Anatomy of the posterolateral corner of the knee on MRI: Normal and Abnormal

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Abstract

Background: Specific components of the posterolateral corner that can be identified on MRI, albeit with some variability, are the biceps femoris tendon, the fibular collateral ligament, the popliteus musculotendinous complex including the popliteofibular ligament, the fabellofibular ligament, and the arcuate ligament. In general, these normally low-signal-intensity structures are defined as "sprain" when there is thickening and intermediate signal intensity within the structure on fat-suppressed fast spin-echo T2-weighted images and as torn when the structure is discontinuous with a visible gap. Some researchers support the use of a coronal oblique plane of imaging to improve visualization of some of the finer, obliquely oriented structures of the posterolateral corner, including the popliteofibular, arcuate, and fabellofibular ligaments, although this has not become routine. Recognition of bone marrow changes in thefibular head, including the so called “arcuate” fracture that may also be seen on radiographs is also helpful in diagnosing posterolateral corner injury. Being aware of the normal and abnormal MRI appearances of the structures of the posterolateral corner of the knee and of the patterns of injury often seen in patients with posterolateral corner rotatory instability will help radiologists suggest the diagnosis of posterolateral corner injury even when not clinically suspected. This diagnosis is especially important in the setting of combined injuries because unrecognized and unaddressed posterolateral corner injuries may contribute significantly to ACL and PCL graft failure.

Keywords: posterolateral corner, Knee,MRI

DOI Number: 10.14704/nq.2022.20.8.NQ44740 **NeuroQuantology 2022; 20(8): 7176:7182**

Introduction

Specific components of the posterolateral corner that can be identified on MRI, albeit with some variability, are the biceps femoris tendon, the fibular collateral ligament, the popliteus musculotendinous complex including the popliteofibular ligament, the fabellofibular ligament, and the arcuate ligament. In general, these normally low-signal-intensity structures are defined as "sprain" when there is thickening and intermediate signal intensity within the structure on fat-suppressed fast spin-echo T2-weighted images and as torn when the structure is discontinuous with a visible gap.. Some researchers support the use of a coronal oblique plane of imaging to improve visualization of some of the finer, obliquely oriented structures of the posterolateral corner, including the popliteofibular, arcuate, and fabellofibular ligaments, although this has not become routine. Recognition of bone marrow changes in thefibular head, including the so called “arcuate” fracture that may also be seen on radiographs is also helpful in diagnosing posterolateral corner injury **(1).**

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***e*ISSN** 1303-5150

The Fibular Collateral Ligament and Biceps Femoris Tendon:

The fibular collateral, or true lateral collateral, ligament originates from a small bone depression just posterior to the lateral femoral epicondyle and just anterior to the femoral attachment of the lateral head of the gastrocnemius tendon and extends distally and posteriorly over an oblique course to insert on the lateral aspect of the fibular head, anterior and distal to the tip of the fibular styloid process. ***(2)***

It is visualized on axial, sagittal, and coronal imaging planes as a low-signal-intensity structure extending from the lateral aspect of the distal femur to the proximal fibula. Just before its insertion, the fibular collateral ligament often joins the distal biceps femoris tendon to form a conjoined structure. ***(3).***

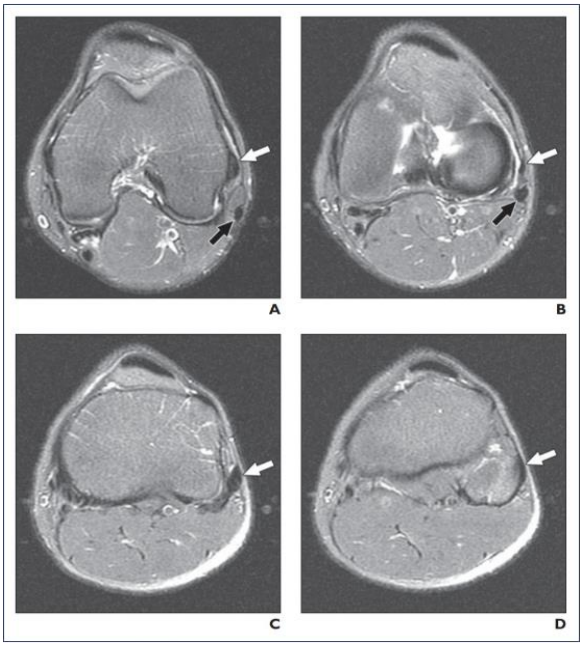

Figure (1): Normal fibular collateral ligament in 21-year-old woman. A, B, CD; Consecutive axial fat-suppressed fast spin-echo T2-weighted images (TR/TE, 4,000/49) show normal appearance of fibular collateral ligament (white arrows, A and B). Distally, fibular collateral ligament often joins with biceps femoris tendon (black arrows, A and B) to form conjoined structure that inserts on lateral aspect of fibular head (white arrows, C and D). ***(3)***

The long and short heads of the biceps femoris tendon typically join above the knee and course distally to insert predominantly onto the fibular head. Although both the long and short heads of the biceps femoris tendon have multiple tendinous and fascial components, not all of these components are consistently visible as separate structures on MRI. ***(4).***

The direct and anterior tendinous arms of the long head of the biceps femoris attach to the anterior and posterolateral aspects of the fibular head, and the direct arm of the short head of the biceps femoris tendon attaches to the more anteromedial aspect of the fibular head, with the anterior arm of the short head attaching along the superolateral edge of the lateral tibia. ***(4)***

On MRI, the insertions of the direct arms of the short and long heads are often seenas a single low-signal-intensity structure oncoronal T2-weighted images, and as mentioned earlier, the biceps femoris tendon is often joined by the fibular collateral ligament just above their insertions to form a conjoined insertion. Injuries to the biceps femoris tendon are often seen in conjunction with posterolateral corner injuries; include myotendinous junction tears above the level of the knee and softtissue or bone avulsion from the fibular head; and are best shown on coronal and axial MR images ***(3).***

The Popliteus Musculotendinous Complex and Popliteofibular Ligament:

The popliteus muscle is a major dynamic stabilizer of the lateral knee and arises from the posterior medial proximal tibia, extending superiorly and laterally to form a tendon that continues into the joint through the popliteal hiatus, deep in relation to the fabellofibular and arcuate ligaments.The popliteus tendon has a major insertion at the anterior aspect of the popliteal sulcus of the lateral femoral

condyle, anterior and inferior to the femoral origin of the fibular collateral ligament. ***(5).***

The popliteus tendon also sends fibers to insert on the posterior horn of the lateral meniscus (anteroinferior, posterosuperior, and posteroinferior popliteomeniscal fascicles) that form a strong attachment to the posterior horn lateral meniscus around the popliteal hiatus and prevent the lateral meniscus from excessive forward displacement during knee extension. ***(6)***

The popliteus tendon and muscle are best seen on axial and coronal images as low and intermediate-signal-intensity structures, respectively. Although avulsions at the femoral insertion may occur, injuries of the popliteus muscle and tendon usually involve the muscle belly or musculotendinous junction. Because this area is a challenge for the arthroscopist to view, the radiologist plays a key role in making this diagnosis. Strain of the musculotendinous junction appear as amorphous increased signal intensity within the tendon and muscle. Disruption of fibers, enlargement of the muscle belly, or both may be present. ***(5).***

The Lateral Head of the Gastrocnemius Tendon and the Fabellofibular Ligament:

The tendon of the lateral head gastrocnemius is located at the far lateral aspect of the lateral gastrocnemius muscle-tendon unit, and injuries to this structure are rare. The fabella is a variably present sesamoid bone in the lateral head gastrocnemius tendon, and the fabellofibular ligament is also variably present, found in approximately 40% of knees in two anatomic studiesand identified on approximately one third of MRI examinations in one study. ***(7).***

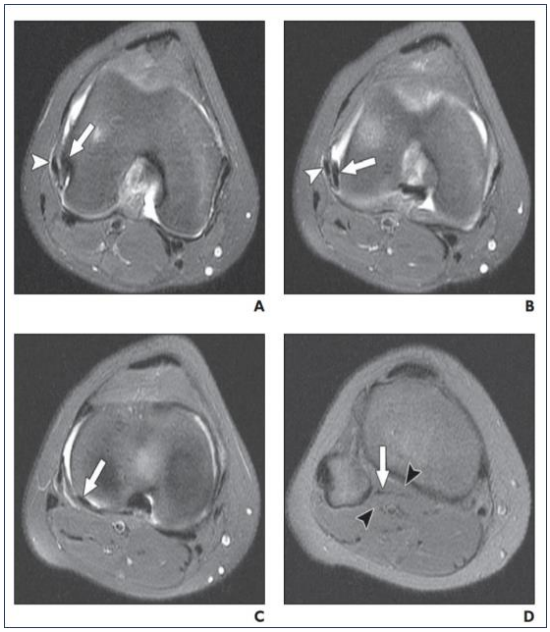

Figure (2): Normal popliteus tendon and muscle in 15-year-old girl. A, B, C, D; Axial fat-suppressed fast spin-echo T2-weighted images (TR/TE, 3,750/46) show normal appearance of popliteus tendon (arrows) and muscle belly (black arrowheads, D) and relationship between popliteus tendon and fibular collateral ligament (white arrowheads, A and B). ***(5).***

The Arcuate Ligament:

The arcuate ligament is a variably present Y-shaped structure with medial and lateral limbs, both of which insert distally at the apex of the fibular styloid process just anterior to the fabellofibular ligament. Several anatomic series have reported the presence of at least one of the limbs as between 47.9% and 71% of knees. The lateral, or upright, limb extends superiorly along the joint capsule to the lateral femoral condyle, and the medial, or arcuate, limb extends superomedially, over the popliteus muscle, to merge with the posterior capsule. ***(2)***

The arcuate ligament is, in general, difficult to visualize on MRI. However, it can be thought of as a thickening of the posterolateral capsule, a portion of which forms the bowed roof of the popliteal hiatus and can be seen as a low-signal structure on axial images. Inspection of the posterolateral joint capsule on axial MR images at the level of the joint

line may revealgross disruption, implying injury to or a tear of the arcuate ligament. The medial limb occasionally can be visualized immediately posterior to the popliteus tendon, just below the level of the popliteal hiatus,on sagittal images. ***(8)***

Some authors advocate the use of a coronal oblique imaging plane to improve visualization of this ligament complex, with visualization using that plane in 46% of patients in one series. Some studies have noted an association between posterolateral corner injuries and a lack of significant joint effusion on MRI; this association is thought to be due to the presence of disruption of the posterior lateral joint capsule. ***(2)***

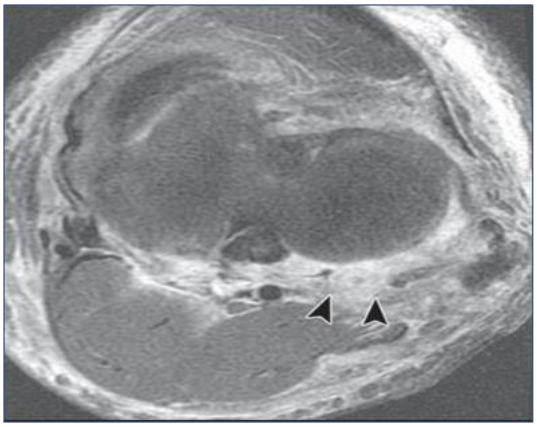

Figure (3): Torn arcuate ligament in 53-year-old man. Axial fat-suppressed fast spin-echo T2-weighted image (TR/TE, 4,000/49) shows tear of posterolateral joint capsule (arrowheads) at level of joint, which is consistent with arcuate ligament tear. ***(2).***

The "Arcuate" Fracture:

The popliteofibular, fabellofibular, and arcuate ligaments attach distally to the fibular styloid process. An avulsion fracture of this styloid process, the so-called "arcuate" sign, often indicates injury to one or more of these ligaments and thus to the posterolateral corner. This fracture may be seen on anteroposterior or lateral knee radiographs as a small, displaced bone fragment. ***(9).***

On MRI, the fracture fragment may be more difficult to identify. The term "arcuate" sign has also been applied to larger avulsion fractures of the fibular head in the region of the conjoined structure insertion. Even in cases without an evident fracture, MRI may reveal edema either localized to the fibular styloid process, suggesting injury to the popliteofibular, fabellofibular, or arcuate ligament, or more diffuse edema in the lateral aspect of the fibular head, suggesting injury to the fibular collateral ligament, biceps femoris tendon, or both. ***(9).***

Figure (4): Arcuate fracture in 55-year-old man. Sagittal fat-suppressed fast spin-echo T2-weighted image (TR/TE, 4,000/75) depicts avulsion fracture of fibular styloid process (arrow), which is also called "arcuate" fracture. ***(9)***

Anterior Medial Tibial Margin Fracture:

Fractures of the peripheral anteromedial tibial plateau have also been described tooccur in the setting of posterolateral corner injury. One study detected this relatively uncommon fracture in six of 16 knees with clinical and MRI evidence of posterolateral corner injury. In two of these cases, the fracture resulted from hyperextension with forced varus angulation, and in the remaining four, the fracture resulted from a direct blow to the anteromedial tibia with the knee flexed. ***(10)***

A mechanism of varus rotation and posterior tibial translation results in disruption of both the posterolateral corner and PCL and allows the anterior medial femoral condyle to impinge on the anteromedial tibial plateau, resulting in fracture of the anteromedial tibial rim. Given its association with posterolateral corner injuries, an anteromedial tibial plateau fracture seen on either radiography or MRI should prompt close clinical and imaging evaluations of the posterolateral corner structures. ***(11)***

Bone Marrow Contusion:

MRI fluid-sensitive sequences are superb in detecting bone marrow contusions. In one series of six patients with acute posterolateral knee injuries, a characteristic bone marrow contusion on the anteromedial femoral condyle was seen in the five patients with complete posterolateral complex disruption. This contusion is best seen as increased signal intensity in the subchondral bone marrow of the weight-bearing surface of the anterior aspect of the medial femoral condyle on sagittal T2-weighted images and is thought to be due to a hyperextension varus type of injury. ***(3).***

Figure (5): Medial femoral condyle contusion in 48-year-old man. Sagittal fat-suppressed fast spin-echo T2-weighted image (TR/TE, 3,750/69) shows increased signal intensity within bone marrow of anterior aspect of medial femoral condyle (arrowheads), consistent with hyperextension varus contusion. ***(3)***

Significance of MRI in injuries of the posterolateral corner of the knee:

Being aware of the normal and abnormal MRI appearances of the structures of the posterolateral corner of the knee and of the patterns of injury often seen in patients with posterolateral corner rotatory instability will help radiologists suggest the diagnosis of posterolateral corner injury even when not clinically suspected. ***(12)***

Although we may not be able to accurately define when instability exists with imaging alone, available data indicate that tears of two or more of the posterolateral structuresmost importantly, the fibular collateral ligament, the popliteus musculotendinous unit including the popliteofibular ligament, and the posterolateral joint capsulesuggest the diagnosis of a high-grade posterolateral corner injury and should direct the orthopedic surgeon to carefully examine for posterolateral corner rotatory instability in the pre- or perioperative setting because urgent repair or reconstruction is associated with better functional outcomes ***(12)***

This diagnosis is especially important in the setting of combined injuries because unrecognized and unaddressed posterolateral corner injuries may contribute significantly to ACL and PCL graft failure. Unrecognized and untreated high-grade posterolateral corner injuries have also been shown to lead to significant posttraumatic osteoarthritis in the affected knee. Conversely, injury to only one of the posterolateral structures supports the presence of a grade I or II injury, which, depending onthe presence of associated injuries, can often be successfully treated nonsurgically. ***(12)***

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***e*ISSN** 1303-5150