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PCL UPDATE (K JONES AND M ALAIA, SECTION EDITORS)

Revision PCL Reconstruction Review/Update

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Abstract

Purpose of Review The primary goal of this review is to update recent literature on revision PCL reconstruction and to discuss factors relevant to surgical failure, surgical indications and goals, patient evaluation, surgical decision-making, graft selection, surgical technique, associated surgical procedures, postoperative rehabilitation, and revision PCL reconstruction results.

Recent Findings Specifically, it is paramount to consider and treat posteromedial and posterolateral instability. Success in revision surgery focuses on appropriate graft choice and precise tunnel placement at anatomical attachment sites. Furthermore, correct tensioning of the graft, secondary or backup fixation and well-designed PT and rehab protocols are integral components. The factors causing failure of the primary reconstruction should be identified, as revision surgery must address the errors and follow strict surgical principals to be successful.

Summary There are many variables that play a role in successful revision posterior cruciate ligament (PCL) reconstruction. In general, as in most ligament reconstruction surgery, it is important to identify and address all associated pathology such as lower extremity malalignment and additional instability.

Keywords PCL · Revision · Graft

Introduction

The posterior cruciate ligament is the primary restraint to posterior tibial translation and also plays a role in rotational stability of the knee. The femoral attachment is the lateral aspect of the medial femoral condyle adjacent to the articular surface, and the tibial attachment is the posterior tibial sulcus. It consists of two bundles—the anterolateral, which is tight in flexion, and posteromedial, which is tight in extension. Posterior cruciate ligament injury is graded by posterior tibial translation relative to the femoral condyles at 90° of flexion, with grade 1 being 1–5 mm of translation, grade 2 as 6–10 mm, and grade 3 as > 10 mm.

Isolated PCL ruptures are rare, but PCL injuries are common findings in multi-ligament knee injuries and knee dislocations. Acute PCL injuries are often treated non-operatively. Those injuries associated with gross instability or multiple ligament knee injury may require reconstruction to stabilize the knee. Chronic PCL deficiency is known to lead to increased patellofemoral and medial compartment contact pressures and thought to progress into early arthritis [1].

The most common reconstruction techniques are transtibial and inlay. As in primary reconstruction, revision surgery is indicated to restore functional stability in a patient with continued desire for increased activity level. Similar to ACL failure, PCL failure is often due to lower extremity malalignment, improper tunnel placement, or unrecognized associated ligamentous injury [2]. Successful revision surgery depends not only on the reconstruction but also in treating concomitant meniscal and chondral injuries.

Indications/Preoperative Assessment

The goal of revision PCL reconstruction is to provide functional stability to the unstable knee. Although pain is a common presentation, the primary focus is treating instability by addressing anterior/posterior translation, varus/valgus instability, and additional pathology in the injured knee.

Thorough preoperative evaluation including physical exam and appropriate imaging is vital to success. A complete set of x-rays including AP, lateral, notch view, and standing hip to

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ankle alignment view are necessary to evaluate tunnel position, overall mechanical alignment, implant type and position, and the presence and amount of arthritis (Fig. 1).

MRI is beneficial to characterize chondral surfaces and meniscal pathology whereas CT is beneficial for characterizing tunnel orientation and osteolysis. Infection should be on the differential in failed reconstruction so labs including CRP and ESR may be indicated, and aspiration with synovial fluid analysis should be considered. Examination under anesthesia, gait analysis, and stress radiographs (lateral stress view) can be useful adjuncts as well.

DePhillipo et al. showed poor sensitivity of MRI in diagnosing chronic PCL tears and PCL reconstruction grafts leading to their use of posteromedial tibial translation measurements. They showed that MRI sensitivity was only 18.1% for identifying PCL graft tears.

If revision surgery is indicated, the surgeon must decide whether it can be done in a single or staged manner and if supplementing osteotomy, chondral procedures, and meniscal work is indicated. Recently, the role of tibial slope has been speculated to play a role in failed ACL and PCL reconstruction, which questions the need for slope changing osteotomy [3•].

Revision PCL is frequently performed in combination with multi-ligamentous reconstruction, and appropriate graft choices for the PCL as well as the other ligament reconstructions are critical. Graft options include patella tendon, quadriceps tendon, or hamstrings auto or allograft or Achilles or tibialis anterior allograft. Some experts prefer allograft for the cruciates in revision surgery and allograft for the collaterals. A recent prospective study showed no statistical difference between autograft, allograft, and hybrid graft in regard to proprioceptive and functional outcomes in PCL reconstruction [4].

Choice of fixation method should be planned and often includes backup fixation techniques to reinforce reconstruction. Hardware removal from prior surgery is often challenging and previous operative reports may be needed to identify implants to have the right equipment available for removal. If bioabsorbable implants were used, these can often be drilled through but osteolysis is a concern and again should be evaluated with a preoperative CT scan.

If staging is indicated, then stage 1 should include hardware removal and bone grafting and stage 2 performed 3–6 months later when CT confirms adequate incorporation of bone graft. Allograft bone dowels have gained popularity and can facilitate revision in one stage with comparable objective and subjective scores [5] (Fig. 2).

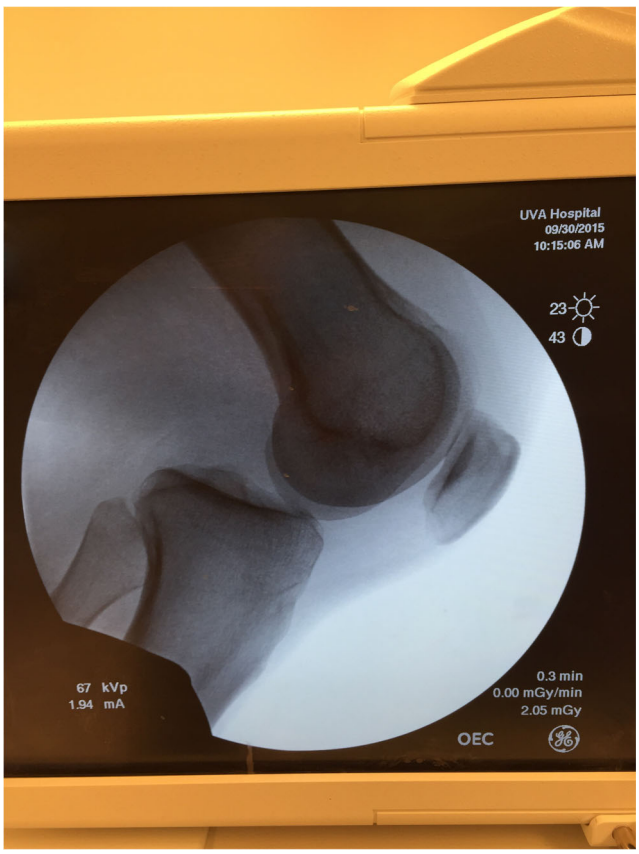

Fig. 1 Grade 3 posterior drawer indicative of PCL and PLC injury

Revision PCL Techniques

The technique for revision PCL surgery must first address and correct the reason for primary failure. Noyes et al. found in a series of 52 failed PCL reconstructions the cause of failure to be multifactorial in 56% [6]. They showed associated posterolateral corner deficiency, improper tunnel placement, and varus malalignment as the most common modes of failure. Proper location of the tibial tunnel is sometimes obscured by capsular

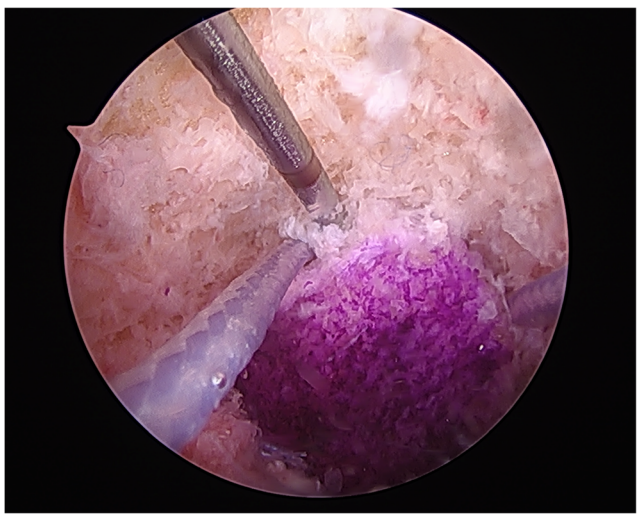

Fig. 2 Revision PCL reconstruction with femoral tunnel drilling after allograft bone dowel placement. The dowel (purple) is used to graft the defect and the new tunnel will be drilled adjacent over the guide wire

adhesions and may require reflection. The tibial tunnel location failure was previously thought to be from too proximal placement leading to decreased ability to resist posterior tibial translation but now that theory is being questioned by anatomic cadaver studies [7]. Fluoroscopy is beneficial in confirming correct pin placement, especially using lateral tibia and femur views. Optimal placement of the femoral tunnel is also paramount and placement too posterior is the most common mistake. In addition, PCL fiber orientation is thought to be more complex at the femoral attachment and can be variable [8]. The PCL fibers on cadaveric dissection showed a continuum of fibers rather than two distinct bundles with significant variation in thickness and shape [9]. Radiographic guidelines from a more recent cadaveric study are available to help with intraoperative assessment of pin placement [7].

Once the reason for failure is clearly understood, the next step is deciding whether the revision will need to be staged or can be performed in one setting. It has been shown that there is a correlation between tibial slope and tibial translation and reconstruction only may be insufficient. If there are alignments or tibial slope issues, then an osteotomy should be considered. Diagnostic arthroscopy facilitates identification and treatment of concomitant meniscal and chondral injuries. Graft material from the prior surgery is excised and hardware removal and bone grafting should be considered. After the determination is made to proceed with reconstruction, the allograft is prepped on the back table or the autograft tissue is harvested and subsequently prepped.

At this point, the surgeon can proceed with transtibial or inlay technique. Shin et al. in a systematic review found no clinical differences between transtibial and inlay in regard to knee scores and stability [10]. Either technique can be used for revision but the surgeon should take into account the previous technique used at the time of the primary PCL reconstruction and the tunnel positions [11]. If the tunnels were adequately positioned and hardware is easily removed, then they can be reused in the revision. If the previous tunnels are poorly positioned but close to where the new tunnels would be, then hardware removal and grafting of the prior tunnels should be considered. If the tunnels are poorly positioned and planned revision tunnels will not be in proximity to them, then hardware can be left and new tunnels can be drilled. If there is any concern about tunnel compromise from prior tunnels, then hardware removal and bone grafting should be considered.

In patients with poor proximal tibia bone stock, the tibial inlay technique may be indicated. A posteromedial safety incision is then made just off the posteromedial border of the tibia about 2 fingerbreadths below the joint line. The fascia is then incised and the interval between the medial head of gastrocnemius and the neurovascular structures posteriorly is created. This incision allows for protection of vital neurovascular structures and to ensure proper PCL tibial tunnel placement. Alternatively, a posteromedial portal can be used for arthroscopic visualization and antegrade or retrograde drilling can ensue without the need for a separate incision. If the tibial inlay technique is used, then a posteromedial incision is used between the semimembranosus and medial head of the gastrocnemius. Richter et al. found that a posteromedial incision can be utilized while avoiding the prone position. By flexing the knee and externally rotating the hip, the incision can be used safely and easily to perform PCL reconstruction [12]. Posterior capsulotomy is made and the PCL graft is secured with a screw and washer.

For a transtibial technique, the PCL guide is placed with the tip at the inferolateral aspect of the PCL insertion site. Once the pin is confirmed in the right position, with fluoroscopy, it is reamed. After the reamer is engaged in the posterior cortex, the pin is reversed to protect plunging with the reamer. The final reaming can also be done by hand as well.

The femoral tunnel may then be drilled inside-out or outside-in depending on preference and to avoid previous hardware (Fig. 3).

The decision to proceed with single-bundle or double-bundle is then made. If a double-bundle method is used, it is imperative to leave an adequate bony bridge between tunnels, usually at least 5 mm. Specific aimers or double-bundle guides can help facilitate adequate tunnel placement but each tunnel should be checked under arthroscopic visualization. The tunnels are then reamed at approximately 100° of flexion. The graft is then secured on the femoral side, usually with interference screw fixation. The tibia is then reduced on the femur and the knee is cycled several times. The knee is then flexed to approximately 90°of flexion and the graft is fixed on the tibial side with an interference screw. This is our preferred technique.

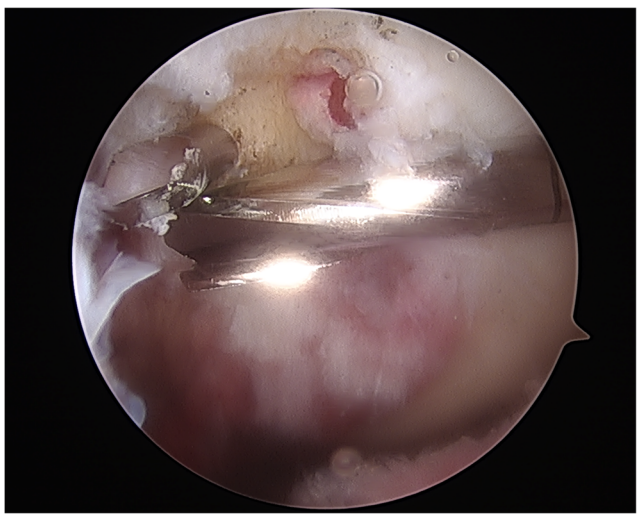

Fig. 3 Arthroscopic image of outside-in PCL femoral tunnel drilling with the superior guide pin marking the single-bundle PCL footprint and the inferior guide pin for the ACL coming in from the accessory anteromedial portal

Backup fixation is usually made on the tibial side using a button, screw and washer or suture anchor. In revision surgery, backup fixation is encouraged and often essential due to compromised bone stock [13]. Double-bundle fixation may be warranted in severe hyperextension. If the double-bundle technique is used, the anterolateral bundle is tensioned at 90° and the posteromedial bundle is tensioned in extension. It is paramount to ensure that full range of motion is present on the table prior to closure.

Outcomes

Overall several studies have shown that revision PCL reconstruction has shown significant relief in pain, stability, and function [2, 6, 10, 14, 15•, 16]. Fanelli et al. reported 75% of patients returned to preinjury Tegner activity scale level of function. In addition, mean HSS and Lysholm scores were 81.5 and 87.3.

Lee et al. noted that 41% of PCL reconstructions failed due to one factor whereas 59% failed due to multiple factors. They noted the most common reasons for failure were unaddressed posterolateral rotatory instability and improper tunnel placement. Their findings showed significant results in postoperative side-to-side differences on posterior stress radiography and IKDC and OAS scores.

DePhillipo et al. noted significant differences in medial compartment posterior tibial translation and showed a cut-off of 3.6 mm in detecting graft failure [17•]. Lee et al. showed statistically significant improved side-to-side differences on posterior stress radiography and improved subjective and objective clinical scores with revision PCL reconstruction [18].

Complications

The most devastating complication of PCL revision is damage to neurovascular structures in the posterior knee, specifically the popliteal artery. Other complications include residual instability, arthrofibrosis, and infection [6].

Future Direction

Weber et al. described an all-arthroscopic tibial inlay double-bundle PCL reconstruction and found comparable clinical and radiographical outcomes to isolated PCL reconstruction and multi-ligamentous reconstruction techniques [19].

Conclusion

Revision PCL reconstruction has shown good outcomes in regard to function, stability, and pain relief. The goal of any revision surgery is to address failures in the primary reconstruction and restore stability and return to desired activity level. Although every case should be individualized, successful revision can be achieved by following a systematic approach. Incorporating properly positioned tunnels, addressing other causes of instability such as posteromedial and posterolateral, confirming no lower extremity malalignment, proper tensioning with adequate primary and backup fixation and standardized rehabilitation allow the best chance for an optimal outcome.

Compliance with Ethical Standards

Conflict of Interest Both authors declare that they have no conflict of interest.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

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