Technical Note

Anterior Cruciate Ligament Over-The-Top Plus Lateral Plasty and Minimally Invasive Double-Bundle Posteromedial Corner Reconstruction

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Abstract: The medial collateral ligament (MCL) and the posteromedial corner (PMC) of the knee are essential structures for maintaining medial knee stability. Chronic MCL instability is infrequent but can necessitate surgical intervention. Various surgical techniques have been described, but they often involve the use of tibial tunnels, which may complicate concurrent ligament reconstructions. This study aims to present a minimally invasive double-bundle PMC reconstruction technique that avoids the use of tibial tunnels. Knee evaluation was performed using standard clinical tests and 1.5-Tesla magnetic resonance imaging. Patients with grade III Hughston MCL injuries were considered for surgery. The technique employs either an autologous semitendinosus graft or a fresh-frozen allograft, usually tibialis anterior, to reconstruct both the superficial MCL and the posterior oblique ligament. The technique described avoids the use of tibial tunnels, preserving tibial bone stock for any future procedures. The graft is secured at the femoral and tibial insertions using bioabsorbable interference screws and titanium staples, respectively. Our minimally invasive double-bundle PMC reconstruction technique offers a feasible and effective solution for patients with chronic medial knee instability. It is particularly beneficial for patients requiring multiple ligament reconstructions, as it avoids tunnel collision and preserves tibial bone stock.

The medial collateral ligament (MCL) is a frequently injured knee ligament. However, due to its high endogenous healing capacity, most MCL tears can be managed conservatively.[1] Chronic MCL instability is a rare occurrence and may require reconstruction in cases of severe valgus knee, multiligament injuries, and grade III tears.[2,3]

The MCL comprises 2 bundles: the superficial (sMCL) and the deep (deep MCL) one. In addition, the posteromedial corner (PMC) complex, which consists of the posterior oblique ligament (POL), the posteromedial horn of the medial meniscus, and the semimembranosus attachments, ensures medial knee stability. All these structures play a vital role in the static and dynamic function of the knee, and injuries to these structures can lead to clinically significant valgus or rotational instability.[4]

Over the years, several surgical techniques have been developed for treating chronic medial knee instability. These techniques include isolated MCL reconstruction, concomitant MCL, and POL reconstruction using anatomical or nonanatomical techniques, respectively.[5-8]

The purpose of this Technical Note is to describe a minimally invasive double-bundle PMC reconstruction surgical technique that uses autologous semitendinosus or a fresh-frozen allograft (usually tibialis anterior) to reconstruct both sMCL and POL without tibial tunnels.

Indications

Knee evaluation is conducted through clinical and radiologic methods. Standard clinical tests such as valgus stress at 0° and 30° of flexion are used to assess the POL and sMCL, respectively. The dial test should be used to confirm PMC tear and to differentiate it from isolated sMCL tear (which can be treated with sMCL

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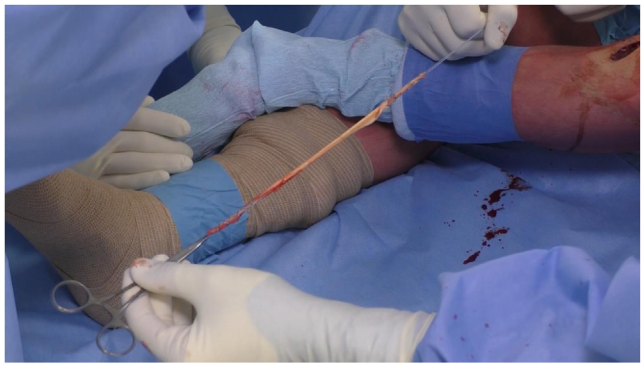

Fig 1. The contralateral leg (left side) semitendinosus is harvested and prepared with No. 2 FiberWire (Arthrex, Naples, FL) with a baseball suture in the 2 free ends. The minimum length of the tendon should be approximately 18 to 20 cm based on the patient's height.

reconstruction alone).[9] A 1.5-Tesla magnetic resonance imaging scan is usually performed to detect associated lesions. Valgus stress radiograph at 0° and 30° of flexion is used to determine the severity of POL and sMCL injury, respectively. Patients who exhibited clinical and radiologic evidence of tears and a medial opening greater than 10 mm (grade III Hughston) are eligible for surgery.[10]

Ethics Approval and Consent to Participate

The work described has been carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki) for experiments involving humans. Informed consent was obtained for experimentation with human subjects.

Surgical Technique (With Video Illustration)

After completing the reconstruction of the anterior cruciate ligament (ACL) using the over-the-top technique plus lateral plasty as previously described by the authors (Fig 1), attention is turned to the reconstruction of the PMC. The chosen graft (tibialis tendon allograft or autologous semitendinosus) is prepared with No. 2 FiberWire (Arthrex, Naples, FL) with a baseball suture in the 2 free ends. The minimum length of the tendon should be approximately 18 to 20 cm based on the patient's height (Fig 1).

The patient is placed supine, and a tourniquet is applied to the upper thigh. The knee is secured on a leg holder, and an arthroscopic anterolateral portal is created to perform a detailed diagnostic arthroscopy using a 4-mm, 30° arthroscope. Any associated injuries are identified and appropriately managed using an anteromedial portal. The arthroscopic "drive-through sign" confirms the pathologic medial joint line opening.[11]

In the case of an associated meniscal lesion, meniscal repair and/or selective meniscectomy should be performed as the first step (Fig 2). If ACL or posterior cruciate ligament lesions are associated with the PMC tear, their reconstruction should be performed before PMC reconstruction. In this case, an ACL using the over-the-top technique plus lateral plasty as described by the authors is performed (Figs 3-6).

After the completion of the arthroscopic procedures, attention is focused on the medial side of the knee (Fig 7). The medial femoral epicondyle is identified, and a 2-cm longitudinal incision is made directly over this structure, carefully avoiding damaging the saphenous nerve and vein.

Under fluoroscopic guidance, the femoral tunnel starting point is just 5 mm proximal and 5 mm posterior to the medial epicondyle (Figs 8 and 9). This point is in between anatomic sMCL and POL insertions. Thereafter, a passing pin is drilled from this point into the epicondyle, from medial to lateral, and out of the lateral aspect of the knee (taking care not to damage medial neurovascular structures). The diameter of the graft looped (femoral) portion is then measured, and a corresponding half-tunnel (usually 7 × 35 mm) is drilled over the passing pin.

The proximal medial tibia is accessed through the incision used for hamstrings harvesting (usually, an ACL reconstruction is associated in approximately 90% of cases), employing a "sliding window" technique. A medial blunt dissection is carried out until the tip of a Klemmer can be visualized along the native MCL fibers.

Next, a "shuttle" suture is passed through the buttonhole of the passing pin in the femoral epicondyle. The pin is then pulled out from the lateral side of the knee, leaving the "shuttle" suture in its place. At this stage, the graft is looped around the femoral "shuttle" suture, and it is then pulled into the femoral half-tunnel. A 23-mm-long bioabsorbable interference screw (MILAGRO; DePuy Mitek, Raynham, MA), which is equal in diameter to the previously performed femoral half-tunnel, is placed close to the graft to

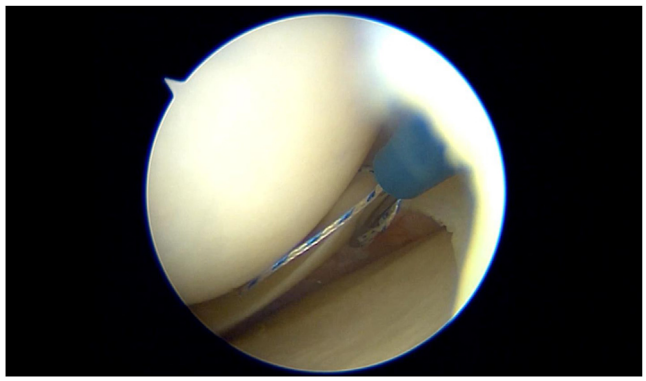

Fig 2. Any associated injuries are identified and appropriately managed using an anteromedial (AM) portal. In the case of an associated meniscal lesion, meniscal repair and/or selective meniscectomy should be performed as the first step.

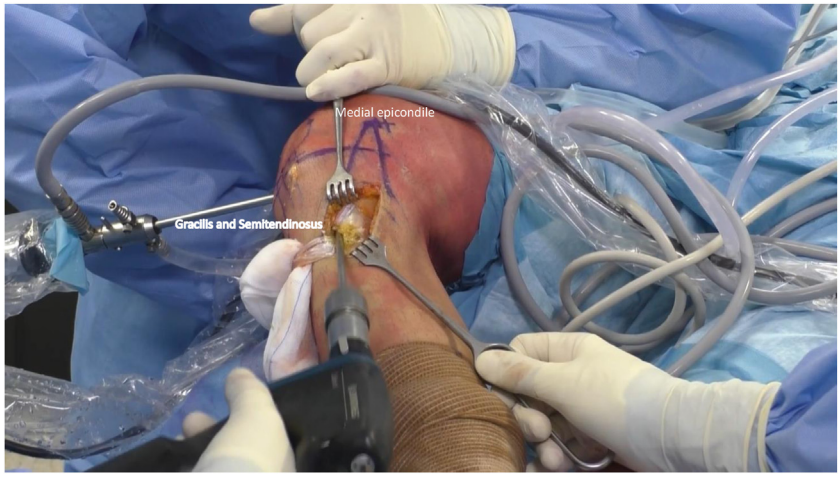

Fig 3. After positioning the guidewire with the help of an arthroscopic compass, the tibial tunnel is drilled, leaving the tendons of the pes anserinus inserted at their insertion point.

Fig 4. The gracilis and semitendinosus tendons are passed into the joint and subsequently in an over-the-top position.

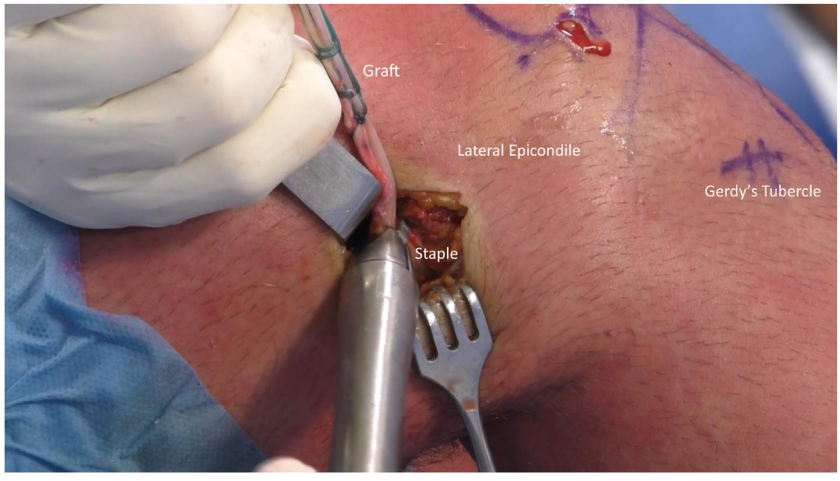

Fig 5. Gracilis and semitendinosus graft is fixed on the femoral side using 2 staples.

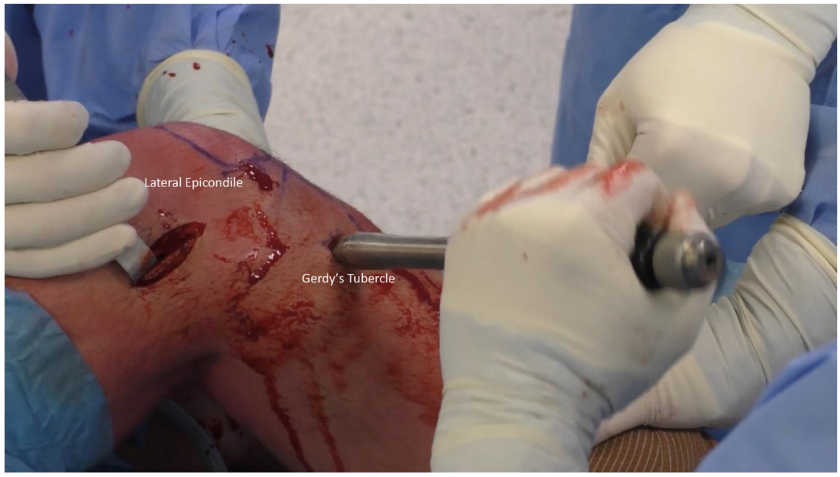

Fig 6. Lateral plasty is fixed at the Gerdy's tubercle using one staple.

ensure its fixation on the femoral side. After that, the 2 free ends of the graft are passed down the soft-tissue plane over knee layer II: the POL graft is passed distally within the substance of the native POL, and the sMCL graft is passed under the sartorius fascia.

Isometry is tested for the sMCL graft bundle by holding the sutures at the distal end of it and moving the knee through a full range of motion. The sMCL graft bundle is then fixed, in anatomic position, approximately 6 cm distal to the joint line using two 6-mm titanium staples (Citieffe, Bologna, Italy) with the knee placed in 90° of flexion and neutral rotation. A 5.5-titanium anchor (TWINFIX, Smith & Nephew, Austin, TX) is used to ensure better neo-sMCL bundle fibers tensioning approximately 2 cm nearby the joint line.

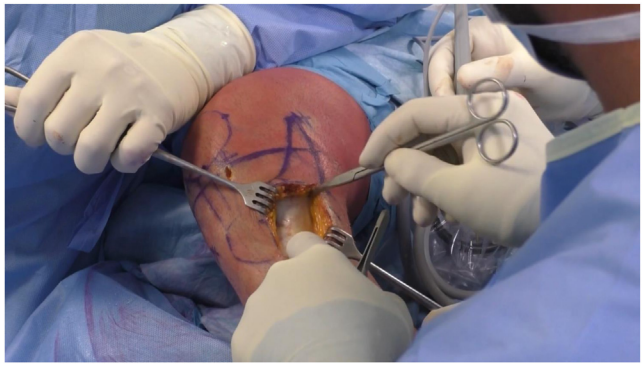

Fig 7. After the completion of the arthroscopic procedures, attention is focused on the medial side of the knee. An incision of about 6 to 7 cm is made at the level of the pes anserinus, directed posteriorly in such a way as to allow for the harvesting of the gracilis and semitendinosus tendons for the reconstruction of the anterior cruciate ligament using the over-the-top technique plus lateral plasty and then to identify the anatomical insertion of the sMCL and POL. (POL, posterior oblique ligament; sMCL, superficial medial collateral ligament.)

Thereafter, the POL graft bundle was fixed using two 6-mm titanium staples (Citieffe) at the medial-posterior corner of the tibia just 2 cm distal from the joint line, with the knee in full extension and neutral rotation. Native POL is anisometric, so isometry tests are unnecessary for the POL graft bundle (Figs 10 and 11).

Rotational stability is evaluated and compared with the examination performed before the reconstruction. After intra-articular drain positioning and wound closure, final radiographic control is employed to confirm correct placement of the staples (Fig 12).

Figure 13 displays an anatomical illustration of the surgical technique. Video 1 summarizes all the steps of the current surgical technique. Tables 1 and 2 illustrate the advantages and disadvantages and pearls and pitfalls, respectively, of our surgical technique.

Discussion

The most important feature of this technique is the avoidance of tibial tunnels. In this way, tibia is intact, and ACL reconstruction or a multiligament reconstruction can be performed without the risk of tunnel interference.

Treatment of grade III MCL injuries remains controversial in orthopaedic sports medicine.[2,12] Several techniques have been used by those who support the reconstruction procedure.[1,2,5-7] Still, to the authors' knowledge, no one has attempted to reconstruct the sMCL and POL through limited dissection using anterior tibialis tendon allograft and without tibial tunnels. This study describes a nonanatomic double-bundle PMC reconstruction technique that restores function and stability.

Most of the reconstruction procedures reported in the literature are nonanatomical techniques that use allograft or autograft. Lind et al.[7] reported a nonanatomical double-bundle MCL reconstruction technique using the semitendinosus tendon retained at the pes anserinus

Fig 8. Intraoperative fluoroscopic-guided femoral tunnel positioning. The starting point is just 5 mm proximal and 5 mm posterior to the medial epicondyle. Moreover, this point is in between anatomic sMCL and POL insertions. (POL, posterior oblique ligament; sMCL, superficial medial collateral ligament.)

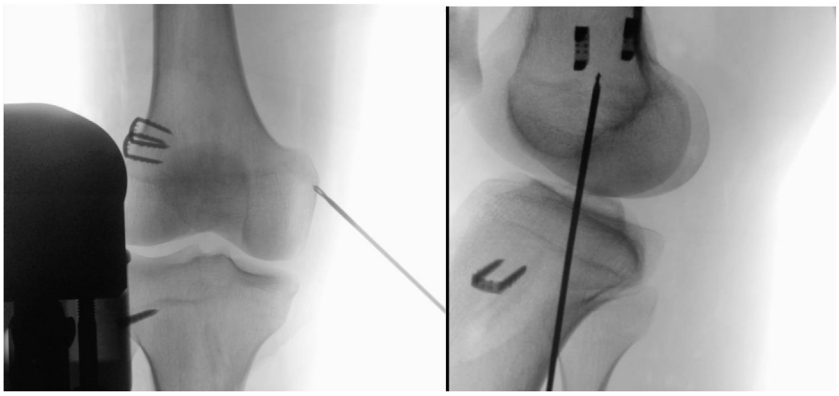

Fig 9. Intraoperative fluoroscopic-guided femoral tunnel positioning. The starting point is just 5 mm proximal and 5 mm posterior to the medial epicondyle. Moreover, this point is in between anatomic sMCL and POL insertions. (POL, posterior oblique ligament; sMCL, superficial medial collateral ligament.)

Fig 10. After securing the graft at the level of the medial femoral epicondyle using an interference screw, the remaining 2 bundles are fixed in an anatomical position at the tibial level using 2 cams per bundle.

insertion, fixed at the medial femoral condyle with an interference screw, and then passed in a tibial drilled hole. However, this nonanatomic and anisometric technique can lead—in our opinion—to increased ligament laxity over time because the semitendinosus muscle is in an anterior position relative to the sMCL footprint.

Joshi et al.[6] developed a new technique for reconstructing the sMCL and POL using the intact semitendinosus muscle at its tibial attachment. It is then rerouted to the native tibial sMCL insertion by a metallic anchor.

LaPrade et al.[13] also reported an anatomical double-bundle PMC reconstruction technique in which the semitendinosus is split to create 2 bundles that are subsequently fixed with 4 interference screws in 4 drilled holes. Nonetheless, using 4 interference screws in this technique renders the surgery more challenging and raises the likelihood of tunnel collision in the context of a multiligament reconstruction. Moreover, Borden et al.[8] have described a similar technique using a tibialis anterior allograft, fixed with 3 different interference screws, one at the femoral condyle and 2 at the tibial sMCL and POL insertion, respectively.

The PMC has 3 principal components: the superficial long fibers (sMCL), the deep meniscal-capsular

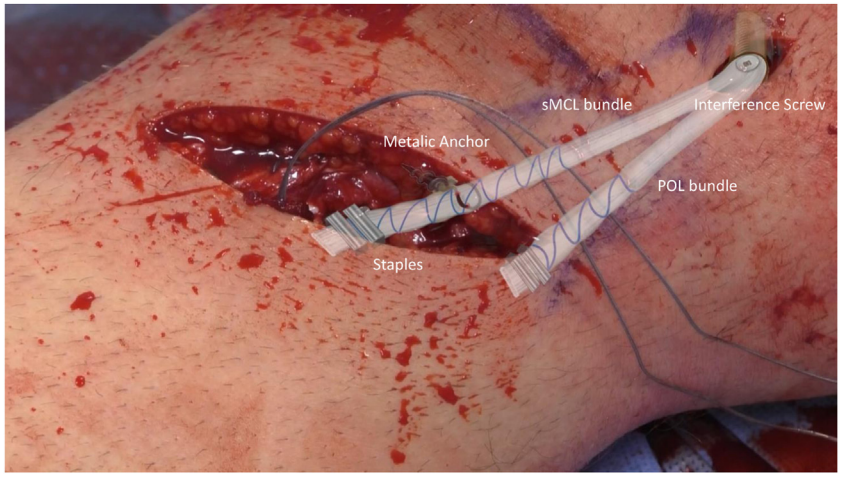

Fig 11. After securing the graft at the level of the medial femoral epicondyle using an interference screw, the remaining 2 bundles are fixed in an anatomical position at the tibial level using 2 cams per bundle.

structures (deep MCL), and the POL. The length change patterns of the native PMC strongly depended on its fiber region. Kittl et al.,[12] in a recent study, showed how the sMCL is tight in flexion, whereas the POL is tight in extension.

Moreover, Kittl et al.[12] highlighted how the femoral graft attachment position would significantly change the graft length patterns. Reconstructing the sMCL with a semitendinosus autograft, left attached distally to its tibial insertion, would appear to have a minimal effect on length change compared with detaching it and using the native tibial attachment site, perhaps obviating the need for tibial fixation.

During intraoperative isometric tests, we consider reproducing the normal sMCL biomechanics mandatory. We adjust the position of the femoral tunnel to best achieve the isometric graft behavior and then fix the sMCL and POL with the knee flexed at 90° and in full extension, respectively.

In conclusion, the presented technique is highly feasible for patients who have experienced multiligament knee injuries or need additional surgical procedures. The use of staples for tibial fixation method preserves bone stock and reduces the risks of tunnel collisions and intraoperative complications in the case of additional procedures such as ACL or posterior

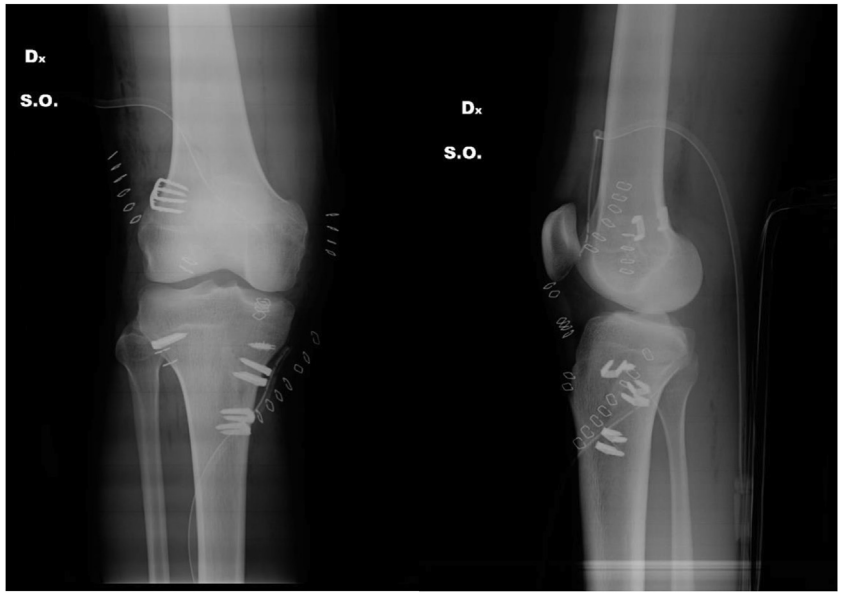

Fig 12. Final radiographic control demonstrates correct femoral and tibial staples positioning and absence of accessory tibial tunnels.

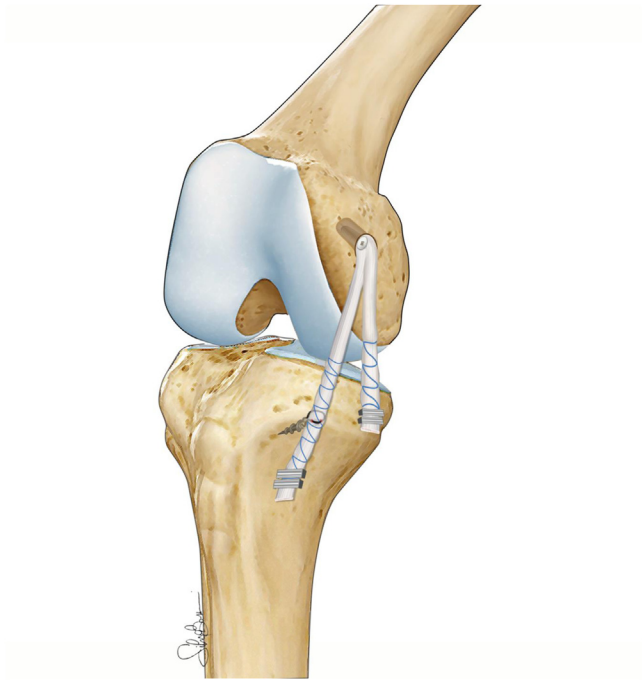

Fig 13. Minimally invasive double-bundle posteromedial corner reconstruction using autologous semitendinosus or fresh-frozen allograft (tibialis anterior) posteromedial corner reconstruction without tibial tunnels.

Table 1. Advantages and Limitations

Advantages	Limitations
Minimally invasive: Less invasive compared with techniques that require tibial tunnels.	Surgical complexity: May require high surgical expertise and precision.
Preservation of tibial bone stock: Beneficial for future procedures, reducing the risk of tunnel interference.	Limited long-term data: Further studies are needed to assess long-term clinical outcomes.
Suitable for multiple ligament reconstructions: Ideal for patients requiring multiple ligament reconstructions	
Avoids tunnel collision: Reduces the risks associated with tunnel collision during surgery.	
Feasibility and effectiveness: Provides a feasible and effective solution for chronic medial knee instability.	

cruciate ligament reconstruction, meniscal allograft transplantation (MAT), high tibial osteotomy (HTO), and deflexion osteotomy.

Disclosures

All authors (G.M.M.M., V.G.R., S.Z.) declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Table 2. Pearls and Pitfalls

Pearls	Pitfalls
Thorough preoperative planning: Essential for determining the appropriateness of this technique for each patient.	Risk of injury to nearby structures: Care must be taken to avoid damage to the saphenous nerve and vein
Careful graft preparation: Ensuring appropriate graft length and strength is critical.	Managing associated injuries: Concurrent injuries (e.g. ACL or PCL lesions) need careful management.
Precise surgical technique: Accurate placement of femoral and tibial insertions is crucial for successful outcomes.	Postoperative care: Requires specific rehabilitation protocols to ensure successful recovery.ACL, anterior cruciate ligament; PCL, posterior cruciate ligament; PMC, posteromedial corner.
Attention to anatomic details: Understanding the anatomy of the knee, especially the PMC, is vital.	

ACL, anterior cruciate ligament; PCL, posterior cruciate ligament; PMC, posteromedial corner.

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