

## Plantar Fasciitis: Diagnosis and Management

Raghu N Kanumalla, James Keane, Starr Matsushita, David Shoup, Alfred L Mauro and Leonard B Goldstein\*

A.T. Still University School of Osteopathic Medicine in Arizona, Mesa, Arizona

**\*Corresponding Author:** Leonard B Goldstein, Assistant Vice President for Clinical Education Development  
A.T. Still University, Mesa, Arizona.

**Received:** January 14, 2018; **Published:** February 26, 2018

### Abstract

Plantar fasciitis is one of the most common causes of foot and heel pain in adults, affecting approximately 10% of the population at some point in their life, with a peak incidence between the ages of 40 and 60 years in the general population, and a younger peak in runners and athletes. Patients experience pain and tenderness at the sole of the foot. The current pathophysiological model primarily focuses on biomechanical stress and repetitive microtrauma resulting in chronic inflammation, as well as disruptions in tissue repair cycles. It is prudent to look beyond the acute inflammatory etiology of plantar fasciitis and understand its development into a chronic, degenerative problem that can spread and further traumatize the plantar fascia. Diagnosis of plantar fasciitis is typically made on a clinical basis, although laboratory, radiographic, and ultrasonographic studies may be utilized to rule out other conditions with similar presenting pain. Multiple treatment strategies are used to manage plantar fasciitis, which range from noninvasive to surgical. These strategies are presented through an osteopathic lens within five models of holistic care, including a discussion of osteopathic manipulation for plantar fasciitis.

**Keywords:** Plantar Fasciitis; Osteopathic Manipulation

### Introduction

Plantar fasciitis is a common foot disorder in which patients experience pain and tenderness at the sole of the foot. Plantar fasciitis is one of the most common causes of foot and heel pain in adults, affecting approximately 1 in 10 persons at some point in their life, with a peak incidence between the ages of 40 to 60 years in the general population, and a younger peak in runners and athletes [1,2]. The plantar fascia, also called the plantar aponeurosis, lies superficially to the muscles of the plantar surface of the foot. It attaches to the anterior medial calcaneal tuberosity and divides distally into five slips. These slips attach at the proximal phalanges and act as a truss to maintain the longitudinal arch of the foot and facilitate shock absorption during ambulation and other weight bearing activities [2-5].

Prevailing hypotheses regarding the pathophysiology of plantar fasciitis involve biomechanical stress leading to inflammation of the plantar fascia, resulting in tightening of the fascia during non-weight bearing periods [6-8]. Biomechanical stressors are common in obese individuals, individuals who engage in prolonged standing or jumping, individuals with either flat feet or high arches, and those with reduced ankle dorsiflexion [2,8]. There is an especially high incidence in runners, suggesting that repetitive microtrauma is the underlying etiology as well [2]. Dancers, especially those performing dance aerobic exercise, also suffer from plantar fasciitis due to stress on the Achilles tendon which translates through the calcaneus to increase tension in the plantar fascia [2]. Decreased knee extension secondary to hamstring tightness also increases load to the forefoot, resulting in increased plantar fascia stress [2].

Repetitive microtrauma with high calcaneal pressure and opposing traction of the forefoot and Achilles tendon lead to microtears in the central bundle of the plantar fascia [9,10]. Cumulative cellular damage is exacerbated by a failed healing pattern that leads to zones of both hyper- and hypoplasia [11]. Disruptions in normal collagen repair cycles, and a continuum of cellular damage similar to that in

Achilles tendinosis and lateral epicondylitis is also seen [12,13]. Microtrauma and disruptions in healing and collagen repair can lead to the development of hyperirritable, tender points in taut fascia that refer pain when palpated or compressed by weight-bearing activities, known as myofascial trigger points [14]. Research also suggests that in chronic tendinopathies, programmed cell death (apoptosis), tissue breakdown, collagen degeneration, and abnormal neurovascular growth contribute significantly to chronic tendinopathies [9,10,15,16]. These findings are accompanied by a distinct lack of chronic inflammatory cells, suggest that in the chronic stages, plantar fasciitis is not mediated by inflammatory processes, as is often hypothesized [9,10,15,16]. Thus repetitive microtears overwhelm inherent repair mechanisms, rather than perpetuate chronic inflammation [16]. Acute inflammation, as well as chronic stress to the plantar fascia can result in a great dilemma for individuals maintaining regular exercise regimens, or who work on their feet. Therefore it is prudent to look beyond the acute inflammatory etiology of plantar fasciitis and understand its development into a chronic, degenerative problem that can spread and further traumatize the plantar fascia.

### **Diagnosis of Plantar Fasciitis**

The diagnosis of plantar fasciitis is typically made on the basis of a thorough history and physical exam. Although generally discussed with respect to runners, the six Ss (shoes, surface, speed, stretching, strength, and structure) can guide the clinician towards diagnosis and treatment [17]. Patients typically present with a history of sharp pain localized to the medial aspect of the heel at the calcaneal insertion of the plantar fascia, as well as the arch of the foot, which occurs with the first few steps in the morning, or after long periods of non-weight bearing [2,6,7,17-19]. After a few steps, the plantar fascia begins to stretch and the pain gradually diminishes, although symptoms often resurface as a throbbing dull ache or fatigue-like sensation in the medial arch of the foot after prolonged periods of weight bearing. Pain may also be present in the arch of the foot [18-20]. Physical exam elicits local point tenderness along the plantar fascia. This is best achieved by dorsiflexing the patient's toes, pulling the plantar fascia taut, and then palpating along the plantar fascia from the heel to the forefoot [2]. Tender points are not only necessary for diagnosis, but are also markers for treatment focus, such as with osteopathic manipulation or corticosteroid injections [2,21].

Laboratory, radiographic, and ultrasonographic studies are generally not necessary to diagnose plantar fasciitis. Ultrasound imaging may demonstrate thickening of the plantar fascia and associated edema from inflammation, but the diagnostic utility of ultrasound for plantar fasciitis has not yet been proven for routine use [2,22,23]. However, these diagnostic modalities may be useful in ruling out other causes of foot and heel pain.

### **Other Causes of Heel and Foot Pain**

The following section is a non-exhaustive discussion of common causes of heel and foot pain in adults.

#### **Inflammatory Disorders**

Plantar fasciitis is generally an isolated condition, however it may also be a manifestation of systemic rheumatic disease such as reactive arthritis and spondyloarthropathies [2]. Serum markers of inflammation, such as erythrocyte sedimentation rate and C-reactive protein, may point towards coexistent inflammatory or rheumatologic disease [2]. Seronegative spondyloarthropathies often present with bilateral enthesitis of the plantar fascia and other tendon attachments, so history and physical exam should explore these possibilities in appropriate demographics who present with signs and symptoms of spondyloarthropathies [2,5].

#### **Neurologic Causes**

Nerve entrapments may occur, such as entrapment of the posterior tibial nerve in the tarsal tunnel causing paresthesia, numbness, and pain at the sole of the foot (tarsal tunnel syndrome) [2]. Tarsal tunnel syndrome can be diagnosed by a positive Tinel's sign over the inferior medial malleolus, wherein percussion over this area will reproduce or exacerbate presenting symptoms [2,5,21,24]. Concomitant gastrocnemius or plantar flexion weakness suggests radiculopathy of the S1 nerve root, and an absent or reduced ankle deep tendon reflex is typical [2]. Peripheral neuropathies may also present with burning pain of the foot, though patients typically have a longstanding history of poorly controlled diabetes mellitus or nutritional deficiency of vitamin B12, such as in alcohol abuse, pernicious anemia, strict vegetarian or vegan diets lacking in fortified grains, gastric bypass surgery, and malabsorptive conditions such as celiac or Crohn's disease [2,25].

**Skeletal Causes**

Heel spurs may be present in approximately 50 percent of patients with plantar fasciitis, however 20 percent of similar age patients without plantar fasciitis also have heel spurs, and thus spurs are not directly linked to its development, and radiography to identify them is not necessary in all patients [2,5]. As plantar fasciitis is common among twenty percent of athletes and others with prolonged weight bearing activities, stress fractures should be ruled out [2,5]. Plain radiographs may help identify fractures, however MRI is far superior at detecting early changes of the bone [2]. Tenderness is typically elicited by medial or lateral pressure on the calcaneus and may be confused for plantar fasciitis [5]. A history of direct trauma or excessive weight bearing exercise can lead to bone contusion, which has more generalized pain than plantar fasciitis tender points [2]. Trauma that is accompanied by point tenderness may indicate severe calcaneal fractures, especially when an axial load is placed on the foot following a fall from a height [2]. Destructive bony processes such as osteomyelitis or bony malignancy should be explored if the patient presents with systemic signs such as fevers, weight loss, deep nocturnal pain, or overlying soft tissue infection as in osteomyelitis [2].

**Soft Tissue Causes**

Achilles tendinopathy produces posterior heel pain, however translation of stresses through the calcaneus to the plantar fascia may result in concomitant plantar fasciitis, especially in dancers [2]. Long distance runners, especially those training for marathons, may experience inflammation of the fascia surrounding the subcutaneous heel fat pad [2]. However, pain on exam is elicited local to the heel pad, and the plantar fascia is not tender to palpation, nor is the pain accentuated by dorsiflexion of the toes as it is in plantar fasciitis [2]. Older adults are prone to atrophy of subcutaneous fat pads, including the heel, however pain due to loss of fat pad cushioning is generally absent in the morning and develops and worsens throughout the day with weight bearing [2]. Piezogenic papules, herniations of fat, may occur along the medial inferior border of the heel and may cause pain on weight bearing [2,26]. Although uncommon, piezogenic papules can be visualized with careful visual inspection and palpation of the foot [2,26,27].

**An Osteopathic Approach and Osteopathic Manipulative Treatment (OMT)**

Osteopathic philosophy emphasizes the holistic treatment of any problem, approached from five interconnected models of care: bio-mechanical, respiratory-circulatory, neurologic, metabolic-energy, and behavioral [21]. These five models allow for a thorough evaluation of the causes and remedies for plantar fasciitis, and there is considerable overlap in the considerations and interventions for each model. Many conventional treatments for plantar fasciitis, such as physiotherapy, iontophoresis, radiotherapy, and botulinum toxin injection, fall under one or more of these treatment models as well. Osteopathic physicians (DOs) utilize manual hands-on techniques, broadly termed Osteopathic Manipulative Treatment (OMT), in addressing aspects of these treatment models. While appropriate osteopathic training is necessary to perform OMT, the holistic approach is not limited to DOs, and can be utilized by a variety of health professionals in the evaluation and treatment of plantar fasciitis. The majority of cases respond to conservative, nonsurgical therapies within 6 to 18 months [28-30]. Approximately 5% to 10% of patients do progress to surgical intervention [30]. Key concepts of the five models of plantar fasciitis are presented below, along with a selection of both conventional and OMT procedures that are most likely to benefit patients. Technique procedures are not elaborated in this article and can be found in the referenced texts.

**The Behavioral Model**

Assessment of the patient's emotional, mental, and spiritual state of being, as well as personal lifestyle choices is necessary in the management of plantar fasciitis. Plantar fasciitis can cause significant distress to the patient, especially if it interferes with social and vocational function. Additionally, appropriate recreational activities, diet, and exercise influence the musculoskeletal, metabolic, and neurologic considerations of plantar fasciitis. Astute clinicians should be aware of these factors in the development and treatment of plantar fasciitis. Patients can engage in protective and therapeutic activities on their own as well. While plantar fasciitis can be quite distressing, patient empowerment in treating this condition can improve outlook, while also addressing the other models of care.

The six Ss (shoes, surface, speed, stretching, strength, and structure) are a useful treatment guide for both athletes and non-athletes suffering from plantar fasciitis [31].

**Shoes:** As will be mentioned in the biomechanical model, patients should wear appropriate shoes for their body habitus and activities. Individuals engaging in exercise routines after a long hiatus may grab their old shoes that do not provide sufficient support. It is recommended that running shoes be replaced after 200 miles of use, but the time to this milestone will vary based on the activity level of each patient, and can be quite costly for the active athlete [31]. Instead, a mark placed on the sole of new shoes, half an inch from the bottom will then be compressed with wear of the shoe. When this mark is only one-eighth of an inch from the bottom of the sole, it is time to consider purchasing new shoes [31]. Proper shoe fit is also essential. When sizing shoes, it is best to do so at the end of the day or after a workout, when feet are at their largest after normal daily weight bearing activities [5]. Advise patients to size shoes with three-eighths to half an inch between the end of the shoe and the longest toe to allow for proper glide during impact [5,31]. Shoe structure should flare laterally and medially at the heel and sole for increased stability, with a half-inch foam lift in the heel to take pressure of the Achilles tendon [31].

**Surface:** Harder surfaces such as concrete will place the plantar fascia under more stress than softer surfaces such as grass, and well-maintained tracks [32]. Runners and others engaged in weight-bearing exercise will benefit from switching their exercise routines to softer surfaces that cushion the impact of their footfalls. For those who stand for prolonged periods of time on a hard surface, a cushioned floor mat, in addition to shoe inserts, may decrease pressure on the foot, decreasing plantar fascial stress (Petraglia).

**Speed:** Runners who quickly increase the intensity of their workouts, particular attempts at reducing race times, may push themselves too hard, resulting in plantar fascial and foot strain to which the tissues cannot properly adapt (Petraglia). A thorough discussion of the patient's running schedule should include setting goals for increasing speed and distance that do not increase too quickly, and should be tailored to the individual's physique, prior running regimens, and goals.

**Stretching:** Stretching of lower extremity muscles is important to correct dysfunctions of muscles outside of the foot and ankle that contribute to pain [5,17,31]. Gastrocnemius and Achilles tendon stretches are especially useful and can be performed by having the patient stand facing a wall, with the affected limb extended straight behind them and toes pointed in slightly. The unaffected limb should be bent and the hips lowered until sufficient stretch is felt in the calf. This is held for 30 seconds followed by a 30 second relaxation period. This cycle of stretch and relax should be performed in a set of 4 - 5 repetitions, 2 - 3 times per day, for 3 - 4 weeks [5,15]. Further eccentric stretching of the gastrocnemius and Achilles can be coupled with stretch of the plantar fascia by placing the distal foot on a slightly elevated surface that allows for the heel to hang lower, stretching the gastrocnemius, Achilles tendon, and plantar fascia [7,16]. Patients can also engage in a plantar fascia massage using a tennis ball rolled under the affected foot for 60 - 90 seconds [5]. The patient has control over the pressure placed on the tennis ball to control the massage and stretch of the fascia to tolerable levels of slight discomfort, but not pain [5]. This stretch can alternatively be achieved using a 15 oz can or frozen half-liter water bottle [16].

**Strength:** Intrinsic foot muscle weakness may contribute to excessive burden on the plantar fascia, and can be addressed by towel curls and toe taps [16]. Towel curls are performed by placing a towel flat on a smooth surface and using the toes to pull the towel towards the patient [16]. Toe taps are performed by placing the foot flat on the floor, lifting all toes off the floor and then repetitively tapping the great toe against the floor, then the lateral four toes, and continuing alternating [16]. Exercises such as picking up marbles and coins with the toes are also helpful for foot strengthening [16]. Strengthening of ankle, leg, and thigh muscles will also prevent compensatory burdens on the foot, longitudinal arch, and plantar fascia.

**Structure:** Structural abnormalities may be present, such as calcaneal spurs, however the presence of such abnormalities is neither sensitive nor specific for plantar fasciitis, as previously discussed. Investigation and treatment of structural abnormalities may be warranted for patients not responding to treatment modalities after several weeks [7]. The use of supportive arch taping has been shown to have some effect, when combined with other conservative modalities such as orthotics and NSAIDs [7,16]. Patients with flat feet may benefit from orthotics [7]. Custom orthotics may be necessary, but can be of considerable cost to the patient [7].

**Diet:** A healthy diet that promotes appropriate weight and BMI, and is rich in nutrients for recovery and healing from workouts and injuries is essential towards metabolic balance. Dietary practices and medical conditions that limit the consumption and absorption of nutrients should be addressed, as will be discussed in the metabolic-energy model.

**Smoking cessation:** Smoking negatively affects respiratory and cardiovascular health, limiting tissue oxygenation and nutrient delivery. Additionally, smoking promotes inflammation in tissues.

### The Biomechanical Model

The biomechanical model of Osteopathy identifies and treats musculoskeletal dysfunctions to improve the motion of joints, muscles, and fascia. As mentioned above, a thorough evaluation of the foot, ankle, leg, knee, and thigh should be completed as dysfunction from these areas can contribute to the development or maintenance of plantar pain (DeStefano). Dysfunctions of the lumbar spine may also be present, although these are discussed further in the neurologic model [17]. Specific osteopathic techniques which can be employed in the treatment of plantar fasciitis include strain counter strain (SCS), muscle energy, myofascial release (MFR), Balanced Ligamentous Tension/Ligamentous Articular Strain (BLT/LAS), and articular techniques including high velocity low amplitude (HVLA).

**Strain Counter Strain:** SCS procedures involve identifying tender points in the tissue and passively positioning the tissue to approximate the bony attachments of muscle, taking advantage of natural neuromuscular reflex arcs to relax tissues [17,21,24,33]. Tender points amenable to counter strain treatment are found at the insertion of the plantar fascia at the calcaneus, as well as in the belly of the quadratus plantae muscle [17,24]. Patients often report significant improvement in plantar fasciitis pain after treatment [34]. SCS treatment should also be directed toward dysfunctions of muscles of the leg, such as the anterior and posterior tibialis muscles, peroneus muscles, and gastrocnemius, as well as the more proximal quadriceps and hamstrings of the thigh. Iliopsoas dysfunction is also commonly found in lower extremity concerns [17]. Such dysfunctions may initiate, perpetuate, or mimic plantar fascial dysfunction [33]. For example the tibialis anterior adds support to the longitudinal arch of the foot and attaches at the navicular and first cuneiform bones [31].

**Muscle Energy:** Muscle energy techniques employ active patient participation in the form of an isometric force against physician resistance, and are especially useful in reducing hypertonicity of muscle groups, particularly in the extremities. Osteopathic muscle energy techniques bear a great resemblance to those utilized by physical therapists and athletic trainers. Common muscular dysfunctions amenable to muscle energy treatment overlap significantly with those amenable to SCS treatment, including the anterior and posterior tibialis muscles, peroneus muscles, gastrocnemius, quadriceps, iliopsoas, and hamstrings [17]. Dysfunctions of these muscles may be prominent in athletes, dancers, and gymnasts, and may perpetuate or mimic plantar fasciitis [2,33].

**Myofascial Release:** MFR treatments have also shown promise in the treatment of plantar fasciitis [35]. MFR techniques may be performed to engage tissue tension or to hold tissues in the direction of the tension, known as direct and indirect variants of MFR, respectively (Nicholas and Nicholas). Plantar fasciitis can be approached with a direct application of MFR, with the physician applying distal and medio-lateral traction on the plantar fascia and overlying soft tissue and skin (Nicholas and Nicholas). Myofascial restrictions should also be investigated and treated in the ankle, leg, and knee. Tibiofibular dysfunction can be treated with indirect MFR in the treatment of knee and other lower extremity dysfunctions [17].

**Balanced Ligamentous Tension/Ligamentous Articular Strain:** ABLT and LAS techniques can resolve ligamentous strains in the lower extremity through positioning of bony attachments to reduce and naturally rebalance tension in ligamentous structures through sclerotomal neurologic reflexes [17,21,24,33]. Useful areas of focus include the metatarsals and interosseus membrane between the tibia and fibula. Of course, the calcaneus must not be ignored, and dysfunctions may be treated with the Boot Jack technique, which also balances tensions between the metatarsals, tarsals, and between the foot and lower leg [36].

**Articulatory and HVLA:** Misalignment and malrotation of lower extremity bones, especially those of the foot, ankle, and leg can disrupt normal tensions in tendons and ligaments, leading to pain. The bones of the foot represent key treatment areas in foot pain and plantar fasciitis in particular because of their ligamentous and muscular attachments within the arches [31]. High velocity, low amplitude (HVLA) thrust techniques or articulation of the joints by repetitively engaging the barrier, reduces pain and restores motion. Areas that warrant assessment include the cuneiforms, which may be treated with the Hiss-whip technique, the cuboid and navicular bones, which are treated with a similar whipping technique, and dysfunctions of the metatarsals, and tibiotalar and fibulotalar dysfunctions [31,37].

### Yoga

Functional postures and movements in yoga can help build and strengthen plantar arches, restore appropriate alignment, and biomechanics of the foot and remaining lower extremity. One case study showed that following a daily yoga program with the following postures for 2 weeks improved plantar fascia pain significantly. The program included: *tadasana* (mountain pose), *adho mukha svanasana* (downward facing dog), *baddha konasana* (bound angle pose), *supine half lotus*, and *virabhadrasana I* (warrior I) [38].

### Conventional Physiotherapy

Conventional physiotherapy includes rest, ice, and contrast bath, where the foot alternates between hot, cold, and hot immersions [32]. Stretching exercises of the plantar fascia and calf muscles can be performed at home [2,32]. Ensure that patients have shoes that offer appropriate support for their body habitus and activities. Patients should also avoid the use of flat shoes and barefoot walking, instead opting for cushion- or crepe-soled shoes, with or without the inclusion of prefabricated heel shoe inserts and cups, or arch supports [2,32]. As repetitive microtrauma is often implicated in the initiation and maintenance of plantar fasciitis, a careful assessment and modification of daily physical activities is a necessary element of management. This is discussed previously in the “six Ss” of the behavioral model. Short term use of nonsteroidal anti-inflammatory drugs (NSAIDs) is reasonable and shows benefit for short-term relief when combined with other conservative modalities, but long-term use should be reserved for patients with known systemic rheumatic disease [2,7].

### Extracorporeal Shock Wave Therapy

Radial or focal shock wave therapy has also been considered for patients not responding to initial nonsurgical treatment, with a decrease in morning pain showing only a small statistically significant benefit that is more effective than placebo [2,5]. Success rates in the literature range from 50 to 94 percent, however controlled and blinded trial evidence is lacking [2,39]. Hypothesized mechanisms of therapeutic effect include destruction of calcifications, and mechanotransduction initiated tissue regeneration and remodeling of tendons [39]. Complications include transient pain and skin redness during and after treatment [39]. Regional anesthesia for the procedure has been associated with precordial pain and superficial skin infection [39]. Dysesthesia, swelling, ecchymosis and/or petechia, severe headache, and a throbbing sensation have also been reported after treatment [39]. Complications are generally limited, however long-term complications are currently unknown [39].

### Surgical Management

Surgery is generally reserved for patients with 6 to 12 months of refractory dysfunction [2]. Approximately 2 to 5 percent of patients with plantar fasciitis progress to the need for surgical intervention [2]. Various surgical procedures for plantar fasciitis are currently used in practice, including open or closed, partial or complete, plantar fascia release with or without excision of abnormal tissue and nerve decompression [2]. Calcaneal spur resection may also be included, however data does not support calcaneal spurs as a causative factor, nor is resection supported as a curative measure [2,5]. While 75 percent of case studies reporting favorable outcomes, patients may suffer from prolonged recovery time and persistent pain [2]. Data from controlled trials of surgical management are lacking [2].

### The Metabolic-Energy Model

Cellular, tissue, and organ systems have various energy and metabolic demands which must be met to achieve proper homeostatic and healing responses [21]. Musculoskeletal and connective tissue dysfunction impedes neuroendocrine and immunological functioning [21]. Appropriate nutrition can promote normal biochemical processes that improve healing and reduce inflammation. Nutritional status is especially important with peripheral nerve dysfunction secondary to nutrient deficiencies such as vitamin B12 [2,25]. Proper nutrition is also essential to achieving and maintaining a healthy weight, which is especially important for obese individuals suffering from plantar fasciitis due to the excess weight-bearing activity that must be supported by the foot arches.

Excessive weight can overload the mechanical truss of the plantar fascia and the longitudinal arch, particularly in individuals that work on their feet. Obese and overweight individuals may also experience new onset plantar fasciitis when initiating an exercise regimen as well. Exercise regimens are discussed in the behavioral model. Dietary modification can help with reducing weight prior to initiating prolonged weight-bearing exercises such as walking or jogging, which are already known to stress the plantar fascia and longitudinal arch [32]. Lower impact regimens for weight loss include cycling or swimming [32].

Anti-inflammatory foods include foods high in Omega-3 fatty acids, such as cold water fish, flaxseed, and walnuts. Additionally, dark leafy greens, brightly colored vegetables and fruit (peppers, carrots, beets, berries, melons, citrus fruit), and whole grains have shown anti-inflammatory benefit in patients without contraindications to consuming these foods [40,41]. There is also evidence suggesting the anti-inflammatory properties of commonly used spices, including turmeric, ginger, rosemary, oregano and cayenne [40,41]. Certain foods should be avoided because of a pro-inflammatory tendency. Patients should be counseled on reducing intake of foods high in trans-fats and Omega-6 fats, processed and red meats, dairy products, partially hydrogenated oils, and corn, cottonseed, grapeseed, peanut and soy oils, refined/white carbohydrates, sodas and juices [40,41].

Glucosamine with hyaluronic acid, as well as collagen supplementation may also be beneficial [42].

Topical use of capsaicin, the active compound in chili peppers, has been shown to be superior to placebo in chronic low back pain and pain from osteoarthritis when used in low concentrations (0.025% to 0.075%), and may be beneficial for the patient with plantar fasciitis [43]. Topical use of arnica montana has also been shown in a double-blind randomized trial of 204 patients to be comparable in efficacy to topical 5% ibuprofen in patients with hand osteoarthritis, and may also be an alternative to systemic and topical NSAIDs in the treatment of plantar fasciitis [43]. Mild to moderate skin reactions may occur with topical capsaicin and arnica montana use, and are generally self-limited [43].

Address nutritional deficiencies - Nutritional deficiencies, particularly vitamin B12 deficiencies, can result in abnormal nociception of peripheral nerves. Patients with conditions affecting the intake or absorption of vitamin B12 should be addressed, as these may exacerbate pain already present from plantar fasciitis. These conditions include alcohol abuse, pernicious anemia, strict vegetarian or vegan diets lacking in fortified grains, gastric bypass surgery, and malabsorptive conditions such as celiac or Crohn's disease [2,25].

Address comorbidities that promote inflammation or disrupt healing - Metabolic derangements can also alter healing. In individuals with risk factors or signs and symptoms, diabetes, renal, and endocrine dysfunctions should be ruled out. Smoking can also be addressed from the metabolic model as it promotes inflammation of many tissues beyond cardiovascular and respiratory tissues.

### **Glucocorticoid Injections**

Glucocorticoid injections are commonly recommended when conservative options fail after four weeks of therapy [2]. Tender points along the plantar fascia are injected with glucocorticoid alone, or mixtures of glucocorticoid and local anesthetic, resulting in short-term pain relief, as well as glucocorticoid-mediated reduction of inflammation. Randomized trials suggest significant pain control and four-week follow up with mixtures, while long-term benefit was found in single injection of glucocorticoid alone at 12 weeks [2]. These trials did not suggest a difference in palpation- versus ultrasound-guided injection, nor was there a difference in single versus peppered injection of glucocorticoid [2]. Judicious use of glucocorticoids is necessary given the risk of heel pad atrophy and rare cases of plantar fascia rupture [2,5]. Common adverse effects of injection include pain, minor subcutaneous bleeding, and risk of infection.

### **Iontophoresis with Dexamethasone**

Iontophoresis involves the delivery of medicine without the use of traditional needles and syringes [20]. Instead, it utilizes a low voltage galvanic current to stimulate the tissues and drive the medicine, typically a topical corticosteroid, into the soft tissue structure [20]. This is achieved because of the polarity of these molecules responding to the small electrical current, in one of two processes known as electromigration, useful for the delivery of charged molecules, and electroosmosis, which is useful for the delivery of neutral but polar molecules across cell membranes [20]. Iontophoresis over a two week period has been shown to be more effective in decreasing pain and improving function compared to conventional physiotherapy alone [20]. The long term effects of iontophoresis have not been well documented at four-week follow up, and is therefore not strongly recommended as a long term solution at this time [2].

### Dry Needling of Myofascial Trigger Points

As described previously, patients suffering from plantar fasciitis may develop myofascial trigger points - hyperirritable, tender points in taut fascia that refer pain when palpated or compressed by weight-bearing activities [14]. Traditional Chinese medicine has utilized acupuncture, as well as dry needling for the treatment of musculoskeletal pain associated with trigger points [14,44]. Dry needling has been reported to alter the biochemical and electrical environment within myofascial trigger points of skeletal muscle and ligaments, including a reduction in substance P and increase in beta-endorphin levels and blood flow [14]. A meta-analysis of seven trials showed that dry needling of myofascial trigger points resulted in significant pain reduction compared to placebo, with maintenance of pain relief at 12-month follow up [14]. Data on the effectiveness of dry needling versus injection is lacking, however [14]. Common adverse effects of dry needling include pain, minor subcutaneous bleeding, and risk of infection.

### Radiotherapy

Radiotherapy is an attractive treatment for patients that utilizes low doses for pain relief [45]. Concerns regarding radiotherapy have centered on possible carcinogenic effects of ionizing radiation [45]. Compared to doses used for cancer treatments, radiotherapy in the treatment of plantar fasciitis has a lower irradiated volume, fraction, and total dose of radiation [45]. The therapeutic benefit is via anti-inflammatory effects that decrease activity of mononuclear immune cells including lymphocytes, macrophages, monocytes, and capillary endothelial cells [45]. Low dose radiotherapy is relatively inexpensive and simple to implement, with no reported signs of acute or late toxicity, and case reports suggesting analgesic effect persisting for several years after treatment [45].

### The Neurologic Model

Aberrancies and impairments of neural function can perpetuate pain, and lead to autonomic imbalance of respiratory, circulatory, and metabolic functions [21]. The human mind is so intricately tied to proper neurologic functioning, that organic causes of behavioral dysfunction should be investigated when indicated. Osteopathic treatment focuses on the reduction of mechanical stresses, balance of neural inputs, and elimination of nociceptive drive [21]. Several areas of the body may be addressed in the treatment of plantar fasciitis.

**Rib raising:** In addition to its role in improving chest wall movement during respiration, rib raising is also tied to balance of the autonomic nervous system via direct stimulation of the sympathetic chain ganglia lying anterior to the ribs between the rib heads and costovertebral articulations [21]. This stimulation ultimately leads to a decrease in sympathetic nervous system influences [21].

**Lumbar dysfunctions:** Sympathetic tone to the lower extremities has been specifically mapped to the first and second lumbar nerve roots and sympathetic ganglia in this region [21]. Furthermore dermatomal and sclerotomal innervation to the lower extremities is via lumbar and sacral nerve roots [21]. Chronic nociceptive input from the periphery, as in plantar fasciitis, can also facilitate segmental dysfunction in the lumbar spine, and once in a dysfunctional state, segments of the lumbar spine can facilitate an abnormal, decreased threshold for nociceptive input from the periphery, including the plantar fascia. This phenomenon is known as a somato-somatic reflex [21]. Therefore it is important to address lumbar dysfunctions that perpetuate abnormal neural reflex arcs contributing to pain.

**Craniosacral treatments:** The sacrum provides parasympathetic influence to the lower extremities via the second, third, and fourth sacral nerve roots [21]. As previously mentioned, a balance must be struck between sympathetic and parasympathetic influence of the tissues. Treatment modalities for the sacral dysfunctions include muscle energy, HVLA, myofascial release, and sacral rocking. The dural and attachments to both the occiput and sacrum, as well as the continuous flow of CSF from the cranium through the spinal cord to the sacrum may necessitate additional evaluation and treatment of cranial dysfunctions, as first described by Dr. William Garner Sutherland [21,46]. Additionally, because the vagus nerve exits the cranium via the jugular foramen in proximity to the occipital condyles and anterior to the transverse processes of C1 and C2, musculoskeletal restrictions of the occipitoatlantal joint (occiput on C1) as well as the atlantoaxial joint (C1 on C2) should be addressed to improve vagal parasympathetic influences on respiratory, circulatory, and other functions of homeostasis [21].

### Botulinum Toxin Injection

Botulinum toxin A inhibits presynaptic release of acetylcholine and substance P at the neuromuscular junction, resulting in muscular weakness of the flexor digitorum brevis muscle and analgesia, respectively [47]. Botulinum toxin A injected directly into soft tissue is also reported to have anti-inflammatory properties at the site of injection [2,47]. Compared with placebo saline injection, botulinum toxin A injection has resulted in significantly better improvement in foot function and pain status [2,47]. Botulinum toxin A also lessened the need for surgical management [47]. Compared to glucocorticoid injection, botulinum toxin A had comparable benefit at one-month follow up [2]. Common adverse effects of injection include pain, minor subcutaneous bleeding, risk of infection, and effects of the toxin on nearby structures via diffusion [48,49].

### The Respiratory-Circulatory Model

The respiratory-circulatory model of Osteopathy seeks to normalize homeostatic responses to pathophysiologic conditions with a focus on arterial supply, venous and lymphatic drainage, and even the proper flow of cerebrospinal fluid to support normal central nervous function [21]. Respiratory and circulatory functions are integral to the regulation of inflammatory and tissue healing process which are disrupted in plantar fasciitis. Osteopathic treatment should focus on improving arterial supply that nourishes pathologic tissue, and venous and lymphatic drainage of excess inflammatory mediators and debris from damaged tissue.

General respiratory-circulatory considerations should address conditions that affect oxygenation and delivery of blood to tissues. Patients with both obstructive and restrictive pulmonary pathology will suffer from decreased oxygenation and gas exchange within the lungs and at the capillary alveolar interface. Mechanical obstructions to breathing, such as obesity and abnormal spinal curvatures should also be addressed. Circulatory compromise can be present in many systemic disorders, including uncontrolled diabetes and hypertension. Appropriate management of these conditions is also necessary. Smoking cessation should be advised to reduce adverse effects on the circulation including vasospasm and atherosclerosis, and generalized inflammation.

**Lymphatics protocol:** A thorough assessment and treatment of the lymphatic drainage to the lower extremities is beneficial in the treatment of plantar fasciitis. Lymphatic drainage of the lower extremities ultimately reaches the main circulation via the thoracic duct, which drains at the intersection of the left internal jugular vein and left subclavian vein [21]. This area, known as the thoracic inlet, is intimately influenced by the surrounding skeletal, muscular, and fascial tissues, including the clavicle, first rib, neck muscles such as the sternocleidomastoid and scalenes, and the fascia of the supraclavicular fossa. Addressing dysfunctions of the structures of the thoracic inlet is prudent, and may be achieved through myofascial release, supraclavicular fossa stretching, and treating dysfunctions of the first rib, neck muscles, and clavicle.

**Rib and diaphragm dysfunctions:** Pressure gradients between the abdomen and thorax are created by the motion of the diaphragm and movement of the chest wall during the respiratory cycle. These pressure gradients drive lymphatic and venous return to the heart [21]. Dysfunctions of the ribs or diaphragm that disrupt normal chest wall movement and pressure gradients should be addressed to improve venous and lymphatic drainage of the lower extremities.

**Rib raising procedures:** Dysfunctions of the costotransverse articulation can limit chest wall movement during the respiratory cycle [21]. The Osteopathic technique of rib raising improves the articular motion at these joints, enhancing chest wall movement.

**Pelvic diaphragm release:** The levator ani muscles form the anatomic and functional inferior border of the pelvis [21]. While their role in genitourinary and hindgut dysfunction is well understood, another equally important function of these muscles is as a horizontal barrier between the lower extremities and the torso. Therefore dysfunction of the pelvic diaphragm should be assessed and treated to improve circulation of the lower extremities. The pelvic diaphragm myofascial release is a common technique utilized to treat dysfunctions of the levator ani musculature [21].

**Myofascial release of the popliteal fossa:** Continuing down the lower extremity, the myofascial structures of the popliteal fossa surround the popliteal vessels, and therefore any restriction of this fascia can impede lower extremity circulation.

Immersion contrast baths, as described under conventional physiotherapy in the biomechanical model, will also aid in improving the circulation of the foot.

### Autologous Whole Blood or Platelet-Rich Plasma Injections

The presence of growth factors in autologous whole blood and platelet-rich plasma solutions is theorized to nourish tissues and stimulate angiogenesis and healing, however clinical trials have not shown significant efficacy in symptom reduction when compared to glucocorticoid injection [2]. Studies have also lacked appropriate blinding and control groups did not show expected improvement in condition over the normal time-course of self-limited plantar fasciitis [2]. Therefore, this treatment modality cannot be strongly recommended at this time.

### Conclusion

Plantar fasciitis is a painful and distressing condition affecting approximately ten percent of the population at some point in their life. A result of repetitive biomechanical stress, a thorough investigation into all of the factors influencing its development, perpetuation, and healing is necessary. While surgical management may be necessary for some patients, the majority will benefit from a holistic and conservative approach to management. Osteopathic manipulation can correct or mitigate many structural abnormalities and musculoskeletal dysfunctions that contribute to plantar fasciitis. However, even those not trained in Osteopathic manipulation can also provide holistic care to their patients by addressing the behavioral, biomechanical, metabolic/energetic, respiratory-circulatory, and neurologic factors at play in plantar fasciitis, enhancing the natural healing processes of the body.

### Bibliography

1. Buchbinder R: "Clinical Practice: Plantar Fasciitis". *The New England Journal of Medicine* 350.21 (2004): 2159-2166.
2. Buchbinder R. "Plantar fasciitis". UpToDate (2017).
3. Schumacher U, et al. "Atlas Of Anatomy". 2<sup>nd</sup> Edition Thieme, New York (2012).
4. David RC. "Sports Injury Assessment and Rehabilitation". 1<sup>st</sup> Edition Churchill-Livingston, New York (1992).
5. Hubbard M and Armstrong A. "Essentials of Musculoskeletal Care". Rosemont, IL: American Academy of Orthopaedic Surgeons (2016).
6. Roberts S. Textbook on Plantar Fasciitis, Heel Spurs, and Heel Pain (2009).
7. Hyland MR, et al. "Randomized Control Trial of Calcaneal Taping, Sham Taping, and Plantar Fascia stretching for Short-Term Management of Plantar Heel Pain". *Journal of Orthopaedic and Sports Physical Therapy* 36.6 (2006): 364-371.
8. Goff J and Crawford R. "Diagnosis and treatment of plantar fasciitis". *American Family* 84.6 (2011): 676-682.
9. Lemont H., et al. "Plantar Fasciitis: A Degenerative Process (Faciosis) without Inflammation". *Journal of the American Podiatric Medical Association* 93.3 (2003): 234-237.
10. Cook JL and Purdam CR. "Is Tendon Pathology a Continuum? A Pathology Model to Explain the Clinical Presentation of Load-Induced Tendinopathy". *British Journal of Sports Medicine* 43.6 (2009): 409-416.

11. Snider MP, *et al.* "Plantar Fascia Release for Chronic Plantar Fasciitis in Runners". *American Journal of Sports Medicine* 11 (1983): 215-219.
12. Monto RR. "Platelet Rich Plasma Treatment for Chronic Achilles Tendinosis". *Foot and Ankle International* 33.5 (2012): 379-385.
13. Gosens T, *et al.* "Ongoing Positive effect of Platelet Rich Plasma versus Corticosteroid Injection in Lateral Epicondylitis: a Double Blind Randomized Controlled Trial with 2 Year Follow-up". *American Journal of Sports Medicine* 39.6 (2011): 1200-1208.
14. He C and Ma H. "Effectiveness of trigger point dry needling for plantar heel pain: a meta-analysis of seven randomized controlled trials". *Journal of Pain Research* (2017).
15. Xu Y and Murrell GA: "The Basic science of Tendinopathy". *Clinical Orthopaedics and Related Research* 466.7 (2008): 1528-1538.
16. Young C., *et al.* "Treatment of plantar fasciitis". *American Family Physician* 63.3 (2001): 467.
17. Glonek T and Nelson K. "Somatic Dysfunction". In *Osteopathic Family Medicine*. Philadelphia: Wolters Kluwer Health/ACOPP. American College of Osteopathic Family Physicians (2015).
18. Roxas M "Plantar Fasciitis: Diagnosis and Therapeutic Considerations". *Alternative Medicine Review* 10.2 (2005): 83-93.
19. Dyck DD Jr and Boyajian O'Neill LA. "Plantar Fasciitis". *Clinical Journal of Sport Medicine* 14.5 (2004): 305-309.
20. Srivastava N and Joshi S. "Comparison between Effectiveness of Iontophoresis and Conventional therapy in the Management of Plantar Fasciitis". *The Indian Journal of Physiotherapy and Occupational Therapy* 11.1 (2017): 1-5.
21. Chila A. "Foundations of Osteopathic Medicine". Philadelphia: Wolters Kluwer Health/Lippincott Williams and Wilkins (2011).
22. Gibbon WW and Long G. "Ultrasound of the plantar aponeurosis (fascia)". *Skeletal Radiology* 28.1 (1999): 21-26.
23. Sabir N., *et al.* "Clinical utility of sonography in diagnosing plantar fasciitis". *Journal of Ultrasound in Medicine* 24.8 (2005): 1041-1048.
24. Channell M and Mason D. "The 5-Minute Osteopathic Manipulative Medicine Consult". Philadelphia, PA: Wolters Kluwer Health/Lippincott Williams and Wilkins (2009).
25. Skerrett P. "Vitamin B12 deficiency can be sneaky, harmful - Harvard health Blog (2013).
26. Ma DL and Vano-Galvan S. "Piezogenic pedal papules". *Canadian Medical Association Journal* 185.18 (2013): E847
27. Shelley WB and Rawnsley HM. "Painful feet due to herniation of fat". *JAMA* 205.5 (1968): 308-309.
28. Gill LH. "Plantar Fasciitis: Diagnosis and Conservative Management". *Journal of the American Academy of Orthopaedic Surgeons* 5.2 (1997): 109-117.
29. Singh D and Angel J. "Plantar Fasciitis and Achilles Enthesopathy". *Clinical Sports Medicine* (2004).
30. Wearing SC., *et al.* "The Pathomechanics of Plantar Fasciitis". *Sports Medicine* 36.7 (2006): 585-611.
31. Kuchera W and Kuchera M. "Osteopathic Principles. In Practice Kirksville, Mo: Kirksville College of Osteopathic Medicine (1992).
32. Sonu P and Aman. "Physiotherapy Treatment in Plantar Fasciitis: A Case Report". *The Indian Journal of Physiotherapy and Occupational Therapy* 9.1 (2015): 54-58.
33. DeStefano. "Greenman's principles of manual medicine". 4<sup>th</sup> edition. Wolters Kluwer, Baltimore (2011).

34. Wynne MW, et al. "Effect of counterstrain on stretch reflexes, hoffman reflexes, and clinical outcomes in subjects with plantar fasciitis". *Journal of the American Osteopathic Association* 106.9 (2006): 547-556.
35. Shah H. "A Study on the effect of Myofascial Release in Plantar Fasciitis". *The Indian Journal of Physiotherapy and Occupational Therapy* 8.2 (2014): 261-266.
36. Speece CA, et al. "Ligamentous Articular Strain: Osteopathic Manipulative Techniques for the Body". (2001).
37. Kimberly P, et al. "Outline Of Osteopathic Manipulative Procedures : The Kimberly Manual". Kirksville, Mo: A.T. Still University of Health Sciences, Kirksville College of Osteopathic Medicine, Department of Osteopathic Manipulative Medicine (2009).
38. Stallworth C. "Therapeutic Yoga for Plantar Fasciitis: A Case Report". *Yoga Therapy in Practice* 1.1 (2005): 4.
39. Roerdink R, et al. "Complications of extracorporeal shockwave therapy in plantar fasciitis: Systematic review". *International Journal Of Surgery* 46 (2017): 133-145.
40. Raket D. "Integrative medicine, 3<sup>rd</sup> edition". Philadelphia, PA, Elsevier (2012).
41. Weil A. "What is the Anti-Inflammatory Diet and Food Pyramid?". (2017).
42. Johnson JJ, et al. "Glucosamine In Treatment Of Plantar Fasciitis: A Pilot Study". *Medicine and Science In Sports and Exercise* 38.5 (2006): S87.
43. Zempsky W. "Use of Topical Analgesics in Treating Neuropathic and Musculoskeletal Pain". *Pain Medicine News* (2013).
44. Solomon M and Goff J. "Acupuncture May Be Helpful for Patients with Plantar Fasciitis". *American Family* 85.10 (2012): 1.
45. Kedzierawski P, et al. "Retrospective Evaluation of the Effectiveness of Radiotherapy in Patients with Plantar Fasciitis (Heel Spurs)". *Reports of Practical Oncology and Radiotherapy* 22.3 (2017): 209-211.
46. Hall J and Guyton A. "Guyton and Hall Physiology Review". Elsevier (2011).
47. Ahmad J, et al. "Treatment of Plantar Fasciitis with Botulinum Toxin A: A Randomized, Controlled Study". *Foot and Ankle International* 38.1 (2016): 1-7.
48. Sundaram H, et al. "Global Aesthetics Consensus: Botulinum Toxin Type A- Evidence-Based Review, Emerging Concepts, and Consensus Recommendations for Aesthetic Use, Including Updates on Complications". *Plastic and Reconstructive Surgery* 137.3 (2016): 518-529.
49. Bartold SJ. "Plantar Heel Pain Syndrome: Overview and Management". *Journal of Bodywork and Movement Therapies* (2004).

**Volume 9 Issue 3 March 2018**

**©All rights reserved by Leonard B Goldstein, et al.**