Arthroscopic Primary Repair of Posterior Cruciate Ligament Injuries

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Posterior cruciate ligament (PCL) injury can present either as an isolated tear or in the setting of a multiligament-injured knee. Most PCL injuries are midsubstance tears and 10%-40% of tears are either bony avulsion or soft tissue avulsion of the femur or tibia. PCL reconstruction is the mainstay for treatment of midsubstance tears, but primary arthroscopic PCL repair can be considered for avulsion tears. Although the literature on PCL injuries and especially PCL repair is scarce, some studies show good results with primary repair techniques. In this article, we describe the surgical technique of arthroscopic primary PCL repair by passing Bunnel-type stitches into the ligament using a reloadable suture passer. Sutures are then fixed either to bone with a suture anchor technique or by passing the sutures through drill holes at the femoral footprint and tying them over a bony bridge or button. Patient selection and surgical indications, including radiographic assessment, are critical to successfully using this technique. The areas of concern and most common pitfalls of this technique are discussed, as well as the postoperative care regimen and reported clinical results to date. When these steps are carefully optimized, successful patient outcomes can be achieved. Although this technique is not meant to be the mainstay of surgical PCL treatment, we believe that the arthroscopic primary PCL repair technique is quite useful in select clinical situations, and should be in the armamentarium of every surgeon treating multiligament-injured knee or isolated PCL injuries.

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Introduction

Posterior cruciate ligament (PCL) injury can present either as an isolated tear or in the setting of a multiligament-injured knee (MLIK). The tears can be bony avulsion tears, soft tissue avulsion “peeloff” tears, or midsubstance tears. The most frequently occurring tear is midsubstance, followed by soft tissue avulsion and lastly bony avulsion tears.1-3 Surgery is generally indicated in cases with grade III tears or in the setting of MLIK.4-6 Approximately 15%-32% of the PCL injuries are reported to be isolated tears,7-9 although in the emergency setting much lower percentages (3%-4%) are reported.1,10 Between 2007 and 2011 in the United States 222 isolated PCL surgeries and 479 PCL surgeries in the MLIK were performed, which makes it an relatively uncommon surgical treatment.9 The literature on PCL injury is scarce and patient populations are often heterogeneous including other knee pathologies, such as posterolateral corner injuries, anterior cruciate ligament (ACL) injury, and neurovascular injuries.3,6,11 The most frequently discussed treatments of PCL injury in literature are conservative treatment, single-bundle reconstruction, double-bundle reconstruction, and primary repair.1,12-16 Historically, there was a role for acute open primary repair of PCL injury in both the isolated tears and in the MLIK.17-19 In the years that followed, primary repair of cruciate ligaments, mostly of the ACL, illustrated increasingly disappointing results and more attention shifted toward arthroscopic PCL reconstruction.20-23
However, most of the evidence leading to abandonment of primary PCL repair technique is insufficient.\textsuperscript{3,5,24} and many studies consisted of heterogeneous populations.\textsuperscript{3,5,25}

After closely examining this historical experience, many authors concluded that primary repair can be a good solution for the bony avulsion or soft tissue avulsion-type tears.\textsuperscript{3,24,26,27} In all, 2 studies showed that approximately 10\%-17\% of the PCL tears have a bony avulsion instead of a ligamentous tear whereas midsubstance tears remain the most common injury.\textsuperscript{36} Several authors also reported on arthroscopic primary repairs of these bony avulsions\textsuperscript{28-30} or peeloff avulsions.\textsuperscript{31-33} The main benefits of primary repair are achieving better proprioception\textsuperscript{34,35} and earlier rehabilitation that prevents development of stiffness.\textsuperscript{36} The benefits of the arthroscopic method of repair is to decrease surgical morbidity and prevent neurovascular damage, wound healing problems, and arthrofibrosis.\textsuperscript{37} Moreover, PCL repair has shown better results than nonoperative treatment,\textsuperscript{38} and performing a PCL repair does not generally preclude or complicate subsequent PCL reconstruction, if it becomes necessary.

Therefore, it is our opinion that it is of benefit for knee ligament surgeons to have this surgical technique within their operative toolbox. We believe there is still a role for primary PCL repair, both in the MLIK and isolated settings, with the caveat that strict patient selection is necessary to prevent higher rates of failure.

**Patient Selection**

Preoperative patient selection is of critical importance to achieve successful outcome of arthroscopic primary PCL repair. A few criteria are essential to consider before indicating a patient for primary repair.

**Type of PCL Tear**

Several types of PCL tears can occur. As reported in the literature, bony avulsion or soft tissue avulsion types can be repaired primarily.\textsuperscript{3,24,26,28} Richter et al.\textsuperscript{3} compared the results of primary PCL repair after an avulsion lesion to the results of primary repair after a midsubstance tear. At 8.2 years of follow-up, the primary repair of avulsion lesions had better Lysholm and Tegner scores, and they found that a higher percentage of patients returned to work or sports activities. Furthermore, Moore and Larson\textsuperscript{38} reported on a case series using primary repair and presented relatively good results with 13 patients having a femoral or tibial tear and 3 patients having a midsubstance tear. Other studies confirmed that the good results with primary repair can be achieved also with the avulsion-type tears.\textsuperscript{24,28,30} Therefore, it is important to critically select the patients who are eligible for this surgical procedure: those patients with either bony avulsion- or soft tissue avulsion-type tears of the femoral or tibial insertion.

**Grade of PCL Tear**

Grade I and II PCL tears are partial tears, whereas grade III is a complete PCL tear. Several authors report good results of nonoperative treatment of the grade I and II tears,\textsuperscript{36,30} although some patients are reported to experience instability and osteoarthritis at long-term follow-up.\textsuperscript{15} Outcomes of nonoperative treatment of grade III tears are less predictable and nonoperative treatment in these patients is frequently associated with development of chondral lesions and instability.\textsuperscript{39,40} Therefore, the general consensus is that surgery is often warranted in grade III tears and these tears are well visualized using magnetic resonance imaging (MRI).\textsuperscript{15,36}

**Time Setting of the Surgical Repair**

A balance should be sought between early and late intervention and the consensus is to perform surgery within 1-3 weeks.\textsuperscript{24,38} This time period is also reported in almost all case series where PCL repairs were performed.\textsuperscript{7,10,26,41,42} A week of waiting is recommended to allow time for capsular structures to heal and thus reduce fluid extravasation during arthroscopic surgery.\textsuperscript{25,35} Delaying repair by greater than 3 weeks is associated with an increased risk of capsular scarring,\textsuperscript{30} fixed tibial posterior subluxation that is harder to reduce,\textsuperscript{38} and decreased ligamentous tissue quality.\textsuperscript{32,43} It is important to note that in the setting of the MLIK, other injuries should be monitored and that these injuries can influence the timing of surgery or the decision to convert to open surgery.\textsuperscript{24}

**Patient Variables**

It is important to understand all patients, including occupational and activity levels before the surgery, and their individual expectations. It is possible that the patient may not want or is not able to undergo a PCL reconstruction with a full rehabilitation program. Arthroscopic primary PCL repair might be possible, whereas reconstruction is not, when weighing the risks and benefits to the patient. As always, it is important to discuss the situation and treatment options thoroughly with the patient.

**Imaging**

Radiographs should be examined to assess concomitant fractures or avulsion fractures that can point in the direction of associated injuries. Anteroposterior and lateral radiographs should be used to assess any bony avulsions, osteochondral lesions, or posterior tibial subluxation.\textsuperscript{30} A gravity sag view can be performed to quantify the posterior subluxation and is performed by a lateral radiograph with the hip in 45° flexion and the knee in 90° flexion; however, this is generally more helpful with chronic injuries.\textsuperscript{44} MRI is still considered the gold standard and has 100% sensitivity and 97%-100% specificity for PCL injury.\textsuperscript{45-48} The sagittal, coronal, and axial planes of the MRI are visualized to detect any femoral or tibial bony avulsions or “peeloff” lesions. Most of the bony avulsion fractures are reported to be at the tibial side,\textsuperscript{40,50} whereas most of the soft tissue avulsions tend to be from the femoral side.\textsuperscript{33,50,31} There is no standardized protocol on how best to evaluate PCL tears, but in general the PCL should be followed in both proximal and distal directions to assess if the
bundles attach to the bone (Fig. 1). In our experience, the length and signal appearance of the PCL on the MRI do not predict a successful repair regarding the ligament tissue quality and its ability to hold sutures. Finally, the MRI is used also to assess other injuries such as posterolateral and posteromedial corner injuries, collateral ligament, ACL, and meniscal lesions. It is important to assess these structures to determine if a patient is a candidate for primary repair in the setting of the MLIK.

**Surgical Technique**

Once patient selection is performed and the MRI is assessed, surgery is planned between 1 and 3 weeks after the injury. The goal of the surgery is anatomical repair of the PCL to optimize function and prevent stiffness and instability. Sometimes surgical timing is difficult owing to other knee injuries or systemic injuries that can cause further delay of the surgery. For our purposes, primary repair of the femoral soft tissue (“peeloff”) avulsion is described as this is the most common injury eligible for arthroscopic primary PCL repair and also the most common type seen by the senior author (G.D.).

Standard knee arthroscopy equipment and implants are used; however, some instrumentation from the shoulder sets is used. Standard arthroscopic anterolateral and anteromedial portals are created and a general inspection of the knee is performed. The PCL is inspected, mobilized, and carefully debrided of any scar tissue. The length of the PCL is assessed using a broad grasper (Cuff Grasper; Arthrex, Naples, FL) that minimizes the risk of further damage to the ligament (Fig. 2). It is important to reduce the posterior tibial subluxation in the sagittal plane during the assessment of the PCL length to prevent a false assessment that the ligament remnant is too short for repair. In 90° of flexion the subluxed tibia should be reduced to 1 cm anterior of the femoral condyles, to assess the exact length of the PCL remnant and its ability to reach the femoral footprint. If the length is sufficient and the injury is of a soft tissue avulsion type, the standard anterior portals can be used. A malleable, large-bore cannula (PassPort Cannula; Arthrex, Naples, FL) is placed into the anteromedial portal for easier suture management (Fig. 3). Accessory portals can be used according to the surgeon’s preference. If the injury is a bony avulsion of the tibia, accessory posterior portals are often necessary, as described by other authors.52-55

For the next step, it is important to understand the insertion anatomy of the PCL of the anterolateral and the posteromedial bundles.56,57 If the 2 individual bundles are identified and isolated, they can be sutured separately. If not, suturing can proceed irrespective of bundle anatomy. A self-retrieving suture-passing device (ScorpionSL Fastpass; Arthrex, Naples, FL) is used to pass sutures through the ligament (Fig. 4). The first pass should be as close to the intact

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**Figure 1** A sagittal MRI image shows a typical proximal PCL avulsion with an intact attachment at the tibial side and an avulsion at the femoral side.

**Figure 2** The length of the PCL can be assessed with the use of a broad grasper. (Color version of figure is available online.)

**Figure 3** On the left of the image a malleable, large-bore cannula is placed into the anteromedial portal for easier suture management. (Color version of figure is available online.)
insertion as possible to maximize the number of suture throws that are passed through the ligament. The suture-passing device is reloaded and each suture limb is then passed through the ligament in the opposite direction. With suture advancement toward the injured part of the ligament, an interlocking Bunnell-type stitch pattern is created, thereby increasing the suture pullout strength. With each subsequent pass, it is important to assess the resistance to prevent a perforation of a previous stitch. A little resistance from the tissue is normal, but when more resistance is met, then the suture-passing device should be repositioned to avoid cutting a previously placed stitch.

Usually 2 sutures are passed through the ligament, which results in 4 free limbs of sutures at the injured end of the tendon. Occasionally, 2 sutures can be passed into each bundle, resulting in 8 free limbs of sutures. It is important to handle the sutures carefully to prevent any soft tissue bridging, tangles, and knots. The sutures can be guided outside the knee via the anterolateral portal, or at times, an accessory stab incision is used (Fig. 5). The femoral footprint of the PCL is then roughened with an arthroscopic burr or shaver whereas the sutures are protected via the portal.

There are 2 ways to provide fixation of the PCL to the femoral footprint. The first technique uses fixation with knotless suture anchors, whereas the second technique passes the sutures transosseously and fixation is achieved by tying over the bone bridge. Both of the techniques are discussed. The goal of both techniques is to recreate an anatomical attachment of the anterolateral and posteromedial bundles of the PCL.

**Anchor Fixation Technique**

In the anchor technique, the arthroscope is switched to the anteromedial portal to ensure that sutures can be placed with an appropriate angle into the footprint on the medial femoral condyle. From the anterolateral portal a suture hole is made at the origin of the anterolateral footprint with a drill or awl, depending on bone quality. With the knee at 90° of flexion, an anterior drawer force is applied to reduce the tibia appropriately. The sutures of the anterolateral bundle are then inserted in the knotless anchor (Swivelock, Arthrex, Naples, FL). The anchor is then deployed in the standard fashion, reapproximating the tissue to its native position (Fig. 6). While maintaining the anterior drawer force, the same procedure is performed to reapproximate the posteromedial bundle fibers to their native position. A gentle posterior drawer force is then applied while the repair is arthroscopically visualized to confirm restoration of stability.

**Bone Bridge Fixation Technique**

The procedure for fixation with tying over the bony bridge is conceptually similar, but it is slightly different from the suture...
anchor technique. Drill holes are created into each bundle footprint through the medial femoral condyle, either anterograde or retrograde using the appropriate drill guides (Fig. 7). If drilling anterograde, a small incision is made over the medial femoral condyle and dissection is performed down to the bone. The PCL femoral guide is placed via the anteromedial portal and is centered on the anterolateral bundle insertion. A cannulated drill (RetroDrill; Arthrex, Naples, FL) is then used to drill into the anterolateral footprint. A nitinol-passing wire is then passed through the drill cannulation to shuttle the repair stitches through the femoral condyle. The same procedure is then performed at the posteromedial footprint. If drilling retrograde, a standard drill can be used via the anterolateral portal with passing sutures used to shuttle the repair stitches. Once all of the repair stitches are passed, the ligament remnant is tensioned back to the wall as visualized by the arthroscopic view. The knee is then set at 90° of flexion, and an anterior drawer force is applied to reduce the tibia to its anatomical position. The suture limbs are then tensioned and tied over the bony bridge between the drill holes (Fig. 8). The senior author’s preferred technique is to tie the stitches through a ligament button (RetroButton; Arthrex, Naples, FL) to minimize soft tissue compression and thereby minimize the risk of creep and secondary laxity. A gentle posterior drawer force is then applied while the repair is arthroscopically visualized to confirm restoration of stability.

**Postoperative Regimen**

The exact nature of postoperative management is dependent on the setting of the PCL repair and is different in the isolated PCL repair vs that in the MLIK. Usually the knee is placed in a hinged knee brace locked in extension in the operating room. It has been shown that keeping the knee in extension minimizes tension on the PCL. The patient is allowed to bear weight with protection of crutches and a locked knee brace. Close attention should be paid to edema control. Weight bearing prevents a decrease in maximum force, prevents ligament stiffness, and prevents increased posterior laxity at follow-up. Furthermore, immediate isometric quadriceps exercises in the extension brace are recommended to minimize muscle atrophy and restore limb control. Quadriceps contraction results in anterior tibial translation and this does not increase tension on the PCL.

After 2-4 weeks, range-of-motion (ROM) exercises are initiated depending on the surgery, surgeon preference, and type of injury. Closed-chain hamstring exercises are started after 6-8 weeks and when both patient and surgeon are confident. Closed-chain exercises are shown to produce less tibiofemoral shear force than open-chain hamstring exercises do. Another benefit of the exercises and the primary repair is to restore the proprioceptive function of the cruciate ligaments. Open-chain hamstring exercises should be avoided for at least 4-6 months.

At 6 and 9 months follow-ups, the muscle strength and ROM are determined. After these follow-ups, gradual return to sport is indicated when the quadriceps and hamstring strength are at least 4/5, when there is full active extension, and active flexion approximates the intact knee up to 15°.

**Results of PCL Repair**

The literature on outcomes of PCL repair is scarce and results of acute repair of PCL are often presented in the setting of MLIK, which makes it difficult to quantify results of PCL repair owing to the heterogeneity of the MLIK group of patients. Other studies that report isolated PCL repair are often heterogeneous in the type of PCL repair performed. A recent meta-analysis in the MLIK compared primary repair of ACL and PCL to reconstruction of ACL and PCL. Although they did not find any significant differences between the 2 groups, the groups lacked homogeneity in both the injury pattern and the treatment regimens. An historical review of the literature on
PCL repair is discussed later, followed by the outcomes of the modern day arthroscopic approach to PCL repair. Additionally, several case reports and small case series have been published on primary PCL repair. In this surgical technique article we do not further assess these studies.

In 1980, Hughston et al performed PCL repair in 29 patients with PCL tears, of which 16 (55%) were located at the femoral insertion, 8 (28%) were located at the tibial location, and 5 (17%) were midsubstance tears. In all, 20 of 29 patients (69%) were available for follow-up and they evaluated the patients outcomes as good, fair, or poor in subjective, functional, and objective evaluation at least 5 years after surgery. In the subjective score, 18 patients outcomes (90%) were rated as good and 2 (10%) as fair. In the functional score, 16 patients outcomes (80%) were rated as good and 4 (20%) were excluded for other reasons, and in the objective score, 13 (65%) patients outcomes were rated as good, 4 (20%) as fair, and 3 (15%) as poor. Unfortunately, the authors did not correlate the injury types with the ratings at the follow-up evaluation. However, the authors did show that good results were achieved in a fair number of their patients, including 14 (70%) patients who had an active sporting life at the follow-up evaluation.

In the same year, Moore and Larson retrospectively reviewed 18 primary PCL repairs in patients with a MLIK. Overall, 9 (50%) of these repairs were femoral tears, 4 (22%) were tibial tears, 3 (20%) were midsubstance tears, 1 was a partial tear, and 1 was unknown. Of these patients, 7 (39%) reported excellent function, 3 (17%) had good functionality, 3 (17%) were fair, and 1 patient reported poor functionality. Also, in this study the authors did not specify which patients had which type of injury. It was noted that 83% of the patients had residual instability in one or more planes, yet 61% of these patients were rated as having excellent or good function.

In 1984, Strand et al retrospectively reviewed acute primary repair of 32 PCL injuries, of which 5 (16%) were bony avulsion-type injuries. At 4 years of follow-up, they reported excellent-good function scores (Lysholm score ≥ 77) in 20 patients (63%) and fair-poor function results in 6 (19%) patients (Lysholm score < 77). Of the 5 patients with bony avulsions, 4 (80%) reported excellent function scores and 1 (20%) reported a poor function score due to bony displacement.

In 1991, Pourmaras and Symeonides performed primary PCL repair in 20 knees, of which 14 patients (70%) had midsubstance tears and 6 (30%) had a femoral ligament avulsion tear. Using the same method of subjective evaluation as that of Hughston et al, 15 patients (75%) reported good results and 5 patients (25%) reported fair results. In the avulsion group, 4 of 6 patients (67%) subjectively reported good results. All patients had a 1+ to 2+ posterior drawer sign postoperatively. The authors concluded that although the posterior drawer sign was positive in all patients, this does not lead to significant functional impairment in everyday activity.

In 1999, Mariani et al retrospectively reviewed 23 patients with combined ACL and PCL injuries who underwent ACL and PCL repair (group 1), ACL reconstruction with PCL repair (group 2), or ACL and PCL reconstruction (group 3). When group 2 and group 3 were compared, the authors found more giving way in group 2, a more marked reversed pivot shift test and more posterior sag. However, the groups were very small (6 patients in both groups) and no statistical analysis was performed. Furthermore, 8 of 23 PCL injuries (35%) were midsubstance tears but the injury type was not specified in the groups. Because of the heterogeneity of injury and repair, in conjunction with the small group size, it is difficult to compare results between PCL reconstruction and PCL repair in this study.

In 2002, Wheatley et al were the first to present an arthroscopic PCL repair series. The authors retrospectively reviewed 13 patients with femoral soft tissue avulsions that were treated arthroscopically, of which 11 were available for follow-up. All of these patients had associated ligament injuries. In these patients, the ACL was reconstructed and other ligaments injuries, including the PCL, were repaired. At a mean follow-up of 4 years, all patients returned to their preinjury level of activity and all athletes, including 2 professional football players, had returned to the same or higher level of competition. All patients achieved full extension and 10 of 11 patients (91%) reached full flexion. The mean Lysholm score was 95.4, which is higher than even the mean postoperative Lysholm score of single-bundle PCL reconstruction in a systematic review of Kim et al (89.6).

The senior author (G.D.) has also treated patients with arthroscopic PCL repair of a soft tissue avulsion of the PCL from its femoral insertion. Of these patients, 3 had a minimum of 24-month follow-up. All 3 patients had a MLIK and were treated with an arthroscopic primary PCL repair. At an average follow-up of 68 months, the average ROM was 0°–127° of flexion. The posterior drawer test result was negative immediately after repair and stability was maintained at the latest follow-up. In addition, MRI was performed at follow-up of a minimum of 2 years and showed healing of the PCL in all cases. The subjective patient scores showed good pain-free functional status with an average Lysholm score of 92 and modified Cincinnati score of 94. There were no intraoperative or postoperative complications. These outcomes showed that a stable and sustained PCL repair is possible with good subjective patient outcomes.

In 2012, Chen et al reported a prospective series of 36 patients with arthroscopic primary PCL repair of tibial bony avulsions. At a mean follow-up of 36 months, the results showed a mean Lysholm score of 95. Normal (grade A) or near-normal (grade B) IKDC scores were reported in 33 patients (91.7%) and abnormal (grade C) scores were noted in 3 patients (8.3%). No complications were noted in all patients and after 3 months all fractures showed union. The authors showed that the arthroscopic PCL repair in these patients is a successful technique with well-documented radiographic healing, good clinical outcomes, and low complication rates.

When reviewing these case series, some reports show that good outcomes are possible with open and arthroscopic primary PCL repair. Although some studies show that postoperative instability can be found, this does not seem to impair...
functional daily activities. Although interpretation of results is difficult owing to heterogeneity in injury type and treatment, these studies show that good results are possible with PCL repair. Certainly arthroscopic PCL primary repair limits the surgical morbidity that the patient experiences, while maximizing the benefit. We do not think that PCL repair should be the primary surgical technique for all patients with PCL injury. However, we think that this technique can be used effectively in carefully selected group of patients. We believe that it would be prudent for every surgeon to have this operative technique in his or her armamentarium. In addition to being a fairly low-morbidity intervention for the patient, arthroscopic PCL primary repair does not burn surgical bridges. In other words, the procedure is simply revised to a PCL reconstruction if that need arises.

Conclusions

Isolated PCL injury is rare and often presents in the setting of a MLIK. Because of the heterogeneity of the patients, literature is scarce on this topic and guidelines to surgically repair the PCL are lacking. Most PCL injuries, both in the MLIK and with isolated injuries, are midsubstance injuries and therefore PCL reconstruction remains the choice of treatment in these injuries. However, with excellent sensitivity and specificity on MRI and advanced arthroscopic technologies, we believe there is a role for primary arthroscopic PCL repair when bony or soft tissue avulsion injuries are present. Although the incidence of this injury is low, results of primary PCL repairs are generally good. Arthroscopic primary PCL repair should be a tool in the armamentarium of the surgeon who treats patients with MLIK or isolated PCL tears.

References
