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PICTORIAL ESSAY

Magnetic Resonance Imaging of Anterior Cruciate Ligament Repair and Complications: a Pictorial Essay

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INTRODUCTION

Anterior cruciate ligament (ACL) is one of the main ligaments of the knee, providing a restraining force to anterior tibial displacement. It is also one of the most commonly injured structures of the knee. High-grade ACL tears are typically treated with reconstruction. Radiological features can be confusing if radiologists are unfamiliar with the normal postoperative appearance of the reconstructed ACL, leading to overdiagnosis of abnormalities and unnecessary arthroscopy. Knowledge of the normal imaging appearance of the knee after ACL reconstruction can also facilitate recognition of complications and enable surgeons to offer timely intervention. In this article, we provide a comprehensive review of imaging of ACL reconstruction and of its common complications.

ANTERIOR CRUCIATE LIGAMENT RECONSTRUCTION PROCEDURES

The most common methods of ACL reconstruction are the autologous bone-patella tendon-bone graft and the autologous hamstring graft.[1] For the autologous bone-patella tendon-bone graft, the central third of the patellar tendon with bone blocks from the patella and tibial tubercle is harvested. The other graft is formed by harvesting the semitendinosus and gracilis tendons from the musculotendinous junction to the tibial insertion and folding them back on themselves. The graft is then secured within the tunnels in the tibia and femur by interference screws.

FEMORAL AND TIBIAL TUNNEL ANATOMY

Femoral Tunnel

The position of the femoral tunnel is crucial in maintaining graft isometry.[2] The optimal position is at the intersection of the posterior femoral cortex with the roof of intercondylar notch, without breaching the posterior femoral cortical bone. On coronal images, the femoral tunnel should lie above the lateral femoral condyle. If the femoral tunnel is too anterior, the graft will become too tense on flexion and too loose on extension. Conversely, if the femoral tunnel is too posterior, the graft will become excessively long and tense on extension.

Tibial Tunnel

The position of the tibial tunnel is important in preventing impingement of the graft against the roof of the intercondylar notch. The optimal position is parallel and posterior to the Blumensaat line (the line along the roof of intercondylar notch).[3] If the tibial tunnel is located too anteriorly, graft impingement will develop. In contrast, if the tibial tunnel is located too posteriorly, the graft will become too loose and ineffective.

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GRAFT IMAGING CHARACTERISTICS

A normal intact ACL graft should have low signal intensity (Figure 1) on short echo time magnetic resonance imaging (MRI) sequences (eg, T1-weighted or proton density images). Intermediate signal intensity is commonly seen within the graft in the first year after ACL reconstruction, which is postulated to be caused by graft revascularisation and synovialisation.[4]

Figure 1. Intact anterior cruciate ligament graft in a 34-year-old woman. Sagittal (a) and coronal (b) proton density-weighted magnetic resonance images showing homogeneous low signal intensity throughout the anterior cruciate ligament graft.

COMPLICATIONS

The main complications after ACL reconstruction can be divided into two groups based on the clinical presentation: decreased range of movement and increased laxity.[5] The most common complications causing decreased range of movement are graft impingement and arthrofibrosis, and the most common complication causing increased laxity is graft disruption. Other miscellaneous complications include harvest site complications, displacement, malposition and fragmentation of fixation materials, cyst in the fixation tunnel, septic arthritis, and vascular complications.

Graft Impingement

The position of tibial tunnel is the most important factor contributing to graft impingement.[3] The patient having ACL graft impingement is typically presented with decreased range of movement. Radiologically, MRI will show a malpositioned tibial tunnel with the graft bowed and impinged on by the anterior-inferior portion of the intercondylar notch or lateral femoral condyle (Figures 2 and 3). Increased signal intensity can be demonstrated within the distal two-thirds of the graft. If untreated, graft rupture may result. Graft impingement is treated by notchplasty, which comprised of resection of portion of intercondylar notch.

Arthrofibrosis

Arthrofibrosis is another complication causing decreased range of movement after ACL reconstruction. Arthrofibrosis involves development of fibrous scar tissue within and around the synovium. It can be classified into two forms, diffuse and focal. In diffuse form, ill-defined or even mass-like area with low signal intensity surrounding the graft. A specific focal form of arthrofibrosis is located at the anterior part of the intercondylar space, commonly referred as a "cyclops lesion" (Figure 4). Radiologically, a nodule (typically 10-15 mm) of low signal intensity is seen anterior of the graft, near the tibial insertion. It is treated by arthroscopic excision.

Graft Disruption

Graft rupture may happen "spontaneously" due to graft impingement or as a result of injury. Radiologically, increased signal intensity similar to that of fluid, fibre discontinuity, and possibly thinning of the graft are seen on T2-weighted sequences (Figure 5). Secondary signs, including anterior tibial translation and uncovering of posterior horn of lateral meniscus, are sometimes present. ACL re-reconstruction is the treatment of choice.

Figure 2. Anterior cruciate ligament graft impingement in a 34-year-old man. Coronal T1 (a) and coronal short tau inversion recovery (b) magnetic resonance images showing a laterally positioned tibial tunnel, with bowing and impingement on anterior cruciate ligament graft by the lateral femoral condyle. (Courtesy of Dr KF Tam, Department of Radiology, North District Hospital)

Cyst in the Fixation Tunnel

During the first 2 years after ACL reconstruction, a small amount of fluid can accumulate within the tunnels. This is usually a harmless process.[6] However, some of them may progress, with cyst formation and tunnel expansion (Figure 6). The cyst may extend beyond the cortex of the bone, forming a palpable nodule. Depends on the severity, cyst resection may be needed.

Figure 3. Anterior cruciate ligament graft impingement in a 23-year-old man. Coronal T2 fat-saturated magnetic resonance image showing impingement on anterior cruciate ligament graft by the lateral femoral condyle, with increased T2 signal in anterior cruciate ligament graft. (Courtesy of Dr Ryan Lee, Department of Radiology, Prince of Wales Hospital)

Figure 4. Small cyclops lesion in a 24-year-old man. Sagittal T1 magnetic resonance image showing a localised low-signal fibrotic nodular focus (0.7 cm) within the posterior Hoffa's fat pad, consistent with a small cyclops lesion.

CONCLUSION

Given the increasing number of patients undergoing ACL reconstruction, it is salient for radiologists to be

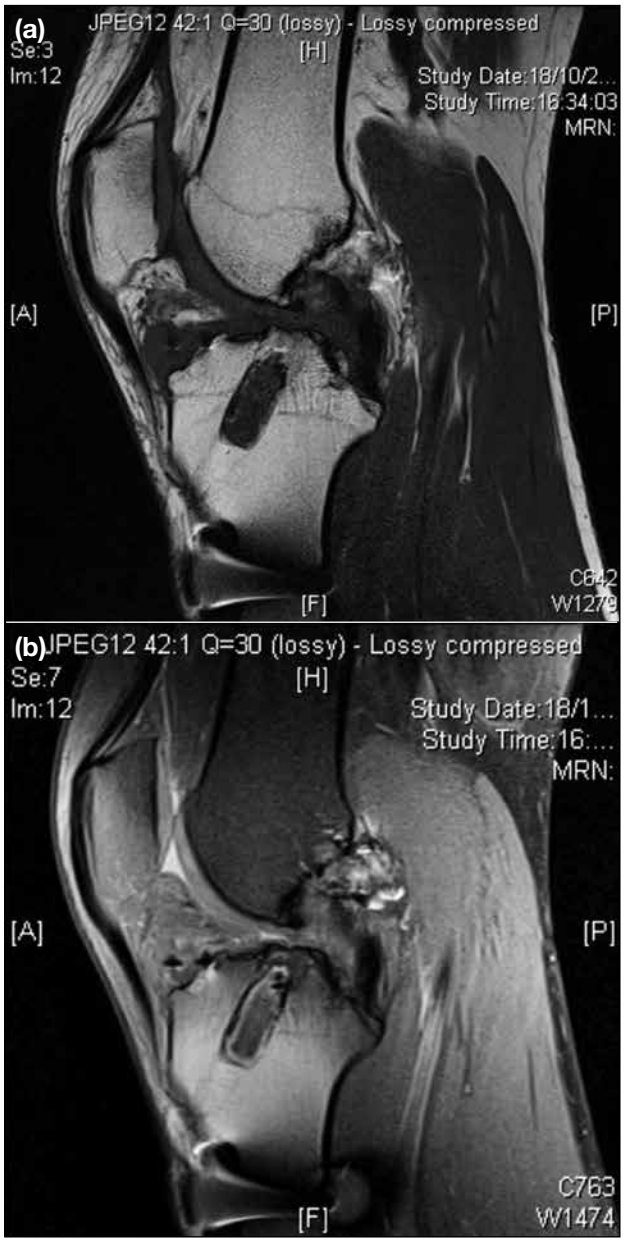

Figure 5. Complete anterior cruciate ligament graft tear in a 37-year-old man. Sagittal T1 (a) and proton density-weighted (b) magnetic resonance images showing discontinuity of fibres of anterior cruciate ligament graft, consistent with complete tear.

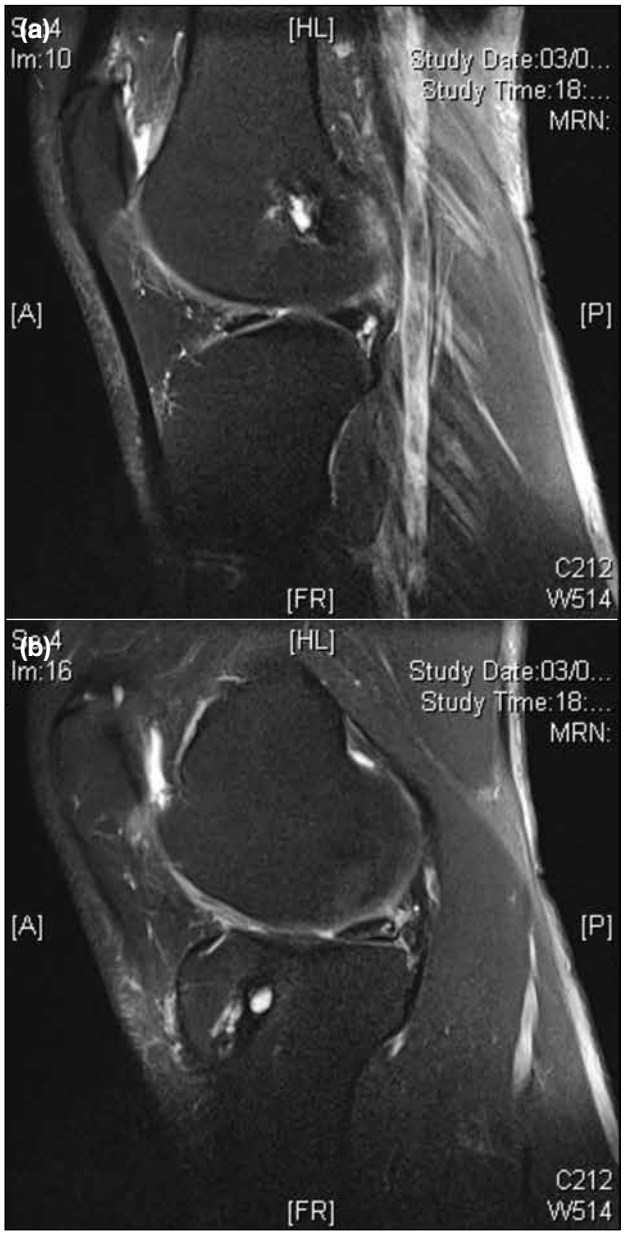

Figure 6. Femoral and tibial tunnel cysts in a 32-year-old man. Sagittal T2 fat-saturation images showing presence of cysts in femoral (a) and tibial (b) tunnels, with mild focal expansion of both tunnels.

familiar with normal MR appearance of knee after ACL reconstruction, as well as the appearance of complications.

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