



Minimally Invasive, Arthroscopic-Assisted, Anatomic Posterolateral Corner Reconstruction

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Abstract: As the anatomy and biomechanics of the posterolateral corner (PLC) of the knee have become better understood, the importance of the PLC's proper function has become a more frequently raised subject. Misdiagnosed chronic posterolateral instability may lead to serious consequences, including cruciate ligament reconstruction graft failure. It has been proved that high-grade PLC injuries need to be treated operatively. Surgical approaches vary, and techniques are still developing. Considering avoidance of an extended surgical approach and minimizing the risk of common peroneal nerve or popliteal artery injuries, we developed the minimally invasive, arthroscopic-assisted, anatomic PLC reconstruction.

The posterolateral corner (PLC) of the knee, with its complex anatomy and function, remains one of the most fascinating and mysterious subjects in knee surgery. The past few decades have provided more sophisticated knowledge about the anatomy, biomechanics, and proper evaluation of the PLC.^{1,2} It has also been proved that injured PLC structures have a poor potential to heal, so chronic posterolateral instability changes the biomechanical behavior, including increased tension on both the native and reconstructed cruciate ligaments.^{3,4} This is why proper diagnosis and management are crucial for the well-being of a patient's knee. Whereas grade A and B PLC injuries can be treated conservatively or with simple repair procedures, grade C injuries should be treated operatively and reconstruction is the method of

choice.^{2,5} Surgical techniques are focused mainly on reconstruction of 3 PLC structures: fibular collateral ligament (FCL), popliteal tendon (PLT), and popliteofibular ligament. Whereas open procedures are associated with an extended surgical approach, arthroscopic techniques are very demanding, require some experience in posterior knee compartment surgery, and are associated with a risk of popliteal artery injury.⁶⁻⁹ In the face of all the aforementioned disadvantages, a minimally invasive anatomic PLC reconstruction with arthroscopic assistance was developed.

Diagnosis

Posterolateral instability of the knee is diagnosed by physical examination (varus stress test, posterolateral drawer test, and dial test in 30° and 90°) and confirmed when increased widening of the lateral joint space (drive-through sign) with elevation of the lateral meniscus in the figure-of-4 position is observed during inspection arthroscopy (Fig 1).

Surgical Technique

Indications and Contraindications

The indications for the described technique are posterolateral instability of the knee of grade B or C according to the classification of Fanelli and Larson¹⁰ when varus relaxation presents and PLT tenodesis is excluded because of poor tendon quality. The contraindications are limited range of motion (extension deficit or flexion <90°), poor bone quality, varus deformity of the knee, advanced degenerative joint

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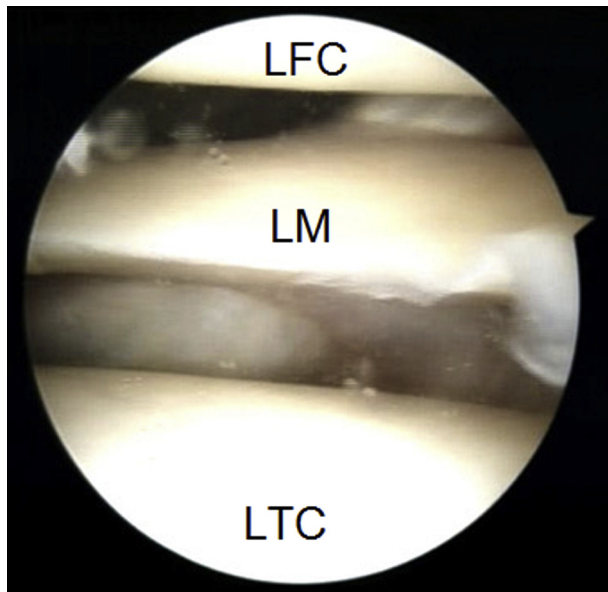


Fig 1. Arthroscopic view from anterolateral viewing portal in left knee. Elevation of the lateral meniscus (LM) and widening of the lateral joint space are shown. A posterolateral corner injury is confirmed. (LFC, lateral femoral condyle; LTC, lateral tibial condyle.)

disease, open physes, and systemic diseases such as rheumatoid arthritis.

Patient Positioning

The surgical procedure is performed with the patient under general or regional anesthesia. The patient is

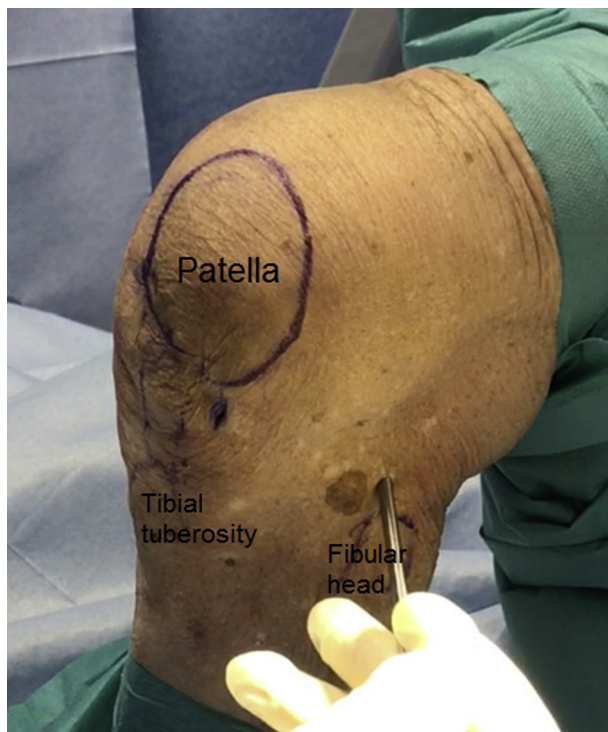


Fig 2. Left knee joint showing position of additional mid-lateral portal.

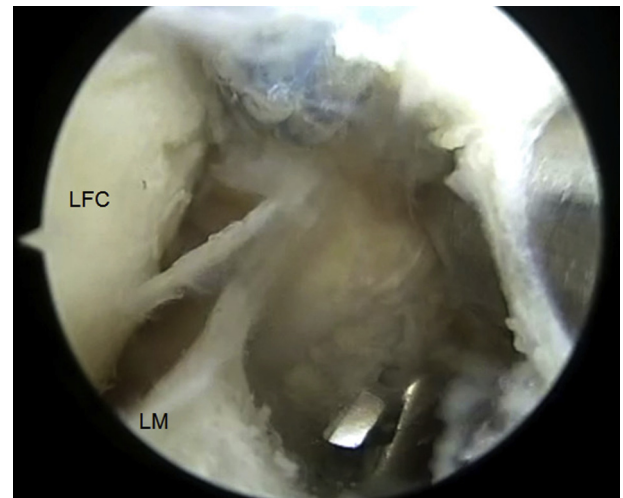


Fig 3. Arthroscopic view from anterolateral viewing portal in left knee. Drilling of the tibial tunnel for popliteal tendon reconstruction is performed with a retrograde drill. It can also be performed in an antegrade manner. (LFC, lateral femoral condyle; LM, lateral meniscus.)

positioned supine. After a clinical examination with the patient under anesthesia, the leg, with a nonsterile thigh tourniquet, is placed in a leg holder and is prepared and draped in a standard sterile fashion.

Diagnostic Arthroscopy and Graft Harvesting

Diagnostic arthroscopy is performed through standard anterolateral and anteromedial portals with a 30° arthroscope (Arthrex, Munich, Germany) to confirm the diagnosis and rule out other intra-articular lesions. Recognized meniscal tears or cartilage defects are addressed immediately, whereas cruciate ligament pathologies are treated immediately after PLC reconstruction. When the diagnosis is confirmed, semitendinosus tendon (ST-T) for the PLT reconstruction and gracilis tendon (G-T) for the FCL reconstruction are harvested and double folded on the ACL TightRope System (Arthrex).

PLT Reconstruction

The procedure starts with the arthroscope introduced through the anterolateral portal into the suprapatellar recess with the knee in full extension. Then, the arthroscope is moved to the lateral recess, and the popliteal complex is visualized. An additional mid-lateral portal is made under arthroscopic control 1.5 cm above the fibular head and 1 cm anterior to the FCL (Fig 2, Video 1). To facilitate visualization, FiberTape (Arthrex), as a retraction suture, is temporarily placed around the PLT using a Scorpion Suture Passer (Arthrex) (Video 1). The proximal part of the Tibial Popliteal Marking Hook (Arthrex) is placed at a point where a horizontal line at the tip of the fibular head crosses a vertical line at the medial edge of the fibular head.¹¹ The drill sleeve for the FlipCutter (Arthrex) is

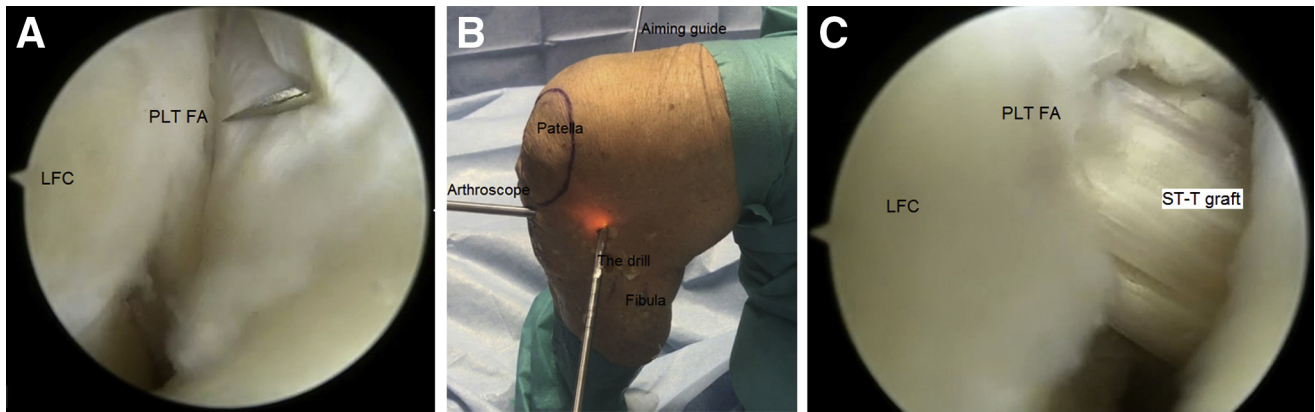


Fig 4. (A) Arthroscopic view from anterolateral viewing portal in left knee. An additional high midlateral portal is made at the level of the popliteal tendon (PLT) femoral attachment (FA). (B) Left knee joint showing drilling of femoral tunnel for PLT reconstruction. The drill matched to the graft size is introduced through the high midlateral portal, positioned in the native PLT FA, and directed just above the medial femoral epicondyle. (C) Arthroscopic view from anterolateral viewing portal in left knee. Semitendinosus tendon (ST-T) graft is introduced into the femoral tunnel in the place of the PLT FA. (LFC, lateral femoral condyle.)

matched to the size of the ST-T graft and is placed below the pes anserinus, and a small skin incision is made. The FlipCutter, matched to the graft size, is used to drill the tibial tunnel for the PLT reconstruction (Fig 3, Video 1). It can also be drilled in an antegrade manner. At the end of this stage, a FiberStick passing suture (Arthrex) is introduced through the tibial tunnel and pulled outside the joint through the midlateral portal (Video 1).

The knee is then flexed to 90°. To create the femoral tunnel for the PLT reconstruction, an additional working portal—the high midlateral portal—is made under visual control at the level of the PLT femoral

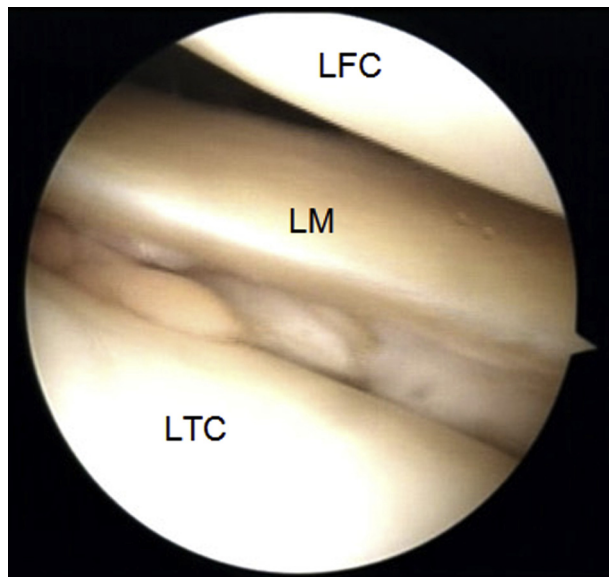


Fig 5. Arthroscopic view from anterolateral viewing portal in left knee. The popliteal tendon graft is fixed on the anteromedial tibial cortex. The tension on the popliteal tendon graft is regulated under visual control until the lateral meniscus (LM) elevation and lateral joint space widening are eliminated. (LFC, lateral femoral condyle; LTC, lateral tibial condyle.)

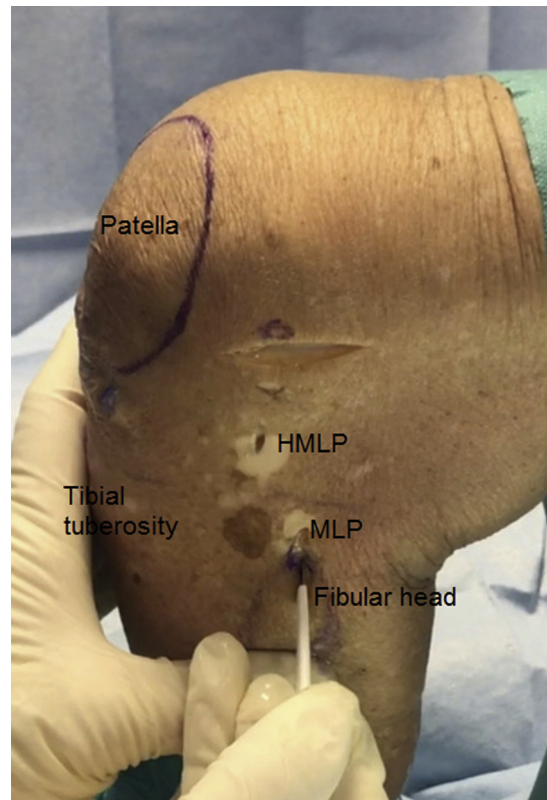


Fig 6. Left knee joint showing approach to fibular collateral ligament reconstruction. A 4- to 5-cm horizontal skin incision is made above the fibular attachment of the fibular collateral ligament. The second 2- to 3-cm vertical skin incision is made above the fibular head. (HMLP, high midlateral portal; MLP, midlateral portal.)

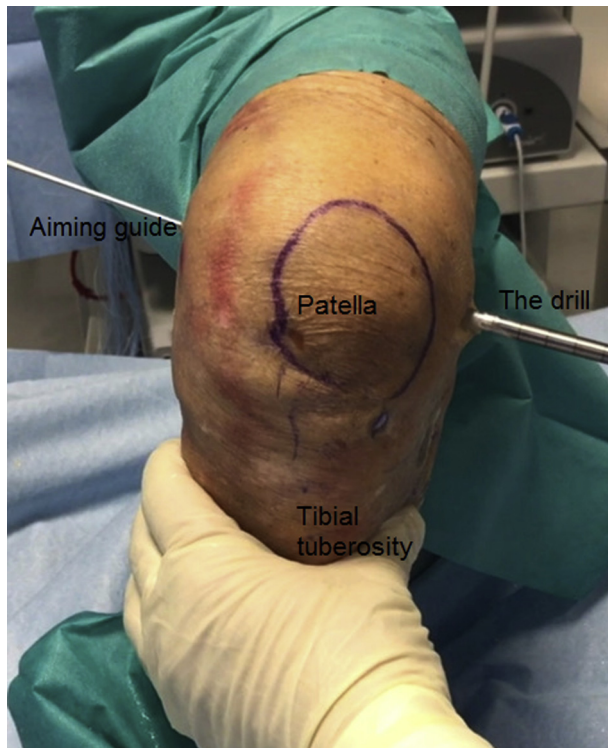


Fig 7. Left knee joint showing drilling of femoral tunnel for fibular collateral ligament reconstruction. The drill matched to the graft size and the aiming guide are positioned from the point proximal and posterior to the lateral femoral epicondyle to the point above the medial femoral epicondyle.

attachment (Fig 4A, Video 1). The ACL TightRope Drill Pin (Arthrex) is introduced through the aforementioned portal, placed in the PLT femoral attachment, and used as an aiming guide to direct the femoral tunnel just above the medial femoral epicondyle. The drill matched to the size of the ST-T graft is used to create the femoral tunnel (Fig 4B, Video 1). Next, a passing suture is introduced through the femoral tunnel and pulled outside the joint through the midlateral portal. It is very important to have both passing sutures in the midlateral working portal without any soft-tissue bridges between them. Then, the ST-T graft is introduced with the passing suture into the femoral tunnel and fixed with the ACL TightRope (Arthrex) on the femoral cortex (Fig 4C, Video 1). The second passing suture is used to pass the other end of the ST-T graft through the tibial tunnel (Video 1). The graft is fixed on the anteromedial cortex with the TightRope ABS Button (Arthrex), and the tension is regulated by twisting the ABS Button with Pean forceps under arthroscopic control until the drive-through sign is eliminated (Fig 5, Video 1).

FCL Reconstruction

The next stage of the procedure starts by making a 4- to 5-cm horizontal skin incision just above the femoral attachment of the FCL and a 2- to 3-cm

vertical skin incision above the fibular head (Fig 6, Video 1). The iliotibial band is sectioned, and the ACL TightRope Drill Pin is placed at the point proximal and posterior to the lateral femoral epicondyle.¹² The aiming guide is used to direct the femoral tunnel of the FCL just above the medial femoral epicondyle. The drill matched to the size of the G-T graft is used to create the femoral tunnel (Fig 7, Video 1). A passing suture is moved through the tunnel. Then, the ACL TightRope Drill Pin is placed in the middle of the fibular head and used to drill the tunnel through the fibular head and proximal tibia directed medially, just below the medial collateral ligament (MCL) distal attachment and pes anserinus. The drill is used to match the tunnel diameter to the size of the G-T graft (Fig 8, Video 1).

The G-T graft is passed across the tibial and fibular tunnels from medial to lateral. Then, the graft is passed below the skin and iliotibial band with Pean forceps and introduced into the femoral tunnel from lateral to medial using the passing suture (Fig 9A, Video 1). The graft is fixed with an ACL TightRope on the medial femoral cortex and with a BioComposite Interference Screw (Arthrex) matched to the tunnel diameter on the fibular head. On the medial tibial cortex, the graft is

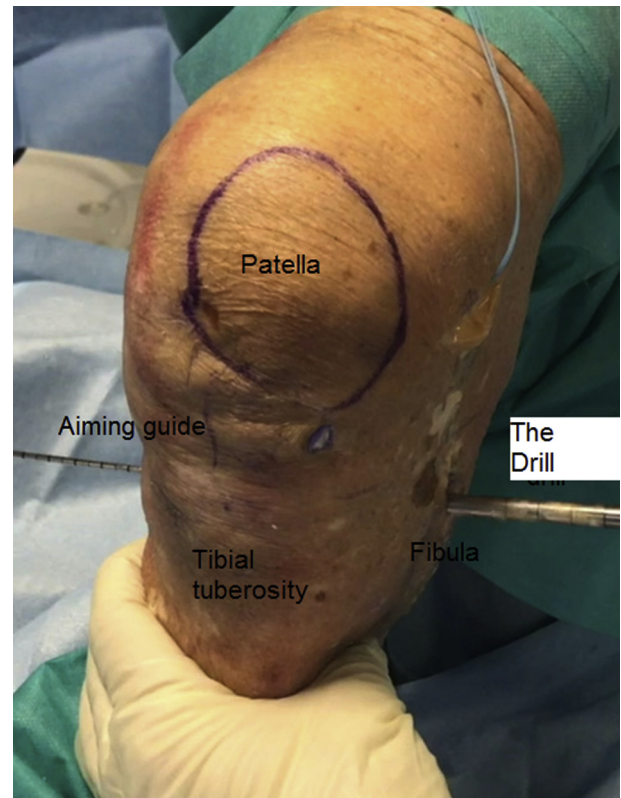
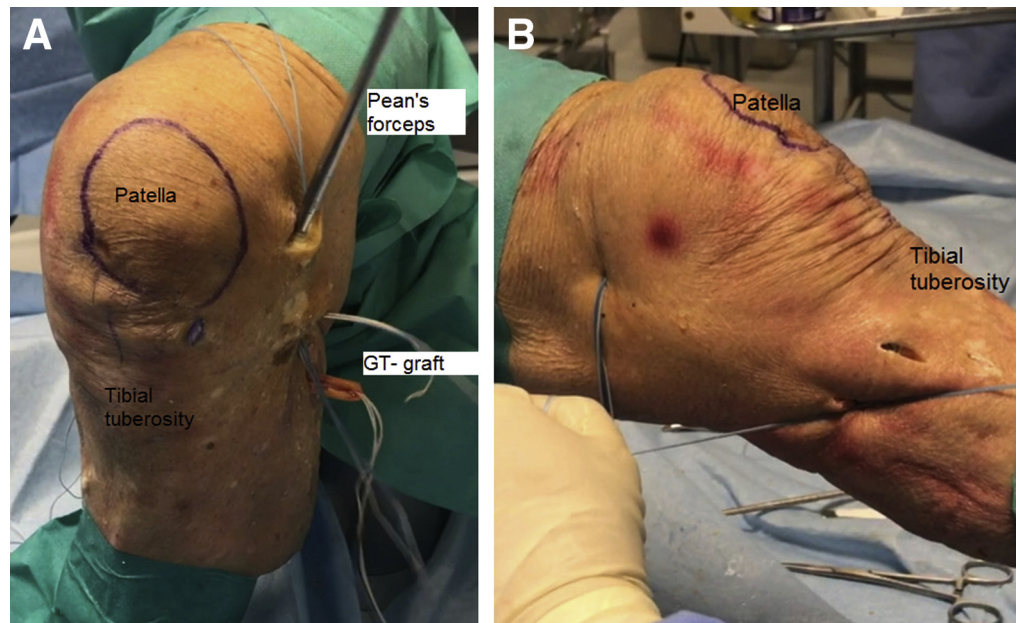


Fig 8. Left knee joint showing drilling of fibular and tibial tunnels for fibular collateral ligament reconstruction. The drill matched to the graft size and the aiming guide are positioned from the point in the middle of the fibular head to the point below the medial collateral ligament distal attachment on the medial tibial cortex.

Fig 9. Left knee joint. (A) Gracilis tendon (GT) graft is passed through the tibial and femoral tunnels from medial to lateral. Then, it is passed below the skin and iliotibial band using Pean forceps, introduced into the femoral tunnel, and fixed on the medial femoral cortex. (B) Fixation of gracilis tendon graft on medial tibial cortex with knee flexed to 30°.



fixed with the ABS Button with the knee in 30° of flexion (Fig 9B, Video 1). The step-by-step approach to minimally invasive anatomic PLC reconstruction with arthroscopic assistance is presented in Table 1.

Rehabilitation

Passive knee motion is started from the second day after surgery. Walking on crutches for 6 weeks and using an orthosis with limited extension (30°) and flexion (90°) are recommended.

Discussion

The minimally invasive anatomic PLC reconstruction with arthroscopic assistance is an efficient and safe method for reconstructing grade B and C PLC injuries. The technique involves reconstruction of the PLT and FCL. One of the most important facts about the presented technique is that each stage of this surgical procedure can also be applied as an isolated procedure: arthroscopic PLT reconstruction or minimally invasive FCL reconstruction. Moreover, it also provides a unique, minimally invasive treatment option for proximal tibiofibular joint instability. The G-T graft passed through the fibular head and the tibial tunnel is a strong, native material for fibular head fixation. It allows one to avoid using hardware in such cases.

The next benefit is that an extended surgical approach can be avoided owing to the use of an arthroscope to visualize the popliteal complex. This minimizes soft-tissue trauma and allows a more aggressive rehabilitation protocol to be introduced. It also reduces the risk of complications such as improper wound healing,

wound infections, and arthrofibrosis of soft tissue in comparison with other, open surgical procedures.^{6,7} Moreover, arthroscopic visualization of the popliteal complex from the anterolateral viewing portal with the creation of 2 additional working portals (midlateral and high midlateral) makes it possible to freely maneuver with instruments in the posterolateral aspect of the knee. In comparison with other arthroscopic techniques, there is no need to create a trans-septal portal and work in the posterior compartment of the knee, where the risk of injury to the popliteal neurovascular bundle is significant.^{9,11}

The PLT reconstruction with ST-T graft can be performed in whole as an arthroscopic procedure with the location of the femoral tunnel exactly in the place of the PLT femoral attachment and the tibial tunnel at the point described by Frosch et al.¹¹ The FCL reconstruction requires 2 small skin incisions above the fibular head and above the femoral attachment of the FCL. Whereas the femoral tunnel is located at the point described by LaPrade et al.,¹² the distal attachment of the FCL is drilled in the middle of the fibular head. There is no need for common peroneal nerve neurolysis. A part of the G-T graft between the femur and fibular head reconstructs the FCL, whereas the part between the bioabsorbable screw on the fibular head and the medial tibial cortex stabilizes the fibular head and the proximal tibiofibular joint. Thus, the presented PLC reconstruction technique allows one not only to reconstruct the PLT and FCL anatomically but also to reconstruct the proximal tibiofibular ligaments.

Table 1. Step-by-Step Approach to Minimally Invasive Anatomic PLC Reconstruction With Arthroscopic Assistance

Stage of Procedure	Important Aspects
1. Confirm diagnosis	During inspection arthroscopy, look for the drive-through sign and elevation of the lateral meniscus in the figure-of-4 position.
2. Rule out other intra-articular lesions	Address meniscal or cartilage lesions at once.
3. Harvest hamstring tendons	Treat injured cruciate ligaments immediately after PLC reconstruction. Harvest ST-T for the PLT reconstruction. Harvest G-T for the FCL reconstruction or fibular head fixation in the case of proximal tibiofibular joint instability.
4. Reconstruct PLT	Place an additional midlateral portal under visual control. Place the retraction suture on the PLT to facilitate maneuvering. Prepare the tibial tunnel for the PLT graft: Position the tunnel between the point at the crossing of a horizontal line at the tip of the fibular head with a vertical line at the medial edge of the fibular head and the point just below the MCL distal attachment on the anteromedial cortex. Perform drilling in a retrograde or antegrade manner. Pass a passing suture through the tibial tunnel, and place it outside the joint through the midlateral portal. Place the high midlateral portal under visual control. Prepare the femoral tunnel for the PLT graft: Use the high midlateral portal to introduce the aiming guide and drill. Position the tunnel between the native PLT femoral attachment and the point just above the medial femoral epicondyle. Pass a passing suture through the femoral tunnel, and place it outside the joint through the midlateral portal. Use passing sutures to pass the ST-T graft through the tunnels, and fix it on the medial femoral cortex and anteromedial tibial cortex. Regulate the tension under visual control until the drive-through sign is eliminated.
5. Reconstruct FCL	Perform a 4- to 5-cm horizontal skin incision above the FCL femoral attachment and a 2- to 3-cm vertical skin incision above the fibular head.* Prepare the femoral tunnel for the FCL graft: Section the ITB and find the lateral femoral epicondyle. Position the tunnel between the point proximal and posterior to the lateral femoral epicondyle and the point above the medial femoral epicondyle. Pass a passing suture through the femoral tunnel. Prepare the fibular/tibial tunnel for the FCL graft*: Position the tunnel between the point in the middle of the fibular head and the point below the MCL distal attachment on the medial tibial cortex.* Pass a passing suture through the fibular/tibial tunnel.* Use passing sutures to pass the G-T graft through the tibial tunnel*; then, pass it below the skin and ITB and introduce it into the femoral tunnel. Fix the G-T graft on the medial tibial cortex, in the fibular head,* and on the medial femoral cortex.

NOTE. The surgeon should remember that the diameter of each tunnel should be matched to the graft size.

FCL, fibular collateral ligament; G-T, gracilis tendon; ITB, iliotibial band; MCL, medial collateral ligament; PLC, posterolateral corner; PLT, popliteal tendon; ST-T, semitendinosus tendon.

*Technique of proximal tibiofibular joint stabilization.

To summarize, the greatest advantage of applying our technique is that it is an anatomic reconstruction with reduced invasiveness, without a necessity for maneuvering in the posterior knee compartment. However, there are also some limitations. The first stage of the procedure is performed with the knee in full extension, whereas the second part is performed with the knee in 90° of flexion. An extension deficit or a flexion angle of less than 90° makes application of our technique impossible. We do not recommend performing the procedure in such cases. Moreover,

autografts are used for reconstruction; their use is always associated with a possible risk of donor-site morbidity. The risk of common peroneal nerve injury, although minimal, also exists. Although the technique does not require very advanced surgical skills, attention should be paid to proper positioning of the tunnels. The exits of the femoral and tibial tunnels should omit the MCL attachments to avoid symptoms from the MCL. Moreover, cruciate ligament reconstructions often must be performed in a 1-stage procedure with PLC reconstruction, so an

Table 2. Advantages and Disadvantages of Minimally Invasive Anatomic PLC Reconstruction With Arthroscopic Assistance

Advantages	Disadvantages
Anatomic reconstruction of the FCL and PLT is performed.	The PFL is not reconstructed.
Arthroscopic PLT reconstruction and minimally invasive FCL reconstruction can be applied as an isolated procedure.	Graft harvesting is required, with possible donor-site morbidity.
A part of the technique can be applied for fibular head stabilization in the case of proximal tibiofibular joint instability.	Inappropriate tunnel positioning can lead to MCL symptoms or tunnel conflicts during other reconstructions.
Invasiveness is reduced, allowing faster recovery.	Wide knee range of motion is required.
Maneuvering in the posterior knee compartment is not required.	The procedure can be costly.
There is a reduced risk of common peroneal nerve injury.	
Very advanced surgical skills are not required.	

FCL, fibular collateral ligament; MCL, medial collateral ligament; PFL, popliteofibular ligament; PLC, posterolateral corner; PLT, popliteal tendon.

inappropriate tunnel location can lead to tunnel conflicts. The advantages and disadvantages of applying our technique are shown in [Table 2](#).

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