

# Plantar fasciitis: a review

**Plantar fasciitis is a common cause of heel pain. The aetiology is not fully understood leading to confusion in terminology. Plantar fasciitis may affect patients of any age, being most common in middle-aged women and younger, predominantly male, runners. If treatment is initiated soon after the onset of symptoms, most patients can be cured within 6 weeks, but usually symptoms have been present for months.**

The plantar fascia arises from the medial calcaneal tuberosity on the plantar surface of the calcaneus (Figure 1). Its main structure inserts through several slips into the plantar plates of the metatarsophalangeal joints, the proximal phalanges of the toes and the flexor tendon sheaths. It is a strong fascial structure which helps maintain the medial longitudinal arch: Daly et al (1992) reported that rupture or surgical division of the plantar fascia leads to a flat foot. Just after heel strike during the first half of the stance phase of the gait cycle, the tibia turns inward and the foot pronates. This stretches the plantar fascia.

The skin and fat in the heel are specialized to accommodate friction and absorb shock. The skin is thicker on the sole of the foot than anywhere else, and a sys-

tem of fibro-elastic septa are arranged in a honey-combed pattern anchored to one another, the calcaneus and the skin, which enclose the subcutaneous fat globules (Figure 2). This structure cushions heel strike and can allow the skin to resist forces up to twice body weight.

## Pathophysiology

Leach et al (1986) described microtears at the calcaneal origin of the plantar fascia, provoking an inflammatory response thought to be produced by repetitive traction of the plantar fascia during walking or running, analogous to a tennis elbow. DeMaio et al (1993) revealed that biopsy specimens show fibroblastic proliferation and chronic granulomatous tissue. A normal plantar

Figure 1. Plantar fasciitis.



Figure 2. The anatomy of the plantar fascia.



Mr NP Cullen is Consultant Orthopaedic Surgeon and Mr D Singh is Consultant Orthopaedic Surgeon in The Foot and Ankle Unit, The Royal National Orthopaedic Hospital, Stanmore, Middlesex HA7 4LP

Correspondence to: Mr NP Cullen

fascia has a thickness of 3 mm; in plantar fasciitis this can be as high as 15 mm (Figure 3).

Independent risk factors for development of plantar fasciitis include: decreased ankle dorsiflexion, patients with high body mass index (>30 kg/m<sup>2</sup>) and individuals who spend the majority of their working day standing (Riddle et al, 2003). Other relative associations are inflammatory arthritides, distance running or walking especially in the untrained, inappropriate footwear and over-pronation during gait (Figure 4).

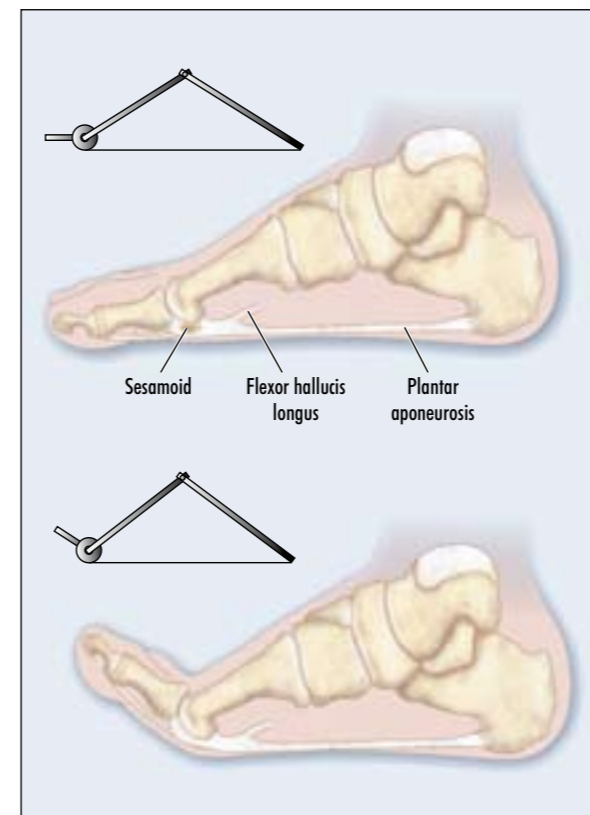
Tightness of the Achilles tendon will predispose to plantar fasciitis because limited dorsiflexion of the foot strains the plantar fascia (Kibler et al, 1991).

In some cases the plantar tubercle extends forward enough to be called a spur. In the general population, 15–25% of people have spurs, and this proportion increases with age and obesity (Rubin and Witten, 1963). The heel spur is usually associated with the flexor digitorum brevis muscle rather than the plantar fascia. The role of the heel spur in plantar fasciitis is controversial; less than half of patients with plantar fasciitis have heel spurs.

## Differential diagnoses

Differential diagnoses for plantar fasciitis include lateral plantar nerve compression (tarsal tunnel syndrome), tibialis posterior inflammation, subcalcaneal bursa or fat-pad pain, calcaneal stress fracture and rarely tumours or infection (Figure 5).

Figure 3. The 'windlass' mechanism of the plantar fascia.



A small percentage of the population has a subcalcaneal bursa, which may become inflamed.

Heel pain can be associated with compression of the nerve to abductor digiti quinti, the first branch of the lateral plantar nerve. In up to a fifth of cases of inferior heel pain, the nerve is seen to be compressed between the abductor digiti quinti muscle and the quadratus plantae muscle, or affected by inflammation of the plantar fascia.

Calcaneal stress fractures present in a similar way to plantar fasciitis, an important distinguishing factor is the persistence of pain with activity and the presence of pain with lateral compression of the heel. Stress fractures may not be evident on plain radiographs and may require magnetic resonance imaging (MRI) or radionuclide bone scanning for diagnosis.

The presence of local swelling and warmth, persisting pain with exercise or night pain may indicate local infection or rarely tumour.

The diagnosis of plantar fasciitis is made on history and physical examination; investigations should be performed in those patients whom the clinical findings are equivocal.

## Clinical presentation

Pain initially may be diffuse or migratory; localizing to the medial calcaneal tuberosity. The history is often one of a gradual onset of pain worst with the first few steps in the morning: the pain may become so incapacitating that the patient limps or hobbles around

Figure 4. Pathophysiology of plantar fasciitis.

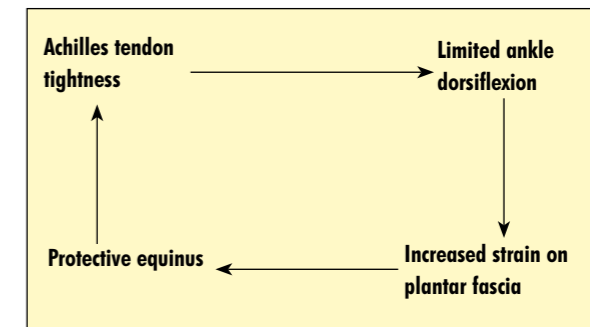
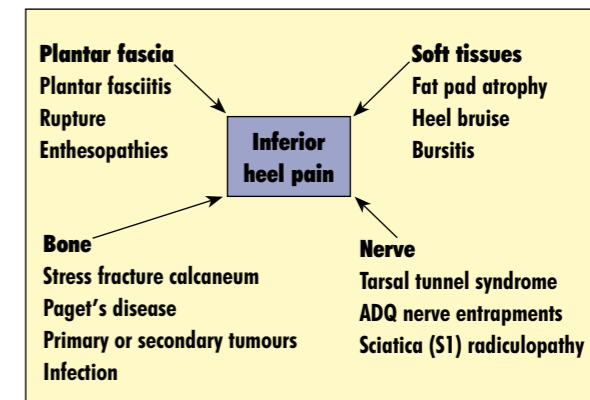


Figure 5. Differential diagnosis of plantar fasciitis and heel pain. ADQ = abductor digiti quinti.



with the heel off the ground. After a few steps, the heel pain tends to diminish, but worsens again with increased activity or after a period of sitting. In the case of calcaneal stress fractures or nerve entrapment pain increases with walking. Nocturnal pain should raise the suspicion of other pathology such as tumour, infections and neuropathic pain (including tarsal tunnel syndrome).

An accurate history of footwear should be obtained: often patients wear shoes with poor cushioning or inadequate arch support, or walk barefoot. Plantar fasciitis is bilateral in up to 15% of patients. Bilateral disease in young patients may indicate a diagnosis of seronegative arthritides.

### Physical examination

Palpation elicits localized tenderness on the anteromedial aspect of the heel. Slight swelling in the area is common. Tightness of the Achilles tendon (ankle dorsiflexion limited by 5° or more) is found in 78% of patients (Amis et al, 1988; DeMaio et al, 1993).

If the tenderness is not specific to the calcaneal tuberosity the diagnosis of plantar fasciitis should be questioned. Tenderness in the centre of the posterior part of the heel may be a result of bruising or atrophy of the heel pad or subcalcaneal bursitis. Positive percussion (Tinel's sign) suggests an entrapment of the nerve to abductor digiti quinti or tarsal tunnel syndrome. The posterior tibial tendon should be examined; Labib et al (2002) described a triad of plantar fasciitis, tibialis posterior tendinosis and tarsal tunnel syndrome. With tenderness on compression of the heel (squeeze test) one should exclude a calcaneal stress fracture.

### Investigations

#### X-ray

A plain lateral radiograph of the heel is usually performed when a stress fracture or erosions resulting from bursitis are suspected. The finding of a heel spur has no diagnostic value (Figure 6).

Figure 6. Lateral radiograph of calcaneus with inferior spur.



#### Isotope scanning

A three phase bone scan could be used when stress fractures are suspected and plain radiographs are normal, but magnetic resonance imaging is preferable.

#### Magnetic resonance imaging and ultrasonography

Magnetic resonance imaging is rarely indicated but may show thickening and inflammation of the fascia. Ultrasound examination may show increased thickness of the plantar fascia and inflammatory changes.

#### Blood tests

A full blood count and erythrocyte sedimentation rate are recommended in patients with bilateral disease or atypical clinical picture.

#### Electrophysiological studies

Tarsal tunnel syndrome may sometimes be confirmed using electrophysiology; Rose et al (2003) showed that 72% of patients with plantar heel pain have abnormal sensory function within the medial calcaneal and medial plantar nerve.

#### Treatment

Plantar fasciitis can be a frustrating disorder to treat successfully; success is more likely with a comprehensive treatment programme. Most authors agree that plantar fasciitis is generally self limiting and DeMaio et al (1993) showed that non-operative management initiated within 6 weeks of the onset of symptoms hastens recovery.

#### Orthoses: heel pads and arch supports

Various rigid, semi-rigid, and soft shoe inserts are available commercially. Rigid plastic orthoses rarely alleviate the symptoms and often aggravate the heel pain. Orthoses made of softer materials provide cushioning, reducing the shock on walking by up to 42% (DeMaio et al, 1993). Because the plantar fascia is stretched during flattening of the foot, it is desirable to design an orthotic device that supports the apical bony structure of the medial longitudinal arch during ambulation. Heel raises alone are less effective as they may not achieve the necessary reduction in plantar fascia strain (Kogler et al, 2001).

#### Advice on footwear

Patients are advised not to walk barefoot on hard surfaces. Kogler et al (1996) suggest that shoes should have an arch support and cushioned heels. Worn shoes may aggravate plantar fasciitis as they lack cushioning. Laced sports shoes are better than open sandals.

#### Non-steroidal anti-inflammatory drugs

Oral anti-inflammatory drugs provide pain relief and are useful in decreasing the inflammation; they should be

prescribed for acute pain and withdrawn as pain subsides. Patients can reduce pain and inflammation by rolling their heel on a refrigerated can of soft drink.

#### Local steroid injection

A steroid injection alone or in combination with local anaesthetic can provide pain relief. An injection is best given from the medial rather than the inferior aspect of the heel. Steroid injections are not without complications, including fat pad atrophy and calcaneal osteomyelitis. Acevedo and Beskin (1998) described iatrogenic rupture of the plantar fascia in up to 15% of cases. Steroid injections are no longer advocated for first-line management but are occasionally used in patients with refractory symptoms.

#### Extracorporeal shock wave therapy

There is increasing evidence that extracorporeal shock wave therapy targeted at the calcaneal origin of the plantar fascia can be effective in resolving intractable plantar fasciitis (Rompe et al, 2003). Studies have suggested that it is at least as effective as steroid injection and has a very low complication rate with no reported cases of plantar fascial rupture (Ogden et al, 2002, 2005).

#### Radiotherapy

Although not widely used, single fractions of low dose radiotherapy have been used to treat plantar fasciitis (Schwarz et al, 2004); there are no data on long-term complications.

#### Exercises for stretching the Achilles tendon

Exercises in plantar fasciitis should be aimed at stretching Achilles tightness, increasing ankle dorsiflexion, and at specific plantar fascial stretching exercises. Most patients with plantar fasciitis have tightness of the Achilles tendon; stretching it interrupts a cycle in which the two disorders aggravate each other. Patients are instructed to stretch the gastrocnemius and soleus components of the triceps surae independently: the gastrocnemius is stretched by keeping the knee extended while passively dorsiflexing the foot, the soleus is stretched by flexing the knee while dorsiflexing the foot. Patients are encouraged to repeat the gentle, sustained stretches at least 10 times, five or six times daily (Figure 7). DiGiovanni et al (2003) have shown that tissue-specific plantar fascia stretches, which involve passive dorsiflexion of the toes with knee bent and ankle dorsiflexed, improve outcomes in patients with chronic plantar fasciitis.

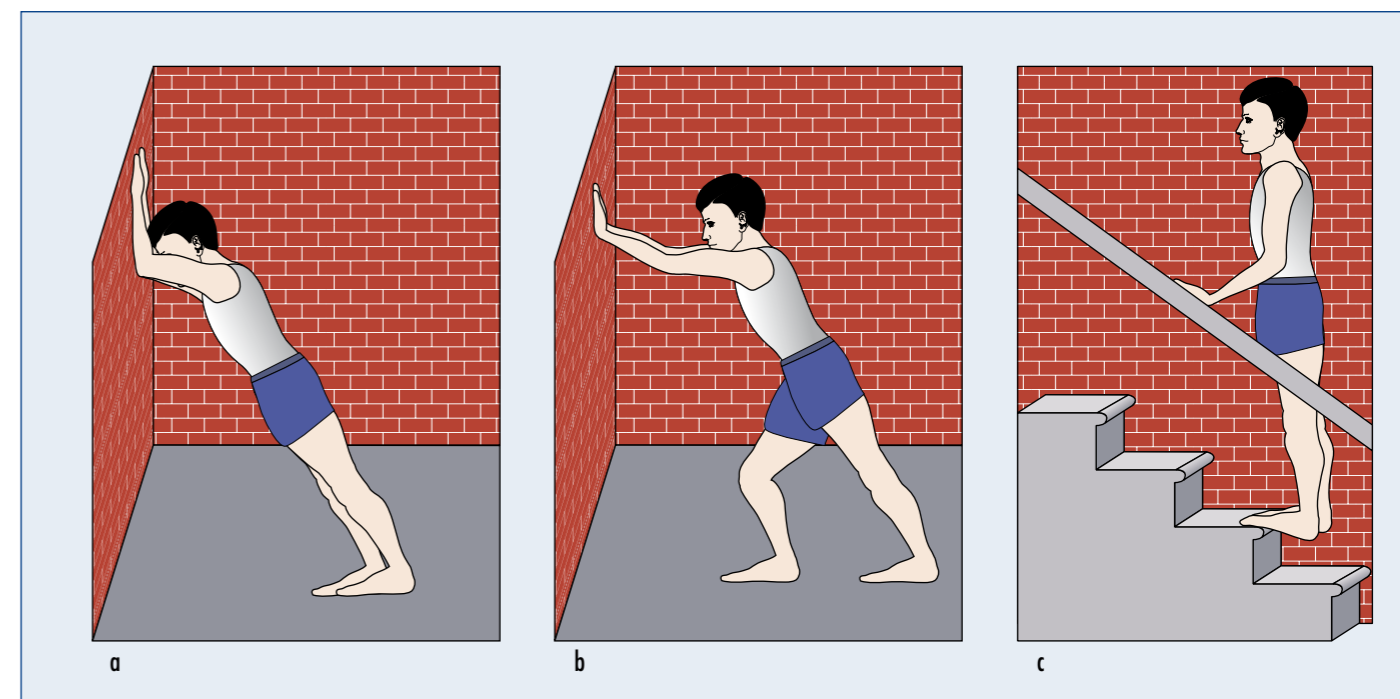
#### Night splints

A moulded ankle-foot orthosis holds the plantar fascia and Achilles tendon in a relative position of stretch during the night, holding the ankle in 5° of dorsiflexion with the toes slightly dorsiflexed. For most patients this orthosis reduces morning pain considerably; Powell et al (1998) described 79% cure rates with the use of splints for an average of 4 months.

#### Below knee casts

Severe pain and marked limitation of activity may be treated with a below knee walking cast providing rest, arch support and preventing tightening of the Achilles tendon.

Figure 7. Exercises for heel cord stretching. a. Stand at arm's length from a wall back knee locked and front knee bent. b. Stand at arm's length from a wall, feet together. Lean to the wall keeping heels on the ground and knees straight. c. Stand on a step – supported on the forefoot only, knees straight, lower the heels until stretch of the calf muscles felt.



## Surgery

Surgical intervention is only considered for intractable pain which has not responded to 12 months of proper conservative treatment. Surgery carries the risk of lateral column pain and rupture of the plantar fascia, described by Brugh et al (2002), which is difficult to manage. Reports describe various surgical procedures, including plantar fascia release, calcaneal spur excision, Steindler stripping and endoscopic releases. Conflitti and Tarquino (2004) advocate neurolysis. All authors claim success with their chosen method; others believe that surgery provides satisfactory results in only 50–60% of cases and that complications are substantial. The surgical procedure should be individualized for each patient. Baxter and colleagues (Murphy et al, 1998) recommend that only 40% of the plantar fascia should be incised to avoid flattening of the arch.

## Conclusions

The authors' management plan uses multiple conservative modes of treatment with an aim of hastening recovery without harming the patient.

It is important to make the patient understand that treatment consists of several methods and that a total, not a fragmented, effort is necessary. Outcomes are improved by early diagnosis and prompt treatment. Patients are reassured that the condition is generally self limiting over several months, and that the bone spur is not causing the symptoms. Davis et al (1994) reported resolution of pain in 90% of 132 painful heels in 11 months, using a similar regimen, not including night splints or occasional casting.

*Conflict of interest: none.*

- Acevedo JI, Beskin JL (1998) Complications of plantar fascia rupture associated with corticosteroid injection. *Foot Ankle Int* **19**: 91–7
- Amis J, Jennings L, Graham D, Graham CE (1988) Painful heel syndrome: radiographic and treatment assessment. *Foot Ankle* **9**: 91–5
- Brugh AM, Fallat LM, Savoy-Moore RT (2002) Lateral column symptomatology following plantar fascial release: a prospective study. *J Foot Ankle Surg* **41**: 365–71
- Conflitti JM, Tarquino TA (2004) Operative outcome of partial

- plantar fasciectomy and neurolysis to the nerve of the abductor digiti minimi muscle for recalcitrant plantar fasciitis. *Foot Ankle Int* **25**: 482–7
- Daly PJ, Kitaoka HB, Chao EYS (1992) Plantar fasciotomy for intractable plantar fasciitis: clinical results and biomechanical evaluation. *Foot Ankle* **13**: 188–95
- Davis PF, Severud E, Baxter DE (1994) Painful heel syndrome: results of non-operative treatment. *Foot Ankle* **5**: 531–5
- DeMaio M, Paine R, Mangine RE, Drez D (1993) Plantar fasciitis. *Orthopaedics* **16**: 1153–63
- DiGiovanni BF, Nawoczenski DA, Lintal ME, Moore EA, Murray JC, Wilding GE, Baumhauer JF (2003) Tissue specific plantar fascia-stretching exercise enhances outcomes in patients with chronic heel pain. A prospective, randomised study. *J Bone Joint Surg Am* **85-A**: 1270–7
- Kibler WB, Goldberg C, Chandler TJ (1991) Functional biomechanical deficits in running athletes with plantar fasciitis. *Am J Sports Med* **19**: 66–71
- Kogler GF, Solomonidis SE, Paul JP (1996) Biomechanics of medial longitudinal arch support mechanisms in foot orthoses and their effect on plantar aponeurosis strain. *Clin Biomech* **11**: 243–52
- Kogler GF, Veer FB, Verhulst SJ, Solomonidis SE, Paul JP (2001) The effect of heel elevation on strain in within the plantar aponeurosis: in vitro study. *Foot Ankle Int* **22**: 433–9
- Labib SA, Gould JS, Rodriguez-del-Rio FA, Lyman S (2002) Heel pain triad (HPT): the combination of plantar fasciitis, posterior tibial tendon dysfunction and tarsal tunnel syndrome. *Foot Ankle Int* **23**: 212–20
- Leach RE, Seavey MS, Salter DK (1986) Results of surgery in athletes with plantar fasciitis. *Foot Ankle* **7**: 156–61
- Murphy GA, Pneumaticos SG, Kamaric E, Noble PC, Trevino SG, Baxter DE (1998) Biomechanical consequences of sequential plantar fascia release. *Foot Ankle Int* **19**(3): 149–52
- Ogden JA, Alvarez RG, Marlow M (2002) Shockwave therapy for plantar fasciitis: a meta-analysis. *Foot Ankle Int* **23**: 301–8
- Ogden JA, Alvarez RG, Levitt RL, Johnson JE, Marlow ME (2005) Electrohydraulic high-energy shock-wave treatment for chronic plantar fasciitis. *J Bone Joint Surg Am* **87-A**: 681–2
- Powell M, Post WR, Keener J, Wearden S (1998) Effective treatment of chronic plantar fasciitis with dorsiflexion night splints: a crossover prospective randomized outcome study. *Foot Ankle Int* **19**: 10–18
- Riddle DL, Pulisic M, Pidcoe P, Johnson RE (2003) Risk factors for plantar fasciitis: a matched case-control study. *J Bone Joint Surg Am* **85-A**: 1338
- Rompe JD, Decking J, Schoellner C, Nafe B (2003) Shock wave application for chronic plantar fasciitis in running athletes. A prospective, randomized, placebo-controlled trial. *Am J Sports Med*, **31**: 268–75
- Rose JD, Malay DS, Sorrento DL (2003) Neurosensory testing of the medial calcaneal and medial plantar nerves in patients with plantar heel pain. *J Foot Ankle Surg* **42**: 173–7
- Rubin G, Witten M (1963) Plantar calcaneal spurs. *Am J Orthop* **5**: 38–55
- Schwarz F, Christie DR, Irving M (2004) Are single fractions of radiotherapy suitable for plantar fasciitis? *Australas Radiol* **48**: 162–9

## KEY POINTS

- Plantar fasciitis is a common diagnosis, characterized by start-up pain improving after the first few steps.
- Diagnosis is usually clinical.
- The aim should be for early diagnosis and initiation of non-operative treatment.
- Non-operative treatment should be multi-modal including Achilles stretches, plantar fascia stretches, orthotics, footwear advice and night splints.
- Most cases settle with non-operative management.
- Consider stress fracture and tarsal tunnel syndrome in patients with atypical symptoms.
- Use steroid injections sparingly because of the risk of plantar fascia rupture.
- Surgery should be considered only for severe persisting pain after a prolonged course of appropriate non-operative treatment.
- Pain is not caused by heel spurs.