Acute Femoral "Peel-Off" Tears of the Posterior Cruciate Ligament: Technique for Arthroscopic Anatomical Repair

Brian D. Giordano, MD, Kenneth E. DeHaven, MD, and Michael D. Maloney, MD

Abstract

Management of posterior cruciate ligament injuries remains a topic of discussion among treating physicians. Injury severity, anatomical location, and presence of concomitant associated knee injuries are important factors that may be used to guide treatment strategies.

Various subtypes of posterior cruciate ligament injury have been identified. Each has unique properties that affect treatment design. Among these subtypes is the acute femoral "peel-off" tear, which represents a distinct pattern of injury that consistently has demonstrated a favorable capacity for healing with repair rather than reconstruction.

In this article, we present an arthroscopic anatomical repair technique that has been used with success at our institution. It is important to properly identify such injuries in a timely manner so that appropriate treatment is initiated and the patient may be spared a lengthier and more technically complex reconstruction procedure.

Posterior cruciate ligament (PCL) injuries can have devastating short- and long-term sequelae if not identified in a timely manner and treated appropriately.[1,2] Although some clinicians debate the natural history and proper treatment of these injuries, most agree on the various patterns of injury that may occur.[3,4] Isolated PCL injuries occur infrequently and respond favorably to structured nonoperative treatment strategies, though many patients fail to regain their preinjury level of athletic activity or function.[5-7] More commonly, associated ligament, tendon, neurovascular, cartilage, or bony injuries accompany acute tears of the PCL.[8,9] When such injuries are encountered concomitantly, surgical reconstruction of the injured PCL is generally indicated.[3,10]

Failure of the native PCL may arise within the midsubstance of the ligament or can occur as an avulsion at either the femoral or tibial origins. Another injury pattern, the so-called acute femoral peel-off tear, is the subject of only a few reports in the literature.[11] This separate and very specific injury type is characterized by a complete, or incomplete, soft-tissue disruption of the PCL at its femoral attachment site without associated bony avulsion. Biomechanical loading studies have been unsuccessful in reproducing this injury pattern; thus, the underlying causative mechanism remains elusive.[12] Strain-rate sensitivity of the ligament fibers is thought to play a key role in producing these injuries, though this has not been clearly established.[11,12] Proper identification of this distinct subset of PCL injuries is important for devising an appropriate treatment plan.

> "Acute femoral peel-off tear...is characterized by a complete, or incomplete, soft-tissue disruption of the PCL at its femoral attachment site without associated bony avulsion."

Current data indicate that acute femoral peel-off injuries are especially amenable to repair rather than reconstruction.[1,3,13] Proponents argue that direct repair not only facilitates precise, anatomical reattachment of the native PCL at its natural footprint, but also preserves intrinsic neural elements, crucial for proprioception and gait biomechanics.[12] Although repair of midsubstance PCL tears has met with a high rate of unsatisfactory results, the literature on repair of proximal PCL tears has been much more favorable.[11,13-22] Although this repair traditionally has been accomplished through an open incision, some authors have recently advocated repair

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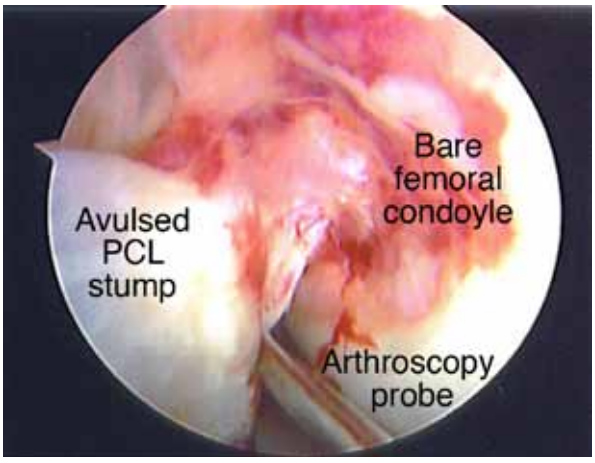


Figure 1. Intraoperative image shows bare medial femoral condyle at native insertion of posterior cruciate ligament.

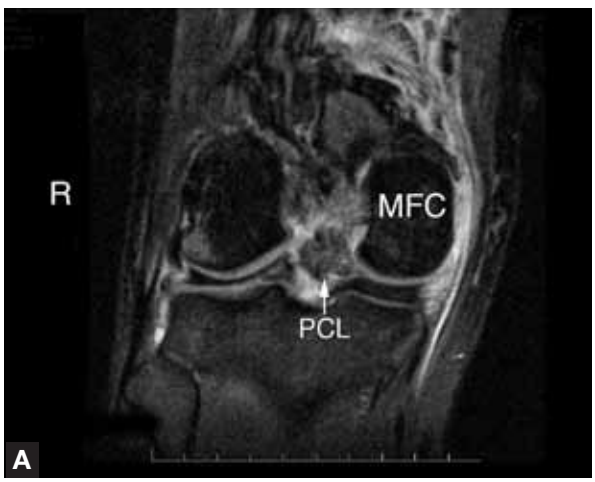
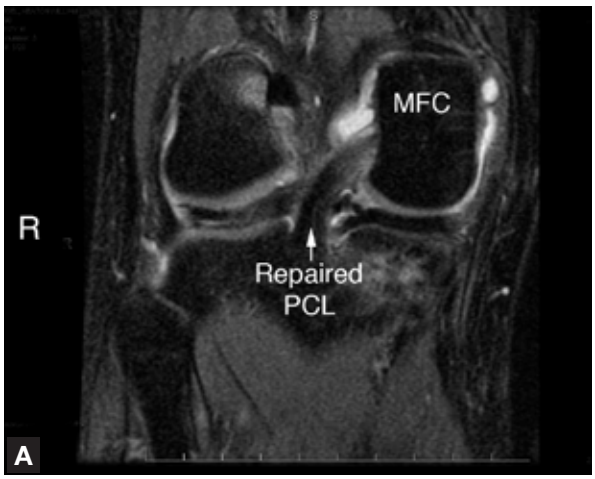


Figure 2. Coronal (A) and sagittal (B) magnetic resonance imaging shows complete soft-tissue separation of posterior cruciate ligament from its insertion at medial femoral condyle.

through an arthroscopic approach.[11,13,20] However, outcome data for arthroscopic repair of these distinct injuries are rare.[11,13,17] In this article, we present our preferred technique for arthroscopic anatomical repair of this distinct subtype of PCL injury.



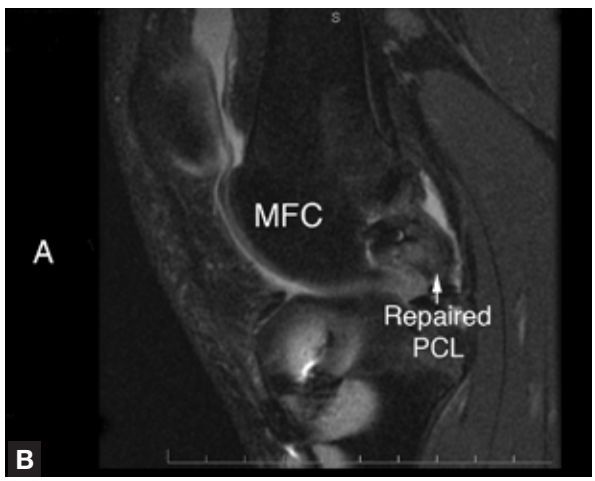
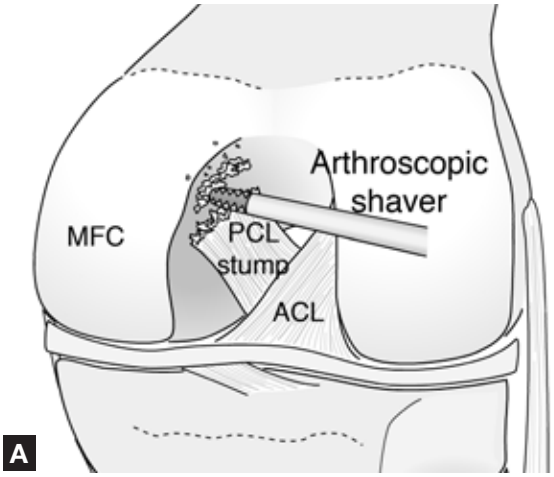


Figure 3. Postoperative coronal (A) and sagittal (B) magnetic resonance imaging of same patient 5 months after arthroscopic posterior cruciate ligament repair shows complete reconstitution of posterior cruciate ligament at its native insertion site.

Technique

Before surgery, the distinction between a midsubstance PCL tear and a femoral peel-off tear is subtle. The 2 injury subtypes are indistinguishable on clinical examination. In some cases, the diagnosis of a PCL peel-off tear is made during surgery, during direct arthroscopic inspection of the PCL insertion. A bare femoral condyle is appreciable on arthroscopic visualization of the PCL attachment site (Figure 1). During preoperative planning, magnetic resonance imaging (MRI) may be useful for identifying detachment of the ligament from the medial femoral condyle (MFC). In addition, MRI can further delineate whether the injury pattern is purely soft tissue or also involves a bony component (Figures 2A, 2B). Postoperative MRI may also be helpful in assessing ligament healing (Figures 3A, 3B).

At our institution, we have successfully used the following technique. With the patient supine on the operating table, standard anterolateral and anteromedial arthroscopy portals are established in the usual fashion. The proximal origin of the PCL is assessed for any intact fibers, and the precise location of disruption is further



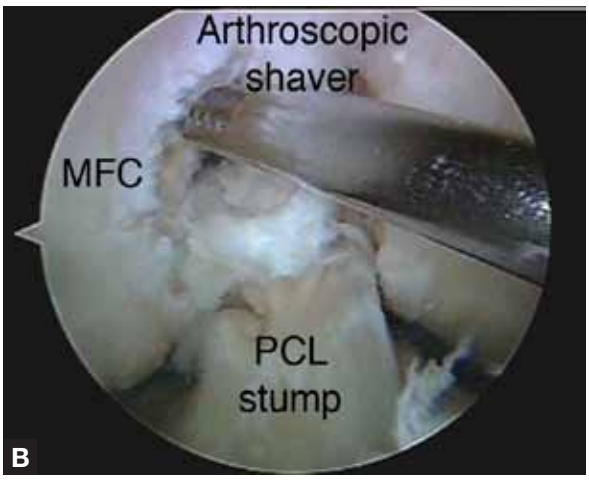
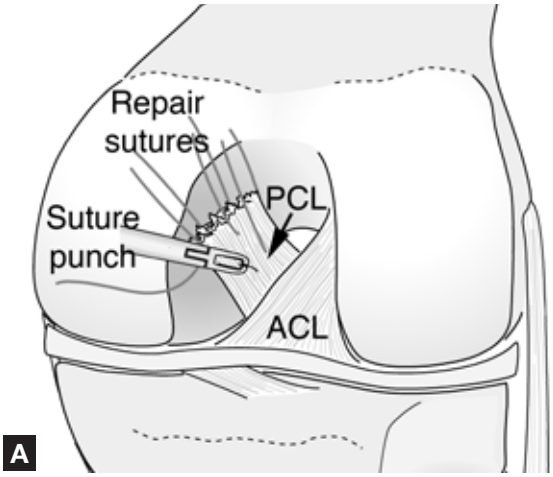


Figure 4. (A) Drawing of arthroscopic shaving instrument being used to débride posterior cruciate ligament stump and native condylar footprint to promote favorable biological healing response. (B) Intraoperative arthroscopic image shows shaver being used to prepare condylar footprint.



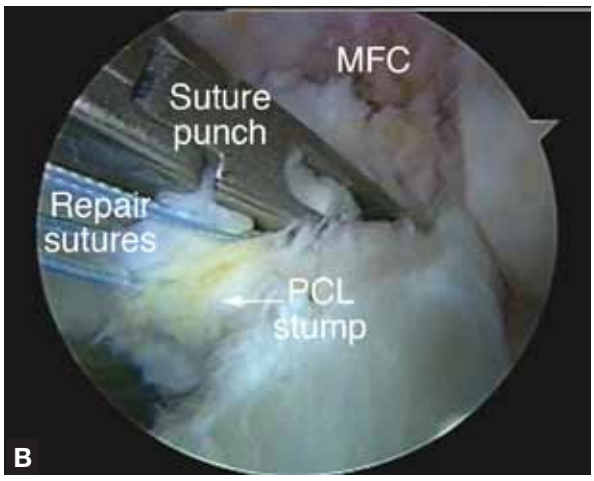


Figure 5. (A) Drawing of multiple nonabsorbable sutures being passed through ligament stump using arthroscopic suture punch. (B) Intraoperative image shows suture punch passing repair sutures through ligament stump.

delineated. A tissue grasper can be used to ensure that the ligament has adequate excursion to facilitate an anatomical repair. Shaving and rasping instruments are used to débride the PCL stump and footprint to promote a biological healing response (Figures 4A, 4B). Care must be taken to preserve any remaining intact PCL attachments.

Next, a suture punch is used to pass multiple nonabsorbable traction sutures through the PCL stump (Figures 5A, 5B). Traction applied to the initial suture allows the suture punch to secure a more substantial "bite" into the ligament substance for optimal incorporation of tissue into the repair construct (Figure 6). We usually attempt to pass at least 4 sutures through the PCL stump, though the exact number is somewhat arbitrary. More importantly, several sutures sufficient to withstand the traction forces necessary to reapproximate the avulsed segment of PCL back to its anatomical origin and maintain adequate tension on the ligament must be passed. For more robust fixation, a free needle may be used to pass additional sutures (Figure 7). After a sufficient number of sutures is placed, traction is again applied to assess ligament excursion and determine appropriate fixation points.

To gain exposure of the outer surface of the MFC, a limited incision is directed longitudinally over the distal

Table. Patient demographics and outcomes.

Patient	Age, y/Gender	Mechanism of Injury	Associated Injuries	Lysholm score	IKDC (Group grade/ Subjective score)	Displacement, mm
1	19/Male	Football	MCL, LM	95	Nearly Normal/90	2.3
2	21/Male	Football	ACL, MCL	95	Normal/92	0.5
3	19/Male	Skiing	LCL, PLC, MM	100	Normal/100	1.1

Abbreviations: ACL = anterior cruciate ligament; IKDC = International Knee Documentation Committee; LM = lateral meniscus, LCL = lateral collateral ligament; MCL = medial collateral ligament; MM = medial meniscus; PLC = posterolateral corner.

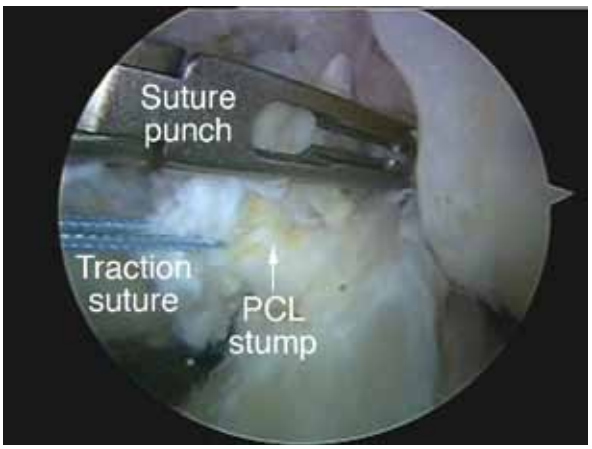


Figure 6. Traction suture being used to obtain improved "bite" by suture punch.

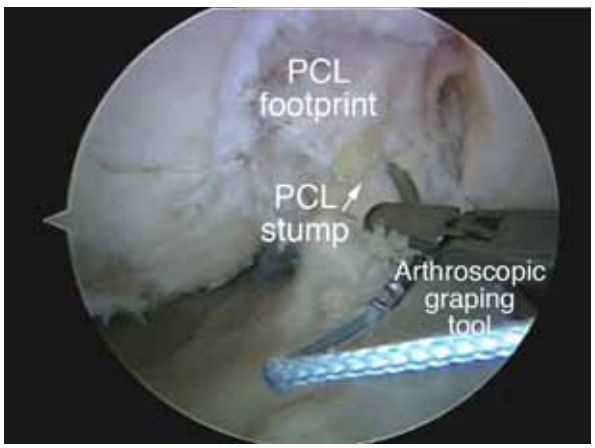


Figure 7. Free needle and nonabsorbable suture being passed through ligament stump using grasping tool.

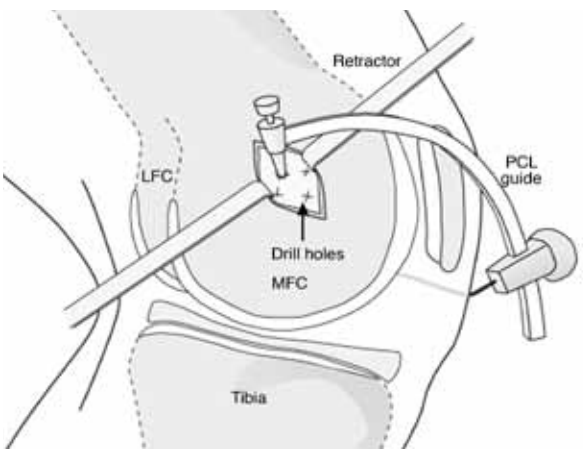
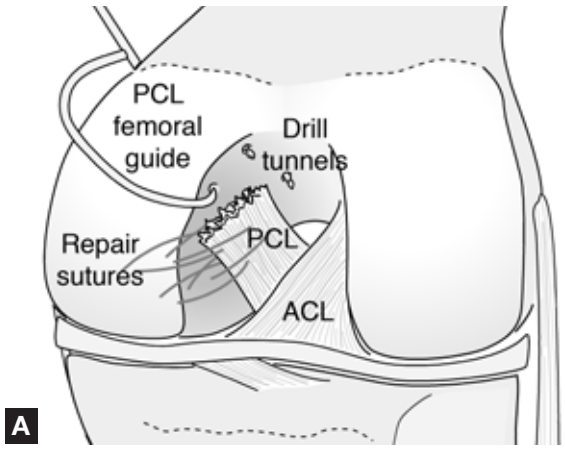


Figure 8. Drawing of medially based counterincision and arthroscopic posterior cruciate ligament guide being positioned for tunnel drilling.

medial femur. A PCL femoral guide is then used to create multiple drill holes through the MFC, in an outside-to-inside fashion (Figures 8, 9A, 9B). The lateral femoral condyle and tibia are illustrated as well. When carefully placed, these holes exit at select points throughout the periphery of the PCL footprint to facilitate accurate reapproximation of the avulsed ligament. Although excellent outcomes have been reported with use of 2 femoral drill holes, we typically create at least 4 holes in the hope to distribute the fibers of the ligament stump over a wider, more anatomical footprint at the inner surface of the MFC.[13] In addition, it is critical that the surgeon maintain the correct orientation of both ligament bundles to facilitate a direct anatomical repair of the PCL at its native footprint. Drill holes should be planned accordingly to allow for proper orientation of the distinct bundles.



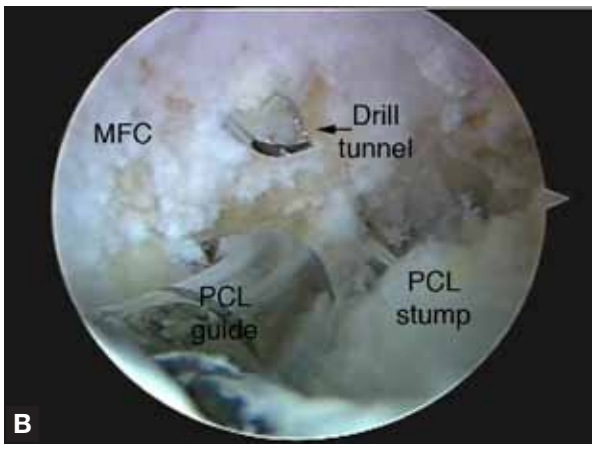


Figure 9. (A) Drawing of femoral drill holes created from outside to inside using posterior cruciate ligament (PCL) guide. Tunnel openings are carefully directed toward select points on periphery of native PCL footprint. (B) Intraoperative image shows use of PCL drill guide to create multiple tunnels for later suture shuttling.

A suture passer is next used to retrieve the repair sutures through the prepared drill holes (Figures 10A, 10B). Careful suture management ensures that the broad PCL expansion is reconstituted by strategically passing sutures through their appropriate drill holes. The sutures are then tensioned under direct arthroscopic visualization so that the ligament stump is satisfactorily reapproximated to its native footprint (Figure 11). We do not routinely countersink the repaired ligament, but, when any redundancy of the ligament stump is encountered before final repair, we may countersink the ligament to remove any remaining laxity. Once adequate tension is applied and

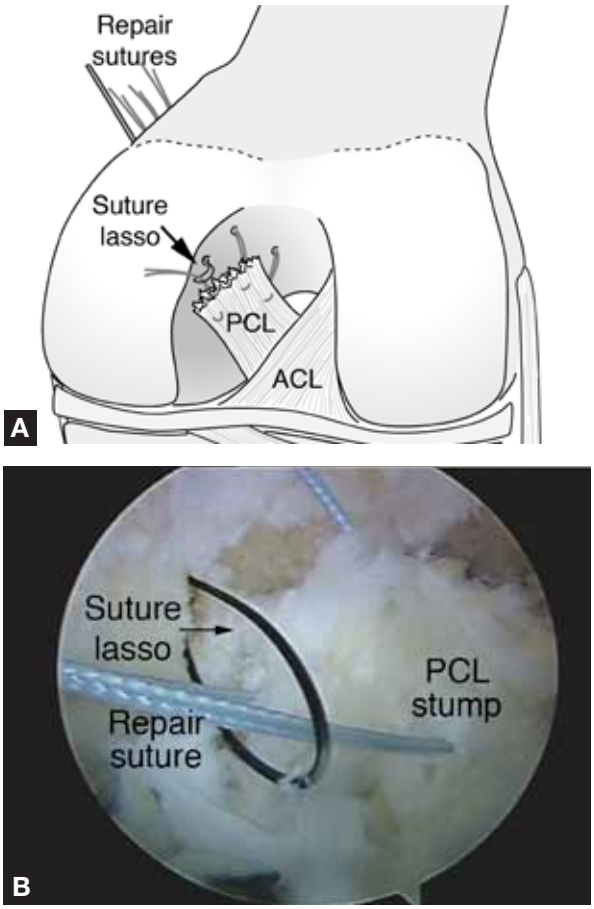


Figure 10. (A) Drawing of retrieval of repair sutures up through femoral drill holes using suture lasso. (B) Intraoperative image shows suture lasso shuttling nonabsorbable suture through prepared drill tunnels.

anatomical reduction obtained, the sutures are tied over bone bridges on the MFC (Figure 12). However, the suture ends are not yet cut. Degree of tension on the repaired PCL should first be assessed arthroscopically through a full physiological range of motion. When necessary, the repair can then be retensioned by tying the adjacent suture ends to each other over the external surface of the MFC. Tying adjacent sutures to each other helps take in any residual slack and provides additional tension at the repair site (Figure 13). Ligament stability should be given a final assessment at the conclusion of the case (Figure 14).

Discussion

Much of the historical literature on repair of femoral-side PCL injuries is anecdotal. Initially, surgical management of these injuries consisted largely of open repair.[16,18,19] In early reports, Clanton and colleagues,[16] Mayer and Micheli,[18] and O'Donoghue[19] described open repair of proximal PCL tears and noted extremely favorable objective and subjective outcomes at final follow-up. In all cases, repair was achieved through an anteromedial arthrotomy and a limited distal medial incision using sutures passed through drill holes in the MFC. Although all patients treated in this manner returned to full preinjury level of activity, asymptomatic residual laxity and instability were often noted on objective testing. More recent studies have also examined suture repair of PCL avulsions from the femoral attachment and noted similar findings.[15,21,22]

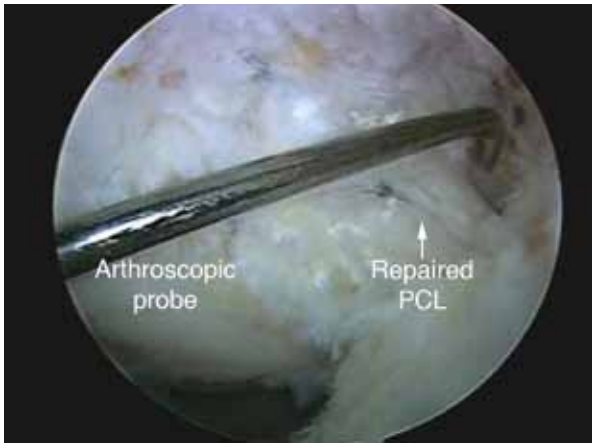


Figure 11. Direct visualization during tensioning repair to ensure that avulsed ligament stump has been anatomically reduced to its native footprint.

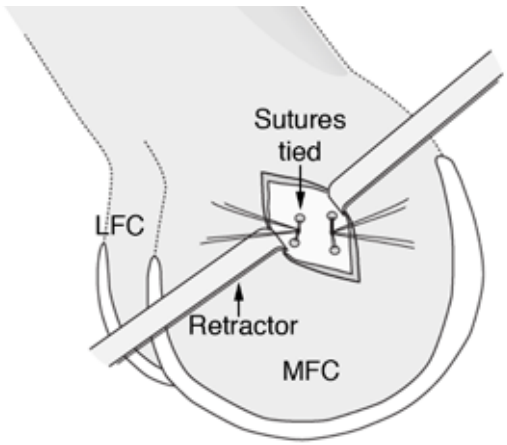


Figure 12. Drawing of passed sutures are tied to each other over bone bridges after tensioning has been performed.

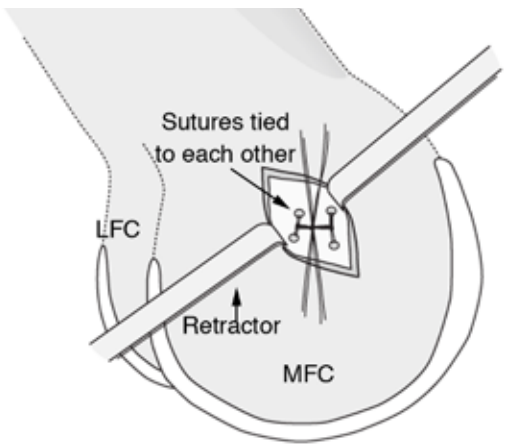


Figure 13. Drawing of sutures from same repair set are tied to one another to eliminate any remaining slack and provide added security to the repair construct.

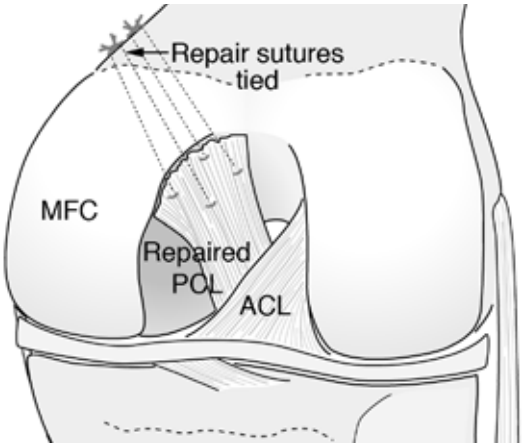


Figure 14. Drawing of final repair construct.

Before 2002, documentation on arthroscopic PCL repair was essentially limited to isolated case studies. Lobenhoffer and colleagues[17] (1997) and Park and Kim[20] (2005) published the first reports of femoral-side PCL soft-tissue avulsion injuries treated arthroscopically. A suture punch was used to place multiple nonabsorbable sutures through the proximal ligament fibers. These repair sutures were then passed through medial-side femoral tunnels prepared with an anterior cruciate ligament guide. Lobenhoffer and colleagues used 2 transfemoral tunnels, and Park and Kim used 4. The transosseous sutures were tensioned and then tied over a bone bridge, facilitating direct reconstitution of the PCL at its native anatomical footprint. Results were overall encouraging. More important, arthroscopic repair of these injuries was thought to have the potential to accurately recreate the native anatomical insertion of both the posteromedial and anterolateral bundles of the PCL through a minimally invasive approach.

To our knowledge, Wheatley and colleagues[13] were the first to report on a series of patients with acute PCL femoral soft-tissue avulsions repaired arthroscopically. Multiple nonabsorbable monofilament sutures were placed through the avulsed PCL ligament using a suture punch, shuttled through 2 bone tunnels created in the femur, and tied over a bone bridge on the medial cortex of the MFC. Any plastic deformity in the remaining ligament stump was addressed by creating a 3-mm trough at the PCL footprint, into which the repaired ligament was countersunk. All 11 of the patients who were available for follow-up returned to preinjury level of competition by a mean of 51.4 months. International Knee Documentation Committee (IKDC) scores revealed that 4 of the 11 patients had normal knee function and the other 7 had nearly normal function. Mean Lysholm and Gillquist score was 95.4 (range, 90-100). Postoperative MRI showed complete healing of the PCL to its femoral avulsion site in all cases.

In a technical note, Ross and colleagues[11] described their clinical experience using a novel arthroscopic technique for repair of acute femoral peel-off tears of the PCL. Their technique makes use of an accessory low lateral portal for femoral drilling. In line with standard diagnostic arthroscopy and mobilization of the injured PCL using a grasper and traction sutures, 3 No. 2 nonabsorbable braided sutures are passed through the substance of the PCL to act as repair sutures. Reamers of various sizes are then sequentially passed over a guide pin placed through the accessory portal to create a bony "socket" at the PCL footprint. A Beath pin is used to pass the repair sutures through the femoral tunnel, and the sutures are then tensioned under arthroscopic visualization as the native PCL is drawn into the femoral tunnel. The passed repair sutures are then retrieved through a counterincision over the MFC and tied over a ligament button with an anterior drawer applied to the knee in 80° to 90° of flexion. Of the 5 patients who over the course of 3 years underwent PCL repair using the described technique, 4 healed uneventfully with 1+ or less posterior drawer; the case of the fifth patient was deemed a clinical failure with 2+ posterior drawer.

Since March 2006 at our institution, we have treated 3 patients for acute femoral peel-off injuries of the PCL. Each patient was a male competitive high school athlete who sustained his injury on the right side during a sporting activity and who incurred multiple concomitant injuries involving the ipsilateral knee (Table). Mean patient age at time of injury was 17 years. All procedures were performed consecutively by Dr. Michael D. Maloney, MD, as described earlier. In all 3 cases, adequate ligament tension was confirmed during surgery. Therefore, none of the repaired ligaments were countersunk. Mean time from injury to surgery was 2 weeks. Both patients who sustained associated anterior cruciate ligament injuries underwent reconstruction with bone–tendon–bone allograft. Mean follow-up at time of most recent evaluation was 24 months. Successful arthroscopic repair of the PCL to its native anatomical footprint was achieved in all cases. There were no intraoperative complications.

All 3 patients showed clinical evidence of successful healing and restoration of ligamentous stability at most recent follow-up and were able to return to preinjury competitive level of athletic activity. Anatomical reconstitution of the avulsed PCL was confirmed on MRI in 1 patient 1 year after surgery (Figures 3A, 3B). Objective testing demonstrated no residual laxity in 2 of the 3 patients and 1+ residual posterior laxity in the third. None of the patients were experiencing subjective instability during daily or athletic activity. All 3 regained full active and passive range of motion. Two reported mild pain and swelling only with very strenuous activities or with kneeling. One had no pain regardless of activity level. At most recent follow-up, International Knee Documentation Committee (IKDC) evaluation revealed normal group scores in 2 of the patients, and nearly normal results in the third, with subjective scores of 90, 92, and 100, respectively. Lateral stress radiographs showed a mean posterior displacement of 1.3 mm compared with the contralateral, normal knee.

Summary

Surgical management of acute femoral peel-off tears of the PCL historically has been favorable, with satisfactory restoration of ligamentous stability and consistent return to premorbid function. Because such injuries have consistently demonstrated a favorable biological capacity for healing, repair, rather than reconstruction, is usually advocated. Whether performed with open or arthroscopic techniques, repair has clear advantages over reconstruction, both in terms of technical complexity and morbidity. It is critical, then, that PCL peel-off tears are properly identified in a timely manner so that an appropriate treatment regimen can be implemented. Acute PCL peel-off tears, however, are not always apparent. Moreover, selecting repair over reconstruction is not always straightforward. MRI can further define the relative degree of soft-tissue or bony involvement as well as the precise location of ligament injury. Even in cases in which the injury is identified during surgery, the treating surgeon must be skilled in the technical elements necessary to repair these injuries or to perform reconstruction when repair is not possible. When these injuries are properly managed, patients can experience full functional recovery and regain ligamentous stability.

Authors' Disclosure Statement

The authors report no actual or potential conflict of interest in relation to this article.

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