Pain In The “Hind End” Of the Foot

Cameron Smith, D.O., Brandon Mason, D.O., Donald Von Borstel, D.O.
Oklahoma State University Medical Center, Department of Radiology
Disclosures

• No relevant disclosures.
Educational Objectives

• To review the differential diagnosis for heel pain and their associated MR imaging findings.
• Discuss pertinent and specific imaging findings that suggest a certain clinical diagnosis.
Introduction

- Heel pain is a common complaint among the general population and is present in 1 of 8 individuals, especially over the age of 50.
- Heel pain is one of the most prevalent complaints necessitating referral to a foot specialist.
- Heel pain generally originates at six major anatomic structures: plantar fascia, tendons, calcaneus, bursae, tarsal tunnel, and plantar fat pad.
- Plantar fasciitis is one of the more common causes of plantar heel pain.
Plantar Fascia

- Plantar fascia is a fibrous aponeurosis that arises along the medial calcaneal tuberosity.
- From the calcaneus, the plantar fascia divides into three components: medial, central and lateral components (Fig. 1a and 1b).
- The central band is the largest adhering to the undersurface of the flexor digitorum brevis.
- At the midsole, the central band divides into 5 bands of superficial and deep components extending toward the toes. This is along with the medial and lateral marginal superficial tracts inserting onto each proximal phalanx.
- The plantar fascia plays a significant role in longitudinal arch support.
Figure 1a. Coronal T1-weighted image of the ankle demonstrating a normal plantar fascia attachment (arrowheads) at the medial calcaneal tuberosity (asterisk).
Figure 1b. Coronal T1-weighted image of the ankle demonstrating the normal medial (arrow), central (arrowheads), and lateral (dashed arrow) bands of the plantar fascia.
Plantar Fasciitis

• Plantar fasciitis is one of the more common causes of plantar heel pain.
• Plantar fasciitis is related to microtrauma at the attachment at the os calcis and can be from repetitive trauma, enthesopathy, pes planus or cavus, or heel cord contractures.
• Stress-related trauma is the most common etiology and usually affects obese middle-age or elderly patients.
• Imaging related findings include thickening of the plantar fascia (greater than 6 mm) at the proximal attachment and high signal intensity on T2-weighted sequences with low to intermediate signal on T1 and proton-density-weighted sequence (Fig. 2).
Figure 2. Coronal proton-density (PD) weighted sequence with the central band of the plantar fascia (white arrow) measuring 7 mm with intermediate intrasubstance signal consistent with plantar fasciitis.
Plantar Fascia Tear

• Plantar fascia tear, or rupture, is a cause of heel pain and is usually traumatic in etiology and acute/sudden in onset.

• Fascial tears are commonly seen in running or jumping athletes.

• Imaging findings of acute tears will demonstrate partial or full-thickness defect of the fascia with hyperintense T2-weighted or short tau inversion recovery sequences (STIR) signal. Peri-fascial fluid-like signal can also be seen (Fig. 3).
Figure 3. PD fat-saturated sequence of the hindfoot with a partial thickness defect of the plantar fascia central band (orange arrow) with increased signal in the peri-fascial soft tissues (dashed arrow).
Plantar Fibromatosis

- Development of fibrous nodules within plantar fascia with similarities to, and associated with, Dupuytren’s contracture of the palmar aponeurosis.
- Fibromatosis usually involves the more distal fascia and the central or medial bands.
- Imaging findings show nodular-thickening of the non-weight bearing portions of the plantar fascia with hypointensities on both T1- and PD-sequences (Fig. 4).
- Hyperintensities of the adjacent subcutaneous soft-tissues on T2- or PD-weighted sequences can be seen.
Figure 4. Sagittal fat-suppressed PD-weighted sequence of the ankle demonstrating hypointense focal nodular thickening (arrow) of the central band. This is consistent with plantar fibromatosis.
Calcaneal Stress Fracture

- Calcaneal stress fractures are common in patients undergoing a new occupation or repetitive motions (i.e. military recruits or runners).

- Stress fractures are further classified as fatigue fracture (overuse in normal bone) or insufficiency fracture (normal use to overuse in abnormal bone).

- Conditions related to insufficiency fractures include metabolic disorders, inflammatory conditions, bone dysplasias, neurological disorders, and therapy. Osteoporosis and rheumatoid arthritis are the most common etiologies.

- Most stress fractures are a result of repetitive activity as opposed to direct trauma.

- Calcaneal stress fractures are more common posterior.
Calcaneal Stress Fracture

- Calcaneal stress fractures are commonly missed or occult on radiograph, especially in the early stages.
- MRI demonstrates linear decreased signal in bone marrow on T1-weighted images which extends to the cortex with surrounding increased marrow signal on T2-weighted and STIR sequences (Fig. 6).

Figure 6. Sagittal T1-weighted image of the ankle demonstrating a linear focus of decreased signal in the posterior calcaneus (arrow) extending to the cortex (arrowhead).
Tarsal Tunnel Syndrome

- Tarsal tunnel syndrome results from neuropathic entrapment or compression within the tarsal tunnel.
- The posterior tibial nerve and its branches can be compressed as it passes through the fibro-osseous tunnel, deep to the flexor retinaculum.
- Components of the tarsal tunnel include the medial talar wall, sustentaculum tali, and medial calcaneal wall. The flexor retinaculum forms the roof.
- Numerous etiologies can result in tarsal tunnel syndrome with up to 40% of the cases being idiopathic.
Tarsal Tunnel Syndrome

- Symptoms are usually pain and sensory deficits with rare motor symptoms.

- Symptoms can suggest the location of entrapment and posterior tibial nerve branch involved.
  - **Medial plantar nerve** can occur at the tarsal tunnel or distally. Patients usually present with heel or arch pain.
  - **Lateral plantar nerve** is commonly entrapped at the tarsal tunnel or distally with loss of sensation on the distal third of the foot.

- Imaging findings of tarsal tunnel syndrome depend on the underlying etiology. Space occupying lesions are well depicted on MRI.
Tarsal Tunnel Syndrome

Figure 7. Axial PD-weight sequence of the ankle with multiple venous varicosities (arrows) within the tarsal tunnel which can result in tarsal tunnel syndrome.
Baxter Neuropathy

• The inferior calcaneal nerve is the first branch of the lateral calcaneal nerve which if entrapped, can result in chronic heel pain that may be mistaken for plantar fasciitis.

• Entrapment can occur at three different sites: adjacent to the fascial edge of a hypertrophied abductor hallucis muscle, medial edge of the quadratus plantae muscle, and most commonly at the medial calcaneal tuberosity.

• Imaging findings are usually related to devernation with increased signal intensity or atrophy of the intrinsic muscle of the foot. Incidental atrophy of the abductor digiti minimi likely reflects a prior clinically missed entrapment (Fig. 8).
Baxter Neuropathy

Figure 8. Coronal PD-weighted image of the ankle demonstrating moderate to severe muscle atrophy of the abductor digiti minimi (arrows) compared to the abductor hallucis (arrowhead) and flexor digitorum brevis (dashed arrow).
Achilles Tendon

- Achilles tendon is formed by the communion of the gastrocnemius and soleus muscles.
- The tendon inserts at the posterior calcaneus, os calcis.
- Tendon injuries can range from complete tears to tendinosis.
- Achilles tendinopathy or tendinosis can be insertional or mid-substance.
- **Non-insertional tendinosis** is usually acute in onset and often proximal to the retrocalcaneal bursa. This entity usually occurs in higher-level athletes.
- **Insertional tendinopathy** results from repetitive trauma and micro tears which usually present with weight-bearing pain in less athletic or sedentary individuals.
Achilles Tendon

- Imaging findings on MR will demonstrate focal or fusiform thickening with diffuse or linear low to intermediate signal on fluid sensitive sequences (Fig. 9 and 10).
- Chronic tendon pathology may lack intrasubstance signal but will be diffuse or focally thickened.

Figure 9. Sagittal STIR sequence of the ankle demonstrating diffuse thickening of the achilles tendon (arrows) with intermediate intrasubstance signal (asterisk) consistent with non-insertional tendinosis.
Achilles Tendon

Figure 10. Sagittal STIR image of the ankle showing increased signal intensity of the distal Achilles tendon near the insertion on the calcaneus (arrows) representing insertional tendinosis. Longitudinal focus of signal intensity is also noted (arrowheads) representing a partial interstitial tear.
Achilles Tendon

- Achilles ruptures, or complete tears, usually occur from 25-40 years of age.
- Activities that require dorsiflexed position while running or jumping are at a greater risk.
- Complete tears will demonstrate a T2-hyperintense signal defect of the tendon (Fig. 11).
- Partial or complete retraction of fibers can be seen, depending on the degree of tearing.
- Chronic tears demonstrate muscle atrophy and fatty infiltration, which correlates with a poorer prognosis for surgical repair.
Figure 11. Sagittal STIR image of the ankle demonstrating complete disruption of the Achilles tendon with increased signal of the tendon fibers (yellow arrow). Retraction of the fibers is also noted (arrowheads).
Haglund Deformity and Syndrome

- Haglund syndrome is the result of both soft tissue and osseous abnormalities.
- A Haglund deformity is a prominent bursal bony projection of the calcaneus usually associated with low-back shoes.
- Haglund syndrome consists of a Haglund deformity, insertional tendinopathy and pre-Achilles bursitis and retrocalcaneal bursitis.
- Imaging findings include:
  - Prominent posterosuperior margin of the calcaneus with or without increased signal intensity of the marrow on the T2 and STIR sequences.
  - Fluid-like signal within the pre-Achilles or retro-Achilles bursa will also be seen.
  - Increased signal on T2/STIR sequences in the Kager (pre-Achilles) fat pad.
  - Insertional tendinosis or tendinopathy of the Achilles tendon.
Figure 12. Sagittal STIR image of the ankle demonstrating a Haglund triad including a prominent posterosuperior calcaneus tuberosity (white arrows), thickening of the Achilles tendon (dashed arrow) with a partial thickness tear of the tendon fibers (arrowheads) and retro-Achilles bursa fluid (orange arrows). Fluid in the pre-Achilles (Kager) fat pad (asterisk) is also noted.
Retro-Achilles and Retrocalcaneal Bursitis

- Bursitis in the retro-Achilles and retrocalcaneal bursa usually is a manifestation of Achilles pathology but can occur as a separate entity.

- Repetitive trauma is one of the more common causes.

- Bursitis can also be seen in rheumatoid arthritis and seronegative spondyloarthropathies.
Flexor Digitorum Longus and Flexor Hallucis Longus Tendons

- Flexor digitorum longus (FDL) and flexor hallucis longus (FHL) tendons are prone to tendonitis and tenosynovitis, which results in a painful posteromedial heel.

- More commonly seen in athletes performing repetitive forceful push offs with the forefoot.

- The tendons course through a shallow groove in the posteromedial aspect of the talus and continue under the sustentaculum tali. On the plantar aspect of the heel, the FHL tendon crosses deep to the FDL tendon before their insertion on the base of the great toe and lesser digit distal phalanges, respectively.
Flexor Digitorum Longus and Flexor Hallucis Longus Tendons

- Tenosynovitis is demonstrated by increase signal intensity on T2-weighted sequences and synovial fluid distending the tendon sheath.

- Usually the FHL tendon is involved.

- Associated tendinosis can also be seen.

- Repetitive acute tenosynovitis can result in fibrous scar formation in the tendinous sheath known as stenosing tenosynovitis.

- Imaging findings of stenosing tenosynovitis will demonstrate an intermediate signal intensity rind surrounding the tendon on both the T1- and T2-weighted sequences.
Figure 13. Axial T2-weighted fat-suppressed image of the ankle demonstrating near circumferential hyperintense signal (arrows) within the flexor hallucis longus tendon sheath (asterisk) consistent with tenosynovitis.
Heel Pad Abnormalities

• The heel fat pad is composed of elastic fibrous septae with closely pack fat cells which acts as a shock-absorber for the heel.

• Numerous causes of heel pain can arise from the fat pad:
  • Infection
  • Trauma (rupturing of the septa)
  • Neoplasm
  • Inflammatory conditions
    • Rheumatoid nodules
Heel Pad Abnormalities

• Rheumatoid nodules usually develop on the pressures areas in the heel, but may occur near the Achilles tendon.

• This entity occurs in 20% of patient who test positive for rheumatoid factor.

• Imaging finding are related to their histologic composition.

• Solid nodules are composed of chronic inflammatory cells and usually show decreased signal intensity on T1- and T2-weighted sequences with post-contrast enhancement.

• Nodules can have central necrosis with increased signal intensity on T2-weighted sequences and peripheral enhancement (Fig. 14).
Heel Pad Abnormalities

Figure 14. Sagittal T1-weighted sequence of the ankle after contrast administration, demonstrating an ovoid peripherally enhancing nodule (arrows) with central hypointensity (asterisk) of the plantar heel pad consistent with a subcutaneous rheumatoid nodule.
Conclusion

• Heel pain is a common musculoskeletal complaint for presentation to primary care or a foot specialist and imaging can be helpful in the clinical evaluation.
• The heel is a complex area to assess with numerous anatomical locations for sources of pathology.
• Understanding the imaging findings and differential diagnoses for heel pain will help guide the clinician to a more accurate diagnosis and earlier treatment.
References