Keeping Bodies in Motion®

by Joshua Dubin, DC, CCSP, CSCS

SPORTS THERAPY

Evidence Based Treatment for Plantar Fasciitis

Review of Literature

ABSTRACT

Plantar fasciitis, a repetitive strain injury of the medial arch and heel, is one of the most common causes of foot pain. The function of the plantar fascia is twofold: statically, it stabilizes the medial longitudinal arch; dynamically, it restores the arch and aids in reconfiguring the foot for efficient toe-off. When this tissue becomes damaged, pain and/or weakness may develop in the area. Risk factors of plantar fasciits include structural abnormalities, overweight, age-related degenerative changes, occupations or activities that require prolonged standing and/or ambulation, and training errors. Literature indicates that plantar fasciitis may be successfully treated using a conservative approach. In recalcitrant cases of plantar fasciitis, however, surgical treatment may be necessary to return the patient to normal activities of daily living or sport. This paper will review the anatomy and kinematics of the foot and ankle, outline common causes of plantar fasciitis, and describe viable treatment and prevention options.

Fig. 1A *Superficial Plantar Muscles of the Foot*

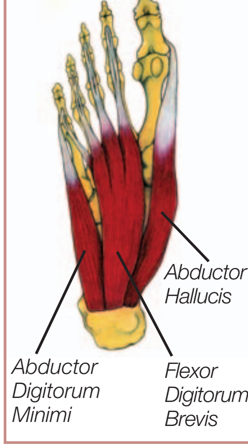
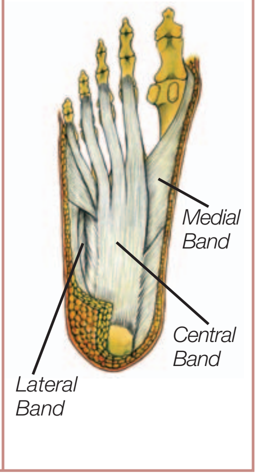


Fig. 1B *Plantar Fascia*



INTRODUCTION

Plantar fasciitis is a common occupational or sport-related repetitive strain injury. Approximately 2 million people in the US are treated annually for plantar fasciitis.[1,2,3,4] The chief initial complaint is typically a sharp pain in the inner aspect of the heel and arch of the foot with the first few steps in the morning or after long periods of non-weight bearing. Usually, after walking approximately ten to twelve steps the plantar fascia becomes stretched and the pain gradually diminishes. However, symptoms may resurface as throbbing, a dull ache, or a fatigue-like sensation in the medial arch of the foot after prolonged periods of standing, especially on unyielding cement surfaces.[5,6,7,8]

The plantar fascia is a thick, fibrous, relatively inelastic sheet of connective tissue originating from the medial heel, where it then passes over the superficial musculature of the foot and inserts onto the base of each toe (figures 1A and 1B). The plantar fascia is the main stabilizer of the medial longitudinal arch of the foot against ground reactive forces, and is instrumental in reconfiguring the foot into a rigid platform before toe-off.[4,9,10] Under normal conditions, the plantar fascia performs this function appropriately without incurring injury.

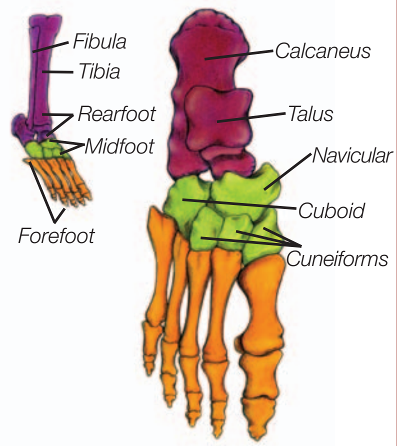
Some risk factors of plantar fasciitis include faulty mechanics of the foot due to structural abnormalities, age-related degenerative changes, overweight, training errors, and occupations involving prolonged standing; those falling into this category include teachers, construction workers, cooks, nurses, military personnel, and athletes training for long distance running events.[7,8,11,12,13,14] In the presence of these risk factors, excessive tensile forces may cause micro-tears in the plantar fascia. Repetitive trauma to the plantar fascia exceeding the fascia's ability to recover may lead to degenerative changes and an increased risk of injury.[5,15,16] Implementation of a conservative treatment and preventative protocol has been shown to be effective in resolving or reducing the symptoms associated with plantar fasciitis.[17,18]

An understanding of the anatomy and kinematics of the foot and ankle, the static and dynamic function of the plantar fascia during ambulation, and knowledge of the contributing risk factors associated with plantar fasciitis aid in developing a proper treatment and preventative protocol for this condition.

ANATOMY OF THE PLANTAR FASCIA AND THE MEDIAL LONGITUDINAL ARCH OF THE FOOT

The foot and ankle can be divided into the rearfoot, midfoot, and forefoot. The rearfoot consists of four bones: the distal aspect of the tibia and fibula (leg bones), the calcaneus (heel bone), and the talus. The midfoot consists of five bones: the cuboid, navicular, and three cuneiforms. The forefoot consists of nineteen bones: five metatarsal bones and fourteen phalanges (figure 2). The plantar fascia originates from the medial calcaneal tuberosity, dividing into a medial, central, and lateral band that attaches to the superior surface of the abductor hallucis, flexor digitorum brevis, and abductor digiti minimi musculature, respectively. The fascia then splits into five slips that cross the metatarsophalangeal joints and inserts onto the phalanges of digits # 1-5.[1,8,19,20]

Fig. 2 Bones of the Foot and Ankle



The foot has a visible medial longitudinal arch (MLA) that aids in distributing the force attributed to weight bearing. The MLA of the foot resembles two rods: a rear rod consisting of the calcaneus and talus, and an anterior rod consisting of the navicular, three cuneiforms, and the first three metatarsals. These rods are connected at their base by the plantar fascia. When force is applied to the apex of the MLA, the arch depresses, the two rods separate, and tension is distributed throughout the plantar fascia[8,21] (figures 3A, 3B). The main ligaments that aid in supporting the MLA are the long and short plantar ligaments and the calcaneonavicular ligament (spring ligament) (figure 4). During static stance the MLA is supported by the plantar fascia, the ligaments, and the osseous architecture of the foot.[1,8,20] During late ambulation, the plantar fascia assumes a dynamic role in reconfiguring both the MLA and the rearfoot in preparation for toe-off.[22,23]

Fig. 3A Diagram illustrating the Medial Longitudinal Arch. The Calcaneus and Talus represent the posterior rod; the Navicular, Cuneiforms, and the first three Metatarsals represent the anterior rod. The Plantar Fascia connects the bases of the two rods.

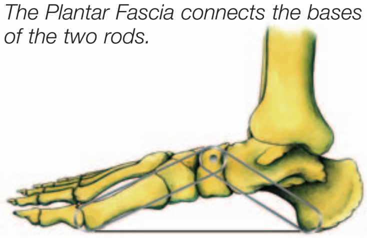
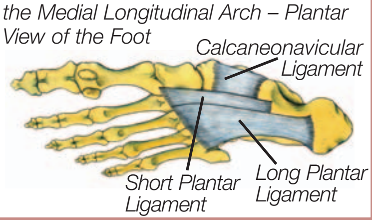


Fig. 3B Diagram illustrating flattening of the Medial Longitudinal Arch, causing separation of the bases of the anterior and posterior rods, placing an increased strain on the Plantar Fascia

Fig. 4 Ligaments that aid in supporting the Medial Longitudinal Arch – Plantar View of the Foot



BIOMECHANICS OF THE FOOT AND ANKLE DURING AMBULATION

A runner's gait can be separated into two phases: the stance phase and the swing phase. During the stance phase, the foot contacts and adapts to the ground surface; during the swing phase, the leg accelerates forward and prepares for ground contact. The stance phase consists of the following four sub-phases: initial contact, loading response, midstance, and terminal stance. During initial contact, the heel contacts the ground surface. The loading response occurs immediately after initial contact, ending when the contralateral foot lifts off of the ground surface. The midstance phase starts when the contralateral foot lifts off of the ground surface; the contralateral leg is now the swing leg. The midstance phase ends as the tension on the gastrocnemius, soleus, and achilles tendon (triceps surae) of the stance leg causes the heel to lift off of the ground surface. The terminal stance phase begins when the heel lifts off of the ground and ends when the swing leg contacts the ground. (figure 5).[19,20,24] The plantar fascia and extrinsic and intrinsic musculature of the foot play an active role in guiding the foot as it transitions from initial contact to toe-off. Efficient function of the plantar fascia and musculature of the foot depends on the configuration of the rearfoot and midfoot articulations during the different sub-phases of gait.[8,25,26]

Fig. 5 The Stance Phases of Running Gait

The rearfoot is comprised of two joints; the talocrural joint and the subtalar joint. The talocrural joint (ankle mortise) consists of the articulation of the distal aspect of the tibia and fibula with the trochlea of the talus. The talocrural joint allows for two primary movements: dorsiflexion, approximating the tibia to the toes, and plantar flexion, pointing the toes downward (figures 6A, 6B).[8,19,29,27]

The subtalar joint consists of the articulation of the undersurface of the talus with the calcaneus (figures 7A, 7B). Movement of the subtalar joint is pivotal in transforming the foot from a rigid lever during initial ground contact to a mobile shock absorber during loading response and early midstance, and back into a rigid lever as the foot prepares for toe-off. The two primary movements that occur at the subtalar joint (STJ) are pronation and supination. Pronation

Fig. 6A Dorsiflexion of the Talocrural Joint (the talocrural joint is indicated by a red line)

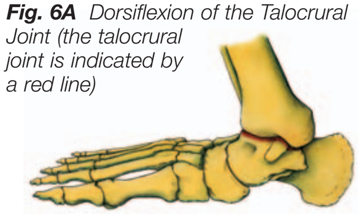
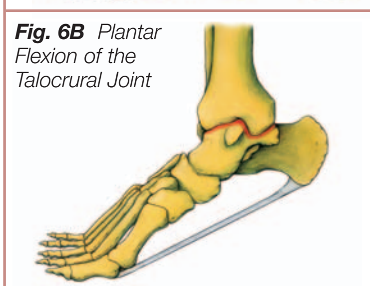


Fig. 6B Plantar Flexion of the Talocrural Joint



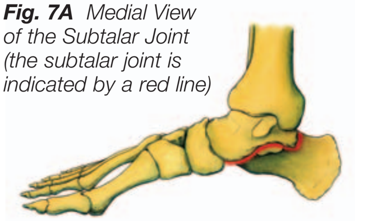


Fig. 7A Medial View of the Subtalar Joint (the subtalar joint is indicated by a red line)

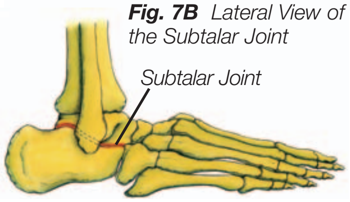


Fig. 7B Lateral View of the Subtalar Joint

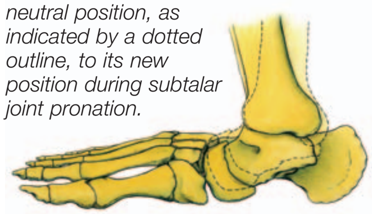


Fig. 7C Diagram illustrating movement of the Tibia, Talus and Navicular from a subtalar joint neutral position, as indicated by a dotted outline, to its new position during subtalar joint pronation.

of the STJ normally occurs during loading response and into early midstance. STJ pronation consists of the following movements: the calcaneus turns outward (eversion); the talus drops downward, distally, and adducts towards the midline; and the talocrural joint dorsiflexes (figure 7C). During initial contact the STJ is normally supinated; it pronates from loading response to early midstance, and then re-supinates later in midstance and into terminal stance. STJ supination consists of the following movements: the calcaneus turns inward (inversion); the talus moves upward, proximally and abducts away from the midline; and the talocrural joint plantarflexes. Freedom of movement of the midfoot is dependent upon the position of the STJ.[8,19,20]

The two main articulations of the midfoot are the talonavicular joint and the calcaneocuboid joint. The midfoot revolves around two joint axes: the longitudinal midtarsal joint angle (LMJA) and the oblique midtarsal joint angle (OMJA). Movement of the midfoot around the LMJA consists of inversion (supination around the LMJA) or eversion (pronation around the LMJA) (figures 8A, 8B, 8C). Movement of the midfoot around the OMJA consists of dorsiflexion and abduction (pronation around the OMJA), and plantar flexion and adduction (supination around the OMJA) (figure 9A, 9B, 9C). STJ pronation during loading response and into early midstance causes the talonavicular joint to diverge and move distally to the calcaneocuboid joint (see figure 7C). This reconfiguration unlocks the midfoot, allowing it to pronate around the OMJA. Pronation of the midfoot around the OMJA will stretch the plantar fascia slightly as the MLA is depressed, transforming the foot from a rigid lever into a mobile adaptor that is better equipped to absorb ground reactive forces. Shortly after early midstance the STJ starts to re-supinate, and should re-supinate back to neutral before terminal stance. STJ re-supination causes the talonavicular joint to move proximally to the calcaneonavicular joint, superimposing these joints, and limiting midfoot and forefoot range of motion. STJ re-supination during midstance locks

Fig. 8A The Longitudinal Midtarsal Joint Angle

Fig. 8B Supination of the Midtarsal Joint around the Longitudinal Midtarsal Joint Angle

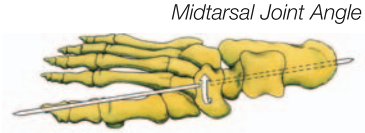
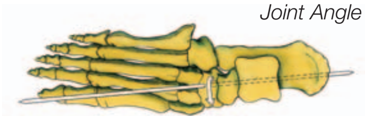


Fig. 8C Pronation of the Midtarsal Joint around the Longitudinal Midtarsal Joint Angle



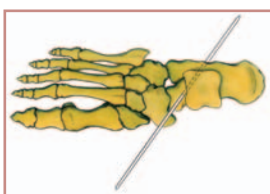


Fig. 9A The Oblique Midtarsal Joint Angle

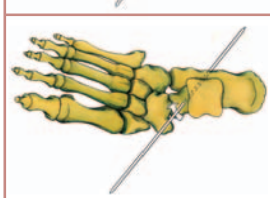


Fig. 9B Pronation of the Midtarsal Joint around the Oblique Midtarsal Joint Angle

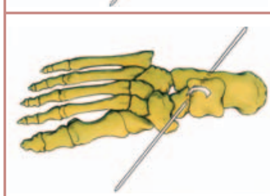


Fig. 9C Supination of the Midtarsal Joint around the Oblique Midtarsal Joint Angle

the lateral column of the foot, including the calcaneocuboid joint, allowing the muscles and fascia of the leg and foot to function more efficiently in guiding the foot into toe-off.[8,19,20]

The peroneus longus and the plantar fascia are actively involved in preparing the foot for toe-off. The tendon of the peroneus longus muscle passes over the outer and plantar aspect of the calcaneocuboid joint and attaches to the undersurface of the base of the first metatarsal (figures 10A, 10B). During late midstance the calcaneocuboid joint functions as a pulley for the tendon of the peroneus longus. This allows the peroneus longus tendon to stabilize the base of the first metatarsal and aid in transferring body weight medially over digits #1-3. The stability of the calcaneocuboid joint pulley system is dependent on re-supination of the STJ during midstance. Later during terminal stance the metatarsophalangeal joint of digit #1 should dorsiflex to approximately sixty-five degrees, causing the distal aspect of the plantar fascia to wrap around the metatarsophalangeal joint. These coordinated movements that occur during terminal stance have been termed the "windlass mechanism".[8,19,20] During the "windlass mechanism," tension on the distal aspect of the plantar fascia is transmitted to its proximal attachment on the medial aspect of the heel, causing the calcaneus to invert and the medial arch to rise as the forefoot re-approximates with the rearfoot.[1,21,23,25] Studies have demonstrated that when thirty-three percent or more of the plantar fascia is surgically released, the medial arch decreases in height and the plantar fascia loses its ability to invert the calcaneus.[21,23,28] During late stance the dynamic action of the peroneus longus and the plantar fascia prepares the foot for an energy-efficient, high-gear toe-off that occurs in a horizontal line over the metatarsophalangeal joints of digits #1-3. Inability of the STJ to re-supinate to neutral before heel lift places an increased load on plantar fascia and peroneus longus as they attempt to stabilize the foot for toe-off. This may predispose the plantar fascia to injury, and also result in a less efficient, low-gear toe-off that occurs in an oblique line over the metatarsophalangeal joints of digits #3, 4 and 5 [8].

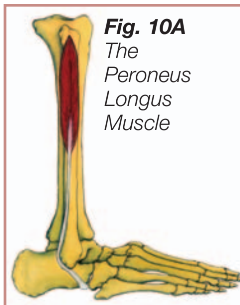


Fig. 10A The Peroneus Longus Muscle

Fig. 10B Plantar View of the Foot and the Peroneus Longus Tendon

Other muscles that help stabilize the MLA and re-supinate the foot include the abductor hallucis, flexor digitorum brevis, flexor digitorum longus, flexor hallucis longus, and tibialis posterior (figures 11A, 11B, 11C). The abductor hallucis and flexor digitorum brevis aid in re-approximating the MLA and stabilizing the foot before toe-off. The flexor digitorum

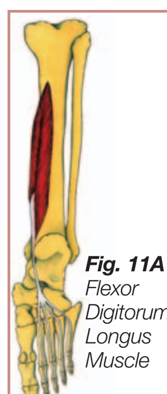


Fig. 11A Flexor Digitorum Longus Muscle

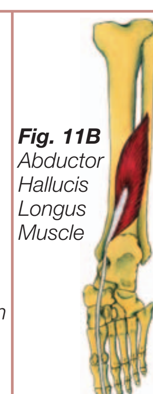


Fig. 11B Abductor Hallucis Longus Muscle

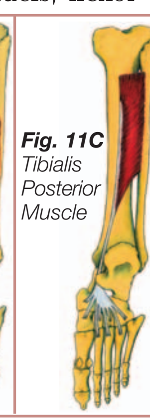


Fig. 11C Tibialis Posterior Muscle

longus, flexor hallucis longus, and the tibialis posterior have tendinous attachment sites near the MLA. The two former muscles are active in resisting pronation from midstance to toe-off, and the tibialis posterior decelerates pronation from loading response to early midstance.[8,19,20]

Under normal circumstances the plantar fascia, plantar ligaments, osseous architecture, and extrinsic and intrinsic musculature of the foot and leg are able to absorb ground reactive forces without incurring injury. However, structural abnormalities may lead to faulty biomechanics of the rearfoot and midfoot. These abnormalities may cause excessive and rapid pronation of the STJ during loading response and into early midstance, or ill-timed pronation that continues into terminal stance. This may lead to an increased strain on the plantar fascia and other supporting structures of the foot, predisposing a person to developing plantar fasciitis. Structural abnormalities associated with excess, prolonged, or ill-timed pronation may include ankle equinous, rearfoot varus, forefoot varus, pes plano valgus, and pes cavus.[1,2,21,29,30]

STRUCTURAL ABNORMALITIES AS RISK FACTORS FOR PLANTAR FASCIITIS

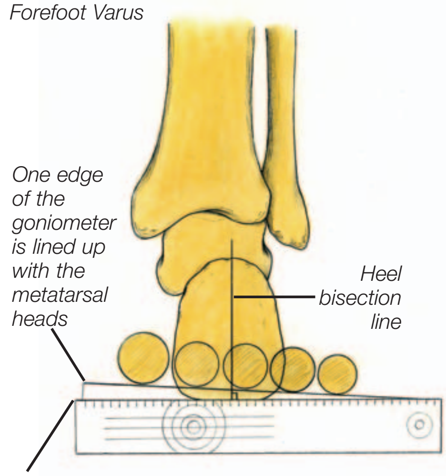
CONDITION	DESCRIPTION	EXPLANATION	CONTRIBUTION TO PLANTAR FASCIITIS
Ankle equinous	A limited range of motion of the talocrural joint in dorsiflexion, most likely caused by diminished flexibility of the triceps surae[15]	Normal range of motion of dorsiflexion of the talocrural joint is twenty degrees. Decreased dorsiflexion of the talocrural joint just before heel lift may be compensated for by pronation of the STJ and pronation of the midfoot around the OMJA. Previous studies have indicated a correlation between a decreased range of motion of talocrural dorsiflexion of less than ten degrees and a predisposition to the development of plantar fasciitis.[8,13,19,20,21,26,30]	May lead to untimely pronation of the rearfoot and midfoot articulations, placing an increased strain on the plantar fascia and other structures of the foot that are attempting to restore the MLA and re-supinate the STJ before toe-off.[8,13,19,20,21,26,30]
Forefoot varus	A situation where the forefoot is inverted in relation to the rearfoot (figure 12).[8,19,20,26]	In order for the forefoot to contact the ground surface, the STJ may continue to pronate into late stance.[8,19,20,26]	May lead to untimely pronation of the rearfoot and midfoot articulations, placing an increased strain on the plantar fascia and other structures of the foot that are attempting to restore the MLA and re-supinate the STJ before toe-off.[8,13,19,20,21,26,30]
Rearfoot varus	An inverted position of the back of the heel (figure 13).[8,19,20,26]	To compensate for a rearfoot varus foot structure, the STJ may pronate rapidly and excessively shortly after initial contact and into early midstance, but is able to re-supinate to neutral by the end of midstance.[8,19,20,26]	May lead to rapid and excessive pronation of the STJ shortly after initial contact and into midstance, placing an increased load on the plantar fascia, ligaments, and musculature of the foot that are attempting to decelerate and limit pronation.[1,3,7,8,13,19,20,26]
Pes plano valgus	A flat foot that may pronate rapidly and excessively.[8]	A study compared activity of the intrinsic musculature in flatfooted and normal-foot-structure individuals during ambulation. In flatfooted patients, the intrinsic musculature fired for a longer time period and were active at an earlier stage of gait, as compared to the normal-foot-structure patients. Electromyographic activity of the abductor hallucis decreased in flatfooted people fitted with orthotics that limited STJ pronation.[8]	May lead to rapid and excessive pronation of the STJ shortly after initial contact and into midstance, placing an increased load on the plantar fascia, ligaments, and musculature of the foot that are attempting to decelerate and limit pronation.[1,3,7,8,13,19,20,26]
Pes cavus	A high arch that is usually restricted in STJ pronation.[8,19,20,26]	During loading response and early midstance the STJ needs to pronate approximately four degrees to allow for proper absorption of ground reactive forces.[8] A pes cavus foot structure, being limited in pronation, will be unforgiving to the ground surface.[22]	With pes cavus, each foot strikes the ground approximately ten thousand to fifteen thousand times per day.[19] Limited pronation of the STJ from loading response to early midstance may limit the pes cavus foot from effectively absorbing ground reactive forces, predisposing a person to plantar fasciitis.[8,19,20,26]

OTHER RISK FACTORS ASSOCIATED WITH PLANTAR FASCIITIS

Training errors contribute to most overuse running injuries. Properly progressed training programs allow the supporting structures of the lower extremities to adapt to increased stresses. Inappropriately increasing the intensity, duration, and frequency of training runs, as well as incorporating hills on the training routes too soon, may overload the supporting structures of the lower extremity, eventually leading to injury.[11,30,31]

Overweight, age-related degenerative changes, and occupations requiring prolonged standing or ambulation contribute to the risk of plantar fasciitis.[1,3,5,11,30,33] Ground reactive forces acting on the plantar fascia and other supporting structures of the foot can reach 1.2 times body weight with walking, and 2.5 to 3.0 times body weight with running.[1,11,25] An injured recreational runner may gain weight if he or she fails to cross train and/or follow proper nutritional guidelines during periods of inactivity. Deconditioned, heavier runners may be predisposed to injury if they progress their training program inappropriately. Obese sedentary individuals are also predisposed to plantar fasciitis. Studies have indicated an association between plantar fasciitis and individuals whose body mass index is 30 kg/m2 or higher.[28,30] Based on clinical experience, certain occupations put individuals at risk for plantar fasciitis; teachers, maids, nurses, military personnel, chefs, and waiters are some examples. These occupations require prolonged standing on unyielding surfaces that predispose the plantar fascia and other supporting structures of the MLA to repetitive tensile ground reactive forces.[13,14,33] Age-related degenerative changes to the plantar fascia and to the fat pad of the heel may predispose to injury by decreasing the shock absorption capabilities of the foot and the ability of the plantar fascia to dissipate tensile forces.[10,11]

Fig. 12 *Goniometer Measurement of Forefoot Varus*



DIAGNOSING PLANTAR FASCIITIS

A practitioner can diagnose plantar fasciitis and discover risk factors for the condition by conducting a detailed history and a physical examination. A history should include initial onset of injury; current symptoms; occupation; recent weight gain; progression of the frequency, intensity, and duration of weekly training runs; whether training routes incorporated hills; age of running shoes; and training goals.

Palpation may reveal tenderness over the medial calcaneal tuberosity and the MLA. These findings are exacerbated by maintaining digital pressure over the tender aspect of the MLA and then recreating the windlass mechanism by dorsiflexing the big toe to approximately sixty-five degrees.[46]

Observation of the MLA of the barefoot weightbearing patient may reveal a pes planus or pes cavus foot structure. A pes plano valgus foot may have callus formation over the second, third, and fourth metatarsophalangeal joints due to ill-timed pronation and a low-gear toe-off.

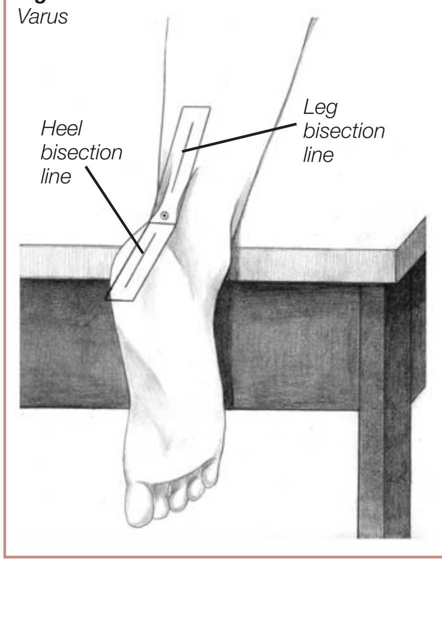
Reference lines should be drawn on the central aspect of the lower leg and the heel; with the patient prone, the STJ neutral position can be found by palpating the front of the talus with one hand and inverting and everting the rearfoot with the other hand. The STJ neutral angle can be measured with the arms of the goniometer positioned over the heel and leg bisection lines. Inversion of the heel line compared to the leg line indicates rearfoot varus. Goniometer measurements are repeated with the patient standing on an elevated box. The weightbearing measurement is compared to the STJ neutral measurement to evaluate for excessive pronation of the STJ in compensation for rearfoot varus or pes planus valgus, or limited pronation common in pes cavus rigidus. The STJ should pronate approximately four degrees as the foot adapts to the ground terrain.[20] Range of motion of the talocrural joint should be conducted with the patient prone, the STJ held in the neutral position, and the leg fully extended. If the talocrural joint is restricted in dorsiflexion measurements should be repeated with the leg flexed to differentiate between gastrocnemius or soleus musculature restrictions. Forefoot varus measurements can be conducted with the patient prone and the rearfoot placed in STJ neutral. One straight edge of the goniometer is lined up across the MTP's and the other edge of the goniometer is placed perpendicular to the calcaneal bisection line (see figures 12 and 13).[8,19,20]

Radiographic examination or a bone scan may aid in ruling out differential diagnoses of calcaneal stress fracture, plantar fascia rupture, osteomyelitis, or Ewing's sarcoma. Studies indicate that calcaneal spurs are coincidental radiographic findings and are not relevant.[8,10,20,54]

Plantar fasciitis is a term used to denote inflammation of the plantar fascia. However, recent studies indicate that plantar fasciitis may be more of a non-inflammatory degenerative process. Sonographic studies have revealed a correlation between marked (four millimeters or greater) degenerative thickening of the plantar fascia and plantar fasciitis. Normal measurements of the thickness of the plantar fascia average approximately two millimeters. Based on these findings, plantar fasciitis may be more aptly termed plantar fasciosis.[2,3,4,5,10,11,13,15,16,33,34]

Babcock et al. surmised that pain due to plantar fasciitis may be due to one of the following mechanisms: "irritation of pain fibers by repeated trauma or chronic pressure from a thickened plantar fascia, ischemic pain from chronic pressure of thickened fascia against digital vessels, enhanced effect of local pain neur transmitters/chemicals such as substance P and glutamate, and increased nociceptor sensitivity secondary to inflammation."[35]

Fig. 13 *Goniometer Measurement of Rearfoot Varus*



TREATMENT OF PLANTAR FASCIITIS

Conservative treatment for plantar fasciitis should focus on decreasing pain, promoting healing, restoring range of motion and strength, correcting training errors, limiting biomechanical deviations caused by structural abnormalities, and maximizing good nutrition (1). In my experience and based on a review of the literature the following treatment protocol is suggested:

- Manual adjustments to the ankle and foot to free up joint motion of the talocrural, subtalar, and midtarsal joint articulations.[33,34]

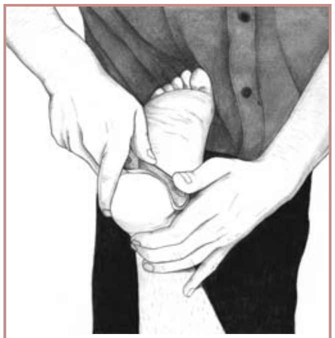


Fig. 14A Active Myofascial Release with the Graston Tool Position 1

Fig. 14B Active Myofascial Release with the Graston Tool Position 2

- Deep tissue procedures, such as the Graston Technique (manual therapy that utilizes specially designed devices) and Active Release Technique (a patented manual therapy technique), to break up scar tissue and restore soft tissue motion. Based on my experience I have found the Graston tool to be particularly useful as a myofascial technique to break up adhesions at the origin of the plantar fascia on the medial calcaneal tubercle (figures 14A,14B). There is considerable clinical evidence to support the effectiveness of deep tissue procedures in treatment of strain/sprain injuries.[36,37,53] Myofascial techniques have been shown to stimulate fibroblast proliferation, leading to collagen synthesis that may promote healing of plantar fasciitis by replacing degenerative tissue with a stronger and more functional tissue.[2,50]
- A home exercise program for myofascial release therapy can be taught to the patient. In this example the patient has plantar fasciitis of the right foot. The seated patient will cross the right leg over the left knee. With the right hand they will then grab the bases of the first, second, and third proximal phalanges and shorten the plantar fascia by flexing the toes at the metatarsophalangeal joints (MTP's). The left hand will apply digital pressure over the medial or central band of the plantar fascia. The patient will then extend the toes at the MTP's with the right hand while applying a distal to proximal traction with the left hand[38](figures 15A,15B). This maneuver can be repeated as necessary. The patient can also be taught how to roll a golf ball, laundry ball with nubs, or frozen plastic bottle under the MLA to stimulate the plantar fascia.

Fig. 15A Self Myofascial Release Position 1

Fig. 15B Self Myofascial Release Position 2

- Implementation of a strength training program for the extrinsic and intrinsic musculature of the foot. Standing and seated calf raises strengthen the gastrocnemius, soleus and the intrinsic musculature of the foot; towel gripping exercises with the toes strengthen the intrinsic musculature of the foot. Utilizing the dorsiflexion assisted resistive device strengthens the tibialis anterior and extensor musculature of the leg that decelerate foot slap. Cable resisted eversion exercises of the foot strengthens the peroneal musculature.[4,8,31,52]
- Stretching routine for the triceps surae and plantar fascia. Triceps surae stretching with the knee extended and bent can be conducted on a slant board, with a pro-stretch device, or on a flat floor surface. Stretching of the plantar fascia can be conducted similarly to the self myofascial release technique. Stretching of the triceps surae and plantar fascia have been shown to improve range of motion of the talocrural joint in dorsiflexion and help in the treatment of plantar fasciitis.[4,31,38]
- Use of a prefabricated night splint. The night splint should incorporate approximately five degrees of dorsiflexion of the talocrural joint and extension of digit #1. The splint passively stretches the fascia overnight and is helpful in alleviating morning heel pain caused by shortening of the fascia.[3,8,38,39] However, there has been a poor compliance associated with the night splint because it is bulky[40]
- A quarter inch or three-quarter inch heel lift can be temporarily utilized to limit compensatory pronation caused by ankle equinous. As range of motion of the talocrural joint improves with therapy, the heel lifts can eventually be removed.[20,31,39]
- Running shoes should be changed every 300-500 miles. A sneaker loses approximately fifty percent of its ability to absorb ground reactive forces after 300-500 miles.[4,31,32]
- Buying the proper running shoe. A pes cavus foot structure may benefit from a cushioned sneaker. The sneaker liner can be removed and replaced with a cushioned liner. The rearfoot varus, pes planus valgus and forefoot varus foot structure may benefit from a motion control sneaker.[41]
- Use of appropriate arch supports as necessary. A semirigid orthosis with a medial arch support no higher than five-eighths of an inch can be utilized to help limit excess pronation.[11,19,20,31,39,42,43]
  - Low Dye taping of the foot has been shown to be effective in limiting pronation.[34,44,45]
  - Recommendation for appropriate training limits. For marathon runners, initially a training base of four miles at sixty-five to seventy-five percent of maximum heart rate should be established. Later, a progressive training schedule should be followed that allows for adaptation of the supporting structures of the foot to withstand future increased stress loads. Long training runs, usually done on weekends, should be limited to a pace that requires sixty-five to seventy-five percent of maximum heart rate to improve aerobic capacity. During the week, a shorter four to eight mile interval run at eighty-five to ninety percent of maximum heart rate is recommended to improve anaerobic capacity. Hill training should be added gradually because of the increased load placed on the lower extremities. The average marathon training schedule consists of 3 shorter runs during the week, and 1 longer run on the weekend. Total mileage should not be increased by more then ten percent per week.[24,31,47]

- Modified training for runners such as swimming, bicycling, and the elliptical machine.[2,8,31]
- A viscoelastic heel cup or a small cushioned doughnut can be placed over the medial calcaneal tubercle to reduce ground reactive forces acting on the proximal aspect of the plantar fascia.[39]
- A cushioned mat can be placed over a hard working surface, reducing ground reactive forces for professionals who stand for prolonged time periods over a fixed spot.
- Nutritional advice. A dietitian can calculate burn rate from daily exercise, and then develop an appropriate a daily meal plan for healthy weight loss or maintenance.
- Ultrasound and electric muscle stimulation combination therapy to restore normal muscle tone, aid in the healing process, and reduce pain.[34,51]
- Inflammation reduction by taking nonsteroidal anti-inflammatory medications per prescription, and applying a cold pack to the MLA for twenty minutes on, one hour off, repeated throughout the day. Iontophoresis with dexamethasone is also a useful modality to decrease inflammation.[48] Histological findings in plantar fasciitis have indicated degenerative changes with no inflammatory precursors 4; therefore, the healing potential of NSAID's, ice therapy, and iontophoresis for the treatment of plantar fasciitis may be limited.
- A short leg walking cast worn for approximately 6 weeks may limit the ground reactive tensile forces acting on the fascia, thereby limiting repetitive strain and promoting healing.[39]

Cortisone injections or surgical management may need to be considered if conservative measures are not successful in alleviating symptoms or allowing the patient to comfortably manage symptoms associated with plantar fasciitis. Corticosteroid injections are useful in relieving pain due to inflammatory changes. However, they should be administered judiciously because multiple injections may cause a plantar fascia rupture.[1,3,4] In recalcitrant cases of plantar fasciitis that limit activities of daily living or prevent participation in sport, surgical management may be a viable option. Plantar fascia endoscopy involves releasing a portion of the thickened, less resilient fascia. Surgical release of the plantar fascia, followed by appropriate therapy, may decrease stiffness that was present in the MLA and allow for manageable or pain free range of motion during activities of daily living or return to sport.[4,8,9,28,34,49] Surgical release of the plantar fascia should not exceed thirty-three percent; releasing any more of the plantar fascia may cause an increased strain on the ligaments and osseous structures that aid in supporting the MLA during static stance, and may limit the ability of the STJ to re-supinate from midstance to toe-off.[28]

CONCLUSION

Plantar fasciitis is one of the most common causes of inferior heel pain. Structural abnormalities, overuse, weakness, overweight, and training errors all contribute to risk of this condition. Repetitive, excessive loads placed on the plantar fascia may lead to degenerative changes that decrease the ability of the plantar fascia to absorb ground reactive forces, and to re-approximate the MLA and re-supinate the STJ in preparation for toe-off. In many cases, conservative care has been found to be successful in alleviating or controlling symptoms related to plantar fasciitis. If conservative care is not effective, a cortisone injection may be useful in decreasing pain symptoms. In recalcitrant cases of plantar fasciitis endoscopic conservative surgery is a viable option.

REFERENCES

1. May T, Judy T, Conti M, Cowan J. Current Treatment of Plantar Fasciitis. Current Sports Medicine Reports 2002; 1:278-84.
2. Dyck D, Boyajian-O'Neill L. Plantar Fasciitis. Clinical Journal of Sports Medicine 2004; 14(5):305-309.
3. Cole C, Seto C, Gazewood J. Plantar Fasciitis: Evidence-Based Review of Diagnosis and Therapy. American Family Physician 2005; 72(11):2237-42.
4. Roxas M. Plantar Fasciitis:diagnosis and therapeutic considerations. Alternative Medicine Review 2005; 10(2):83-93.
5. Martin J, Hosch J, Goforth WP, Murff R, Lynch DM, Odom R. Mechanical Treatment of Plantar Fasciitis. Journal of the American Podiatric Association 2001; 91(2):55-62.
6. Wearing S, Smeathers J, Urry S. The Effect of Plantar Fasciitis on Vertical Foot-Ground Reaction Force. Clinical Orthopaedics and Related Research 2003; 409:175-85.
7. Travell JG, Simons DG. Myofascial Pain and Dysfunction The Trigger Point Manual, Volume Z. Baltimore:Williams & Wilkins, 1999.
8. Banks AS, Downey MS, Martin DE, Miller SJ. Foot and Ankle Surgery. Philadelphia: Lipincott Williams & Wilkins, 2001.
9. Cheung J, Zhang M, An K. Effects of Plantar Fascia Stiffness on the Biomechanical Responses of the Ankle-Foot Complex. Clinical Biomechanics 2004; 19(8):839-46.
10. Aldridge T. Diagnosing Heel Pain in Adults. American Family Physician 2004; 70(2):332-8.
11. Fillipou D, Kalliakmanis A, Triga A, Rizos A, Grigoriadis E. Sport Related Plantar Fasciitis. Current Diagnostic and Therapeutic Advances. Folia Medica 2004; 46(3):56-60.
12. Placzek R, Deuretzbacher G, Buttgereit F, Meiss A. Treatment of Chronic Plantar Fasciitis with Botulinum Toxin A. Annals of the Rheumatic Diseases 2005; 64(11):1659-61.
13. Wearing S, Smeathers J, Yates B, Sullivan P, Urry S, Dubois P. Sagittal Movement of the Medial Longitudinal Arch is Unchanged in Plantar Fasciitis. Medicine & Science in Sports & Exercise 2004; 36(10):1761-67.
14. Sobel E, Levitz S, Caselli M, Christos P, Rosenblum J. The Effect of Customized Insoles on the Reduction of Postwork Discomfort. Journal of the American Podiatric Association 2001; 91(10):515-20.
15. Lemont H, Ammirati K, Usen N. Plantar Fasciitis:A Degenerative Process Without Inflammation. Journal of the American Podiatric Association 2003; 93(3):234-37.
16. Huang YC, Wang LY, Wang HC, Chang KL, Leong CP. The Relationship Between the Flexible Flatfoot and Plantar Fasciitis:Ultrasonographic Evaluation. Chang Gung Medical Journal 2004; 27(6):443-8.
17. Sitzman K. Managing Plantar Fasciitis. AAOHN Journal 2005; 53(1):52.

18. Lynch DM, Goforth WP, Martin J, Odom R, Preece C, Kotter M. Conservative Treatment of Plantar Fasciitis. Journal of the American Podiatric Association 1998; 88(8):375-80.
19. Michaud TC. Foot Orthosis and Other Forms of Conservative Foot Care. Newton, MA:Thomas C Michaud, 1997.
20. Donatelli RA. The Biomechanics of the Foot and Ankle, 2nd Editition. Philadelphia:F.A. Davis, 1996.
21. Fuller E. The Windlass Mechanism of the Foot:A Mechanical Model to Explain Pathology. Journal of the American Podiatric Association 2000; 90(1):35-46.
22. Gefen A. The in vivo elastic properties of the plantar fascia during the contact phase of walking. Foot & Ankle International 2003; 24(3):238-44.
23. Ward E, Cocheba J, Phillips R. In Vivo Forces in the Plantar Fascia During the Stance Phase of Gait. Journal of the American Podiatric Association 2003; 93(6):429-42.
24. Norkin CC, Levangie PK:Joint Structure and Function: A Comprehensive Analysis (2nd Edition). F.A. Davis, Philadelphia 1992.
25. Rodgers M. Dynamic Biomechanics of the Normal Foot and Ankle During Walking and Running. Physical Therapy 1988; 68(12):1822-30.
26. Tiberio D. Pathomechanics of Structural Foot Deformities. Physical Therapy 1988; 68(12):1840-49.
27. Inman VT:Human Locomotion. Can. Med. Assoc. J. 94:1047, 1966.
28. Saxena A. Uniportal Endoscopic Plantar Fasciotomy:A Prospective Study on Athletic Patients. Foot & Ankle International 2004; 25(12):882-9.
29. Seligman D, Dawson R. Customized Heel Pads and Soft Orthotics to Treat Heel Pain and Plantar Fasciitis. Archives of Physical Medicine and Rehabilitation 2003; 84(10):1564-67.
30. Riddle D, Pulisic M, Pidcoe P, Johnson R. Risk Factors for Plantar Fasciitis:A Matched Case-Control Study. The Journal of Bone and Joint Surgery 2003; 85-A(5): 872-77.
31. Reid DC. Sports Injury Assessment and Rehabilitation. New York:Churchill Livingston, 1992.
32. Messier SP, Edwards DG, Martin DF, et al. Etiology of Iliotibial Band Friction Syndrome in Distance Runners. Medicine & Science in Sports & Exercise 1995; 27(7):951-60.
33. Young B, Walker M, Strunce J, Boyles R. A Combined Treatment Approach Emphasizing Impairment-Based Manual Physical Therapy for Plantar Heel Pain:A Case Series. The Journal of Orthopaedic & Sports Physical Therapy 2004; 34(11):725-33.
34. Hyde T. Conservative Management of Sports Injury. Baltimore:Williams & Wilkins, 1997; pp 477-82.
35. Babcock M, Foster L, Pasquina P, Bahman J. American Journal of Physical Medicine and Rehabilitation 2005; 84(9):649-54.
36. Walker JM. Deep Transverse Frictions in Ligament Healing. Journal of Orthopaedic Sports Physical Therapy 1984; 6(2):89-94.
37. Brosseau L, Casimiro, Milne S, et al. Deep Transverse Friction Massage for Treating Tendinitis. Cochrane Database Syst Rev 2002; (4):CD003528.
38. Didiovanni B, Nawoczenski D, Lintal M, Moore E, Murray J, Wilding G, Baumhauer J. Tissue-Specific Plantar Fascia-Stretching Exercise Enhances Outcomes in Patients with Chronic Heel Pain: A Prospective, Randomized Study. The Journal of Bone & Joint Surgery 2003; 85-A(7):1270-77.
39. Sobel E, Levitz S, Caselli M. Orthoses in the Treatment of Rearfoot Problems. Journal of the American Podiatric Association 1999; 89(5):220-33.
40. Stadler T, Johnson D, Stephens M. What is the Best Treatment for Plantar Fasciitis? The Journal of Family Practice 2003; 52(9):714-17.
41. Butler R, Davis I, Hamill J. Interaction of Joint Type and Footwear on Running Mechanics. The American Journal of Sports Medicine 2006; 34(12):1998-2005.
42. Landorf K, Keenan A, Herbert R. Effectiveness of Different Types of Foot Orthoses for the Treatment of Plantar Fasciitis. Journal of the American Podiatric Association 2004; 94(6):542-49.
43. Kogler G, Veer F, Solomonidis S, Paul J. The Influence of Medial and Lateral Placement of Orthotic Wedges on Loading of the Plantar Aponeurosis:An in Vitro Study. Journal of Bone & Joint Surgery 1999; 81-A(10): 1403-1413.
44. Landorf K, Radford J, Keenan A, Redmond A. Effectiveness of Low-Dye Taping for the Short-term Management of Plantar Fasciitis. Journal of the American Podiatric Association 2005; 95(6):525-30.
45. Radford J, Burns J, Buchbinder R, Landorf K, Cook C. The Effect of Low-Dye Taping on Kinematic, Kinetic, and Electromyographic Variables. Journal of Orthopaedic & Sports Physical Therapy 2006; 36(4):232-41.
46. DeGarceau D, Dean D, Requejo SM, Thordarson DB. The association between plantar fasciitis and Windlass test results. Foot & Ankle International 2004; 25(9):687-8.
47. Smurawa T. Overuse Injuries Curb Triathlon Preparation Efforts. Biomechanics 2006; 13(5).
48. Pellecchia GL, Hamel H, Behnke P. Treatment of infrapatellar tendonitis: a combination of modalities and transverse friction massage versus iontophoresis. J Sports Rehabil 1994:3(2):35-145.
49. 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 International 2004; 25(7):482-7.
50. Leadhetter W. Cell Matrix Response in Tendon Injury. Clinics in Sports Medicine 1997; 11(3):533-579.
51. Gum SL, Reddy GK, Stehno-Bittel L, Enwemeka CS. Combined Ultrasound, Electrical Muscle Stimulation, and Laser Promote Collagen Synthesis with Moderate Changes in Tendon Biomechanics. Am J Phys Med Rehabil 1997; 76(4):288-96.
52. Allen RH, Gross MT. Toe Flexors Strength and Passive Extension Range of Motion of the First Metatarsophalangeal Joint in Individuals with Plantar Fasciitis. Journal of Orthopaedic & Sports Physical Therapy 2003; 33(8): 468-78.
53. Kvist M, Jarvinen M. Clinical histochemical and biomechanical features in repair of muscle and tendon injuries. Int J Sports Med 1982;3 Suppl 1:12-14.
54. Zhu F, Johnson J, Hirose C, Bae K. Chronic Plantar Fasciitis: Acute Changes in the Heel after Extracorporeal High-Energy Shock Wave Therapy—Observations at MR Imaging. Radiology 2005; 234(1):206-10.