Sonographic evaluation of heel pain: plantar fasciitis and beyond.

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Learning objectives

- To review the normal sonographic anatomy of the plantar aspect of the foot.
- To enumerate various disorders that can present as heel pain and describe their sonographic features.
Background

Heel pain is a general term used to describe pain and discomfort experienced anywhere in or around the rear of the foot. This complaint may cause significant disability and interfere with routine activities. It is common among orthopaedic patients and accounts for more than 1 million doctor visits annually in the United States. Approximately 1 in 10 people are expected to develop heel pain during their lifetime, with more than 2 million individuals undergoing treatment for this reason annually in the United States. Heel pain has long been recognized as highly prevalent in the senior population, which affects approximately one third seniors older than 65 years. This complaint is the most common in active people over the age of 40. It has been estimated to affect about 10% of runners and is present in the general population at the same rate. Heel pain also is relatively common in active children and adolescents between the ages of 8 and 13.

Establishing an accurate diagnosis can be challenging due to the complex regional anatomy and the close proximity of potential pain generators. Anatomically, heel pain may arise from six structures: the plantar fascia, tendons (e.g., Achilles, flexor digitorum longus), calcaneus, various bursae, the tarsal tunnel, and the heel plantar fat pad. Additionally, accessory muscles may cause heel pain. Ultrasound (US) represents an accessible and relatively inexpensive imaging tool for the assessment of heel pain. Furthermore, it offers the advantage of comparison with the contralateral side. Although magnetic resonance imaging (MRI) is considered the gold standard in the assessment of certain conditions, US is effective in the diagnosis of pathologic conditions affecting the medial ankle and heel and correlates well with MRI.

In this educational poster we focus on the use of US in the assessment of heel pain. We first review the normal anatomy and then review the causes of heel pain, with attention to the clinical and US findings.
Findings and procedure details

1. US anatomy and guideline for heel evaluation:

Medial midfoot and hindfoot: tibialis posterior tendon, flexor digitorum longus tendon and flexor hallucis longus tendon and tarsal tunnel (Fig. 1).

**Patient position:** The patient is seated with the plantar surface of the foot rolled internally.

**Medial retromalleolar short-axis view** is the reference location to locate the upper part of the tarsal tunnel and its contents, allowing to visualize from front to back:

- The tibialis posterior tendon, just behind the medial malleolus, covered by the flexor retinaculum.
- The flexor digitorum longus tendon, smaller than the previous one. The flexor digitorum longus tendon needs to be examined down to reach the sustentaculum tali.
- The vasculonervous elements of the tarsal tunnel (artery and posterior tibial veins, tibial nerve).
- The flexor hallucis longus tendon, although sometimes it is difficult to detect because deeply located in front of the Achilles tendon.

Lateral midfoot and hindfoot: peroneal tendons (Fig. 2).

**Patient position:** From the position described previously, roll the forefoot slightly internally.

**Lateral retromalleolar short-axis view** allows to examine the peroneal tendons (long-axis planes are of limited utility). Because these tendons are around the malleolus, it is necessary to tilt the transducer to maintain the US beam perpendicular to them and avoid anisotropy as scanning progresses. These tendons need to be followed upwards for approximately 5 cm and downwards through the inframalleolar region. The superior and inferior peroneal retinacula must be also checked.

Posterior aspect of heel: Achilles tendon, retroachilles and retrocalcaneal bursae (Fig. 3).

**Patient position:** The patient is on a prone position with the foot hanging out of the examination table.

The Achilles tendon must be examined from its myotendinous junction to its calcaneal insertion by means of transverse and longitudinal planes. While scanning the Achilles tendon on short-axis planes, the probe must be tilted on each side of the tendon to assess
the peritendinous envelope. It is recommended to measure the size of the Achilles tendon only on transverse planes.

**Plantar aspect of heel**: plantar fascia (Fig. 4).

**Patient position**: The patient is on a prone position with the foot hanging out of the examination table.

The transducer must be placed over the plantar aspect of the hindfoot to examine the calcaneal insertion of the plantar fascia. Long-axis scans obtained just medial and lateral to midline are used. It is recommended to measure the fascia at the point where it leaves the calcaneal tuberosity.

**2. Conditions associated with heel pain**: (Fig. 5).

**Medial midfoot and hindfoot:**

**Tibialis posterior tendinosis and tenosynovitis** (Fig. 6): The tibialis posterior (TP) tendon forms in the distal third of the leg and lies closely apposed to the tibia posteromedially. Distally, the TP tendon sits in a medial or posterior concavity on the medial edge of the posterior tibia. Just lateral to the TP tendon lies the flexor digitorum tendon. The TP tendon curves distally around the medial malleolus. It is at this level that the tendon lies beneath the flexor retinaculum, which prevents the flexor tendons from bowstringing as they curve around the malleolus. Past the tarsal tunnel, the TP tendon has a complex insertion.

Chronic tendinopathy lesions manifest in three ways: hypertrophied and heterogeneous tendon, decreased size of the tendon (partial tear), and complete tear.

Tenosynovitis can occur before, during, or after a rupture. It is variably associated with suffusion of the sheath, thickening, and hyperemia of the synovia on Doppler.

**Flexor digitorum longus and flexor hallucis longus tendinosis and tenosynovitis** (Fig. 6, Fig. 7): The flexor digitorum longus (FDL) and flexor hallucis longus (FHL) tendons course through the posteromedial ankle. The FDL tendon lies just posterolateral to the posterior tibial tendon, running posterior to the talus. The two tendons cross in the midfoot at the level of the navicular bone, at a point known as the master knot of Henry (tendon disease in the region of the master knot of Henry may result in entrapment of the adjacent medial plantar nerve).
Tendinosis and tenosynovitis of either the FHL tendon or (less commonly) the FDL tendon may cause posteromedial heel pain. It is important to differentiate tenosynovitis from the frequently observed asymptomatic distention of the FHL tendon sheath by fluid. Ankle joint effusion often decompresses into the FHL tendon sheath due to a common normal communication between the two structures. FHL and FDL tenosynovitis can be identified at US as accumulation of fluid and/or synovial thickening within the tendon sheath. Normal distention of the FHL tendon sheath may reach the plantar soft tissues, down to the master knot of Henry. The presence of peritendinous hyperemia at Doppler imaging can be helpful in distinguishing reactive effusion from inflamed, thickened synovium. At US, FHL and FDL tendinosis and degeneration related to mechanical attrition will manifest as characteristic tendon thickening and heterogeneity with no discrete tendon tear. In contrast, complete tendon tear manifests as a focal tendon gap with thickening of the opposing tendon stumps.

Tarsal tunnel syndrome (Fig. 8): The tarsal tunnel is a fibro-osseous canal that is bounded by the flexor retinaculum superficially and the medial surfaces of the talus and calcaneus on its deep surface. It contains the posterior tibial nerve, the three medial tendons (posterior tibial, FDL, and FDH tendons), and the posterior tibial artery and posterior tibial veins. Tarsal tunnel syndrome refers to a compression or entrapment neuropathy of the tibial nerve and its branches within the tarsal tunnel. Clinical manifestations of tarsal tunnel syndrome are variable and depend on the individual nerves damaged and the duration and extent of neural compression. The most common symptoms are pain and paresthesias in the toes, sole, or heel. Common causes of tarsal tunnel syndrome include fracture deformity, anomalous muscles, tenosynovitis of the flexor tendons, and ganglia or large vessels that compress the nerves in the tunnel. US is effective in the identification of space occupying lesions within the tarsal tunnel.

Lateral midfoot and hindfoot:

Peroneal tendinosis and tenosynovitis (Fig. 9): The peroneus brevis muscle arises from the distal two-thirds of the lateral fibula and the adjacent intermuscular septa and inserts onto the tuberosity on the lateral aspect of the proximal fifth metatarsal bone. The peroneus longus muscle originates from the lateral condyle of the tibia, the head and proximal two-thirds of the lateral fibula, the intermuscular septa, and adjacent fascia. Its tendon passes inferior to the cuboid bone in a bone tunnel termed the cuboid tunnel and inserts onto the plantar surface of the first cuneiform bone laterally and the proximal first metatarsal bone. The peroneal tendons share a common peroneal synovial sheath posterior to the lateral malleolus and descend down the lateral leg, passing through a fibro-osseous tunnel posterior to the lateral malleolus called the retromalleolar groove. The peroneus brevis tendon is usually located anteromedial to the peroneus longus tendon within the groove.
Patients present with swelling and tenderness along the tendon sheath. Tenosynovitis manifests as accumulation of fluid and/or synovial thickening within the tendon sheath. The presence of peritendinous hyperemia at Doppler imaging can be helpful in distinguishing reactive effusion from inflamed, thickened synovium. Tendinosis manifests as tendon thickening and heterogeneous echogenicity.

Others peroneal tendons disorders, such as tears or instability, can be assessed with ultrasound; however, they do not usually manifest as talalgia.

**Posterior aspect of heel:**

**Achilles tendon:** The Achilles tendon is formed by the union of the tendons of the gastrocnemius and soleus muscles and inserts on the posterior aspect of the calcaneus. It is not invested by a synovial sheath, but is surrounded by thin connective tissue, paratenon.

Terminology used to describe overuse injuries of the Achilles tendon can be confusing and inconsistent. Tendinopathy includes the clinical syndrome of tendon pain, swelling, and impaired performance; thus, it has been suggested as the ideal term to use when describing Achilles tendon injuries. Excluding tendon tears, these injuries can be classified into 3 types: midportion tendinopathy, insertional tendinopathy and paratendinopathy.

**Midportion Achilles tendinopathy** (Fig. 10) is the clinical syndrome of pain, swelling, and impaired performance located 2 cm to 7 cm above the calcaneal insertion and manifests as tendon thickening (>8 mm) with loss of the normal anterior concave margin, fusiform hypoechoic swelling of the tendon without disruption of the fibers. Hyperemia may be present due to hypervascularity, not secondary to inflammation.

Achilles tendinopathy involving the calcaneal insertion of the tendon is known as **insertional Achilles tendinopathy** (Fig. 11) and is one of the main causes of posterior heel pain. Insertional tendinopathy is characterized by posterior heel pain along with swelling and tenderness over the tendon near its insertion. US findings are the same that in the midportion tendinopathy. Calcifications and ossifications in the distal tendon occur with this condition and can be associated with retrocalcaneal and/or retro-Achilles bursitis.

Isolated fluid and/or edema in Kager fat pad should be termed **paratendinopathy** (Fig. 12). The potential space between the peritenon and tendon can fill with fluid and exudate, leading to thickening of the peritenon and the patient can present with palpable crepitus. Paratendinopathy manifests as isoechoic soft-tissue thickening or hypoechoic fluid surrounding the Achilles tendon.
Retroachilles bursitis (Fig. 12): Retroachilles bursa is a potential bursa that is superficial to the Achilles tendon at the level of Achilles tendon insertion. Retroachilles bursitis produces a painful, tender subcutaneous swelling overlying the Achilles tendon, usually at the level of the shoe counter.

Retrocalcaneal bursitis (Fig. 13): Retrocalcaneal bursa is located between the Achilles tendon and posterosuperior calcaneus. Retrocalcaneal bursitis may manifest as an inflammatory arthropathy, accompanying Achilles tendinitis, or occur as an isolated disorder. Retrocalcaneal bursitis is associated with posterior heel pain worsened by passive dorsiflexion of the ankle. Bursal distention produces tender swelling behind the ankle with bulging on both sides of the tendon.

Haglund Syndrome (Fig. 14): Haglund syndrome is a constellation of findings that includes insertional Achilles tendinosis, retrocalcaneal bursitis and retroachilles bursitis. It results in posterior ankle pain often the result of mechanical irritation from wearing low-back rigid shoes. This syndrome can be associated with a Haglund deformity, which refers to an osseous prominence at the posterior superior aspect of calcaneus, which develops from irritation of the distal Achilles tendon and adjacent soft tissues.

Plantar aspect of heel:

Plantar fasciitis (Fig. 15): Plantar fasciitis is the most common cause of heel pain. It can be due to variety of conditions, including long-distance running, obesity, pes cavus, pes planus, prolonged standing, and spondyloarthropathies. Patients usually experience start-up pain, that is, plantar medial heel pain that culminates either with their first steps in the morning or subsequent to prolonged periods of rest. This pain is typically sharp and does not radiate.

The US findings of proximal plantar fasciitis, include hypoechoic thickening of the plantar fascia, loss of barillar echotexture, and loss of fascial edge sharpness. Affectation of the medial compartment is most frequent, but the lateral compartment must also be assessed (Fig. 16). Other sonographic findings of proximal plantar fasciitis include cortical irregularity of the calcaneus, often with an associated enthesophyte, and perifascial edema in acute cases. It is generally accepted that a plantar aponeurosis thickness of 4 mm is consistent with plantar fasciitis, although a minority of individuals with out proximal plantar fasciitis can have a normally large central aponeurosis. Comparison with the contralateral side as well as other characteristic findings of plantar fasciitis can help distinguish a normally large plantar fascia from a thickened one due to fasciopathy. The use of Doppler imaging is often normal with plantar fasciopathy, but rarely may demonstrate varying degrees of hyperemia in the proximal plantar aponeurosis and surrounding tissue.
Sometimes liquid collections adjacent to the plantar fascia may be observed, which is known as subcalcaneal bursitis (Fig. 17) and manifests clinically as plantar fasciitis.

Calcaneal spur (Fig. 18): Calcaneal spurs usually originate from the medial calcaneal tuberosity at the attachment of the exor digitorum brevis and abductor hallucis muscles; however. Although a higher proportion of spurs is noted in plantar fasciitis, their presence is not specific.

Plantar fascia rupture (Fig. 19): Tear of the plantar fascia can occur from progression of chronic plantar fasciitis or acute sports-related injury in athletes or be related to local corticosteroid injections. Characteristic US features include disruption of the normal fascial band with surrounding hypoechoic tissue due to inflammation and hematoma. Partial injuries or strain of the plantar fascia can present as thickening of the band without significant disruption of fibers. Partial plantar fascia tears can be hard to differentiate from severe fasciopathy. A history of a sudden tearing sensation or sonographic demonstration of separation of the central cord during dynamic dorsiflexion of the ankle and great toe can aid in distinguishing fasciopathy from a partial tear.

Plantar fibromatosis (Fig. 20): Plantar fibromatosis or Ledderhose disease is a relatively uncommon benign but locally invasive lesion that is characterized by fibrous proliferation arising from the plantar fascia. Most lesions are solitary and unilateral; however, approximately one-third of lesions are bilateral, and one-fourth of patients have multiple lesions. The nodules can lead to pain, contracture, and even walking disability. The sonographic appearance of a plantar fibroma includes a hypoechoic fusiform nodular thickening within the central cord of the plantar fascia. Typically, the nodule is located more superficial within the aponeurosis having a predilection for the medial region of the cord. Color Doppler imaging shows vascularity in cases of an inflammatory fibroma or atypical cases.

Foreign body (Fig. 21): The differential diagnosis of a plantar heel pain should include a foreign body. US is the study of choice for detection of radiolucent foreign bodies. For all foreign bodies, US can aid assessment of the surrounding soft tissues and demonstrate associated soft-tissue complications. Foreign bodies often appear as linear hyperechoic band-like structures, and may be surrounded by granulomatous tissue that has a hypoechoic halo appearance. Surrounding hyperemia on color Doppler is frequent; especially, in more acute cases. Depending on the size of the foreign body, glass and metal may produce a posterior reverberation artifact while wood, thorns, and plastic usually demonstrate posterior acoustic shadowing. US can also guide percutaneous removal.
Fig. 1: Ultrasound evaluation of medial midfoot and hindfoot.

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Fig. 2: Ultrasound evaluation of lateral midfoot and hindfoot.
Fig. 3: Ultrasound evaluation of posterior aspect of heel. Achilles tendon (arrowheads).

Fig. 4: Ultrasound evaluation of plantar aspect of heel. Plantar fascia (arrowheads).
Fig. 5: Conditions associated with heel pain.

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**Fig. 6:** TP and FDL tenosynovitis in a 49-year-old female. A, B) Short-axis US images show thickening and alteration of the echogenicity of the PT and FDL tendons (white and black arrows, respectively), which shows moderate amount of fluid in peritendinous sheath with synovial thickening (arrowheads), and hyperemia intra and peritendinous. C, D) Long-axis US images show the PT tendon.

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**Fig. 7:** FHL tenosynovitis in a 22-year-old male. A, B) Short-axis US images show circumferential distention of the FHL tendon sheath by hypoechoic fluid (arrowheads). C) Long-axis US image shows focal distention of the FHL tendon sheath (black arrows). The normal hyperechoic fibrillar tendon architecture is maintained (white arrows).

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Fig. 8: Tarsal tunnel syndrome. A) Tarsal tunnel syndrome in a 51-year-old female with ganglion in the tarsal tunnel. Short-axis US image shows the lobulated ganglion (arrowheads) between the tibial nerve and the posterior tibial artery. B, C) Tarsal tunnel syndrome in a 82-year-old woman with tibial nerve schwannoma in the tarsal tunnel. Long-axis US images show the hypoechoic well-defined mass with internal vascularity in continuity with the tibial nerve (white arrows).

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Fig. 9: Peroneal tenosynovitis in a 47 year-old female. A, B, C) Short-axis US images show significant amount of fluid in the peroneal tendon sheath, with thickening of the synovium and significant hyperemia.

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**Fig. 10:** Midportion Achilles tendinopathy in a 50-year-old female. A) Longitudinal extended field-of-view US image; B) Short-axis US image; C) Long-axis US image. Images show enlarged the midportion Achilles tendon (*) with loss of normal concave anterior margin (arrowheads) and intratendinous hyperemia.

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**Fig. 11:** Insertional Achilles tendinopathy in a 64-year-old female. A, B) Long-axis US images show enlarged and hypoechoic distal Achilles tendon (*), with calcifications (white arrows) and hyperemia.

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Fig. 12: Retroachilles bursitis and paratendinopathy in a 20-year-old male. A, B, C) Long-axis US images show retroachilles bursa distension by a hypoechogenic fluid collection (arrowheads) and isoechoic paratenon thickening (arrows) with hyperemia. The Achilles tendon itself is not thickened (*) and doesn’t show signs of tendinopathy.

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**Fig. 13:** Distal Achilles tendinosis and retrocalcaneal bursitis in a 32-year-old male. A, B) Long-axis US images; C) Longitudinal extended field-of-view US image; D) Short-axis US image. US images show retrocalcaneal bursa distension by a hypoechogenic fluid collection (arrowheads) with synovial thickening (white arrows) and hypervascularized wall. The fusiform swelling (*) and hyperemia areas in the Achilles tendon represent a tendinosis.

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**Fig. 14:** Haglund Syndrome in a 53-year-old female. A) Longitudinal extended field-of-view US image; B, C) Long-axis US images; D) Lateral standing radiograph. Images demonstrate the prominent osseous protuberance at the posterosuperior margin of the calcaneus (arrow). US image show the hypoechoic deeper fibers of the Achilles tendon adjacent to the posterosuperior tuberosity of the calcaneus (*) with internal vascularity. Retrocalcaneal bursitis is also present (arrowheads).

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Fig. 15: Left plantar fasciitis in a 51-year-old female. A) Long-axis US image shows the normal plantar fascia of the right foot (*); B) Long-axis US image shows the left plantar fascia, which is observed thickened and hypoechoic.

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**Fig. 16:** Lateral plantar fasciitis in a 53-year-old male. A) Long-axis US image; B) Longitudinal extended field-of-view US image. The lateral band of the plantar fascia (*) is observed thickened and hypoechoic.

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**Fig. 17:** Subcalcaneal bursitis in a 32-year-old female. A, B) Long-axis US images show a hypoechoogenic fluid collection in relation with the plantar fascia and the calcaneus. The plantar fascia itself is not thickened (*) and doesn’t show signs of plantar fasciitis.

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Fig. 18: Plantar fasciitis and calcaneal spur in a 41-year-old female. A) Long-axis US image; B) Lateral standing radiograph. Thickening and alteration of the echogenicity of the medial component of the plantar fascia (*) with associated calcaneal spur is observed (arrows).

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**Fig. 19:** Partial tear of the plantar fascia in a 63-year-old female. A) Long-axis US image; B, C) Short-axis US images. US images show the plantar fascia hypoechoic and thickened (arrows) and a small insertional plantar fascia tear (arrowheads). Note hyperemia demonstrated with Power-Doppler US in C).

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**Fig. 20:** Plantar fibromatosis (Ledderhose disease) in a 62-year-old female. A) Longitudinal extended field-of-view US image; B) Short-axis US image. US images show two solid hypoechoic and fusiform lesions (arrowheads) in relation with the medial component of the plantar fascia (arrows).

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Fig. 21: Foreign body in the Achilles tendon in a 36-year-old female. A) Long-axis US image; B) Short-axis US image. A foreign body with posterior acoustic shadow (arrow) is observed in the thickness of the achilles tendon (*). Paratendinopathy is also present (arrowheads).

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Conclusion

Ultrasound imaging is a very useful tool to assess different conditions that can cause heel pain. Being familiar with the anatomy and the differential diagnosis is essential in order to achieve the correct diagnosis.
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