

Plantar fasciitis

Anatomy & Pathophysiology

PLANTAR FASCIA & HEEL ANATOMY

- Plantar heel spurs originate in the flexor digitorum brevis [10].
- The flexor digitorum brevis is innervated by the medial plantar nerve [10].
- The plantar calcaneonavicular ligament, also known as the spring ligament, attaches proximally to the sustentaculum tali and distally to the navicular [10].
- The long plantar ligament attaches proximally to the calcaneus and distally to the cuboid and first to fifth metatarsals [10].
- The short plantar ligament attaches proximally to the calcaneus and distally to the cuboid [10].
- The medial calcaneal nerve may exit through the abductor hallucis fascia or plantar fascia at the level of a plantar fascia release [2].

TARSAL TUNNEL & NEUROVASCULAR ANATOMY

- The tarsal tunnel is a fibroosseous tunnel within the posteromedial ankle and hindfoot containing the tibial nerve, posterior tibial artery, accompanying veins, posterior tibial tendon, flexor digitorum longus, and flexor hallucis longus tendons [3].
- The flexor retinaculum acts as the roof of the tarsal tunnel and extends from the medial malleolus to the medial side of the calcaneal tuberosity [3].
- The floor of the tarsal tunnel is formed by the medial distal tibia, talus, and calcaneus [3].
- The tibial nerve divides into three terminal branches before reaching the foot: the medial calcaneal nerve, lateral plantar nerve, and medial plantar nerve [3].
- The medial calcaneal nerve branches first from the tibial nerve and travels posteriorly to the subcutaneous tissue [3].
- The lateral plantar nerve passes under the abductor hallucis, over the medial fascia of the quadratus plantae, deep to the plantar fascia, and under the heel to the flexor digitorum brevis [3].
- The medial plantar nerve innervates the abductor hallucis and continues under the abductor and plantar fascia to form common digital nerves terminating in the first, second, and third web spaces [3].

- The medial plantar nerve supplies motor branches to the interossei and lumbricals [3].
- The lateral plantar nerve supplies motor branches to the intrinsic muscles [3].
- Distal tarsal tunnel syndrome involves entrapment of the distal tibial nerve branches as they enter the foot [3].
- Sources of constriction beneath and adjacent to the tarsal tunnel include bone fragments, tenosynovitis, ganglia, soft-tissue encroachment in inflammatory arthritis, varicosities, neural tumors, perineural fibrosis, tarsal coalition, and calcaneal osteotomies [3].
- A fixed valgus hindfoot can predispose to chronic traction neuropathy of the posterior tibial nerve or one of its branches [3].

FOOT COMPARTMENTS & MUSCULATURE

- The medial compartment of the foot lies on the plantar surface of the hallux and contains the intrinsic muscles of the great toe and flexor digiti minimi [9].
- The lateral compartment of the foot lies on the plantar surface of the fifth metatarsal and contains the abductor digiti minimi [9].
- The central compartment of the foot lies on the plantar surface of the foot and is divided into a superficial layer containing flexor digitorum brevis and a deep calcaneal layer containing quadratus plantae [9].
- The interosseous compartment of the foot lies dorsal to the other compartments between the metatarsals and contains digital nerves [9].
- Manoli and Weber proposed that there are nine compartments in the foot, with each of the four interosseous muscles and adductor hallucis lying in separate compartments [9].
- The barrier between the superficial and calcaneal compartments of the foot becomes incompetent at a pressure of 10 mm Hg [9].
- The peroneus longus inserts on the plantar aspect of the medial cuneiform and base of the first metatarsal [10].
- The peroneus brevis inserts on the lateral aspect of the base of the fifth metatarsal [10].
- At the level of the peroneal tubercle, the peroneus brevis lies dorsal to the peroneus longus [10].
- The extensor digitorum brevis is the only dorsal intrinsic muscle of the foot and is innervated by the lateral terminal branch of the deep peroneal nerve [10].
- Lumbrical muscles are located plantar to the transverse metatarsal ligament, while interosseous tendons are dorsal [10].
- The tibialis posterior inserts on the navicular and medial cuneiform [10].
- The flexor hallucis longus inserts on the distal phalanx of the great toe [10].
- The flexor digitorum longus inserts on the distal phalanges of the second to fifth toes [10].

ANKLE & HINDFOOT LIGAMENTS

- The deltoid ligament is composed of a superficial layer (tibionavicular and tibiocalcaneal) that crosses the ankle and subtalar joint, and a deep layer (anterior and posterior tibiotalar) that crosses the ankle joint only [10].
- The anterior talofibular ligament is the weakest lateral ankle ligament, is intracapsular, and limits inversion in plantar flexion [10].
- The calcaneofibular ligament crosses both the ankle and the subtalar joint and limits inversion in neutral or dorsiflexion [10].
- The posterior talofibular ligament limits posterior talus displacement and external rotation [10].
- The tibionavicular ligament limits talar external rotation [10].
- The tibiocalcaneal ligament limits hindfoot eversion [10].
- The anterior tibiotalar ligament limits lateral displacement of the talus and external rotation [10].
- The posterior tibiotalar ligament limits lateral displacement of the talus [10].
- The Lisfranc ligament attaches proximally to the medial cuneiform and distally to the base of the second metatarsal [10].
- The interosseous talocalcaneal ligament, also known as the cervical ligament, attaches between the talus and calcaneus [10].
- The bifurcate ligament attaches from the calcaneus to the cuboid and navicular [10].

VASCULAR ANATOMY

- The dorsalis pedis artery is a continuation of the anterior tibial artery that passes deep under the inferior extensor retinaculum [4].
- The dorsalis pedis artery lies between the tendons of the extensor hallucis longus medially and the extensor digitorum longus laterally as it passes anterior to the ankle joint [4].
- The deep peroneal nerve lies immediately lateral to the dorsalis pedis artery [4].
- The first dorsal metatarsal artery is the continuation of the dorsalis pedis artery and runs distally on the dorsal surface of the first dorsal interosseous muscle [4].
- The deep plantar, or communicating, artery leaves the dorsalis pedis at the base of the first metatarsal and passes toward the plantar surface of the foot between the heads of the first dorsal interosseous muscle [4].
- The deep plantar artery communicates with the lateral plantar artery to complete the plantar arterial arch [4].
- The first dorsal metatarsal artery may lie superficial to or within the substance of the first dorsal interosseous muscle in 78% to 88% of feet [4].
- The first dorsal metatarsal artery may lie plantar to the first metatarsal in 12% to 22% of feet [4].
- The diameter of the dorsalis pedis artery may range from 1.8 to 3 mm [4].
- The plantar surface of the foot is innervated by the digital branches of the medial plantar nerve [4].
- The first web space is innervated by the deep peroneal nerve [4].

CQ HAND + UPPER LIMB

- The dorsal surfaces of the toes and foot receive sensory innervation through the superficial peroneal nerve branches [4].

CAVUS FOOT PATHOPHYSIOLOGY

- Cavus foot is defined as a foot with an abnormally high arch [1].
- Cavus foot frequently accompanies hindfoot varus deformity, known as cavovarus foot [1].
- Clawing of the toes and demonstrable weakness of ankle or foot muscles may be present in cavus foot [1].
- Calluses beneath the metatarsal heads and heel skin are common in cavus foot [1].
- Hindfoot varus in individuals with a cavovarus deformity is nonstructural if it can be corrected with the “block test” [1].
- The cause of cavus foot is usually muscle imbalance in a growing foot [1].
- Cavus foot is rarely found in early childhood but is fairly frequent after 8–10 years of age [1].
- Intrinsic muscle weakness is a major cause of cavus foot, with weakness of the peroneal or anterior tibialis muscles also implicated [1].
- Cavus foot is rarely found in the absence of an underlying neuromuscular condition [1].
- Cavus foot is a marker for neuromuscular disease [1].
- In severe cavus foot, the forefoot is severely plantar flexed on the hindfoot, requiring marked ankle dorsiflexion to compensate [1].
- When cavus becomes too severe, ankle dorsiflexion is blocked, leading to anterior ankle impingement and pain [1].
- The inability to dorsiflex further compromises forefoot clearance, eventually allowing only the metatarsals to contact the floor [1].
- This condition can be misinterpreted as ankle plantarflexion contracture, potentially leading to unnecessary heel cord release [1].

Investigations

IMAGING MODALITIES

- MRI is a fundamental tool in the workup of a patient with a soft-tissue or bone tumor in the foot [20].
- MRI allows detection and definition of masses in the foot due to excellent multiplanar anatomic information [20].
- Plantar fibroma or plantar fibromatosis is usually easily confirmed by MRI by the presence of a signal-poor mass arising from the plantar fascia [20].
- Interdigital or Morton neuroma is most frequently found in the distal third metatarsal interspace on MRI [20].
- Unlike most other tumors, interdigital neuroma lacks increased signal on T2-weighted MRI sequences [20].

- MRI can detect osteomyelitis quite early, well before radiographic abnormalities are visible [20].
- The sensitivity of MRI for osteomyelitis approaches 100%, but the reported specificity is less [20].
- In neuropathic patients, the specificity of MR signal abnormalities for osteomyelitis is reduced [20].
- Normal MRI marrow signal confidently excludes osteomyelitis in almost all cases of pedal osteomyelitis [20].
- MRI is the modality of choice for the evaluation of surrounding soft-tissue infection in the foot [20].
- Contrast-enhanced MRI sequences are helpful in defining nonenhancing fluid collections, abscesses, and devascularized or gangrenous tissue [20].
- MRI and ultrasound are used to demonstrate soft-tissue problems, such as tendon and ligament injuries [17].
- MRI and ultrasound can be used to diagnose joint effusions and bone infections [17].
- Computed tomography (CT) scans are important in assessing fractures and for congenital bony coalitions [17].
- Radio-isotope scanning is excellent for localizing areas of abnormal blood flow or bone remodelling activity, which suggest the presence of covert infection [17].
- Ultrasonography has been reported to be 85% accurate in diagnosing interdigital neuroma [14].
- MRI may be useful in diagnosing interdigital neuroma, and the administration of contrast medium may increase its accuracy [14].
- Weight-bearing radiographs are useful for excluding a stress fracture of the metatarsal neck in the evaluation of interdigital neuroma [14].
- Injection of the involved web space with local anesthetic that results in relief of neuritic symptoms is diagnostic of interdigital neuroma [14].
- Injections performed under ultrasound guidance for interdigital neuroma had higher short-term relief compared with blind injections [14].
- MRI can be useful in the diagnosis of metatarsalgia, such as distinguishing among a neuroma, cyst, bursa, or synovitis [18].
- The radiographic evaluation for metatarsalgia includes weight-bearing anteroposterior, lateral, and oblique views of the foot [18].
- The skyline view of the metatarsal heads is helpful to evaluate their overall alignment, particularly in cases resulting from previous surgery [18].
- MRI of the spine is indicated with unilateral involvement in pes cavus [21].
- Weight-bearing radiographs are required for the evaluation of pes cavus [21].
- An increased Meary angle, where the long axis of the talus intersects the long axis of the first metatarsal dorsally on the lateral view, is a radiographic finding in pes cavus [21].
- The normal value for the Meary angle is 0° to 5° [21].
- An increased calcaneal pitch, defined as the intersection of a line running along the undersurface of the calcaneus and the floor, is a radiographic finding in pes cavus [21].

- A calcaneal pitch greater than 30° indicates a calcaneocavus foot [21].
- Stress X-rays complement the clinical tests for ankle stability [17].
- If stress manoeuvres are painful, they can be carried out under general anaesthesia [17].
- In the adult, standard X-ray views of the ankle are AP, mortise (an AP view with the ankle internally rotated 15–20 degrees), and lateral [17].
- Medial and lateral oblique projections allow better assessment of the subtalar joint [17].
- The calcaneum is usually X-rayed in axial and lateral views [17].
- X-ray under load, weight-bearing, is helpful in showing the coronal relationship of heel to tibia in stance [17].
- The foot, toes, and intertarsal joints are well displayed in standing dorsoplantar and lateral views [17].

CLINICAL EXAMINATION

- The Mulder sign is elicited by squeezing the foot while palpating the web space, and a painful click is diagnostic of an interdigital neuroma [14].
- Plantar foot pain just distal to and between the metatarsal heads, often described as “burning,” is characteristic of interdigital neuroma [14].
- Patients with interdigital neuroma often feel as if they are walking on a marble [14].
- Symptoms of interdigital neuroma are typically aggravated by activity or by wearing shoes with high heels or a narrow toe box [14].
- Patients with interdigital neuroma often note that they feel better in their bare feet and get quick relief by removing their shoes [14].
- The involved ray should be evaluated for metatarsophalangeal (MTP) joint instability, especially if the second web space is symptomatic [14].
- Neuromas rarely occur in the first and fourth web spaces, so for pain that occurs in these areas, other causes of forefoot pain should be considered [14].
- Hindfoot flexibility is assessed by placing a 1-inch block under the lateral border of the foot (Coleman block test) [21].
- A neurologic examination and a family history are essential in the evaluation of pes cavus [21].
- Unilateral involvement in pes cavus suggests a focal diagnosis, such as spinal cord anomaly or nerve injury [21].
- Bilateral involvement and a positive family history are common with Charcot-Marie-Tooth disease [21].
- The physical examination of the foot and lower extremity for metatarsalgia begins with the patient standing [18].
- The plantar aspect of the foot is carefully evaluated for evidence of callus formation in metatarsalgia [18].
- The metatarsal heads are palpated individually to assess for generalized plantar fat pad atrophy, a prominent fibular condyle, synovitis, or possibly a transfer lesion beneath a metatarsal head [18].

- The patient should be evaluated for a postural problem of the foot, such as a flat foot or cavus foot, during the clinical evaluation of metatarsalgia [18].
- Diagnosis of cavus foot requires a thorough search for the underlying cause and may require neurologic consultation, spinal MRI, and electromyographic (EMG) studies [1].
- One of the most common symptoms of cavus foot is anterior ankle pain, sometimes associated with toe walking [1].
- In severe cavus foot, ankle dorsiflexion is blocked, leading to anterior ankle impingement and pain [1].
- The inability to dorsiflex further compromises forefoot clearance, and eventually, only the metatarsals can contact the floor in severe cavus foot [1].
- This condition can be misinterpreted as ankle plantarflexion contracture, leading to unnecessary (and possibly harmful) heel cord release [1].
- Patients with pes cavus may report instability, such as ankle sprains [21].

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