Amol Saxena
Brian Fullem

CHAPTER

32

Plantar Fascia Injuries

Disclosures: Drs. Saxena and Fullem have performed funded research for Storz Medical AG and received something of value. Dr. Saxena receives royalties from Mondeal NA/Tekartis, holds stock in Alter-G, Inc and serves on their advisory board.

Plantar fascia pathology, aka plantar fasciopathy, is one of the most common entities encountered by musculoskeletal specialists. It is estimated that 20% of the general population will experience some type of plantar heel pain at some point in their lives and 2 million are treated annually in the United States alone (1–6). The condition plantar fasciitis, aka "heel-spur syndrome" (which is also now coined "fasciosis" due to histopathologic findings) is common with many types of sports participants (7). It is one of the most common complaints in running athletes. Classic symptoms include pain with the first steps in the morning and after rest (post-static dyskinesia). It typically feels better with activity, though over-zealous exercise can exacerbate symptoms during activity. Chronic plantar fasciitis/fasciosis can be debilitating and may last 12 or more months but it does not have to be as we will discuss below. It has been reported that over 90% of these types of cases resolve by 12 months; this is difficult to accurately report due to the fact that patients may seek treatment from many providers (1,3,5,6,8–11). Unless follow-up assessments occur at 12 or more months after onset by the same provider, this may only be conjecture. Most studies on non-operative treatments only evaluate patients for symptoms up to 1 year or less, and do not report on the activity level (or the need for cessation). We believe most plantar fasciitis is controlled, but not necessarily cured. In addition to "classic" plantar fasciitis, other conditions such as calcaneal stress fractures and periostitis, plantar fascia and muscle ruptures, and local nerve entrapment can occur (12). Table 32.1 shows common differential diagnoses for plantar fasciopathy. The current evidence-based treatment options of these conditions will be discussed, with a focus on athletically active individuals.

FUNCTIONAL ANATOMY

The plantar fascia is an aponeurosis that covers the plantar structures of the foot, deep to the subcutaneous tissue and heel fat pad. The central portion of the plantar fascia courses from the medial process of the calcaneal tuberosity distally to blend with the flexor tendon sheaths. There are three distinct bands: Medial, central and lateral. The lateral band attaches to the lateral process of the calcaneal tuberosity proximally. The proximal fibers blend with the periosteum of the calcaneus which also blends with the distal Achilles expansion (13–15). "Classic," aka "proximal plantar fasciitis," is located in the region of the medial process of the calcaneal tuberosity where the medial and central bands attach (Fig. 32.1). The plantar aponeurosis has been described to act like a "windlass" mechanism. Clinically, this is demonstrated by dorsiflexion of the digits which causes retrograde increase in arch height due to the windlass mechanism (13–15). This is also known as the "Hubscher maneuver" or the "test of Jack" (Fig. 32.2). Inferiorly, the plantar fascia is covered by the calcaneal fat pad which consists of columns of fibrous septae containing adipose tissue. More distal, the fascia is covered by a thin layer of subcutaneous tissue. Deep (superior) to the plantar fascia is the first plantar muscular layer which includes the abductor hallucis, flexor digitorum brevis and abductor digiti minimi (13–15).

The so-called infra-calcaneal spur if present is located within the first plantar muscular layer or the deeper intrinsic muscle layers (such as the quadratus plantae) that originate from the plantar aspect of the calcaneus. (One should note that an infra-calcaneal spur is essentially a component of myositis ossificans of the plantar muscles, not the fascia. This calcification is present in approximately 40% of asymptomatic individuals, therefore the "heel spur" is generally of inconsequence.) The innervation to the region primarily occurs from the medial and lateral plantar nerves off of the tibial nerve. The muscular branch from the lateral plantar nerve to the abductor digiti minimi can become entrapped, causing symptoms such as neuritis and heel pain (12). The vascular supply to this region occurs from the posterior tibial artery which also has medial and lateral plantar branches. The venae comitantes (paired veins) course within the neurovascular bundle in the posterior medial ankle and have branches that course deeply to the fascia and muscular layers. Engorgement of these veins can cause "pseudo-tarsal tunnel" syndrome (12,16).

CLINICAL EXAMINATION AND DIAGNOSTIC CONSIDERATIONS

A typical history is obtained. Given that many patients have symmetric foot type and range of motion (ROM), there should be an attempt to find the causative agent such as erroneous

TABLE 32.1 Differential Diagnoses for Plantar Fasciitis

Local etiology:
1. Plantar fascia rupture
2. Plantar muscular strain/rupture
3. Infra-calcaneal bursitis
4. Calcaneal stress fracture/periostitis
5. Plantar nerve entrapment
6. Tarsal tunnel syndrome
7. Flexor tenosynovitis
8. Posterior tibial dysfunction
9. Spring ligament sprain/tear
10. Midfoot stress fracture
11. Plantar fibroma
12. Fat-pad atrophy
13. Chronic compartment syndrome
14. Achilles tendofasciitis
15. Calcaneal apophysitis
16. Tumor or cyst
Systemic:
17. Enthesopathy/inflammatory arthropathy
18. Spondyloarthropathy
19. Peripheral neuropathy
20. Paget's disease
Referred:
21. Radiculopathy
22. Spinal stenosis

Figure 32.1. Typical plantar fasciitis location.

shoe gear or training error. This is substantiated by the observation that many athletes already have inserts or orthoses when they develop plantar fasciopathy. Patients often relate with plantar fasciitis that their symptoms began the morning after extended activity or use of atypical shoe gear. Their symptoms typically are worst with the "first morning steps," after prolonged sitting, and gets better with activity unless they over-extend themselves; then the pain can get worse, causing them to limp. Typical pain is at the medial tubercle of the calcaneus, though gait modification can cause symptoms laterally as well (Fig. 32.3). Repetitive activity, over-working one limb, such as practising a tennis serve or running on a track in one direction can be causative factors. Patients usually can bear weight with plantar fasciitis. Burning maybe present with typical plantar fasciitis but numbness and tingling should not be, nor should swelling, throbbing or bruising. Evaluation of lower-extremity ROM and foot type is performed (neutral, planus, or cavus). Asymmetry in ROM or limb length is assessed. Increased BMI has been associated but most athletes, other than American football players, have normal BMI (17). In fact, most runners who usually have lower BMI are commonly afflicted (11).

History is, however, the most important for differential diagnosis. If patients felt a sudden "pop," suspicion should be for a plantar fascia rupture. Previous localized corticosteroid injection, oral steroid and quinolone use may have occurred prior to onset of rupture. Patients with ruptures often cannot bear weight easily, and relate that they felt as if their "arch met the shoe" or their arch suddenly collapsed. Their posterior

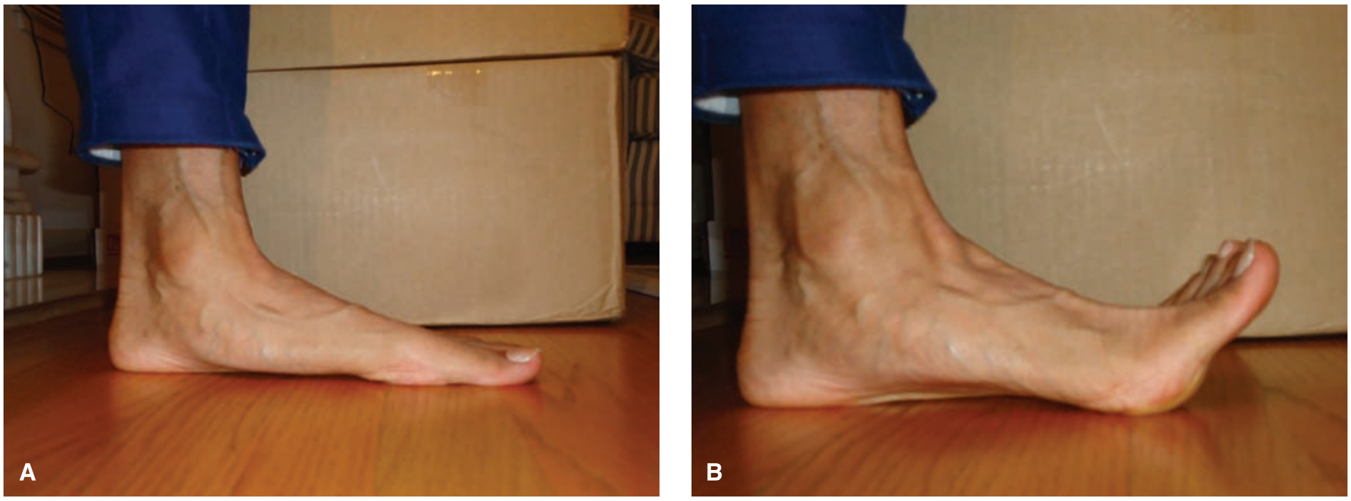


Figure 32.2. **A:** Hubscher maneuver will increase arch height **B:** dorsiflexion of the hallux.

Figure 32.3. The location of lateral column pain.

Figure 32.5. Infra-calcaneal spur in a patient with inflammatory arthropathy.

tibial and flexors will be intact. In addition, passive extension of the toes causes pain as it stretches the ruptured ligament and possibly associated intrinsic plantar muscles such as the abductor hallucis. Bruising and swelling are present with ruptures of both the fascia and the muscles (17–21) (Fig. 32.4).

Patients with stress fractures and periostitis often complain of pain that increases with activity, along with the presence of throbbing. If there is pain with squeezing the calcaneus (positive "squeeze test") then suspicion should be high for at least periostitis if not stress fracture (17). Radiographs such as plain x-ray are often *not* helpful in early cases of plantar fasciitis; however, when patients complain of "bony" symptoms, x-rays are typically performed. A large calcaneal spur or inferior erosions are associated with inflammatory arthropathy (16) (Fig. 32.5). Appropriate lab tests for gout, rheumatoid arthritis, and seronegative arthropathies such as Reiter's, psoriatic or ankylosing spondylitis via an HLA B27 marker can be ordered in these situations. A clinical pearl is that anti-inflammatories (NSAIDs) typically do not help much in most cases of plantar fasciitis/fasciosis, since most often no inflammation may be present; however, when NSAIDs do help, there may be one of these underlying conditions. Referral to a rheumatologist should be considered in this situation and when labs are "positive." As mentioned earlier, many asymptomatic patients have a "spur" present, whereas many symptomatic patients have no spur. This is one reason why x-rays are not often requested initially. Our practice is to take initial x-rays (lateral, axial and often oblique views) when patients complain of "bony" symptoms, if bruising and swelling are present, and if there is a positive "squeeze" test. Calcaneal stress fractures can be seen on plain film, as well as technetium bone scans and MRI scans. Diagnostic ultrasound is useful to determine ruptures as is MRI. The thickness of the plantar fascia has been utilized to determine if cases will become chronic or require surgery (22,23). However, caution should be taken on judging the severity of plantar fasciitis by its thickness alone. Some ethnic groups and athletes have thicker plantar fascia with no symptoms (24). We prefer MRI over ultrasound, as other entities such as stress fracture, tenosynovitis of the deeper flexor tendons, plantar fibromas, dilatation of veins and space-occupying lesions can be evident.

Figure 32.4. Patient with plantar fascia rupture. From Fullem B, Saxena A. Plantar Fasciitis. In: Saxena A, ed. *International Advances in Foot and Ankle Surgery*. London: Springer;2012:253–260.

Nerve symptoms manifest by numbness and tingling in the arch and/or heel. These symptoms will be present despite rest and activity. Local nerve entrapment can be aggravated by increased activity level, such as in tarsal tunnel syndrome; this can be caused by traction of the tibial nerve from excessive pronation for instance, or increased venous dilatation from prolonged standing can occur. Lateral plantar nerve entrapment usually occurs on the plantar lateral aspect of the heel (as opposed to typical plantar fasciitis and ruptures in which symptoms occur primarily medially). Note should be taken that not all lateral symptoms are due to nerve conditions; lateral compensation from medial heel pain can overload the ligaments and tendons on this side of the foot as well. Electro-diagnostics tests such as EMG/NCV can help delineate local versus more proximal nerve entrapment (such as radiculopathy and spinal stenosis) (12,16,22).

Figure 32.6. **A:** Calf stretch. **B:** Arch stretch. With permission from Saxena A, Granot A. Post-operative physical therapy for foot and ankle surgery. In: Saxena A, ed. *International Advances in Foot and Ankle Surgery*. London: Springer;2012:509–534.

THERAPEUTIC OPTIONS FOR PLANTAR FASCIITIS

Plantar fasciitis is a frustrating condition to providers and patients alike in that there are so many causative agents and therefore many therapies that seemingly "work" and it is difficult to predict "healing time." For athletes, return to activity (RTA) and return to competition can be critical (17). Recently, more evidence-based treatment approach has been adopted. We recommend an initial "three-pronged" approach: Stretching, support, and icing, along with activity modification as needed.

PHASE 1 (0 TO 3 MONTHS FROM ONSET)

The first line of treatment for plantar fasciitis is calf and arch stretching. Contracture of the gastrocnemius–soleus complex has been shown to be associated with plantar fasciitis. Caution should be taken when dealing with athletic patients as many of them have symmetric contracture (aka "equinus") and are often only symptomatic on one side. Stretching the arch and plantar fascia seems to have more of an impact (25–29) (Fig. 32.6). We have our patients hold these stretches for 15 to 30 seconds and perform them twice daily.

The next line of treatment for plantar fasciitis is appropriate shoe gear and inserts. A stiff-shanked athletic-type shoe is recommended. A shoe that flexes in the arch can cause and exacerbate symptoms (30) (Fig. 32.7). Current basketball and soccer shoe designs incorporate these "cut-out" features in order to make the shoe more light and flexible, but have been associated with an increased incidence of plantar fasciopathy in our practice. In addition, there is a current phenomenon of "barefoot running" and "minimalist shoes."

Current scientific evidence shows that when running "less protected," there is an increase in stride cadence, and subsequent decrease in contact time. While there may be less impact on the heel since the gastrocnemius–soleus complex needs to contract sooner, there is more force taken up elsewhere in the

Figure 32.7. Inappropriate shoe flexibility. With permission from Fullem B, Saxena A. Plantar Fasciitis. In: Saxena A, ed. I*nternational Advances in Foot and Ankle Surgery*. London: Springer; 2012:253–260.

Figure 32.8. Sample over-the-counter arch supports with built-in heel cup.

foot. Lower–heel-height shoes (and barefoot) do increase the strain on the Achilles complex, but decrease the force on the patellofemoral joint (31–35). More research needs to be done to see which type of athletes will benefit from minimalistic shoe gear, but we caution asymptomatic runners to only try barefoot running in limited amounts on safe surfaces such as grass or a cushioned track. More study needs to be done to evaluate the effects of strengthening barefoot as well, especially in regards to prevention of foot injury such as plantar fasciopathy.

Research has shown that an over-the-counter arch support with a heel cup can be helpful (8,31) (Fig. 32.8). Some patients try a heel cup or heel cushion, or even a higher-heeled shoe, but biomechanical studies show that this can increase the tension on the plantar fascia distally. Similarly, an insert with too high an arch can actually increase the tension on the medial fascia or aggravate the flexor tendons. We recommend that patients try an arch support which feels comfortable immediately, rather than have them try to "break it in." Taping is an option particularly for athletes who do not use supportive shoe gear or need to be barefoot during their sport (36,37) (Fig. 32.9). We try to have patients avoid walking barefoot during this phase. Finally, the third line of treatment is to reduce pain and inflammation if present. This is where patients can try NSAIDs but we also have them massage their arch and heel for 5 minutes by rolling their heel to the arch on a frozen water bottle, twice daily (Fig. 32.10). The primary benefit of cryotherapy for plantar fasciitis appears to be analgesia. The added benefit of massage concomitant with cryotherapy is unknown.

Physical therapy is often prescribed for plantar fasciitis and modalities such as ultrasound and iontophoresis. In studies comparing both ultrasound and iontophoresis, no significant long-term benefit has been documented. Iontophoresis using 5% acetic acid was found to be more beneficial than 0.4% dexamethasone, though both were only evaluated in the short term (6 weeks post-treatment) (37,38). We find that the benefit of physical therapy is for the evaluation of gait and functional weaknesses, limb-length inequality and to establish core strengthening which has been associated with many lower-extremity pathologies. One randomized study showed that mechanical exercise was more beneficial than utilizing electrophysiologic

Figure 32.9. Figure of 8 arch tape as alternative to "Low-Dye" tape. With permission from Fullem B, Saxena A. Plantar Fasciitis. In: Saxena A, ed. *International Advances in Foot and Ankle Surgery.* London: Springer; 2012:253–260.

agents such as ultrasound followed by iontophoresis with dexamethasone in physical therapy. Patients in the mechanical-exercise group had several mobilization and stretching maneuvers performed on them for their entire lower extremity by a licensed physical therapist, twice weekly for 2 weeks, then once a week for another 2 weeks (six visits total). The patients in both groups had BMIs greater than 30, so unlikely they were athletic and no mention was made of activity level. Though this study had power, the end point was 6 months post-treatment so it is difficult to know the lasting effects of the interventions (28). As of now, based on the current literature, iontophoresis and ultrasound benefits appear short term and minimal significance for plantar fasciitis (28,37,38).

If patients are having plantar fascia symptoms during or immediately after their activity, we have them decrease or even discontinue the offending activity. Cross-training with non-impact sports or running on an Alter-G™ (Alter-G, Inc.,

Figure 32.10. Rolling on frozen water bottle for massage and cryotherapy.

Figure 32.11. Alter-G Treadmill (courtesy Alter-G, Inc., Milpitas, CA, USA). With permission from Saxena A, Granot A. Post-operative physical therapy for foot and ankle surgery. In: Saxena A, ed. *International Advances in Foot and Ankle Surgery.* London: Springer; 2012:509–534.

Milpitas, CA, USA) treadmill may be allowed (Fig. 32.11). This treadmill allows weight-bearing activity at reduced bodyweight. Air is pumped in a chamber over the treadmill such that bodyweight can be reduced as low as 20%. We typically allow running at 60% and progress them to higher values, all the way up to 100% (full) bodyweight. We also try to have patients decrease the amount they are standing during the day.

Night splints have been found to be of value for patients complaining of morning pain (39,40). Because most patients find difficulty sleeping with them through the night and most athletes are not as concerned with the "first-step" pain, we recommend them as an adjunct, but not a primary treatment. Some athletes erroneously adopt the "more is better" approach and apply the night splint too aggressively; traction neuritis of the tibial and sural nerves has been anecdotally noted from excessive ankle dorsiflexion.

PHASE 2

If patients have been compliant with the stretching, OTC supports, icing and activity modification, and are still limited by their plantar fasciitis symptoms, then we consider three other options: Injections, custom orthoses and radial pulsed pressure wave therapy, aka "sound waves," such as D-Actor EPAT™ (Storz Medical AG, Tägerwilen, Switzerland) or SwissDolorclast™ (EMS Medical Systems, Switzerland). Unfortunately, in the United States, patients (and oftentimes providers) will only recommend therapies that are covered by indemnity insurance. On the other end of the spectrum and equally unfortunate, is that financial incentives such as "cash" for uncovered services may motivate recommendations as well. These factors such as cost and financial incentives, need to be taken into account as therapeutic guidelines are established in an evidence-based manner.

INJECTION THERAPY

Corticosteroid injections are generally covered by insurances. Therefore this is a common practice. We recommend these injections if the patient is unable to do their daily activities ("adls") and sport. The theory behind these injections is that they break down the degenerated tissue, decrease pain and provoke a healing response (31). Risks include rupture of the plantar fascia and plantar fat-pad atrophy. Anecdotally, the two authors of this chapter have experienced less than 10 possible steroid-injection-induced ruptures that they are aware of in over 40+ years of clinical practice between them. Generally 1 to 1.5 cc of medium-term–acting steroid (such as betamethasone 6mg/mL or a mixture of dexamethasone 4mg/mL and depo-medrol acetate 40 mg/mL) is deposited in the fascia space inferiorly and superiorly to the fascia origin, generally from a medial or plantar medial approach (Fig. 32.12 A–C). Ultrasonic-guided injections have been anecdotally reported to be more accurate; however, the familiarity of the anatomy of the provider rendering the injection has not been studied (41). An experienced provider (i.e., musculoskeletal specialist) should be able to render a corticosteroid injection without ultrasonic guidance, thereby saving additional medical costs. If a palpable inferior mass is felt (so-called "infra-calcaneal bursa"), this can be injected. Tumors in this region are rare; however, if there is suspicion, MRI should be performed prior to injection. Plantar fibromas have been noted in approximately 25% of surgical cases of plantar fasciitis; it may be difficult to differentiate between the two pathologies in this location (23).

Patients are advised to refrain from running and jumping for 1 week post-corticosteroid injection and must maintain their regimen from Phase 1. If the first injection was significantly helpful, a second injection can be rendered 1 or more months later. We rarely give more than three injections to one area; however, if there is a long time span, it may be considered safe. The number of injections to this area over a certain timeframe has not been thoroughly studied.

Platelet-rich plasma (PRP) and autologous blood injections (ABI) have been rendered for plantar fasciitis. These injections have not been critically studied (Level III or higher) in regards to this condition. However, when compared to placebo for Achilles tendinopathy, no significant difference has been found with PRP/ABI. There are several confounding factors with PRP such as an individual's platelet count, preparation technique, and post-injection protocols (42–45). Also, as noted above, finances play a factor. Because PRP injections are not covered by insurance, they are often not recommended early in the treatment phase. Though PRP injections appear safe, and in other applications may have a role in stimulating healing, a recent meta-analysis determined there is insufficient beneficial evidence for tendinopathy and plantar fasciopathy (45). Given the fact that there is only anecdotal evidence at this time, we generally do not recommend these based on the current literature for plantar fasciopathy (42–45).

Figure 32.12. Injection techniques. **A:** Medial approach with anesthesia first being injected. **B:** Injection with corticosteroid after medial heel is numb, slightly inferior to plantar fascia origin. **C:** Plantar medial approach.

FOOT ORTHOSES

If over-the-counter arch supports have provided some degree of relief, and patients have been compliant with the other “Phase 1” components of plantar fascia “therapy,” we will recommend custom devices to be considered. In the United States, there is a large variability on insurance coverage of these devices. Unfortunately, there are no definitive theories on the types of devices based on foot morphology, as there is much variability with this issue as well. Plantar fasciitis occurs in all foot types. One study found no difference with heel valgus but a higher medial arch was noted (46). It has been postulated that cavus feet benefit from softer, more accommodative inserts, whereas planus foot types benefit from firmer and more supportive inserts (46,47).

“Functional” (often thermoplastic) devices that are constructed by molds or scans of a patient’s foot that take into account the foot type, lower-extremity ROM or restrictions, activity level, body habitus and shoe gear; these would be considered custom devices. These devices are typically “posted” or canted in varus to reduce excessive pronation or valgus to reduce excessive supination. Kogler et al. showed on a cadaver model that there is less tension on the plantar fascia medially when the forefoot is placed on a forefoot valgus wedge (48). A plantar fascia “groove” can be incorporated into the foot orthosis to decrease pressure on the tender fascia band or prominent tendons. This is an orthotic modification in which there is an accommodation several millimeters deep that transverses the long axis of the orthoses (Fig. 32.13A and B). Scherer relates that though many orthosis manufacturers have this as an option, there are no published data on the effectiveness of this accommodation (47). Studies show effectiveness of custom foot orthoses for plantar fasciitis to be as high as 91%, though at best, only Level III evidence exists (5,31,48,50,51). Uden et al. found several high level studies supporting the use of orthoses, but admittedly, it is difficult to conduct a Level II or higher study (31).

While it is generally acknowledged that patients should utilize their foot orthoses with ambulation while they are symptomatic with their lower-extremity condition, it is unknown for how long they should maintain them (46,47,49). We generally see if patients can “wean” themselves off their devices as their condition becomes under control. An analogous

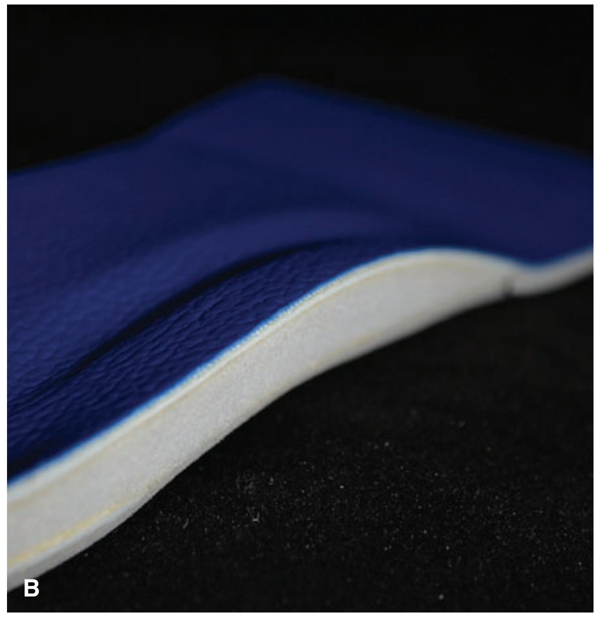


Figure 32.13. **A:** Semi-rigid thermoplastic custom device with plantar fascia groove. **B:** Cavus foot type of flexible device with plastic foam and poly-shell. (Photos courtesy of Plus Labs, Rancho Santa Fe Springs, CA, USA.)

situation is a cervical collar after whiplash; as patients recover, they no longer need their splint. Conversely, when patients necessitate eyeglasses, they only receive benefit when they use them. If patients do seem to have significant structural malalignment, we recommend them to continue with their foot orthoses. This needs to be studied further. It may be unrealistic to consider plantar fasciitis "cured" if patients need to continue with their devices; a better term would be "controlled."

PLANTAR FASCIA RUPTURES

Plantar fascia ruptures are increasingly common and should be included in the spectrum of plantar fasciopathy (17–21). This may be due to more awareness of the condition and also the increased use of MRI/ultrasound to evaluate plantar fascia conditions. Patients with ruptures notice an acute onset of intense symptoms in the arch or heel, and may even relate a "pop" sensation. Ecchymosis is common as seen in Figure 32.4. There is difficulty with weight bearing and pain with passive extension of the toes. There may be a history of prior plantar fasciitis symptoms and even prior injections. Differential diagnosis includes heel contusion, calcaneal fracture/stress fracture, pathologic fracture and heel fat-pad rupture (Fig. 32.14). Athletes in lateral motion sports such as basketball and soccer are increasingly using lighter shoe gear with less arch support. The stress of lateral sports places more torque on the arch structures making plantar fascia common with these sports. MRI examination is helpful in certain situations, particularly when "downtime" assessment is needed (Fig. 32.15). Generally, plantar fascia ruptures take longer to heal than plantar "muscle" ruptures. In our study, using our treatment protocol, athletes were able to return to their sport on an average of 9 weeks after plantar fascia rupture (17). Treatment for plantar fascia rupture includes cast-boot immobilization, with non—weight-bearing the first three weeks. Weight bearing is allowed when edema and pain have subsided. Often, an arch support is placed within the boot when weight bearing is commenced. Patients maintain their boot until they are pain-free, which is generally 3 to 6 weeks post-rupture. Cross-training is allowed on a stationary bike with the boot on, as well as swimming with the boot off (but no "flip turns"). Physical therapy is initiated at 3 to 6 weeks which included gradual stretching and strengthening, along with modalities such as electrical stimulation and cryotherapy as needed. Gradual return to sport with an arch support or custom orthosis generally occurs around 9 or more weeks post-rupture. In our study on 18 athletes, using this protocol with an average follow-up of 4 or more years, none of the patients in our series necessitated surgery, had chronic

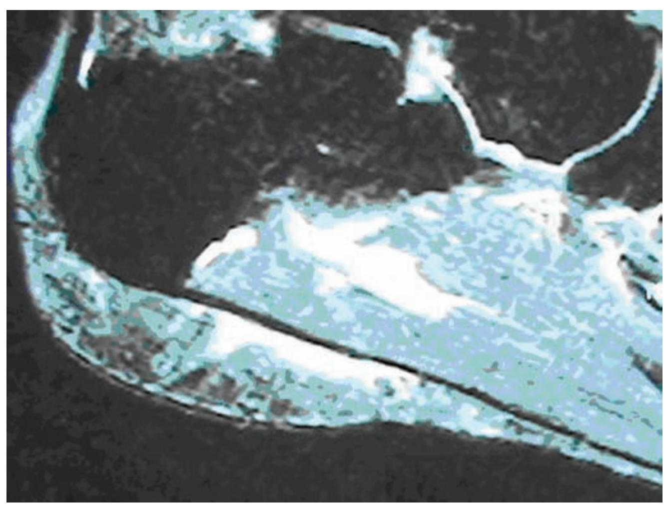


Figure 32.14. MRI of a fat-pad rupture in an elite triple jumper. Note the intact fascia and musculature, and disruption of the fat pad.

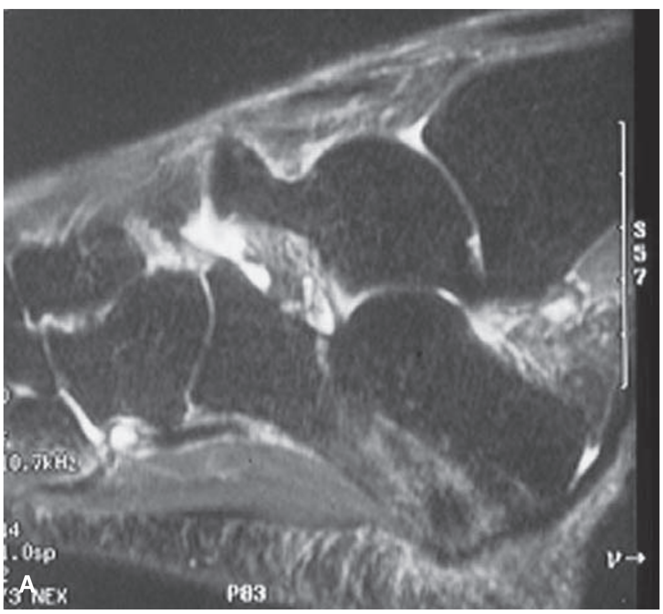
Figure 32.15. MRI of plantar fascia rupture. Longitudinal rupture in a basketball player who was able to return to play in 2 weeks. With permission from Fullem B, Saxena A. Plantar Fasciitis. In: Saxena A, ed. *International Advances in Foot and Ankle Surgery.* London: Springer; 2012:253–260.

plantar fasciitis, nor sustained a re-rupture with an average follow-up range of 2 to 10 years. We surmise that a plantar fascia rupture essentially releases the tension on the fascia and is essentially a "self-performed" surgery, with seemingly excellent results.

CALCANEAL STRESS FRACTURES/ PERIOSTITIS

Some patients with chronic plantar fasciitis can develop periostitis and stress fractures at the proximal attachment. This appears to be more common in osteopenic females. With plantar fascia ruptures, the weak point is the degenerated fascia attachment. When there is osteopenia or osteoporosis, the calcaneus is the weak point and it fatigues. These patients relate that their pain gets worse with activity, has a throbbing or deep ache quality, usually exhibit swelling and have difficulty weight bearing. They have a positive "squeeze test"; compression of the calcaneus from medial to lateral creates significant pain (Fig. 32.16). X-rays may show sclerosis in the calcaneal tuberosity often perpendicular to the plantar fascia pull (30) (Fig. 32.17 A and B). Bone scans and MRI are diagnostic (Fig. 32.18 A and B). The stress fractures associated with plantar fasciitis are different from other overuse stress fractures of the calcaneus which show sclerosis more superior and parallel to the subtalar joint (30). Metabolic assessment for calcaneal stress fractures and endocrine consult can be helpful. The treatment for calcaneal stress fractures/periostitis is cast boot immobilization for 4 to 6 weeks. As with plantar fascia ruptures, cross-training in a boot on a stationary bike or swimming is allowed. Normalization of endocrine or metabolic abnormality such as diabetes, anorexia, hyperthyroidism should be achieved before the athlete is allowed to return to weight-bearing sport. The use of an Alter-G™ (Milpitas, CA, USA) treadmill may be allowed during the healing phase. Generally patients return to their sport after 6 to 12 weeks.

Figure 32.16. Squeeze test to determine calcaneal stress fracture and periostitis.



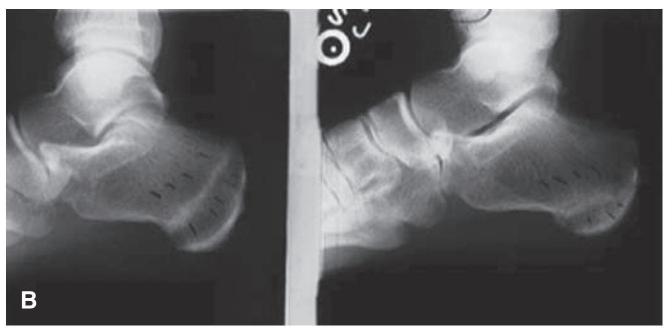


Figure 32.17. **A:** MRI showing stress fracture from plantar fasciitis. **B:** X-ray showing bilateral stress fractures from osteoporosis. Note the difference in fracture orientation.

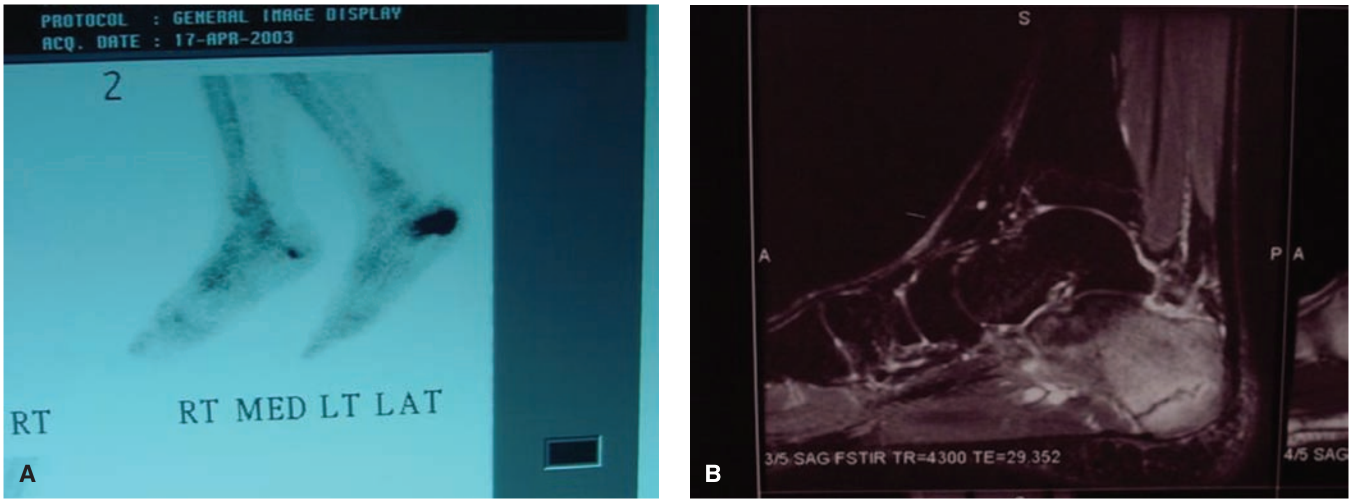


Figure 32.18. **A:** Bone scan for stress fracture. **B:** MRI for stress fracture.

EXTRACORPOREAL SHOCK WAVE THERAPY/SOUND WAVE

Extracorporeal shock wave therapy (ESWT) was first described for the treatment of plantar fasciitis by Rompe in 1996 (52). Since then, many authors have studied different forms of ESWT or orthotripsy for plantar fasciitis (9,10,52–61). The term "shock wave" is not accurate for many of the current effective devices available in the United States (56). In fact, two of the most readily available devices in the United States, D-Actor EPAT™ (Storz Medical AG, Tägerwilen, Switzerland) and SwissDolorclast™ (EMS Medical Systems, Switzerland) emit radial pressure waves, not shock waves (56). Furthermore, the terminology "high energy" and "low energy" is outdated and inaccurate.

While it has been found that "low-energy" devices produce more favorable results for plantar fasciitis and Achilles tendinopathy, many machines including radial devices can generate "high energy" (defined as ≥0.25 mJ/mm^2). The current differentiation between "sound-wave" devices are the radial pressure devices such as the ones noted above, and pulsed ultrasonic devices such as the Duolith™ (Storz Medical AG, Tägerwilen, Switzerland). The radial pressure devices are generally less costly, but both technologies can be administered without anesthesia. In fact, local anesthesia has been shown to decrease efficacy (58,59). The pulsed ultrasonic devices have broader applications beyond enthesopathies such as treatment for non-unions, avascular necrosis and wound healing. We collectively term both technologies, radial and ultrasonic, as "sound wave."

The actual sound-wave treatment involves introducing sound waves to the injured area to help regenerate the damaged tissue with local hyperemia, inhibition of pain fibers possibly through denervation and provide for growth of new blood vessels (neovascularization). The application had historically been divided into ultrasonic, aka "high energy," via one treatment, and radial, aka "low energy," using three to four treatments with weekly intervals. Early reports on the efficacy of ESWT showed a wide range of effectiveness from 40% to 70% and in some cases it was less effective than placebo. However, Rompe et al. reported that the use of local anesthesia, which was required for high-energy applications, lowered the effectiveness of the treatment. They stress the importance of being able to perform the ESWT/sound wave without anesthesia at the point of maximal tenderness for the best results; this is termed "patient focused" (58). Recently Klonschinski et al. concluded that ESWT dose-dependently activates and sensitizes primary afferent nociceptive C-fibers, and that both activation and sensitization were prevented if local anesthesia (LA) was applied in the treatment area. These results suggest that LA substantially alters the biologic responses of ESWT (59). Similar to other studies of the effectiveness of treatments for plantar fasciopathy, the follow-up and outcome-evaluation period is at the most, 1 year post-treatment. It is important to decipher the literature based on the energy level, blind versus unblinded, placebo-controlled, whether local anesthesia was utilized and post-treatment follow-up.

More recent Level I and II studies of sound wave, in particular with radial devices, show very favorable results. In many randomized, placebo-controlled studies, significant differences in outcomes between actual therapy and placebo have been documented. In one recent Level I study presented at both the American Academy of Orthopedic Surgeons Annual and American Orthopedic Society for Sports Medicine meetings showed 69% reduction in pain for plantar fasciitis with a focused pulsed ultrasonic device as compared to 34.5% for placebo after 1 year post-treatment. In this study of 246 patients, no other intervention was allowed, including refraining from NSAIDs, and a 6-week "wash-out" period from prior corticosteroid injections. Athletic patients were allowed to continue to exercise and no ruptures of the plantar fascia occurred post-treatment. Patients in this study were followed up to 2 years post-treatment (57).

Our current protocol for sound wave is to treat patients who are unresponsive to other treatments such as the ones described above in Phase 1. If patients have a relatively neutral foot type and appropriate shoe gear, and are limited in their

Figure 32.19. "EPAT/D-Actor" sound-wave machine. (Storz Medical AG, Tägerwilen, Switzerland). With permission from Fullem B, Saxena A. Plantar Fasciitis. In: Saxena A, ed. *International Advances in Foot and Ankle Surgery.* London: Springer; 2012: 253–260.

activity level by their plantar fasciitis, then we will offer them sound wave. Some patients may choose a corticosteroid injection first, realizing that there is a small chance of rupture with the injection and that they must restrict running and jumping activity for at least a week. Sound-wave treatment should ideally be delayed for 6 weeks after a corticosteroid injection as this may blunt the desired response. Sound-wave treatments are typically rendered three times, at weekly intervals for 2,500 pulses at 11 Hz, and 4.0 Bar with radial devices (Fig. 32.19). Patients are advised to avoid NSAIDs, and ideally ice, as both of these may decrease the body's response. Treating the calf trigger point has been anecdotally advocated. If athletic patients are sore after activity, we let them use ice and acetaminophen if needed (9,10,57). Maximum effectiveness is typically seen at 12 to 20 weeks following treatment with very few side effects being reported (9,10,55,57–59). Objective findings such as decreased plantar fascia thickness noted on ultrasound, has been shown to correlate with decreased symptoms (22,60). Consistent with other high-level studies using these types of devices, we are able to relieve approximately 70% of our patients' symptoms (9,10,55,57–59).

Cost-effectiveness is becoming critical in the treatment of many chronic medical conditions. When figuring costs associated for the typical treatment paradigm for plantar fasciopathy, on average over US $2,500 (excluding radiologic examinations) is incurred prior to the decision to consider sound wave (Table 32.2). Other than cost of treatment, there is little to no downside to the use of sound-wave technology. An argument could be made to consider sound wave earlier in the treatment algorithm, as it is perhaps the most rigorously studied therapy for treatment of plantar fasciopathy. A randomized study showed that stretching is more effective for initial treatment of plantar fasciitis than sound wave, so we recommend a trial of Phase-1 treatments first (61). However, when dealing with athletes, given the relative safety of sound-wave devices, early intervention may prevent chronic fasciitis and allow faster RTA. Sound wave should be strongly considered as treatment option before considering surgical management for plantar fasciopathy.

TABLE 32.2 **Sample Charges in US$ From 12 Orthopedic and Podiatric offices for the Treatment of Plantar Fasciopathy Nationwide (Excluding Radiologic Examinations) Before Considering Sound Wave, Surgery, etc.**

Doctor's office visits (initial and 2+ follow-up)	$700+
Physical therapy (minimum 6 visits)	$1,200+
Over-the-counter inserts and night splint	$60+
NSAIDs (OTC and Rx)	$15+
Custom orthoses	$350+
Corticosteroid injection	$250+
TOTAL	**$2,560+**

SURGERY FOR PLANTAR FASCIITIS

Surgery for plantar fasciitis is generally reserved for the less than 10% of the patients who are unresponsive to non-surgical treatment. Saxena reported results of a prospective Level III study on endoscopic plantar fasciotomy. His cohort comprised of 29 patients who underwent surgery for isolated plantar fasciitis, out of 866 patients seen for plantar fasciitis during the 5-year study period (11). Mean pre-operative treatment prior to surgery was 19.6 months and minimum post-operative follow-up was 2 years. This underscores the number of patients who may necessitate surgical intervention is low and that the duration of pre-operative symptoms prior to considering surgery is much more than a year.

One of the most difficult and essentially undocumented aspects of treating patients with plantar fasciopathy is how to determine if surgery is indicated. We generally do not operate on patients unless they have had symptoms and treatment for a minimum of 12 months. However, if athletic patients have had all the appropriate non-surgical treatments mentioned above, and have been unable to return to sport to their desired activity level for 6 months, we may recommend surgery for these individuals. In some unusual cases with elite runners, if there is no improvement after 3 months, because the findings show return to running is often 2 to 3 months, and even sooner with an Alter-G™, we rarely may consider surgery at this point, particularly if the Olympics or major championships are looming within a year (11). Two things to keep in mind are that for many individual sports such running and tennis, there is often no "down season" and the athletes have a very defined way of measuring their recovery (i.e., maintaining their speed or ranking). Patients may not want to rest for fear of losing fitness. We do not recommend operating on these individuals unless they have refrained from the offending activity for at least 2 months.

In general, there are relatively few studies on foot and ankle surgery on athletes. Two studies from the 1980s described an open approach, with good results (62,63). Interestingly, most studies on athletic patients who had good outcomes are on runners (11,62,63). Saxena's study was prospective, used an endoscopic approach and is the largest on athletic patients. All the athletic patients returned to their sports on average 2.7 months post-surgery with a minimum 2-year follow-up with only one patient with transient lateral symptoms. Even patients with BMI over 27 had good outcomes if they were motivated to exercise (11).

Plantar fascia surgery can be performed in three basic ways: Open, percutaneous, and endoscopic. It is generally accepted that partial plantar fascia release is the critical portion of the procedure and that a spur, if present, does not need to be removed. This is substantiated by the finding that many *asymptomatic* individuals have an infra-calcaneal spur (64). The open technique is performed from a medial approach, with an oblique incision, with the release of the abductor hallucis, and transection of the medial portion of the central plantar fascia. With this approach, nerve decompression for nerve entrapment can be performed, though different incisional approaches may be needed if nerve pathology is the primary problem (65–68). Studies comparing the open to the endoscopic approach, show a longer RTA, higher wound complications and nerve entrapment along with longer healing time with the open technique (11,12). One thing that all approaches have in common, including nerve release, is that they all include partial plantar fascia release and have protection post-operatively.

A percutaneous "instep" plantar fasciotomy can be performed for plantar fasciitis. The incision is made transversely, within the skin lines, distal to the plantar fascia origin (Fig. 32.20). The medial and lateral margins of the central plantar fascia band are indentified; the medial 50% is transected (69,70). There are no studies reporting the activity level of patients with this technique but it does appear that it is analogous to creating a plantar fascia rupture.

The senior author's preferred technique for plantar fasciotomy is the endoscopic approach. The patient is placed supine. A 4.0 30 degree endoscope is utilized. A medial

Figure 32.20. Instep plantar fasciotomy incision. With permission from Fullem B, Saxena A. Plantar Fasciitis. In: Saxena A, ed. *International Advances in Foot and Ankle Surgery.* London: Springer; 2012:253–260.

incision within the skin lines is made distal to the plantar fascia origin. A fascial elevator is used to create a pathway inferior to the plantar fascia. An obturator/cannula assembly is placed in the medial incision and advanced laterally along the pathway, tenting the skin laterally. The endoscope is introduced medially; the plantar fascia should be visualized superiorly. Transillumination is used laterally to create a lateral portal; the cannula is then advanced through the skin and stabilized. The endoscope is then placed in the lateral portal to confirm tissue planes, again showing the fascia superiorly. The camera is then temporarily rotated 180 degrees inferiorly to determine the mid-point of the central plantar fascia. This will be the "end point" of the medial transection. The endoscope is rotated back and an endoscopic knife is placed medially (Mondeal NA/Tekartis, San Diego, CA and Mondeal Gmbh, Mülheim, Germany). As the blade is advanced from medial to the lateral end point, the endoscope is kept stationary so that inadvertent lateral transection does not occur. The toes are dorsiflexed to aid in transection. Sterile cotton swabs or suction can be used to aid in visualization. The ends of the transected plantar fascia should be visible (Fig. 32.21A–H). After irrigation, and instrument removal, 1cc of dexamethasone phosphate is injected in the region of the transection. Any remaining medial fibers are transected under direct visualization. The skin is re-approximated. Post-operatively, patients are placed in a short walker boot for 4 weeks; the first 2 weeks non—weight-bearing. Sutures are removed at 2 weeks. Physical therapy is begun at 4 weeks. The post-operative non—weight-bearing phase is critical in avoiding post-operative lateral column pain. Runners can RTA as soon as 4 weeks on an Alter-G treadmill and 7 weeks on regular running surfaces (11,71–74).

Other researchers have studied "indirect" surgery for plantar fasciopathy. Because ankle equinus has been correlated with plantar fasciitis, surgery to reduce the contracture has been studied. A recent Level IV study showed reasonable results from a proximal medial gastrocnemius tenotomy in relieving patients' symptoms. Abbassian et al. reported on 21 patients who had this procedure, with no weakness noted post-surgery, no brace was needed and 81% had good to excellent results (75). Surgery for gastrocnemius equinus may address the etiology of plantar fasciopathy but keep in mind that athletic patients may have symmetric equinus bilaterally and symptoms only unilaterally. Many asymptomatic individuals may have equinus, particularly athletes (76).

Another technique that has gained interest for the treatment of plantar fasciitis is the "TOPAZ" technique (Arthrocare, San Diego, CA). The technique uses radiofrequency in the region of the plantar fascia symptoms. To date, only Level IV studies have been reported with follow-up of 6 to 12 months (77,78). Epidermal cyst formation has been noted from this modality (79). Another radiofrequency technique is utilized for nerve ablation to the plantar fascia region. Significant reduction of the patients' pain using the VAS in this retrospective study was found. Similar to gastrocnemius recession and TOPAZ™, nerve ablation is somewhat novel as the plantar fascia integrity is maintained (80). As with most surgical results being reported, activity levels such as return to sports have not been reported by these "alternative" techniques.

Figure 32.21. **A:** Medial incision from endoscopic plantar fasciotomy. **B:** Insertion of fascial elevator. **C:** Insertion of obturator cannula. **D:** Insertion of endoscope. **E:** View of plantar fascia superiorly. **F:** Lateral portal. **Note:** incision should be horizontal. (*continued*)

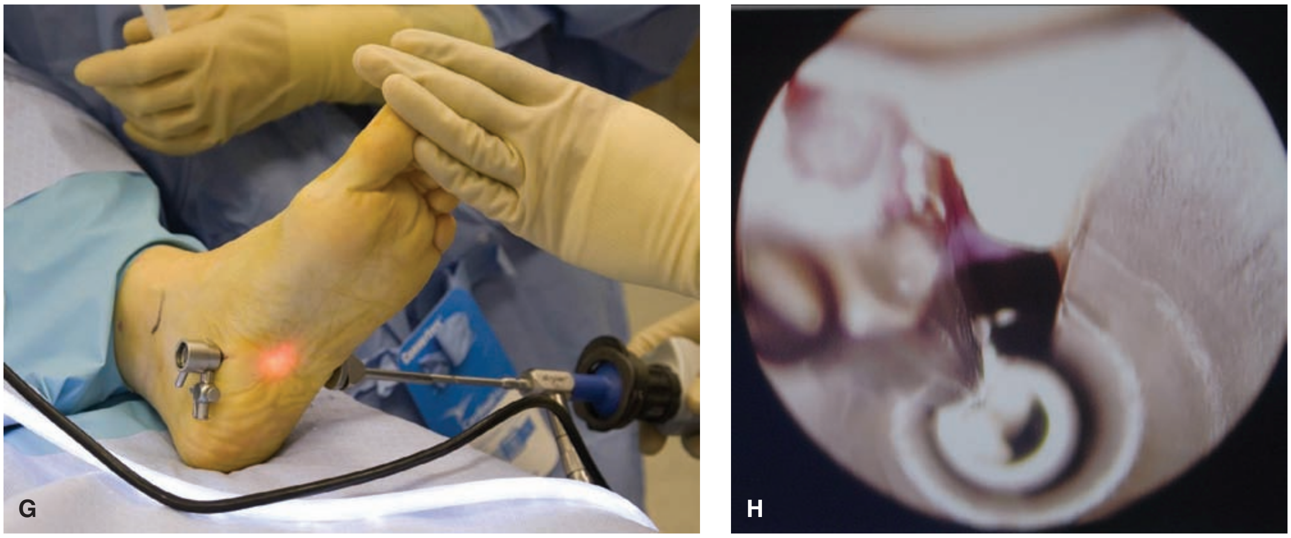


Figure 32.21. (*continued*) **G:** Transillumination to determine transection point at 50% of the central band's width. **H:** View of endoscopic blade (Mondeal Gmbh, Mühleim, Germany). With permission from Fullem B, Saxena A. Plantar Fasciitis. In: Saxena A, ed. *International Advances in Foot and Ankle Surgery*. London: Springer; 2012:253–260.

SUMMARY

Plantar fasciitis is a condition that has multiple etiologies and often lasts 12 months. Definitive diagnosis to rule out other entities such as rupture, stress fracture, and nerve entrapment is crucial. It is reported that 90% of cases "resolve" by a year, though this is difficult to determine for certain. Further study is needed to understand how some therapeutic options such as cryotherapy work and when to employ certain diagnostics such as x-ray (81,82). Plantar fasciitis is a condition that is controlled, but not necessarily cured. Table 32.3 summarizes recent research findings. Current evidence-based literature recommendations for initial ("Phase 1") treatment include stretching the calf and arch, pain control with cryotherapy and possible NSAIDs, and the use of an arch support or tape, along with appropriate shoe gear and activity modification. In unresponsive cases to these measures, the next level of treatment ("Phase 2") options such as corticosteroid injection (though athletes have to refrain from running and jumping for a week due to risk of rupture), custom foot orthoses, and ESWT/sound-wave therapy can be commenced. Recalcitrant cases, particularly runners, benefit from surgical partial plantar fasciotomy.

TABLE 32.3 Summary of Benefits of Current Treatment Options for Plantar Fasciopathy

PHASE 1:	
Stretching of calf and arch	High-level evidence
Over-the-counter arch supports	Medium-level evidence
Cryotherapy	Medium-level evidence
Night splints	High- and medium-level evidence
NSAIDs	Low level (unless inflammatory arthropathy)
Physical therapy (US and Ionto)	Low level
PHASE 2:	
ESWT/sound wave	High-level evidence
Custom orthoses	Medium-level evidence
Corticosteroid injection	Medium-level evidence
PRP/ABI	Low level
SURGERY:	
Endoscopic plantar fasciotomy	High- and medium-level evidence
Open and percutaneous fasciotomy	Low level
Gastrocnemius recession	Low level
TOPAZ	Low level

Experimental/Under-reported therapies: LASER, acupuncture, needling, massage.
Note: High = Level I and II, Medium = Level III, Low = Level IV and V.

REFERENCES

1. Taunton JE, Ryan MB, Clement DB, et al. A retrospective case-control analysis of 2002 running injuries. *Br J Sports Med* 2002;36(2):95–101.
2. Riddle DL, Schappert SM. Volume of ambulatory care visits and patterns of care for patients diagnosed with plantar fasciitis: a national study of medical doctors. *Foot Ankle Int* 2004;25:303–310.
3. Wolgin M, Cook C, Graham C, et al. Conservative treatment of plantar heel pain: long-term follow-up. *Foot Ankle Int* 1994;15:97–102.
4. O'Brien D, Martin WJ. A retrospective analysis of heel pain. *J Am Podiatr Med Assoc* 1985;75:416–418.
5. Scherer PR. Biomechanics Graduate Research Group for 1988: Heel spur syndrome: pathomechanics and nonsurgical treatment. *J Am Podiatr Med Assoc* 1991;81:68–72.
6. Lynch DM, Goforth WP, Martin JE, et al. Conservative treatment of plantar fasciitis: a prospective study. *J Am Podiatr Med Assoc* 1998;88:375–380.
7. Lemont H, Ammirati KM, Usen N. Plantar fasciitis: a degenerative process (fasciosis) without inflammation. *J Am Podiar Med Assoc* 2003;93(3):234–237.
8. Pfeffer G, Bacchetti P, Deland J, et al. Comparison of custom and prefabricated orthoses in the initial treatment of proximal plantar fasciitis. *Foot Ankle Int* 1999;20(4):214–221.
9. Gerdesmeyer L, Frey C, Vester J, et al. Radial extracorporeal shock wave therapy is safe and effective in the treatment of chronic recalcitrant plantar fasciitis: results of a confirmatory randomized placebo-controlled multicenter study. *Am J Sports Med* 2008;36(11):2100–2109.
10. Gollwitzer H, Diehl P, von Korff A, et al. Extracorporeal shock wave therapy for chronic painful heel syndrome: a prospective, double blind, randomized trial assessing the efficacy of a new electromagnetic shock wave device. *J Foot Ankle Surg* 2007;46(5):348–357.
11. Saxena A. Uniportal endoscopic plantar fasciotomy: a prospective study on athletic patients. *Foot Ankle Int* 2004;25(12):882–889.

12. Wapner KL, Puri RD. Heel and subcalcaneal pain. In: Thordarson DB, ed. *Orthopaedic Surgical Essentials: Foot & Ankle.* Philadelphia, PA: Lippincott Williams & Wilkins; 2004:182–194.
13. Bøjsen-Möller F, Flagstad KE. Plantar aponeurosis and internal architecture of the ball of the foot. *J Anat* 1976;121:599–611.
14. Pontious J, Flanigan KP, Hillstrom HJ. Role of the plantar fascia in digital stabilization. A case report. *J Am Podiatr Med Assoc* 1996;86:43–47.
15. Sarrafian S. *Anatomy of the Foot and Ankle: Descriptive, Topographic, Functional.* Philadelphia, PA: Lippincott; 1993:591–602.
16. Gould JS. Tarsal tunnel syndrome. *Foot Ankle Clin* 2011;16(2):275–286.
17. Saxena A, Fullem B. Plantar fascia ruptures in athletes. *Am J Sports Med* 2004;32(3):662–665.
18. Acevedo JI, Beskin JL. Complications of plantar fascia rupture associated with corticosteroid injection. *Foot Ankle Int* 1998;19(2):91–97.
19. Sellman JR. Plantar fascia rupture associated with corticosteroid injection. *Foot Ankle Int* 1994;15:376–381.
20. Leach R, Jones R, Silva T. Rupture of the plantar fascia in athletes. *J Bone Joint Surg Am* 1978;60:537–539.
21. Kim C, Cashdollar MR, Mendicino RW, et al. Incidence of plantar fascia ruptures following corticosteroid injection. *Foot Ankle Spec* 2010;3(6):335–337.
22. Mahowald S, Legge BS, Grady JF. The correlation between plantar fascia thickness and symptoms of plantar fasciitis. *J Am Podiatr Med Assoc* 2011;101(5):385–389.
23. Hafner S, Han N, Pressman M, et al. Proximal plantar fibroma as an etiology for recalcitrant plantar heel pain. *J Foot Ankle Surg* 2011;50(2):153-157.
24. Uzel M, Cetinus E, Ekerbicer HC, et al. The influence of athletic activity on the plantar fascia in healthy young adults. *J Clin Ultrasound* 2006;34(1):17–21.
25. Digiovanni BF, Nawoczenski DA, Lintal ME, et al. Tissue-specific plantar fascia-stretching exercise enhances outcomes in patients with chronic heel pain: a prospective, randomized study. *J Bone Joint Surg Am* 2003;85:1270–1277.
26. Patel A, Digiovanni B. Association between plantar fasciitis and isolated contracture of the gastrocnemius. *Foot Ankle Int* 2011;32:5–8.
27. Sweeting D, Parish B, Hooper L, et al. The effectiveness of manual stretching in the treatment of plantar heel pain: a systematic review. *J Foot Ankle Res* 2011;4:19.
28. Cleland JA, Abbott JH, Kidd MO, et al. Manual physical therapy and exercise versus electrophysical agents and exercise in the management of plantar heel pain: a multicenter randomized clinical trial. *J Orthop Sports Phys Ther* 2009;39(8):573–585.
29. Digiovanni BF, Nawoczenski DA, Malay DP, et al. Plantar fascia-specific stretching exercise improves outcomes in patients with chronic plantar fasciitis. A prospective clinical trial with two-year follow-up. *J Bone Joint Surg Am* 2006;88(8):1775–1781.
30. Fullem B, Saxena A. Plantar Fasciitis. In: Saxena A, ed. *International Advances in Foot and Ankle Surgery.* London: Springer; 2012:253–260.
31. Uden H, Boesch E, Kumar S. Plantar fasciitis - to jab or to support? A systematic review of the current best evidence. *J Multidiscip Healthc* 2011;4:155–164.
32. Squadrone R, Gallozzi C. Biomechanical and physiological comparison of barefoot and two shod conditions in experienced barefoot runners. *J Sports Med Phys Fit* 2009;49:6–13.
33. Smith GA, Bressel E, Branscomb J. Impact acceleration of the leg: comparison of shod and barefoot treadmill running. *Med Sci Sports Exer* 2010;42:133–134.
34. Divert C, Mornieux G, Freychat P, et al. Barefoot-shod running differences: shoe or mass effect. *Int J Sports Med* 2008;29:512–518.
35. Squadrone R, Gallozzi C. Biomechanical and physiological comparison of barefoot and two shod conditions in experienced barefoot runners. *J Sports Med Phys Fitness* 2009;49:6–13.
36. van de Water AT, Speksnijder CM. Efficacy of taping for the treatment of plantar fasciosis: a systematic review of controlled trials. *J Am Podiatr Med Assoc* 2010;100(1):41–51.
37. Osborne HR, Allison GT. Treatment of plantar fasciitis by LowDye taping and iontophoresis: short term results of a double blinded, randomised, placebo controlled clinical trial of dexamethasone and acetic acid. *Br J Sports Med* 2006;40(6):545–549.
38. Gudeman SD, Eisele SA, Heidt RS Jr, et al. Treatment of plantar fasciitis by iontophoresis of 0.4% dexamethasone. A randomized, double-blind, placebo-controlled study. *Am J Sports Med* 1997;25(3):312–316.
39. Berlet GC, Anderson RB, Davis H, et al. A prospective trial of night splinting in the treatment of recalcitrant plantar fasciitis: the ankle dorsiflexion dynasplint. *Orthopedics* 2002;25(11):1273–1275.
40. Al-Bluwi MT, Sadat-Ali M, Al-Habdan IM, et al. Efficacy of EZStep in the management of plantar fasciitis: a prospective, randomized study. *Foot Ankle Spec* 2011;4(4):218–221.
41. Louwers MJ, Sabb B, Pangilinan PH. Ultrasound evaluation of a spontaneous plantar fascia rupture. *Am J Phys Med Rehabil* 2010;89(11):941–944.
42. Taylor DW, Petrera M, Hendry M, et al. A systematic review of the use of platelet-rich plasma in sports medicine as a new treatment for tendon and ligament injuries. *Clin J Sport Med* 2011;21(4):344–352.
43. Andia I, Sánchez M, Maffulli N. Platelet rich plasma therapies for sports muscle injuries: any evidence behind clinical practice? *Expert Opin Biol Ther* 2011;11(4):509–518.
44. Paoloni J, De Vos RJ, Hamilton B, et al. Platelet-rich plasma treatment for ligament and tendon injuries. *Clin J Sport Med* 2011;21(1):37–45.
45. Sheth U, Simunovic N, Klein G, et al. Efficacy of Autologous Platelet-rich plasma use for orthopedic indications: a meta-analysis. *J Bone Joint Surg Am* 2012;94:298–307.
46. Ribeiro AP, Trombini-Souza F, Tessutti V, et al. Rearfoot alignment and medial longitudinal arch configurations of runners with symptoms and histories of plantar fasciitis. *Clinics (Sao Paulo)* 2011;66(6):1027–1033.
47. Scherer P. Chapter 3: Mechanically Induced Plantar Fasciitis and Subcalcaneal Pain in Recent Advances. In: Scherer P, ed. *Orthotic Therapy: Improving Clinical Outcomes with a Pathology-Specific Approach.* Albany, NY: Lower Extremity Publishing LLC; 2011:43–55.
48. Kogler G, Veer FB, Solomonidis SE. The influence of medial and lateral placement of orthotic wedges on loading of the plantar aponeurosis. *J Bone Joint Surg Am* 1999;81A:1403–1413.
49. Roos E, Engstrom M, Soderberg B. Foot orthoses for the treatment of plantar fasciitis. *Foot Ankle Int.* 2006;27(8):606–611.
50. Landorf KB, Keenan AM, Herbert RD. Effectiveness of foot orthoses to treat plantar fasciitis. *Arch Intern Med* 2006;166(6):1305–1310.
51. Baldassin V, Gomes CR, Beraldo PS. Effectiveness of prefabricated and customized foot orthoses made from low-cost foam for non-complicated plantar fasciitis: a randomized controlled trial. *Arch Phys Med Rehab.* 2009;90(4):701–706.
52. Rompe JD, Hopf C, Nafe B, et al. Low-energy extracorporeal shock wave therapy for painful heel: a prospective controlled single-blind study. *Arch Orthop Trauma Surg* 1996;115(2):75–79.
53. Ho C. Extracorporeal shock wave treatment for chronic plantar fasciitis (heel pain). *Issues Emerg Health Technol* 2007;96(1):1–4.
54. Chuckpaiwong B, Berkson EM, Theodore GH. Extracorporeal shock wave for chronic proximal plantar fasciitis: 225 patients with results and outcome predictors. *J Foot Ankle Surg* 2009;48(2):148–155.
55. Marks W, Jackiewicz A, Witkowski Z, et al. Extracorporeal shock-wave therapy (ESWT) with a new-generation pneumatic device in the treatment of heel pain. A double blind randomised controlled trial. *Acta Orthop Belg* 2008;74(1):98–101.
56. Saxena A, Ramdath S, O'Halloran P, et al. Letter to the editor. *J Foot Ankle Surg* 2011; 50(6):753–754.
57. Gollwitzer H, Saxena A, Didomenico L, et al. Focus ESWT for chronic plantar fasciitis. *J Bone Joint Surg* 2012 (in press)
58. Rompe JD, Meurer A, Nafe B, et al. Repetitive low-energy shock wave application without local anesthesia is more efficient than repetitive low-energy shock wave application with local anesthesia in the treatment of chronic plantar fasciitis. *J Orthop Res* 2005;23(4): 931–941.
59. Klonschinski T, Ament SJ, Schlereth T, et al. Application of local anesthesia inhibits effects of low-energy extracorporeal shock wave treatment (ESWT) on nociceptors. *Pain Med* 2011;12(10):1532–1537.
60. Hammer DS, Adam F, Kreutz A, et al. Ultrasonographic evaluation at 6-month follow-up of plantar fasciitis after extracorporeal shock wave therapy. *Arch Orthop Trauma Surg* 2005;125(1):6–9.
61. Rompe JD, Cacchio A, Weil L Jr, et al. Plantar fascia-specific stretching versus radial shock-wave therapy as initial treatment of plantar fasciopathy. *J Bone Joint Surg Am* 2010; 92(15):2514–2522.
62. Snider MP, Clancy WG, McBeath AA. Plantar fascia release for chronic plantar fasciitis in runners. *Am J Sports Med* 1983;11:215–219.
63. Leach RE, Seavey MS, Salter DK. Results in surgery in athletes with plantar fasciitis. *Foot Ankle Int* 1986;7:156–161.
64. Shama SS, Kominsky SJ, Lemont H. Prevalence of non-painful heel spur and its relation to postural foot position. *J Am Podiar Med Assoc* 1983;73(3):122–123.
65. Sinnaeve F, Vandeputte G. Clinical outcome of surgical intervention for recalcitrant infero-medial heel pain. *Acta Orthop Belg* 2008;74:483–488.
66. Hendrix CL, Jolly GP, Garbalosa JC, et al. Entrapment neuropathy: the etiology of intractable chronic heel pain syndrome. *J Foot Ankle Surg* 1998;37:273–279.
67. Dellon AL. Technique for determining when plantar heel pain can be neural in origin. *Microsurgery* 2008;28:403–406.
68. Baxter DE. Release of the nerve to the abductor digiti minimi In: Kitaoka HB, ed. *Master Techniques in Orthopaedic Surgery of The Foot and Ankle.* Philadelphia, PA: Lippincott Williams and Wilkins; 2002:359.
69. Woelffer KE, Figura MA, Sandberg NS, et al. Five-year follow-up results of instep plantar fasciotomy for chronic heel pain. *J Foot Ankle Surg* 2000;39(4):218–223.
70. Boberg J. Plantar fascia surgery in master techniques. In: Chang T, ed. *Podiatric Surgery: The Foot and Ankle.* Lippincott: Philadelphia, PA; 2005:222–224.
71. Bazazz R, Ferkel R. Results of endoscopic plantar fascia release. *Foot Ankle Int* 2007;28: 549–556.
72. Shapiro S. Endoscopic plantar fasciotomy. In: Scuderi G, Tria A, eds. *Minimally Invasive Surgery in Orthopedics.* New York, NY: Springer; 2009:427–436.
73. Bader L, Park K, Gu Y, et al. Functional outcome of endoscopic plantar fasciotomy. *Foot Ankle Int* 2012;33(1):37–43.
74. Saxena A. Endoscopic plantar fasciotomy versus pulsed ultrasonic soundwave in runners. *J Musc Lig Tend* (in press)
75. Abbassian A, Kohls-Gatzoulis J, Solan MC. Proximal medial gastrocnemius release in the treatment of recalcitrant plantar fasciitis. *Foot Ankle Int* 2012;33(1):14–19.
76. Saxena A, Kim W. Ankle dorsiflexion in adolescent athletes. *J Am Podiatr Med Assoc* 2003;93(4):312–314.
77. Weil L Jr, Glover JP, Weil LS Sr. A new minimally invasive technique for treating plantar fasciosis using bipolar radiofrequency: a prospective analysis. *Foot Ankle Spec* 2008;1(1): 13–18.
78. Sean NY, Singh I, Wai CK. Radiofrequency microtenotomy for the treatment of plantar fasciitis shows good early results. *Foot Ankle Surg* 2010;16(4):174–177.
79. Ferguson K, Thomson AG, Moir JS. Case study: Epidermoid cyst following percutaneous Topaz coblation for plantar fasciitis. *Foot (Edinb)* 2012;22(1):46–47.
80. Liden B, Simmons M, Landsman AS. A retrospective analysis of 22 patients treated with percutaneous radiofrequency nerve ablation for prolonged moderate to severe heel pain associated with plantar fasciitis. *J Foot Ankle Surg* 2009;48(6):642–647.
81. Bizzini M. Ice and modern sports physiotherapy: still cool? *Br J Sports Med* 2012;46: 219.
82. Levy JC, Mizel MS, Clifford PD, et al. Value of radiographs in the initial evaluation of nontraumatic adult heel pain. *Foot Ankle Int* 2006;27(6):427–430.