All-Inside Posterior Cruciate Ligament Reconstruction

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Introduction

The incidence of posterior cruciate ligament (PCL) injury has been reported with significant variability in the literature. A review by Shelbourne et al. [1] demonstrated a PCL disruption incidence of 1–44 % in acute knee injuries [2–7]. This large variation appears to be dependent on the specific population being studied. For example, Miyasaka [6] reported a 3 % incidence of PCL injury in the general population, and Fanelli [7] reported a 38 % incidence of PCL injury in patients with hemarthrosis of the knee at a regional trauma center. The literature provides clinicians with an estimation of PCL injury risk, but the true incidence remains elusive due to unreported injuries.

The mechanism of PCL injury typically involves a traumatic, posteriorly directed force to the tibia with the knee in a flexed position. This mechanism commonly occurs during a motor vehicle collision or when an athlete falls on their knee with the foot plantarflexed [8,9]. Additional implicated mechanisms include hyperflexion, hyperextension, and extreme rotation [10–12].

Although PCL tears can occur in isolation, they are more commonly seen in the setting of the multiple-ligament-injured knee [11,13–16]. In a recent study by Becker et al. [17], 65 of 82 patients (79 %) presenting with a multiple-ligament knee injury had evidence of PCL injury on MRI. Whether isolated or combined, PCL injuries must be evaluated with an in-depth history, detailed physical examination, and advanced imaging. Treatment options include nonoperative management, repair, or reconstruction. This chapter focuses on the initial management of PCL injuries and evidence to support our preferred all-inside PCL reconstruction technique.

Physical Examination

The physical examination begins with a thorough neurovascular assessment. Many of these injuries occur from high-energy mechanism, and exclusion of a compartment syndrome is important. A full lower-extremity assessment is then performed, including knee range of motion, limb alignment, gait, and ligament stability.

Three physical exam tests determine the integrity of the PCL: posterior drawer, posterior sag, and quadriceps active. The posterior drawer maneuver is the most effective with a sensitivity of 90 % and a specificity of 99 % [18,19]. This maneuver is performed by applying a posterior force to the tibia with the knee flexed at 90°and the hip flexed at 45°. The amount of tibial translation on the femur determines the test grade: grade 1 = less than 5 mm, grade 2 = 5–10 mm, and grade 3 = greater than 10 mm. The anterior margin of the tibial condyles lies approximately 10 mm anterior to the femoral condyles anatomically when the knee is flexed to 90°. A grade 2 posterior sag (grade 2 PCL injury) is diagnosed when the tibial condyles are flush with the femoral condyles, and a grade 3 posterior sag is present if the tibial condyles translate posterior to the femoral condyles. The quadriceps active test is performed with the patient in a supine position with the knee flexed to 90°. The examiner then applies a counter force to the patient's ankle in order to resist knee extension while the patient contracts their quadriceps muscles. Anterior translation of the tibia during this maneuver suggests a PCL injury, since the initial posterior tibial translation is reduced by quadriceps contraction.

PCL disruption frequently occurs in the setting of the multi-ligament-injured knee [11,13–16]. Assessment of the anterior cruciate ligament (ACL) with a PCL injury is challenging. The examiner must pay attention to the position of the tibia relative to the femoral condyles when performing

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the Lachman's test and pivot shift tests. The increased posterior translation of the tibia relative to the femur in a PCL-deficient knee may cause false-positive examination maneuvers. The examiner must focus on the tibial start point and endpoint during both the pivot shift and Lachman tests. Increased anterior tibial translation with a firm endpoint suggests an intact ACL, whereas increased anterior tibial translation with a soft endpoint is consistent with both disruption of the ACL and PCL.

Assessment of posterolateral corner (PLC), integrity involves a variety of examination maneuvers including the dial test at 30° and 90°, external rotation recurvatum test, external rotation drawer test, and reverse pivot shift test. The dial test is performed by examining the lateral movement of the tibial tubercle with an external rotation force at both 30° and 90° of knee flexion. Increased tibial tubercle external rotation of greater than 10° compared to the contralateral side denotes a significant difference. A positive dial test at 90° of knee flexion indicates PCL injury and at 30° of flexion indicates PLC injury. The external rotation recurvatum test is performed with the patient supine and both knees fully extended. With the patient fully relaxed, the examiner lifts the patient's legs off the table by grasping the foot. Relative hyperextension combined with external rotation of the tibia indicates a positive exam. The external rotation drawer test is performed with the patient supine and the injured knee flexed to 90°. The examiner externally rotates the tibia and applies a posterior force similar to a posterior drawer test. Posterior displacement or increased step-off of the tibial plateau indicates a positive exam finding. The reverse pivot shift test is performed with the patient supine. The examiner begins with the knee flexed, applies valgus and external rotational forces, and slowly extends the knee. Reduction of the posteriorly subluxated lateral tibial plateau is considered a positive test.

Imaging

Plain radiographs and magnetic resonance imaging (MRI) are utilized when assessing a PCL-injured knee. Anteroposterior (AP) and supine lateral radiographs of the knee are used to assess for posterior tibiofemoral subluxation, fractures, asymmetry of the joint spaces, and bony avulsion of the tibial insertion of the PCL. A fibular head avulsion fracture with posterior tibiofemoral subluxation on the supine lateral view suggests both PCL and PLCinjuries.

Numerous studies have demonstrated the benefit of stress radiographs in the evaluation of the PCL-injured knee [20–22]. Shulz et al. [21] found that greater than 8 mm of posterior displacement on stress radiograph demonstrates isolated PCL injury, whereas greater than 12 mm of posterior displacement represents combined PCL and PLC injuries. A cadaveric sectioning study by Sekiya et al. [22] correlated stress radiograph displacement and posterior drawer examination findings in isolated PCL-sectioned and combined PCL- and PLC-sectioned knees. The authors found an average of 9.8 mm of posterior tibial displacement on stress radiograph and a grade 2 posterior drawer test when only the PCL was sectioned. This posterior displacement increased to an average of 19.4 mm and a grade 3 posterior drawer test when both the PCL and the PLC structures were sectioned. Thus, it was concluded that greater than 10 mm of posterior displacement on lateral supine stress radiograph and a grade 3 posterior drawer test indicates injury to the PCL and PLC.

MRI is the best imaging modality to assess the PCL in an injured knee. Complete disruption or signal change within the PCL can be seen, but it is critical to correlate the imaging findings with physical examination. 3-Tesla MRI scanners are most useful when evaluating the ligaments and other soft tissue structures, including menisci, chondral surfaces, tendons, muscles, and capsular structures.

Indications for PCL Reconstruction

Management of both isolated and combined PCL injuries is still being debated within the orthopedic literature. Several studies have demonstrated successful clinical and functional outcomes after nonoperative management of isolated PCL injuries [1,11,15,23,24] using bracing and physical therapy. A natural history study on isolated PCL injuries by Parolie et al. [5] revealed that 80 % of patients were satisfied with their knee function and 84 % had returned to their sport prior to injury at a mean follow-up of 6.2 years.

Patel et al. [25] retrospectively reviewed 58 knees with isolated PCL injuries treated without surgery. Within this series, 24 % of patients had grade A (partial tear), 76 % grade B (complete tear), and 0 % grade C (tibia is displaced behind the femur) on posterior drawer testing. The authors found that 90 % of knees had mild or no pain, 93 % did not demonstrate any swelling, and only 8 % of patients reported episodes of giving way. The mean Lysholm score was 85.2 with 92 % of knees reporting as good or excellent. No correlation was found between degree of laxity and final outcome score.

Shelbourne et al. [1,15,24] have since performed a prospective case series looking at both short- and long-term outcomes after acute, isolated PCL injuries treated nonoperatively. In the most recent publication of this series, 68 patients at a mean follow-up of 17.6 years reported an International Knee Documentation Committee (IKDC) [26] score of 73.4. Furthermore, they found no correlation between PCL laxity grades and outcome measures. Of the 68 patients in this cohort, 44 had both subjective and objective measures available. This subset of patients had a mean follow-up of 14.3 years (range, 10–21 years). Mean muscle strength in the injured knee was found to be 97% compared to the uninvolved leg with all patients demonstrating normal range of motion. The overall grade of radiographs was normal in 59% of patients, nearly normal in 30%, abnormal in 9%, and severely abnormal in 1% at long-term follow-up. Additionally, 11% of patients had medial joint space narrowing greater than 2 mm. The grade of radiographically measured osteoarthritis, however, was not significant in any knee compartment based on PCL laxity. A major limitation of this long-term study was that none of the 44 patients had an initial PCL injury greater than grade 2.

The successful results seen from nonoperative treatment in the previously mentioned studies are likely skewed because only grade 1 and 2 isolated PCL injuries were studied. We therefore, only recommend nonoperative management for these lower-grade injuries. In higher-grade PCL tears, we recommend surgical management. Operative indications for the PCL-injured knee include:

- Avulsion fracture of the PCL tibial insertion (open reduction and internal fixation)
- Acute or chronic isolated grade 3 PCL injury (ligament reconstruction)
- PCL insufficiency in the setting of the multiple-ligament-injured knee (ligament reconstruction)

Scientific Rationale

There are a variety of different PCL reconstruction techniques that have been developed including arthroscopic transtibial, open inlay, and arthroscopic inlay. Bone tunnel creations in these techniques have used "inside-out," "outside-in," and "all-inside" techniques. PCL reconstruction graft construct options include anterolateral (AL), single-bundle or ALand posteromedial (PM) bundle, double-bundle reconstructions using either allograft or autograft. The all-inside PCL reconstruction is our preferred technique based on current evidence in the literature.

Transtibial Versus Inlay

The arthroscopic transtibial technique is performed by drilling a tunnel from the anterior portion of the tibia to the footprint of the PCL. As the graft passes through the tibia, it is forced to make the "killer turn" around the posterior tibial margin. In a biomechanical study by Markolf et al. [27], the authors compared the transtibial and tibial inlay PCL reconstruction techniques using a bone–patellar tendon–bone (BTB) allograft. Each graft construct was placed through 2000 cycles of 50–300 N tensile force. Ten of the 31 knees (32%) in the transtibial technique group failed before completing 2000 cycles and none of the 31 knees (0%) failed in the inlay technique group. The location of graft failure in all of these cases occurred at the point of the "killer turn" along the posterior aspect of the tibia at the level of the PCL facet. Additionally, when comparing change in graft thickness of the 21 paired grafts that survived, they found that the transtibial group had greater graft attrition than the inlay group. The authors did note, however, that both groups had significant graft damage and increase in graft length after 2000 cycles. The authors concluded that while both techniques demonstrated graft attrition and lengthening, the inlay technique had significantly less graft failure.

In another study by McAllister et al. [28], the authors compared 12 cadaveric knees fixed with either the transtibial or inlay PCL reconstruction techniques. The knees underwent AP tibial loading of 200 N for 50 cycles. Two of the 12 (17%) grafts fixed by the transtibial technique failed prior to completing 50 cycles, but none of the 12 (0%) failed in the inlay reconstruction group. The graft failures occurred at the point of the "killer turn." The authors also found that both groups had a significant increase in mean AP laxity at 90°after 50 cycles, but found no difference between the two groups in this regard.

In a more recent cadaveric study comparing these two techniques, Margheritini et al. [20] measured posterior tibial displacement at various knee angles in ten knees. The knees were tested in both the PCL-intact and PCL-deficient states, and were then reconstructed with either the transtibial or inlay techniques. The authors found that both reconstruction techniques reduced the posterior tibial displacement at all knee flexion angles, but found no significant difference between the two reconstruction groups.

While the biomechanical studies demonstrate lower failure rates when using the inlay versus the transtibial technique, the clinical data cloud this debate. We performed a systematic review of the literature [29] and found no important advantage of one technique over the other. Satisfactory subjective and objective outcomes were seen in both types of reconstruction. The mean score for patients reconstructed with the transtibial technique was found to be 77.8 with 77.7% normal and nearly normal responses in the objective IKDC scoring system. The mean IKDC score for patients reconstructed with the inlay technique was 75.1 with 100% normal and nearly normal response. Additionally, both techniques had equivalent results on posterior stress radiographic measurements. The transtibial technique demonstrated a mean difference of 3.5 mm and the inlay technique demonstrated a mean difference of 4.3 mm when compared to the contralateral knee. Furthermore, arthrometer measurements showed no significant difference between the two groups.

While a few studies have attempted to directly compare the transtibial and inlay techniques, the results are difficult to interpret because graft selection and number of bundles reconstructed were inconsistent. Regardless, each of these studies demonstrated that both techniques produced similar clinical and functional outcomes.

Campbell et al. [30] published the first arthroscopic inlay technique in 2007 utilizing a BTB allograft and a RetroDrill (Arthrex, Naples, FL, USA) to create the tibial socket. This technique has the benefit of avoiding the "killer turn" while eliminating the morbidity associated with a large posterior incision and capsulotomy. Bovid et al. [31] presented a case report using the arthroscopic inlay technique in a skeletally immature patient. This technique enabled the tibial socket to be created without violating the physis. At 17 months postoperatively, the patient returned to full function, however, no long-term follow-up has been presented to date.

Salata and Sekiya [32] published a further modification of the Campbell and Bovid techniques using a FlipCutter (Arthrex, Naples, FL, USA) in order to create the tibial socket. In their technique, a PCL guide was used to drill a guide wire posteriorly toward the tibial footprint of the PCL. Then, a 3.5-mm cannulated drill is reamed over the guide pin. Next, the FlipCutter was advanced through the created tunnel and was deployed once exiting the cortex. The authors then performed retrograde drilling of the tibial socket using the FlipCutter. The authors argue that the anatomic position of the tibial insertion of the PCL in this technique avoids the killer turn, similar to the Campbell and Bovid techniques. The FlipCutter is more easily positioned, however, and it avoids intra-articular assembly seen with the RetroDrill.

Single Bundle Versus Double Bundle

Both single-bundle and double-bundle PCL reconstructions have demonstrated satisfactory clinical outcomes [33–39]. While authors who support the double-bundle technique argue that it restores native PCL biomechanics and anatomy, clinical studies have thus far shown equivalent results with both reconstruction techniques.

The native PCL complex consists of the AL bundle, PM bundle, and the anterior and posterior meniscofemoral ligaments (AMFL, PMFL). The weaker PM bundle tightens when the knee is flexed to approximately 20–30°. The stronger AL bundle tightens at 80–90°of knee flexion and is the primary constraint to posterior tibial displacement [40]. As such, the AL bundle is reconstructed during single-bundle PCL reconstruction.

Markolf et al. [41] performed a biomechanical study that sought to compare single- and double-bundle PCL reconstruction. In this cadaveric study, the authors measured AP laxity and PCL forces at various angles of knee flexion. The measurements were obtained with the PCL intact, sectioned, reconstructed with a single-bundle technique, and reconstructed with a double-bundle technique. The authors found that the single-bundle technique restored native PCL forces better than the double-bundle technique. The double-bundle reconstruction created higher than normal PM graft forces, which could not be explained. However, the authors did find that the mean AP laxity of the single-bundle reconstructions was 1.1–2.0 mm greater than the double-bundle technique at 0–30°of flexion. They questioned whether this increase in force would eventually cause elongation of the graft and eventually gain more AP tibial laxity.

Whiddon et al. [42] compared single-bundle and double-bundle PCL reconstruction in the presence of a PLC injury using ten cadaveric knees. The authors first examined each knee with an intact PCL using the posterior drawer and dial test exam maneuvers, as well as stress radiographs. The PCL and PLC of each knee were disrupted. This was accomplished by sectioning the PCL and by removing the FCL and popliteus femoral attachments with an osteotome creating a large bone block. The authors then performed single-bundle and double-bundle PCL reconstruction with and without the PLC fixed back to the lateral femur. The authors found that in the setting of a disrupted PLC, the double-bundle PCL reconstruction showed less posterior tibial displacement. However, when the PLC was restored, no difference in posterior tibial displacement was noted between the single- or double-bundle techniques. The authors concluded that because PLC reconstructions tend to stretch out, the double-bundle technique may be superior in the setting of combined PCL and PLC injuries.

Similar to the biomechanical data, clinical studies continue to demonstrate equivalent results when directly comparing single- versus double-bundle PCL reconstruction techniques. Wang et al. [36] performed a prospective study in which they reconstructed 19 patients with single AL bundle reconstructions and compared them to 16 patients with double-bundle reconstructions. Lysholm, Tegner, and IKDC scores were utilized to measure functional outcomes. Radiographic examination and ligamentous laxity were also measured. The authors found no significant difference in all of these parameters measured between the single- and double-bundle PCL reconstruction groups.

Yoon et al. [43] also performed a prospective randomized trial comparing arthroscopic single- versus double-bundle PCL reconstruction. A single surgeon performed 25 single-bundle reconstructions and 28 double-bundle reconstructions in patients with isolated PCL injuries. An Achilles tendon allograft was used in all cases. Both the single- and double-bundle reconstructions were performed using an arthroscopic transtibial technique for the tibial portion and "outside-in" femoral tunnel placement. The authors found that the double-bundle reconstruction had 1.4 mm less posterior tibial displacement and higher IKDC scores than the single-bundle construct. All other measures of evaluation, including range of motion, stress radiographs, and Tegner and Lysholm scores, demonstrated no difference between the two groups.

Fanelli et al. [44] published a series of 90 consecutive patients (45 single- and 45 double-bundle reconstructions) in an effort to compare the two reconstruction techniques. All of the patients in this series had PCL-based multiple-ligament-injured knees. The surgical technique was identical for the single- and double-bundle groups, except the double-bundle group had a second tunnel created on the femur for the PM bundle. All patients had a minimum of 2-year follow-up and evaluation, including stress radiography, KT-1000 arthrotomy, Tegner, Lysholm, and Hospital for Special Surgery outcome scores. The author found no difference between the single- and double-bundle PCL reconstructions.

Our preferred technique is a single AL bundle reconstruction because it reduces surgery time and clinical evidence demonstrates no advantage to performing a double-bundle reconstruction.

Femoral Tunnel: "Outside-In" Versus "Inside-Out"

For the femoral side of the PCL reconstruction, both "outside-in" and "inside-out" techniques have been developed. The "outside-in" technique is performed by creating an incision on the medial side of the knee with dissection through the vastus medialis oblique (VMO) muscle. A tunnel is then drilled from the medial cortex of the femur to the intercondylar notch using an arthroscopically placed PCL femoral footprint guide. The "inside-out" technique is performed by creating an accessory inferolateral portal. Through this portal, with the knee flexed to approximately 100°, a guide pin is inserted into the femoral footprint and then over-reamed through the femoral cortex.

A proposed advantage of the "outside-in" technique is the avoidance of the second so-called killer turn, otherwise called the "critical corner," which is prevalent with the "inside-out" technique. Much like the "killer turn" in the tibial tunnel, many authors believe that too large of an angle can cause graft lengthening and even failure. In their biomechanical study, Handy et al. sought to measure the "critical corner" angle in both "outside-in" and "inside-out" techniques using nine cadaveric knees. The authors found that the "outside-in" group had graft/femoral tunnel angles of 50° with the knee in flexion and −14° in extension. The "inside-out" group had graft/femoral tunnel angles of 87° in flexion and 27° in extension. It was concluded that the "outside-in" technique reduces the angle of the "critical corner."

In another biomechanical study by Schoderbek Jr. et al. [45], the authors sought to compare the "critical corner" of the "outside-in" and "inside-out" techniques with the knee flexed at 90° and 120°. The authors found that the mean graft/femoral tunnel angle was significantly less at both of these flexion points using the "outside-in" method. Therefore, the authors recommend the use of the "outside-in" technique because it creates smaller angles for the PCL graft. Tompkins et al. [46] recently performed a study comparing the ability of the "outside-in" and "inside-out" techniques to place tunnels into the anatomic femoral footprint of the PCL. The authors found that both techniques were equal in the ability to correctly place the femoral tunnel. While the biomechanical studies may show an increased risk of graft failure with the "inside-out" technique due to the increased "critical corner" angulation, clinical studies have shown successful outcomes with both techniques [35–37,39,43,44]. We have performed several revision PCL cases where the previous surgeons used an "outside-in" technique and reamed right through the femoral articular cartilage. Although we have used both techniques in the past, we currently prefer the "inside-out" technique because it allows us to use the reamer as a guide placed directly onto the PCL femoral footprint thereby, decreasing the risk of articular cartilage blowout.

AutograftVersus Allograft

A wide variety of graft types have been used for reconstruction of the PCL. While some authors prefer allograft due to decreased surgery time, less donor-site morbidity, and adequate graft length, others prefer using autograft due to graft availability and decreased risk of disease transmission or rejection. We performed a systematic review comparing the use of [47] allograft and autograft in PCL reconstruction. At minimum 2-year follow-up, both graft constructs produced satisfactory clinical and functional outcomes as measured by Lysholm, IKDC, and Tegner scoring systems. Additionally, we found no statistically significant difference between allograft and autograft with stress radiograph measurements and arthrometer testing.

Because the majority of PCL reconstructions are performed in the setting of multiple-ligament surgery, we currently use allograft tissue for the reasons mentioned above. In order to perform the all-inside technique with current fixation strategies, a minimum 36-cm-long graft is required. It would be extremely difficult to find an autograft option for a graft of this length. Therefore, our preferred graft choice is a tibialis anterior or peroneus longus nonirradiated allograft when performing the all-inside PCL reconstruction technique.

All-Inside PCL Reconstruction Surgical Technique

Patient Positioning

With the patient supine, a bilateral knee examination under anesthesia is performed to assess ligament integrity. The limb is then positioned, prepped, and draped.

Graft Preparation

The graft is prepared using a graft preparation board, which maintains tension on both femoral and tibial TightRopes (Arthrex, Naples, FL, USA). The graft is folded in a quadruple-looped fashion and sewn together with a number #2 FiberWire suture (Fig. 12.1). The graft is then marked with a sterile pen at 25 mm from both the femoral and tibial sides for intraoperative assessment of graft position in the tibial and femoral sockets. The prepared total graft length should be 95–100 mm.

Tibial Preparation

After a standard diagnostic arthroscopy, an accessory PM portal is placed in order to expose the PCL tibial footprint between the mamillary bodies. The PCL guide is inserted through the anteromedial (AM) portal and positioned at the base of the PCL facet (Fig. 12.2). Proper placement of the guide can be confirmed with fluoroscopy as needed (Fig. 12.3). A FlipCutter (Arthrex, Naples, FL, USA) is then drilled from anterior to posterior through the tibia until the drill tip penetrates the posterior cortex (Fig. 12.4). The PCL guide is used to protect the FlipCutter from plunging into the posterior neurovascular structures. The FlipCutter is then deployed and used to create the tibial socket with a depth of at least 35–40 mm (Fig. 12.5). The tibial socket is then

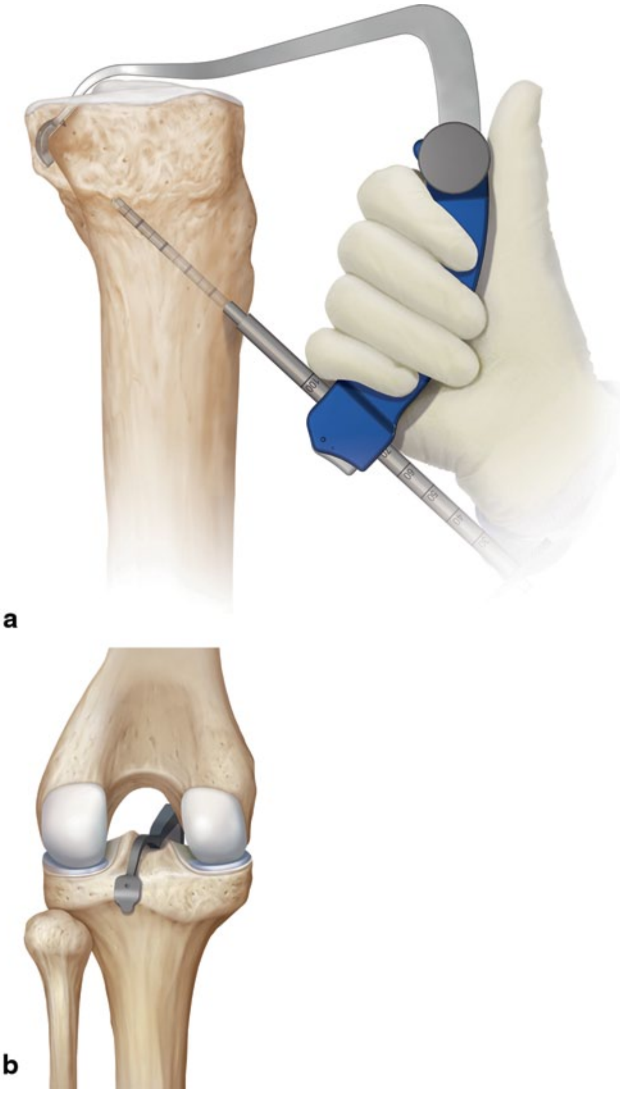
a
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Fig. 12.2 **a** PCL guide positioned for the creation of the tibial tunnel. **b** Posterior view of PCL guide positioned just proximal to the distal edge of the posterior facet

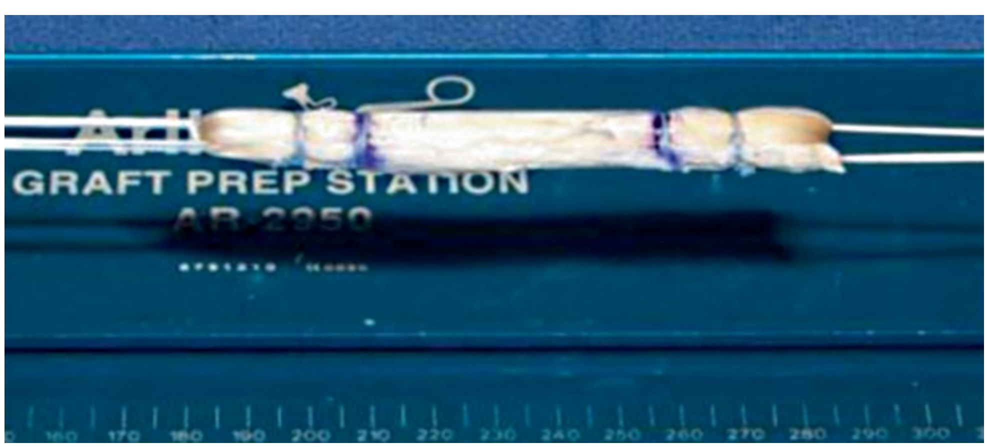

Fig. 12.1 Prepared tibialis anterior allograft under tension on a GraftLink preparation board (Arthrex, Naples, FL, USA) for PCL reconstruction

Fig. 12.3 Lateral fluoroscopic image showing proper placement of the PCL guide at the base of the PCL facet

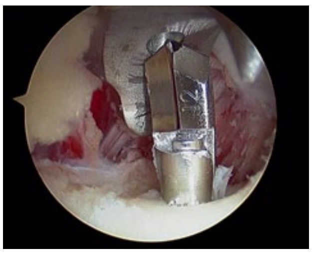

Fig. 12.4 Intraoperative arthroscopic image of the 12-mm FlipCutter (Arthrex, Naples, FL, USA) penetrating the posterior tibial cortex. The PCL guide acts to protect the neurovascular bundle while drilling. View from the AM portal

Fig. 12.5 The FlipCutter (Arthrex, Naples, FL, USA) is used to back-ream to a depth of at least 35–40 mm when making the tibial tunnel

cleaned out using a shaver. Passing sutures are then placed into the socket and pulled through the joint out of the AM or AL portals (Figs. 12.6 and 12.7).

Femoral Preparation

The native femoral AL bundle footprint of the PCL is exposed and some of the fibers are preserved to aid placement of the femoral socket. A guide wire is placed through an accessory, distal inferolateral portal and inserted into the

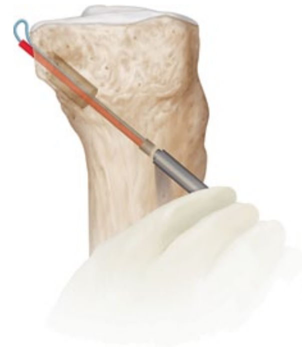

Fig. 12.6 A passing suture is placed through the drill sleeve into the joint for graft passage purposes

Fig. 12.7 Intraoperative arthroscopic image of passing sutures within the tibial socket. View from the PM portal

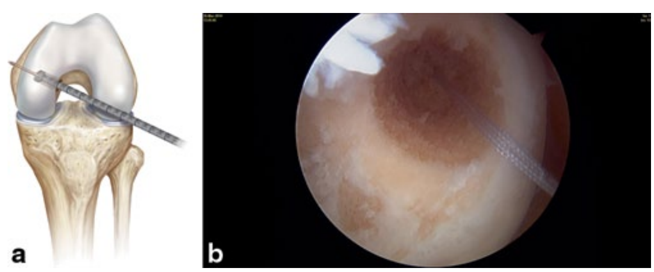

Fig. 12.8 **a** Creation of the femoral socket using an r eventual graft passage. The femoral socket should be drilled to at least 25 mm. **b** Intraoperative arthroscopic image of passing sutures within the femoral socket. View from the AM portal

center of the anatomic footprint. An 11- or 12-mm reamer is then passed over a guide wire and positioned at the most distal and anterior margins of the footprint. This avoids the risk of cartilage blowout as the reamer basically acts as a guide. The femoral socket is then reamed to a depth of at least 25 mm (Fig. 12.8a). Similar to the tibial side, a passing suture is then placed for eventual graft passage (Fig. 12.8b).

Securing the Graft

The passing sutures on both the tibial and femoral sides are first pulled through an accessory inferolateral portal. These sutures should be looped around the TightRope sutures, which were previously sewn to the prepared graft. In our experience, we prefer passing the graft into the tibial socket first (Fig. 12.9), which allows the entire graft to be inside the knee joint before completing the reconstruction. We then pull graft into the femoral socket (Fig. 12.10) while maintaining tension on the tibial TightRope sutures. It is important to maintain counter-tension on the femoral side of the graft as the TightRope device is deployed. The TightRope sutures should be tensioned in order to seat the graft to a depth of approximately 20 mm in the femoral socket. The arthroscope is then placed into the PM portal and the tibial portion of the graft is visualized to ensure that at least 20 mm of graft is in the tibial socket. If there is excess length, the femoral TightRope can be tightened, pulling the graft further into the femoral socket. The knee is cycled with 20 cycles of knee flexion, maintaining tension on the tibial TightRope (Fig. 12.11). This takes some creep out of the graft construct. With the knee at 80–90° of flexion, a 16-mm Attachable Button System (ABS; Arthrex, Naples, FL, USA) button is secured to the tibial TightRope and tensioned (Fig. 12.12). Retensioning the femoral-sided TightRope is the final step in securing the PCL graft in both the femoral and tibial sockets (Fig. 12.13). If desired, secondary fixation on the tibial side can be performed. Our preferred technique is to secure the tibial sutures with a 5.5-mm push lock (Arthrex, Naples, FL, USA). Tying the sutures around a post is another viable option. A final AP radiograph of the all-inside PCL GraftLink technique is shown (Fig. 12.14).

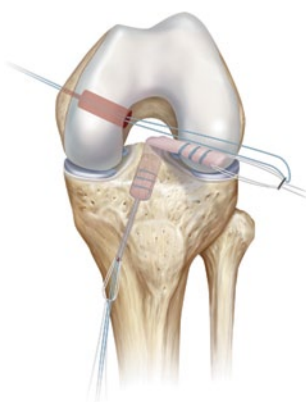

Fig. 12.9 The tibial side of the graft is pulled into the socket before the femoral side. Final tibial fixation is not performed at this time

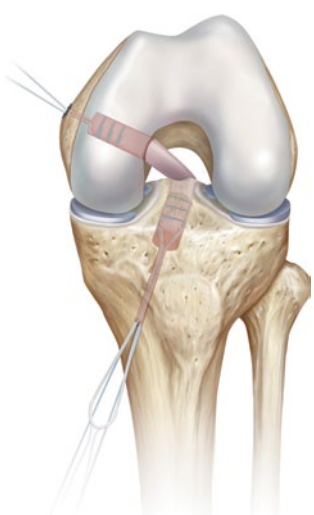

Fig. 12.10 The femoral side of the graft is pulled into the socket and is secured with a TightRope cortical button while maintaining tension on the tibial side of the graft

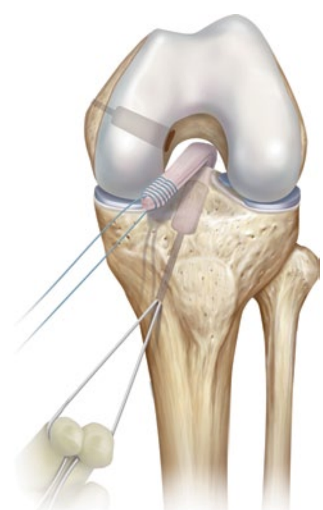

Fig. 12.11 Tensioning of the tibial sutures

Fig. 12.12 ABS tibial TightRope button (Arthrex, Naples, FL, USA) is secured and sutures are cut

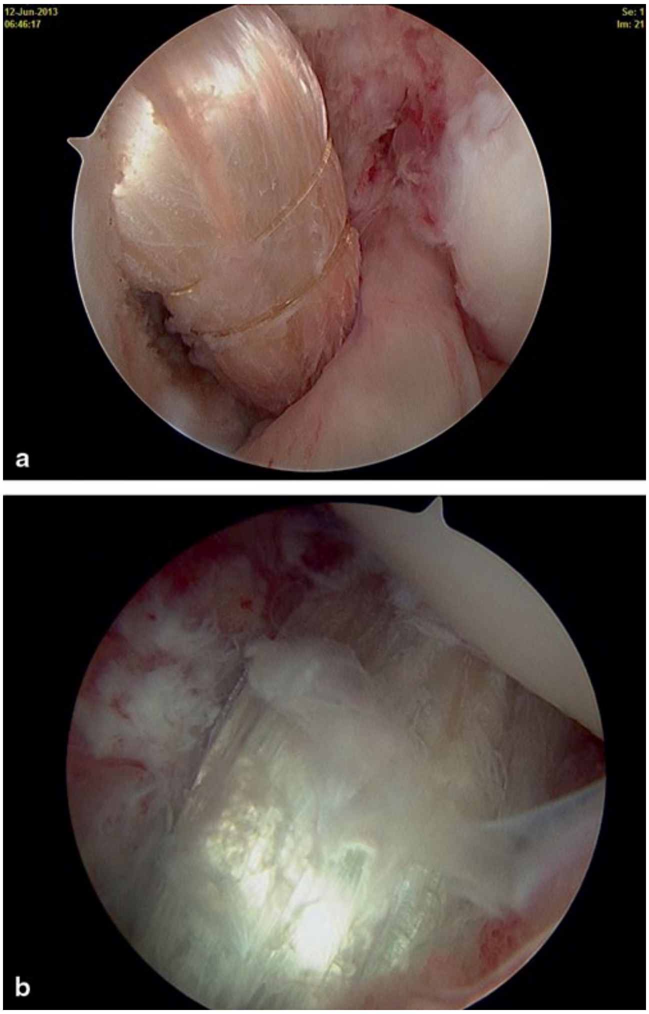

Fig. 12.13 **a** Intraoperative arthroscopic image with the femoral side of the graft in position. View from the AL portal. Note the intact ACL. **b** Intraoperative arthroscopic image with the tibial side of the graft in position. At least 20 mm of graft should be seated within the tibial socket. View from the PM portal

Fig. 12.14 Anteroposterior postoperative radiographs of PCL reconstruction using the all-inside technique. Patient also underwent posterolateral corner reconstruction

Conclusion

Numerous surgical techniques for PCL reconstruction have demonstrated successful clinical and functional outcomes [29–39,43,44]. These techniques include arthroscopic transtibial, open inlay, and arthroscopic inlay. Advances in surgical technique and instrumentation have led to the development of a novel all-inside PCL reconstruction. This technique utilizes suspensory fixation in both tibial and femoral sockets and allows for either allograft or autograft to be used. This reconstruction avoids the "killer turn" seen with the transtibial technique, which may decrease the chance of graft attrition while delivering decreased morbidity and excellent visualization using an all-arthroscopic approach. While early results using this technique are promising, long-term clinical and functional outcome studies are needed to validate this novel PCL reconstruction.

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