Technical Note

Double Vector: A Combined Biomechanical and Anatomical Posterolateral Corner Reconstruction Technique

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Abstract: Posterolateral corner (PLC) injuries are complex knee injuries that are becoming increasingly frequent. Often undiagnosed and underestimated, a systematic diagnostic workup is necessary to assess the severity of PLC injury in order to then be able to select the proper surgery approach. Anatomical and nonanatomical PLC-reconstruction techniques have been described. In this Technical Note, we describe our technique of biomechanical reconstruction of PLC in case of severe posterolateral rotational instability.

The posterolateral corner (PLC) is a complex set of dynamic and static anatomical structures that work in conjunction to guarantee varus and rotational stability to the knee. The fibular collateral ligament (FCL), the popliteus tendon (PLT), and the popliteofibular ligament (PFL) represent the main components and stabilizers of the PLC.[1-3]

PCL isolate injuries represent a relatively uncommon lesion, considering the mechanism of trauma is frequently associated with anterior cruciate ligament (ACL) and posterior cruciate ligament (PCL) lesions.[4,5] PLC injury is often ignored. Simple PCL reconstruction, ignoring PLC reconstruction, causes varus and external rotation of the knee, resulting in knee instability.[6]

For this reason, numerous studies have been conducted regarding the anatomy and biomechanical properties of the PLC, as well as its imaging characteristics,[7,8] and this knowledge has influenced the diagnosis and treatment strategies of these lesions. There are several PLC-reconstruction techniques that can be divided into anatomical or nonanatomical and currently there are conflicting opinions on which is the best technique. In this article, we present our PLC-reconstruction technique, which aims to combine the principles of anatomical reconstruction and especially regarding the biomechanics of the PLC: reconstructing the lateral collateral ligament vector and the popliteus vector separately, aiming to restore anteroposterior and mediolateral stability in case of high-grade posterolateral laxity (posterior drawer test extremely positive) and partial lesion of the PCL (side to side >5 mm and <8 mm).

Surgical Technique (With Video Illustration)

Patient Positioning

The patient is placed supine in a standard arthroscopic position with a lateral leg holder that allows nearly full flexion of the knee during the entire procedure. An inflatable tourniquet is placed at the base of the thigh.

Graft Harvesting and Preparation

Autograft or allograft (gracilis and semitendinosus) are whipstitched one by one near the distal insertion and at the free proximal end with a high-resistance, nonabsorbable suture (FiberWire 2; Arthrex, Naples, FL). The popliteus graft is 20 cm, and the fibular collateral ligament graft is 26 cm. In the popliteus graft,

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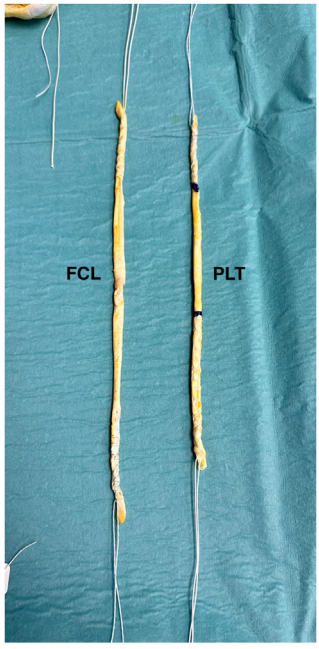

Fig 1. Graft preparation. Allografts (GR and ST) are singly whipstitched with a high-resistance, nonabsorbable suture. The PLT is 20 cm, and the FCL graft is 26 cm. The popliteus graft with whipstitched sutures of different lengths, 3 cm and 5 cm, is shown. (FCL, fibular collateral ligament graft; PLT, popliteus tendon graft.)

the whipstitched suture has different lengths: 3 cm and 5 cm (Fig 1).

Tunnel Positioning and Landmarks

The head of the fibula, lateral epicondyle of femur, and Gerdy's tubercle of tibia are identified by palpation. An 8-cm vertical skin incision is made posteriorly to the lateral epicondyle and extended distally in front of the fibula's head. The femoral biceps fascia is incised longitudinally to identify the fibula's head (Fig 2). Using

Fig 3. Tibial tunnel position and drill. The patient is supine in a standard arthroscopic position. The anterolateral aspect of right knee is shown. The tibial guide pin is positioned lateral to the flat spot on the anterolateral tibia, distally to Gerdy's tubercle (black arrow), until posterior tibial facing. Tibial posterior soft tissues are protected by a spoon (red arrow). The tunnel is created with a minimum 7-mm reamer.

a proper guide, the tibial guide pin is positioned lateral to the flat spot on the anterolateral tibia, distally to Gerdy tubercle, until posterior tibial facing.

Tibial posterior soft tissues are protected by a spoon and tibial tunnel is created with a minimum 7-mm reamer (Fig 3). Then, the iliotibial band is split and 2 femoral guide pins are positioned: one on depression just posterior to the lateral epicondyle (FCL femoral attachment) and one on the popliteus tendon attachment on the femur, 18.5 mm anterior to FCL attachment (Fig 4).[9]

Popliteus Graft Passage and Fixation

The graft is passed in the tibial tunnel and pulled up under the iliotibial band (Fig 5). Then, a shuttle wire is passed into the distal femoral tunnel and fixed with a

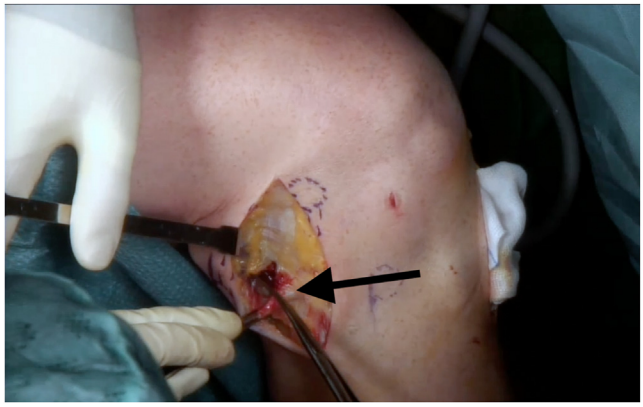

Fig 2. Femoral biceps fascia dissection. The patient is supine in a standard arthroscopic position. Lateral aspect of right knee is shown. The common peroneal nerve is palpated, explored, and protected. Femoral biceps fascia (black arrow) is incised and dissected longitudinally to identify fibula's head.

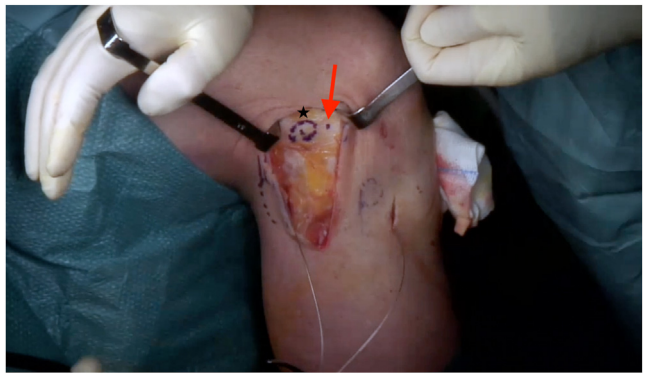

Fig 4. Femoral tunnels position. The patient is supine in a standard arthroscopic position. Lateral aspect of right femur: FCL femoral attachment: depression just posterior to the lateral epicondyle (star), the popliteus tendon attachment on the femur: 18,5 mm anterior to FCL attachment are identified (red arrow). (FCL, fibular collateral ligament graft).

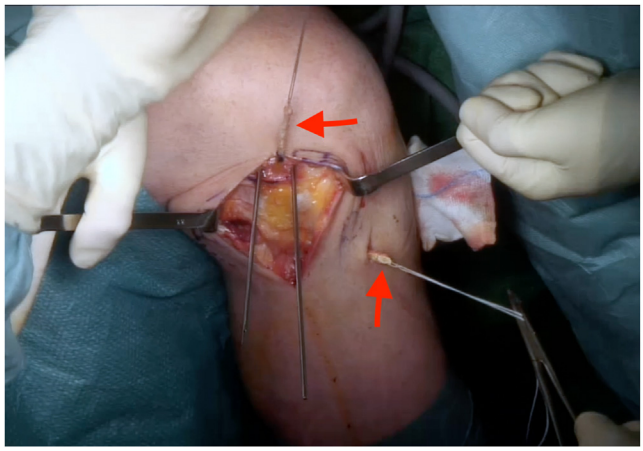

Fig 5. PLT graft passage. The patient is supine in a standard arthroscopic position. Lateral view of right knee is shown. The PLT graft is passed in the tibial tunnel and pulled up under the iliotibial band (red arrows). (PLT, popliteus tendon graft.)

bioabsorbable interference screw matching the dimension of the tunnel and with a minimum diameter of 7 mm (BIORCI; Smith & Nephew, Andover, MA).

With the knee at a 90° angle of flexion, neutral rotation and pushing tibia from behind, the graft is fixed with a bioabsorbable interference screw (BIORCI; Smith & Nephew) matching the dimension of the tunnel (Fig 6).

Fibular Head Tunnel and FCL Graft Passage and Fixation

Fibular head posterior soft tissues are protected by a spoon, and the guide pin is positioned from the anterior to the posterior and the tunnel is created with a fitting to allograft diameter reamer (Fig 7). The graft is passed

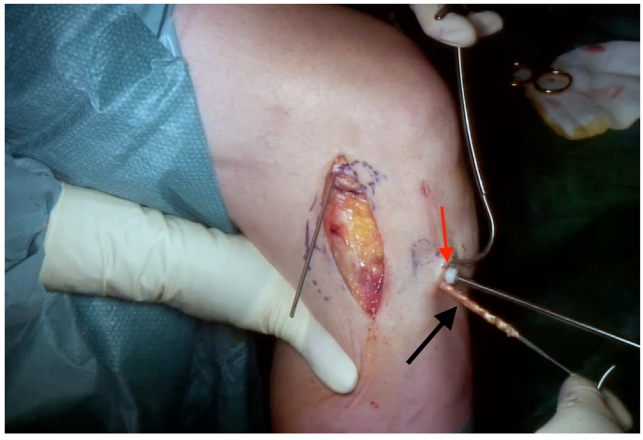

Fig 6. PLT tibial side tensioning and fixation. The patient is supine in a standard arthroscopic position. Lateral view of right knee at 90° of flexion is shown; the tibia is in neutral rotation and pushed from behind. The PLT graft (black arrow) is tensioned and fixed with a bioabsorbable interference screw (BIORCI; Smith & Nephew) (red arrow). (PLT, popliteus tendon graft.)

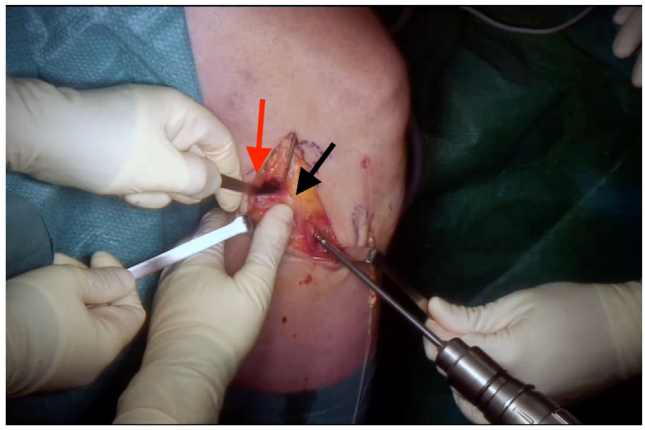

Fig 7. Fibular head tunnel. The patient is supine in a standard arthroscopic position. Lateral aspect of right knee is shown. The peroneal head is identified (black arrow), palpated and fibular head posterior soft tissues are protected by a spoon (red arrow). After the guide pin is positioned from anterior to posterior, a tunnel is created with a fitting to allograft diameter reamer.

in the peroneal tunnel and both strands are pulled up under the iliotibial band (Fig 8). With a shuttle wire, the grafts are passed into the proximal femoral tunnel then with proper tensioning is fixed in 10° of flexion and neutral rotation with a bioabsorbable interference screw (BIORCI; Smith & Nephew) matching the dimension of the tunnel (Fig 9 and Video 1).

Postoperative Rehabilitation Protocol

The knee is kept in a PCL knee brace for the first 40 days. The operated leg is kept non–weight-bearing for at least 30 days; after this, a partial progressive weight-bearing protocol is adopted, aiming to reach full weight-bearing in 2 weeks. Full range of motion is recovered progressively as tolerated in 30 days.

After a 1-month rehabilitation program focused on proprioceptive and neuromotor training is completed, the next step is for the patient to go to a specialized center with a standard protocol for PCL rehabilitation. A gradual return to sport is allowed starting from 6 months, and the patient can return to play 9 months after the surgery. Pearls and pitfalls of our technique are shown in Table 1, and advantages and disadvantages in Table 2.

Discussion

Since the PLC structure was described, several surgical techniques have been described, including the arthroscopic-assisted technique,[10] open techniques,[2] and attempts at entirely arthroscopic techniques.[11] Among the open techniques, the most used are the Laprade, Arciero, and modified Larson techniques.[12,13] The Laprade method has been a very effective method of anatomical reconstruction.[14,15]

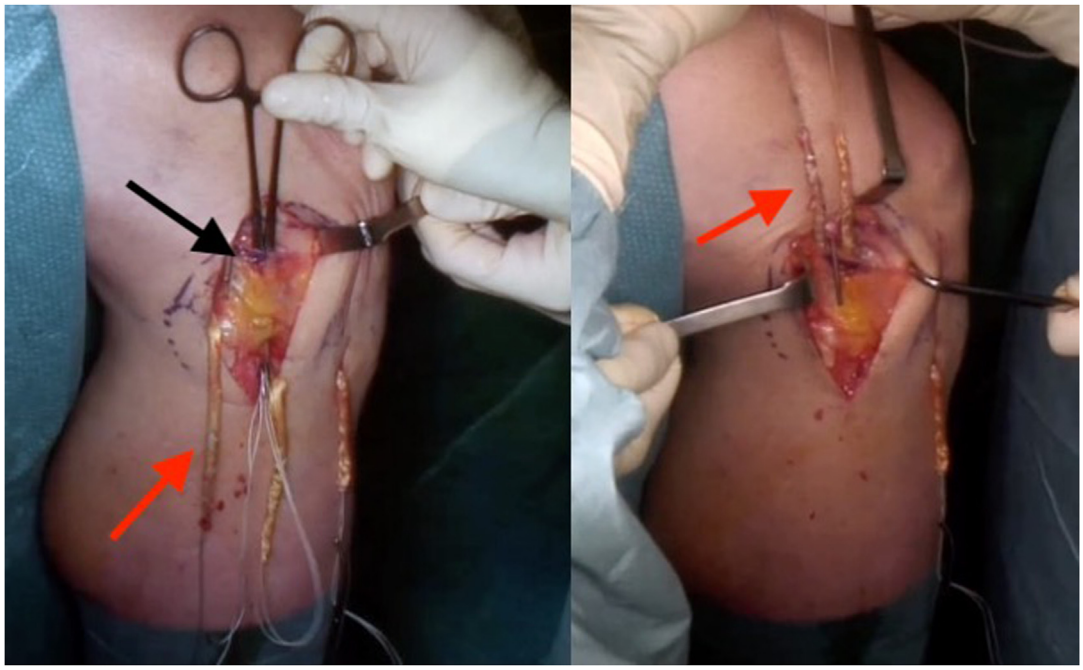

Fig 8. FCL graft passage. The patient is supine in a standard arthroscopic position. Lateral view of right knee is shown. The FCL graft (red arrows) is passed in the peroneal tunnel and pulled up under the iliotibial band (black arrow). (FCL, fibular collateral ligament graft.)

Currently, a debate persists about whether there is the need to reconstruct the FCL, PLT, and PFL independently or whether the reconstruction based only on the fibula is adequate or whether a combined reconstruction based on the tibia and the fibula is necessary to maximize knee stability.

The Larson technique, which is a fibulofemoral-based technique, is less technically demanding and offers encouraging clinical results, but because it is nonanatomical, it has less posterior stabilization and is therefore not suitable for high-grade PLC lesions.[13] In contrast, the open LaPrade anatomical reconstruction provides better stabilization but is technically demanding, and the large exposure has the potential to compromise soft tissue.[2,14,15]

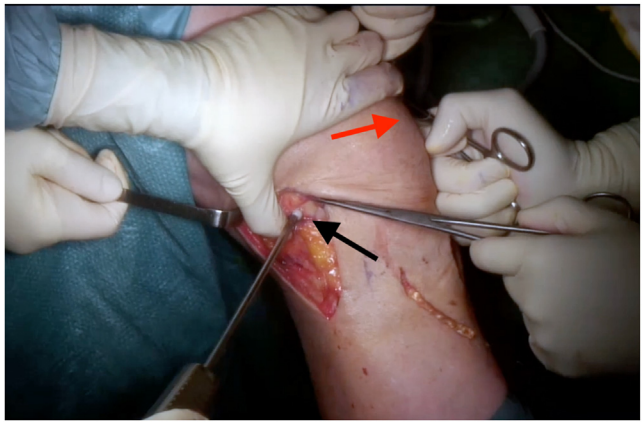

Fig 9. FCL graft tensioning and fixation. The patient is supine in a standard arthroscopic position. Anterolateral view of right knee at 10° of flexion is shown; the tibia is in neutral rotation. FCL is fixed with proper tensioning from the medial (red arrow) and a bioabsorbable interference screw (BIORCI; Smith & Nephew) (black arrow) matching the dimension of the tunnel. (FCL, fibular collateral ligament graft.)

The potential advantages of reconstruction according to Arciero et al.[16] include less dissection, fewer tunnels and implants, and less risks for posterior neurovascular structures. Furthermore, in a biomechanical comparative study by Treme et al.,[17] no statistical difference was found in the ability to restore external rotation and varus angulation stability between the LaPrade and Arciero techniques, although the study may have been underpowered.

Our technique is based on the reconstruction of 2 stabilization vectors, one anteroposterior (controlled by

Table 1. Pearls and Pitfalls

Pearls
• In the popliteus graft, the whipstitched suture has different lengths, 3 cm and 5 cm for the different length of tunnels, in order to use the graft's thickest part.
• Partial lesion of PCL and positive drive-through sign >1 cm during arthroscopy
• The popliteal graft must be fixed at 90° of flexion pushing the tibia from posterior to anterior
• Early rehabilitation protocol
Pitfalls
• Avoid knee rotations during graft fixation
• The tibial tunnel should not be superficial, almost 2 cm inferior to joint line

PCL, posterior cruciate ligament.

Table 2. Advantages and Disadvantages

Advantages
• Restoration of anteroposterior and mediolateral vectors
• Two reconstructions biomechanically isolated
• The procedure is easily reproducible, faster than other anatomic reconstruction
• No transperoneal screw is used
• No large skin incision and exposure of soft tissues
Disadvantages
• Two grafts
• Two femoral tunnels
• Can be difficult for surgeon to perform a concomitant ACL or PCL reconstruction

ACL, anterior cruciate ligament; PCL, posterior cruciate ligament.

the PLT) and one in varus–valgus (controlled by the FCL), with the use of 2 femoral tunnels (Fig 10).

Moreover, both grafts are tensioned at different degrees of flexion–extension: the PLT at a 90° angle of flexion with posterior thrust; the FCL in full extension and neutral rotation.

Since tibial rotation degrees are difficult to quantify and poorly reproducible, in order to avoid risk of overconstraining and joint stiffness, grafts are fixed in femorotibial neutral rotation.

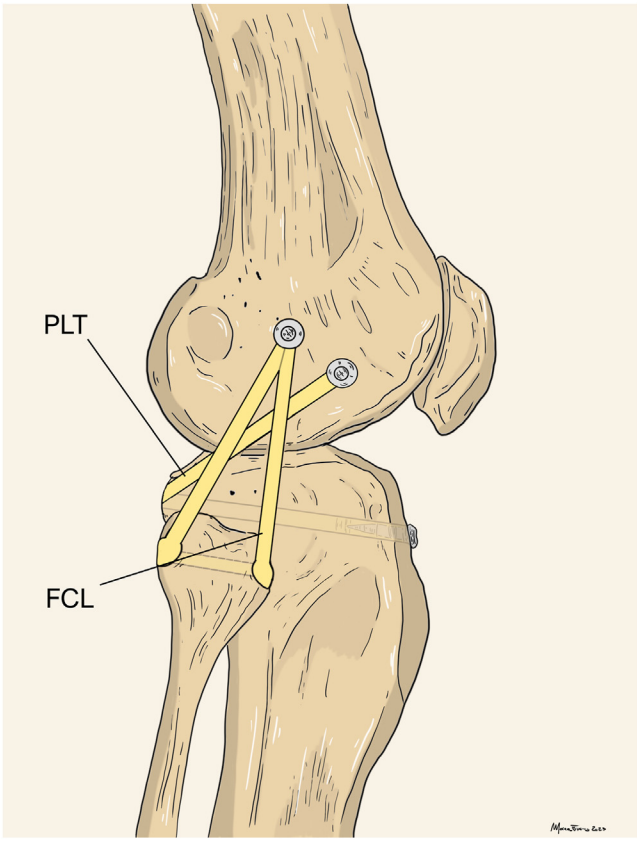

Fig 10. Technique schematic drawing. Lateral aspect of knee. Schematic drawing of double-vector PLC-reconstruction technique. (FCL, fibular collateral ligament graft; PLC, posterolateral corner; PLT, popliteus tendon graft.)

Ho et al.[18] evaluated the effect of 1 or 2 femoral tunnels as part of a fibula-based reconstruction in 5 knees. They found that both techniques improved external rotation and posterior tibial translation, although the stability of the 2-tunnel technique was superior.

The Arciero technique is based on a single femur tunnel and does not reconstruct the anteroposterior vector adequately, moreover this technique can't give different tension during fixation of the 2 bundles. For this reason, Arciero technique may be ineffective in high-grade PLC lesions, and cannot be defined as either anatomical or functional.

The Laprade technique represents a technique of wide exposure of soft tissues, long-lasting and difficult to replicate. Allowing the reconstruction of the PLT and PFL which provide the anteroposterior translation, but it does not have a correct tensioning of the popliteus because both grafts pass in a single tunnel and are blocked by a single tibial screw.

There is also a considerable interpersonal variability of peroneal head dimension and bone consistency; therefore, the interference screw can be maximum 6-mm diameter to avoid the high risk of a fracture.

In view of the large potential for posterior drawer correction and based on current research, the author also believes that our technique is valid for patients with knee dislocation outcomes (knee dislocation type 1 lateral/knee dislocation type 3 lateral), partial PCL tear with posterior drawer less than 6 mm, and severe posterolateral instability with posterolateral drawer extremely positive. The procedure is also faster than other anatomic reconstruction and easily reproducible.

Disclosure

The authors report no conflicts of interest in the authorship and publication of this article. Full ICMJE author disclosure forms are available for this article online, as supplementary material.

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