MRI of Sports Related Injuries – Ankle: Tendon and Ligament

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Learning Objectives

- Review the normal anatomy of ankle tendons and ligaments
- Understand pitfalls in MR imaging of the ankle tendons and ligaments
- Understand the types of injury to ankle tendons and ligaments seen in sporting activities and their MRI appearances

Introduction

The ankle joint is particularly vulnerable to injury when undertaking athletic activities. Ankle sprains alone are considered to account for up to 30% of all athletic injuries and the lateral collateral ligament complex of the ankle is described as being the most frequently injured single structure in the body (1, 2). Of particular interest is the vulnerability of the ankle to both acute traumatic injury and to injury sustained through chronic repetitive overuse, both patterns of injury being frequently seen in professional and amateur sports participants. While patterns of injury in the ankle may involve a variety of structures including cartilage and bone, this article and the accompanying lecture will focus on the tendons and ligaments.

Tendon Anatomy

The tendons about the ankle act to move the foot and ankle and also act as dynamic stabilisers of the ankle.

a) The Achilles and Plantaris tendons

The **Achilles tendon** is the largest tendon in the body and passes the ankle joint posteriorly in a superficial location. It arises from the gastrocnemius and soleus muscles and inserts onto the calcaneus with a broad attachment. The tendon is well demonstrated on sagittal and axial MR images where, like all tendons at the ankle, it should appear of low signal on all imaging sequences. The tendon should be less than 1 cm in sagittal thickness and appear concave or flat anteriorly (Fig 1). It does not have a

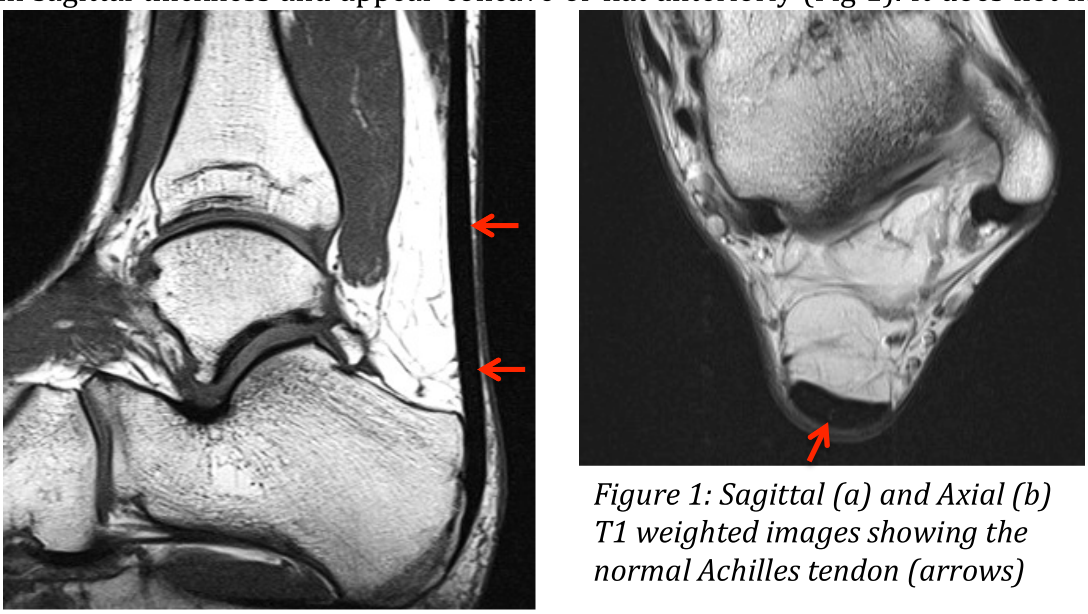


Figure 1: Sagittal (a) and Axial (b) T1 weighted images showing the normal Achilles tendon (arrows)

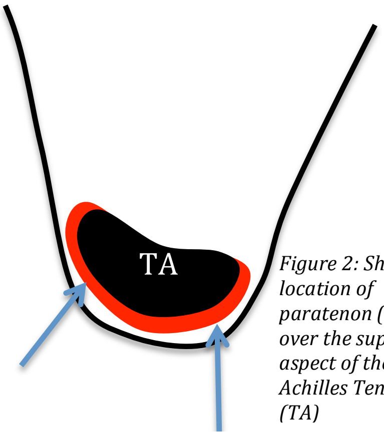


Figure 2: Showing location of paratenon (arrows) over the superficial aspect of the Achilles Tendon (TA)

Figure 3: T1 weighted axial image. The plantaris tendon (small arrow) is seen inserting onto the calcaneum just medial to the Achilles tendon (large arrow)

tendon sheath, but is surrounded by a paratenon on its superficial aspect (Fig 2). This is not normally seen, or is seen as a very thin high signal cuff of tissue on T2 imaging.

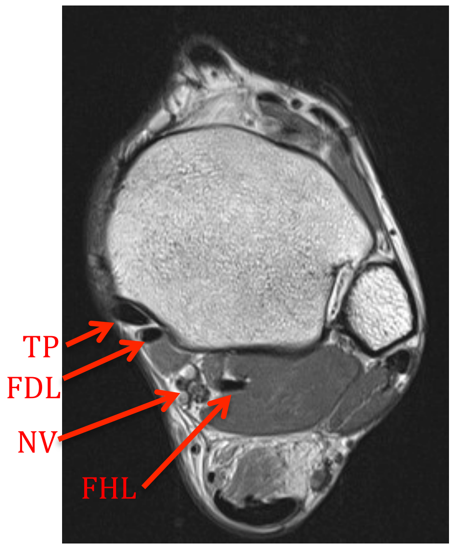
A **retrocalcaneal bursa** may be identified deep to the Achilles tendon just proximal to its insertion. It is normal to see a small amount of fluid in this bursa. The **pre-Achilles bursa** lies adjacent to the Achilles tendon on its superficial surface, which is not seen in the normal situation.

The **plantaris tendon** is seen in 90% of individuals as a small tendon which either inserts onto the calcaneus just medial to the Achilles tendon or blends with the medial aspect of the tendon proximal to the Achilles insertion (Fig 3). The plantaris tendon arises from the plantaris muscle and obtains the medial side of the Achilles tendon by passing between the soleus and gastrocnemius muscles.

b) The medial tendons

The medial tendons comprise, from anterior to posterior, the **tibialis posterior** (TP), **flexor digitorum longus** (FDL) and **flexor hallucis longus** (FHL). The TP and FDL pass immediately behind the medial malleolus and are separated from the FHL by the posterior tibial neurovascular bundle (Fig 4). These tendons all have synovial tendon sheaths and are held in place by the flexor retinaculum which creates a fibro-osseous tarsal tunnel through which the tendons and neurovascular structures pass. The order of the tendons from anterior to posterior can be remembered by the mnemonic **T**OM (**T**P), **D**ICK (F**D**L) AND **A** (**a**rtery) **V**ERY (**v**ein) **N**ERVOUS (**n**erve) **H**ARRY (F**H**L). The TP is oval and approximatly twice the size of FDL. It may normally have a thickened apperance and show increased signal at its insertion onto the navicular. The FHL runs in a groove on the back of the talus. Its tendon sheath communicates with the ankle joint and it is normal to see fluid in the sheath.

Figure 4: The medial tendon group. (NV = neurovascular bundle). Note the relative sizes of the tendons and their relationships



c) The Peroneal Tendons

The **peroneus longus** (PL) and **brevis** (PB) pass on the lateral aspect of the ankle behind the lateral malleolus. They lie next to each other at the level of the malleolus but more distally become separated by the peroneal tubercle (Fig 5).

These tendons have synovial tendon sheaths and are held in place by a retinaculum. While the peroneus brevis may appear flattened, it should never appear C shaped

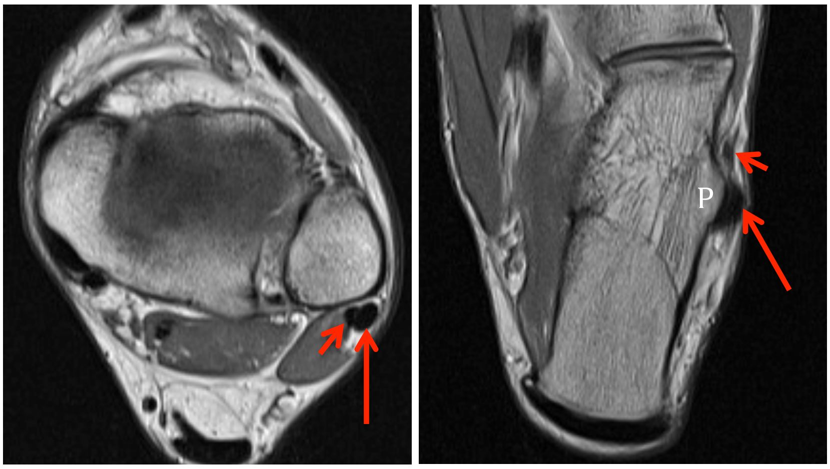


Figure 5:The peroneal tendons are seen at the level of the lateral malleolus (A) and at the level of the peroneal tubercle (B). PB (small arrow) PL (large arrow) P = peroneal tubercle

d) The Anterior Tendons

The final group of tendons we will consider are the anterior tendons. These comprise the large **Tibialis Anterior** (TA) along with **Extensor Hallucis Longus** (EHL) and **Extensor Digitorum Longus** (EDL) (Fig 6). These are maintained in place by a superior and inferior retinaculum. They run in synovial sheaths but it is rare to see fluid surrounding the normal anterior tendons. The majority of patients (83 – 95%) also have an additional anterior muscle, the **peroneus tertius** which arises from the anterior fibula and inserts onto the 5th metatarsal (3). It may share a tendon sheath with EDL

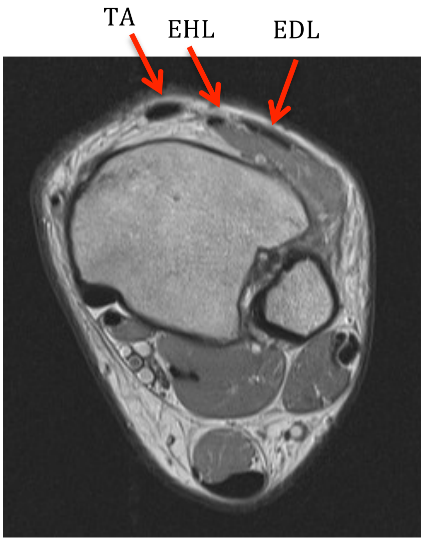


Figure 6: Anterior Tendons shown on axial T1 weighted image

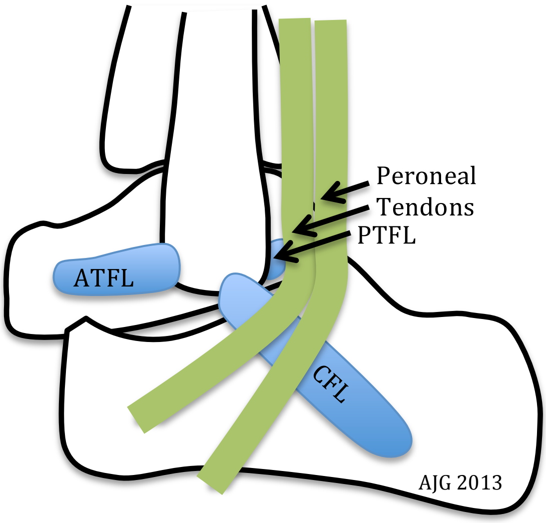
Ligament Anatomy

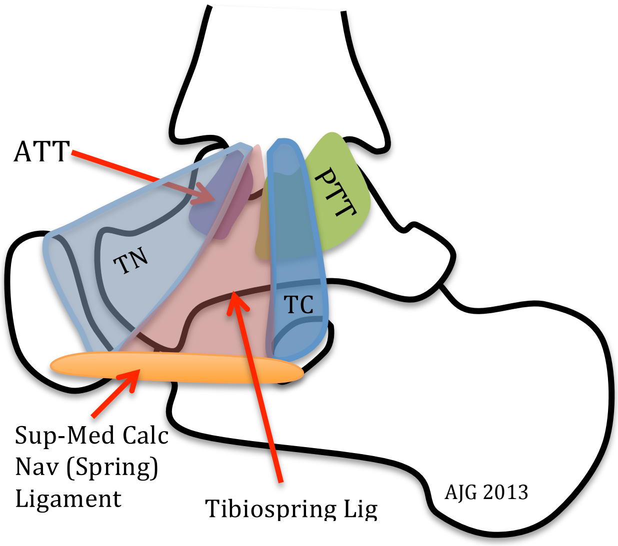
a) The Lateral Collateral Ligament Complex

Comprises 3 ligaments:

- **The anterior tibiofibular ligament (ATFL)**, which runs horizontally in the neutral position from the anterior tip of the lateral malleolus to the talar neck. It is seen well on axial imaging.
- **The calcaneofibular ligament (CFL)** running as a thin band deep to the peroneal tendons from the tip of the fibula to the lateral calcaneus. This ligament is seen on coronal and axial imaging. With orthogonal imaging it is usually not seen on a single slice, but must be followed on consecutive slices.

- ***The posterior talofibular ligament (PTFL)*** is deep and lies medial to the lateral malleolus in the concavity found there





b) The Medial Collateral Ligament Complex (Deltoid Ligament)

The **deltoid ligament** is a strong complex of ligaments which form deep and superficial layers. The deep layer comprises posterior (PTT) and anterior (ATT) tibiotalar ligaments. The superficial layer includes the talocalcaneal ligament (TC) passing between the medial malleolus and sustentaculum tali and the talonavicular ligament (TN). The posterior tibiotalar ligament is the strongest component.

c) The Tibiofibular Ligaments

Figure 7: The anterior tibio-fibular ligament seen on the single slice on a coronal PD (fat sat) image (arrow).

The distal **tibiofibular (syndesmotic) ligaments** are vital for maintaining the stability of the talocrural joint. They comprise anterior and posterior ligaments, the anterior being the more important and the more frequently injured. The anterior ligament has an oblique course between the fibula (inferior-lateral) and the tibia (superior and medial) and is therefore visualised on consecutive axial sequences. It may occasionally be seen on coronal imaging (Fig 7). The posterior ligament also passes obliquely inferolateral to medial-superior and is followed on axial images. Posteriorly an intermalleolar ligament passes across the posterior joint line. It should not be confused with an intra-articular loose body (Fig 8) .

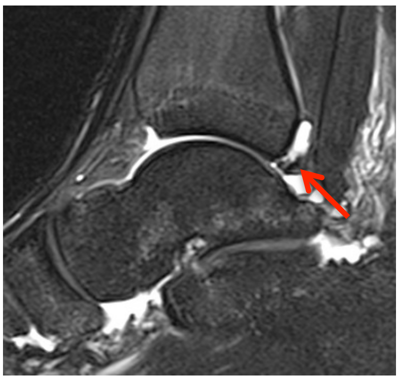


Figure 8: The intermalleolar ligament (arrow) shown on a sagittal (T2 fat sat) image.

d) The Ligaments of the Sinus Tarsi

The **sinus tarsi** contains 5 ligaments which include the talocalcaneal ligaments, and orgins of the inferior extensor retinaculum. Together the ligaments act with the lateral ankle ligaments to stabilise the lateral aspect of the ankle and hindfoot (4, 5). In addition to the ligaments, the sinus tarsi contains an arterial anastomosis and nerve endings. All this is surrounded by fat, which provides the predominant signal from the sinus.

Figure 9: Accessory soleus muscle inserting onto the calcaneus (arrows)

Figure 10: Peroneus quartus muscle and tendon (arrow)

Accessory Muscles and Tendons

Numerous accessory muscles and their tendons have been described about the ankle (6). The two most frequently seen are the accessory soleus, which may present as a soft tissue mass, and the peroneus quartus. The accessory soleus muscle arises from the anterior surface of the soleus, or from the fibula and tibia and passes anterior or anteromedial to the Achilles tendon (Fig 9). It has a variable insertion either into the calcaneus or the Achilles tendon. It may or may not have a tendon. The peroneus quartus originates from the peroneus brevis in the majority of cases and descends with the peroneus longus and brevis, most frequently inserting onto the calcaneus (Fig 10).

Imaging Pitfalls

Besides the intermalleolar ligament several other potential traps for the unwary exist when imaging the ankle tendons and ligaments.

The course taken by the medial and lateral tendons means that they may show magic angle effect as they pass round the malleoli. If high signal is detected in the tendons long TE imaging should be reviewed, as this will eliminate magic angle effect, confirming the signal abnormality is genuine (Fig 11).

Accessory ossicles are frequently seen in the region of the ankle and the os peronei may be found within the peroneus longus tendon as it passes inferolateral to the cuboid bone. If it is not recognised it can be misinterpreted as focal thickening of the tendon and reported as tendinopathic change.

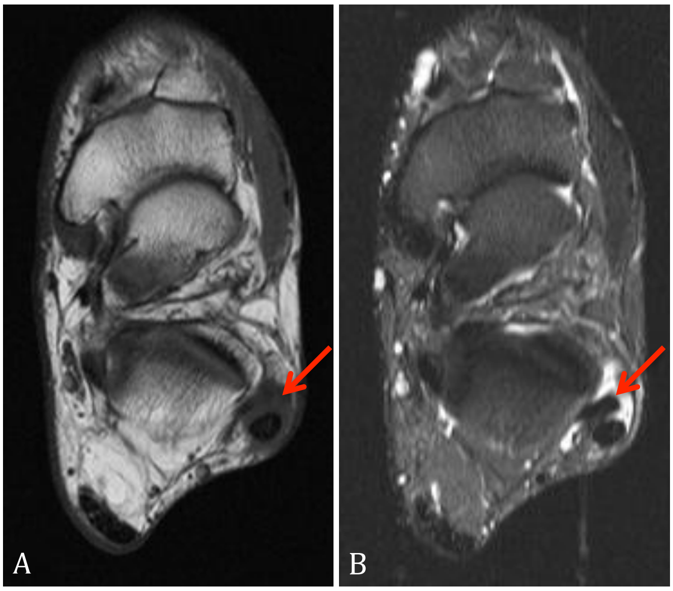


Figure 11: Magic Angle effect. A) Shows a T1 weighted axial image with abnormal intermediate signal shown in the peroneus brevis (arrow). B) On a T2 weighted image with a longer TE the tendon returns a normal low signal confirming the appearance in A is due to magic angle effect. The T2 image also shows fluid surrounding the peroneal tendons.

Figure 12: Achilles tendinopathy. Axial T1w SE. The tendon (arrow) is markedly thickened with loss of the normal flat/concave anterior border. High signal is seen within the tendon

Tendon Injury

Ankle tendon injury is a common finding in those undertaking sports activity.

a) Tendinopathy

Chronic and repetitive activity undertaken by athletes may lead to microtraumatic damage to the tendons resulting in tendinopathy (also known as tendinosis). Tendinopathy was once referred to as tendinitis, but this term is no longer used as it implies an inflammatory process. Increasing age is recognised as an important risk factor for the development of tendinopathy.

Tendinopathy shows common features on MRI imaging regardless of the tendon involved. These changes comprise tendon thickening and increased signal shown on short and long TE imaging. The tendons most frequently identified as showing tendinopathic change are the Achilles tendon and tibialis posterior (Fig 12). Tendinopathic change is less commonly seen in the tibialis anterior tendon where it tends to be a finding in older athletes. Tendinopathy can result from impingement of the tendon. This is seen in the Achilles tendon in association with the Haglund deformity (a bone outgrowth from the posterior calcaneus) with tendinopathy occurring adjacent to the bone prominence. There is frequently retrocalcaneal bursitis.

b) Peritendinous Inflammation

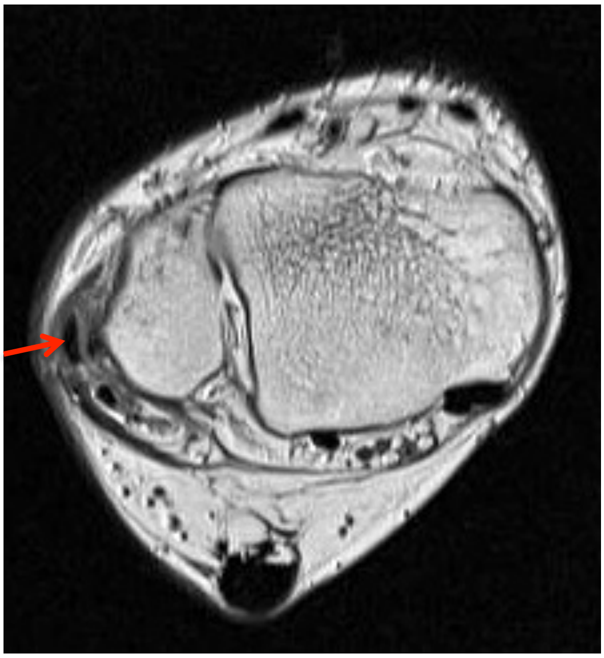


Figure 13: Axial T1 SE. Anterior dislocation of the peroneus longus tendon (arrow) in a patient who had previously sustained a fibular fracture. The disrupted retinaculum can also be appreciated.

Inflammatory change around tendons is well demonstrated on MRI and may occur in association with tendinopathy. In the case of the Achilles tendon this is seen as paratenonitis, with thickening of the high signal change paratenon noted on MR imaging, while tendons with a tenosynovium may show tenosynovitis. Here fluid and synovitis are seen surrounding the tendon.

c) Peroneal Tendon Dislocation

This may occur congenitally in patients with an absence of the retinaculum or following traumatic disruption of the retinaculum. The dislocation may be intermittent and ultrasound has advantages over MRI in allowing a dynamic assessment for dislocation, but MRI will demonstrate a dislocation of one or both tendons and also allows identification of any associated tendon pathology (Fig 13).

d) Tendon Tear

Achilles tendon rupture is a major injury for any patient, but especially in athletes where it can be career threatening. Tears of the Achilles tendon usually occur on a background of chronic tendinopathy and therefore most frequently occur in older patients, typically middle-aged men. Tears may be full or partial thickness and are well demonstrated on MRI. When the tear is full thickness complete discontinuity of the tendon is identified,

Figure 14: Sagittal T2 FSE image with fat sat. There is a full thickness Achilles tendon tear with complete tendon discontinuity.

Figure 15: Axial PD image showing a longitudinal split tear of peroneus brevis (arrow)

the torn tendon usually appearing tendinopathic (Fig 14). Partial thickness tears involve part of the cross-sectional area of the tendon, but in cases of tendinopathy small fissure tears and intrasubstance tearing, seen as focal linear water signal clefts, may be observed. Distinguishing a small tear from focal tendinopathy can be difficult, although generally the tear will show brighter T2 fluid intensity than is commonly seen with intratendinous myxoid tendinopathy. Full thickness tear of the Achilles tendon may occur in the presence of an intact plantaris tendon, which can mask the clinical picture. Isolated tears of the plantaris can also be seen and may mimic a tear of the Achilles. Tears of the Tibialis posterior, peroneal tendons and the tibialis anterior may also be seen and again generally occur on a background of tendinopathy. A type of partial thickness tear seen commonly in the peroneal tendons, most commonly peroneus brevis, is the longitudinal split tear which at the level of the tear will give the impression of an additional tendon (Figure 15).

Ligament Injury

Injuries to the ankle ligaments are one of the commonest acute traumatic injuries sustained in sporting activity. MRI plays an important role in assessing the site and extent of any ligament injury and also allowing assessment of associated injuries, for instance injury to osteochondral surfaces or tendons. Peroneal tendon pathology, including tears, subluxation and tenosynovitis is particularly common in patients with chronic ankle instability.

Ligament tears can be classified as full or partial thickness tears. Clinicians will often use a grading system (1 to 3) for ligament injury based on clinical examination. Grade 3

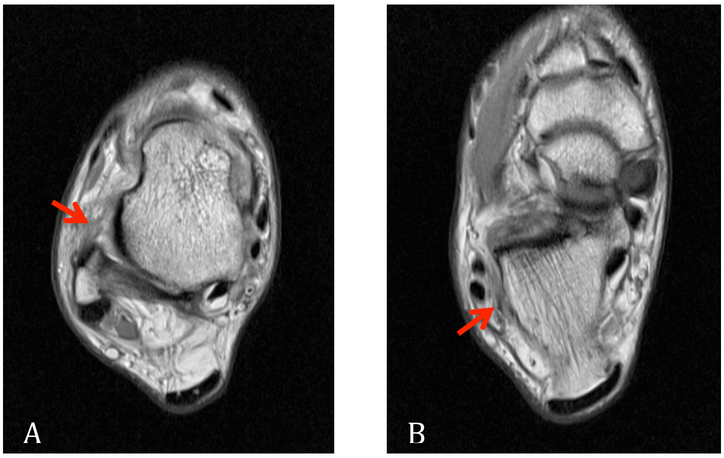


Figure 16: Axial PD images. There are full thickness (grade 3) tears of (A) the ATFL and (B) the CFL (arrows)

represents a full thickness tear and this will usually be evident on MRI. Grade 2 ligament injuries are expected to show partial thickness tears while grade 1 lesions show oedematous change in the ligament without macroscopic disruption. However it is important to recognise that this grading system is fundamentally a clinical system and the distinction between the lower grade tears is imprecise on MRI. Chronically ligaments often heal with scarring, appearing thickened and irregular on MRI. However the chronic appearances of torn ligaments include a normal appearing ligament and a completely absent ligament. Ligament tears leading to chronic instability patterns are implicated in the development of ankle impingement syndromes.

a) The Lateral Collateral Ligament Complex

85% of ankle injuries involve an inversion mechanism and consequently the lateral collateral ligaments are commonly injured (7) (Fig 16). Disruption usually involves first the ATFL, followed by the CFL. It is unusual to tear the PTFL without major ankle trauma usually involving ankle dislocation. When acutely torn discontinuity of the ligament may be shown, but with lower grade injuries thickening and heterogenous change within the ligament are seen. Adjacent oedema and haemorrhage will usually be evident, and fluid in the peroneal tendon sheath is an indirect sign suggesting ligamentous disruption. A tiny cortical defect at the ATFL attachment may be seen representing a cortical avulsion, and an associated “bright rim sign” is reported as a helpful feature (8).

b) Syndesmotic Ligaments

It is important to review the syndesmotic ligaments, as injury to the syndesmosis (high ankle sprain) is relatively common in the sporting population. Around 10% of ankle injuries involve a partial tear of the syndesmotic ligaments. (9). Generally the anterior ligament tears first. If these injuries are unrecognised patients can be left with chronic pain and instability.

c) The Deltoid Ligament

Deltoid ligament injury occurs less commonly than injury to the lateral complex (Fig 17). When torn the deltoid ligament tear is commonly associated with lateral ligament injury, fibular fracture or syndesmosis injury (7). It is relatively common for the deltoid ligament, particularly the deep posterior talotibial fibres, to appear oedematous in association with lateral collateral ligament tears due to compression sustained during inversion

Figure 17: T2 TSE coronal with fat sat showing full thickness disruption of the deltoid ligament.

injury (10). The majority of deltoid ligament injuries are full thickness and if the posterior tibiotalar fibres are seen to be torn, the weaker superficial tibionavicular and tibiocalcalcaneal ligaments are also likely to be torn (11).

d) The Sinus Tarsi

Sinus tarsi syndrome has a number of causes, but most commonly results from trauma. Its aetiology is poorly understood, but ligament injury and scarring have been implicated. It gives rise to lateral pain and tenderness and hindfoot instability. Characteristically patients with the sinus tarsi syndrome lose the fat signal from the sinus, a feature said to be due to the presence of fluid, inflammatory tissue and fibrosis in the sinus. Associated bone marrow edema may be seen in the roof and floor of the sinus tarsi. The limitations of MRI in assessing the integrity of the ligaments in the sinus tarsi have been highlighted (5).

Conclusion

Tendon and ligamentous injury at the ankle form some of the commonest injuries sustained during sporting activity. MRI is readily able to demonstrate these injuries assessing their extent and associated structural damage.

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