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Anatomy and Biomechanics of the Posterior Cruciate Ligament and Posterolateral Corner

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The knowledge and understanding of the anatomy and biomechanical function of the posterior cruciate ligament (PCL) and posterolateral corner (PLC) of the knee is vitally important when evaluating injury and considering reconstruction. The PCL and the PLC both have important roles to play in the stability of the knee. Through numerous experimental designs, the biomechanical roles of the PCL and PLC have been clarified. The PCL's most well-defined role is as a primary restraint and stabilizer to posterior stress. It appears that this role is greatest at higher degrees of knee flexion. The natural history of a PCL deficiency leads to increased contact pressures and degeneration of both the medial and patellofemoral compartments. The PLC is a restraint to posterior translation, posterolateral rotation, external rotation, and varus loads. It is important to recognize a PLC injury before cruciate ligament reconstruction, as a failure to diagnose may lead to subsequent graft rupture. Poor surgical outcomes after PCL reconstruction have been attributed to many factors, the most common of which include the following: additional intra-articular pathology, poor fixation methods, insufficient knowledge of PCL or PLC anatomy leading to improper tunnel placement, and poor surgical candidates. In this article, we attempt to provide a framework for understanding the anatomy and biomechanics of the PCL and PLC and their surgical implications.

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Overview

The knowledge and understanding of the complex anatomy and biomechanical function of the native posterior cruciate ligament (PCL) and the posterolateral corner (PLC) is vitally important when evaluating a knee injury and considering reconstruction.[1] As injuries to the PLC are not as frequent as those to the cruciate ligaments or medial structures of the knee, there is often a delay in diagnosis. However, PLC injuries typically occur in combination with either one or both cruciate ligaments, but isolated injuries to the PLC do occur. DeLee et al[2] found that only 12 of 735 (1.6%) knees undergoing ligamentous treatment were due to isolated PLC injury. If left untreated, PLC injuries can lead to residual symptoms of instability, articular cartilage degeneration, and failure of cruciate ligament reconstructions.[3,4] This article serves as a foundation for understanding the complex anatomy and biomechanics of the PCL and PLC, which can help aid in diagnosis and treatment.

Anatomy

We first describe the gross and microscopic anatomy of the PCL, and then describe each component of the PLC. The main components of the PLC include the iliotibial tract, biceps femoris, lateral collateral ligament (LCL), popliteus muscle-tendon complex (PMTC), popliteofibular ligament (PFL), fabellofibular ligament, and the arcuate ligament. Other

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smaller contributors include the popliteotibial fascicle, popliteomeniscal fascicles, middle third of the lateral capsular ligament, posterior horn of lateral meniscus, coronary ligament, and the posterolateral part of the joint capsule. In an effort to categorize these structures, Seebacher et al[5] divided the lateral structures of the knee into 3 layers, from superficial to deep. Layer I contains the iliotibial tract and the superficial biceps femoris. Layer II contains the quadriceps retinaculum anteriorly and the patellofemoral ligament posteriorly. Layer III being the deepest and most important is further divided into superficial and deep lamina by the lateral geniculate artery running between the 2 layers. The superficial lamina includes the LCL and the fabellofibular ligament and the deep lamina contains the coronary ligament, popliteus tendon, PFL, capsule, and the arcuate ligament.[5]

Posterior Cruciate Ligament

The PCL is named because of its insertion on the posterior aspect of the proximal tibia, and is the largest of the intra-articular ligaments. The PCL originates from a broad, concave, semicircular area along the medial femoral condyle within the intracondylar notch. The PCL inserts into a depression known as the posterior intercondyloid fossa or the PCL fossa, just inferior to joint line, between the 2 tibial plateaus, and posterior to the tibial spine (Fig. 1).[6] The PCL consists of longitudinally oriented collagen fibers, which is narrowest in its middle portion and fans out superiorly and to a lesser extent inferiorly.[7] The fibers of the PCL attach to the femoral footprint in a lateral to medial orientation and to the tibial footprint in an anterior to posterior orientation. Average length of the PCL is 38 mm and the average width within the middle portion is 11 mm.[1,7,8] The PCL has a wide variation in shape and size of its femoral attachments, towing to variation in intercondylar notch sizes, whereas the tibial attachment's size and shape are more consistent.[9] The substance of the ligament is made up of 2 distinct but inseparable bundles, which allow for resistance of

Figure 1 Sagittal view MRI illustrating the PCL ligament. MRI, magnetic resonance imaging. (Color version of figure is available online.)

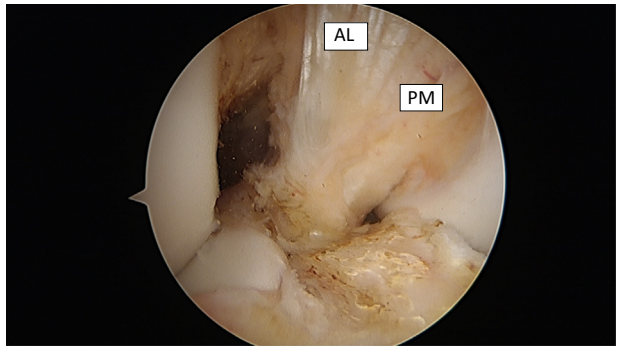

Figure 2 Arthroscopic photograph depicting the anterolateral bundle (AL) and posteromedial bundle (PM) of the PCL in an ACL-deficient knee at 90° of knee flexion. The AL bundle is steeper (more vertical) and tighter in flexion, as demonstrated here. (Color version of figure is available online.)

posterior translation in both extension and flexion. The bundles are named by their position within the femoral footprint or attachment: anterolateral bundle and posteromedial bundle (Fig. 2). To help identify these bundles during dissection or arthroscopy, other anatomical landmarks have been identified.

On the femoral side, the medial intercondylar ridge defines the proximal limit of the insertion of the PCL, whereas the medial bifurcate ridge separates the insertion sites of the 2 bundles[10] (Fig. 3B). There is a change in slope as each bundle approaches the femoral insertion site, putting the bundles in different planes when the knee is flexed. The PCL footprint on the femur is made up of approximately 55% anterolateral bundle and 45% posteromedial bundle. The mean distance between the centers of the anterolateral and posteromedial bundles on the femur is 12.1 mm. The distal margins of the anterolateral and posteromedial bundles are a mean of 1.5 and 5.8 mm proximal to the notch articular cartilage, respectively.[11] Although the femoral footprint size is nearly equal between the 2 bundles, the anterolateral bundle's cross sectional area is significantly larger than the posteromedial bundle. The PCL is stronger than the medial collateral and anterior cruciate ligaments (ACLs), with the anterolateral bundle providing the major contribution to the PCL strength.[12]

The tibial insertions of the anterolateral and posteromedial bundle occur within the PCL fossa that is trapezoidal in shape and becomes wider inferiorly (Fig. 3A). The anterolateral bundle is attached at the superolateral aspect of the footprint and the posteromedial bundle is seen in the inferomedial portion of the fossa. Identification of each bundle is made easier with each bundle attachment having separate slopes. Across 21 knees, this change in slope angle was found to be an average of 14.5°.[13] Also, an extensive portion of the posteromedial bundle is below the posterior part of the tibial rim, whereas none of the anterolateral bundle attachment is below the tibial rim. The superolateral and superomedial corners of the footprint were both represented by depressions, and a reproducible ridge represented the inferior border, all of which could be identified with arthroscopy.[14] The average length and width of the anterolateral tibial insertion site are 7.8 and