

The Attachments of the Fiber Bundles of the Posterior Cruciate Ligament: An Anatomic Study

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Purpose: This study aimed to provide data on the sizes and locations of the attachments of the posterior cruciate ligament (PCL) to the tibia and the femur. **Methods:** We studied 39 cadaveric knees. The PCL consistently separated into anterolateral (AL) and posteromedial (PM) fiber bundles. Data were obtained to describe the size, position, and center of the PCL bundles related to clock positions and referenced to the center of the circular posterior medial condyle on the femur, as well as to the mediolateral and anteroposterior dimensions of the tibia. The coordinates for the femoral attachment of the PCL bundles were measured parallel to the femoral shaft and to the femoral intercondylar notch roof. **Results:** A wide variation in shape and size of the PCL attachment was found on the femur, but the pattern of attachment to the tibia was consistent. The tibial attachment of the PCL occupied the posterior intercondylar fossa. The AL bundle's anterior limit was the root of the posterior horn of the medial meniscus, and the PM bundle extended below the joint line by 7 ± 2 mm (mean \pm SD). On the femur, the AL bundle was centered at 7 ± 2 mm from the articular cartilage at $10:20 \pm 00:30$ o'clock, and the PM bundle was centered at 10 ± 3 mm from the cartilage at $08:30 \pm 00:30$ o'clock. The PCL extended from beyond the 12-o'clock position in all specimens. **Conclusions:** Accurate knowledge of the anatomic positions of the bundles of the PCL on both femur and tibia is essential to developing more successful reconstruction techniques. **Clinical Relevance:** The results of this study may be applied to the design of guidance systems for double-bundle PCL reconstruction techniques and as a reference for graft tunnel placement in in vitro or clinical follow-up studies. **Key Words:** Posterior cruciate ligament—Fiber bundle—Attachment—Anatomy.

Reconstruction of the injured posterior cruciate ligament (PCL) aims to restore one of the major knee stabilizers. Chronic instability as a result of a PCL injury can result in recurrent pain and swelling and, ultimately, early arthrosis of the knee joint.¹⁻³ The natural history of a grade 1 or 2 tear is reported as

satisfactory when treated nonoperatively, but a grade 3 tear or a combined PCL and posterolateral corner injury results in considerable disability.^{4,5} The PCL has been reported to possess 2 functional bundles^{2,6}: anterolateral (AL) and posteromedial (PM). These names reflect their relative positions on the femur. These are not strictly anatomic separations of the ligament but can be isolated by their distinct patterns of tension at differing angles of knee flexion.⁷ Reconstruction techniques involving reconstruction of the AL bundle are successful in restoring posterior laxity in the flexed knee but may not restore knee kinematics to normal.⁸ Using a double-bundle technique is reported to more closely reproduce the functions of the PCL.⁹⁻¹¹ The AL bundle is considered to form up to 85% of the cross section of the PCL in midsection,⁷ but the AL attachments to the tibia and femur are nearly equal in size to the PM bundle.

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A.E. was supported by the London Deanery of the Postgraduate Medical Board, and A.M.J.B. was supported by an Arthritis Research Campaign lectureship, Chesterfield, England. The authors report no conflict of interest.

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0749-8063/07/2303-5307\$32.00/0*

doi:10.1016/j.arthro.2006.11.005

At present, the indications for a single- or double-bundle PCL reconstruction remain undefined. This may relate to a lack of consistency of graft placement in different studies; at present, quantitative data describing the locations of the PCL fiber bundles objectively are lacking. Therefore the aim of this study was to obtain geometric data that could be used for guiding the placement of anatomic graft tunnels during surgery or assessing their placement at review.

METHODS

We studied 39 articulated cadaveric knees. The specimens had not been fixed but had been frozen and used in other studies. The ages of the specimens were not known in all cases, but they were from subjects aged between 60 and 80 years. The specimens had been previously studied for anterior cruciate ligament attachments, and therefore the lateral femoral condyles had been removed, exposing the femoral attachment of the PCL. The tibial plateau remained attached to the femoral medial condyles by the PCL and medial collateral ligaments. The mean notch width (17.5 mm) and posterior medial femoral condyle diameter (36.1 mm) matched the sizes quoted in other studies.¹²⁻¹⁵ The mean anteroposterior and mediolateral dimensions of the tibial plateau (53.1×77.5 mm) matched those reported by Staubli and Rauschning¹⁶ and Kurosawa et al.,¹⁷ and therefore the sizes of the specimens represented a good cross section of the population.

The synovial covering of the PCL was removed carefully. The 2 bundles of the PCL were identified according to their tension and fiber orientations at differing knee flexion angles. The boundary between the 2 bundles was identified by a combination of the visual appearance of tightening/slackening and probing and feeling with the tip of a MacDonal dissector.

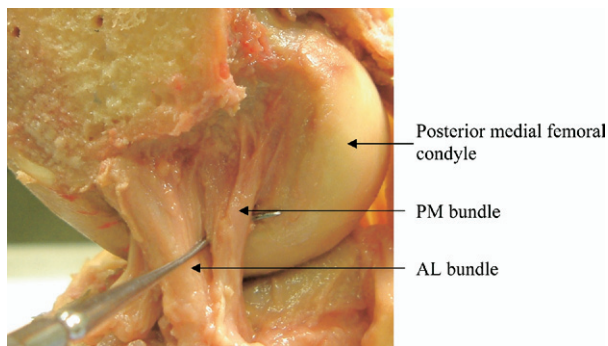


FIGURE 1. Separation of PM bundle from AL bundle with knee in extension.

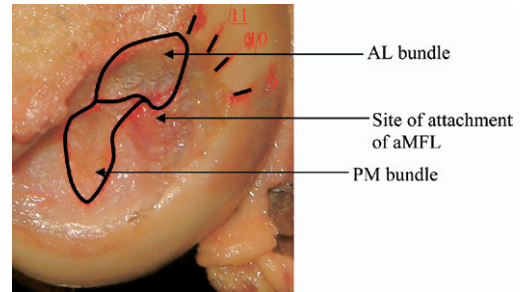


FIGURE 2. PCL femoral attachment outlined, plus marks around edge of intercondylar notch showing positions at 12 to 3 o'clock.

The PM bundle was tighter than the AL bundle in full knee extension. When the knee was flexed, the AL bundle became taut whereas the PM bundle relaxed. Repeated flexion-extension movements allowed the boundary between these zones of reciprocal behavior to be confirmed. Furthermore, when viewed from posteriorly, the PM bundle was oblique to the joint long axis whereas the AL bundle lay in the sagittal plane.¹⁸ The PCL was thus separated into 2 bundles, which were ligated and divided (Fig 1).

The tibial stumps were separated bluntly to their attachment on the tibia. The AL bundle's anterior attachment was immediately posterior to the attachment of the posterior horn of the medial meniscus to the tibia. The PL bundle's most posterior and distal attachment was on the posterior surface of the proximal tibia. Its fibers blended with those of the tibial periosteum and the attachment of the capsule to the tibia, but its distal limit was demarcated by the presence of a small transverse ridge on the tibia. The bundles were excised individually, and the outlines of their attachments were marked in ink on the tibia.

In a similar manner the femoral stumps were separated carefully to their attachments on the wall of the femoral medial condyle. The AL bundle blended with the edge of the articular cartilage at the anterior limit of the femoral intercondylar notch, except where indented by the attachment of the anterior meniscofemoral ligament (aMFL) of Humphrey. The PM bundle extended distally on the wall of the medial femoral condyle to within 5 mm of the cartilage edge. Either one or both of the meniscofemoral ligaments were present in all specimens and were excised. The PCL bundles were excised individually from the femur and their attachments marked in ink (Fig 2).

Before the lateral femoral condyle was detached, the width of the femoral intercondylar notch had been

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