Meniscal Tears
-linear increased signal extending to an articular surface is the hallmark of a tear
-tears of the medial and lateral menisci should be characterized with regard to the morphology and extent of the tears
-careful assessment of the meniscal tear morphology in all 3 planes of imaging is key to detect radial tears of the free edge or displaced fragments of meniscal tissue
-the morphology and extent of meniscal tearing on MRI predicts tear stability
-radial tears begin at the free edge and interrupt the circumferential hoop fibers of the meniscus resulting in meniscal dysfunction with load transfer to the adjacent articular cartilage and subchondral cancellous bone
-chondral defects, joint space narrowing, and osteoarthritis result from meniscal dysfunction and progressive axial malalignment of the tibial and femur
-stress fractures with surrounding bone marrow edema are most commonly seen in the medial femoral condyle and medial tibia secondary to radial or complex tears of the medial meniscus; the bone within the subchondral fracture is at risk to develop osteonecrosis therefore a follow-up MRI is typically useful in this setting to ensure fracture healing and exclude osteonecrosis
-radial tears of the posterior horn of the medial meniscus may occur at the posterior margin of the medial tibial spine near the posterior medial meniscal root attachment; these tears may be missed at arthroscopy due to difficult access to this region of the knee from standard viewing portals
-radial tears and displaced flap tears of the posterior horn of the lateral meniscus may occur at the posterior margin of the lateral tibial spine near the posterior lateral meniscal root attachment; these tears may also be missed at arthroscopy due to difficult access to this region of the knee from standard viewing portals; displaced lateral meniscal flap tears in this area are highly associated with tears of the anterior cruciate ligament
-radial and complex meniscal tears as well as bone marrow edema are more commonly seen in painful acutely symptomatic knees when compared with the asymptomatic opposite knee; horizontal meniscal tears and osteoarthritis are present in a similar percentage of asymptomatic opposite knees

Chondral Defects
-articular cartilage consists of a thin superficial layer of decreased signal, an intermediate layer of increased signal, and a thick deep layer of decreased signal on MRI
-angle dependent signal (the magic angle phenomenon) influences the signal within articular cartilage as in others tissues with parallel collagen fibers
-chondral softening may be characterized by a geographic region of decreased signal; this finding is commonly seen in the central trochlea
- Chondral defects are characterized by fluid replacing the articular cartilage; gas, meniscal tissue, or fat from an adjacent fat pad may occasionally extend into a chondral defect rather than fluid, making the defect less conspicuous.
- Chondral flaps, loose bodies, and fissures are detected by careful observation of the chondral surfaces with MRI.
- Tissues that are perpendicular to the surface of the joint are typically stable whereas chondral fissures that are parallel to the joint surface are unstable and may result in displaced chondral flap lesions.
- Articular cartilage can heal with repair tissue that is a mixture of hyaline articular cartilage and fibrocartilage after a successful microfracture procedure or autologous chondrocyte implantation (ACI) procedure or simply after an osteotomy of the knee to correct alignment.
- MRI is useful for evaluating the success of various chondral resurfacing procedures.

ACL Tears

MR imaging can be used to accurately diagnose ACL tears and has been the standard imaging technique in clinical practice for about the last 20 years. The information provided by MR imaging can help establish the anatomic diagnosis of a complete ligament rupture or may identify a less severe degree of sprain injury. MR imaging can also help determine if there has been an acute ACL rupture versus a chronic ACL deficiency based on the morphology of the ligament. Rupture of the ACL is a common sports-related injury that is usually a straightforward diagnosis with MR imaging. The ACL is composed of anteromedial and posterolateral bundles that reciprocally tighten in flexion and extension. The anatomy of these bundles is well seen with MR imaging. Although an acute, complete rupture is the most commonly encountered situation in clinical practice, partial tears and lesser degrees of ACL sprain injury may occur and may preferentially involve either the anteromedial or the posterolateral bundle. The mid-proximal fibers of the ACL most commonly rupture leading to a proximal stump of the ligament on the femur, posterior sloping of the distal fibers on the sagittal MR images, and a fluid filled gap at the site of the tear.

Axial, sagittal, and coronal images are all necessary to evaluate the status of the ACL due to the oblique course of the ligament through the intercondylar notch. The axial and coronal planes are especially useful for differentiating femoral avulsion of the ACL and lesser degrees of sprain injury from the more typical midsubstance rupture. Coronal and sagittal images are useful for detecting an avulsion fracture of the tibial attachment of the ACL that is most commonly seen in skeletally immature patients. Evaluation of the ACL in all three planes also facilitates detection of scarring of the ligament fibers due to previous injury that may be quite subtle when only looking at the ACL on the sagittal images. As with other ligament injuries, ACL injury is followed by a healing response with thickening and scarring of the ligament fibers. Ligament healing is characterized on MR imaging by a gradual resolution of ligament edema with the development of ligament thickening and poor definition of the fiber bundles that is variable in extent. The torn ACL fibers may also atrophy and resorb or they may scar to the PCL or to the
intercondylar notch in an area inferior to the normal femoral attachment site resulting in more severe degrees of ligament dysfunction.

A ganglion cyst of the ACL may be confused with rupture of the ACL on MR imaging. A ganglion cyst of the ACL may develop after an acute injury and may be seen in association with scarring of the ligament fibers. An ACL ganglion cyst is characterized on MR imaging by a septated, lobulated fluid collection along the margins of the ligament as well as more poorly defined fluid or intermediate signal synovial thickening that peripherally displaces the ligament fibers. The ligament fibers remain in continuity and typically appear either taut or mildly lax on the sagittal images. An intraosseous component of the ganglion cyst with surrounding reactive bone marrow edema at the ACL attachment sites is another common associated finding that helps in differentiating an ACL ganglion cyst from the much more commonly encountered acute rupture of the ACL. A component of the ganglion cyst may sometimes be seen extending into the anterior root attachment and anterior horn of the lateral meniscus.

Lateral bone contusions often accompany acute injuries of the ACL. These contusions are caused by impaction of the anterior aspect of the lateral femoral condyle with the posterior aspect of the lateral tibial plateau that occurs when the ACL ruptures. Anterior subluxation of the lateral tibial condyle relative to the lateral femoral condyle occurs at the time of injury and explains the location of these bone contusions; moreover, anterior tibial translation relative to the lateral femoral condyle can be observed on sagittal MR images as a sign of ACL insufficiency. Anterior tibial translation and other secondary signs may be helpful in prompting a more careful analysis of ACL morphology, especially when a chronically torn ACL has scarred to the PCL or the femur and is not obviously disrupted or sloping posteriorly on the sagittal images.

**PCL Tears**

PCL injuries are less common than ACL injuries. Midsubstance rupture of the PCL as well as proximal and distal avulsions of the ligament from the tibia and the femur may occur and are well seen with MR imaging. Scarring of the PCL from prior injury is characterized by a lax appearance of the ligament on sagittal images as well as a thickening of the ligament fibers without edema. Ganglion cysts of the PCL are less common than ganglion cysts of the ACL but have a similar appearance.

The PCL is composed of anterolateral and posteromedial bundles that reciprocally tighten in flexion and extension. The posteromedial bundle is relatively tight in extension and the anterolateral bundle is relatively tight in flexion. Isolated posteromedial bundle tears may be seen on MR imaging as a consequence of hyperextension injury to the knee. Less severe hyperextension injuries of the knee may injure the physiologically taut fibers of the posteromedial bundle of the PCL prior to fully tearing the entire PCL.

When combined rupture of both the ACL and the PCL along with collateral ligament injury is identified with MR imaging, the possibility of knee dislocation and associated dissection of the popliteal artery should be considered. An intraluminal flap or thrombus in the popliteal artery may occasionally be detected on the routine MR
MR angiography may be performed after the standard MR study of the knee without moving the patient and is more accurate than the routine images for detecting injuries of the popliteal artery.

**Other Ligament Injuries**

Sprains of the MCL are also common sports-related injuries. The mid-proximal fibers of the MCL are typically torn. Patients with this injury do well with conservative treatment. Thickening and scarring of the mid-proximal MCL is a very common finding on MRI reflecting the frequency of this injury that is typically treated without surgery. Less commonly, the MCL may completely avulse from the medial epicondyle of the femur proximally or its tibial attachment distally. Distal MCL tears may occasionally be displaced superficial to the pes anserinus tendons and may therefore not heal well without surgery, analogous to a Stener lesion in the thumb.

MCL injuries are best evaluated with axial and coronal T2-weighted images. The axial plane is useful for distinguishing MCL injury from sprains of the medial patellar retinaculum. The medial retinaculum and medial patellofemoral ligament are typically injured during lateral patellar dislocation. Contusions of the anterolateral, nonarticular portion of the lateral femoral condyle and the medial pole of the patella on MR imaging are important clues to the diagnosis of a recent lateral patellar dislocation. This injury is not suspected clinically in 50-90% of cases. Transient lateral patellar dislocation is often complicated by chondral fractures in the patellofemoral compartment that are detectable with good technique and careful inspection on MR imaging.

Isolated LCL tears are unusual and are typically associated with either cruciate ligament injuries or tears of other lateral structures such as the iliotibial band, the biceps femoris tendon, the popliteus tendon, the popliteofibular ligament, or the arcuate ligament. These posterolateral corner injuries as well as posteromedial corner injuries that may involve the posterior oblique ligament and semimembranosus tendon can be characterized with MR imaging.

**Tendinopathies**

Direct trauma or sudden overload of the extensor mechanism may result in quadriceps muscle strain, rupture of either the quadriceps tendon or the patellar tendon, or fracture of either the patella or tibial tuberosity. Repetitive overload of the extensor mechanism is more common and typically results in tendinosis and partial tearing of the patellar tendon (jumper's knee). MR imaging typically reveals abnormal signal and thickening of the deep, superior fibers of the patellar tendon adjacent to the inferior pole of the patella. Although this condition is typically treated conservatively, surgical debridement may be quite effective in athletes with focal nodules of tendinosis and mucoid degeneration. Localized edema is commonly seen in the superolateral aspect of Hoffa’s fat pad related to contusion or impingement of the fat between the patellar tendon and the lateral margin of the femoral trochlea. Localized edema is less commonly seen in the suprapatellar fat pad deep to the distal quadriceps tendon as a sign of inflammation in association with quadriceps tendinosis.

MR imaging may be useful in other sports-related overuse conditions such as the iliotibial band friction syndrome. There is typically edema in the fat between the iliotibial band and the lateral femoral condyle with a normal iliotibial band however there is
occasional thickening or signal abnormality of the iliotibial band seen in severe cases of iliotibial band friction syndrome. Thickening of either a medial patellar plica or a suprapatellar or infrapatellar plica is commonly seen on MR imaging and may be associated with patellofemoral compartment chondromalacia and anterior knee pain.

REFERENCES


