Articulated Bone Block for Posterior Cruciate Ligament Reconstruction Using Bone—Patellar Tendon—Bone Autograft: Surgical Technique to Facilitate Graft Passage

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Abstract: Posterior cruciate ligament reconstruction using the transtibial technique provides successful clinical outcomes. However, a bone—patellar tendon—bone (BTB) autograft with the transtibial technique has not been used by some surgeons because of concerns with graft passage from the tibial to the femoral tunnels (sharp turn) that can damage graft fibers. In the present surgical technique, an arthroscopic, transtibial, single-bundle technique for posterior cruciate ligament reconstruction using the BTB autograft with an easy and effective technical tip to facilitate graft passage is presented. Once the BTB is harvested, the femoral bone block is divided into 2 equal-sized blocks providing an articulated structure while preserving the tendon component. This facilitates the passage of the BTB tendon once it is entered in the posterior tibia and the graft has to make a sharp turn to reach the femoral tunnel. This easy and effective technique tip may avoid graft damage during the sharp turn, while maintaining all the advantages of a BTB autograft (bone-to-bone healing, own tissue with fast incorporation, and strong fixation and stability).

Posterior cruciate ligament (PCL) reconstruction is a challenging procedure for which several surgical techniques and types of graft have been described. In general, clinical outcomes are satisfactory using the transtibial and tibial inlay reconstruction techniques. However, the better graft choice is controversial. There are 3 most common types of graft used in PCL reconstruction:

Bone—patellar tendon—bone (BTB) autograft or allograft, hamstring tendon autograft or allograft, or Achilles tendon allograft. Although BTB autograft is the technique of choice by many surgeons for the anterior cruciate ligament reconstruction, concerns with graft passage during the transtibial technique made some surgeons abandon this type of graft in favor of the hamstring tendons or Achilles allograft. It has been demonstrated that the sharp turn during graft passage from the tibial to the femoral tunnel may damage graft fibers. The purpose of this Technical Note is to report an arthroscopic single-bundle transtibial technique for PCL reconstruction using the BTB autograft with an easy and effective technical tip to facilitate graft passage.

Surgical Technique

Intercondylar notch and footprint debridement

Intravenous anesthesia and femoral block is typically used in all cases. The patient is placed in the supine position with the knee flexed and the leg and foot hanging over the end of the bed, and the contralateral leg in hip flexion and abduction in a leg holder. The operative extremity is prepared and draped in the usual fashion for routine knee

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Table 1. Summary of Key Points of the Surgical Technique

| Step-by-Step Technique                          | Description of the Steps                                                                                                                                                                                                 |
|------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| **Step 1: Debridement of intercondylar and femoral PCL remnants** | **Visualization:** arthroscopic in the anterolateral portal  
**Instruments:** shaver and tissue ablation device from the anteromedial portal  
**Technique:** debridement of PCL remnants in the intercondylar notch and femoral attachment |
| **Step 2: Debridement of tibial attachment of the PCL** | **Visualization:** arthroscopic in the anterolateral portal first, and in the posteromedial portal after  
**Instruments:** shaver and tissue ablation device from the anterolateral portal  
**Technique:** the posteromedial portal is first created using an 8.5-mm cannula. Then, the tibial attachment is debrided with a shaver and tissue ablation device from both the posteromedial and anterolateral portals |
| **Step 3: Graft harvest** | Longitudinal skin incision centered over the patellar tendon. Harvest of the central third of the patellar tendon with 10 mm × 10 mm bone blocks |
| **Step 4: Graft preparation** | A small saw is used to cut the femoral bone block at its midpoint taking care not to damage the tendinous part. Place two 2.4-mm drill holes in the upper and lower thirds of the femoral bone block, and a single one at the center of the tibial bone block. Then, a nonabsorbable suture is looped around the 2 drill holes and through the articulated part of the bone block |
| **Step 5: Tibial tunnel preparation** | **Visualization:** arthroscopic in the posteromedial portal  
**Instruments:** PCL tibial guide, 2.4-mm drill, and 10-mm reamer  
**Technique:** the PCL tibial guide is placed in the PCL footprint with the bifurcated tip in the champagne-glass drop-off line, and a 2.4-mm drill advanced to the joint under direct visualization through the posteromedial portal. Then, once the entry point in the tibial footprint is confirmed, the 10-mm reamer is used to create a tunnel from the tibial proximal cortex to the PCL footprint |
| **Step 6: Femoral tunnel preparation** | **Visualization:** arthroscopic in the anterolateral portal  
**Instruments:** PCL femoral guide, 2.4-mm drill, and 10-mm reamer  
**Technique:** the PCL femoral guide is placed in the anatomic location leaving 8 mm between the center of the guide and the bone-cartilage interface. Then, a 2.4-mm drill is used and the 10-mm reamer afterward to create a femoral tunnel at the medial femoral condyle to the PCL femoral footprint |
| **Step 7: Graft passage** | **Visualization:** arthroscopic in posteroomedial portal  
**Instruments:** transport suture, probe (if necessary)  
**Technique:** a transport suture is placed connecting both tunnels. Then the graft is brought into the joint through the tibial tunnel, and a probe may be used to assist in the sharp turn in the back of the tibia. Then, the arthroscope is placed in the anterolateral portal and the probe in the anteroomedial portal to assist in the final graft positioning in the femoral tunnel |
| **Step 8: Femoral graft fixation** | **Visualization:** arthroscopic in the anterolateral portal  
**Instruments:** Nitinol flexible wire, tap, and screw  
**Technique:** the Nitinol flexible wire is placed proximal to distal and medial to lateral from the medial aspect of the medial femoral condyle to the PCL femoral footprint, and the tap first (if needed) and the interferential screw used (typically 10 mm × 25 mm for a 10-mm-diameter tibial tunnel) |
| **Step 9: Tibial graft fixation** | **Visualization:** arthroscopic in the posteroomedial portal  
**Instruments:** Nitinol flexible wire, tap, and screw  
**Technique:** the Nitinol flexible wire is placed distal to proximal from the anteromedial cortex of the proximal tibia, and the tap first (if needed) and the interferential screw used (typically 10 mm × 25 mm for a 10-mm-diameter tibial tunnel). The graft should be fixed at 60° of knee flexion and correcting the posterior tibial displacement |

PCL, posterior cruciate ligament.
arthroscopy. The procedure can be performed using a standard 30° arthroscope. The anteromedial and anterolateral portals are created close to the patellar tendon to facilitate the visualization of the posteromedial and posterolateral aspects of the knee. The step-by-step technique and its pitfalls/risks with corresponding solutions have been summarized in Tables 1 and 2. The PCL remnants in the intercondylar area and femoral insertion are removed using the shaver and tissue ablation device through the anteromedial portal while the arthroscope is in the anterolateral portal.

The next step is to excise the tibial attachment of the PCL. The arthroscope is used to visualize the posteromedial aspect of the knee through the anterolateral portal. Under direct visualization, a spinal needle is used to gain access to the posteromedial knee and then an 11-blade knife is used to create an opening within the capsule that is big enough to place a cannula. An 8.5-mm-diameter threaded cannula is recommended in case a curved shaver has to be used. A tissue ablation device is placed in the posteromedial portal under direct visualization from the anterolateral portal, and the tibial attachment of the PCL is removed. A curved shaver can also be used from the posteromedial portal provided the instrument is never used facing the posterior capsule. The arthroscope can also then be placed in the posteromedial portal and the instruments in the anterolateral portal to complete the tibial PCL attachment debridement.

**Graft Harvest and Preparation**

The arthroscope is removed from the joint and the tourniquet inflated. The central third of the BTB is harvested in a routine manner. A longitudinal skin incision centered over the patellar tendon from the inferior pole of the patella to the tibial tubercle is made. After opening the paratenon, a 10 mm size (for both femur and tibial sides) BTB autograft is typically harvested. A knife is used to cut the patellar tendon longitudinally in the central third from the inferior pole.

| Pitfalls/Risks | Solutions |
|---------------|-----------|
| Damage to the saphenous nerve | • Use of a knife only for skin  
• Use of straight mosquito to dilate the capsule opening |
| Damage of the popliteal neurovascular bundle | • Leave at least 6 cm of space between the gastrocnemius and the operating table  
• Work with the knee at 90° of flexion  
• Avoid working on the coronal plane with instruments from the posteromedial portal (keep them always directed anteriorly usually at approximately 30°) |
| Difficult graft passage in the tibial tunnel | • The shaver should always be used facing anteriorly and never toward the posterior capsule  
• Adequate positioning of the tip of the PCL tibial guide, and careful advancement of the 2.4-mm drill into the joint. Use fluoroscopy if needed |
| Difficult graft passage from the most proximal part of the tibial tunnel to the intercondylar notch | • Use a curved curette to the tip of the drill guide to protect the popliteal space while using the 10-mm reamer |
| Difficult graft passage in the intercondylar notch | • Complete removal of PCL remnants and any osteophyte in the medial femoral condyle |
| Difficult graft passage in the femoral tunnel | • Use of an articulated bone block, as described above  
• Use of a probe from the anteromedial portal (arthroscope in the anterolateral portal) to assist in graft entrance into the femoral tunnel |
| PCL, posterior cruciate ligament. | |
of the patella to the tibial tubercle. Then a saw first and an osteotome next are used to finalize BTB harvest. Care must be taken to prevent bone block breakage by avoiding the lever on the bone with the osteotome.

The patellar bone block is cut in the middle leaving 2 equal parts (Fig 1, Video 1). A small saw is first used and then the finalization of the cut is made by hand (Video 1). Care must be taken to preserve the tendon tissue intact so that both bone blocks are not disconnected during graft passage. A 2.4-mm drill is used to create a hole into each bone block of the patellar side, and a single one at the center of the tibial bone block. A nonabsorbable suture is looped around the 2 drill holes and through the articulated part of the bone block and the tendon-to-bone interface, so as to create a figure-of-eight-like loop (Fig 2, Video 1).

Tunnel Preparation

The tibial tunnel is created using an Acufex PCL tibial guide (Smith & Nephew, Andover, MA). The arthroscope is placed in the posteromedial portal and the tip of the tibial guide is positioned at the champagne-glass drop-off. A 2.4-mm drill is advanced with caution until it is visualized. Then, a 10-mm reamer is advanced with the protection of a curved, angled curette to create the tibial tunnel.

The arthroscope is switched to the anterolateral portal and the Acufex PCL femoral guide (Smith & Nephew) is positioned leaving 8 mm between the center of the guide and the bone-cartilage interface. A 2.4-mm drill is used outside-in after a small incision is made in the lateral aspect of the knee and a 10-mm reamer used afterward to create the femoral tunnel. Then, a transport suture is used to connect both tunnels.

Graft Passage and Fixation

The arthroscope is placed in the posteromedial portal, and the graft is brought into the joint through the tibial tunnel (Figs 3 and 4, Video 1). A probe may be used to assist in the sharp turn at the back of the tibia, where the articulated femoral bone block of the graft will be extremely useful to avoid tendon fiber damage (Figs 3 and 4, Video 1). Once the femoral side of the graft is in the intercondylar area, the arthroscope is placed in the anterolateral portal and the BTB graft is entered in the femoral tunnel also with the help of a probe. Then, an outside-in Nitinol wire is placed proximal to distal and medial to lateral through the lateral incision (Figs 3 and 4, Video 1), and an interference screw is placed in the femoral tunnel from outside the joint medially until the tip is observed from the anterolateral portal and left flush with the medial wall of the intercondylar notch. A Biosure (Smith & Nephew) bioabsorbable interference screw with the same diameter as the femoral tunnel is typically used (most commonly a 10 mm × 25 mm screw for a 10-mm tunnel). Several cycles of flexion-extension may be performed at this point to assure adequate fixation of the femoral side and rule out impingement or obvious asymmetry in graft tension.
throughout the range of motion. Then the arthroscope is placed in the posteromedial portal to visualize the Nitinol wire entering the posterior aspect of the joint from the proximal anterior cortex of the tibia. A Biosure (Smith & Nephew) bioabsorbable interference screw is also used for the tibial side, assuring adequate tension. The interference screw typically has the same diameter as the tibial tunnel (most commonly a 10 mm × 25 mm screw for a 10-mm tunnel). The graft is fixed at 60° of flexion but, most importantly, making sure that the posterior tibial displacement has been corrected. Although the diameter of the femoral and tibial screws is typically the same as the diameter of the last reamer used, this has to be adapted depending on the quality of the bone.

**Discussion**

This Technical Note describes an easy and helpful technical tip to facilitate graft passage and avoid the killer turn during PCL reconstruction using a BTB autograft. This method creates an articulated femoral bone block in the patellar side of the autograft, which allows easy graft passage from the tibial to the femoral tunnels in the transtibial technique. The clinical relevance of this technical tip is that it keeps the advantages of an autologous BTB autograft (bone-to-bone healing,

![Fig 3. Arthroscopic view of the left knee showing the bone–patellar tendon–bone autograft passage inside the joint from the tibial to the femoral tunnel. (A) Arthroscopic view from the posteromedial portal demonstrating the entrance of the articulated femoral bone block into the joint from the back of the tibia. Note that the tendon tissue (asterisk) is preserved and is key to avoid both bone blocks to separate. (B) Arthroscopic view from the anterolateral portal demonstrating the entrance of the articulated femoral bone block into the femoral tunnel. A probe (black arrow) is used to assist placing the graft into the femoral tunnel. Note how the articulated bone block (asterisk) is extremely helpful to facilitate graft positioning into the femoral tunnel. (MFC, medial femoral condyle; MTP, medial tibial plateau; PC, posterior capsule; PCL, posterior cruciate ligament.)](image)

![Fig 4. Drawing of the left knee demonstrating the articulated femoral bone block technique for posterior cruciate ligament reconstruction using the bone–patellar tendon–bone autograft. (A) Passing of the bone–patellar tendon–bone autograft through the tibial tunnel. Note how a probe through the cannula placed in the posteromedial portal is used to aid in graft passage. (B) Positioning the bone–patellar tendon–bone autograft in the femoral tunnel with the aid of a probe. Note how the posterior displacement of the tibia is corrected (the anterior cruciate ligament is tighter) when the posterior cruciate ligament is reconstructed.](image)
own tissue, fast graft incorporation, and strong fixation and stability) while minimizing a described downside of this type of graft (difficult graft passage—killer turn).

The transtibial and the tibial inlay techniques for PCL reconstruction have essentially provided equally satisfactory clinical outcomes. However, many surgeons have abandoned the use of a BTB autograft when using the transtibial technique because of difficult graft passage at the back of the tibia, the so-called killer turn. The killer turn has been suggested to damage graft fibers. This made some surgeon to either switch to the tibial inlay or, most commonly, to change the type of graft to the hamstring tendon autograft or Achilles allograft. Nevertheless, the BTB autograft offers many potential advantages: bone-to-bone healing, own tissue, fast graft incorporation, and strong fixation and stability.

In conclusion, the use of an articulated femoral bone block facilitates graft passage during PCL reconstruction using a BTB autograft with the transtibial technique. This technical tip avoids graft damage during the killer turn and keeps the advantages of a BTB autograft: bone-to-bone healing, own tissue, fast graft incorporation, and strong fixation and stability.

### Table 3. Advantages and Disadvantages of the Surgical Technique

| Advantages                                      | Disadvantages                      |
|------------------------------------------------|------------------------------------|
| Use of a BTB autograft allows the use of own tissue and bone-to-bone healing | Donor site morbidity |
| Use of a postomedial viewing portal allows an adequate and anatomic positioning of the tibial tunnel, and avoids the need for intraoperative radiation from the use of fluoroscopy | Increased operative time |
| An articulated femoral bone block facilitates graft passage and avoids the deleterious effects of a sharp turn to the tendon fibers | |

BTB, bone–patellar tendon–bone.

### References

1. Mariani PP, Adriani E, Santori N, Maresca G. Arthroscopic-assisted posterior cruciate ligament reconstruction using patellar tendon autograft: A technique for graft passage. *Arthroscopy* 1996;12:510-512.
2. Bergfeld JA, McAllister DR, Parker RD, Valdevit AD, Kambic HE. A biomechanical comparison of posterior cruciate ligament reconstruction techniques. *Am J Sports Med* 2001;29:129-136.
3. Song EK, Park HW, Ahn YS, Seon JK. Transtibial versus tibial inlay techniques for posterior cruciate ligament reconstruction: Long-term follow-up study. *Am J Sports Med* 2014;42:2964-2971.
4. MacGillivray JD, Stein BE, Park M, Allen AA, Wickiewicz TL, Warren RF. Comparison of tibial inlay versus transtibial techniques for isolated posterior cruciate ligament reconstruction: Minimum 2-year follow-up. *Arthroscopy* 2006;22:320-328.
5. Kitamura N, Yasuda K, Yamanaka M, Tohyama H. Biomechanical comparisons of three posterior cruciate ligament reconstruction procedures with load-controlled and
displacement-controlled cyclic tests. Am J Sports Med 2003;31:907-914.

6. Chen CH, Chou SW, Chen WJ, Shih CH. Fixation strength of three different graft types used in posterior cruciate ligament reconstruction. Knee Surg Sports Traumatol Arthrosoc 2004;12:371-375.

7. Lin YC, Chen SK, Liu TH, Cheng YM, Chou PP. Arthroscopic transtibial single-bundle posterior cruciate ligament reconstruction using patellar tendon graft compared with hamstring tendon graft. Arch Orthop Trauma Surg 2013;133:523-530.

8. Maruyama Y. Shitoto K. Baba T. Kaneko K. Evaluation of the clinical results of posterior cruciate ligament reconstruction—a comparison between the use of the bone tendon bone and semitendinosus and gracilis tendons. Sports Med Arthrosc Rehabil Ther Technol 2012;4:30.