Technical Note

Combined Posterior Cruciate Ligament and Superficial Medial Collateral Ligament Knee Reconstruction: Avoiding Tunnel Convergence

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Abstract: Combined posterior cruciate ligament (PCL) and medial collateral ligament (MCL) injuries represent a complex pathology that requires a thorough clinical and radiographic examination to diagnose and identify all injured structures. Anatomic reconstruction of the injured ligaments is recommended, including double-bundle PCL reconstruction and superficial MCL augmentation. In the setting of this complex reconstruction, several technical aspects require consideration and preoperative planning, including the risk of femoral tunnel convergence on the medial aspect of the femoral condyle. This article details our technique for combined anatomic double-bundle PCL reconstruction and superficial MCL augmentation to avoid tunnel convergence. Level I (knee); level II (PCL).

Anatomic double-bundle posterior cruciate ligament reconstruction (PCLR) has been shown to better restore anatomy and knee kinematics[1] as well as improve objective measures of posterior translation and International Knee Documentation Committee scores[2-4] in comparison to single-bundle reconstruction. Superficial medial collateral ligament augmentation using semitendinosus and gracilis autograft has been reported to restore near-native stability to the medial side of the knee.[5,6] Techniques for isolated double-bundle PCLR[7] and superficial medial collateral ligament (sMCL) augmentation[8] have previously been described.

Femoral and tibial tunnel convergence is a risk of multiple concurrent ligament reconstructions. The tunnel location for anatomic reconstruction has been defined,[6,9,10] as have the optimal intertunnel relationships to avoid convergence (Fig 1).[11,12] The purpose of this article is to describe our technique for combined anatomic double-bundle PCL reconstruction and superficial MCL augmentation to avoid tunnel convergence.

Surgical Technique

Details of the technique are shown in Video 1. Pearls and pitfalls of the technique and advantages and

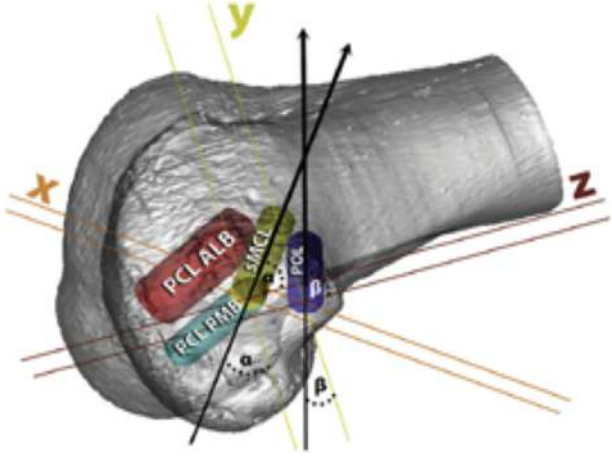

Fig 1. To avoid collision with the posteromedial bundle (PMB) of the posterior cruciate ligament (PCL), the superficial medial collateral ligament (sMCL) should be aimed 40° anteriorly and proximally (with the patient in the supine position, the surgeon drops the hand, and the reamer aims 40° up and 40° toward the hip joint). ALB, anterolateral bundle. Reprinted with permission from Moatshe et al.[11]

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Table 1. Pearls and Pitfalls

Pearls	Pitfalls
An anteromedial incision will facilitate easier PCL tunnel drilling.	When drilling the sMCL tunnel, aiming at 0° in the axial and coronal plane risks convergence with the ALB and PMB tunnels.
When drilling the sMCL tunnel, aim 20° to 40° anteriorly and 40° proximally to avoid tunnel convergence.	
The PCL grafts should be tensioned and fixed on the tibia before proceeding with sMCL femoral fixation.	

ALB, anterolateral bundle; PCL, posterior cruciate ligament; PMB, posteromedial bundle; sMCL, superficial medial collateral ligament.

disadvantages are described in Tables 1 and 2, respectively. Details of the surgical technique for both isolated double-bundle PCLR[13] and superficial MCL augmentation[8] can be found in individual technique articles; however, salient points regarding combined reconstruction and avoiding tunnel convergence are summarized below.

Objective Diagnosis

Combined PCL and MCL knee injuries should be diagnosed through accurate physical examination and imaging methods (standard and stress radiographs and magnetic resonance imaging).

Indications and Contraindications

Surgical management of acute PCL and sMCL injuries is indicated when there are multiligament injuries or a knee dislocation involving these structures.[14] Regarding chronic PCL injury, indications include functional limitations resulting from the PCL tear (e.g., difficulty with deceleration, incline descent, or stairs) and PCL stress radiographic laxity >8 mm in a symptomatic patient.[15] Regarding chronic grade III MCL injuries, surgery is indicated when functional rotatory or side-to-side instability persists despite conservative therapy, including bracing and a rehabilitation program for at least 6 weeks after injury.

Patient Positioning and Anesthesia

The patient is placed in the supine position on the operating table. After induction of general anesthesia, a bilateral knee examination is performed to evaluate for any concurrent ligamentous instability and to assess knee range of motion. A well-padded thigh tourniquet is placed on the operative leg, which is placed into a leg holder (Mizuho OSI, Union City, CA). The contralateral knee is placed into an abduction stirrup (Birkova Products, Gothenburg, NE), and the foot of the operating table is lowered, allowing the surgeon to freely manipulate the knee as needed.

Graft Preparation

For the double-bundle PCLR technique, Achilles tendon and anterior tibialis allografts are prepared in the fashion previously described.[13]

Surgical Approach

A skin incision is made on the anteromedial aspect of the knee between the adductor tubercle and medial aspect of the patella, extending ~7 to 8 cm distal to the joint line, which also facilitates creation of the PCL tibial tunnel. Semitendinosus and gracilis tendons are identified, and an open-ended hamstring stripper (Smith & Nephew, Andover, MA) is used to detach them proximally. Two double-loaded suture anchors (Mitek, Westwood, MA) are then used to fix the tendons to the tibia ~6 to 7 cm distal to the joint line in the location of the sMCL remnant. The tendons are passed proximally, and the sMCL femoral insertion is identified (Fig 2).

Avoiding Tunnel Convergence

After the sMCL femoral insertion is identified, sharp dissection is performed to bone to clear the area of soft tissue. An eyelet pin is placed at this point with an aiming guide (Arthrex), aiming 40° anteriorly and 40° proximally to avoid tunnel convergence and the trochlea. A 7-mm tunnel is then over-reamed (Reamer; Arthrex) to a depth of 35 mm to create a socket, and a passing suture is placed through the tunnel. The tendons are marked at the femoral insertion and whipstitched 30 mm proximal, and the excess lengths of the tendons are cut.

Table 2. Advantages and Disadvantages

Advantages	Disadvantages
Provides sufficient bone mass for multiple tunnels in limited environment	Extreme oblique tunnel placement (>40°) may create difficulty for hardware fixation
Reduces the chances of damage to fixation devices in close proximity to each other	
Reduces probability of graft failure by avoiding potential damage to reconstruction grafts	

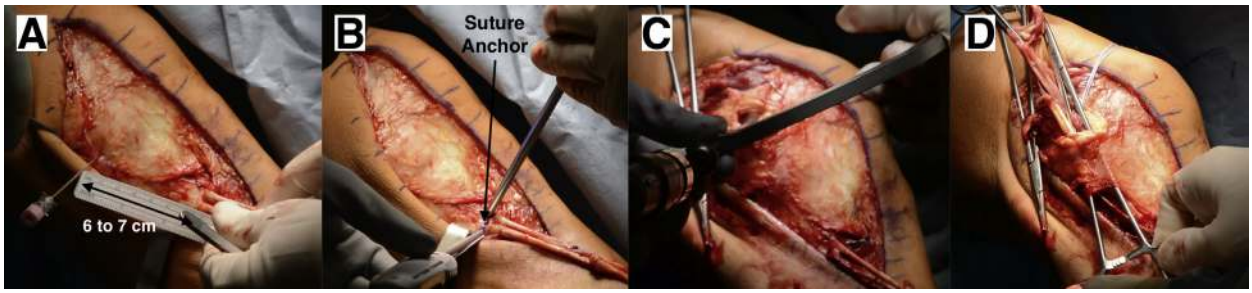

Fig 2. Exterior view of a left knee, showing that once the hamstring tendons have been harvested with their distal attachments left intact, 6 to 7 cm from the joint line is measured (A) establishing the tibial attachment, suture anchors are placed at this insertion (B), the femoral attachment is located and drilled 40° proximal (C) to avoid tunnel convergence with the posterior cruciate ligament reconstruction tunnels, and finally the grafts are passed beneath the sartorious fascia (D).

PCL Reconstruction

Attention is turned to PCL reconstruction. Routine arthroscopy is performed through anterolateral and anteromedial portals. Arthroscopic landmarks are used to identify the anatomic attachment sites of the PCL bundles (Fig 3).[9] After the ALB and PMB tunnels are reamed and passing sutures are placed, a posteromedial portal is made for identification and debridement of the PCL tibial attachment. A guide pin is drilled, entering the anteromedial aspect of the tibia ~6 cm distal to the joint line and centered between the anterior tibial crest and the medial tibial border. Care is taken to avoid the semitendinosus and gracilis tendons and sMCL suture anchors. Pin placement is checked with intraoperative fluoroscopy,[9] and the tibial tunnel is reamed, followed by passing a large smoother (Gore Smoother Crucial Tool; Smith & Nephew) through the tibial tunnel and pulling it out the anteromedial arthroscopic portal. The posteromedial bundle (PMB) and anterolateral bundle (ALB) grafts are passed and fixed in the femur and pulled through the tibial tunnel with the smoother. The ALB is fixed with the knee flexed to 90° and in neutral rotation and secured with a fully threaded, bicortical 6.5 × 40-mm cannulated cancellous screw (Arthrex) and an 18-mm spiked washer (Arthrex).[1] The PMB is then secured to the tibia with the knee in full extension with the same size screw and washer that were used for ALB fixation (Fig 4).

sMCL Augmentation

Attention is turned back to sMCL augmentation. The whipstitched tendon grafts are pulled through the femoral tunnel with the passing suture, and traction is maintained on the graft. The knee is positioned at 20° of flexion with neutral rotation, and a gentle varus force is applied. A 7 × 25-mm bioabsorbable screw (Arthrex) is used to fix the graft in place. To reproduce the proximal tibial attachment of the sMCL, a double-loaded suture anchor (Mitek) is placed 12 mm distal to the joint line, and the sutures are tied to the grafts with the knee positioned at 20° of flexion and neutral rotation.

Once fixation is complete, the knee is flexed to determine the "safe zone" range of movement that can be initiated during the early postoperative period. It is important that the sMCL graft is able to be fully flexed

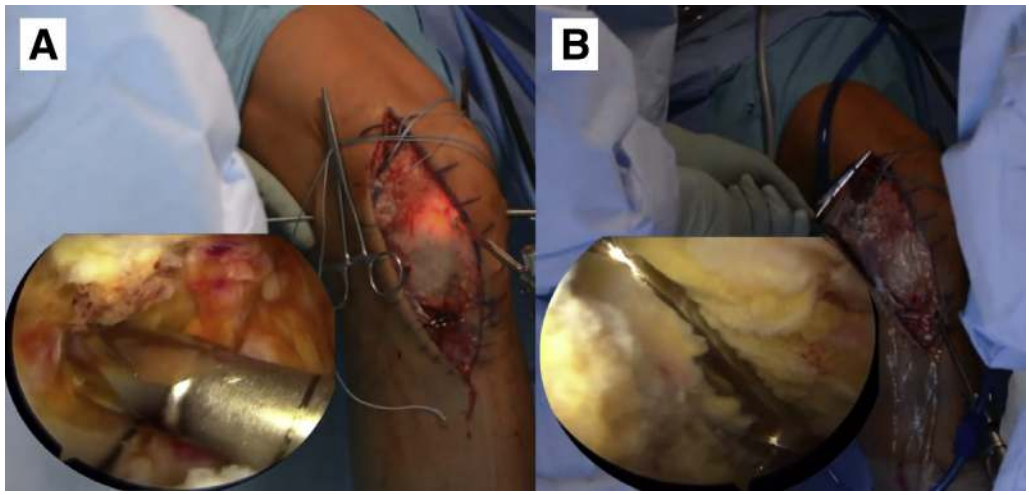

Fig 3. Exterior and arthroscopic view of a left knee. The femoral attachment sites are identified for both the anterolateral and posteromedial bundles, then drilled and over-reamed (A), followed by identification and reaming through the tibial attachment site (B).

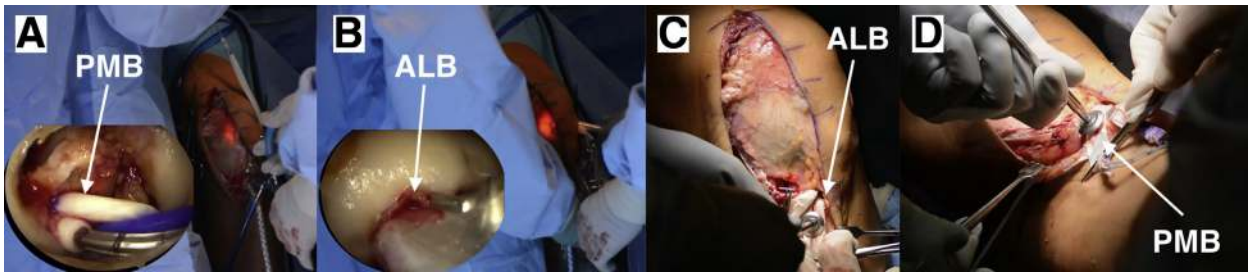

Fig 4. Exterior and arthroscopic views of the graft tensioning sequence for the posterior cruciate ligament (PCL) in a left knee, proceeding by femoral fixation of the posteromedial bundle (PMB) (A) and anterolateral bundle (ALB) (B), fixation of the ALB to the tibia with the knee in 90° of flexion and neutral rotation (C), and finally the PMB tibial attachment with the knee in full extension (D).

with no excessive tension through a full range of knee motion. The excess portions of the PCL grafts are excised, and the skin and subcutaneous tissues are closed with a subcuticular suture.

Postoperative Protocol

After the procedure, the patient is to remain nonweightbearing for 6 weeks on crutches. Physical therapy begins on postoperative day 1 with a focus on pain control, reducing edema, and knee motion. The patient is placed into a knee immobilizer for ~3 to 5 days and then is transitioned into a dynamic PCL brace (PCL Rebound brace; Ossur Americas, Foothill Ranch, CA). Knee range of motion is limited from 0° to 90° for the first 2 weeks and is performed only in the prone position to avoid excessive tension on the PCL reconstruction grafts. Weightbearing is initiated at 6 weeks postoperatively along with low-resistance cycling on a stationary bike. Once patients can tolerate 20 minutes of walking with a nonantalgic gait pattern, a periodized strength program, which focuses on the sequential development of muscular endurance, strength, and power, is commenced. Knee flexion during weightbearing exercise is limited to 70° until 16 weeks postoperatively to avoid excessive PCLR graft strain, and then progressed without limitation. Open-chain isolated hamstring contractions are also avoided for the first 16 weeks after surgery. At 6 months postoperatively, patients are allowed to discontinue the dynamic PCL brace for routine daily use if the side-to-side difference in kneeling PCL stress radiographs is <2 mm. Patients may begin a gradual return to activity progression, with full clearance determined after passing a functional sports test and repeat kneeling PCL and valgus stress radiographs at 12 months postoperatively.

Discussion

Combined PCL and sMCL injuries represent a complex pathology, and special consideration should be given to the technical aspects of combined ligament reconstruction. Tunnel convergence in multiple ligament knee reconstruction can compromise graft integrity and fixation and lead to reconstruction failure. Moatshe et al.[11] showed the optimal tunnel relationships during multiple ligament knee reconstructions to avoid tunnel convergence. During medial knee reconstruction, tunnel collision occurred between the sMCL and anterolateral bundle (16 of 21, 76%) and posteromedial bundle (19 of 21, 90%) of the PCL when the sMCL was oriented at neutral (0°) in both the axial and coronal planes. Aiming the sMCL tunnel 20° to 40° anteriorly and 40° proximally avoided tunnel convergence in 18 of 21 (86%) of patients (Fig 3). Camarda et al.[16] also reported that tunnel convergence could be avoided by aiming the sMCL tunnel 40° proximally.

Good results have been reported with both isolated double-bundle PCLR[13] and sMCL augmentation.[6] However, there are no studies assessing the outcome of combined PCL reconstruction and sMCL augmentation. We encourage other groups to test the validity of this technique with regard to avoiding tunnel convergence and to assess for long-term patient outcomes.

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