INTRODUCTION

Posterior cruciate ligament (PCL) disruption occurs in isolation and in association with damage to other knee ligaments. Isolated PCL injury is typically caused by a force applied to the anterior tibia with the knee in a flexed position, such as the dashboard mechanism in a motor vehicle collision. Combined PCL and other knee ligament injuries are usually caused by higher energy trauma. Regardless of mechanism, appropriate assessment and treatment decision-making rely on an accurate history, thorough physical examination, and appropriate imaging. A comprehensive knowledge of the anatomy and biomechanical function of the PCL is crucial for surgical management. While controversies exist in PCL reconstruction methods, graft selection, and rehabilitation protocols, we will focus on the all-inside PCL reconstruction technique and the current evidence to support our preferred technique.

OPERATIVE TREATMENT

Controversies persist regarding the optimal surgical reconstruction technique for PCL disruption. Options include the arthroscopic transtibial technique, the open inlay technique, and more recently, the arthroscopic inlay technique. In regards to the graft, options include single bundle anterolateral reconstruction versus double bundle anterolateral with posteromedial bundle reconstruction using either allograft or autograft. The bone tunnels may be positioned utilizing an inside-out or outside-in technique. Newer all inside PCL reconstruction techniques are currently being developed.

**Transtibial versus Inlay**

The most common technique for PCL reconstruction utilizes the arthroscopic transtibial technique in which a tunnel is drilled through the tibia from anterior to posterior. The graft is passed through the tibia, making a sharp angle, or so-called “killer turn” up to the femur. This sharp angle has been implicated in graft failure and increased laxity due to the increased tissue stress and potential for graft thinning and lengthening. An alternate technique for tibial fixation is the open inlay technique. This technique requires a posterior arthrotomy in order to attach the bone block from the graft to the posterior tibia using a washer and screw construct. The inlay technique allows the surgeon to attach the graft to the tibia in an anatomic fashion and allows for more physiologic forces to the graft. More recently, authors have described an arthroscopic inlay technique utilizing a retrograde technique to ream the tibia and allow for the anatomic fixation of the PCL graft with decreased morbidity or in the skeletally immature.

Several authors have biomechanically studied tibial tunnel and tibial inlay PCL reconstruction techniques. Both Markolf et al. and McAllister et al. compared the mechanical response of allograft PCL reconstructions after either the transtibial or inlay technique in cadaveric knees and found all grafts that failed occurred in reconstructions using the transtibial technique and failed at the “killer turn.”
From a clinical standpoint, we performed a systematic review of transtibial versus inlay posterior cruciate ligament reconstruction and found no important advantage of one technique over another.\textsuperscript{10} Review of subjective outcomes revealed overall satisfactory outcomes with both techniques. Objective outcomes also showed no significant difference between the transtibial and inlay techniques.

**Single Bundle versus Double Bundle**

There are a variety of techniques for single bundle PCL reconstruction, but it is universally accepted that a single bundle PCL reconstruction should reconstruct the anterolateral (AL) bundle of the PCL. As discussed previously, some authors prefer a transtibial technique and some prefer the inlay technique for tibial fixation. The femoral tunnel is placed at the anatomic footprint of the AL bundle and can be drilled in an inside-out or outside-in method.

Several authors have shown satisfactory outcomes for ligament stability, stress radiography, arthrometer testing, and functional outcomes including IKDC and Lysholm scores with single bundle PCL reconstruction using all types of grafts.\textsuperscript{11-13}

Biomechanical comparison has shown no distinct advantage in regards to AP laxity for either single or double bundle reconstruction techniques.\textsuperscript{20,22,23} However, Whidden et al. found that in the setting of PLC deficiency, double bundle reconstructions had less posterior translation, but this difference was eliminated with the PLC reconstructed.\textsuperscript{23} Tsukada et al. also found that double bundle reconstructions had decreased posterior translation when both a posterior force with external tibial torque applied.\textsuperscript{20} These findings suggest double bundle PCL reconstruction may have an advantage in the setting of a combined posterolateral corner injury, though further study is needed.

From a clinical perspective, several authors have compared outcomes after single and double bundle PCL reconstruction using clinical examination; functional outcomes scores such as IKDC, Lysholm, and Tegner scores; stress radiography; and arthrometry. Wang et al. found no significant difference in functional assessments, functional outcomes scores, ligament laxity, or radiographic changes at final follow-up.\textsuperscript{18} Yoon et al. showed the double bundle reconstruction had 1.4 mm decreased posterior tibial displacement and was superior on IKDC examination forms when compared to single bundle reconstruction. However, there was no significant difference between single and double bundle reconstruction for any of the other evaluation methods.\textsuperscript{15} When comparing stress radiography, KT-1000 arthrotomy, Tegner, Lysholm, and Hospital for Special Surgery knee outcomes scores, Fanelli et al. found no significant difference in any of the parameters tested.\textsuperscript{24}

**Outside-in versus Inside-out Femoral Tunnel Preparation**

Placement of the femoral tunnels can be performed with either a traditional outside-in or an alternative inside-out technique. For the outside-in technique, the tunnels are drilled using a guide and starting from the medial aspect of the knee so they enter the intercondylar notch from outside the femoral cortex. This technique does require an extra incision and violates the vastus medialis oblique (VMO) muscle in order to pass the drill. The inside-out technique was developed as advances in arthroscopic repair made it more feasible. With this technique, the tunnels are drilled via the inferolateral portal, starting within the intercondylar notch and drilling through the medial femoral cortex. This technique avoids violating the VMO, as well as allowing for drilling of the tunnel directly through the anatomic footprint of the PCL. This method does create a larger graft-femoral tunnel angle which some surgeons feel can lead to graft loosening or failure due to increased bending of the graft, much like the “killer turn” for tibial tunnels.

Handy et al.\textsuperscript{25} and Schoderbek Jr. et al.\textsuperscript{26} performed a biomechanical comparison of the outside-in and inside-out techniques for femoral tunnel placement and concluded that the outside-in technique reduces the graft-femoral tunnel angle. Clinically though, this difference may not be relevant as many authors have had good outcomes using the inside-out technique\textsuperscript{11,14,18,24,37} and the outside-in technique.\textsuperscript{15,16}
**Autograft versus Allograft**

Very few studies directly compare autograft to allograft PCL reconstruction. Wang et al. found no significant difference in objective or subjective outcomes between graft types.²⁹ Ahn et al. found a significantly greater Lysholm score in the autograft group (90.1) compared to the allograft group (85.8) but no significant difference between the two groups when comparing IKDC score and posterior tibial displacement on stress radiographs.³⁰

We recently performed a systematic review comparing allograft versus autograft use in PCL reconstruction and could not identify a significant advantage to either graft source.²⁸ Subjectively, at final follow-up of at least two years, both autograft and allograft reconstruction produced satisfactory outcomes in all measures with no appreciable difference. Objective findings at last clinical follow-up also showed no difference between the graft types.

**ALL-INSIDE PCL RECONSTRUCTION SURGICAL TECHNIQUE**

**Patient Positioning**

The patient is positioned supine on the operating table, perioperative antibiotics are administered and general anesthesia is induced. Both knees are examined to assess the integrity of the cruciate and collateral ligaments. The operative leg is prepped and draped in standard fashion with a tourniquet is place high on thigh.

**Graft Preparation**

A tibialis anterior or peroneus longus graft with a minimum length of 36 cm is prepared using a ______ preparation board. A _______ RT is placed on the femoral end and a _______ ABS is placed on the tibial end. Two circumferential 0 ______ sutures incorporating all 4 tendon strands are placed at 1 and 2.5 cm from each end of the graft. These sutures create a coupled, 4-stranded construct with a total length of 95 – 100 mm. The graft is then placed on the board under 20 mm of tension.

**Arthroscopic “All-Inside” PCL Reconstruction**

Standard superomedial, inferomedial, inferolateral, and accessory inferomedial portals are placed. A diagnostic arthroscopy documents all osseous, chondral, meniscal, and ligamentous pathology. After a thorough assessment of the knee, an accessory posteromedial portal is created to release the tibial footprint of the native PCL in-between the mammillary bodies. The PCL guide is then placed through the AM portal and positioned proximal to the distal edge of the PCL facet. Fluoroscopy and/or arthroscopic visualization through the posteromedial portal are used to confirm proper guide placement. The drill sleeve is placed flush on the tibia and the total intraosseous distance is measured. A guide wire is then drilled and proper placement can be confirmed with fluoroscopy. With the guide in position, the guide wire is removed and the 12 mm __________ (Arthrex, Naples, FL) is advanced through the posterior cortex of the tibia. The __________ is then deployed and a 35 - 40 mm socket is created. The PCL guide acts to protect the neurovascular bundle during guide wire placement and reaming.

After clearing out the tibial socket, a passing suture is then placed through the drill sleeve into the joint and retrieved out the inferomedial portal.

**Femoral Preparation**

Our preferred technique is an inside-out, single, anterolateral bundle reconstruction. PCL fibers are debrided from the lateral wall of the medial femoral condyle with retention of the anterolateral bundle footprint to aid femoral socket placement. A spade tip guide wire centered on the anatomic footprint of the anterolateral bundle is drilled out the medial cortex of the femur. The intraosseous distance is measured from the guide wire for later graft passage. An 11 or 12 mm reamer placed over the guide wire is used to create the femoral socket to a minimum depth of 25mm. A passing suture is then pulled into the joint and retrieved out the inferomedial portal for later graft passage.
Completing the Reconstruction

The sutures from both femoral and tibial sockets (Figures 1 a-b) are pulled through the accessory inferolateral portal for graft passage. The tibial end of the graft is inserted first into the joint and deep into the tibial socket. With tension on the graft, the femoral side is inserted into the femoral socket. The femoral __________ device is brought through the medial cortex while maintaining counter-tension at the femoral tip of the graft and the button is deployed. The __________ sutures are sequentially tensioned to insert the graft into the socket to a depth of approximately 20 mm.

![Figure 1A](image1.png) ![Figure 1B](image2.png)

Tension is placed on the tibial side of the graft with the knee flexed to 90 degrees. The arthroscope is placed in the posteromedial portal to verify a minimum of 20mm of tibial graft within the socket (Figure 2 a-b). If there is excess graft in the tibial socket, additional graft is pulled into the femoral socket. The 40 mm deep tibial socket ensures that the graft can be tensioned without bottoming out.

![Figure 2A](image3.png) ![Figure 2B](image4.png)

Final graft tensioning and fixation are performed with the knee flexed to 80 degrees. The ABS button is attached to the tibial tightrope and the sutures are sequentially tightened to inset the graft into the tibial socket. Alternate tensioning of both femoral and tibial __________ sutures maximizes graft tension. Backup fixation on the tibial side is achieved by securing the graft sutures with an anchor or screw-post construct. Final anteroposterior and lateral radiographs are shown (Figure 3 a-b).

![Figure 3A](image5.png) ![Figure 3B](image6.png)
POST-OPERATIVE REHABILITATION

Rehabilitation protocols should be individualized according to the specific surgical procedures performed. We prescribe the rehabilitation protocol of Fanelli et al. because of the excellent reported outcomes over time.\textsuperscript{31,32} We apply a standard rehabilitation brace and if a collateral repair/reconstruction is performed, mold the brace in the operating room in order to unload the medial- or lateral-side reconstruction as indicated. The rehabilitation brace is locked in full extension for a minimum of three weeks and the patient is allowed toe-touch weightbearing only for six weeks after surgery. Knee range of motion begins at week 4 with prone, passive flexion to protect the posteriorly based reconstruction. Progressive resistance, closed kinetic chain strength training, along with proprioceptive exercises are also instituted after 6 weeks. Open kinetic chain hamstring strengthening exercises are avoided until 6 months following surgery. At 2 months following surgery, a custom unloader brace with a slight varus or valgus moment as indicated is prescribed. The patient wears this brace for all weight-bearing activities during the first year after surgery and then for all athletic activities thereafter.

SUMMARY

Advances in PCL reconstruction have led to the development of less invasive procedures. The all-inside technique is an arthroscopic method using tibial and femoral sockets, extracortical fixation and a high strength graft. Early results are promising, but research is necessary to document clinical outcome.
REFERENCES