Plantar fasciitis affects an estimated 2 million persons who present annually for medical treatment.1 Runners comprise over 76% of athletes with this condition.2,3 Men and women appear to be equally affected.4 Plantar fasciitis classically presents as medial heel pain that is sharp and most severe with the first step out of bed in the morning or after prolonged rest. This condition is generally self-limiting, but complete resolution may take 6 to 18 months or longer.5 Aggressive management using combination therapies is most efficacious and affords athletes the best opportunity to recover quickly and fully. An understanding of risk factors and pathophysiology will help in identifying athletes predisposed to developing plantar fasciitis, as well as in formulating the most effective preventive and therapeutic treatment plan.

**RISK FACTORS**

Plantar fasciitis can occur acutely, as with trauma, but more often presents as chronic plantar foot pain of insidious onset associated with chronic overload. In approximately 85% of patients, the etiology is undetermined.6,7 Risk factors for developing plantar fasciitis can be divided into anatomic, biomechanical, and environmental and are presented in Table 1. Limited ankle dorsiflexion (≤10°) has been reported as the most important independent risk factor.8 This limitation may cause compensatory excessive pronation of the subtalar joint, which increases the tensile load to the plantar aponeurosis.9

**PATHOPHYSIOLOGY**

Plantar fasciitis has been referred to as heel pain syndrome and heel spur syndrome, because the pain is usually localized to the insertion of the plantar aponeurosis at the medial tubercle of the calcaneus. The plantar fascia extends from this tubercle to the metatarsal heads, forming the longitudinal arch that provides support for the foot. Excessive load or tension on this aponeurosis can lead to the condition commonly referred to as plantar fasciitis. Historically, plantar fasciitis has been considered an inflammatory process. However, in recalcitrant cases, it appears that a degenerative process affecting collagen5 or degenerative fasciosis10 occurs without evidence of inflammation. Lemont et al10 performed histologic examination of surgical biopsies, revealing increased fibroblasts, ground substance, and vascularity, not the expected inflammatory mediators.5,10 This improved understanding may impact the use of anti-inflammatory therapies for chronic plantar fasciitis.

**TREATMENT**

Treatment should be aggressive, should be initiated as early as possible, and should include a multifaceted approach that addresses underlying anatomic and biomechanical conditions, training errors, and risk factors. Assessment of underlying risk factors is the foundation for successful treatment and prevention. Treatment options discussed are summarized in Table 2.

**Relative Rest**

Relative rest must be a part of the treatment plan, allowing athletes to continue to train in some capacity without exacerbating symptoms. Relative rest relieves microtrauma caused by repetitive overload. Wolgin et al11 reported 25% of patients citing rest as the treatment that best relieved pain. Cross-training should be considered to maintain aerobic fitness levels. Relieving the overuse component through rest is critical to the prevention of further injury.

**Stretching**

Stretching is the single most effective method of treatment. Of the 83% of patients who improved with stretching, 29% indicated that stretching was most effective in relieving pain as compared with other modalities.11 Stretching should include techniques targeted at the entire lower extremity, especially the plantar fascia and gastrocnemius-Achilles complex.

The athlete can target the plantar fascia at home using a tennis ball, golf ball, or 15-oz can rolled under the arch to provide an adequate stretch. To accentuate further the stretch on
the fascia, the athlete can rest the affected foot on the contra-
lateral or unaffected thigh, applying firm dorsiflexion of the
great toe, thus increasing the stretch of the plantar fascia (Fig. 1). Manual stretching techniques such as myofascial release
and deep tissue massage can be used to stretch the fascia.
Stretching the gastrocsoleus-Achilles complex is
achieved using wall stretches with a straight knee to isolate the
gastrocnemius muscle and with a bent knee to target the soleus
muscle. These stretches can also be performed using a curb or
stair. Stretching techniques focusing on the plantar fascia has
been shown to accelerate recovery time and is more effective
than those directed exclusively at the gastrocsoleus-Achilles
complex. Early prescriptions should be given for a home
stretching program and possibly for physical therapy referral.
Specific stretching techniques appear in Table 2.

**Night Splints**

Dorsiflexion night splints ($90^\circ$) relieve pain by provid-
ing continuous passive stretching during rest and sleep. Their
use may decrease duration of symptoms, and they can be pur-
chased without a prescription. Powell et al\textsuperscript{13} reported that 88% of patients using night splints for 1 month experienced
improvement in their symptoms. They can be bulky and uncom-
fortable but may return the athlete to peak performance more
quickly. Frequently, night splints are reserved for recalcitrant
plantar fasciitis; we propose that they be considered at the on-
set of symptoms in athletes.

**Strengthening**

Plantar flexor muscle strength deficits were cited by
Kibler et al\textsuperscript{14} as contributing to plantar fasciitis. Martin et al\textsuperscript{15} reported that strengthening exercises provide the greatest
decrease in pain in 34.9% of patients with plantar fasciitis.
Strengthening exercises for the intrinsic muscles of the foot are
designed to improve longitudinal arch support and decrease
stress on the plantar fascia.

Athletes can perform strengthening exercises every hour
throughout the day by simple tapping of the toes with the foot
planted. The desired technique is to raise the toes and press
them each individually to the floor. Additionally, with a towel
placed on the floor, the athlete is instructed to keep the heel
planted and gather the towel by curling the toes. As strength
improves, weight can be added to the towel to increase resis-
tance.

Strengthening of the gastrocsoleus-Achilles complex is
accomplished using heel raises. The athlete begins with both
legs at once and progresses to single leg repetitions. As
strength improves, resistance can be increased using dumb-
bells or free weights. We recommend that athletes perform
strengthening exercises 3 times per day with 12 to 15 repeti-
tions per set. Pain should be monitored with modifications in
frequency and intensity to avoid exacerbation or return of
symptoms.

**Anti-inflammatory Therapies**

Recent histologic evidence identifying collagen degra-
dation, as opposed to inflammatory markers in surgical biopsy
specimens, raises questions about the utility of anti-
inflammatory therapy such as NSAIDs for chronic plantar fasciitis.\textsuperscript{5,10} While NSAIDs are effective in some patients and were reported in 1 study to be the most effective treatment by 11% of subjects,\textsuperscript{11} the use of NSAIDs should be limited to a brief duration. Specifically, this may be 1 to 2 weeks at a time during the most acute flare-ups.

Ice applied to the attachment of the aponeurosis following activity can decrease pain and inflammation. At home, the athlete can use ice massage to stretch the fascia. Iontophoresis can be used to deliver corticosteroid such as dexamethasone to the deep plantar aponeurosis. Gudeman et al reported improvement after 2 weeks but no long-term difference at 6 weeks.\textsuperscript{16,17} Difficulties with this treatment are the time requirement and expense, as optimal therapy requires administration 2 to 3 times per week by a qualified professional. Recommendations are to reserve iontophoresis for elite athletes and laborers prevented from working due to symptoms.\textsuperscript{16}

Corticosteroid injections are controversial and are not a first-line therapy due to the associated risks and possible complications. They should be reserved for recalcitrant cases of plantar fasciitis. Studies have shown a 70% success rate using steroid injections when applied early in the disease process.\textsuperscript{7,18} Injections can be performed using a plantar or medial approach with or without ultrasound guidance. Complications include rupture of the plantar fascia and fat pad atrophy. Although rupture of the plantar fascia is uncommon, injection of corticosteroids has been suggested as a contributing factor.\textsuperscript{3,19,20} Most patients had resolution of symptoms associated with rupture within 6 to 8 weeks.\textsuperscript{3,21} Still, the use of corticosteroid injections in plantar fasciitis remains controversial.

\textbf{Arch Supports}

The longitudinal arch is designed to distribute forces generated at heel strike. Anatomic, biomechanical, and environmental factors causing abnormal distribution of these forces can result in plantar fasciitis. Arch supports, through taping or orthoses, can alter the transmission of forces and decrease stress. As a simple noninvasive treatment, they can be considered a first-line treatment of plantar fasciitis in combination with a stretching program.

\begin{table}
\centering
\caption{Treatment Options for Plantar Fasciitis}
\begin{tabular}{lll}
\hline
\textbf{Treatment} & \textbf{Benefit} & \textbf{Comments} \\
\hline
Relative rest & Decrease pain, slow degenerative process & Cross-training to maintain fitness \\
Stretching & Increase mobility of plantar fascia & Plantar fascia: 15-oz can rolled under arch, cross-friction massage, great toe extension, towel stretch \\
 & Decrease tension of gastrocsoleus-Achilles complex & Gastrocsoleus: slant board, wall stretch, curb or stair stretch \\
Night splints (90\(^\circ\)) & Prolonged passive stretch & Commercially available, compliance difficult \\
Strengthening & Improve structural integrity of longitudinal arch & Toe curls \\
 & Improve plantar flexor strength & Toe taps \\
 & & Heel raises \\
Anti-inflammatory agents & & \\
NSAIDs & Pain control & Short course \\
 & Local pain control & Risk of GI problems \\
Ice & & 15 minutes 2–3 times day \\
Iontophoresis & Decrease inflammation, local pain control & Time-consuming, reserve for elite athletes or laborers \\
Corticosteroid injections & Decrease inflammation, local pain control & Use in later stages, risk of plantar fascia rupture, atrophy \\
Arch supports & & \\
Arch taping & Stabilize midfoot structures & Inexpensive, trial modality \\
OTC arch supports & Stabilize midfoot structures & Mild pes planus \\
 & & Adolescents experiencing rapid growth \\
 & & Symptoms less than 8 weeks \\
Customs orthotics & Stabilize midfoot structures & Ideal for anatomical problems \\
 & Correct anatomical problems & Expensive \\
Shoes & Correct anatomical and biomechanical factors & Change shoes every 300–500 miles \\
 & & Check for correctable problems \\
ESWT & Induce inflammatory response & High-energy: single treatment, local anesthesia needed \\
 & Increase neovascularization & Low-energy: multiple treatment sessions, no anesthesia needed, standardization still needed \\
Surgery & Pain control & Failed conservative therapy at least 6 months, often much longer \\
\hline
\end{tabular}
\end{table}
Arch taping is also a simple, cost-effective treatment of plantar fasciitis. In patients with pes planus or pes cavus, a single arch taping treatment is less expensive than over-the-counter (OTC) arch supports. It is also useful as a treatment trial. If arch taping relieves pain, then advancing to an OTC or custom-made orthotic should be considered.

Patients with mild pes planus may benefit from OTC arch supports. They are useful for pediatric athletes who experience rapid foot growth, making custom orthotics cost-prohibitive. OTC arch supports coupled with a formal stretching program offer greater benefit than custom-made orthotics for the initial treatment of plantar fasciitis of duration less than 8 weeks.

In patients with plantar fasciitis of duration greater than 8 weeks, the use of custom orthotics may be efficacious. In a pilot study of 15 patients with a mean age of 44 years and plantar fasciitis with a duration of 21 months, semirigid custom orthotics significantly improved pain and functional disability scores by 66% and 75%, respectively. Custom orthotic devices for plantar fasciitis are commonly semirigid, covering 3/4 to the entire foot. They have been extremely effective in controlling overpronation, first metatarsal head motion, pes planus, valgus heel alignment, and leg length discrepancies, all of which may be risk factors for this condition.

Shoes

Shoes that are properly fitted with well-supported arches and midsoles can absorb forces transmitted through the foot during walking and prolonged standing. Athletes should be encouraged to limit time spent walking barefoot or in sandals. Some popular recommendations for footwear include using shoes with a minimal 1” heel height and a stable midfoot shank, as recent shoe design changes utilizing a 2-piece outsole may contribute to developing plantar fasciitis. These design changes result in weaker midsoles that increase stress on the plantar fascia and thus should be avoided.

A simple change in shoes is reported to improve symptoms in 14% of patients with plantar fasciitis. Runners should replace their shoes every 300 to 500 miles because of an older shoe’s tendency to provide inadequate support.

Extracorporeal Shock Wave Therapy

Extracorporeal shock wave therapy (ESWT) is delivered as acoustic waves that propagate rapidly in 3-dimensional space and cause a sudden rise in pressure at the wave front (i.e., medial tubercle of the calcaneus). The intent is to elicit an inflammatory response that promotes neovascularization and healing. In most studies using ESWT, success is defined as 50% reduction in pain. It is customarily given as either 3 moderate-energy treatments given over a 3-week period requiring no anesthesia or as a single high-energy treatment requiring regional anesthesia.

A review of current literature suggests that moderate-energy ESWT given over several sessions is an ineffective treatment. However, using single high-energy treatment, Alvarez reported that at 12 months, 20 of 20 patients met criteria for success, and 65% were pain-free at 24 months. This brings up the main point of controversy surrounding this treatment: whether single high-energy treatments will ultimately prove effective when repeated moderate-energy doses have not. The US FDA granted approval of electrohydraulic devices for single high-energy use in chronic proximal plantar fasciitis. However, more research is needed to support the use of single high-energy ESWT in this condition. When considered, ESWT use should be limited to patients who have had pain for at least 6 months and have not satisfactorily responded to conservative management strategies including stretching, strengthening, orthoses, and corticosteroid injections.

Surgical Treatment

Surgical intervention has been the last resort for the 5% of all patients with plantar fasciitis who have failed all other options. In general, the success rate for surgical intervention is quite high. In some studies, over 90% achieved a satisfactory functional outcome. Generally, the surgical approach, open or endoscopic, involves transection of the plantar aponeurosis. Complications of surgical procedures include flattening of the longitudinal arch and heel hypoesthesia.

**SUMMARY**

Athletes should be educated about the symptoms of plantar fasciitis and advised to seek medical attention early so that aggressive mechanical management may be implemented and the duration of condition shortened. Athletes are highly motivated to return to competition, and those with plantar fasciitis will benefit most from a multifaceted approach to treatment, including a good home exercise program. Management should be directed toward treating underlying causes (e.g., pes planus) and implementing an aggressive plan of relative rest, stretching, and strengthening. Physical therapy should include manual techniques directed specifically to the plantar fascia and consideration of modalities such as iontophoresis. Nonsteroidal anti-inflammatory therapies can be beneficial in acute plantar fasciitis, but corticosteroid injections should be used with caution due to the increased risk of rupture of the fascia. There is burgeoning evidence to support collagen degeneration and not inflammation as the primary pathology of calcaneal plantar fasciitis. ESWT provides a nonsurgical option for athletes with plantar fasciitis of duration at least 6 months resistant to aggressive home and physical therapy. Plantar fasciotomy and other operative procedures should be reserved for athletes who have failed all other therapies.
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REFERENCES

8. Sarrafian SK. Functional characteristics of the foot and plantar aponeurosis under tibiotalar loading. Foot Ankle. 1987;8:4–18.
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