Abstract

Plantar fasciitis is the most common cause of plantar heel pain. Its characteristic features are pain and tenderness, predominately on the medial aspect of the calcaneus near the sole of the heel. Considering a complete differential diagnosis of plantar heel pain is important; a comprehensive history and physical examination guide accurate diagnosis. Many nonsurgical treatment modalities have been used in managing the disorder, including rest, massage, nonsteroidal anti-inflammatory drugs, night splints, heel cups/pads, custom and off-the-shelf orthoses, injections, casts, and physical therapy measures such as shock wave therapy. Most reported treatment outcomes rely on anecdotal experience or combinations of multiple modalities. Nevertheless, nonsurgical management of plantar fasciitis is successful in approximately 90% of patients. Surgical treatment is considered in only a small subset of patients with persistent, severe symptoms refractory to nonsurgical intervention for at least 6 to 12 months.

Epidemiology

Severe recalcitrant heel pain is a relatively commonly observed phenomenon. Although this condition is frequently referred to as heel spurs, currently accepted terms of greater accuracy are plantar fasciitis (acute inflammatory stage) and plantar fasciosis (chronic degeneration). Plantar fasciitis can be a painful and debilitating condition that often frustrates not only the patient but also the physician. Plantar fasciitis is defined as an inflammation of the origin of the plantar fascia and surrounding perifascial structures. There is no “gold standard” or benchmark diagnostic criterion for plantar fasciitis, but the clinical presentation is well recognized. The accepted hallmarks are pain and palpable tenderness in the area of the medial tubercle of the calcaneus, pain that is increased when taking the first few steps in the morning, and pain that is worse with continued weight bearing. Despite extensive efforts taken to understand this disorder, foot surgeons continue to debate the source and etiology of plantar heel pain as well as the most appropriate modality of treatment.

Plantar fasciitis is the most common cause of plantar heel pain, accounting for 80% of patients with symptoms. It is estimated that 1 in 10 persons may experience inferior heel pain at some time. Demographic surveys indicate that nearly two million patients receive treatment of plantar fasciitis each year in the United States, comprising 1% of all visits to orthopaedists. The peak age of incidence in the general population is between 40 and 60 years. Risk factors include running...
athletes, occupations that involve prolonged standing, pes planus, limited ankle dorsiflexion, and obesity. In one third of cases, the condition involves both feet. The disorder is prevalent in persons with seronegative arthritis because many of these patients have disease at the site of attachment of tendons or ligaments to bone.

**Anatomy**

The plantar fascia originates at the anteromedial aspect of the calcaneus and spreads broadly as it extends distally to divide into five digital bands at the metatarsophalangeal joints. Each band inserts into the base of the proximal phalanx of each toe. Vertical fibers divide the plantar fascia, creating three separate compartments for the intrinsic plantar muscles. Additionally, fibers merge with the dermis, transverse metatarsal ligaments, and the flexor tendon sheaths. The plantar fascia is inelastic, with maximal elongation of 4%. During the toe-off phase of gait, the metatarsophalangeal joints are dorsiflexed, resulting in high tensile forces concentrated at the calcaneal origin of the plantar fascia. This was described in 1954 by Hicks, who named the phenomenon the “windlass effect” of the plantar fascia (Figure 1).

With walking, the heel absorbs a force of 110% × body weight at heel strike, with running, this force increases to 200%. The fat pad of the calcaneus is a honeycomb pattern of fibroelastic septa that completely enclose fat globules. This closed-cell pattern of the fat pad allows it to function as a shock absorber. After age 40 years, the fat pad begins to atrophy, with loss of water, collagen, and elastic tissue. The overall thickness and height of the fat pad decreases, resulting in diminished shock absorbency and reduced protection of the calcaneal tuberosity.

**Etiology**

Plantar fasciitis was originally described in 1812 by Wood, who believed it to be the result of inflammation secondary to tuberculosis. As infectious theories were discredited, the role of the heel spur in plantar fasciitis was popularized. DuVries promoted the concept of physical impingement into the plantar fat pad. Cadaveric dissections demonstrated the presence of the spur within the flexor digitorum brevis rather than within the plantar fascia itself. Approximately 50% of patients with heel pain will have heel spurs. Williams et al found that 75% of patients who had heel pain also had spurs, compared with 63% of patients with no heel pain. It is now widely accepted that heel spurs can occur with plantar fasciitis, but they are not the cause.

As a result of cadaveric studies, entrapment of the first branch of the lateral plantar nerve (FBLPN) was proposed as the source of plantar fasciitis. Histologic examination of the FBLPN in patients with chronic heel pain revealed evidence of demyelination and perineurial fibrosis. Pain from FBLPN compression has been differentiated from that of plantar fascial pain based on location of maximal tenderness.

The word fasciitis implies an inflammatory process; however, histologic evidence does not support this concept. Findings demonstrate myxoid degeneration, microtears in the fascia, collagen necrosis, and angiofibroplastic hyperplasia. These changes are more consistent with a degenerative process without inflammation, likely secondary to repetitive microtrauma at the origin of the plantar fascia.

**Clinical Presentation**

The diagnosis of plantar fasciitis is based on the patient’s history and clinical examination. Patients report a gradual onset of inferior heel pain that is intensely worse with the first steps in the morning or after a period of prolonged standing. The pain tends to lessen with activity but worsens by the end of the day. The pain tends to lessen with activity but worsens by the end of the day. The pain tends to lessen with activity but worsens by the end of the day. The pain tends to lessen with activity but worsens by the end of the day. The pain tends to lessen with activity but worsens by the end of the day.
Plantar Fasciitis: Evaluation and Treatment

**Table 1**

**Differential Diagnosis of Heel Pain**

<table>
<thead>
<tr>
<th>Neurologic</th>
<th>Enthesopathies</th>
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<tbody>
<tr>
<td>Tarsal tunnel syndrome</td>
<td>Peripheral neuropathy</td>
</tr>
<tr>
<td>First branch of the lateral plantar nerve entrapment</td>
<td>S1 radiculopathy</td>
</tr>
<tr>
<td>Medial calcaneal nerve entrapment</td>
<td>Soft tissue</td>
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<tr>
<td>Flexor hallucis longus tendinitis</td>
<td>Plantar fascia rupture</td>
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<tr>
<td>Plantar fibromatosis</td>
<td>Achilles tendinitis</td>
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<tr>
<td>Posterior tibial tendinitis</td>
<td>Skeletal</td>
</tr>
<tr>
<td>Calcaneal stress fracture</td>
<td></td>
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<tr>
<td>Bone contusion</td>
<td></td>
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<tr>
<td>Infections (osteomyelitis/subtalar pyarthrosis)</td>
<td></td>
</tr>
<tr>
<td>Subtalar arthritis</td>
<td></td>
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<tr>
<td>Inflammatory arthropathies</td>
<td></td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>Neurogenic etiologies traditionally result from a nerve entrapment or compression syndrome.</td>
</tr>
<tr>
<td>Neoplasm</td>
<td>An L5-S1 radiculopathy can present with symptoms involving plantar heel pain.</td>
</tr>
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| Vascular insufficiency      | Imaging plays a limited role in routine clinical evaluation for plantar fasciitis. Conventional radiographs are often unrewarding. Levy et al evaluated the cost effectiveness and clinical value of routine radiographs in patients with atraumatic plantar heel pain. Of 215 patients, no single radiograph affected the diagnosis or treatment. Therefore, radiographic evaluation would be appropriate only in patients who fail to improve with appropriate treatment in a reasonable amount of time or in patients with an atypical history or physical examination. A triple-phase bone scan may reveal increased uptake in the area of the medial calcaneal tubercle and can be helpful in differentiating between plantar fasciitis and a calcaneal stress fracture.

**Differential Diagnosis**

Although plantar fasciitis is the most common source of inferior or plantar foot pain, many conditions can cause inferior heel pain. A complete history and physical examination most often will direct the physician to the appropriate diagnosis and treatment plan. Neurogenic etiologies traditionally result from a nerve entrapment or compression syndrome. Tarsal tunnel syndrome and medial calcaneal nerve compression produce pain along the medial and plantar areas of the foot. In addition, patients with these conditions often report burning and tingling and have a positive Tinel sign. Dorsiflexion of the toes does not exacerbate their symptoms.

The FBLPN (Baxter nerve) innervates the abductor digiti quinti, quadratus plantae, and flexor digitorum brevis muscles. It passes just superior to the insertion of the plantar fascia on the medial calcaneal tuberosity. Compression of this nerve causes maximal pain over the plantar medial aspect of the foot, which can be confused with plantar fasciitis. Because of the nerve’s close proximity to the medial calcaneal tubercle, many authors feel that both conditions are often present.

An L5-S1 radiculopathy can present with symptoms involving plantar heel pain. A history that includes radiating symptoms in the leg, combined with a thorough neurologic examination (ie, reflexes, motor strength), can facilitate diagnosis of this condition. Patients with peripheral neuropathies, common in diabetics, frequently report foot and heel pain. Typically, these patients lack a focal area of discomfort and do not report improvement with non-weight bearing.

Calcaneal stress fractures typically present with diffuse swelling and warmth of the hindfoot. Medial-lateral compression of the calcaneus (ie, the squeeze test) evokes pain in patients with calcaneal stress fracture. Flexor hallucis tendinitis also presents with plantar heel pain; tenderness with resisted flexion of the great toe can differentiate this condition from plantar fasciitis. Pain along the midportion of the plantar fascia, in addition to palpable nodules within the fascial substance, points to plantar fibromatosis. Patients with rupture of the plantar fascia typically describe acute onset of pain. Examination may reveal a subtle collapse in the medial longitudinal arch and a palpable gap within the substance of the fascia. Most of these ruptures heal successfully with nonsurgical treatment involving immobilization and prolonged non-weight bearing. Finally, patients with fat pad atrophy report centralized heel pain. Palpation of the heel pad will reveal a flattened, atrophied surface.
neal stress fracture. Proponents of magnetic resonance imaging (MRI) in the management of plantar fasciitis argue that MRI is most helpful in excluding other causes of heel pain. Typical MRI findings include fascial thickening and increased signal intensity in the substance of the plantar fascia. Ultrasonographic examination of patients with plantar fasciitis has demonstrated thickened, hypoechoic fascia and is equally effective in the diagnosis of plantar fasciitis, as are bone scintigraphy and MRI. Unlike these modalities, ultrasound is quick and inexpensive, and it involves no radiation exposure. MRI or triple-phase bone scans should be ordered to rule out occult pathology only when the heel pain has not resolved after 4 to 6 months of nonsurgical treatment.

Less commonly ordered laboratory testing to be considered include blood testing and electromyographic nerve conduction velocity studies. Serum hematologic and immunologic testing can detect systemic disorders that contribute to heel pain. Human leukocyte antigen-B27, complete blood count, erythrocyte sedimentation rate, rheumatoid factor, antinuclear antibodies, and uric acid may be considered in patients with bilateral or atypical heel pain. Electromyography and nerve conduction velocity studies are effective at identifying spinal radiculopathy and diffuse peripheral neuropathy as well as local nerve entrapment, such as tarsal tunnel syndrome. The most common nerve entrapment confused with plantar fasciitis is the FBLPN. Unfortunately, electrodiagnostic studies are not helpful in making this diagnosis.

Nonsurgical Treatment

A wide variety of management strategies have been developed to treat plantar fasciitis. Nonsurgical treatment is the mainstay of treating plantar heel pain. A systematic review in 2003 evaluated 26 different conservative treatments that have been recommended for the treatment of plantar fasciitis. Of these, only heel pads, orthoses, corticosteroid injections, night splints, and extracorporeal shock wave therapy (ESWT) have been evaluated in randomized trials. Since then, additional randomized controlled trials, primarily focusing on ESWT, have been published.

Nonsteroidal Anti-inflammatory Drugs

In a retrospective review, Wolgin et al found that 39 of 51 patients (76%) recorded as having used nonsteroidal anti-inflammatory drugs (NSAIDs) had “successful” outcomes. No conclusion could be drawn, however, because any given patient could have used more than one treatment. Gill and Kiebzak reviewed the effectiveness of several nonsurgical treatments and found that 27% of patients reported significant improvement with use of NSAIDs, whereas 28% felt that they were ineffective. Recently, in a prospective, double-blind randomized controlled study, Donley et al compared the pain and disability scores between a group treated with an NSAID (celecoxib) and a placebo group. Although a trend toward improved pain relief was seen in the NSAID group, no statistical significance was obtained between the two treatment arms. To date, no study has specifically examined the effectiveness of this treatment alone.

Orthoses/Inserts

Foot orthoses are designed to optimize biomechanical loading of the foot, decrease excessive pronation, off-load the plantar fascia at its origin, and recreate the shape of the heel pad. Commonly used orthoses include prefabricated silicone/rubber heel cups, prefabricated arch supports, felt pads, and custom arch supports. Pfeffer et al randomized 236 patients into five treatment groups: one control and four with different shoe inserts. The patients treated with the prefabricated inserts (ie, silicone heel pad, felt pad, rubber heel cup) had superior improvement in heel pain. A later participant-blinded, randomized controlled trial divided 135 patients into three groups [sham orthosis, off-the-shelf orthosis, customized orthosis]. At the 12-month review, there was no significant difference between all groups.

Physical Therapy

Many local therapy modalities have been proposed for treatment of plantar fasciitis. Support for therapies such as icing, heat, and massage has largely been based on anecdotal data. One prospective, double-blind randomized controlled study did not demonstrate any benefit from magnetic insoles. Other small, randomized controlled trials showed no evidence to support therapeutic ultrasound, low-intensity laser therapy, or exposure to an electrogenerating device. Gudeman et al compared iontophoresis of dexamethasone with a placebo group in a prospective, double-blind, randomized controlled study; these authors reported a benefit in pain relief with the treatment group at 2 weeks but no statistically significant difference at 1 month.

A stretching program has traditionally been the primary treatment therapy modality for patients with plantar fasciitis. Protocols have varied from Achilles tendon stretching to plantar fascia–specific stretching. The goal of plantar fascia–specific stretching is to optimize tissue tension through a controlled stretch of the plantar fascia by recreating the windlass mechanism (Figure 2). An Achilles tendon–stretching program typically involves several stretches that attempt to maximize the length of both the gastrocnemius and soleus muscle groups (Figure 3). One recent prospective, nonblinded, randomized controlled study by DiGiovanni et al compared these two protocols. The authors showed that heel pain
Over the past several years, botulinum toxin A (BTX-A) has been increasingly used for various medical conditions, including chronic tennis elbow (ie, lateral epicondylitis). Interest in its possible role in the treatment of plantar fasciitis has led to several recent clinical trials studying its efficacy. It is proposed that botulinum toxin may be effective not only secondary to paralysis of the injected muscles (ie, abductor hallucis, flexor digitorum brevis, quadratus plantae) but also because of direct analgesic and anti-inflammatory properties. Babcock et al studied the effect of BTX-A in a double-blind, randomized controlled trial. The authors demonstrated statistically significant improvement in the BTX-A group in all studied measures, with no side effects. These patients, however, were followed for only 8 weeks. Further investigation with larger numbers and longer follow-up are needed before the role of botulinum toxin injections in the treatment of plantar fasciitis is established.

Injections

Despite the widespread practice of treating plantar fasciitis by injection of corticosteroids, typically combined with a local anesthetic, there is limited evidence of its effectiveness in providing sustained pain relief. One study found improved symptoms at 1 month but not at 6 months compared with a control group. Recently, interest has developed in the use of ultrasonography to improve the accuracy, and therefore the outcome, of corticosteroid injection. A study by Tsai et al using this technique showed a lower recurrence rate of heel pain. However, a second study by Kane et al did not demonstrate ultrasound-guided injection to be any more effective than the palpation-guided technique. Complications associated with corticosteroid injection have been reported, including rupture of the plantar fascia and fat pad atrophy.

Tisdel and Harper hypothesized that a short period of casting would unload the heel and immobilize the plantar fascia, thus minimizing repetitive microtrauma. Several retrospective studies have supported the efficacy of casting; however, no prospective controlled trials of immobilization have been published.

Extracorporeal Shock Wave Therapy

Extracorporeal shock wave therapy (ESWT) is a recent and increasingly popular therapeutic approach used to treat recalcitrant plantar fasciitis. It has been shown to be effective in 60% to 80% of cases. ESWT is based on lithotripsy technology, in which shock waves (ie, acoustic impulses) are targeted to the plantar fascia origin. Three modalities that can be used to generate the shock wave include electrohydraulic, electromagnetic, and piezoelectric. Currently, the US Food and Drug Administration has approved electrohydraulic (high-energy) and electromagnetic (low-energy) devices for the treatment of chronic plantar heel pain. However, the therapeutic mechanism involved still remains a topic of speculation. Ogden et al have hypothesized that the shock waves cause a controlled microdisruption of plantar fascial tissue, which initiates a healing response within the fascia. It is thought that this response promotes revascularization, releases local growth factors, recruits appropriate stem cells, and allows the fascia to adapt to biologic and biomechanical demands. Since 1996, there have been many reports of good and excellent results from the use of ESWT application for plantar fasciitis, both in Europe and the United States.

Currently, no consensus exists concerning the repeated use of low-energy shock waves versus high-energy waves. Low-energy ESWT is defined as shock waves between 0.04 and 0.12 mJ/mm², and high-
energy ESWT is at levels >0.12 mJ/mm². In the past few years, results of several well-designed, randomized controlled studies have supported both approaches. In their prospective randomized trial, Rompe et al concluded that, at 6 and 12 months, three treatments with 2,100 low-energy shocks were safe and effective at reducing morning pain in the treatment group compared with the control group. Maier et al reported good or excellent results in 75% of 48 heels after low-energy shock waves were applied three times at weekly intervals. In their prospective randomized trial, Oged et al reported that a single application of 1,500 high-energy shocks was safe, with good results in 47% of their patients. Buch et al reported that 62% of patients who received one application of 3,800 high-energy shocks had good results.

In a randomized, placebo-controlled, double-blind clinical trial, Kudo et al confirmed that, at 3 months, there was a statistically significant improvement in symptoms in a treatment group that received one application of 3,800 high-energy shock waves. In another randomized controlled trial, 83% of patients who received 1,500 high-energy shocks in a single session reported good or excellent results at a follow-up of 72 months. The authors did not report any ill effects from the ESWT treatment.

The procedure is commonly performed with the patient under conscious sedation along with regional anesthesia (ankle block). It is well tolerated by patients, and no serious side effects have been reported.

Current indications for ESWT include 6 months of plantar fasciitis heel pain that has been recalcitrant to at least three nonsurgical therapy modalities. Contraindications to ESWT include patients with hemophilia, coagulopathies, malignancy, and open bone growth physes.

Surgical Treatment

Although plantar fasciitis is often a self-limited problem that does not cause excessive disability in most patients, surgery may be indicated when symptoms persist. Unfortunately, no randomized controlled studies have evaluated the effectiveness of surgery in comparison with nonsurgical treatment programs to manage these cases.

Plantar fasciotomy, either partial or complete, is the common surgical procedure chosen for treating recalcitrant cases. Although it has been reported to have an acceptable success rate, several studies have shown that <50% of patients reported satisfaction following surgery and that many patients continue to have functional limitations.

Release of the plantar fascia has risks of complications and can be associated with prolonged healing and rehabilitation times. Plantar fascia release is thought to alter the biomechanics of the foot and decrease foot arch stability. Partial and total release of the plantar fascia has been shown to decrease tarsal arch height, lead to increased strain of the cuboid attachment areas of the plantar ligaments, and intensify stress in the midfoot and metatarsal bones. Postoperatively, patients may experience acute plantar fasciitis, forefoot stress fractures, calcaneal and cuboid fractures, and medial or lateral column foot pain. Biomechanical and finite-element studies have shown that release of >40% of the plantar fascia has detrimental effects on other ligamentous and bony structures in the foot; therefore, releases should be limited.

A large number of surgical techniques have been described for plan-
surgery that is based on expert opinion.\textsuperscript{51} Essentially, the society recommends nonsurgical treatment before undergoing surgical treatment. Nonsurgical treatment should be used for a minimum of 6 months and, preferably, for 12 months because >90\% of patients respond positively to nonsurgical management. The AOFAS recommends initial treatments with heel padding, medications, and stretching; custom orthoses and extended physical therapy are used as a second-line option. Furthermore, a medical evaluation should be considered before surgery, and the patient must be advised of the risks and complications of surgery. In addition, an open procedure, as opposed to an endoscopic procedure, should be done when nerve compression is involved. This recommendation is based on suggestions that the risk of nerve injury may be higher with endoscopic procedures than with open procedures.

A new, less invasive surgical technique using bipolar radiofrequency microtenotomy (TOPAZ MicroDebrider; ArthroCare Sports Medicine, Sunnyvale, CA) has been described to treat recalcitrant plantar fasciitis.\textsuperscript{52} Radiofrequency stimulation, both in the heart and in wound healing, has led to increased angiogenesis. Investigators have reported that this technique was technically simple to perform and was much less invasive than conventional surgery. Patients had a rapid and uncomplicated recovery and reported minimal to no pain 7 to 10 days following the procedure. Pain relief persisted or improved through 24 months.\textsuperscript{52} Although promising, this procedure has not been studied in a prospective, randomized trial in patients with plantar fasciitis.

**Summary**

In our algorithm for the treatment of plantar fasciitis, the patient initially is counseled to pursue daily activities as tolerated; pain should be the guide to his or her activities. When a patient can tolerate over-the-counter anti-inflammatory medications, these are recommended. Narcotics are not routinely prescribed. A pair of heel pads or over-the-counter orthoses are dispensed at the time of the first office visit, and patients are given handouts describing an exercise program (Figures 2 and 3). These exercises should be done before getting out of bed in the morning, in the afternoon, and before bedtime, as well as after any period of prolonged sitting. In addition, a night splint is often fitted to keep the plantar fascia stretched during sleep. The patient is reassured that surgery is uncommon. Frequently, patients come into the office with radiographs showing a heel spur and request to have it removed. The physician should attempt to minimize the role of the so-called spur, which often requires counseling to dispel myths that the patient was told from friends or other clinicians.

According to this algorithm, the patient is treated for approximately 4 to 6 weeks. When the pain is not controlled, multiple treatment modalities are attempted to manage the pain, assuming that the fasciitis runs its course and resolves on its own. First, a corticosteroid injection is given in the region of the anteromedial calcaneal tuberosity, followed by immobilization in a cast or Cam walker. Second, physical therapy is started, a custom orthosis with a deep heel cup is made, and prescription-strength NSAIDs are given. In addition, a lateral radiograph of the heel is taken prior to any anticipated invasive procedure to rule out a stress fracture or other pathologic process.

Rarely, at a follow-up visit, approximately 4 to 6 weeks later, the patient still reports discomfort. If some improvement has been made, the treatment plan is continued. If no improvement is noted, MRI may then be ordered to help confirm the diagnosis of plantar fasciitis, particularly when there are other con-
founding pathologic conditions or when the course is atypical. Alternative treatment may be considered, such as the use of ESWT. Finally, if the patient has failed all other treatments and has significant pain that prevents him or her from work and recreation, surgery is offered. When surgery is necessary, we prefer a small plantar medial incision with either release of the medial one-third edge of the plantar fascia or decompression of the FBLPN, along with the subtotal plantar fascia release.

Nonsurgical treatment of proximal plantar fasciitis has a reported success rate of 85% to 90%. The clinician needs to counsel the patient that it may take as long as 6 to 12 months for all pain to resolve. Surgical treatment of plantar fasciitis should be considered only as a final resort when prolonged nonsurgical treatment (>12 months) fails to provide pain relief. When fasciotomy is necessary, partial release of <40% is recommended.

References

Evidence-based Medicine: There are a number of level I/II prospective randomized studies referenced (3, 27, 28, 29, 30, 31, 34, 37, 38, 43, 45) along with a number of excellent case-control retrospective studies.

Citation numbers printed in bold type indicate references published within the past 5 years.

34. Babcock MS, Foster L, Pasquina P, et al: Treatment of pain attributed to plantar fasciitis with butalbital oxin A:


