

Knee and Ankle Ligaments: Magnetic Resonance Imaging Findings of Normal Anatomy and at Injury

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Abstract

Ligamentous injuries of the lower limb are a common entity sustained during sports activities and military training. Magnetic resonance (MR) imaging of the knee and ankle is playing an increasingly important role in the detection, diagnosis and prognosis of these injuries and their associated complications. MR imaging with its exquisite soft tissue contrast resolution and multiplanar capability is increasingly seen as the modality of choice for evaluating ligamentous injuries of the knee and ankle. Representative knee and ankle MR studies from a tertiary referral hospital are used to illustrate both the normal appearance and typical radiological features of common ligamentous injuries of the knee and ankle. A thorough understanding of the MR appearances of these injuries is crucial to the radiologist and clinicians involved in the management of these patients.

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Introduction

Ligamentous injuries of the knee and ankle are a common entity among athletes. Knee sprains can account for up to 30% of injuries in skiers,¹ whilst up to 74% of professional footballers develop ligamentous sprains of the lateral ankle ligaments.² Such injuries can result in significant downtime of these sporting professionals. A fast, accurate and reliable diagnosis of such injuries following trauma is crucial to both the athlete and the sports medicine physician.

Magnetic resonance (MR) imaging with its exquisite soft tissue contrast resolution and multiplanar capability is increasingly seen as the modality of choice for the confirmation and prognostic evaluation of such ligamentous injuries of the knee and ankle joints. A sensitivity and specificity of up to 93%³ to 96%⁴ and 89%³ to 98%⁴ respectively are reported for the diagnosis of anterior cruciate ligament (ACL) injuries with MRI. Lateral ligamentous complex injuries of the ankle are also relatively well picked up on MR imaging, with a sensitivity and specificity of 74% and 100% respectively,⁵ amongst other ligamentous injuries.

Methods

MR imaging studies of the knee and ankle from a tertiary referral hospital were drawn upon for the use of this article.

The studies were done on a 1.5T closed-bore superconducting magnet with a dedicated extremity knee/ankle quadrature transmit-receive coil. Acute ligamentous injuries typically manifest with increased fluid content and oedema. As such, fluid sensitive sequences, such as FSE T2-weighted, inversion recovery and proton-density sequences, are most appropriate in the imaging of these ligamentous injuries. These were obtained in the standard sagittal, coronal and axial imaging planes. Representative images of the major ligaments within the knee and ankle joints in their normal and their injured state were selected from these studies.

Ligaments of the Knee and Some Common Injuries

The ligamentous stabilisers of the normal knee joint comprise 4 main ligaments; the medial and lateral collateral ligaments, as well as the anterior cruciate ligament (ACL) and posterior cruciate ligament (PCL). The lateral collateral ligament (LCL) arises from the lateral condyle of the femur and attaches to the lateral side of the head of the fibula (Fig. 1). This ligament has a slight anterior inclination as it descends and hence is seen over a succession of contiguous coronal images. Its deep surface has no attachment to the lateral meniscus. The LCL is the primary restraint to varus forces of the knee.

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The medial collateral ligament arises from the medial condyle of the femur, below the adductor tubercle and attaches to the medial surface of the body of the tibia, some 2 to 2.5 cm distal to the surface of the tibial plateau. There is normal intimate adherence of the deep surface of ligament to the periphery of the medial meniscus (Fig. 1). Tears of the LCL and MCL are illustrated (Figs. 2 and 3 respectively).

The meniscomfemoral ligaments are a pair of ligaments which run from the posterior horn of the lateral meniscus to the lateral aspect of the medial femoral condyle. One of the ligaments runs anterior to whilst the other runs posterior to the PCL; these are called the ligaments of Humphrey and Wrisberg (Fig. 4) respectively. Gupta and colleagues⁶ found a 93% incidence of either of these ligaments in a cadaveric study. Fifty per cent of the specimens revealed

the presence of both meniscomfemoral ligaments. Recognition of these normal ligaments is important so that their presence will not be confused with pathology.

The ACL and PCL criss-cross each other when viewed on either the side or the front of the knee, giving them their cruciform configuration and hence their names. The ACL arises from the medial aspect of the lateral femoral condyle and runs inferiorly, medially and anteriorly. The ligament also fans out at the distal aspect before its insertion in the midline of the tibia (Fig. 5). The ACL acts as the principal restraint to anterior tibial translation with respect to the femur. Secondary functions of the ACL also include prevention of excessive internal rotation of the tibia as well as to limit the varus-valgus angulation and hyperextension of the knee.

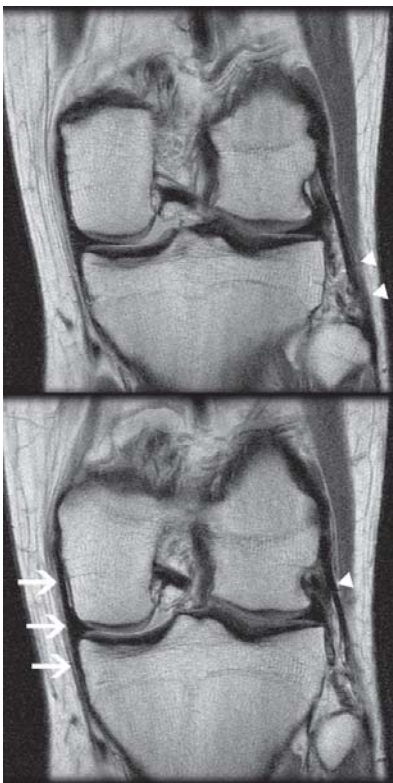


Fig. 1. Coronal proton-density images of the knee show a normal lateral collateral ligament (LCL) seen passing across successive images from the lateral femoral condyle to the head of the fibula (white arrowheads). The normal medial collateral ligament (MCL) is seen passing from the medial femoral condyle to the medial surface of the body of the tibia (white arrows). Note the normal adherence of the MCL with the underlying medial meniscus.



Fig. 2. Coronal proton-density image of the knee showing attenuation and thinning in the mid-portion of the LCL (black arrowhead), which indicates a partial tear.



Fig. 4. Coronal proton-density image of the knee revealing the ligament of Wrisberg (white arrowheads) which is one of the two meniscomfemoral ligaments. The ligament runs from the posterior horn of the lateral meniscus to the lateral aspect of the medial femoral condyle. This ligament sits posterior to the PCL (white arrow).



Fig. 3. Coronal proton-density image of the knee showing a complete tear and avulsion of the femoral attachment of the MCL (black arrow). The free end of the ligament is identified, and no ligament fibres are seen in continuity.



Fig. 5. Sagittal proton-density image of the knee showing the normal anterior cruciate ligament (white arrow), with the ligament fibres running parallel to the roof of the intercondylar notch (Blumensaat's line).



Fig. 6. Sagittal proton-density image of the knee showing the normal posterior cruciate ligament (white arrow) with complete signal void and a curved configuration, with the knee in the extended position.

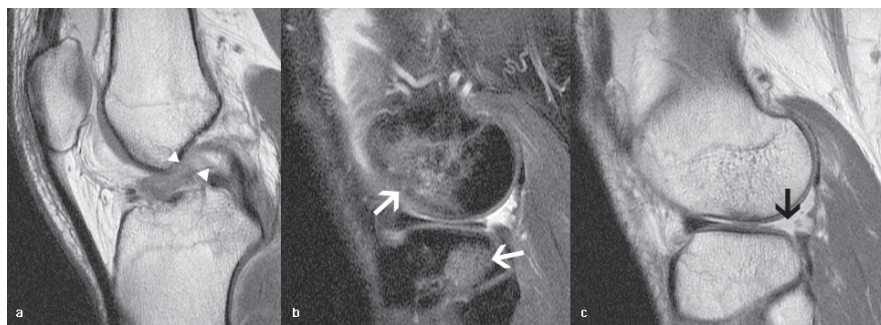


Fig. 7a. Sagittal proton-density images of the knee showing a torn anterior cruciate ligament (white arrowheads) and an abnormal horizontal orientation of the remaining inferior portion. Fig. 7b. Sagittal fat-suppressed proton-density image of the lateral aspect of the knee shows associated increased signal intensity, indicating bone marrow oedema pattern of the anterior aspect of the weight-bearing portion of the lateral femoral condyle, and the opposing posterolateral aspect of the tibial plateau (white arrows). This is due to impaction of these 2 areas at the time of tibial translation during the original injury. Fig. 7c. Sagittal proton-density image of the medial aspect of the knee shows absence of the posterior horn of the medial meniscus, indicating a meniscal tear as part of the injury complex (black arrow).



Fig. 8. Sagittal proton-density image of the knee showing an intact reconstructed anterior cruciate ligament (white arrowheads) held in place by interference screws.



Fig. 9. Sagittal proton-density image of the knee showing complete disruption of the reconstructed anterior cruciate ligament, with no intact graft fibres visualised (white arrowheads).



Fig. 10. Sagittal proton-density image of the knee showing an ovoid intermediate density lesion (white arrow) anterior to the reconstructed ACL. This represents arthrofibrosis or a cyclops lesion, which is causing impingement in extension of the knee.



Fig. 11. Sagittal proton-density image of the knee shows a sprained posterior cruciate ligament (black arrowheads).

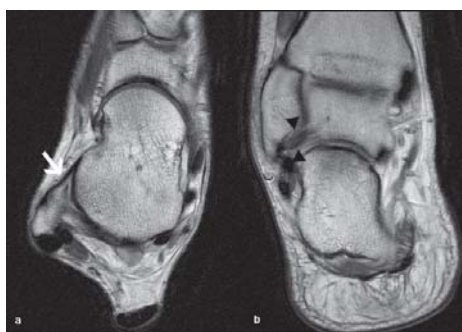
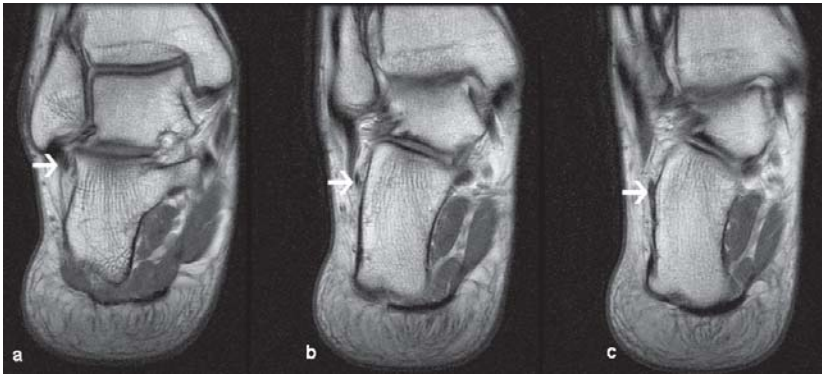


Fig. 12a. Axial proton-density image of the ankle shows an intact normal anterior talofibular ligament, between the anterior aspect of the distal fibula and the lateral aspect of the talus (white arrow). Fig. 12b. Coronal proton-density image of the ankle showing a normal posterior talofibular ligament as it courses from the medial aspect of the lateral malleolus to the talus (black arrowheads).



Figs. 13 a-c. Consecutive coronal proton density images of the ankle show a normal calcaneofibular ligament (white arrows) descending obliquely from the lateral malleolus to the lateral surface of the calcaneum.



Fig. 14a. Axial proton-density image showing a normal tibionavicular ligament (white arrow). Fig. 14b. Coronal proton-density image showing a normal calcaneotibial ligament (white arrowheads).



Fig. 15. Coronal proton-density image of the ankle demonstrating normal superficial and deep components of the talotibial (deltoid) ligament (white arrow), fanning out as it passes from the medial malleolus to the posterior talus.

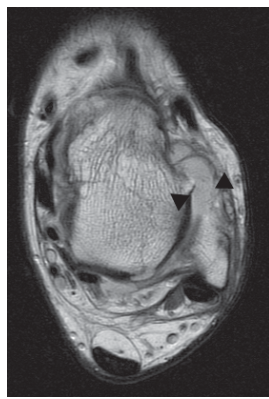


Fig. 16. Axial proton-density image of the ankle demonstrates complete disruption of the anterior talofibular ligament as indicated by the absence of the ligament along its expected course (black arrowheads).



Fig. 17. Coronal proton-density image of the ankle reveals increased signal with disruption of the calcaneofibular ligament (black arrowheads) compatible with an acute tear.

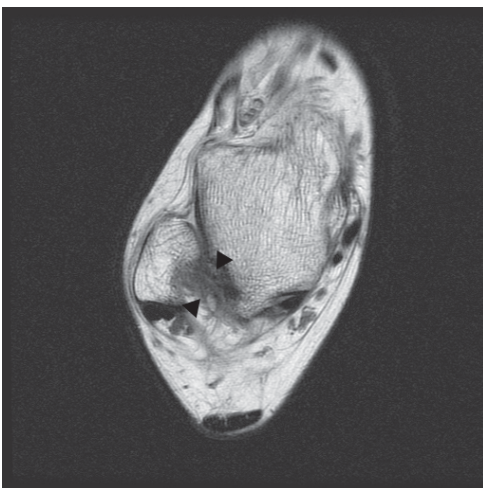


Fig. 18. Axial proton-density image demonstrating a partial tear of the posterior talofibular ligament (black arrowheads).



Fig. 19. Coronal proton-density image revealing a thickened Deltoid ligament (white arrow) with increased signal compatible with a sprain.

The PCL arises from the posterior intercondylar fossa of the tibia, extends superiorly, anteriorly and laterally to attach to the lateral aspect of the medial femoral condyle (Fig. 6). In full extension of the knee, which is the usual position for MR imaging, the ACL is usually taut and runs parallel to the roof of the intercondylar notch (Blumensaat's line), while PCL is lax and has a curved orientation, with a sharp bend. The PCL is also more uniformly signal void as compared to the ACL.

Tears in the ACL are common in twisting injuries of the knee whilst in extension. This commonly occurs on the sports field with the foot planted on the ground while the torso is in rotation. In contact sports, the ACL can also be injured with a direct posterior force to the knee or calf. The ACL fibres can be seen to be completely or partially disrupted with abnormal morphology and signal intensity. There are also secondary signs of an ACL tear which include a buckled PCL, anterior displacement of the tibia (anterior drawer sign), uncovering of the posterior horn of the lateral meniscus and a typical pattern of bone contusion at the lateral femoral condyle and posterolateral tibial plateau.⁷ Bone contusion can occur up to 72% and 12% in complete and partial ACL tears respectively.⁸ There can also be associated injuries including meniscal tears (Figs. 7a-c),⁹ which have an incidence of 52% during an acute ACL injury, increasing to 83% in a chronically cruciate deficient knee.¹⁰ Tears of the lateral meniscus were slightly more common in the acute ACL-injured knee, while medial meniscal tears were more common in the chronic setting.¹¹ Reconstruction of the ACL (Fig. 8) after an injury is one of the commonest ligamentous reconstructions done today. As with the native ligament, a reconstructed ligament can also be subjected to stresses and be injured or torn (Fig. 9).¹² Localised anterior arthrofibrosis or a "cyclops lesion" is also a known complication after ACL reconstruction which may lead to extension block (Fig. 10).^{13,14}

PCL tears commonly occur whilst the knee is in flexion. During a "dashboard injury", the knee is flexed as the anterior tibia hits the dashboard of the vehicle during a head-on collision.¹⁵ This drives the tibia posterior in relation to the femur and sprains or tears the PCL (Fig 11). In sports, the same mechanism of injury is seen when a direct force is applied to the anterior surface of the tibia, as in a soccer tackle from the front.

Ligaments of the Ankle and Some Common Injuries

In the ankle, the major ligaments are broadly divided into those on the lateral and the medial aspects of the ankle and subtalar joints. On the lateral aspect, the anterior talofibular (Fig. 12a), calcaneofibular (Figs. 13a-c) and posterior talofibular (Fig. 12b) ligaments arise from the lateral malleolus and attach to the lateral talus, lateral calcaneum

and posterior talus respectively. On the medial aspect, there is the deltoid ligament which comprises 4 ligaments separated into their superficial and deep parts. The superficial part consists of the tibionavicular (Fig. 14a), calcaneotibial (Fig. 14b) and posterior talotibial (Fig. 15) ligaments. These arise from the deep surface of the medial malleolus and attaches to the navicular, sustentaculum tali of the calcaneum and the posterior talus respectively. The deep part of the deltoid ligament comprises of only the anterior tibiotalar ligament, which arises from the medial malleolus and attaches to the medial surface of the talus. This deep portion of the deltoid ligament commonly has a striated appearance on MR imaging.¹⁶ Adequate demonstration of all these ligaments can be achieved with a combination of axial and coronal plane imaging.¹⁷

The spectrum of ligament injury can range from an intact ligament with surrounding haemorrhage and oedema, to fraying, partial visualisation and complete rupture of the ligament.¹⁸ The ligaments on the lateral aspect are commonly injured during forced inversion of the foot. Injury can occur at the anterior talofibular (Fig. 16), calcaneofibular (Fig. 17) and posterior talofibular (Fig. 18) ligaments, with the anterior talofibular ligament being the most commonly involved, and the posterior talofibular ligament being the least commonly injured.^{19,20} The deltoid ligament can be injured during forced eversion of the foot (Fig. 19).

Conclusion

MR imaging is an important tool in evaluating for knee and ankle ligamentous injuries. The detailed understanding of the normal anatomy of these ligaments and their pathological appearances can aid in early and accurate detection of these injuries so that appropriate and timely treatment can be carried out to limit the downtime of the injured athlete.

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