

Medial Collateral Ligament Reconstruction With Anteromedial Reinforcement for Medial and Anteromedial Rotatory Instability of the Knee



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Abstract: Even though structures of the medial side of the knee have a high potential to heal without surgery, in some circumstances injuries of this region may lead to development of chronic medial and anteromedial rotatory instability (AMRI). In those circumstances, surgery should be performed. Current-day surgical techniques are focused on recreating the function of the main stabilizers of the medial side of the knee, which are the medial collateral ligament and the posterior oblique ligament, but they omit the role of the anteromedial capsule. Nonetheless, they are able to restore at most “near-native” biomechanics of the joint, are highly invasive, and require advanced skills in posteromedial knee surgery. Maybe we should take a look at chronic medial instability and AMRI from the other side? We present a minimally invasive reconstruction of the superficial medial collateral ligament with anteromedial reinforcement for the AMRI component. Level of evidence: 1 (knee) and 2 (collateral ligaments).

Whereas the injuries of the medial side of the knee are commonly identified with superficial medial collateral ligament (sMCL) tears, the anatomy and biomechanics of this region are complex.¹ The most important anatomic structures for the stability of the medial side of the knee involve the sMCL, the deep medial collateral ligament (dMCL), the posterior oblique ligament (POL), and other elements of the posteromedial corner.² These structures act as a primary restraint to valgus stresses and rotatory movements of the tibia, and when they are damaged, medial and posteromedial instability develop. In the last few years,

the role of the anteromedial capsule has also been reported in the literature.³ This structure is the main static stabilizer of the anterior one-third of the medial side of the knee and may be damaged during medial knee

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The authors report the following potential conflicts of interest or sources of funding: K.M. reports Zimmer Biomet consultant, PTArthro board. R.F.L. reports consultant and royalties, Arthrex, Össur, and Smith and Nephew; editorial board, AJSM, JEO, and KSSTA. Full ICMJE author disclosure forms are available for this article online, as [supplementary material](#).

Received February 26, 2019; accepted March 17, 2019.

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2212-6287/19262

<https://doi.org/10.1016/j.eats.2019.03.019>

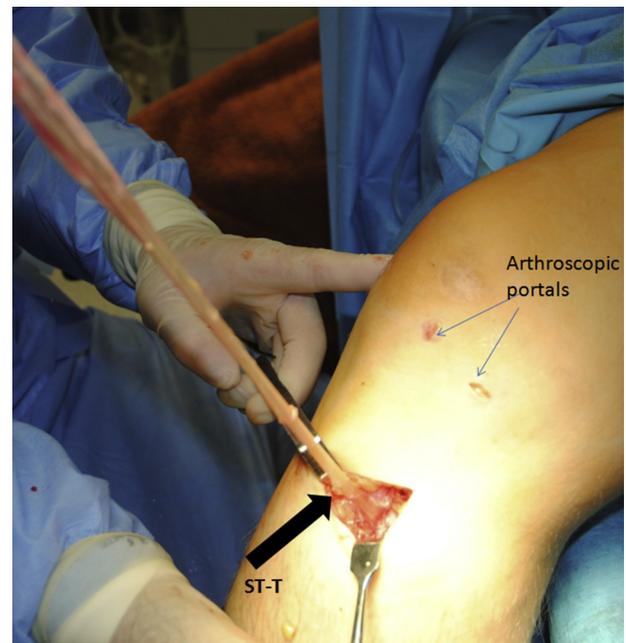


Fig 1. Medial side of the right knee. Semitendinosus tendon (ST-T) harvested from its proximal part, using an open-ended hamstring stripper, with preserved tibial attachment. Medial portals after previously performed arthroscopy are visible.

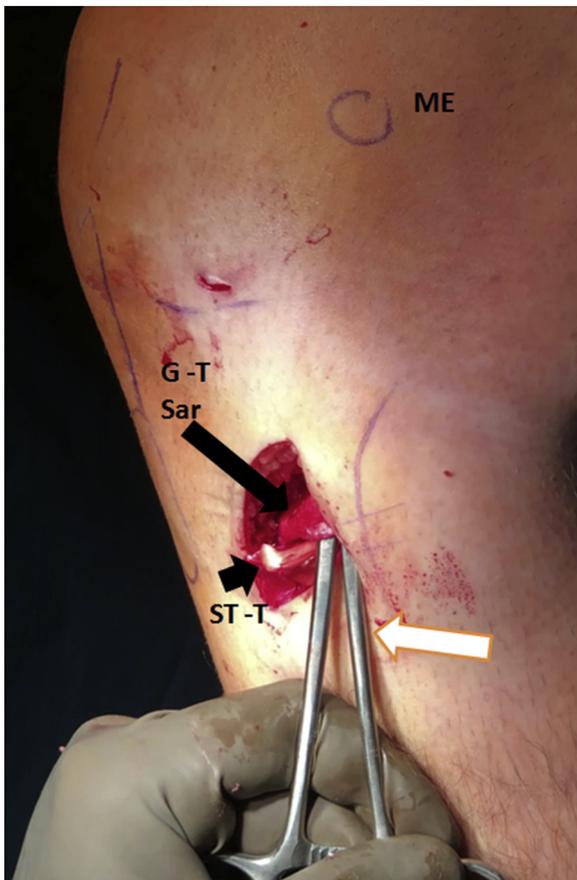


Fig 2. Medial side of the right knee in flexion. A natural path under intact gracilis tendon (G-T) and sartorius (Sar) is found along the course of the superficial medial collateral ligament to the medial epicondyle (ME) using a long, sequentially closed and opened Pean's forceps (white arrow). ST-T, semitendinosus tendon.

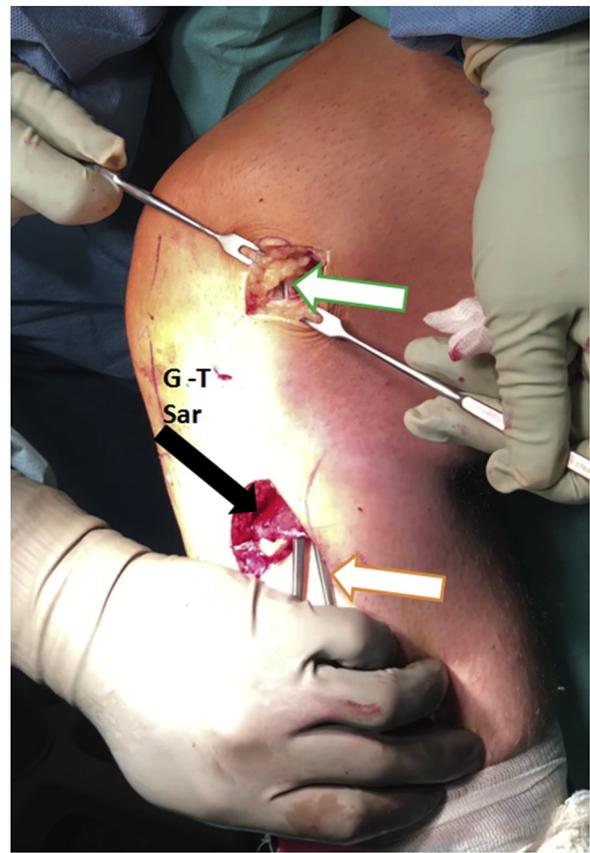


Fig 3. Medial side of the right knee in flexion. The second 4-cm-long incision at the level of the medial epicondyle is performed just above the tip (white arrow with green contour) of Pean's forceps (white arrow with orange contour) introduced through the natural path of the superficial medial collateral ligament below the lower margin of gracilis tendon (G-T) and sartorius (Sar).

injuries, intensifying the medial and anteromedial rotatory instability (AMRI) caused by an sMCL tear.⁴ It has been proven that the direction of AMRI, like the direction of the posterolateral rotatory instability, places an additional strain on intraarticular structures such as the anterior cruciate ligament (ACL) or the posterior cruciate ligament (PCL), which can lead to tears or reconstruction graft failures.¹ This is why we call medial knee instability together with AMRI the “hidden enemy” of cruciate ligaments and their grafts.

Because of the high potential to heal without surgery, surgical intervention in acute injuries is indicated only when a concurrent ACL or PCL tear exists and involves the acute repair or reconstruction of damaged medial structures.⁵ For chronic valgus instability with medial gapping and multiligament injuries, surgical management is the method of choice and involves the reconstruction, rather than just repair, of the main medial stabilizers of the knee: the sMCL and the POL.^{1,5-9} Currently, ~28 surgical techniques for medial reconstructions exist, but only 1 is anatomic for the

sMCL and allows restoration of “near-native” knee biomechanics in the coronal plane.^{7,8} In the literature, there is a need for less invasive, less technically demanding, and more reproducible techniques.⁸ Our aim is to present a minimally invasive surgical technique of sMCL reconstruction with anteromedial reinforcement for torn anteromedial structures of the knee.

Surgical Technique

Indications

Valgus instability with or without AMRI of the knee.

Contraindications

Damaged or previously harvested semitendinosus (ST) tendon, lack of full extension, skin lesions in the area of surgery, or a noncooperative patient.

Patient Positioning and Preparation

The patient is positioned supine on the operating table with a nonsterile thigh tourniquet placed on the

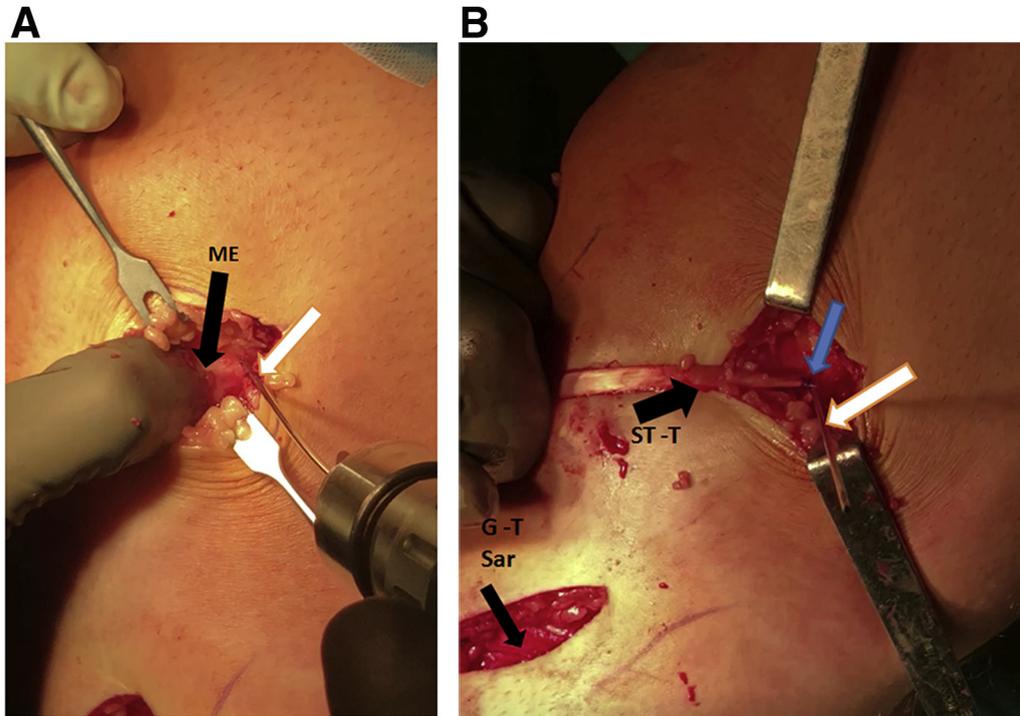


Fig 4. (A) Medial side of the right knee in flexion. The medial epicondyle (ME) is identified by palpation. A 1.6-mm Kirschner wire (K-wire) (white arrow) is placed in the point 3.2 mm proximal and 4.8 mm posterior to the center of the ME as the starting point for the isometry assessment. (B) Medial side of the right knee. Semitendinosus tendon (ST-T) graft is wrapped around the K-wire (white arrow), placed in the potential femoral point of isometry, and marked with a sterile marker (blue arrow). The isometry of the graft is checked through the full range of knee motion and confirmed when the mark on the graft does not move >1 mm from the K-wire. G-T, gracilis tendon; Sar, sartorius.

operated leg. After induction of spinal or general anesthesia, knee stability examination is performed (Video). The knee is prepared and draped in a sterile fashion. A diagnostic arthroscopy should be performed to rule out other intraarticular lesions and confirm significant opening of the medial compartment. Concomitant intraarticular pathologies should be treated first, except ACL reconstruction, which is performed after the medial side reconstruction. Note that when the posteromedial arthroscopic portal is used, subcutaneous tissue edema resulting from fluid extravasation in the area of medial reconstruction can be expected.

sMCL Reconstruction With Anteromedial Reinforcement

To facilitate orientation on the medial side of the knee, the most important anatomic landmarks are ticked with a sterile marker on the skin. They include the medial epicondyle (ME), the medial border of the tibia, the medial joint line, and hamstring tendons close to the pes anserinus (Video). An oblique, 5-cm-long skin incision above the hamstrings is performed with a

scalpel (Video). Blunt dissection of the subcutaneous tissue is done until the sartorial fascia becomes visible and hamstring tendons can be identified. The sartorial fascia is incised under the lower border of the semitendinosus tendon (ST-T), and the proximal part of the ST-T is harvested with an open-ended hamstring stripper (Johnson & Johnson, Mitek, New Brunswick, NJ), whereas the distal hamstring attachments to the tibia are left intact (Figure 1, Video).

The natural path under the intact gracilis tendon (G-T) and sartorius is found along the course of the sMCL to the ME using a long, sequentially closed and opened Pean's forceps (Figure 2, Video). The second, oblique, 4-cm-long skin incision is made at the level of the ME (Figure 3, Video). The tip of the Pean's forceps allows one to find the right place and not cut structures below. The ME is identified by palpation, and a 1.6-mm Kirschner wire (K-wire) is placed 3.2 mm proximal and 4.8 mm posterior to its center, in the native sMCL insertion as a starting point. Because the natural distal insertion of the ST-T lies anterior to the distal insertion point of the sMCL, the isometric femoral spot for reconstruction is usually located 5 to 8 mm proximal to

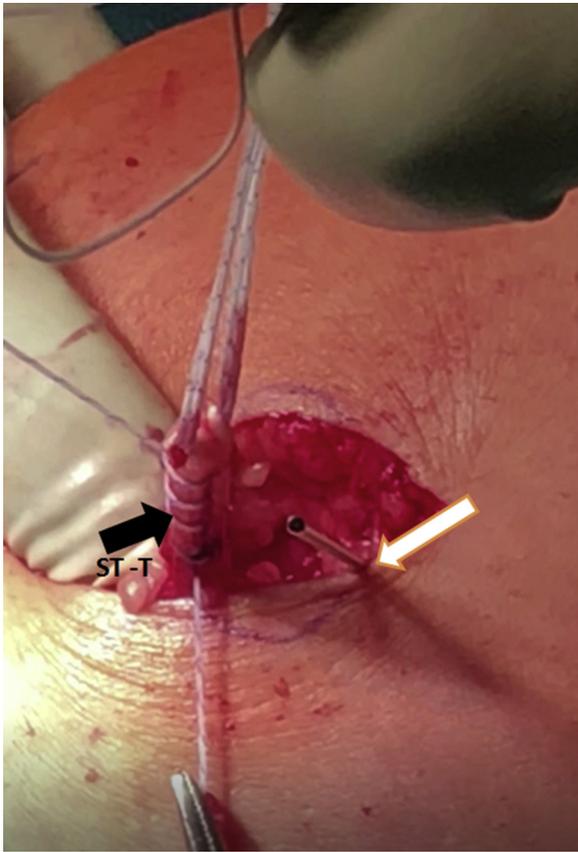


Fig 5. Medial side of the right knee. Semitendinosus tendon (ST-T) graft is double-folded at the ToggleLoc device with ZipLoop Technology and whipstitched at a distance of 2 cm with MaxBraid Suture No. 2. A Kirschner wire is placed in the femoral point of isometry (white arrow).

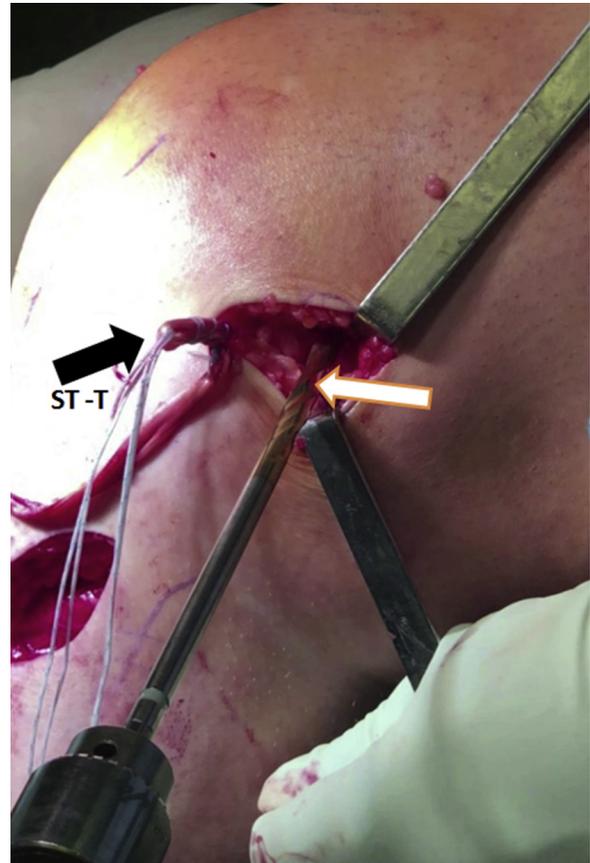


Fig 6. Medial side of the right knee in flexion. The drill (white arrow) matched to the size of the double-folded semitendinosus tendon (ST-T) graft is used to make a femoral tunnel for stabilization of the whipstitched part. The drill should be directed proximally and anteriorly.

the starting point (Figure 4A, Video). Now the ST-T is passed underneath the G-T and sartorius using the Pean's forceps toward the upper incision window and wrapped around the K-wire (Video). The ST-T is marked with a sterile marker at the point next to the K-wire, and the isometry of the graft is checked through the full range of knee motion (Figure 4B, Video). The isometry of reconstruction is confirmed when the graft does not move on the K-wire >1 mm in the range of 0° to 90° of knee flexion and becomes lax in higher degrees of flexion (Video).

The ST-T is double-folded at the ToggleLoc device with ZipLoop Technology (Zimmer Biomet Polska, Warsaw, Poland) and whipstitched for a distance of 2 cm with MaxBraid Suture No. 2 (Zimmer Biomet) (Figure 5, Video). The thickness of the graft is measured, and the femoral tunnel, matched to the size of the graft, is made in the previously identified insertion point with a pin guide and drill (Figure 6, Video). The femoral tunnel should be directed proximally and

anteriorly to avoid collision with the intercondylar notch and the potential course of the femoral tunnel for PCL reconstruction. With an eyelet pin and passing suture, the graft is introduced to the femoral tunnel, fixed on the lateral cortex with a ToggleLoc device, and properly tensioned (Figure 7, Video). In this way, the anterior branch of the construction plays a role of supra-anatomic, isometric anteromedial reinforcement for anteromedial structures.

In the next step, the posterior branch of the graft is used to reconstruct the sMCL. At the beginning, the posterior branch of the ST-T and the tensioning strands (MaxBraid Suture No. 5 [Zimmer Biomet]) from the ToggleLoc device are passed below the skin toward the native distal tibial attachment of the sMCL with Pean's forceps (Video). On the line parallel and close to the posterior tibial cortex, the distal point of isometry for the sMCL graft is searched as before (Figure 8, Video). A 1-cm-long incision along the vertical fibers is

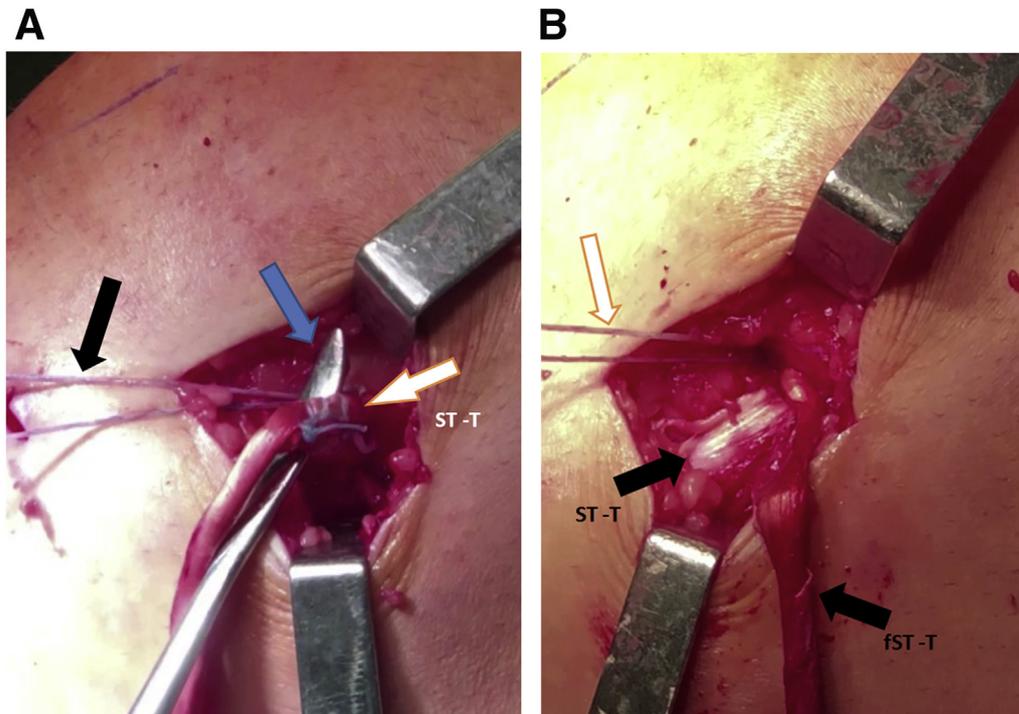


Fig 7. Medial side of the right knee in flexion. (A) The whipstitched part of the semitendinosus tendon (ST-T) graft (white arrow) is introduced to the femoral tunnel, fixed on the lateral cortex with a ToggleLoc device, and properly tensioned with tensioning sutures (MaxBraid Suture No. 5) (black arrow). A blunt elevator (blue arrow) is used to facilitate introducing the graft. (B) The whipstitched part of the ST-T graft is introduced to the femoral tunnel and tensioned with MaxBraid Suture No. 5 (white arrow), forming an anterior branch, which performs anteromedial reinforcement. The free part of the semitendinosus tendon graft (fST-T) will be used for superficial medial collateral ligament reconstruction.

performed on the sMCL native distal attachment. A drill 1 to 1.5 mm larger than the measured size of the graft is used to ream the tibial socket in the point of isometry on the medial cortex. The drill is then changed to 4.5 mm, and the tibial tunnel is directed anterolaterally until the lateral tibial cortex is overdrilled (Figure 9, Video). The graft is whipstitched at a distance of 2 cm distal and 0.5 cm proximal to the point of isometry. The rest of the ST-T is cut. The whipstitched part is a little bit longer than the socket part to have some sutures at the entrance, which prevents friction on the cortical bone of the tibia.

The graft and tensioning strands of the ToggleLoc device are sequentially passed into the tibial tunnel using eyelet pins (Figure 10, Video). A Guardsman Interference Screw (Conmed Linvatec Polska, Warsaw, Poland), 1 mm smaller than the diameter of the tibial tunnel, is used for fixation of the posterior branch of reconstruction on the medial tibial cortex (Figure 11A, Video). As a secondary stabilization on the lateral tibial cortex, a cortical button (Medgal, Bialystok, Poland) is used (Figure 11B, Video). In this way, the posterior

branch of the construction is an anatomic reconstruction of the sMCL reinforced with a brace-like mechanism, which is created with the MaxBraid Suture No. 5 from the ToggleLoc device running from the femoral to tibial points of isometry.

Rehabilitation Protocol

Because the reconstruction is completely isometric, passive range of motion in 0° to 90° is safe and starts on the first postoperative day. Walking on crutches is recommended for 6 weeks. For the first 2 postoperative weeks, the patient uses a simple straight knee immobilizer, then the Quantum (BREG, Carlsbad, CA) brace dedicated for lateral osteoarthritis of the knee is recommended for walking. From week 4, the brace is set for 0° to 90°, and after week 6, full active range of motion is allowed. We discontinue bracing gradually after the third month. For the first 6 weeks, quadriceps strengthening exercises, cocontraction exercises, and patella and scar mobilization are performed.

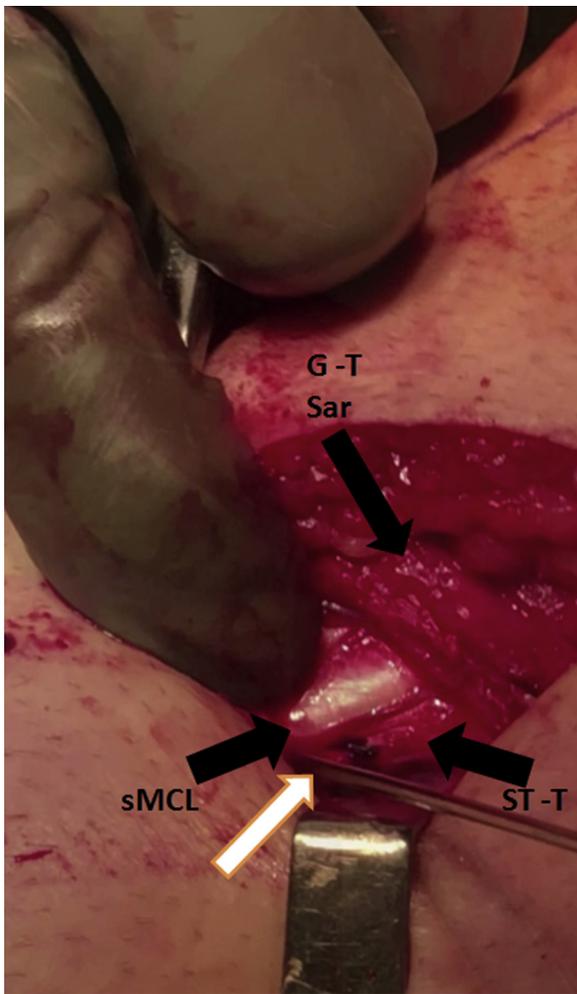


Fig 8. Medial side of the right knee in flexion. Proximal tibia. The Kirschner wire (white arrow) is positioned in the potential point of isometry on the line parallel and close to the posterior tibial cortex. The isometry is checked in the previously described manner. G-T, gracilis tendon; Sar, sartorius, sMCL, native superficial medial collateral ligament; ST-T, semitendinosus tendon graft.

Discussion

The presented surgical technique provides a unique approach to the treatment of medial instability with or without AMRI. Many surgical techniques have been developed for medial instability, but only 1 was anatomic for the sMCL and able to restore near-native biomechanics of the medial side of the knee⁷; however, that technique could not always be used because of its high invasiveness and high surgical skill requirement.⁸ Other procedures often use the ST-T graft with intact distal attachment to perform a double-bundle reconstruction with single femoral fixation; in these cases, the anterior branch of construction is supposed to play the role of the sMCL, whereas the posterior branch recreates the function of the POL.^{5,8} However, this

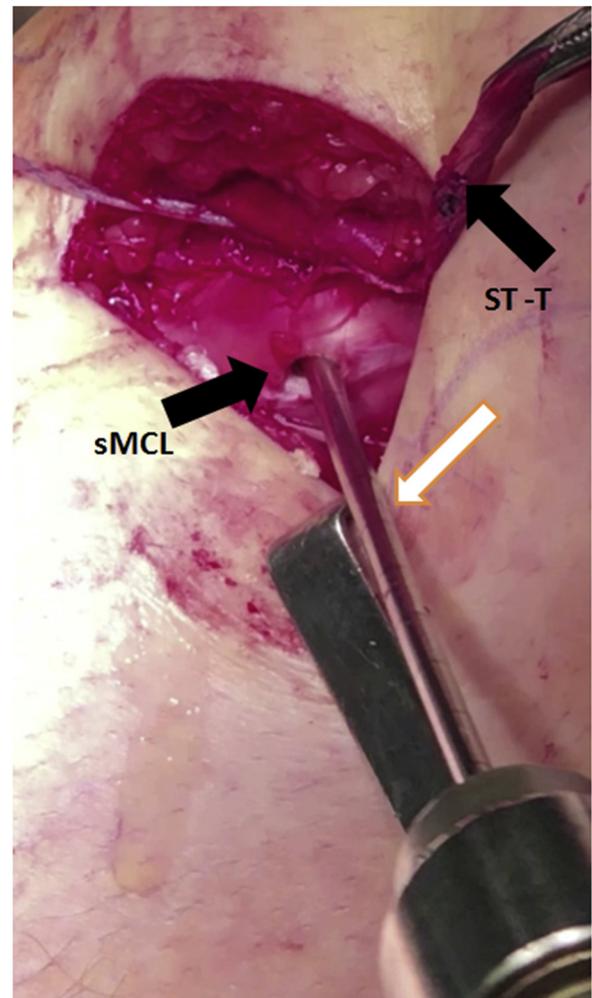


Fig 9. Medial side of the right knee in flexion. Proximal tibia. The drill (white arrow) is used to create the tibial tunnel for superficial medial collateral ligament (sMCL) reconstruction in the point of isometry. ST-T, semitendinosus tendon graft.

solution seems to have worse results: it cannot restore medial knee stability in the coronal plane, because the sMCL is reconstructed nonanatomically.⁸ Moreover, the POL graft is often tensioned with the knee in flexion, which is inconsistent with the native biomechanics of this ligament.²

Unlike other procedures using the ST-T graft with a preserved tibial attachment, the surgical technique we present uses the anterior branch as a supra-anatomic reinforcement resisting the anteromedial instability, whereas the posterior branch is used to reconstruct the sMCL anatomically. It restores a firm valgus restraint. Moreover, the whole construction is isometric in the range of 0° to 90° of flexion, allowing introduction of early rehabilitation with passive motion in a safe zone starting at the first postoperative day. Such early motion prevents arthrofibrosis, the common complication of medial knee surgeries.⁹

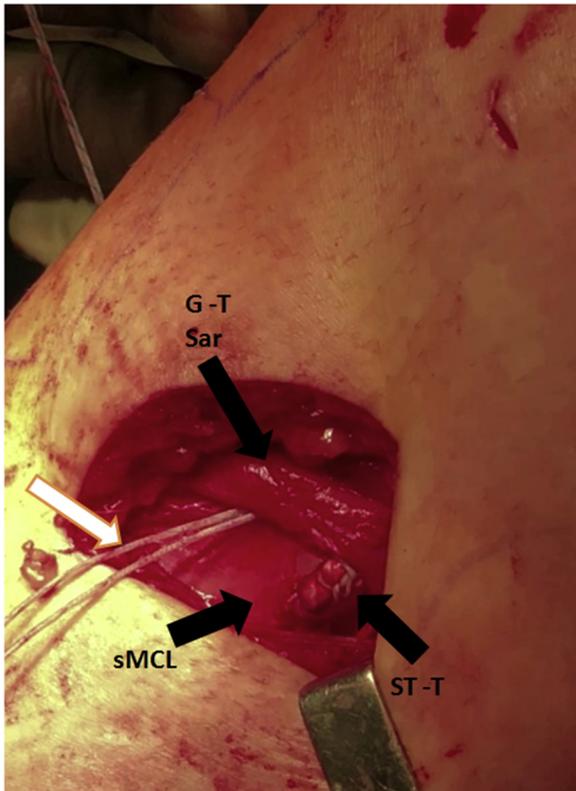


Fig 10. Medial side of the right knee in flexion. Proximal tibia. The whipstitched semitendinosus tendon (ST-T) graft and tensioning strands of the ToggleLoc device (white arrow) are sequentially introduced to the tibial tunnel. G-T, gracilis tendon; Sar, sartorius; sMCL, native medial collateral ligament.

A specific surgical tip for the procedure is preserving the tensioning strands of the ToggleLoc device fixed on the femur, passing them parallel to the sMCL graft, and introducing them to the tibial tunnel. In this way, the strands perform internal bracing, reinforcing the sMCL graft, and also allow for regulation of tension of the whole reconstruction until final fixation of the graft on the lateral tibial cortex. Moreover, the second fixation on the tibial side using a cortical button on the lateral tibial cortex allows the use of a titanium screw for initial stabilization that is smaller than the size of the tunnel, avoiding graft damage or amputation.

There are also some disadvantages of the sMCL reconstruction with anteromedial reinforcement. First of all, the construction is only partially anatomic. The conception of a supra-anatomic anterior branch that resists AMRI seems to be clinically efficient and appealing, especially because it obviates the necessity of posterior knee surgery, but it requires further thorough biomechanical evaluation. Proper patient selection is also necessary; in particular, posteromedial instability has to be excluded. Moreover, the surgery cannot be performed when the ST-T is damaged or previously harvested, and using the ST-T graft for medial side reconstruction does not preserve the autograft that could be used for other ligament reconstructions. The advantages and disadvantages of the technique are summarized in the [Table 1](#). The study protocol was approved by a bioethics committee.

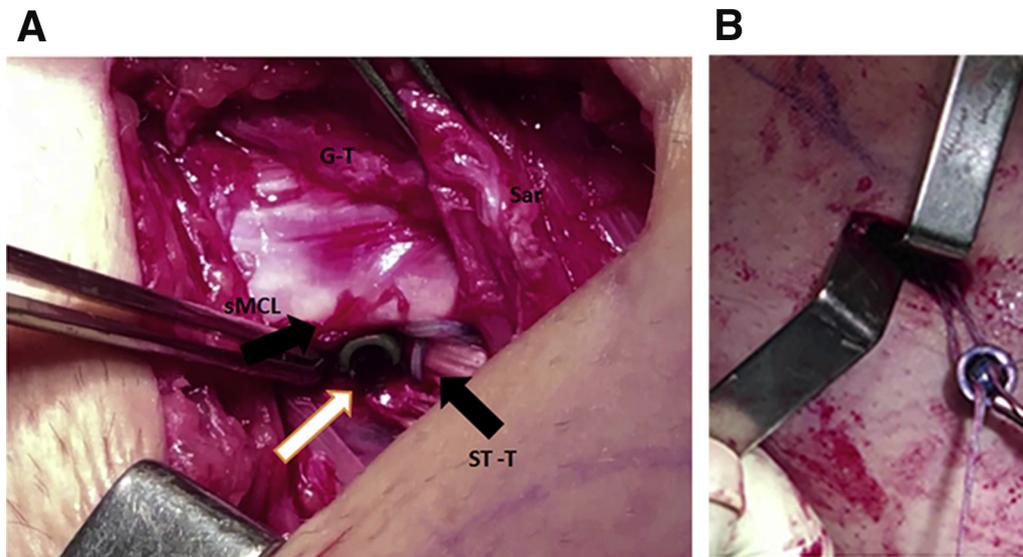


Fig 11. (A) Medial side of the proximal tibia. The whipstitched semitendinosus tendon (ST-T) graft stabilized with the Guardsman Interference Screw (white arrow). (B) Lateral side of the proximal tibia. Secondary stabilization on the lateral tibial cortex with the cortical button. G-T, gracilis tendon; Sar, sartorius; sMCL, native medial collateral ligament.

Table 1. Advantages and Disadvantages of Anatomic sMCL Reconstruction With Anteromedial Reinforcement

Advantages	Disadvantages
Anatomic sMCL reconstruction using an autograft with preserved blood supply, which provides firm valgus stability of the knee in the coronal plane	The proximal tibial attachment of the sMCL is not reconstructed
Anteromedial reinforcement for anteromedial rotatory instability component	Anteromedial reinforcement is a supra-anatomic structure
Isometric reconstruction in the range of 0° to 90° of flexion, allowing for early passive range of motion and reducing the risk of arthrofibrosis	Transient palpation pain around the placed femoral tunnel
Double stabilization on the tibial side allows use of a titanium screw smaller than the diameter of the tunnel, preventing graft devastation	The procedure cannot be performed if the semitendinosus tendon was injured or harvested
Posterior branch plays the role of the sMCL, braced with the MaxBraid Suture No. 5 from the ToggleLoc device running from the femoral to tibial points of isometry	The procedure does not preserve the autograft for other reconstructions
Preservation of dynamic medial stability of the knee by leaving gracilis and sartorius tendons intact	
Reduced invasiveness, using 3 small skin incisions	
Preservation of the native tissue of the sMCL	

sMCL, superficial medial collateral ligament.

Conclusions

We believe that the technique presented can be an answer to the reported need for a less invasive surgical approach that is more reproducible and less technically demanding than those currently available.⁸

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