KNEE: LIGAMENTS AND TENDONS

Course: MRI of Sports Related Injuries

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Highlights

1. In the knee, single ligament injuries can usually be diagnosed accurately with physical examination; the role of MR imaging is typically to identify associated injuries, especially in the menisci and articular cartilage.
2. Posterolateral corner injuries are typically combined with cruciate ligament tears. MR imaging and surgical treatment should address the fibular collateral ligament, popliteus tendon complex, and the biceps femoris tendon.
3. When both cruciate ligaments are torn, there has been a transient knee dislocation requiring evaluation of the neurovascular structures and extensor mechanism.
4. Like other tendons in the body, quadriceps and patellar tendon injuries fall along the tendonopathy/partial tear/complete tear spectrum.
5. In acute patellar dislocations, osteochondral fractures and loose bodies affect management; in recurrent patellar instability the trochlear anatomy, integrity of the medial retinaculum, and insertion site of the patellar tendon influence treatment.

Ligament Injuries

The two cruciate ligaments together with the collateral ligament complexes provide stability for the knee joint. The knee is frequently injured in sports. More than half of the injuries that result in a hemarthrosis are associated with ligament tears. Two-thirds of these cases are isolated ligament injuries, most commonly involving the medial collateral ligament (MCL) or the anterior cruciate ligament (ACL). Physical examination is highly accurate for the diagnosis of an isolated ligament rupture in the knee; MR imaging is performed in these athletes to confirm and stage the ligament injuries, but more importantly to diagnose coexistent meniscal and articular cartilage abnormalities that influence clinical management. However, in knees where more than one ligament is torn, physical examination is less accurate than MR imaging. Imaging plays a particularly important role in posterior cruciate ligament (PCL) tears – which are combined with other ligament injuries 50% of the time – and in injuries to the posterolateral corner (PLC), which almost invariably occur in combination with other ligament tears.

The ACL is composed of two main bundles, and will typically appear striated on MR images. Continuous ligament fibers are normally visible from the femur to the tibia in all three imaging planes, and the fiber orientation should be as steep as or steeper than the roof of the intercondylar notch on sagittal images. Mucoid degeneration may occur with aging, resulting in high-signal intensity material between the otherwise intact ligament fibers. While these degenerated ligaments may be symptomatic, the ligaments are still functional. A diagnosis of ligament rupture should only be made when there is discontinuity of the actual ACL bundle(s), or when no ligament fibers are visible. Bone marrow contusions or impaction fractures are common in the anterolateral femoral condyle and in the posterior tibial plateaus in knees with incompetent ACLs, but the presence of bone infractions is not related to the acuteness or completeness of the ligament injury.

In sports like skiing, approximately 1/3 of knees with ACL tears also have MCL injuries; coexistent meniscal tears (especially in the lateral meniscus) are common when both ligaments are torn. The normal MCL has a superficial portion that extends from the medial femoral epicondyle to the medial tibia, approximately 7 cm below the knee joint line. Above the knee, the anterior MCL has a free edge, while the posterior MCL wraps around the posteromedial corner of the knee forming the posterior oblique ligament. The superficial MCL is best evaluated in the coronal and transverse planes. The deep MCL is a specialized thickening of medial knee joint capsule, closely adherent to the outer aspect of the medial meniscus. Like the superficial MCL, the deep ligament can tear at, above, or below the joint line. While isolated, acute MCL injuries are usually treated nonoperatively, in patients with combined ACL + MCL injuries who have residual medial laxity after reconstruction of the ACL, reconstruction of at least the posterior oblique component may be offered to the patient. MR findings that predict residual MCL laxity in combined injuries include rupture of both the superficial and deep MCL components and a superficial MCL tear that crosses the joint line.

Like the ACL, the normal PCL is visible in the intercondylar notch in all three imaging planes, extending from the femur to the tibia. Partial PCL injuries are more common than complete tears, and in general these heal spontaneously. Isolated complete PCL ruptures are usually managed by reconstruction. Additionally, PCL tears that are combined with PLC injuries will also be reconstructed, but in these cases, outcomes are worse compared to those with isolated injuries.

The PLC is comprised of at least seven structures, but surgery typically only addresses three of them, all of which are visible on MR images. The fibular collateral ligament courses caudally from the lateral femoral epicondyle. Distally, it joins with the distal biceps femoris tendon to form the conjoined ligament, which then inserts on the lateral aspect of the fibular head. These structures should be evaluated for continuity on both the coronal and transverse images. The popliteus muscle belly originates from the posterior cortex of the proximal tibia and sends its tendon superolaterally in an oblique course through the knee joint, first lying peripheral to the posterolateral corner of the lateral meniscus, and then inserting on the lateral femur just deep and distal to the fibular collateral ligament origin. A small ligament that originates on the proximal fibular tip – the popliteofibular ligament – attaches to the popliteus tendon as it enters its hiatus. This ligament, together with the popliteus tendon, forms the popliteus complex, which is visible in all three imaging planes.

The radiologist should specifically look for PLC injuries in all patients with cruciate ligament tears, because combined injuries result in more instability than isolated injuries, and because outcomes after cruciate ligament reconstruction are poor if a torn PLC is not recognized and managed acutely. Important clues to a subtle PLC injury include anteromedial bone bruises in the femur or tibia, and fractures of the fibular head.

Lastly, the radiologist should assume that any knee where both cruciate ligaments are torn, or where three or more ligaments are torn, has suffered a dislocation. The importance here is that knee dislocations may spontaneously reduce and the clinician may not suspect a transient dislocation, especially acutely when swelling prevents a thorough physical examination. Popliteal artery injuries occur in approximately 30% of knee dislocations, and are a surgical emergency. The integrity of the artery needs to be assessed any time a dislocation is suspected. Additionally, injuries to the peripheral nerves and patellar tendon can accompany knee dislocations and be unsuspected clinically, although these injuries do not need to be managed emergently.

Extensor Mechanism (Tendon) Injuries

The patella is a sesamoid bone within the fibers of a common extensor tendon that extends from the quadriceps muscles to the tibial tubercle. The portion of the extensor mechanism tendon below the patella is designated as the patellar tendon. On MR images, the normal patellar tendon has a uniform cross-sectional size, and is 7 mm or less in thickness. The tendon has a sharply defined posterior margin where it abuts Hoffa's fat pad. The normal tendon may not have homogeneous low signal intensity: Longitudinal stripes of higher signal intensity are common and normal. Additionally, artifact from the magic angle phenomenon contributes to bands of increased signal intensity when the tendon is not taut. The quadriceps consists of four tendons arranged into three layers, with the vastus medialis and lateralis tendons fusing to form a middle layer, deep to the rectus femoris tendon and superficial to the tendon of the vastus intermedius. The total thickness of the layered tendon should be 1-2 mm thicker than the patellar tendon, and like the patellar tendon, the thickness should be uniform and the margins sharp throughout its course. Stripes of fat or synovium are usually visible between the three layers.

Repetitive eccentric loading without adequate rest and recovery results in chronic tendon degeneration (tendonopathy). Tendonopathy of the extensor mechanism is especially common in jumping sports like basketball and volleyball. The hallmarks of tendonopathy on MR images are enlargement of the tendon, which can either be focal or diffuse, and indistinctness of the tendon margins. Tendon enlargement correlates to ischemic degeneration histologically. Often, ischemic disease will be accompanied by areas of myxoid degeneration, which show higher signal intensity than normal tendon on MR images. However, the signal intensity of degenerated tendon should not be as bright as fluid on water-sensitive (T2-weighted or STIR) sequences, and will not disrupt the contour of the tendon. In the knee, tendonopathy most frequently involves the proximal patellar tendon (where it is referred to as "jumper's knee") and in the distal quadriceps tendons. Tendonopathy may be painful or clinically silent. Nevertheless, tendonopathy is the major risk factor for tendon rupture. Normal tendons can avulse from their bone attachments or can be lacerated by an open injury with a sharp object, but will not rupture. Thus in every instance of a partial or full-thickness tendon tear, MR imaging should demonstrate evidence of underlying tendonopathy.

On MR images, a tendon tear will demonstrate macroscopic disruption of some or all of the tendon fibers. For partial tears that are completely within the tendon substance, the internal tendon signal should equal that of fluid. When a complete tear is present, the radiologist should indicate the size of the tendon gap, estimate the degree of underlying tendonopathy, and comment on the presence or absence of muscle atrophy. For tears of the quadriceps tendon, it is often necessary to place an RF coil above the knee and make axial images through the distal thigh to trace each of the four component tendons.

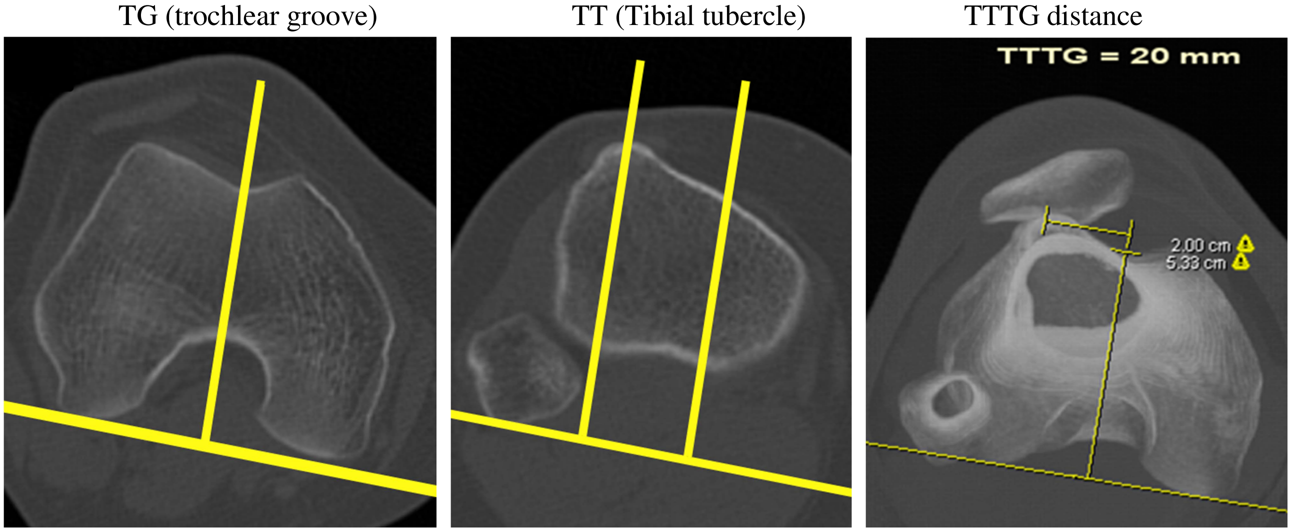
The static and dynamic restraints of the patellofemoral joint are also part of the extensor mechanism. Lateral dislocation of the patella is a common sports injury. The diagnosis may not be appreciated clinically because many injuries are transient and spontaneously reduce, leaving the patient with a large effusion and pain, which mimics other injuries like ACL tears. The role of MR imaging differs in the evaluation of acute and recurrent patellar dislocations, but in both scenarios the radiologist should concentrate on findings that will influence management.

The best clues that a patient has had a recent lateral patellar dislocation-relocation injury are bone contusions or fractures involving the anterior, outer aspect of the lateral femoral condyle and/or the inferomedial patella. These occur when the two bones strike each other, during either patellar dislocation or reduction. The knee will typically also show a large hemarthrosis.

Initial patellar dislocations are treated conservatively with rest, pain medications, and quadriceps muscle strengthening. Surgery may be indicated for patients with an accompanying lesion of the cruciate ligaments or menisci. Arthroscopy is also indicated when the initial dislocation produces an unstable chondral or osteochondral fracture, especially with a displaced fragment in the joint. These injuries can originate from either the patella or trochlea, from the same locations as typical bone contusions. Most injuries include a portion of the bone cortex and so the displaced fragment (which is often located in the infrapatellar joint space) will be visible radiographically. However, radiographs underestimate the size of displaced fragments because they are mostly cartilaginous. The size of the fragment(s) and their donor site(s) will influence the decision of whether to repair or simply resect them.

For patients with recurrent patellar dislocations, surgical treatment should address any predisposing anatomic factors. The radiologist should specifically image and comment on these issues. Hypoplasia of the superior trochlea is easiest to appreciate on lateral radiographs. Merchant and other axial projections only show one portion of the trochlea, and not the superior aspect that may be affected in isolation. The trochlear depth should be assessed qualitatively on transverse MR images through the upper trochlear cartilage. Unfortunately, effective surgical treatments for trochlear hypoplasia are lacking. Soft tissue repair or reconstruction is effective for incompetent medial retinacular structures. The most important component of the retinaculum is the medial patellofemoral ligament (MPFL), which is the first structure visible on transverse images caudal to the vastus medialis obliquus muscle. The MPFL should normally attach anteriorly to the medial patella and posteriorly, to the fibers of the medial collateral ligament. Tears can occur in the mid substance of the ligament or at either insertion. Lastly, distal realignment procedures can help patients whose patellar tendon inserts in a relatively lateral position. This is best assessed using the tibial tubercle-trochlear groove (TTTG) measurement, as illustrated. Knees with TTTG values greater than 20 mm usually require some type of tibial tubercle transfer osteotomy. Measurements between 15 and 20 mm are considered borderline, while those less than 15 mm probably indicate that distal patellar tendon realignment will not be of great benefit.

TG (trochlear groove) TT (Tibial tubercle) TTTG distance



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