cryosurgery for the treatment of heel pain. *Foot Ankle Int.* 2009;30(6):500-5.
279. Kalaci A, Cakici H, Hapa O, Yanat AN, Dogramaci Y, Sevinc TT. Treatment of plantar fasciitis using four different local injection modalities: a randomized prospective clinical trial. *J Am Podiatr Med Assoc.* 2009;99(2):108-13.
280. Lee TG, Ahmad TS. Intralesional autologous blood injection compared to corticosteroid injection for treatment of chronic plantar fasciitis. A prospective, randomized, controlled trial. *Foot Ankle Int.* 2007;28(9):984-90.
281. Kiter E, Celikbas E, Akkaya S, Demirkan F, Kilic BA. Comparison of injection modalities in the treatment of plantar heel pain: a randomized controlled trial. *J Am Podiatr Med Assoc.* 2006;96(4):293-6.
282. Jabbari B. Botulinum neurotoxins in the treatment of refractory pain. *Nat Clin Pract Neurol.* 2008;4(12):676-85.
283. Babcock MS, Foster L, Pasquina P, Jabbari B. Treatment of pain attributed to plantar fasciitis with botulinum toxin a: a short-term, randomized, placebo-controlled, double-blind study. *Am J Phys Med Rehabil.* 2005;84(9):649-54.
284. Placzek R, Deuretzbacher G, Meiss AL. Treatment of chronic plantar fasciitis with Botulinum toxin A: preliminary clinical results. *Clin J Pain.* 2006;22(2):190-2.
285. Gobel H, Heinze A, Reichel G, Hefter H, Benecke R. Efficacy and safety of a single botulinum type A toxin complex treatment (Dysport) for the relief of upper back myofascial pain syndrome: results from a randomized double-blind placebo-controlled multicentre study. *Pain.* 2006;125(1-2):82-8.
286. Qerama E, Fuglsang-Frederiksen A, Kasch H, Bach FW, Jensen TS. A double-blind, controlled study of botulinum toxin A in chronic myofascial pain. *Neurology.* 2006;67(2):241-5.
287. Richards BA, Jensen. A double-blind, controlled study of botulinum toxin A in chronic myofascial pain. *Neurology.* 2007;68(12):963; author reply -4.
288. Ferrante FM, Bearn L, Rothrock R, King L. Evidence against trigger point injection technique for the treatment of cervicothoracic myofascial pain with botulinum toxin type A. *Anesthesiology.* 2005;103(2):377-83.

289. Lew MF, Adornato BT, Duane DD, et al. Botulinum toxin type B: a double-blind, placebo-controlled, safety and efficacy study in cervical dystonia. *Neurology*. 1997;49(3):701-7.
290. Charles PD. Botulinum neurotoxin serotype A: a clinical update on non-cosmetic uses. *Am J Health Syst Pharm*. 2004;61(22 Suppl 6):S11-23.
291. Vadoud-Seyedi J. Treatment of plantar hyperhidrosis with botulinum toxin type A. *Int J Dermatol*. 2004;43(12):969-71.
292. Sevim S, Dogu O, Kaleagasi H. Botulinum toxin-A therapy for palmar and plantar hyperhidrosis. *Acta Neurol Belg*. 2002;102(4):167-70.
293. Graham HK, Boyd R, Carlin JB, et al. Does botulinum toxin a combined with bracing prevent hip displacement in children with cerebral palsy and "hips at risk"? A randomized, controlled trial. *J Bone Joint Surg Am*. 2008;90(1):23-33.
294. Galli M, Cimolin V, Valente EM, Crivellini M, Ialongo T, Albertini G. Computerized gait analysis of botulinum toxin treatment in children with cerebral palsy. *Disabil Rehabil*. 2007;29(8):659-64.
295. Rousseaux M, Launay MJ, Kozlowski O, Daveluy W. Botulinum toxin injection in patients with hereditary spastic paraparesis. *Eur J Neurol*. 2007;14(2):206-12.
296. Rousseaux M, Buisset N, Daveluy W, Kozlowski O, Blond S. Comparison of botulinum toxin injection and neurotomy in patients with distal lower limb spasticity. *Eur J Neurol*. 2008;15(5):506-11.
297. Burbaud P, Wiart L, Dubos JL, et al. A randomised, double blind, placebo controlled trial of botulinum toxin in the treatment of spastic foot in hemiparetic patients. *J Neurol Neurosurg Psychiatry*. 1996;61(3):265-9.
298. Baricich A, Carda S, Bertoni M, Maderna L, Cisari C. A single-blinded, randomized pilot study of botulinum toxin type A combined with non-pharmacological treatment for spastic foot. *J Rehabil Med*. 2008;40(10):870-2.
299. Huang YC, Wei SH, Wang HK, Lieu FK. Ultrasonographic guided botulinum toxin type A treatment for plantar fasciitis: an outcome-based investigation for treating pain and gait changes. *J Rehabil Med*. 2010;42(2):136-40.
300. Li M, Goldberger BA, Hopkins C. Fatal case of BOTOX-related anaphylaxis? *J Forensic Sci*. 2005;50(1):169-72.
301. Blockley NJ. The painful heel; a controlled trial of the value of hydrocortisone. *Br Med J*. 1956;1(4978):1277-8.
302. Crawford F, Atkins D, Young P, Edwards J. Steroid injection for heel pain: evidence of short-term effectiveness. A randomized controlled trial. *Rheumatology (Oxford)*. 1999;38(10):974-7.
303. Kriss S. Injectable steroids in the management of heel pain. A prospective randomised trial. *British Journal of Podiatry*. 2003;6(2):40-2.
304. Yucel I, Yazici B, Degirmenci E, Erdogmus B, Dogan S. Comparison of ultrasound-, palpation-, and scintigraphy-guided steroid injections in the treatment of plantar fasciitis. *Arch Orthop Trauma Surg*. 2009;129(5):695-701.
305. Acevedo JI, Beskin JL. Complications of plantar fascia rupture associated with corticosteroid injection. *Foot Ankle Int*. 1998;19(2):91-7.
306. Sellman JR. Plantar fascia rupture associated with corticosteroid injection. *Foot Ankle Int*. 1994;15(7):376-81.
307. Ryan M, Fraser S, McDonald K, Taunton J. Examining the degree of pain reduction using a multielement exercise model with a conventional training shoe versus an ultraflexible training shoe for treating plantar fasciitis. *Phys Sportsmed*. 2009;37(4):68-74.
308. Sampson S, Gerhardt M, Mandelbaum B. Platelet rich plasma injection grafts for musculoskeletal injuries: a review. *Curr Rev Musculoskelet Med*. 2008;1(3-4):165-74.
309. Barrett S, Erredge S. Growth factors for chronic plantar fasciitis. *Podiatry Today*. 2004;1737-42.
310. Dogramaci Y, Kalaci A, Emir A, Yanat AN, Gokce A. Intracorporeal pneumatic shock application for the treatment of chronic plantar fasciitis: a randomized, double blind prospective clinical trial. *Arch Orthop Trauma Surg*. 2010;130(4):541-6.
311. Hassan F. Percutaneous fenestration of the anteromedial aspect of the calcaneus for resistant heel pain syndrome. *Foot Ankle Surg*. 2009;15(2):90-5.
312. Weil L, Jr., Glover JP, Weil LS, Sr. A new minimally invasive technique for treating plantar fasciosis using bipolar radiofrequency: a prospective analysis. *Foot Ankle Spec*. 2008;1(1):13-8.

313. Faraj A, Querishe M. Surgical treatment for plantar fasciitis. *The Foot*. 2002;12224-6.
314. Conflitti JM, Tarquinio TA. Operative outcome of partial plantar fasciectomy and neurolysis to the nerve of the abductor digiti minimi muscle for recalcitrant plantar fasciitis. *Foot Ankle Int*. 2004;25(7):482-7.
315. Hogan KA, Webb D, Shereff M. Endoscopic plantar fascia release. *Foot Ankle Int*. 2004;25(12):875-81.
316. Jarde O, Diebold P, Havet E, Boulu G, Vernois J. Degenerative lesions of the plantar fascia: surgical treatment by fasciectomy and excision of the heel spur. A report on 38 cases. *Acta Orthop Belg*. 2003;69(3):267-74.
317. Bazaz R, Ferkel RD. Results of endoscopic plantar fascia release. *Foot Ankle Int*. 2007;28(5):549-56.
318. Cheung JT, An KN, Zhang M. Consequences of partial and total plantar fascia release: a finite element study. *Foot Ankle Int*. 2006;27(2):125-32.
319. Jerosch J, Schunck J, Liebsch D, Filler T. Indication, surgical technique and results of endoscopic fascial release in plantar fasciitis (E FRPF). *Knee Surg Sports Traumatol Arthrosc*. 2004;12(5):471-7.
320. Brugh AM, Fallat LM, Savoy-Moore RT. Lateral column symptomatology following plantar fascial release: a prospective study. *J Foot Ankle Surg*. 2002;41(6):365-71.
321. Myerson MS, Berger BI. Nonunion of a fracture of the sustentaculum tali causing a tarsal tunnel syndrome: a case report. *Foot Ankle Int*. 1995;16(11):740-2.
322. Mezrow CK, Sanger JR, Matloub HS. Acute tarsal tunnel syndrome following partial avulsion of the flexor hallucis longus muscle: a case report. *J Foot Ankle Surg*. 2002;41(4):243-6.
323. DiStefano V, Sack JT, Whittaker R, Nixon JE. Tarsal-tunnel syndrome. Review of the literature and two case reports. *Clin Orthop Relat Res*. 1972;8876-9.
324. Ng WM, Chan KY. Tarsal tunnel syndrome caused by ganglion. *Med J Malaysia*. 2004;59 Suppl F69-71.
325. Cheung YY, Rosenberg ZS, Colon E, Jahss M. MR imaging of flexor digitorum accessorius longus. *Skeletal Radiol*. 1999;28(3):130-7.
326. Keck C. The tarsal tunnel syndrome. *J Bone Joint Surg*. 1962;44180-4.
327. Linscheid RL, Burton RC, Fredericks EJ. Tarsal-tunnel syndrome. *South Med J*. 1970;63(11):1313-23.
328. Francis H, March L, Terenty T, Webb J. Benign joint hypermobility with neuropathy: documentation and mechanism of tarsal tunnel syndrome. *J Rheumatol*. 1987;14(3):577-81.
329. Lloyd K, Agarwal A. Tarsal-tunnel syndrome, a presenting feature of rheumatoid arthritis. *Br Med J*. 1970;3(5713):32.
330. Bilge O, Ozer MA, Govsa F. Neurovascular branching in the tarsal tunnel. *Neuroanatomy*. 2003(2):39-41.
331. DeLisa JA, Saeed MA. The tarsal tunnel syndrome. *Muscle Nerve*. 1983;6(9):664-70.
332. Edwards WG, Lincoln CR, Bassett FH, 3rd, Goldner JL. The tarsal tunnel syndrome. Diagnosis and treatment. *Jama*. 1969;207(4):716-20.
333. Goodgold J, Kopell HP, Spielholz NI. The tarsal-tunnel syndrome. Objective diagnostic criteria. *N Engl J Med*. 1965;273(14):742-5.
334. Gondring WH, Trepman E, Shields B. Tarsal tunnel syndrome: assessment of treatment outcome with an anatomic pain intensity scale. *Foot Ankle Surg*. 2009;15(3):133-8.
335. Kinoshita M, Okuda R, Morikawa J, Jotoku T, Abe M. The dorsiflexion-eversion test for diagnosis of tarsal tunnel syndrome. *J Bone Joint Surg Am*. 2001;83-A1835-9.
336. Lam S. Tarsal tunnel syndrome. *J Bone Joint Surg*. 1967;49B(1):87-92.
337. Patel A, Gaines K, Malamut R, Parks T, del Toro D, Holland N. Usefulness of electrodiagnostic techniques in the evaluation of suspected tarsal tunnel syndrome: an evidence-based review. *Muscle Nerve*. 2005;32236-40.
338. Rosenberg ZS, Beltran J, Bencardino JT. From the RSNA Refresher Courses. Radiological Society of North America. MR imaging of the ankle and foot. *Radiographics*. 2000;20 Spec NoS153-79.
339. Campbell SE. MRI of sports injuries of the ankle. *Clin Sports Med*. 2006;25(4):727-62.
340. Finkel JE. Tarsal tunnel syndrome. *Magn Reson Imaging Clin N Am*. 1994;2(1):67-78.

341. Vijayan J, Therimadasamy AK, Teoh HL, Chan YC, Wilder-Smith EP. Sonography as an aid to neurophysiological studies in diagnosing tarsal tunnel syndrome. *Am J Phys Med Rehabil*. 2009;88(6):500-1.
342. Girish G, Finlay K, Landry D, et al. Musculoskeletal disorders of the lower limb--ultrasound and magnetic resonance imaging correlation. *Can Assoc Radiol J*. 2007;58(3):152-66.
343. Hochman MG, Zilberfarb JL. Nerves in a pinch: imaging of nerve compression syndromes. *Radiol Clin North Am*. 2004;42(1):221-45.
344. Lee D, Dauphinee DM. Morphological and functional changes in the diabetic peripheral nerve: using diagnostic ultrasound and neurosensory testing to select candidates for nerve decompression. *J Am Podiatr Med Assoc*. 2005;95(5):433-7.
345. Sofka CM, Collins AJ, Adler RS. Use of ultrasonographic guidance in interventional musculoskeletal procedures: a review from a single institution. *J Ultrasound Med*. 2001;20(1):21-6.
346. Chang M, Ger L, Hsieh P, Huang S. Two weeks of prednisolone was as effective as four weeks in improving carpal tunnel syndrome symptoms *J Bone Joint Surg Am*. 2003;85:1624.
347. Chang MH, Chiang HT, Lee SS, Ger LP, Lo YK. Oral drug of choice in carpal tunnel syndrome. *Neurology*. 1998;51(2):390-3.
348. Chang MH, Ger LP, Hsieh PF, Huang SY. A randomised clinical trial of oral steroids in the treatment of carpal tunnel syndrome: a long term follow up. *J Neurol Neurosurg Psychiatry*. 2002;73(6):710-4.
349. Herskovitz S, Berger AR, Lipton RB. Low-dose, short-term oral prednisone in the treatment of carpal tunnel syndrome. *Neurology*. 1995;45(10):1923-5.
350. Hui AC, Wong SM, Tang A, Mok V, Hung LK, Wong KS. Long-term outcome of carpal tunnel syndrome after conservative treatment. *Int J Clin Pract*. 2004;58(4):337-9.
351. Hui AC, Wong SM, Wong KS, et al. Oral steroid in the treatment of carpal tunnel syndrome. *Ann Rheum Dis*. 2001;60(8):813-4.
352. Wong SM, Hui AC, Tang A, et al. Local vs systemic corticosteroids in the treatment of carpal tunnel syndrome. *Neurology*. 2001;56(11):1565-7.
353. Mishra S, Prabhakar S, Lal V, Modi M, Das CP, Khurana D. Efficacy of splinting and oral steroids in the treatment of carpal tunnel syndrome: a prospective randomized clinical and electrophysiological study. *Neurol India*. 2006;54(3):286-90.
354. Chang C, Shih C, Penn I, Tiu C, Chang T, Wu J. Wrist injuries in adolescent gymnasts of a Chinese opera school: radiographic survey. *Radiology*. 1995;195:861-4.
355. Pal B, Mangion P, Hossain M, Wallace A, Diffey B. Should diuretics be prescribed for idiopathic carpal tunnel syndrome? Results of a controlled trial. *Clin Rehabil*. 1988;22:299-301.
356. Keniston RC, Nathan PA, Leklem JE, Lockwood RS. Vitamin B6, vitamin C, and carpal tunnel syndrome. A cross-sectional study of 441 adults. *J Occup Environ Med*. 1997;39(10):949-59.
357. Nalamachu S, Crockett RS, Gammaitoni AR, Gould EM. A comparison of the lidocaine patch 5% vs naproxen 500 mg twice daily for the relief of pain associated with carpal tunnel syndrome: a 6-week, randomized, parallel-group study. *MedGenMed*. 2006;8(3):33.
358. Nalamachu S, Crockett RS, Mathur D. Lidocaine patch 5 for carpal tunnel syndrome: how it compares with injections: a pilot study. *J Fam Pract*. 2006;55(3):209-14.
359. Galer BS, Rowbotham MC, Perander J, Friedman E. Topical lidocaine patch relieves postherpetic neuralgia more effectively than a vehicle topical patch: results of an enriched enrollment study. *Pain*. 1999;80(3):533-8.
360. Franson J, Baravarian B. Tarsal tunnel syndrome: a compression neuropathy involving four distinct tunnels. *Clin Podiatr Med Surg*. 2006;23(3):597-609.
361. Carter R, Aspy CB, Mold J. The effectiveness of magnet therapy for treatment of wrist pain attributed to carpal tunnel syndrome. *J Fam Pract*. 2002;51(1):38-40.
362. Radin EL. Tarsal tunnel syndrome. *Clin Orthop Relat Res*. 1983(181):167-70.
363. Branco K, Naeser MA. Carpal tunnel syndrome: clinical outcome after low-level laser acupuncture, microamps transcutaneous electrical nerve stimulation, and other alternative therapies--an open protocol study. *J Altern Complement Med*. 1999;5(1):5-26.

364. Tal-Akabi A, Rushton A. An investigation to compare the effectiveness of carpal bone mobilisation and neurodynamic mobilisation as methods of treatment for carpal tunnel syndrome. *Man Ther.* 2000;5(4):214-22.
365. Sucher BM. Palpatory diagnosis and manipulative management of carpal tunnel syndrome. *J Am Osteopath Assoc.* 1994;94(8):647-63.
366. Davis PT, Hulbert JR, Kassak KM, Meyer JJ. Comparative efficacy of conservative medical and chiropractic treatments for carpal tunnel syndrome: a randomized clinical trial. *J Manipulative Physiol Ther.* 1998;21(5):317-26.
367. Burke J, Buchberger DJ, Carey-Loghmani MT, Dougherty PE, Greco DS, Dishman JD. A pilot study comparing two manual therapy interventions for carpal tunnel syndrome. *J Manipulative Physiol Ther.* 2007;30(1):50-61.
368. Oztas O, Turan B, Bora I, Karakaya MK. Ultrasound therapy effect in carpal tunnel syndrome. *Arch Phys Med Rehabil.* 1998;79(12):1540-4.
369. Bakhtiary AH, Rashidy-Pour A. Ultrasound and laser therapy in the treatment of carpal tunnel syndrome. *Aust J Physiother.* 2004;50(3):147-51.
370. Ebenbichler GR, Resch KL, Nicolakis P, et al. Ultrasound treatment for treating the carpal tunnel syndrome: randomised "sham" controlled trial. *Bmj.* 1998;316(7133):731-5.
371. Aygul R, Ulvi H, Karatay S, Deniz O, Varoglu AO. Determination of sensitive electrophysiologic parameters at follow-up of different steroid treatments of carpal tunnel syndrome. *J Clin Neurophysiol.* 2005;22(3):222-30.
372. Breuer B, Sperber K, Wallenstein S, et al. Clinically significant placebo analgesic response in a pilot trial of botulinum B in patients with hand pain and carpal tunnel syndrome. *Pain Med.* 2006;7(1):16-24.
373. Tsai CP, Liu CY, Lin KP, Wang KC. Efficacy of botulinum toxin type a in the relief of Carpal tunnel syndrome: A preliminary experience. *Clin Drug Investig.* 2006;26(9):511-5.
374. Pfeiffer WH, Cracchiolo A, 3rd. Clinical results after tarsal tunnel decompression. *J Bone Joint Surg Am.* 1994;76(8):1222-30.
375. Sammarco GJ, Chang L. Outcome of surgical treatment of tarsal tunnel syndrome. *Foot Ankle Int.* 2003;24(2):125-31.
376. Turner JA, Franklin G, Fulton-Kehoe D, et al. Early predictors of chronic work disability associated with carpal tunnel syndrome: a longitudinal workers' compensation cohort study. *Am J Ind Med.* 2007;50(7):489-500.
377. Gimeno D, Amick BC, 3rd, Habeck RV, Ossmann J, Katz JN. The role of job strain on return to work after carpal tunnel surgery. *Occup Environ Med.* 2005;62(11):778-85.
378. McKeon PO, Hertel J. Systematic review of postural control and lateral ankle instability, part I: can deficits be detected with instrumented testing. *J Athl Train.* 2008;43(3):293-304.
379. Fong DT, Hong Y, Chan LK, Yung PS, Chan KM. A systematic review on ankle injury and ankle sprain in sports. *Sports Med.* 2007;37(1):73-94.
380. Puffer J. The sprained ankle. *Sports Med.* 2000;3(5):38-49.
381. Birrer RB, Fani-Salek MH, Totten VY, Herman LM, Politi V. Managing ankle injuries in the emergency department. *J Emerg Med.* 1999;17(4):651-60.
382. Safran MR, Zachazewski JE, Benedetti RS, Bartolozzi AR, 3rd, Mandelbaum R. Lateral ankle sprains: a comprehensive review part 2: treatment and rehabilitation with an emphasis on the athlete. *Med Sci Sports Exerc.* 1999;31(7 Suppl):S438-47.
383. Garrick JG, Requa RK. The epidemiology of foot and ankle injuries in sports. *Clin Podiatr Med Surg.* 1989;6(3):629-37.
384. Lindenfeld TN, Schmitt DJ, Hendy MP, Mangine RE, Noyes FR. Incidence of injury in indoor soccer. *Am J Sports Med.* 1994;22(3):364-71.
385. van den Bekerom MP, Oostra RJ, Alvarez PG, van Dijk CN. The anatomy in relation to injury of the lateral collateral ligaments of the ankle: a current concepts review. *Clin Anat.* 2008;21(7):619-26.
386. Cooke MW, Marsh JL, Clark M, et al. Treatment of severe ankle sprain: a pragmatic randomised controlled trial comparing the clinical effectiveness and cost-effectiveness of three types of mechanical ankle support with tubular bandage. The CAST trial. *Health Technol Assess.* 2009;13(13):iii, ix-x, 1-121.

387. Safran MR, Benedetti RS, Bartolozzi AR, 3rd, Mandelbaum BR. Lateral ankle sprains: a comprehensive review: part 1: etiology, pathoanatomy, histopathogenesis, and diagnosis. *Med Sci Sports Exerc.* 1999;31(7 Suppl):S429-37.
388. Ferran NA, Maffulli N. Epidemiology of sprains of the lateral ankle ligament complex. *Foot Ankle Clin.* 2006;11(3):659-62.
389. van Rijn RM, van Os AG, Bernsen RM, Luijsterburg PA, Koes BW, Bierma-Zeinstra SM. What is the clinical course of acute ankle sprains? A systematic literature review. *Am J Med.* 2008;121(4):324-31 e6.
390. Alparslan L, Chiodo CP. Lateral ankle instability: MR imaging of associated injuries and surgical treatment procedures. *Semin Musculoskelet Radiol.* 2008;12(4):346-58.
391. Baumhauer JF, O'Brien T. Surgical considerations in the treatment of ankle instability. *J Athl Train.* 2002;37(4):458-62.
392. Cheng M, Tho KS. Chrisman-Snook ankle ligament reconstruction outcomes--a local experience. *Singapore Med J.* 2002;43(12):605-9.
393. Karlsson J, Eriksson BI, Sward L. Early functional treatment for acute ligament injuries of the ankle joint. *Scand J Med Sci Sports.* 1996;6(6):341-5.
394. Gutierrez GM, Kaminski TW, Douex AT. Neuromuscular control and ankle instability. *PM R.* 2009;1(4):359-65.
395. Hertel J. Functional instability following lateral ankle sprain. *Sports Med.* 2000;29(5):361-71.
396. Hertel J. Sensorimotor deficits with ankle sprains and chronic ankle instability. *Clin Sports Med.* 2008;27(3):353-70, vii.
397. Grimm DJ, Fallat L. Injuries of the foot and ankle in occupational medicine: a 1-year study. *J Foot Ankle Surg.* 1999;38(2):102-8.
398. Clark TW, Janzen DL, Ho K, Grunfeld A, Connell DG. Detection of radiographically occult ankle fractures following acute trauma: positive predictive value of an ankle effusion. *AJR Am J Roentgenol.* 1995;164(5):1185-9.
399. Clark TW, Janzen DL, Logan PM, Ho K, Connell DG. Improving the detection of radiographically occult ankle fractures: positive predictive value of an ankle joint effusion. *Clin Radiol.* 1996;51(9):632-6.
400. Lindstrand A. New aspects in the diagnosis of lateral ankle sprains. *Orthop Clin North Am.* 1976;7(1):247-9.
401. Bahr R, Pena F, Shine J, et al. Mechanics of the anterior drawer and talar tilt tests. A cadaveric study of lateral ligament injuries of the ankle. *Acta Orthop Scand.* 1997;68(5):435-41.
402. Tohyama H, Yasuda K, Ohkoshi Y, Beynon BD, Renstrom PA. Anterior drawer test for acute anterior talofibular ligament injuries of the ankle. How much load should be applied during the test? *Am J Sports Med.* 2003;31(2):226-32.
403. Kovaleski JE, Norrell PM, Heitman RJ, Hollis JM, Pearsall AW. Knee and ankle position, anterior drawer laxity, and stiffness of the ankle complex. *J Athl Train.* 2008;43(3):242-8.
404. van Dijk CN. Management of the sprained ankle. *Br J Sports Med.* 2002;36(2):83-4.
405. Nyska M, Amir H, Porath A, Dekel S. Radiological assessment of a modified anterior drawer test of the ankle. *Foot Ankle.* 1992;13(7):400-3.
406. de Vries JS, Kerkhoffs GM, Blankevoort L, van Dijk CN. Clinical evaluation of a dynamic test for lateral ankle ligament laxity. *Knee Surg Sports Traumatol Arthrosc.* 2010;18(5):628-33.
407. Kerkhoffs G, Blankevoort L, Kingma I, van Dijk N. Three-dimensional bone kinematics in an anterior laxity test of the ankle joint. *Knee Surg Sports Traumatol Arthrosc.* 2007;15(6):817-24.
408. Docherty CL, Rybak-Webb K. Reliability of the anterior drawer and talar tilt tests using the LigMaster joint arthrometer. *J Sport Rehabil.* 2009;18(3):389-97.
409. Molinari A, Stolley M, Amendola A. High ankle sprains (syndesmotic) in athletes: diagnostic challenges and review of the literature. *Iowa Orthop J.* 2009;29:130-8.
410. Gerber JP, Williams GN, Scoville CR, Arciero RA, Taylor DC. Persistent disability associated with ankle sprains: a prospective examination of an athletic population. *Foot Ankle Int.* 1998;19(10):653-60.
411. Nilsson S. Sprains of the lateral ankle ligaments. *J Oslo City Hosp.* 1983;33(2-3):13-36.
412. Moller-Larsen F, Wethelund JO, Jurik AG, de Carvalho A, Lucht U. Comparison of three different treatments for ruptured lateral ankle ligaments. *Acta Orthop Scand.* 1988;59(5):564-6.

413. van Dijk CN, Molenaar AH, Cohen RH, Tol JL, Bossuyt PM, Marti RK. Value of arthrography after supination trauma of the ankle. *Skeletal Radiol*. 1998;27(5):256-61.
414. Lahde S, Putkonen M, Puranen J, Raatikainen T. Examination of the sprained ankle: anterior drawer test or arthrography? *Eur J Radiol*. 1988;8(4):255-7.
415. van Dijk CN, Lim LS, Bossuyt PM, Marti RK. Physical examination is sufficient for the diagnosis of sprained ankles. *J bone Joint Surg BR*. 1996;78(6):958-62.
416. Brooks SC, Potter BT, Rainey JB. Treatment for partial tears of the lateral ligament of the ankle: a prospective trial. *Br Med J (Clin Res Ed)*. 1981;282(6264):606-7.
417. Dunlop MG, Beattie TF, White GK, Raab GM, Doull RI. Guidelines for selective radiological assessment of inversion ankle injuries. *Br Med J (Clin Res Ed)*. 1986;293(6547):603-5.
418. Lloyd S. Selective radiographic assessment of acute ankle injuries in the emergency department: barriers to implementation. *CMAJ*. 1986;135(9):973-4.
419. Seah R, Mani-Babu S. Managing ankle sprains in primary care: what is best practice? A systematic review of the last 10 years of evidence. *Br Med Bull*. 2010.
420. van der Wees PJ, Hendriks EJ, Bruls V, Dekker J, de Bie RA. Applicability of the Ottawa Ankle Rules in primary care: results from a pilot study. *J Eval Clin Pract*. 2010.
421. Agrawal P, Kosowsky JM. Clinical practice guidelines in the emergency department. *Emerg Med Clin North Am*. 2009;27(4):555-67, vii.
422. Atkinson P, Boyle A, Chisholm E. X-ray requesting patterns before and after introduction of the Ottawa Knee Rules in a UK emergency department. *Eur J Emerg Med*. 2004;11(4):204-7.
423. Bachmann LM, Kolb E, Koller MT, Steurer J, ter Riet G. Accuracy of Ottawa ankle rules to exclude fractures of the ankle and mid-foot: systematic review. *Bmj*. 2003;326(7386):417.
424. Ivins D. Acute ankle sprain: an update. *Am Fam Physician*. 2006;74(10):1714-20.
425. Stiell IG, Greenberg GH, McKnight RD, et al. Decision rules for the use of radiography in acute ankle injuries. Refinement and prospective validation. *Jama*. 1993;269(9):1127-32.
426. Wolfe MW, Uhl TL, Mattacola CG, McCluskey LC. Management of ankle sprains. *Am Fam Physician*. 2001;63(1):93-104.
427. Fan J, Woolfrey K. The effect of triage-applied Ottawa Ankle Rules on the length of stay in a Canadian urgent care department: a randomized controlled trial. *Acad Emerg Med*. 2006;13(2):153-7.
428. Derksen RJ, Bakker FC, Geervliet PC, et al. Diagnostic accuracy and reproducibility in the interpretation of Ottawa ankle and foot rules by specialized emergency nurses. *Am J Emerg Med*. 2005;23(6):725-9.
429. Lohrer H, Nauck T, Arentz S, Scholl J. Observer reliability in ankle and calcaneocuboid stress radiography. *Am J Sports Med*. 2008;36(6):1143-9.
430. Oae K, Takao M, Uchio Y, Ochi M. Evaluation of anterior talofibular ligament injury with stress radiography, ultrasonography and MR imaging. *Skeletal Radiol*. 2010;39(1):41-7.
431. Frost SC, Amendola A. Is stress radiography necessary in the diagnosis of acute or chronic ankle instability? *Clin J Sport Med*. 1999;9(1):40-5.
432. Martin DE, Kaplan PA, Kahler DM, Dussault R, Randolph BJ. Retrospective evaluation of graded stress examination of the ankle. *Clin Orthop Relat Res*. 1996(328):165-70.
433. Naran KN, Zoga AC. Osteochondral lesions about the ankle. *Radiol Clin North Am*. 2008;46(6):995-1002, v.
434. Pinar H, Akseki D, Kovanlikaya I, Arac S, Bozkurt M. Bone bruises detected by magnetic resonance imaging following lateral ankle sprains. *Knee Surg Sports Traumatol Arthrosc*. 1997;5(2):113-7.
435. Nikken JJ, Oei EH, Ginai AZ, et al. Acute ankle trauma: value of a short dedicated extremity MR imaging examination in prediction of need for treatment. *Radiology*. 2005;234(1):134-42.
436. Remplik P, Stabler A, Merl T, Roemer F, Bohndorf K. Diagnosis of acute fractures of the extremities: comparison of low-field MRI and conventional radiography. *Eur Radiol*. 2004;14(4):625-30.
437. Brown KW, Morrison WB, Schweitzer ME, Parellada JA, Nothnagel H. MRI findings associated with distal tibiofibular syndesmosis injury. *AJR Am J Roentgenol*. 2004;182(1):131-6.
438. Martin B. Ankle sprain complications: MRI evaluation. *Clin Podiatr Med Surg*. 2008;25(2):203-47, vi.

439. Gremeaux V, Coudreuse JM, Collado H, et al. Comparative study of clinical and ultrasonographic evaluation of lateral collateral ligament sprains of the ankle. *J Sports Med Phys Fitness*. 2009;49(3):285-91.
440. Guillodo Y, Riban P, Guennoc X, Dubrana F, Saraux A. Usefulness of ultrasonographic detection of talocrural effusion in ankle sprains. *J Ultrasound Med*. 2007;26(6):831-6.
441. Dalton JD, Jr., Schweinle JE. Randomized controlled noninferiority trial to compare extended release acetaminophen and ibuprofen for the treatment of ankle sprains. *Ann Emerg Med*. 2006;48(5):615-23.
442. Kayali C, Agus H, Surer L, Turgut A. The efficacy of paracetamol in the treatment of ankle sprains in comparison with diclofenac sodium. *Saudi Med J*. 2007;28(12):1836-9.
443. Ekman EF, Ruoff G, Kuehl K, et al. The COX-2 specific inhibitor Valdecoxib versus tramadol in acute ankle sprain: a multicenter randomized, controlled trial. *Am J Sports Med*. 2006;34(6):945-55.
444. Slatyer MA, Hensley MJ, Lopert R. A randomized controlled trial of piroxicam in the management of acute ankle sprain in Australian Regular Army recruits. The Kapooka Ankle Sprain Study. *Am J Sports Med*. 1997;25(4):544-53.
445. Ekman EF, Fiechtner JJ, Levy S, Fort JG. Efficacy of celecoxib versus ibuprofen in the treatment of acute pain: a multicenter, double-blind, randomized controlled trial in acute ankle sprain. *Am J Orthop (Belle Mead NJ)*. 2002;31(8):445-51.
446. Sloan J, Hain R, Pownall R. Benefits of early anti-inflammatory medication following acute ankle injury. *Injury*. 1989;20:81-3.
447. Bahamonde LA, Saavedra H. Comparison of the analgesic and anti-inflammatory effects of diclofenac potassium versus piroxicam versus placebo in ankle sprain patients. *J Int Med Res*. 1990;18(2):104-11.
448. Dreiser RL, Riebenfeld D. A double-blind study of the efficacy of nimesulide in the treatment of ankle sprain in comparison with placebo. *Drugs*. 1993;46 Suppl 1:183-6.
449. Goldie IF, Gunterberg B, Jacobson C. Foot volumetry as an objective test of the effect of antiphlogistic drugs in ankle sprains. A preliminary study. *Rheumatol Rehabil*. 1974;13(4):204-7.
450. Moran M. Double-blind comparison of diclofenac potassium, ibuprofen and placebo in the treatment of ankle sprains. *J Int Med Res*. 1991;19(2):121-30.
451. Petrella R, Ekman EF, Schuller R, Fort JG. Efficacy of celecoxib, a COX-2-specific inhibitor, and naproxen in the management of acute ankle sprain: results of a double-blind, randomized controlled trial. *Clin J Sport Med*. 2004;14(4):225-31.
452. Nadarajah A, Abraham L, Lau FL, Hwang LJ, Fakir-Bolte C. Efficacy and tolerability of celecoxib compared with diclofenac slow release in the treatment of acute ankle sprain in an Asian population. *Singapore Med J*. 2006;47(6):534-42.
453. Duncan JJ, Farr JE. Comparison of diclofenac sodium and aspirin in the treatment of acute sports injuries. *Am J Sports Med*. 1988;16(6):656-9.
454. Adams ID. Diflunisal in the management of sprains. *Curr Med Res Opin*. 1978;5(7):580-3.
455. Viljakka T, Rokkanen P. The treatment of ankle sprain by bandaging and antiphlogistic drugs. *Ann Chir Gynaecol*. 1983;72(2):66-70.
456. Finch WF, Zanaga P, Mickelson MM, Grochowski KJ. A double-blind comparison of flurbiprofen with diflunisal in the treatment of acute ankle sprains and strains. *Curr Med Res Opin*. 1989;11(7):409-16.
457. Hayes TB, Fyvie A, Janke PG, Vandenburg MJ, Currie WJ. Sulindac versus ibuprofen in sprains and strains. *Br J Sports Med*. 1984;18(1):30-3.
458. McLatchie GR, Allister C, MacEwen C, et al. Variable schedules of ibuprofen for ankle sprains. *Br J Sports Med*. 1985;19(4):203-6.
459. Aghababian RV. Comparison of diflunisal and acetaminophen with codeine in the management of grade 2 ankle sprain. *Clin Ther*. 1986;8(5):520-6.
460. Andersson S, Fredin H, Lindberg H, Sanzen L, Westlin N. Ibuprofen and compression bandage in the treatment of ankle sprains. *Acta Orthop Scand*. 1983;54(2):322-5.
461. Dupont M, Beliveau P, Theriault G. The efficacy of antiinflammatory medication in the treatment of the acutely sprained ankle. *Am J Sports Med*. 1987;15(1):41-5.

462. Fredberg U, Hansen PA, Skinhoj A. Ibuprofen in the treatment of acute ankle joint injuries. A double-blind study. *Am J Sports Med.* 1989;17(4):564-6.
463. Hewitt DJ, Todd KH, Xiang J, Jordan DM, Rosenthal NR. Tramadol/acetaminophen or hydrocodone/acetaminophen for the treatment of ankle sprain: a randomized, placebo-controlled trial. *Ann Emerg Med.* 2007;49(4):468-80, 80 e1-2.
464. Kerkhoffs GM, Struijs PA, de Wit C, Rahlfs VW, Zwipp H, van Dijk CN. A double blind, randomised, parallel group study on the efficacy and safety of treating acute lateral ankle sprain with oral hydrolytic enzymes. *Br J Sports Med.* 2004;38(4):431-5.
465. Brakenbury PH, Kotowski J. A comparative study of the management of ankle sprains. *Br J Clin Pract.* 1983;37(5):181-5.
466. Craig RP. The quantitative evaluation of the use of oral proteolytic enzymes in the treatment of sprained ankles. *Injury.* 1975;6(4):313-6.
467. Calandre EP, Ruiz-Morales M, Lopez-Gollonet JM, et al. Efficacy of oral streptokinase-streptodornase in the treatment of ankle sprains. *Clin Orthop Relat Res.* 1991(263):210-4.
468. Karavana SY, Guneri P, Ertan G. Benzydamine hydrochloride buccal bioadhesive gels designed for oral ulcers: preparation, rheological, textural, mucoadhesive and release properties. *Pharm Dev Technol.* 2009;14(6):623-31.
469. Elswood R, MacLeod D. Treatment of ankle sprains with benzydamine. *Practitioner.* 1985;22970-1.
470. Airaksinen OV, Kyrklund N, Latvala K, Kouri JP, Gronblad M, Kolari P. Efficacy of cold gel for soft tissue injuries: a prospective randomized double-blinded trial. *Am J Sports Med.* 2003;31(5):680-4.
471. Matthews P, Derry S, Moore RA, McQuay HJ. Topical rubefaciants for acute and chronic pain in adults. *Cochrane Database Syst Rev.* 2009(3):CD007403.
472. Bleakley CM, McDonough SM, MacAuley DC. Some conservative strategies are effective when added to controlled mobilisation with external support after acute ankle sprain: a systematic review. *Aust J Physiother.* 2008;54(1):7-20.
473. D'Anchise R, Bulitta M, Giannetti B. Comfrey extract ointment in comparison to diclofenac gel in the treatment of acute unilateral ankle sprains (distortions). *Arzneimittelforschung.* 2007;57(11):712-6.
474. Koll R, Buhr M, Dieter R, et al. Efficacy and tolerance of a comfrey root extract (Extr. Rad. Symphyti) in the treatment of ankle distortions: results of a multicenter, randomized, placebo-controlled, double-blind study. *Phytomedicine.* 2004;11(6):470-7.
475. Predel HG, Giannetti B, Koll R, Bulitta M, Staiger C. Efficacy of a comfrey root extract ointment in comparison to a diclofenac gel in the treatment of ankle distortions: results of an observer-blind, randomized, multicenter study. *Phytomedicine.* 2005;12(10):707-14.
476. U.S. Food and Drug Administration. FDA Advises Dietary Supplement Manufacturers to Remove Comfrey Products From the Market. Available at: <http://wayback.archive-it.org/7993/20170111070437/http://www.fda.gov/Food/RecallsOutbreaksEmergencies/SafetyAlertsAdvisories/ucm111219.htm>. 2001.
477. Frahm E, Elsasser U, Kammereit A. Topical treatment of acute sprains. *Br J Clin Pract.* 1993;47(6):321-2.
478. Lester AA. Management of sprained ankles. A double-blind study. *Practitioner.* 1981;225(1356):935-6.
479. Mazieres B, Rouanet S, Velicy J, Scarsi C, Reiner V. Topical ketoprofen patch (100 mg) for the treatment of ankle sprain: a randomized, double-blind, placebo-controlled study. *Am J Sports Med.* 2005;33(4):515-23.
480. Diebschlag W, Nocker W, Bullingham R. A double-blind study of the efficacy of topical ketorolac tromethamine gel in the treatment of ankle sprain, in comparison to placebo and etofenamate. *J Clin Pharmacol.* 1990;30(1):82-9.
481. Dreiser RE, Charlot J, Lopez A, Ditisheim A. Clinical evaluation of niflumic acid gel in the treatment of uncomplicated ankle sprains. *Curr Med Res Opin.* 1990;12(2):93-9.
482. Dreiser RL, Roche R, De Sahb R, Thomas F, Leutenegger E. Flurbiprofen local action transcutaneous (LAT): clinical evaluation in the treatment of acute ankle sprains. *Eur J Rheumatol Inflamm.* 1994;14(4):9-13.

483. Mahler P, Mahler F, Duruz H, Ramazzina M, Liguori V, Mautone G. Double-blind, randomized, controlled study on the efficacy and safety of a novel diclofenac epolamine gel formulated with lecithin for the treatment of sprains, strains and contusions. *Drugs Exp Clin Res.* 2003;29(1):45-52.
484. Oakland C. A comparison of the efficacy of the topical NSAID felbinac and ultrasound in the treatment of acute ankle injuries. *Brookwood Medical Publications Ltd.* 1993;89-96.
485. Campbell J, Dunn T. Evaluation of topical ibuprofen cream in the treatment of acute ankle sprains. *J Accid Emerg Med.* 1994;11(3):178-82.
486. Stanton D, Lazaro R, MacDermid J. A systematic review of the effectiveness of contrast baths. *J Hand Ther.* 2009;2257-70.
487. Cote DJ, Prentice WE, Jr., Hooker DN, Shields EW. Comparison of three treatment procedures for minimizing ankle sprain swelling. *Phys Ther.* 1988;68(7):1072-6.
488. Lamb SE, Marsh JL, Hutton JL, Nakash R, Cooke MW. Mechanical supports for acute, severe ankle sprain: a pragmatic, multicentre, randomised controlled trial. *Lancet.* 2009;373(9663):575-81.
489. Lamb SE, Nakash RA, Withers EJ, et al. Clinical and cost effectiveness of mechanical support for severe ankle sprains: design of a randomised controlled trial in the emergency department [ISRCTN 37807450]. *BMC Musculoskelet Disord.* 2005;61.
490. Dettori JR, Basmania CJ. Early ankle mobilization, Part II: A one-year follow-up of acute, lateral ankle sprains (a randomized clinical trial). *Mil Med.* 1994;159(1):20-4.
491. Dettori JR, Pearson BD, Basmania CJ, Lednar WM. Early ankle mobilization, Part I: The immediate effect on acute, lateral ankle sprains (a randomized clinical trial). *Mil Med.* 1994;159(1):15-20.
492. Beynon BD, Renstrom PA, Haugh L, Uh BS, Barker H. A prospective, randomized clinical investigation of the treatment of first-time ankle sprains. *Am J Sports Med.* 2006;34(9):1401-12.
493. Ardevol J, Bolibar I, Belda V, Argilaga S. Treatment of complete rupture of the lateral ligaments of the ankle: a randomized clinical trial comparing cast immobilization with functional treatment. *Knee Surg Sports Traumatol Arthrosc.* 2002;10(6):371-7.
494. Eiff MP, Smith AT, Smith GE. Early mobilization versus immobilization in the treatment of lateral ankle sprains. *Am J Sports Med.* 1994;22(1):83-8.
495. Watts BL, Armstrong B. A randomised controlled trial to determine the effectiveness of double Tubigrip in grade 1 and 2 (mild to moderate) ankle sprains. *Emerg Med J.* 2001;18(1):46-50.
496. O'Hara J, Valle-Jones JC, Walsh H, et al. Controlled trial of an ankle support (Malleotrain) in acute ankle injuries. *Br J Sports Med.* 1992;26(3):139-42.
497. Boyce SH, Quigley MA, Campbell S. Management of ankle sprains: a randomised controlled trial of the treatment of inversion injuries using an elastic support bandage or an Aircast ankle brace. *Br J Sports Med.* 2005;39(2):91-6.
498. Leanderson J, Bergqvist M, Rolf C, Westblad P, Wigelius-Roovers S, Wredmark T. Early influence of an ankle sprain on objective measures of ankle joint function. A prospective randomised study of ankle brace treatment. *Knee Surg Sports Traumatol Arthrosc.* 1999;7(1):51-8.
499. Zwipp H, Schievink B. Primary orthotic treatment of ruptured ankle ligaments: a recommended procedure. *Prosthet Orthot Int.* 1992;16(1):49-56.
500. Korkala O, Rusanen M, Jokipii P, Kytomaa J, Avikainen V. A prospective study of the treatment of severe tears of the lateral ligament of the ankle. *Int Orthop.* 1987;11(1):13-7.
501. Cetti R, Christensen SE, Corfitzen MT. Ruptured fibular ankle ligament: plaster or Pliton brace? *Br J Sports Med.* 1984;18(2):104-9.
502. Muwanga CL, Quinton DN, Sloan JP, Gillies P, Dove AF. A new treatment of stable lateral ligament injuries of the ankle joint. *Injury.* 1986;17(6):380-2.
503. Scotece GG, Gunthrie MR. Comparison of three treatment approaches for Grade I and II ankle sprains in active duty soldiers. *J Orthop Sports Phys Ther.* 1992;15(1):19-23.
504. Airaksinen O, Kolari PJ, Miettinen H. Elastic bandages and intermittent pneumatic compression for treatment of acute ankle sprains. *Arch Phys Med Rehabil.* 1990;71(6):380-3.
505. Wilkerson GB, Horn-Kingery HM. Treatment of the inversion ankle sprain: comparison of different modes of compression and cryotherapy. *J Orthop Sports Phys Ther.* 1993;17(5):240-6.
506. Thompson C, Kelsberg G, St Anna L, Poddar S. Clinical inquiries. Heat or ice for acute ankle sprain? *J Fam Pract.* 2003;52(8):642-3.

507. Sloan JP, Hain R, Pownall R. Clinical benefits of early cold therapy in accident and emergency following ankle sprain. *Arch Emerg Med*. 1989;6(1):1-6.
508. Hocutt JE, Jr., Jaffe R, Rylander CR, Beebe JK. Cryotherapy in ankle sprains. *Am J Sports Med*. 1982;10(5):316-9.
509. Tremblay MA, Corriveau H, Boissy P, et al. Effects of orthopaedic immobilization of the right lower limb on driving performance: an experimental study during simulated driving by healthy volunteers. *J Bone Joint Surg Am*. 2009;91(12):2860-6.
510. van den Hoogenband C, van Moppes F, Coumans P, Stapert J, Greep J. Study on clinical diagnosis and treatment of lateral ligament lesion of the ankle joint. A prospective clinical randomized trial. *Int J Sports Med*. 1984;5:159-61.
511. Gronmark T, Johnsen O, Kogstad O. Rupture of the lateral ligaments of the ankle: a controlled clinical trial. *Injury*. 1980;11(3):215-8.
512. Bleakley CM, O'Connor SR, Tully MA, et al. Effect of accelerated rehabilitation on function after ankle sprain: randomised controlled trial. *Bmj*. 2010;340c1964.
513. Bleakley CM, McDonough SM, MacAuley DC, Bjordal J. Cryotherapy for acute ankle sprains: a randomised controlled study of two different icing protocols. *Br J Sports Med*. 2006;40(8):700-5; discussion 5.
514. Okcu G, Yercan HS. Is it possible to decrease skin temperature with ice packs under casts and bandages? A cross-sectional, randomized trial on normal and swollen ankles. *Arch Orthop Trauma Surg*. 2006;126(10):668-73.
515. Bleakley CM, O'Connor S, Tully MA, Rocke LG, Macauley DC, McDonough SM. The PRICE study (Protection Rest Ice Compression Elevation): design of a randomised controlled trial comparing standard versus cryokinetic ice applications in the management of acute ankle sprain [ISRCTN13903946]. *BMC Musculoskelet Disord*. 2007;8:125.
516. Green T, Refshauge K, Crosbie J, Adams R. A randomized controlled trial of a passive accessory joint mobilization on acute ankle inversion sprains. *Phys Ther*. 2001;81(4):984-94.
517. Hubbard TJ, Denegar CR. Does Cryotherapy Improve Outcomes With Soft Tissue Injury? *J Athl Train*. 2004;39(3):278-9.
518. Stockle U, Hoffmann R, Schutz M, von Fournier C, Sudkamp NP, Haas N. Fastest reduction of posttraumatic edema: continuous cryotherapy or intermittent impulse compression? *Foot Ankle Int*. 1997;18(7):432-8.
519. Rucinski T, Hooker D, Prentice W, Jr., Shields E, Cote-Murray D. The effects of intermittent compression on edema in postacute ankle sprains. *JOSPT*. 1991;14(2):65-9.
520. Man IO, Morrissey MC. Relationship between ankle-foot swelling and self-assessed function after ankle sprain. *Med Sci Sports Exerc*. 2005;37(3):360-3.
521. Laba E, Roestenburg M. Clinical evaluation of ice therapy for acute ankle sprain injuries. *NZ J Physiotherapy*. 1989;17(2):7-9.
522. Michlovitz SL, Smith W, Watkins M. Ice and high voltage pulsed stimulation in treatment of acute lateral ankle sprains\*. *J Orthop Sports Phys Ther*. 1988;9(9):301-4.
523. Barker A, Barlow PS, Porter J, et al. A double blind clinical trial of low power pulsed shortwave therapy. *Physiotherapy*. 1985;71(12):500-4.
524. McGill S. The effects of pulsed short wave therapy on lateral ligament sprain of the ankle. *NZ J Physiotherapy*. 1988;16:21-4.
525. Pasila M, Visuri T, Sundholm A. Pulsating shortwave diathermy: value in treatment of recent ankle and foot sprains. *Arch Phys Med Rehabil*. 1978;59(8):383-6.
526. Pennington GM, Danley DL, Sumko MH, Bucknell A, Nelson JH. Pulsed, non-thermal, high-frequency electromagnetic energy (DIAPULSE) in the treatment of grade I and grade II ankle sprains. *Mill Med*. 1993;158(2):101-4.
527. Seiger C, Draper DO. Use of pulsed shortwave diathermy and joint mobilization to increase ankle range of motion in the presence of surgical implanted metal: A case series. *J Orthop Sports Phys Ther*. 2006;36(9):669-77.
528. Wilson DH. Treatment of soft-tissue injuries by pulsed electrical energy. *Br Med J*. 1972;2(5808):269-70.

529. Man IO, Morrissey MC, Cywinski JK. Effect of neuromuscular electrical stimulation on ankle swelling in the early period after ankle sprain. *Phys Ther.* 2007;87(1):53-65.
530. de Bie RA, de Vet HC, Lenssen TF, van den Wildenberg FA, Kootstra G, Knipschild PG. Low-level laser therapy in ankle sprains: a randomized clinical trial. *Arch Phys Med Rehabil.* 1998;79(11):1415-20.
531. Stergioulas A. Low-level laser treatment can reduce edema in second degree ankle sprains. *J Clin Laser Med Surg.* 2004;22(2):125-8.
532. Zammit E, Herrington L. Ultrasound therapy in the management of acute lateral ligament sprains of the ankle joint. *Phys Ther Sport.* 2005;6:116-21.
533. Nyanzi CS, Langridge J, Heyworth JR, Mani R. Randomized controlled study of ultrasound therapy in the management of acute lateral ligament sprains of the ankle joint. *Clin Rehabil.* 1999;13(1):16-22.
534. Van Der Windt DA, Van Der Heijden GJ, Van Den Berg SG, Ter Riet G, De Winter AF, Bouter LM. Ultrasound therapy for acute ankle sprains. *Cochrane Database Syst Rev.* 2002(1):CD001250.
535. Williamson JB, George TK, Simpson DC, Hannah B, Bradbury E. Ultrasound in the treatment of ankle sprains. *Injury.* 1986;17(3):176-8.
536. Makuloluwe RT, Mouzas GL. Ultrasound in the treatment of sprained ankles. *Practitioner.* 1977;218(1306):586-8.
537. Fong DT, Chan YY, Mok KM, Yung P, Chan KM. Understanding acute ankle ligamentous sprain injury in sports. *Sports Med Arthrosc Rehabil Ther Technol.* 2009;114.
538. Zhang F, Miao Y. Acupuncture treatment for sprains of the ankle joint in 354 cases. *J Tradit Chin Med.* 1990;10(3):207-8.
539. Mou ZX. Treatment of 31 cases of acute ankle sprain by puncturing yangchi. *J Tradit Chin Med.* 1987;7(1):71.
540. Paris DL, Baynes F, Gucker B. Effects of the neuroprobe in the treatment of second-degree ankle inversion sprains. *Phys Ther.* 1983;63(1):35-40.
541. Bennett M, Best TM, Babul S, Taunton J, Lepawsky M. Hyperbaric oxygen therapy for delayed onset muscle soreness and closed soft tissue injury. *Cochrane Database Syst Rev.* 2005(4):CD004713.
542. Borromeo CN, Ryan JL, Marchetto PA, Peterson R, Bove AA. Hyperbaric oxygen therapy for acute ankle sprains. *Am J Sports Med.* 1997;25(5):619-25.
543. Kanhai A, Losito JM. Hyperbaric oxygen therapy for lower-extremity soft-tissue sports injuries. *J Am Podiatr Med Assoc.* 2003;93(4):298-306.
544. Coetzer D, Brantingham J, Nook B. The relative effectiveness of piroxicam compared to manipulation in the treatment of acute grades 1 and 2 inversion ankle sprains. *J Neuromusculoskeletal System.* 2001;9(1):1-12.
545. Collins N, Teys P, Vicenzino B. The initial effects of a Mulligan's mobilization with movement technique on dorsiflexion and pain in subacute ankle sprains. *Man Ther.* 2004;9(2):77-82.
546. Eisenhart AW, Gaeta TJ, Yens DP. Osteopathic manipulative treatment in the emergency department for patients with acute ankle injuries. *J Am Osteopath Assoc.* 2003;103(9):417-21.
547. Kohne E, Jones A, Korporaal C, Price J, Brantingham J, Globe G. A prospective, single-blinded, randomized, controlled clinical trial of the effects of manipulation on proprioception and ankle dorsiflexion in chronic recurrent ankle sprain. *J Am Chiropractic Assoc.* 2007;;44(5):7-17.
548. Lopez-Rodriguez S, Fernandez de-Las-Penas C, Albuquerque-Sendin F, Rodriguez-Blanco C, Palomeque-del-Cerro L. Immediate effects of manipulation of the talocrural joint on stabilometry and baropodometry in patients with ankle sprain. *J Manipulative Physiol Ther.* 2007;30(3):186-92.
549. Pellow JE, Brantingham JW. The efficacy of adjusting the ankle in the treatment of subacute and chronic grade I and grade II ankle inversion sprains. *J Manipulative Physiol Ther.* 2001;24(1):17-24.
550. Vicenzino B, Branjerdporn M, Teys P, Jordan K. Initial changes in posterior talar glide and dorsiflexion of the ankle after mobilization with movement in individuals with recurrent ankle sprain. *J Orthop Sports Phys Ther.* 2006;36(7):464-71.
551. Sitler M, Ryan J, Wheeler B, et al. The efficacy of a semirigid ankle stabilizer to reduce acute ankle injuries in basketball. A randomized clinical study at West Point. *Am J Sports Med.* 1994;22(4):454-61.

552. Amoroso PJ, Ryan JB, Bickley B, Leitschuh P, Taylor DC, Jones BH. Braced for impact: reducing military paratroopers' ankle sprains using outside-the-boot braces. *J Trauma*. 1998;45(3):575-80.
553. Mickel TJ, Bottoni CR, Tsuji G, Chang K, Baum L, Tokushige KA. Prophylactic bracing versus taping for the prevention of ankle sprains in high school athletes: a prospective, randomized trial. *J Foot Ankle Surg*. 2006;45(6):360-5.
554. Stasinopoulos D. Comparison of three preventive methods in order to reduce the incidence of ankle inversion sprains among female volleyball players. *Br J Sports Med*. 2004;38(2):182-5.
555. Emery CA, Rose MS, McAllister JR, Meeuwisse WH. A prevention strategy to reduce the incidence of injury in high school basketball: a cluster randomized controlled trial. *Clin J Sport Med*. 2007;17(1):17-24.
556. McGuine TA, Keene JS. The effect of a balance training program on the risk of ankle sprains in high school athletes. *Am J Sports Med*. 2006;34(7):1103-11.
557. Hupperets MD, Verhagen EA, van Mechelen W. Effect of unsupervised home based proprioceptive training on recurrences of ankle sprain: randomised controlled trial. *Bmj*. 2009;339b2684.
558. Hupperets MD, Verhagen EA, van Mechelen W. The 2BFit study: is an unsupervised proprioceptive balance board training programme, given in addition to usual care, effective in preventing ankle sprain recurrences? Design of a randomized controlled trial. *BMC Musculoskelet Disord*. 2008;971.
559. Rotem-Lehrer N, Laufer Y. Effect of focus of attention on transfer of a postural control task following an ankle sprain. *J Orthop Sports Phys Ther*. 2007;37(9):564-9.
560. Coughlan G, Caulfield B. A 4-week neuromuscular training program and gait patterns at the ankle joint. *J Athl Train*. 2007;42(1):51-9.
561. Engebretsen AH, Myklebust G, Holme I, Engebretsen L, Bahr R. Prevention of injuries among male soccer players: a prospective, randomized intervention study targeting players with previous injuries or reduced function. *Am J Sports Med*. 2008;36(6):1052-60.
562. Mohammadi F. Comparison of 3 preventive methods to reduce the recurrence of ankle inversion sprains in male soccer players. *Am J Sports Med*. 2007;35(6):922-6.
563. Verhagen E, Bobbert M, Inklaar M, et al. The effect of a balance training programme on centre of pressure excursion in one-leg stance. *Clin Biomech* 2005;20(10):1094-100.
564. Verhagen E, van der Beek A, Twisk J, Bouter L, Bahr R, van Mechelen W. The effect of a proprioceptive balance board training program for the prevention of ankle sprains: a prospective controlled trial. *Am J Sports Med*. 2004;32(6):1385-93.
565. Verhagen EA, van Tulder M, van der Beek AJ, Bouter LM, van Mechelen W. An economic evaluation of a proprioceptive balance board training programme for the prevention of ankle sprains in volleyball. *Br J Sports Med*. 2005;39(2):111-5.
566. Wedderkopp N, Kalltoft M, Lundgaard B, Rosendahl M, Froberg K. Prevention of injuries in young female players in European team handball. A prospective intervention study. *Scand J Med Sci Sports*. 1999;9(1):41-7.
567. Melnyk M, Schloz C, Schmitt S, Gollhofer A. Neuromuscular ankle joint stabilisation after 4-weeks WBV training. *Int J Sports Med*. 2009;30(6):461-6.
568. Finestone A, Novack V, Farfel A, Berg A, Amir H, Milgrom C. A prospective study of the effect of foot orthoses composition and fabrication on comfort and the incidence of overuse injuries. *Foot Ankle Int*. 2004;25(7):462-6.
569. Richie DH, Jr. Effects of foot orthoses on patients with chronic ankle instability. *J Am Podiatr Med Assoc*. 2007;97(1):19-30.
570. Sesma AR, Mattacola CG, Uhl TL, Nitz AJ, McKeon PO. Effect of foot orthotics on single- and double-limb dynamic balance tasks in patients with chronic ankle instability. *Foot Ankle Spec*. 2008;1(6):330-7.
571. MacLean CL, Davis IS, Hamill J. Short- and long-term influences of a custom foot orthotic intervention on lower extremity dynamics. *Clin J Sport Med*. 2008;18(4):338-43.
572. Chiu MC, Wang MJ. Professional footwear evaluation for clinical nurses. *Appl Ergon*. 2007;38(2):133-41.
573. Curtis CK, Laudner KG, McLoda TA, McCaw ST. The role of shoe design in ankle sprain rates among collegiate basketball players. *J Athl Train*. 2008;43(3):230-3.

574. Fong DT, Hong Y, Li JX. Cushioning and lateral stability functions of cloth sport shoes. *Sports Biomech.* 2007;6(3):407-17.
575. Fong DT, Mao DW, Li JX, Hong Y. Greater toe grip and gentler heel strike are the strategies to adapt to slippery surface. *J Biomech.* 2008;41(4):838-44.
576. Fraley M. Clearing a path to floor safety. *Occup Health Saf.* 2009;78(9):42-4.
577. Knapik JJ, Brosch LC, Venuto M, et al. Effect on injuries of assigning shoes based on foot shape in air force basic training. *Am J Prev Med.* 2010;38(1 Suppl):S197-211.
578. Knapik JJ, Swedler DI, Grier TL, et al. Injury reduction effectiveness of selecting running shoes based on plantar shape. *J Strength Cond Res.* 2009;23(3):685-97.
579. Knapik JJ, Trone DW, Swedler DI, et al. Injury reduction effectiveness of assigning running shoes based on plantar shape in marine corps basic training. *Am J Sports Med.* 2010;38(9):1759-67.
580. Mangan BW. Sometimes a shoe is just a shoe? Not in the workplace. *Occup Health Saf.* 2006;75(10):54, 6, 8 passim.
581. Perry SD, Radtke A, McIlroy WE, Fernie GR, Maki BE. Efficacy and effectiveness of a balance-enhancing insole. *J Gerontol A Biol Sci Med Sci.* 2008;63(6):595-602.
582. Barrett JR, Tanji JL, Drake C, Fuller D, Kawasaki RI, Fenton RM. High- versus low-top shoes for the prevention of ankle sprains in basketball players. A prospective randomized study. *Am J Sports Med.* 1993;21(4):582-5.
583. Pope RP, Herbert RD, Kirwan JD, Graham BJ. A randomized trial of preexercise stretching for prevention of lower-limb injury. *Med Sci Sports Exerc.* 2000;32(2):271-7.
584. Puls A, Gribble P. A comparison of two Thera-Band training rehabilitation protocols on postural control. *J Sport Rehabil.* 2007;16(2):75-84.
585. Ekstrand J, Gillquist J, Liljedahl SO. Prevention of soccer injuries. Supervision by doctor and physiotherapist. *Am J Sports Med.* 1983;11(3):116-20.
586. van Rijn RM, van Heest JA, van der Wees P, Koes BW, Bierma-Zeinstra SM. Some benefit from physiotherapy intervention in the subgroup of patients with severe ankle sprain as determined by the ankle function score: a randomised trial. *Aust J Physiother.* 2009;55(2):107-13.
587. van Rijn RM, van Os AG, Kleinrensink GJ, et al. Supervised exercises for adults with acute lateral ankle sprain: a randomised controlled trial. *Br J Gen Pract.* 2007;57(543):793-800.
588. Youdas JW, McLean TJ, Krause DA, Hollman JH. Changes in active ankle dorsiflexion range of motion after acute inversion ankle sprain. *J Sport Rehabil.* 2009;18(3):358-74.
589. Wester JU, Jespersen SM, Nielsen KD, Neumann L. Wobble board training after partial sprains of the lateral ligaments of the ankle: a prospective randomized study. *J Orthop Sports Phys Ther.* 1996;23(5):332-6.
590. Laufer Y, Rotem-Lehrer N, Ronen Z, Khayutin G, Rozenberg I. Effect of attention focus on acquisition and retention of postural control following ankle sprain. *Arch Phys Med Rehabil.* 2007;88(1):105-8.
591. Christakou A, Zervas Y, Lavallee D. The adjunctive role of imagery on the functional rehabilitation of a grade II ankle sprain. *Hum Mov Sci.* 2007;26(1):141-54.
592. Bassett SF, Prapavessis H. Home-based physical therapy intervention with adherence-enhancing strategies versus clinic-based management for patients with ankle sprains. *Phys Ther.* 2007;87(9):1132-43.
593. Holme E, Magnusson SP, Becher K, Bieler T, Aagaard P, Kjaer M. The effect of supervised rehabilitation on strength, postural sway, position sense and re-injury risk after acute ankle ligament sprain. *Scand J Med Sci Sports.* 1999;9(2):104-9.
594. Hale SA, Hertel J, Olmsted-Kramer LC. The effect of a 4-week comprehensive rehabilitation program on postural control and lower extremity function in individuals with chronic ankle instability. *J Orthop Sports Phys Ther.* 2007;37(6):303-11.
595. Hoiness P, Glott T, Ingjer F. High-intensity training with a bi-directional bicycle pedal improves performance in mechanically unstable ankles--a prospective randomized study of 19 subjects. *Scand J Med Sci Sports.* 2003;13(4):266-71.
596. Bernier JN, Perrin DH. Effect of coordination training on proprioception of the functionally unstable ankle. *J Orthop Sports Phys Ther.* 1998;27(4):264-75.

597. Han K, Ricard MD, Fellingham GW. Effects of a 4-week exercise program on balance using elastic tubing as a perturbation force for individuals with a history of ankle sprains. *J Orthop Sports Phys Ther.* 2009;39(4):246-55.
598. Powers M, Buckley B, Kaminski T, Hubbard T, Ortiz C. Six weeks of strength and proprioception training does not affect muscle fatigue and static balance in functional ankle instability. *J Sport Rehabil.* 2004;13201-27.
599. Kidgell DJ, Horvath DM, Jackson BM, Seymour PJ. Effect of six weeks of dura disc and mini-trampoline balance training on postural sway in athletes with functional ankle instability. *J Strength Cond Res.* 2007;21(2):466-9.
600. McKeon PO, Hertel J. Systematic review of postural control and lateral ankle instability, part II: is balance training clinically effective? *J Athl Train.* 2008;43(3):305-15.
601. Chaiwanichsiri D, Lorprayoon E, Noomanoch L. Star excursion balance training: effects on ankle functional stability after ankle sprain. *J Med Assoc Thai.* 2005;88 Suppl 4S90-4.
602. Ross SE, Arnold BL, Blackburn JT, Brown CN, Guskiewicz KM. Enhanced balance associated with coordination training with stochastic resonance stimulation in subjects with functional ankle instability: an experimental trial. *J Neuroeng Rehabil.* 2007;447.
603. Petrella MJ, Cogliano A, Petrella RJ. Original research: long-term efficacy and safety of periarticular hyaluronic acid in acute ankle sprain. *Phys Sportsmed.* 2009;37(1):64-70.
604. Petrella RJ, Petrella MJ, Cogliano A. Periarticular hyaluronic acid in acute ankle sprain. *Clin J Sport Med.* 2007;17(4):251-7.
605. Clark BL, Derby AC, Power GR. Injuries of the lateral ligament of the ankle. Conservative vs. operative repair. *Can J Surg.* 1965;8(4):358-63.
606. Ajs A, Younger AS, Maffulli N. Anatomic repair for chronic lateral ankle instability. *Foot Ankle Clin.* 2006;11(3):539-45.
607. Aydogan U, Glisson RR, Nunley JA. Extensor retinaculum augmentation reinforces anterior talofibular ligament repair. *Clin Orthop Relat Res.* 2006;442210-5.
608. Boyer DS, Younger AS. Anatomic reconstruction of the lateral ligament complex of the ankle using a gracilis autograft. *Foot Ankle Clin.* 2006;11(3):585-95.
609. Corte-Real NM, Moreira RM. Arthroscopic repair of chronic lateral ankle instability. *Foot Ankle Int.* 2009;30(3):213-7.
610. Kerkhoffs GM, Handoll HH, de Bie R, Rowe BH, Struijs PA. Surgical versus conservative treatment for acute injuries of the lateral ligament complex of the ankle in adults. *Cochrane Database Syst Rev.* 2007(2):CD000380.
611. Mahajan RH, Dalal RB. Modified incision for Brostrom lateral ligament reconstruction of the ankle. *J Orthop Surg (Hong Kong).* 2009;17(2):199-201.
612. Muijs SP, Dijkstra PD, Bos CF. Clinical outcome after anatomical reconstruction of the lateral ankle ligaments using the Duquenois technique in chronic lateral instability of the ankle: a long-term follow-up study. *J bone Joint Surg BR.* 2008;90(1):50-6.
613. Schmidt R, Benesch S, Friemert B, Herbst A, Claes L, Gerngross H. Anatomical repair of lateral ligaments in patients with chronic ankle instability. *Knee Surg Sports Traumatol Arthrosc.* 2005;13(3):231-7.
614. Pijnenburg AC, Bogaard K, Krips R, Marti RK, Bossuyt PM, van Dijk CN. Operative and functional treatment of rupture of the lateral ligament of the ankle. A randomised, prospective trial. *J bone Joint Surg BR.* 2003;85(4):525-30.
615. Povacz P, Unger SF, Miller WK, Tockner R, Resch H. A randomized, prospective study of operative and non-operative treatment of injuries of the fibular collateral ligaments of the ankle. *J Bone Joint Surg Am.* 1998;80(3):345-51.
616. Freeman MA. Instability of the foot after injuries to the lateral ligament of the ankle. *J bone Joint Surg BR.* 1965;47(4):669-77.
617. Freeman MA. Treatment of ruptures of the lateral ligament of the ankle. *J bone Joint Surg BR.* 1965;47(4):661-8.
618. Sommer HM, Arza D. Functional treatment of recent ruptures of the fibular ligament of the ankle. *Int Orthop.* 1989;13(2):157-60.

619. Specchiulli F, Cofano RE. A comparison of surgical and conservative treatment in ankle ligament tears. *Orthopedics*. 2001;24(7):686-8.
620. Evans GA, Hardcastle P, Frenyo AD. Acute rupture of the lateral ligament of the ankle. To suture or not to suture? *J bone Joint Surg BR*. 1984;66(2):209-12.
621. Niedermann B, Andersen A, Andersen SB, et al. Rupture of the lateral ligaments of the ankle: operation or plaster cast? A prospective study. *Acta Orthop Scand*. 1981;52(5):579-87.
622. Karlsson J, Lundin O, Lind K, Styf J. Early mobilization versus immobilization after ankle ligament stabilization. *Scand J Med Sci Sports*. 1999;9(5):299-303.
623. Karlsson J, Rudholm O, Bergsten T, Faxen E, Styf J. Early range of motion training after ligament reconstruction of the ankle joint. *Knee Surg Sports Traumatol Arthrosc*. 1995;3(3):173-7.
624. de Vries JS, Krips R, Sierevelt IN, Blankevoort L. Interventions for treating chronic ankle instability. *Cochrane Database Syst Rev*. 2006(4):CD004124.
625. Lin CWC, Moseley AM, Refshauge KM. Rehabilitation for ankle fractures in adults (Review). *The Cochrane Collaboration*. 2009(2).
626. Court-Brown C, McQueen M, Tornetta P. Ankle fractures. In: Tornetta P, Einhorn T, eds. *Trauma*. Philadelphia, PA: Lippincott Williams & Wilkins; 2006:366-82.
627. Jensen SL, Andresen BK, Mencke S, Nielsen PT. Epidemiology of ankle fractures. A prospective population-based study of 212 cases in Aalborg, Denmark. *Acta Orthop Scand*. 1998;69(1):48-50.
628. French B, Tornetta P, 3rd. Hybrid external fixation of tibial pilon fractures. *Foot Ankle Clin*. 2000;5(4):853-71.
629. Syed MA, Panchbhavi VK. Fixation of tibial pilon fractures with percutaneous cannulated screws. *Injury*. 2004;35(3):284-9.
630. Campbell JT. Foot and ankle fractures in the industrial setting. *Foot Ankle Clin*. 2002;7(2):323-50.
631. Wilson FC. Fractures of the ankle: pathogenesis and treatment. *J South Orthop Assoc*. 2000;9(2):105-15.
632. Michelson JD. Ankle fractures resulting from rotational injuries. *J Am Acad Orthop Surg*. 2003;11(6):403-12.
633. Michelson JD, Magid D, McHale K. Clinical utility of a stability-based ankle fracture classification system. *J Orthop Trauma*. 2007;21(5):307-15.
634. Daffner RH. Ankle trauma. *Semin Roentgenol*. 1994;29(2):134-51.
635. Gardner MJ, Demetrakopoulos D, Briggs SM, Helfet DL, Lorch DG. The ability of the Lauge-Hansen classification to predict ligament injury and mechanism in ankle fractures: an MRI study. *J Orthop Trauma*. 2006;20(4):267-72.
636. Shariff SS, Nathwani DK. Lauge-Hansen classification--a literature review. *Injury*. 2006;37(9):888-90.
637. Heim D, Schmidlin V, Ziviello O. Do type B malleolar fractures need a positioning screw? *Injury*. 2002;33(8):729-34.
638. Arimoto HK, Forrester DM. Classification of ankle fractures: an algorithm. *AJR Am J Roentgenol*. 1980;135(5):1057-63.
639. Kennedy JG, Johnson SM, Collins AL, et al. An evaluation of the Weber classification of ankle fractures. *Injury*. 1998;29(8):577-80.
640. Madeley NJ, Srinivasan CM, Crandall JR, Hurwitz S, Funk JR. Retrospective analysis of malleolar fractures in an impact environment. *Annu Proc Assoc Adv Automot Med*. 2004;48235-48.
641. Nielsen JO, Dons-Jensen H, Sorensen HT. Lauge-Hansen classification of malleolar fractures. An assessment of the reproducibility in 118 cases. *Acta Orthop Scand*. 1990;61(5):385-7.
642. Gehr J, Neber W, Hilsenbeck F, Friedl W. New concepts in the treatment of ankle joint fractures. The IP-XS (XSL) and IP-XXS (XXSL) nail in the treatment of ankle joint fractures. *Arch Orthop Trauma Surg*. 2004;124(2):96-103.
643. Mandi DM, Nickles WA, Mandracchia VJ, Halligan JB, Toney PA. Ankle fractures. *Clin Podiatr Med Surg*. 2006;23(2):375-422, vii.
644. Mandracchia DM, Mandracchia VJ, Buddecke DE, Jr. Malleolar fractures of the ankle. A comprehensive review. *Clin Podiatr Med Surg*. 1999;16(4):679-723.
645. Park JC, McLaurin TM. Acute syndesmosis injuries associated with ankle fractures: current perspectives in management. *Bull NYU Hosp Jt Dis*. 2009;67(1):39-44.

646. Gross RH. Foot and ankle injuries and disorders. *Adolesc Med.* 1998;9(3):599-609, vii.
647. Chu A, Weiner L. Distal fibula malunions. *J Am Acad Orthop Surg.* 2009;17(4):220-30.
648. Makwana NK, Bhowal B, Harper WM, Hui AW. Conservative versus operative treatment for displaced ankle fractures in patients over 55 years of age. A prospective, randomised study. *J bone Joint Surg BR.* 2001;83(4):525-9.
649. Rowley DI, Norris SH, Duckworth T. A prospective trial comparing operative and manipulative treatment of ankle fractures. *J bone Joint Surg BR.* 1986;68(4):610-3.
650. Salai M, Dudkiewicz I, Novikov I, Amit Y, Chechick A. The epidemic of ankle fractures in the elderly--is surgical treatment warranted? *Arch Orthop Trauma Surg.* 2000;120(9):511-3.
651. Wyrsh B, McFerran MA, McAndrew M, et al. Operative treatment of fractures of the tibial plafond. A randomized, prospective study. *J Bone Joint Surg Am.* 1996;78(11):1646-57.
652. Marsh JL, Muehling V, Dirschl D, Hurwitz S, Brown TD, Nepola J. Tibial plafond fractures treated by articulated external fixation: a randomized trial of postoperative motion versus nonmotion. *J Orthop Trauma.* 2006;20(8):536-41.
653. Charopoulos I, Kokoroghiannis C, Karagiannis S, Lyritis GP, Papaioannou N. Maisonneuve fracture without deltoid ligament disruption: a rare pattern of injury. *J Foot Ankle Surg.* 2010;49(1):86 e11-7.
654. Millen JC, Lindberg D. Maisonneuve Fracture. *J Emerg Med.* 2009.
655. Madhusudhan TR, Dhana SRM, Smith IC. Report of the case of a rare pattern of Maisonneuve fracture. *J Foot Ankle Surg.* 2008;47(2):160-2.
656. Duchesneau S, Fallat LM. The Maisonneuve fracture. *J Foot Ankle Surg.* 1995;34(5):422-8.
657. Weber M, Burmeister H, Flueckiger G, Krause FG. The use of weightbearing radiographs to assess the stability of supination-external rotation fractures of the ankle. *Arch Orthop Trauma Surg.* 2010;130(5):693-8.
658. Sherbondy PS, Sebastianelli WJ. Stress fractures of the medial malleolus and distal fibula. *Clin Sports Med.* 2006;25(1):129-37, x.
659. Haraguchi N, Haruyama H, Toga H, Kato F. Pathoanatomy of posterior malleolar fractures of the ankle. *J Bone Joint Surg Am.* 2006;88(5):1085-92.
660. Richter J, Schulze W, Muhr G. Stable ankle joint fractures. Indication for surgical or conservative management? *Orthopade.* 1999;28(6):493-9.
661. Early JS. Talus fracture management. *Foot Ankle Clin.* 2008;13(4):635-57.
662. Rush SM, Jennings M, Hamilton GA. Talus fractures: surgical principles. *Clin Podiatr Med Surg.* 2009;26(1):91-103.
663. Judd DB, Kim DH. Foot fractures frequently misdiagnosed as ankle sprains. *Am Fam Physician.* 2002;66(5):785-94.
664. Chaney DM, Troups J, Foster J. Osteochondral fractures of the talus. *Clin Podiatr Med Surg.* 2001;18(3):481-93.
665. Buzzard B, Pratt R, Briggs P, Siddique M, Tasker A, Robinson S. Is pulsed shortwave diathermy better than ice therapy for reduction of oedema following calcaneal fractures? Preliminary trial. *Physiotherapy.* 2003;89:34-42.
666. Dooley P, Buckley R, Tough S, et al. Bilateral calcaneal fractures: operative versus nonoperative treatment. *Foot Ankle Int.* 2004;25(2):47-52.
667. Guyer BH, Levinsohn EM, Fredrickson BE, Bailey GL, Formikell M. Computed tomography of calcaneal fractures: anatomy, pathology, dosimetry, and clinical relevance. *AJR Am J Roentgenol.* 1985;145(5):911-9.
668. Ibrahim T, Rowsell M, Rennie W, Brown AR, Taylor GJ, Gregg PJ. Displaced intra-articular calcaneal fractures: 15-year follow-up of a randomised controlled trial of conservative versus operative treatment. *Injury.* 2007;38(7):848-55.
669. Kingwell S, Buckley R, Willis N. The association between subtalar joint motion and outcome satisfaction in patients with displaced intraarticular calcaneal fractures. *Foot Ankle Int.* 2004;25(9):666-73.
670. Knight JR, Gross EA, Bradley GH, Bay C, LoVecchio F. Boehler's angle and the critical angle of Gissane are of limited use in diagnosing calcaneus fractures in the ED. *Am J Emerg Med.* 2006;24(4):423-7.

671. Mitchell MJ, McKinley JC, Robinson CM. The epidemiology of calcaneal fractures. *Foot (Edinb)*. 2009;19(4):197-200.
672. Born CT, Tahernia AD. Imaging of calcaneal fractures. *Clin Podiatr Med Surg*. 1997;14(2):337-56.
673. Daftary A, Haims AH, Baumgaertner MR. Fractures of the calcaneus: a review with emphasis on CT. *Radiographics*. 2005;25(5):1215-26.
674. Howard JL, Buckley R, McCormack R, et al. Complications following management of displaced intra-articular calcaneal fractures: a prospective randomized trial comparing open reduction internal fixation with nonoperative management. *J Orthop Trauma*. 2003;17(4):241-9.
675. Karasick D. Fractures and dislocations of the foot. *Semin Roentgenol*. 1994;29(2):152-75.
676. Myerson MS. The diagnosis and treatment of injury to the tarsometatarsal joint complex. *J Bone Joint Surg BR*. 1999;81(5):756-63.
677. Cakir H, Van Vliet-Koppert ST, Van Lieshout EM, De Vries MR, Van Der Elst M, Schepers T. Demographics and outcome of metatarsal fractures. *Arch Orthop Trauma Surg*. 2010.
678. Hatch RL, Alsobrook JA, Clugston JR. Diagnosis and management of metatarsal fractures. *Am Fam Physician*. 2007;76(6):817-26.
679. Strayer SM, Reece SG, Petrizzi MJ. Fractures of the proximal fifth metatarsal. *Am Fam Physician*. 1999;59(9):2516-22.
680. Prokuski LJ, Saltzman CL. Challenging fractures of the foot and ankle. *Radiol Clin North Am*. 1997;35(3):655-70.
681. Chen RC, Shia DS, Kamath GV, Thomas AB, Wright RW. Troublesome stress fractures of the foot and ankle. *Sports Med Arthrosc*. 2006;14(4):246-51.
682. Weinfeld SB, Haddad SL, Myerson MS. Metatarsal stress fractures. *Clin Sports Med*. 1997;16(2):319-38.
683. Wilder RP, Sethi S. Overuse injuries: tendinopathies, stress fractures, compartment syndrome, and shin splints. *Clin Sports Med*. 2004;23(1):55-81, vi.
684. de Clercq PF, Bevernage BD, Leemrijse T. Stress fracture of the navicular bone. *Acta Orthop Belg*. 2008;74(6):725-34.
685. Jones MH, Amendola AS. Navicular stress fractures. *Clin Sports Med*. 2006;25(1):151-8, x-xi.
686. Larsen D. Assessment and management of foot and ankle fractures. *Nurs Stand*. 2002;17(6):37-46; quiz 7-8.
687. Wardrope J, English B. *Musculo-skeletal Problems in Emergency Medicine*. New York, NY: Oxford University Press; 1998.
688. Moore JA, Jr., Shank JR, Morgan SJ, Smith WR. Syndesmosis fixation: a comparison of three and four cortices of screw fixation without hardware removal. *Foot Ankle Int*. 2006;27(8):567-72.
689. Scott AM. Diagnosis and treatment of ankle fractures. *Radiol Technol*. 2010;81(5):457-75.
690. Koval KJ, Egol KA, Cheung Y, Goodwin DW, Spratt KF. Does a positive ankle stress test indicate the need for operative treatment after lateral malleolus fracture? A preliminary report. *J Orthop Trauma*. 2007;21(7):449-55.
691. Catalano LW, 3rd, Barron OA, Glickel SZ. Assessment of articular displacement of distal radius fractures. *Clin Orthop Relat Res*. 2004(423):79-84.
692. Harness NG, Ring D, Zurakowski D, Harris GJ, Jupiter JB. The influence of three-dimensional computed tomography reconstructions on the characterization and treatment of distal radial fractures. *J Bone Joint Surg Am*. 2006;88(6):1315-23.
693. Katz MA, Beredjiklian PK, Bozentka DJ, Steinberg DR. Computed tomography scanning of intra-articular distal radius fractures: does it influence treatment? *J Hand Surg Am*. 2001;26(3):415-21.
694. Ogawa BK, Charlton TP, Thordarson DB. Radiography versus computed tomography for displacement assessment in calcaneal fractures. *Foot Ankle Int*. 2009;30(10):1005-10.
695. Chen PY, Wang TG, Wang CL. Ultrasonographic examination of the deltoid ligament in bimalleolar equivalent fractures. *Foot Ankle Int*. 2008;29(9):883-6.
696. Christodoulou G, Korovessis P, Giarmenitis S, Dimopoulos P, Sdougos G. The use of sonography for evaluation of the integrity and healing process of the tibiofibular interosseous membrane in ankle fractures. *J Orthop Trauma*. 1995;9(2):98-106.
697. Wang CL, Shieh JY, Wang TG, Hsieh FJ. Sonographic detection of occult fractures in the foot and ankle. *J Clin Ultrasound*. 1999;27(8):421-5.

698. Delacerda FG. A case study: application of ultrasound to determine a stress fracture of the fibula. *J Orthop Sports Phys Ther.* 1981;2(3):134-6.
699. Paiement GD, Renaud E, Dagenais G, Gosselin RA. Double-blind randomized prospective study of the efficacy of antibiotic prophylaxis for open reduction and internal fixation of closed ankle fractures. *J Orthop Trauma.* 1994;8(1):64-6.
700. Gillespie WJ, Walenkamp GH. Antibiotic prophylaxis for surgery for proximal femoral and other closed long bone fractures. *Cochrane Database Syst Rev.* 2010(3):CD000244.
701. Slobogean GP, O'Brien PJ, Brauer CA. Single-dose versus multiple-dose antibiotic prophylaxis for the surgical treatment of closed fractures. *Acta Orthop.* 2010;81(2):256-62.
702. Petersen MM, Lauritzen JB, Schwarz P, Lund B. Effect of nasal salmon calcitonin on post-traumatic osteopenia following ankle fracture. A randomized double-blind placebo-controlled study in 24 patients. *Acta Orthop Scand.* 1998;69(4):347-50.
703. Boursinos LA, Karachalios T, Poultsides L, Malizos KN. Do steroids, conventional non-steroidal anti-inflammatory drugs and selective Cox-2 inhibitors adversely affect fracture healing? *J Musculoskelet Neuronal Interact.* 2009;9(1):44-52.
704. Sudmann E, Hagen T. Indomethacin-induced delayed fracture healing. *Arch Orthop Unfallchir.* 1976;85(2):151-4.
705. Centers for Disease Control and Prevention. Guideline 2: The pre-travel consultation. Routine vaccine-preventable diseases. *Travelers' Health - Yellow Book*; 2009: Available at [www.cdc.gov/travel/yellowbook/2010/Guideline-2/tetanus.aspx](http://www.cdc.gov/travel/yellowbook/2010/Guideline-2/tetanus.aspx).
706. White BJ, Walsh M, Egol KA, Tejwani NC. Intra-articular block compared with conscious sedation for closed reduction of ankle fracture-dislocations. A prospective randomized trial. *J Bone Joint Surg Am.* 2008;90(4):731-4.
707. Furia JP, Alioto RJ, Marquardt JD. The efficacy and safety of the hematoma block for fracture reduction in closed, isolated fractures. *Orthopedics.* 1997;20(5):423-6.
708. Alioto RJ, Furia JP, Marquardt JD. Hematoma block for ankle fractures: a safe and efficacious technique for manipulations. *J Orthop Trauma.* 1995;9(2):113-6.
709. Brink O, Staunstrup H, Sommer J. Stable lateral malleolar fractures treated with aircast ankle brace and DonJoy R.O.M.-Walker brace: a prospective randomized study. *Foot Ankle Int.* 1996;17(11):679-84.
710. Kosuge DD, Mahadevan D, Chandrasenan J, Pugh H. Managing type II and type IV Lauge-Hansen supination external rotation ankle fractures: current orthopaedic practice. *Ann R Coll Surg Engl.* 2010;92(8):689-92.
711. McGonagle L, Ralte P, Kershaw S. Non-union of Weber B distal fibula fractures: a case series. *Foot Ankle Surg.* 2010;16(3):e63-7.
712. van den Bekerom MP, Haverkamp D, Kloen P. Biomechanical and clinical evaluation of posterior malleolar fractures. A systematic review of the literature. *J Trauma.* 2009;66(1):279-84.
713. De Vries J, Wijgman A, Sierevelt I, Schaap G. Long-term results of ankle fractures with a posterior malleolar fragment. *J Foot Ankle Surg.* 2005;44(3):211-7.
714. Stuart PR, Brumby C, Smith SR. Comparative study of functional bracing and plaster cast treatment of stable lateral malleolar fractures. *Injury.* 1989;20(6):323-6.
715. Joukainen A, Partio EK, Waris P, et al. Bioabsorbable screw fixation for the treatment of ankle fractures. *J Orthop Sci.* 2007;12(1):28-34.
716. Bauer M, Bergstrom B, Hemborg A, Sandegard J. Malleolar fractures: nonoperative versus operative treatment. A controlled study. *Clin Orthop Relat Res.* 1985(199):17-27.
717. Phillips WA, Schwartz HS, Keller CS, et al. A prospective, randomized study of the management of severe ankle fractures. *J Bone Joint Surg Am.* 1985;67(1):67-78.
718. SooHoo NF, Krenek L, Eagan MJ, Gurbani B, Ko CY, Zingmond DS. Complication rates following open reduction and internal fixation of ankle fractures. *J Bone Joint Surg Am.* 2009;91(5):1042-9.
719. Ng A, Barnes ES. Management of complications of open reduction and internal fixation of ankle fractures. *Clin Podiatr Med Surg.* 2009;26(1):105-25.
720. Karladani AH, Granhed H, Edshage B, Jerre R, Styf J. Displaced tibial shaft fractures: a prospective randomized study of closed intramedullary nailing versus cast treatment in 53 patients. *Acta Orthop Scand.* 2000;71(2):160-7.

721. Fernandes HJ, Sakaki MH, Silva Jdos S, dos Reis FB, Zumioti AV. Comparative multicenter study of treatment of multi-fragmented tibial diaphyseal fractures with nonreamed interlocking nails and with bridging plates. *Clinics (Sao Paulo)*. 2006;61(4):333-8.
722. Keating JF, O'Brien PJ, Blachut PA, Meek RN, Broekhuysen HM. Locking intramedullary nailing with and without reaming for open fractures of the tibial shaft. A prospective, randomized study. *J Bone Joint Surg Am*. 1997;79(3):334-41.
723. Zelle BA, Bhandari M, Espiritu M, Koval KJ, Zlowodzki M. Treatment of distal tibia fractures without articular involvement: a systematic review of 1125 fractures. *J Orthop Trauma*. 2006;20(1):76-9.
724. Guo JJ, Tang N, Yang HL, Tang TS. A prospective, randomised trial comparing closed intramedullary nailing with percutaneous plating in the treatment of distal metaphyseal fractures of the tibia. *J bone Joint Surg BR*. 2010;92(7):984-8.
725. Im GI, Tae SK. Distal metaphyseal fractures of tibia: a prospective randomized trial of closed reduction and intramedullary nail versus open reduction and plate and screws fixation. *J Trauma*. 2005;59(5):1219-23; discussion 23.
726. Bozkurt M, Ocguder DA, Ugurlu M, Kalkan T. Tibial pilon fracture repair using Ilizarov external fixation, capsuloligamentotaxis, and early rehabilitation of the ankle. *J Foot Ankle Surg*. 2008;47(4):302-6.
727. Dunbar RP, Barei DP, Kubiak EN, Nork SE, Henley MB. Early limited internal fixation of diaphyseal extensions in select pilon fractures: upgrading AO/OTA type C fractures to AO/OTA type B. *J Orthop Trauma*. 2008;22(6):426-9.
728. Evans JM, Gardner MJ, Brennan ML, Phillips CJ, Henley MB, Dunbar RP. Intramedullary fixation of fibular fractures associated with pilon fractures. *J Orthop Trauma*. 2010;24(8):491-4.
729. Gardner MJ, Mehta S, Barei DP, Nork SE. Treatment protocol for open AO/OTA type C3 pilon fractures with segmental bone loss. *J Orthop Trauma*. 2008;22(7):451-7.
730. Papadokostakis G, Kontakis G, Giannoudis P, Hadjipavlou A. External fixation devices in the treatment of fractures of the tibial plafond: a systematic review of the literature. *J bone Joint Surg BR*. 2008;90(1):1-6.
731. Ruland RT, Hogan CJ, Cannon DL, Slade JF. Use of dynamic distraction external fixation for unstable fracture-dislocations of the proximal interphalangeal joint. *J Hand Surg Am*. 2008;33(1):19-25.
732. Wang C, Li Y, Huang L, Wang M. Comparison of two-staged ORIF and limited internal fixation with external fixator for closed tibial plafond fractures. *Arch Orthop Trauma Surg*. 2010;130(10):1289-97.
733. Kaukonen JP, Lamberg T, Korkala O, Pajarinen J. Fixation of syndesmotic ruptures in 38 patients with a malleolar fracture: a randomized study comparing a metallic and a bioabsorbable screw. *J Orthop Trauma*. 2005;19(6):392-5.
734. Kennedy JG, Soffe KE, Dalla Vedova P, et al. Evaluation of the syndesmotic screw in low Weber C ankle fractures. *J Orthop Trauma*. 2000;14(5):359-66.
735. Missbach-Kroll A, Meier L, Meyer P, Burckhardt A, Eisner L. Kirschner wire transfixation of syndesmosis rupture--an alternative treatment of type B and C malleolar fractures. *Swiss Surg*. 2003;9(1):19-25.
736. Soin SP, Knight TA, Dinah AF, Mears SC, Swierstra BA, Belkoff SM. Suture-button versus screw fixation in a syndesmosis rupture model: a biomechanical comparison. *Foot Ankle Int*. 2009;30(4):346-52.
737. Thordarson DB, Bains R, Shepherd LE. The role of ankle arthroscopy on the surgical management of ankle fractures. *Foot Ankle Int*. 2001;22(2):123-5.
738. Hoiness P, Stromsoe K. Tricortical versus quadricortical syndesmosis fixation in ankle fractures: a prospective, randomized study comparing two methods of syndesmosis fixation. *J Orthop Trauma*. 2004;18(6):331-7.
739. Zalavras C, Thordarson D. Ankle syndesmotic injury. *J Am Acad Orthop Surg*. 2007;15(6):330-9.
740. Lin CC, Moseley AM, Refshauge KM, Haas M, Herbert RD. Effectiveness of joint mobilisation after cast immobilisation for ankle fracture: a protocol for a randomised controlled trial [ACTRN012605000143628]. *BMC Musculoskelet Disord*. 2006;746.
741. Thordarson DB, Samuelson M, Shepherd LE, Merkle PF, Lee J. Bioabsorbable versus stainless steel screw fixation of the syndesmosis in pronation-lateral rotation ankle fractures: a prospective randomized trial. *Foot Ankle Int*. 2001;22(4):335-8.

742. Hamid N, Loeffler BJ, Braddy W, Kellam JF, Cohen BE, Bosse MJ. Outcome after fixation of ankle fractures with an injury to the syndesmosis: the effect of the syndesmosis screw. *J bone Joint Surg BR*. 2009;91(8):1069-73.
743. Pritchett JW. Rush rods versus plate osteosyntheses for unstable ankle fractures in the elderly. *Orthop Rev*. 1993;22(6):691-6.
744. Takao M, Uchio Y, Naito K, Fukazawa I, Kakimaru T, Ochi M. Diagnosis and treatment of combined intra-articular disorders in acute distal fibular fractures. *J Trauma*. 2004;57(6):1303-7.
745. Stromsoe K, Hoqevold HE, Skjeldal S, Alho A. The repair of a ruptured deltoid ligament is not necessary in ankle fractures. *J bone Joint Surg BR*. 1995;77(6):920-1.
746. Maffulli N, Testa V, Capasso G. Use of a tourniquet in the internal fixation of fractures of the distal part of the fibula. A prospective, randomized trial. *J Bone Joint Surg Am*. 1993;75(5):700-3.
747. Kankare J, Partio EK, Hirvensalo E, Bostman O, Rokkanen P. Biodegradable self-reinforced polyglycolide screws and rods in the fixation of displaced malleolar fractures in the elderly. A comparison with metallic implants. *Ann Chir Gynaecol*. 1996;85(3):263-70.
748. Rokkanen P, Bostman O, Vainionpaa S, et al. Biodegradable implants in fracture fixation: early results of treatment of fractures of the ankle. *Lancet*. 1985;1(8443):1422-4.
749. Kankare J, Hirvensalo E, Rokkanen P. Malleolar fractures in alcoholics treated with biodegradable internal fixation. 6/16 reoperations in a randomized study. *Acta Orthop Scand*. 1995;66(6):524-8.
750. Dijkema AR, van der Elst M, Breederveld RS, Verspui G, Patka P, Haarman HJ. Surgical treatment of fracture-dislocations of the ankle joint with biodegradable implants: a prospective randomized study. *J Trauma*. 1993;34(1):82-4.
751. Bucholz RW, Henry S, Henley MB. Fixation with bioabsorbable screws for the treatment of fractures of the ankle. *J Bone Joint Surg Am*. 1994;76(3):319-24.
752. Ahl T, Dalen N, Lundberg A, Wykman A. Biodegradable fixation of ankle fractures. A roentgen stereophotogrammetric study of 32 cases. *Acta Orthop Scand*. 1994;65(2):166-70.
753. Reed MR, Wright K, Du Fosse J, Cross AT. Ankles can be immobilized in a backslab or wool and crepe postoperatively: a randomized prospective trial. *Injury*. 1998;29(2):152-3.
754. Dogra AS, Rangan A. Early mobilisation versus immobilisation of surgically treated ankle fractures. Prospective randomised control trial. *Injury*. 1999;30(6):417-9.
755. Lehtonen H, Jarvinen TL, Honkonen S, Nyman M, Vihtonen K, Jarvinen M. Use of a cast compared with a functional ankle brace after operative treatment of an ankle fracture. A prospective, randomized study. *J Bone Joint Surg Am*. 2003;85-A(2):205-11.
756. Franke J, Goldhahn S, Audige L, Kohler H, Wentzensen A. The dynamic vacuum orthosis: a functional and economical benefit? *Int Orthop*. 2008;32(2):153-8.
757. Hedstrom M, Ahl T, Dalen N. Early postoperative ankle exercise. A study of postoperative lateral malleolar fractures. *Clin Orthop Relat Res*. 1994(300):193-6.
758. Ahl T, Dalen N, Holmberg S, Selvik G. Early weight bearing of malleolar fractures. *Acta Orthop Scand*. 1986;57(6):526-9.
759. Ahl T, Dalen N, Selvik G. Ankle fractures. A clinical and roentgenographic stereophotogrammetric study. *Clin Orthop Relat Res*. 1989(245):246-55.
760. Tropp H, Norlin R. Ankle performance after ankle fracture: a randomized study of early mobilization. *Foot Ankle Int*. 1995;16(2):79-83.
761. Honigsmann P, Goldhahn S, Rosenkranz J, Audige L, Geissmann D, Babst R. Aftertreatment of malleolar fractures following ORIF -- functional compared to protected functional in a vacuum-stabilized orthosis: a randomized controlled trial. *Arch Orthop Trauma Surg*. 2007;127(3):195-203.
762. van Laarhoven CJ, Meeuwis JD, van der Werken C. Postoperative treatment of internally fixed ankle fractures: a prospective randomised study. *J bone Joint Surg BR*. 1996;78(3):395-9.
763. Egol KA, Dolan R, Koval KJ. Functional outcome of surgery for fractures of the ankle. A prospective, randomised comparison of management in a cast or a functional brace. *J bone Joint Surg BR*. 2000;82(2):246-9.
764. Sondenaa K, Hoigaard U, Smith D, Alho A. Immobilization of operated ankle fractures. *Acta Orthop Scand*. 1986;57(1):59-61.

765. DiStasio AJ, 2nd, Jaggars FR, DePasquale LV, Frassica FJ, Turen CH. Protected early motion versus cast immobilization in postoperative management of ankle fractures. *Contemp Orthop*. 1994;29(4):273-7.
766. Vioreanu M, Dudeney S, Hurson B, Kelly E, O'Rourke K, Quinlan W. Early mobilization in a removable cast compared with immobilization in a cast after operative treatment of ankle fractures: a prospective randomized study. *Foot Ankle Int*. 2007;28(1):13-9.
767. Vioreanu M, O'Brian D, Dudeney S, et al. Early exercising in removable cast compared with immobilisation in cast after operative treatment of ankle fractures. A prospective randomised study. *J bone Joint Surg BR*. 2006;88-B(Suppl II):280.
768. Ahl T, Dalen N, Lundberg A, Bylund C. Early mobilization of operated on ankle fractures. Prospective, controlled study of 40 bimalleolar cases. *Acta Orthop Scand*. 1993;64(1):95-9.
769. Finsen V, Benum P. Osteopenia after ankle fractures. The influence of early weight bearing and muscle activity. *Clin Orthop Relat Res*. 1989(245):261-8.
770. Finsen V, Saetermo R, Kibsgaard L, et al. Early postoperative weight-bearing and muscle activity in patients who have a fracture of the ankle. *J Bone Joint Surg Am*. 1989;71(1):23-7.
771. Jelinek JA, Porter DA. Management of unstable ankle fractures and syndesmosis injuries in athletes. *Foot Ankle Clin*. 2009;14(2):277-98.
772. Porter DA, May BD, Berney T. Functional outcome after operative treatment for ankle fractures in young athletes: a retrospective case series. *Foot Ankle Int*. 2008;29(9):887-94.
773. Fitzgerald P, Fitzgerald F, Burke P, Moran R, Bouchier-Hayes D. Can Venous Function or Swelling Be Improved After Ankle Fractures. *IJMS*. 1994;163(4):161-2.
774. Mora S, Zalavras CG, Wang L, Thordarson DB. The role of pulsatile cold compression in edema resolution following ankle fractures: a randomized clinical trial. *Foot Ankle Int*. 2002;23(11):999-1002.
775. Thordarson DB, Ghalambor N, Perlman M. Intermittent pneumatic pedal compression and edema resolution after acute ankle fracture: a prospective, randomized study. *Foot Ankle Int*. 1997;18(6):347-50.
776. Caschman J, Blagg S, Bishay M. The efficacy of the A-V Impulse system in the treatment of posttraumatic swelling following ankle fracture: a prospective randomized controlled study. *J Orthop Trauma*. 2004;18(9):596-601.
777. Christie A, Willoughby G. The effect of interferential therapy on swelling following open reduction and internal fixation of ankle fractures. *Physiotherapy Therapy and Practice*. 1990;63-7.
778. Hernandez M, Rivkin G, Leibner ED, Shiloach M, Elishoov O, Liebergall M. Prevention of immobilization related muscular atrophy using the myospare device: a controlled, randomized, open study to investigate the feasibility, safety and efficacy of electrical gastrocnemius stimulation in ankle fractures. *J bone Joint Surg BR*. 2006;88-B(Suppl II):333-4.
779. Wahlstrom O. Stimulation of fracture healing with electromagnetic fields of extremely low frequency (EMF of ELF). *Clin Orthop Relat Res*. 1984(186):293-301.
780. Nilsson GM, Jonsson K, Ekdahl CS, Eneroth M. Effects of a training program after surgically treated ankle fracture: a prospective randomised controlled trial. *BMC Musculoskelet Disord*. 2009;10:118.
781. Moseley AM, Herbert RD, Nightingale EJ, et al. Passive stretching does not enhance outcomes in patients with plantarflexion contracture after cast immobilization for ankle fracture: a randomized controlled trial. *Arch Phys Med Rehabil*. 2005;86(6):1118-26.
782. Lin CW, Moseley AM, Haas M, Refshauge KM, Herbert RD. Manual therapy in addition to physiotherapy does not improve clinical or economic outcomes after ankle fracture. *J Rehabil Med*. 2008;40(6):433-9.
783. Wilson FM. Manual therapy versus traditional exercises in mobilisation of the ankle post-ankle fracture. A pilot study. *NZ Journal of Physiotherapy*. 1991:11-6.
784. Handolin L, Kiljunen V, Arnala I, et al. No long-term effects of ultrasound therapy on bioabsorbable screw-fixed lateral malleolar fracture. *Scand J Surg*. 2005;94(3):239-42.
785. Mei-Dan O, Hetsroni I, Mann G, Melamed Y, Nyska M. Prevention of avascular necrosis in displaced talar neck fractures by hyperbaric oxygenation therapy: a dual case report. *J Postgrad Med*. 2008;54(2):140-3.
786. Butler J, Foex B. Best evidence topic report. Hyperbaric oxygen therapy in acute fracture management. *Emerg Med J*. 2006;23(7):571-2.

787. Karamitros AE, Kalentzos VN, Soucacos PN. Electric stimulation and hyperbaric oxygen therapy in the treatment of nonunions. *Injury*. 2006;37 Suppl 1S63-73.
788. Greensmith JE. Hyperbaric oxygen therapy in extremity trauma. *J Am Acad Orthop Surg*. 2004;12(6):376-84.
789. Ginandes CS, Rosenthal DI. Using hypnosis to accelerate the healing of bone fractures: a randomized controlled pilot study. *Altern Ther Health Med*. 1999;5(2):67-75.
790. Furlong J, Morrison WB, Carrino JA. Imaging of the talus. *Foot Ankle Clin*. 2004;9(4):685-701, v.
791. Berlet GC, Lee TH, Massa EG. Talar neck fractures. *Orthop Clin North Am*. 2001;32(1):53-64.
792. Thordarson DB, Krieger LE. Operative vs. nonoperative treatment of intra-articular fractures of the calcaneus: a prospective randomized trial. *Foot Ankle Int*. 1996;17(1):2-9.
793. Ebraheim NA, Biyani A, Padanilam T, Paley K. A pitfall of coronal computed tomographic imaging in evaluation of calcaneal fractures. *Foot Ankle Int*. 1996;17(8):503-5.
794. Alexander AH, Lichtman DM. Surgical treatment of transchondral talar-dome fractures (osteochondritis dissecans). Long-term follow-up. *J Bone Joint Surg Am*. 1980;62(4):646-52.
795. Canale ST, Belding RH. Osteochondral lesions of the talus. *J Bone Joint Surg Am*. 1980;62(1):97-102.
796. Flick AB, Gould N. Osteochondritis dissecans of the talus (transchondral fractures of the talus): review of the literature and new surgical approach for medial dome lesions. *Foot Ankle*. 1985;5(4):165-85.
797. Pettine KA, Morrey BF. Osteochondral fractures of the talus. A long-term follow-up. *J bone Joint Surg BR*. 1987;69(1):89-92.
798. Zeiss J, Ebraheim N, Rusin J, Coombs RJ. Magnetic resonance imaging of the calcaneus: normal anatomy and application in calcaneal fractures. *Foot Ankle*. 1991;11(5):264-73.
799. Haygood TM, Teasdall R. Computed tomographic evaluation of calcaneal fractures. *J South Orthop Assoc*. 1997;6(1):62-8.
800. Koval KJ, Sanders R. The radiologic evaluation of calcaneal fractures. *Clin Orthop Relat Res*. 1993(290):41-6.
801. Gilmer PW, Herzenberg J, Frank JL, Silverman P, Martinez S, Goldner JL. Computerized tomographic analysis of acute calcaneal fractures. *Foot Ankle*. 1986;6(4):184-93.
802. Buckley R, Tough S, McCormack R, et al. Operative compared with nonoperative treatment of displaced intra-articular calcaneal fractures: a prospective, randomized, controlled multicenter trial. *J Bone Joint Surg Am*. 2002;84-A(10):1733-44.
803. Johal HS, Buckley RE, Le IL, Leighton RK. A prospective randomized controlled trial of a bioresorbable calcium phosphate paste (alpha-BSM) in treatment of displaced intra-articular calcaneal fractures. *J Trauma*. 2009;67(4):875-82.
804. Longino D, Buckley RE. Bone graft in the operative treatment of displaced intraarticular calcaneal fractures: is it helpful? *J Orthop Trauma*. 2001;15(4):280-6.
805. Parmar HV, Triffitt PD, Gregg PJ. Intra-articular fractures of the calcaneum treated operatively or conservatively. A prospective study. *J bone Joint Surg BR*. 1993;75(6):932-7.
806. Tezval M, Dumont C, Sturmer KM. Prognostic reliability of the Hawkins sign in fractures of the talus. *J Orthop Trauma*. 2007;21(8):538-43.
807. Schulze W, Richter J, Russe O, Ingelfinger P, Muhr G. [Prognostic factors for avascular necrosis following talar fractures]. *Z Orthop Ihre Grenzgeb*. 2002;140(4):428-34.
808. Thordarson DB. Talar body fractures. *Orthop Clin North Am*. 2001;32(1):65-77, viii.
809. Gobbi A, Francisco RA, Lubowitz JH, Allegra F, Canata G. Osteochondral lesions of the talus: randomized controlled trial comparing chondroplasty, microfracture, and osteochondral autograft transplantation. *Arthroscopy*. 2006;22(10):1085-92.
810. Ferrel RD, Sgaglione NA, Del Pizzo W. Arthroscopic treatment of osteochondral lesions of the talus: technique and results. *Orthop Trans*. 1990;14:172-3.
811. Tol JL, Struijs PA, Bossuyt PM, Verhagen RA, van Dijk CN. Treatment strategies in osteochondral defects of the talar dome: a systematic review. *Foot Ankle Int*. 2000;21(2):119-26.
812. McGahan PJ, Pinney SJ. Current concept review: osteochondral lesions of the talus. *Foot Ankle Int*. 2010;31(1):90-101.

813. Makki D, Alhajjar HM, Walkay S, Ramkumar U, Watson AJ, Allen PW. Osteosynthesis of displaced intra-articular fractures of the calcaneum: a long-term review of 47 cases. *J Bone Joint Surg BR*. 2010;92(5):693-700.
814. Marx RC, Mizel MS. What's new in foot and ankle surgery. *J Bone Joint Surg Am*. 2008;90(4):928-42.
815. Kinner B, Schieder S, Muller F, Pannek A, Roll C. Calcaneocuboid joint involvement in calcaneal fractures. *J Trauma*. 2010;68(5):1192-9.
816. Thordarson DB, Greene N, Shepherd L, Perlman M. Facilitating edema resolution with a foot pump after calcaneus fracture. *J Orthop Trauma*. 1999;13(1):43-6.
817. Rammelt S, Amlang M, Barthel S, Gavlik JM, Zwipp H. Percutaneous treatment of less severe intraarticular calcaneal fractures. *Clin Orthop Relat Res*. 2010;468(4):983-90.
818. O'Brien J, Buckley R, McCormack R, et al. Personal gait satisfaction after displaced intraarticular calcaneal fractures: a 2-8 year followup. *Foot Ankle Int*. 2004;25(9):657-65.
819. Radnay CS, Clare MP, Sanders RW. Subtalar fusion after displaced intra-articular calcaneal fractures: does initial operative treatment matter? *J Bone Joint Surg Am*. 2009;91(3):541-6.
820. Brauer CA, Manns BJ, Ko M, Donaldson C, Buckley R. An economic evaluation of operative compared with nonoperative management of displaced intra-articular calcaneal fractures. *J Bone Joint Surg Am*. 2005;87(12):2741-9.
821. Myerson MS, Juliano PJ, Koman JD. The use of a pneumatic intermittent impulse compression device in the treatment of calcaneus fractures. *Mil Med*. 2000;165(10):721-5.
822. Dickson KF, Friedman J, Buchholz JG, Flandry FD. The use of BoneSource hydroxyapatite cement for traumatic metaphyseal bone void filling. *J Trauma*. 2002;53(6):1103-8.
823. Henning JA, Jones CB, Sietsema DL, Bohay DR, Anderson JG. Open reduction internal fixation versus primary arthrodesis for lisfranc injuries: a prospective randomized study. *Foot Ankle Int*. 2009;30(10):913-22.
824. Zwitter EW, Breederveld RS. Fractures of the fifth metatarsal; diagnosis and treatment. *Injury*. 2010;41(6):555-62.
825. Mologne TS, Lundeen JM, Clapper MF, O'Brien TJ. Early screw fixation versus casting in the treatment of acute Jones fractures. *Am J Sports Med*. 2005;33(7):970-5.
826. Wiener BD, Linder JF, Giattini JF. Treatment of fractures of the fifth metatarsal: a prospective study. *Foot Ankle Int*. 1997;18(5):267-9.
827. Hatch RL. Differentiating foot fractures from ankle sprains. *Am Fam Physician*. 2003;67(7):1438.
828. Gehrman RM, Renard RL. Current concepts review: Stress fractures of the foot. *Foot Ankle Int*. 2006;27(9):750-7.
829. Muthukumar T, Butt SH, Cassar-Pullicino VN. Stress fractures and related disorders in foot and ankle: plain films, scintigraphy, CT, and MR Imaging. *Semin Musculoskelet Radiol*. 2005;9(3):210-26.
830. Brockwell J, Yeung Y, Griffith JF. Stress fractures of the foot and ankle. *Sports Med Arthrosc*. 2009;17(3):149-59.
831. Mann JA, Pedowitz DI. Evaluation and treatment of navicular stress fractures, including nonunions, revision surgery, and persistent pain after treatment. *Foot Ankle Clin*. 2009;14(2):187-204.
832. Fetzer GB, Wright RW. Metatarsal shaft fractures and fractures of the proximal fifth metatarsal. *Clin Sports Med*. 2006;25(1):139-50, x.
833. Coris EE, Lombardo JA. Tarsal navicular stress fractures. *Am Fam Physician*. 2003;67(1):85-90.
834. Haverstock BD. Stress fractures of the foot and ankle. *Clin Podiatr Med Surg*. 2001;18(2):273-84.
835. Harris JS, Sinnott PL, Holland JP, et al. Methodology to update the practice recommendations in the American College of Occupational and Environmental Medicine's Occupational Medicine Practice Guidelines, second edition. *J Occup Environ Med*. 2008;50(3):282-95.