Technical Note

Anatomical Repair With Achilles Tendon Allograft Augmentation for Distal Medial Collateral Ligament Ruptures

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Abstract: Several conditions may require medial collateral ligament (MCL) surgery, especially when high physical demands are required. Thus, we described a technique for anatomical repair of distal MCL rupture using a distal anchor and MCL augmentation through Achilles tendon allograft with proximal bone block and interference screw. This procedure fixes an anchor distally at the tibia. Then, the ligament endings are sutured using a continuous simple-type technique. Subsequently, a low-radiated Achilles tendon allograft is attached proximally and fixed through an interference screw. Finally, the allograft is sutured using a continuous simple-type technique. Our anatomical MCL repair and augmentation allows a reinforced anatomical technique to control the valgus instability caused by MCL distal ruptures, considering the MCL axial traction and posterior oblique ligament fiber orientations.

The medial collateral ligament (MCL) restricts up to 78% of knee valgus.[1] However, injuries have a prevalence of 16.5%[2] and incidence of 0.24 to 7.30 per 1,000 people per year,[3,4] often requiring surgery.[5] MCL deficiency increases the knee valgus, external rotation, and anteromedial internal rotation constraints.[6] Posteromedial capsule/posterior oblique ligament (POL) deficiency can increase the internal rotation laxity during the final flexion degrees.[6] Severe or persistent valgus instability, distal Stener-type injuries, associated anterior cruciate ligament ruptures, avulsion fractures with POL compromise, or multiligament knee injuries[4] necessitate MCL biomechanics restoration.[7,8]

MCL augmentation enhances ligamentous healing and ultimate tensile strength.[9-12] Furthermore, when an Achilles allograft with the bone block is used, bone-to-bone healing and a constant length (isometric reconstruction) are achieved.[9] Although a bone block gives the Achilles allograft additional proximal attachment advantages,[13] it is relevant to control the radiation dose to ensure that the graft strength remains unaffected.[14]

To perform an anatomical repair of MCL with Achilles tendon allograft augmentation, here we aim to describe the technique for anatomical repair of distal MCL rupture using a distal anchor and MCL augmentation through an Achilles tendon allograft with proximal bone block and interference screw.

Surgical Technique

Video 1 details the anatomical repair and augmentation of the MCL with an Achilles tendon. The eligibility criteria and recommendations are shown in Table 1 and Table 2, respectively.

Allograft

This Technical Note follows the recommendation of Zamorano et al.[14] for Achilles allograft preparations and Food and Drug Administration regulations. Blood

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Table 1. Eligibility Criteria for sMCL Repair and Augmentation

Inclusion Criteria	Exclusion Criteria
• Severe valgus instability (clinical and radiologic radiograph with valgus stress) • Distal Stener-type injuries • Residual medial laxity valgus after conservative treatment grade III of MCL • Posteromedial corner injuries with POL involvement	• There is no particular restriction to using the Achilles allograft for MCL augmentation.

MCL, medial collateral ligament; POL, posterior oblique ligament; sMCL, superficial medial collateral ligament.

cultures for HIV, syphilis, B and C hepatitis tests, detailed clinical records, and disease screening of donors must be added for each allograft. Allografts may receive a low dose (b2 mRad) of radiation and should be stored frozen at −80°C. Tissue cleaning and disinfecting processes should warrant no adverse mechanical or biological impairment.

Technique

Patients are placed in a supine position with the hip and knee flexed at 90°, and sedation, anesthesia, and a tourniquet are used for exploratory knee arthroscopy.[15] All patients are administered antibiotic prophylaxis, according to the protocols of Zamorano et al.[14]

Medial knee stability, MCL, cruciate ligaments, and associated intra-articular injuries are explored by arthroscopy using conventional anteromedial and anterolateral portals between 0° and 30° of knee flexion. The drive-through sign for the medial compartment is assessed and evaluated positively when an excessive medial compartment opening (greater than 1 cm) with valgus stress at 30° of flexion is noted.[16]

The MCL, medial femoral condyle, interjoint line, medial tibial plateau (Fig 1A), and the open approach line crossing from the pes anserinus to medial epicondyle parallel to the posterior border of the MCL (Fig 1B and C) are marked on the skin. Then, an incision is performed from the pes anserinus toward the medial epicondyle using a No. 15 scalpel. The skin is undermined, and the sartorius fascia is dissected until the MCL is exposed using Metzenbaum curved scissors[15] (Fig 1C). Special caution must be taken to avoid damaging the saphenous nerves, genicular arteries, sartorius, and pes anserinus tendons. Also, monopolar electrocauterization is used when needed. At the end of this first step, the complete visualization is permitted of the damaged superficial MLC (Fig 2A), interjoint line (Fig 2B), deep MCL, and the anterior fibers of the POL (Fig 2C).

Table 2. Pearls and Pitfalls of MCL Repair and Augmentation Using an Achilles Tendon Allograft

Pearls	Pitfalls
• This reattachment and augmentation technique is better for acute MCL injuries. • To confirm the MCL distal rupture through MRI images. • To look for the drive-through sign. • A standardizing technique allows for obtaining the maximum potentialities of the graft. • No donor site morbidity. • High tensile resistance of the Allograft. • To attach the repaired MCL 6 cm distal from the joint line to reproduce the superficial fascicle of the MCL. • There is a healing advantage due to anatomical fixation by bone-to-bone at the femoral insertion. • To insert the proximal insertion of MCL at the center of the femoral epicondyle. • To develop the technique with 30° of knee flexion, neutral rotation, and slight knee varus. • To test the valgus stress between 0° and 30° of knee flexion.	• MCL chronic injuries make it difficult for the native MCL to reattach. • The intraoperative fluoroscopy should be considered to assist in the attachment of MCL. • The high risk of tunnel coalition at the femoral insertion should be considered when an ACL reconstruction is performed.

ACL, anterior cruciate ligament; POL, posterior oblique ligament; MCL, medial collateral ligament; MRI, magnetic resonance imaging.

After exposure of MCL, a quadruple high-resistance No. 2 suture with equal resistance and a titanium anchor of 5.5 × 16.3 mm (AR-1928SNF-2, Corkscrew FT II Suture Anchor; Arthrex, Naples, FL) is placed at the neutral axis of the MCL 60 mm from the joint line until the distal superficial medial collateral ligament (sMCL) insertion[15] (Fig 2D). The anchor tunnel is guided using an orthopaedic punch corkscrew instrument (AR-1927PB; Arthrex) as deep as the anchor mark indicates (Fig 3A). Then, the anchor tunnel is drilled through an orthopaedic punch tap corkscrew with a threaded punch to diminish the high resistance the cortical tibial bone offers to the anchor attachment (Fig 3B). This procedure prevents the anchor fracture during the surgery. The general principle of using the threaded punch is to obtain the anchor tunnel dimensions described by the fabricant. Finally, a titanium anchor of 5.5 × 16.3 mm (Corkscrew FT II Suture Anchor; Arthrex) is placed perpendicular to the tibia into the anchor tunnel (Fig 3D).

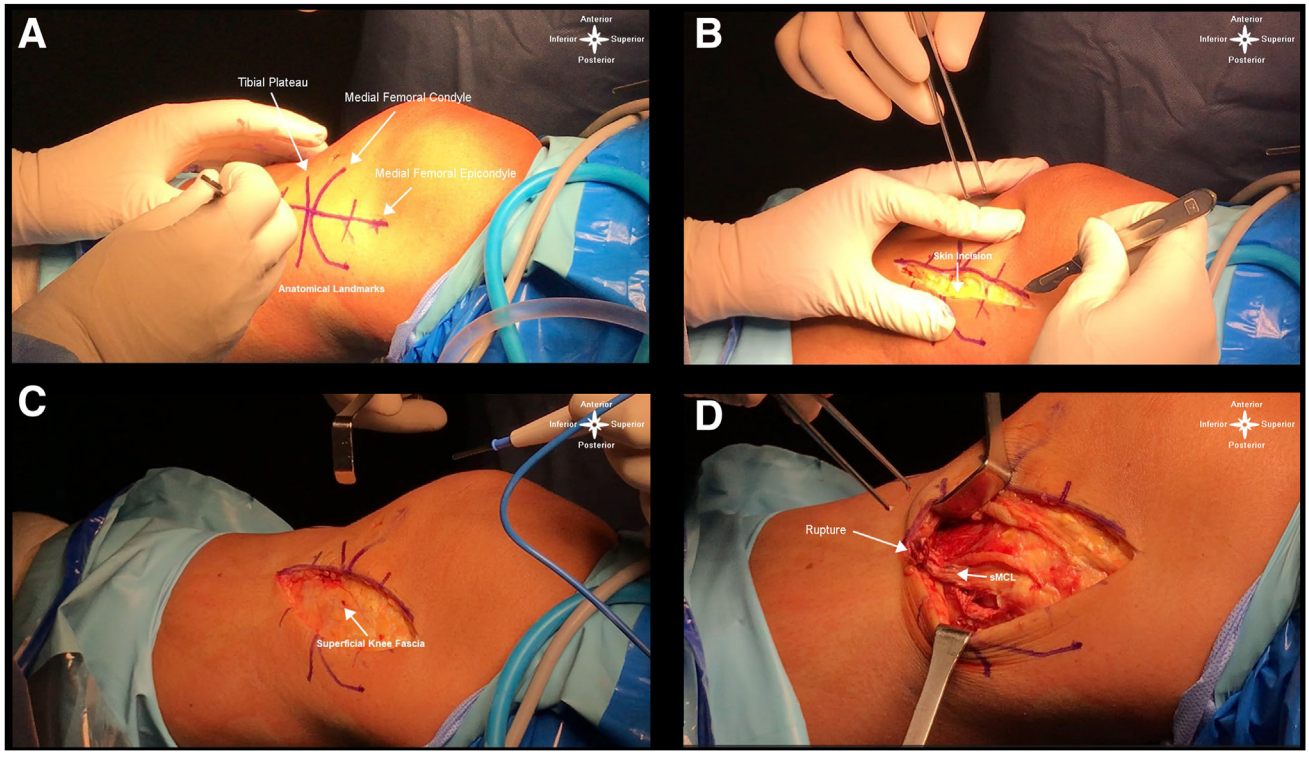

Fig 1. Skin preparation and medial collateral ligament exposure. (A) Anatomical landmarks marked on the skin (tibial plateau, medial femoral condyle, and medial femoral epicondyle). (B) The skin incision is made to expose the superficial medial collateral ligament (sMCL). (C) Superficial knee fascia exposure. (D) Exposure of the distal rupture of sMCL after sartorius fascia dissection. Medial view of the right leg with the patient in a supine position.

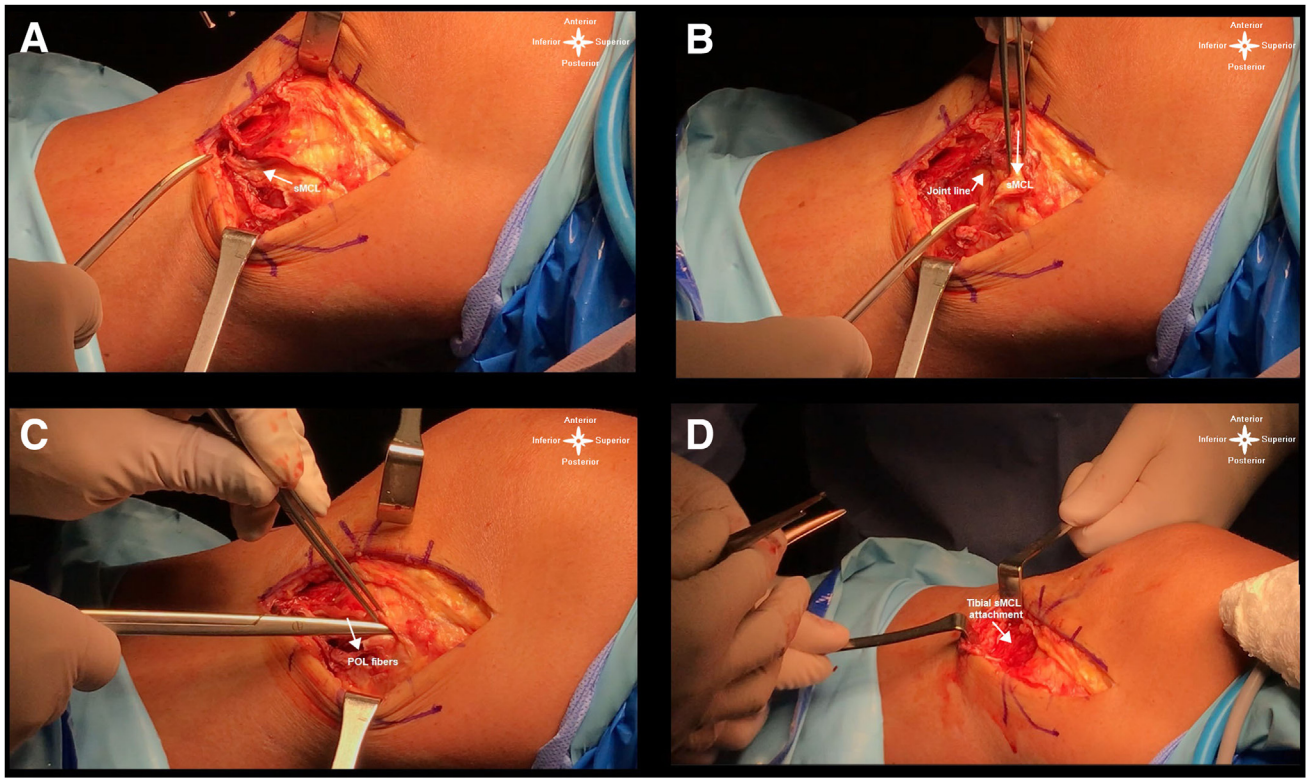

Fig 2. Medial knee ligaments and tibial attachment. (A) Superficial medial collateral ligament (sMCL) distal rupture. (B) Joint knee interline. (C) Anterior fibers of the posterior oblique ligament fibers (POL). (D) Tibial attachment of the sMCL. Medial view of the right leg with the patient in a supine position.

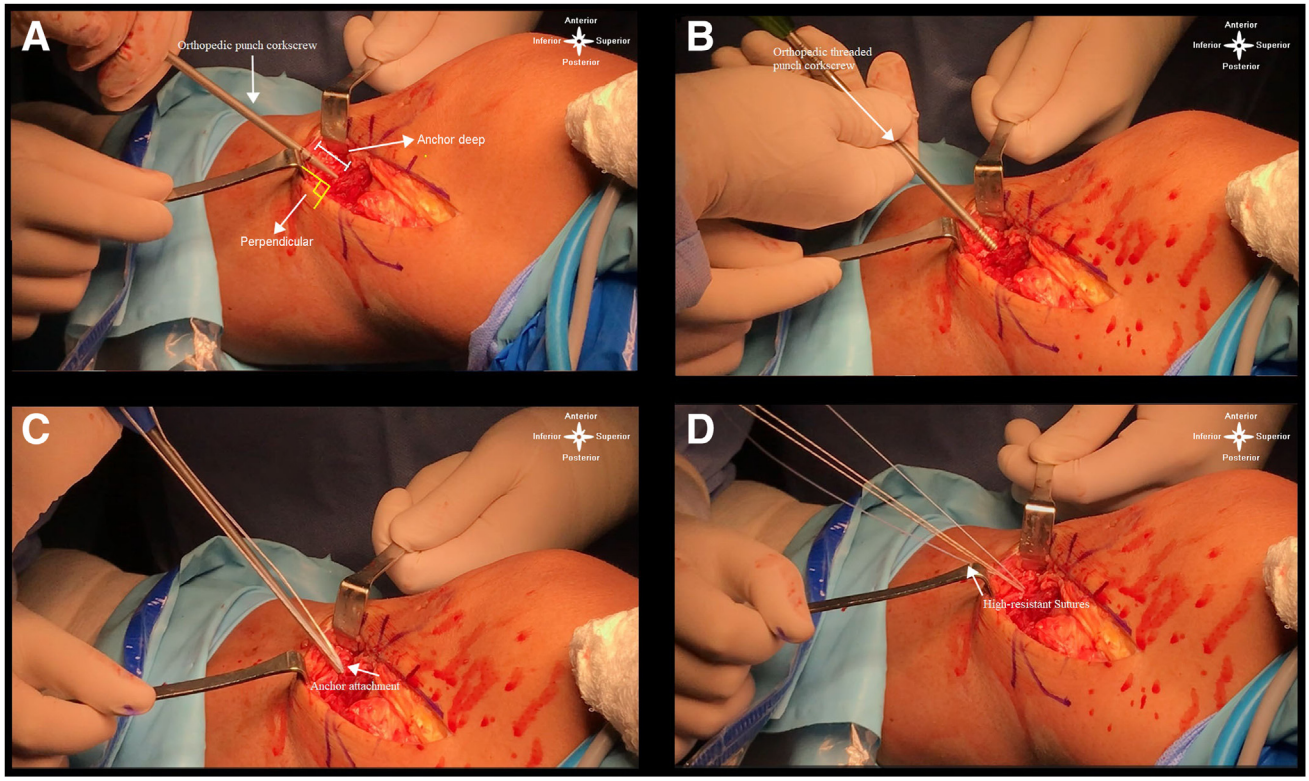

Fig 3. Anchor attachment at distal insertion (tibial bone) of the superficial medial collateral ligament (sMCL). (A) The orthopaedic punch corkscrew is placed perpendicular to the tibia bone (yellow illustration) approximately 60 mm from the knee joint line over the sMCL traction axis drilling as depth as the fabricant recommends (white illustration). (B) The tibial tunnel is drilled through an orthopaedic threaded punch corkscrew to avoid the anchor fracture due to the high stiffness of the tibial bone. (C) Perpendicular attachment of the anchor at sMCL axis traction in the tibial bone. (D) The 4 high-resistance sutures need to repair and augment the sMCL. Medial view of the right leg with the patient in a supine position.

Once the anchor is attached, the first pair of high-resistance sutures are used to repair the sMCL and the anterior fibers of the POL. The last suture pairs are reserved for ligament augmentation. The sMCL repair begins by suturing the proximal end to the distal attachment using a terminal-terminal technique with simple continuous sutures, quadruple overhand knots, and 2 simple knots (Fig 4 A-C). Then, the POL fibers are sutured with the sMCL with simple continuous sutures and tied with a simple knot fashion[8] (Fig 4D).

Then, a femoral condyle tunnel at the medial epicondyle for the Achilles tendon allograft attachment is created (Fig 5A). The Achilles tendon allograft preparation typically takes 10 to 15 minutes[14] and results in an allograft of 7 × 20-mm bone block (Fig 5B). The femoral tunnel is oriented through a fluoroscopy instrument, which also serves to check the final results. The condyle is drilled using a twist bit (Arthrex) to create a tunnel typically 3 to 5 mm longer than the allograft block bone,[14] resulting in a femoral tunnel of 7 mm × 25 mm (Fig 5B).

Finally, the allograft is attached and guided with a Kirchner wire proximally at the medial femoral epicondyle, according to Zamorano et al.[14] The tension on the repaired sMCL is given by the knee in 30° of flexion, neutral rotation, and slight varo. The bone block is fixed through a cannulated titanium interferential screw of 7 × 25 mm (AR-1371; Arthrex) with a manual screwdriver (Fig 5C). Then, the Achilles tendon allograft is continuously sutured at two-thirds distally from the middle line of the allograft, from caudal to cranial, from the repaired sMCL (inferior plane) to the allograft (superior plane) with triple central overhand knots and 2 simple knots (Fig 5D and Fig 6A). The middle portion of the posterior border of the allograft is oriented toward the POL with a simple and continuous suturing fashion (Fig 6B). The remnant allograft is dissected (Fig 6 C and D), and the medial stability is tested through a valgus stress test.[17] Finally, the opened tissues are closed by a layer of absorbable VICRYL 2.0 sutures and ETHILON 3.0 sutures (Ethicon, Somerville, NJ) to close the skin.

Discussion

The anisotropic nature of MCL implies an anatomical repair and reinforcement to improve the impaired MCL ultimate strength,[12,18] especially when the medial stability is compromised.[19] Our technique proposes an

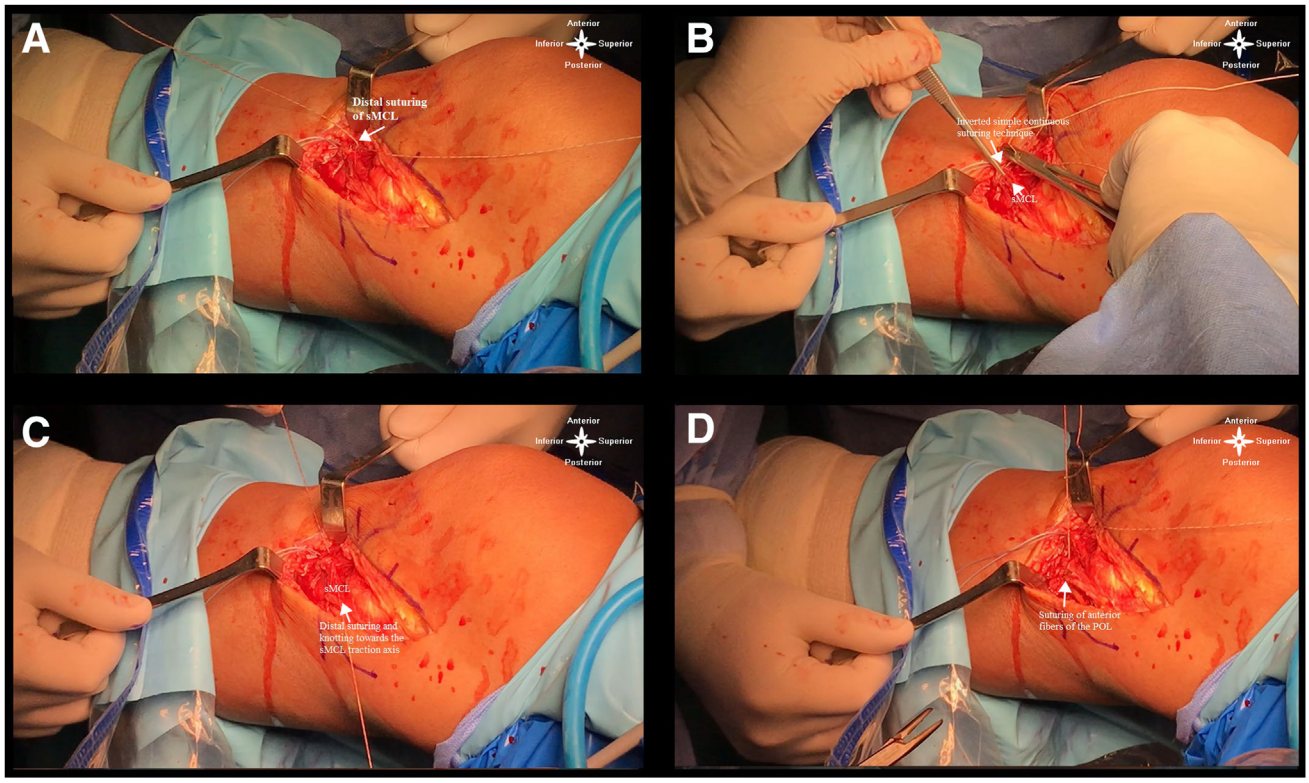

Fig 4. Superficial medial collateral ligament (sMCL) and posterior oblique ligament (POL) suturing and knotting. (A) The distal sMCL endings are sutured and knotted. (B) A simple inverted continuous suturing technique performs across the sMCL. (C) The suturing and knotting aim a repair considering the axial traction of the sMCL. (D) The repair of sMCL also considers the suturing of POL fibers. Medial view of the right leg with the patient in a supine position.

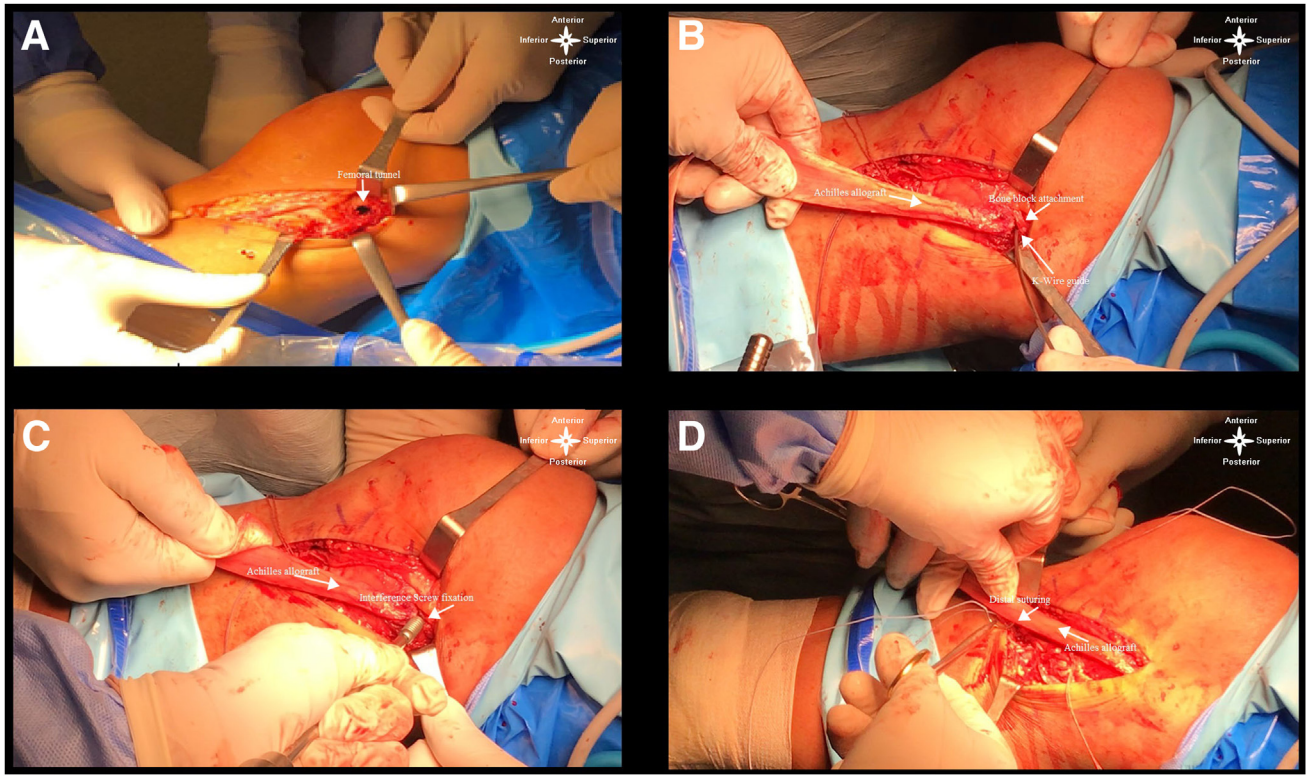

Fig 5. Femoral tunnel and Achilles allograft fixation. (A) Femoral tunnel. (B) Bone block of Achilles allograft attachment through Kirshner wire (k-wire). (C) Interference screw fixation at the femoral tunnel. (D) Distal Achilles allograft suturing to the sMCL. Medial view of the right leg with the patient in a supine position.

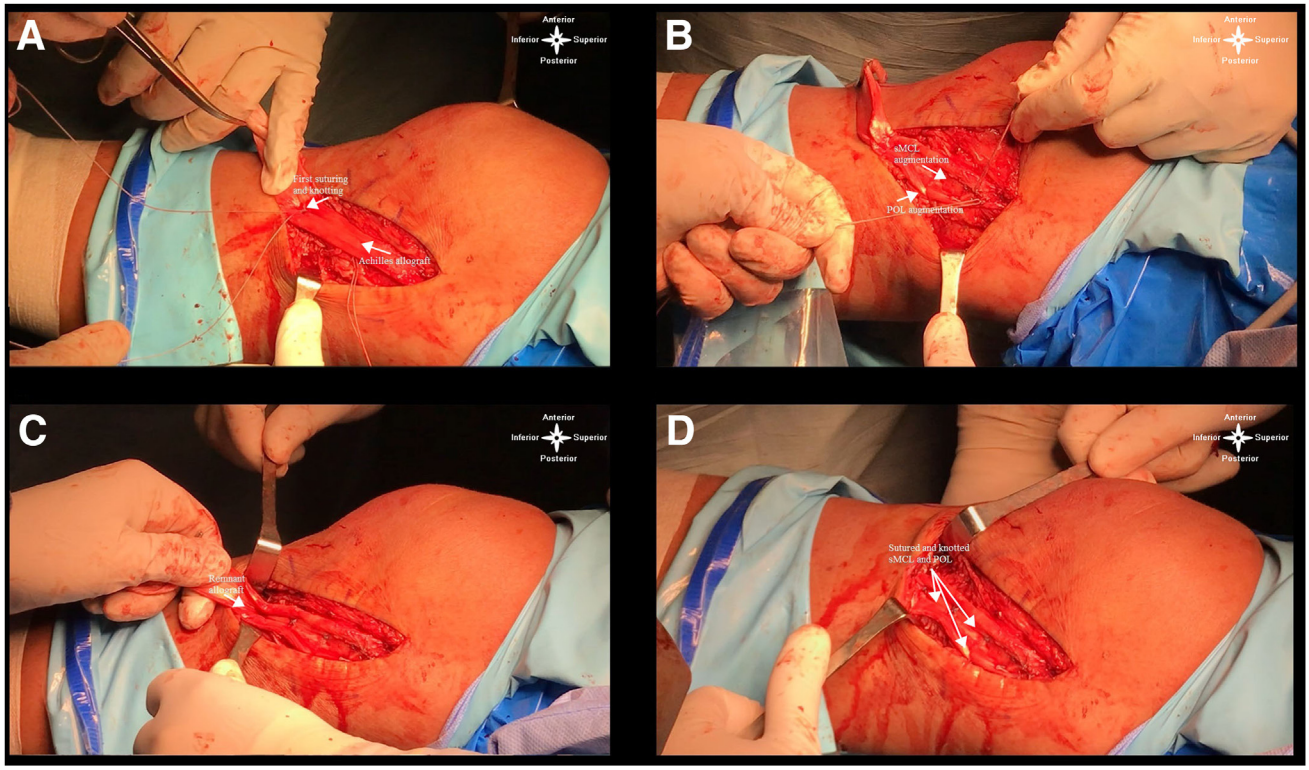

Fig 6. Superficial medial collateral ligament (sMCL) and anterior fibers of the posterior oblique ligament (POL) augmentation. (A) First step of sMCL augmentation. (B) Augmentation of the anterior fiber of the POL across the whole sMCL. (C) Remnant Achilles allograft. (D) Finalized augmentation of sMCL and anterior fibers of the POL. Medial view of the right leg with the patient in a supine position.

anatomical repair of the MCL to restore the traction axis function of the native MCL. The technique is in coherence with anatomical repair recommendations for MCL, which has been indicated as a better repair technique than nonanatomical and tendon transfer procedures.[8] Our technique also aims to increase the cross-sectional area of the repaired MCL and anterior fibers of the POL to obtain greater strength.[8,9,11] The choice to perform a ligament augmentation is not trivial because a typically ruptured MCL has lower mechanical properties and worse collagen conditions.[11,20] The pearls and pitfalls of our MCL repair and augmentation using an Achilles tendon allograft are summarized in Table 2.

Our proposed technique uses a previously standardized allograft technique.[14] The anchor and bone block attachments are the rigid components. Meanwhile, sutures are the elastic and deformable components oriented both in the mechanical traction axis of the MCL and across the mechanical axis of the POL fibers, both needed for the anisometric behavior of the MCL.

In conclusion, a standardized and appropriate anatomical MCL repair and allograft augmentation allows a reinforced anatomical technique to control the valgus instability caused by MCL distal ruptures.

Disclosures

All authors (R.Y., A.S., H.Z., G.C., C.Y., A.N., C.D.F.) declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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References

1. Phisitkul P, James SL, Wolf BR, Amendola A. MCL injuries of the knee: Current concepts review. *Iowa Orthop J* 2006;26:77-90.

2. Cristiani R, van de Bunt F, Kvist J, Stålman A. High prevalence of superficial and deep medial collateral ligament injuries on magnetic resonance imaging in patients with anterior cruciate ligament tears. *Arthroscopy* 2024;40:103-110.
3. Vosoughi F, Rezaei Dogahe R, Nuri A, Ayati Firoozabadi M, Mortazavi J. Medial collateral ligament injury of the knee: A review on current concept and management. *Arch Bone Jt Surg* 2021;9:255-262.
4. Kim C, Chasse PM, Taylor DC. Return to play after medial collateral ligament injury. *Clin Sports Med* 2016;35:679-696.
5. Lavoie-Gagne OZ, Retzky J, Diaz CC, et al. Return-to-play times and player performance after medial collateral ligament injury in elite-level European soccer players. *Orthop J Sports Med* 2021;9:23259671211033904.
6. Miyaji N, Holthof SR, Ball SV, Williams A, Amis AA. Medial collateral ligament reconstruction for anteromedial instability of the knee: A biomechanical study in vitro. *Am J Sports Med* 2022;50:1823-1831.
7. LaPrade MD, Kennedy MI, Wijdicks CA, LaPrade RF. Anatomy and biomechanics of the medial side of the knee and their surgical implications. *Sports Med Arthrosc Rev* 2015;23:63-70.
8. DeLong JM, Waterman BR. surgical techniques for the reconstruction of medial collateral ligament and posteromedial corner injuries of the knee: A systematic review. *Arthroscopy* 2015;31:2258-2272.e1.
9. Marx RG, Hetsroni I. Surgical technique: Medial collateral ligament reconstruction using Achilles allograft for combined knee ligament injury. *Clin Orthop Relat Res* 2012;470:798-805.
10. Mowers C, Jackson GR, Condon JJ, et al. Medial collateral ligament reconstruction and repair show similar improvement in outcome scores, but repair shows higher rates of knee stiffness and failure: A systematic review. *Arthroscopy* 2023;39:2231-2240.
11. Kubo T, Takahashi T, Saitsu A, Ae R, Sekiya H, Takeshita K. Material properties of suture augmentation of knee medial collateral ligament repair did not influence length changes or failure loads in a caged porcine model. *Arthrosc Sports Med Rehabil* 2023;5:e629-e635.
12. Holuba K, Vermeijden HD, Yang XA, O'Brien R, van der List JP, DiFelice GS. Treating combined anterior cruciate ligament and medial collateral ligament injuries operatively in the acute setting is potentially advantageous. *Arthroscopy* 2023;39:1099-1107.
13. Kang SH, Sohn KM, Lee DK, Lee BH, Yang SW, Wang JH. Arthroscopic posterior cruciate ligament reconstruction: The Achilles tendon allograft versus the quadriceps tendon allograft. *J Knee Surg* 2020;33:553-559.
14. Zamorano H, Yáñez-Diaz R, Vergara F, et al. Achilles tendon allograft preparation technique for anterior cruciate ligament reconstruction: A technical note. *Arthrosc Tech* 2021;10:e2143-e2150.
15. Trofa DP, Sonnenfeld JJ, Song DJ, Lynch TS. Distal knee medial collateral ligament repair with suture augmentation. *Arthrosc Tech* 2018;7:e921-e926.
16. Billières J, Hopper GP, Carrozzo A, et al. Arthroscopic medial compartment drive-through sign for knee medial collateral ligament complex injuries. *Arthrosc Tech* 2022;11:e763-e766.
17. Jung KH, Youm YS, Cho SD, Jin WY, Kwon SH. Iatrogenic medial collateral ligament injury by valgus stress during arthroscopic surgery of the knee. *Arthroscopy* 2019;35:1520-1524.
18. Willinger L, Shinohara S, Athwal KK, Ball S, Williams A, Amis AA. Length-change patterns of the medial collateral ligament and posterior oblique ligament in relation to their function and surgery. *Knee Surg Sports Traumatol Arthrosc* 2020;28:3720-3732.
19. Ren D, Liu Y, Zhang X, Song Z, Lu J, Wang P. The evaluation of the role of medial collateral ligament maintaining knee stability by a finite element analysis. *J Orthop Surg Res* 2017;12:64.
20. Encinas-Ullán CA, Rodríguez-Merchán EC. Isolated medial collateral ligament tears: An update on management. *EFORT Open Rev* 2018;3:398-407.