Technical Note

Reconstruction of Superficial Medial Collateral Ligament: Modified Danish Technique with Dual Adjustable Loop Suspensory Fixation

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Abstract: Injury to the superficial medial collateral ligament (MCL) is treated conservatively for low-grade injury and with surgery for high-grade injury, especially in association with cruciate ligament injury. Acute injuries are treated with MCL repair, and chronic injury requires reconstruction. Anatomic MCL reconstruction can be done using free allograft or autograft and fixed using screws or suspensory fixation. We describe here an anatomic technique that is a modification of a Danish technique in which we reroute the semitendinosus, keeping its tibial attachment intact. The semitendinosus is rerouted anatomically in the tibial tunnel, and a graft is then passed anatomically in the femoral tunnel. The graft is fixed in both tunnels with adjustable loop suspensory fixation, which gives the unique advantage of controlled tensioning of the graft for MCL reconstruction. In this technique further re-tensioning is possible if the knee is unstable in valgus stress, even after final fixation.

The medial collateral ligament (MCL) is the most commonly injured knee ligament.[1] The MCL accounts for 42% of all knee injuries,[2] and its incidence is increasing in sports, particularly in contact sports such as football and hockey.[3] Grade 1 and Grade 2 MCL injuries are treated conservatively with rest, ice, and physiotherapy. Grade 3 MCL requires surgical intervention if the nonoperative method fails.[4] Reconstruction of the MCL is necessary for the treatment of chronic instability and in association with multiligament injuries. There are different techniques of medial side reconstruction that have evolved over the last 2 decades. Many techniques have been described for superficial MCL (sMCL) reconstruction, with single-bundle and double-bundle techniques used for the associated posterior oblique ligament (POL) using both allografts and autografts.[5] Among these, one of the most common techniques with a good outcome (keeping the semitendinosus tibial attachment intact) is described by Lind et al.[6] and is popularly known as the *Danish technique*. We describe a technique for sMCL reconstruction, which is a modification of the Danish technique. In this technique, the semitendinosus is rerouted anatomically in the tibial tunnel with an adjustable loop UltraButton (Smith & Nephew Endoscopy, Andover, MA), and on the femoral side an adjustable loop UltraButton is also used with a 2-incision technique. This technique is more anatomic and gives better control of tensioning of the graft on both the femoral and tibial sides. Re-tensioning is possible even after fixation because of the adjustable loop, and fine adjustment can be done without under- or over-constraining the MCL.

Surgical Technique

The patient is placed in the supine position after induction of spinal anesthesia. The knee is suspended from the table with a tourniquet, and the lateral thigh post is thigh support for the operated side limb, and the opposite side foot is resting on a circular chair (Fig 1). The knee is examined with the patient under anesthesia for valgus instability in flexion and extension and any

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All authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper. Full ICMJE author disclosure forms are available for this article online, as supplementary material.

Received May 24, 2023; accepted July 20, 2023.

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2212-6287/23760

https://doi.org/10.1016/j.eats.2023.07.039

Fig 1. Position of limb: Left knee in the supine position with a side post; the patient is on the edge of the table to allow bending for knee arthroscopy. The tourniquet is applied to the thigh proximally, and the heel is placed over a mayo trolley.

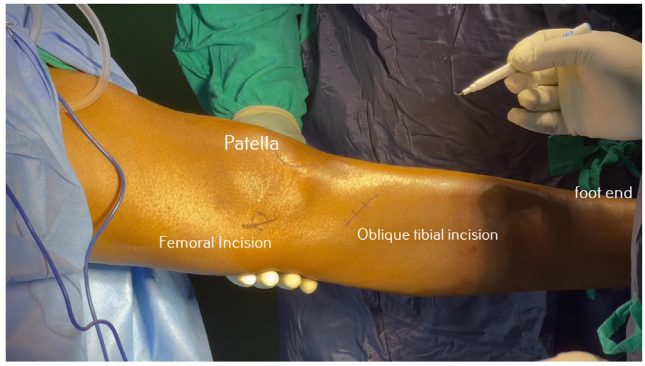

Fig 2. With the left knee in the supine position, surface marking is done for the 2-incision technique. The first marking is a vertical longitudinal incision of 2 cm centered over the attachment of the MCL at the femoral epicondyle, and distally for harvest. Marking is a 4 cm oblique incision centered over the palpable semitendinosus.

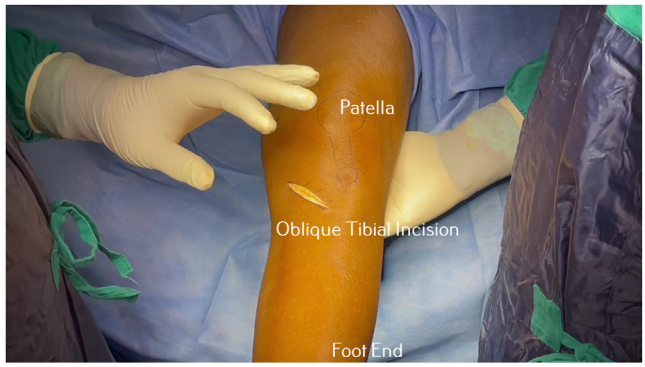

Fig 3. With the left knee in the supine position, an oblique incision over tibial side skin is made, and the subcutaneous fascia is dissected.

posteromedial rotation instability. Diagnostic knee arthroscopy is performed, the cruciate ligaments are reconstructed, and meniscal pathology is treated.

Our procedure of isolated sMCL reconstruction is a 2-incision technique for exposure of the tibial and femoral anatomic points. It begins with surface marking (Fig 2), followed by a 4 cm oblique incision between the tibial tuberosity and the posterior border of the tibia centered over the palpable pes tendons (Fig 3). The semitendinosus tendon is palpated over the sartorius

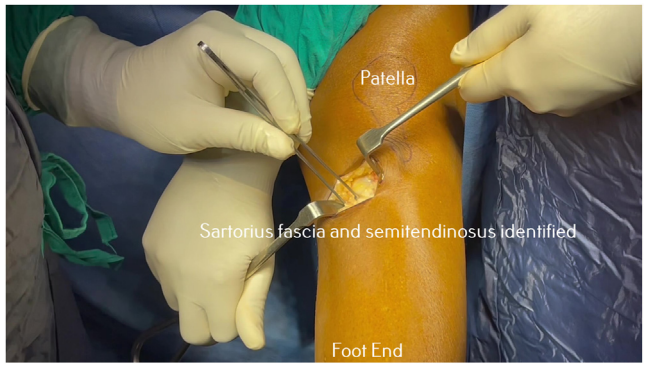

Fig 4. With the left knee in the supine position, the sartorius fascia is identified, and the underlying semitendinosus is palpated, and an incision is made over the fascia.

Fig 5. With the left knee in the supine position, the semitendinosus is identified, lifted, and looped over with Ethibond.

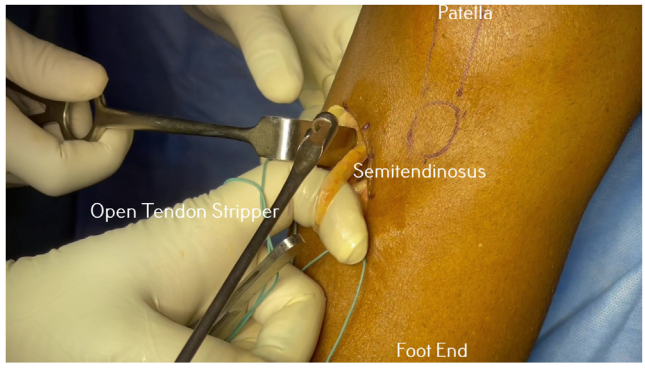

Fig 6. With the left knee in the supine position, an open tendon stripper is used to mount on the semitendinosus for harvest.

fascia, and the fascia is incised just above it (Fig 4). The semitendinosus is isolated with curved artery forceps, and a loop of suture is placed for traction over the graft (Fig 5). The semitendinosus vincula are identified and cut to avoid premature amputation of the graft. The graft is harvested using an open tendon stripper, keeping its insertion on the tibia as described in the Danish technique (Fig 6). The muscle is cleaned from the tendon (Fig 7), and the diameter of the double-looped graft is measured (Fig 8). A semitendinosus loop is created after doubling the graft up to 15 mm to accommodate it in the tibial tunnel. The graft is passed

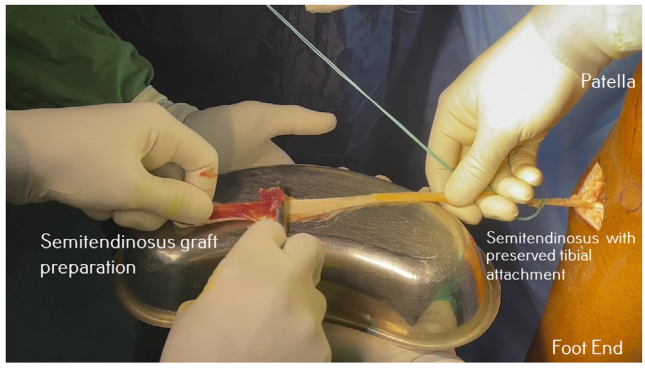

Fig 7. With the left knee in in supine position, the graft is harvested after expansion to keep the tibial attachment intact, and the muscle is cleaned with a scalpel after graft is placed on a kidney tray.

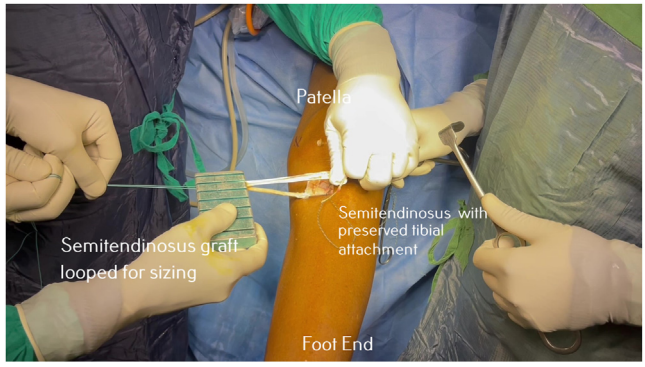

Fig 8. With the left knee in the supine position, Ethibond is placed over the semitendinosus to make a loop, and graft thickness is measured using a graft sizer.

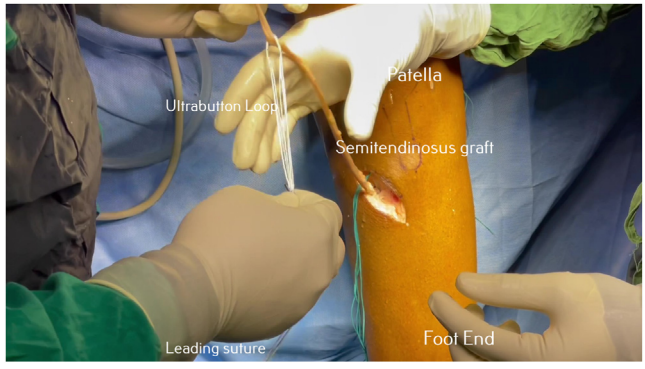

Fig 9. With the left knee in the supine position, an UltraButton is taken, and the graft with an intact tibial attachment is passed through its loop.

on to an adjustable loop UltraButton (Smith & Nephew Endoscopy), and the graft diameter is confirmed at this stage (Fig 9). The sMCL is identified at an anatomic footprint, which lies approximately 6.5 cm below the joint line and is marked with cautery (Fig 10a). A 2.7 mm wire is drilled through the tibia from the medial to the lateral cortex (Fig 10b). This is followed by drilling with a 4.5 mm endoscopic Endobutton drill (Smith

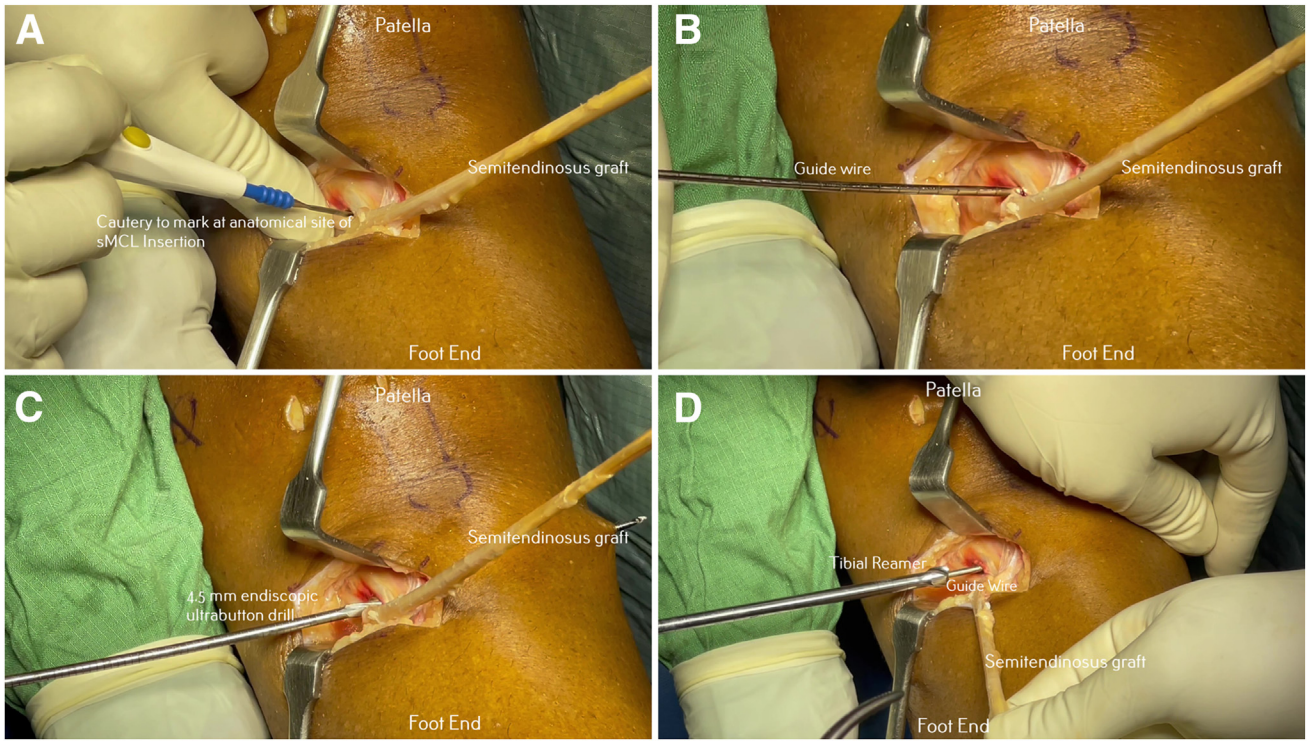

Fig 10. (a) With the left knee in the supine position, the anatomic insertion site of tibial attachment of superficial MCL is marked with cautery 6.5 cm below the joint line and 1.5 cm anterior to the posteromedial border of tibia. (b) With the left knee in the supine position, a 2.7 mm guidewire is drilled into the tibia from medial to lateral at the anatomic site marked with cautery. (c) With the left knee in the supine position, a 4.5 mm Endobutton cannulated drill is drilled over a 2.7 mm guidewire in the tibia from the medial to lateral cortex at the anatomic site. (d) With the left knee in the supine position, a 7 mm cannulated drill is drilled over a 2.7 mm guidewire in the tibia from medial to lateral up to 25 mm at the anatomic site.

& Nephew Endoscopy) up to the lateral cortex of the tibia (Fig 10c). The length of this 4.5 mm tunnel is measured. Next a 25 mm socket is created (10 mm extra compared to the looped graft length of 15 mm) using a 7 mm–diameter drill corresponding to the doubled graft diameter (Fig 10d). The anterior cortex of the tunnel is chamfered to avoid graft abrasion. A looped suture mounted over a Beath pin is passed in this socket for relaying (Fig 11a). An adjustable loop UltraButton fixation device (Smith & Nephew Endoscopy) is mounted on the graft, and leading sutures are passed in the parked suture loop for relay. The total tunnel length can be marked on the UltraButton loop to avoid overshooting of the button from the lateral cortex of the tibia. Next a button is passed in the socket and flipped over the lateral cortex (Fig 11b). Gradual synching of the adjustable loop is done in such a way that 15 mm of the semitendinosus double looped graft is inside the tunnel (Figs 11c,d). At this stage the graft is fixed at the tibial insertion of the sMCL with 15 mm of graft inside the tunnel, with a further potential of tensioning by virtue of the adjustable loop. So an additional socket length of 10 mm is empty for further tensioning after the femoral fixation.

Another longitudinal incision of 3 cm length is placed at the medial femoral condyle. Femoral insertion of the sMCL is identified at the epicondyle, after which a 2.7 mm wire is drilled through the isometric point proximally and posteriorly. This is followed by drilling a 4.5 mm tunnel, using the Endobutton drill guide, through both cortexes, and the length of the tunnel is measured. A 30 mm femoral socket (10 mm extra than the desired graft length for re-tensioning, if needed after fixation) is created using a 7 mm drill (Fig 12a). The free end of graft is passed under the subfascial plane with blunt dissection at the femoral side incision (Fig 12b). The graft is looped on an adjustable loop UltraButton (Smith & Nephew Endoscopy) and doubled up to 20 mm, and the diameter is reconfirmed. Graft length of 20 mm is marked and whipstitched with a suture (Fig 12c). A relay suture is passed for the adjustable loop. An UltraButton Adjustable loop is

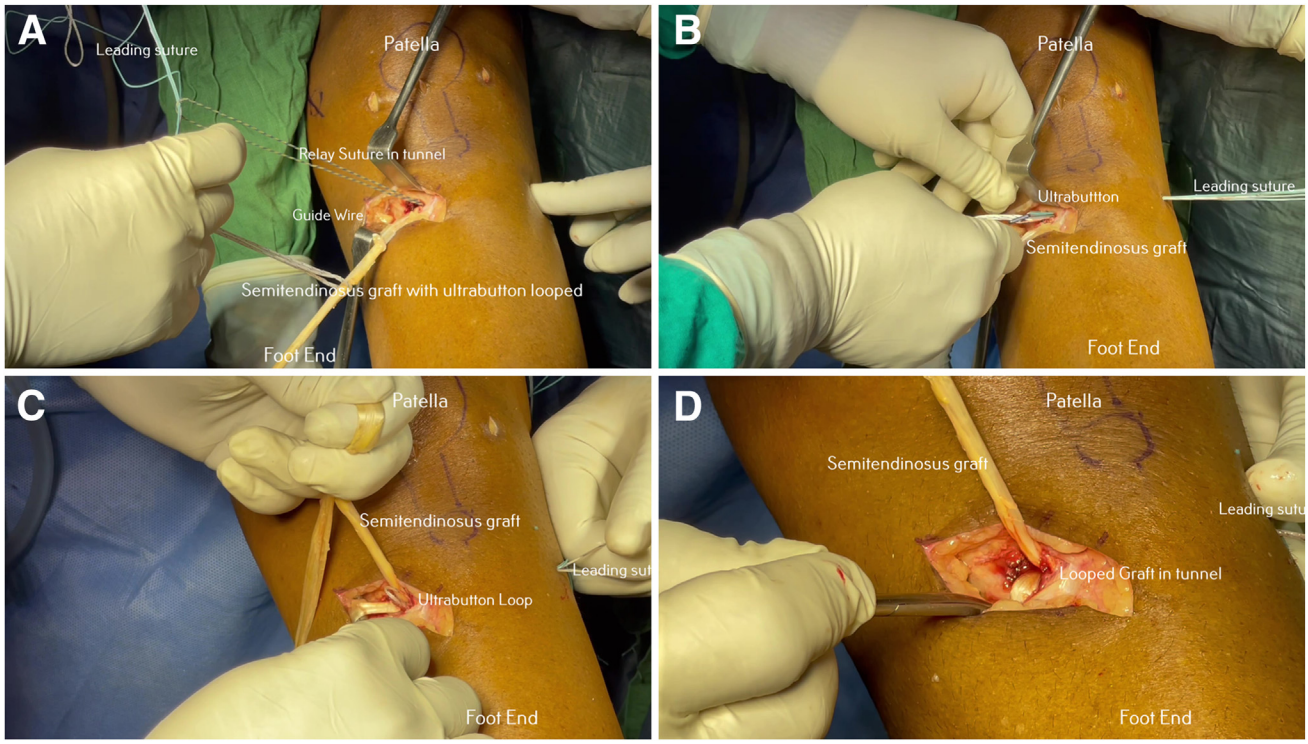

Fig 11. (a) With the left knee in the supine position, a relay suture is passed in the tibial tunnel. Over this relay suture loop, a leading suture of UltraButton previously mounted on the semitendinosus graft is passed. (b) With the left knee in the supine position, a leading suture of UltraButton is passed through the lateral skin. This leading suture is pulled in such a way to keep UltraButton horizontal to pass through the 4.5 mm tunnel drilled previously. (c) With the left knee in the supine position, an UltraButton is flipped over the lateral cortex, and a loop of UltraButton is pulled to shorten the adjustable loop to pass the looped semitendinosus graft into the tunnel. (d) With the left knee in the supine position, further shortening of adjustable loop is continued so that graft is inside the tunnel for approximately 15 mm.

marked up to the total length previously calculated for proper flipping. We prefer to use an image intensifier to confirm flipping of the button on the cortex. Next an UltraButton loop is shortened so that 20 mm of looped graft is inside the femoral tunnel (Fig 12d,e). Both the tibial and femoral side adjustable loops are tightened at 20° of flexion and neutral rotation. Tension of the graft is checked by probe and finger (Fig 13a). Valgus stress testing is also done to check for stability of the repair and to determine whether further tensioning is needed. The remaining graft of the semitendinosus is relayed at the inferior incision (Fig 13b) and tied to the MCL graft and the native MCL. A box stich is taken 1.5 cm below the joint line, and similar sutures are taken at the mouth of the femoral tunnel between the MCL remnant and the graft (Fig 13c). Valgus stress testing is done at 0° and 20° of flexion to recheck stability (Fig 14). Even at this stage, further tightening of the graft is possible if there is valgus laxity (Video 1). The wound is closed in layers.

This modification of the Danish technique is an anatomic reconstruction that prevents the minimal valgus laxity and improves the overall outcome. A schematic representation of this technique versus other techniques is illustrated in Figures 15 and 16.

Postoperative Rehabilitation

The patient is kept in a long knee immobilizer for 3 weeks, followed by a hinge kneecap. Initial range of movement is kept at 0° to 90° for 1 week and then up to 120° for the next week. Full movements are allowed by the end of 4 weeks. The patient is kept non-weightbearing for 6 weeks, and then full weightbearing is permitted. Strength training is allowed at 3 months, jogging at 6 months, and return to sports after 9 months.

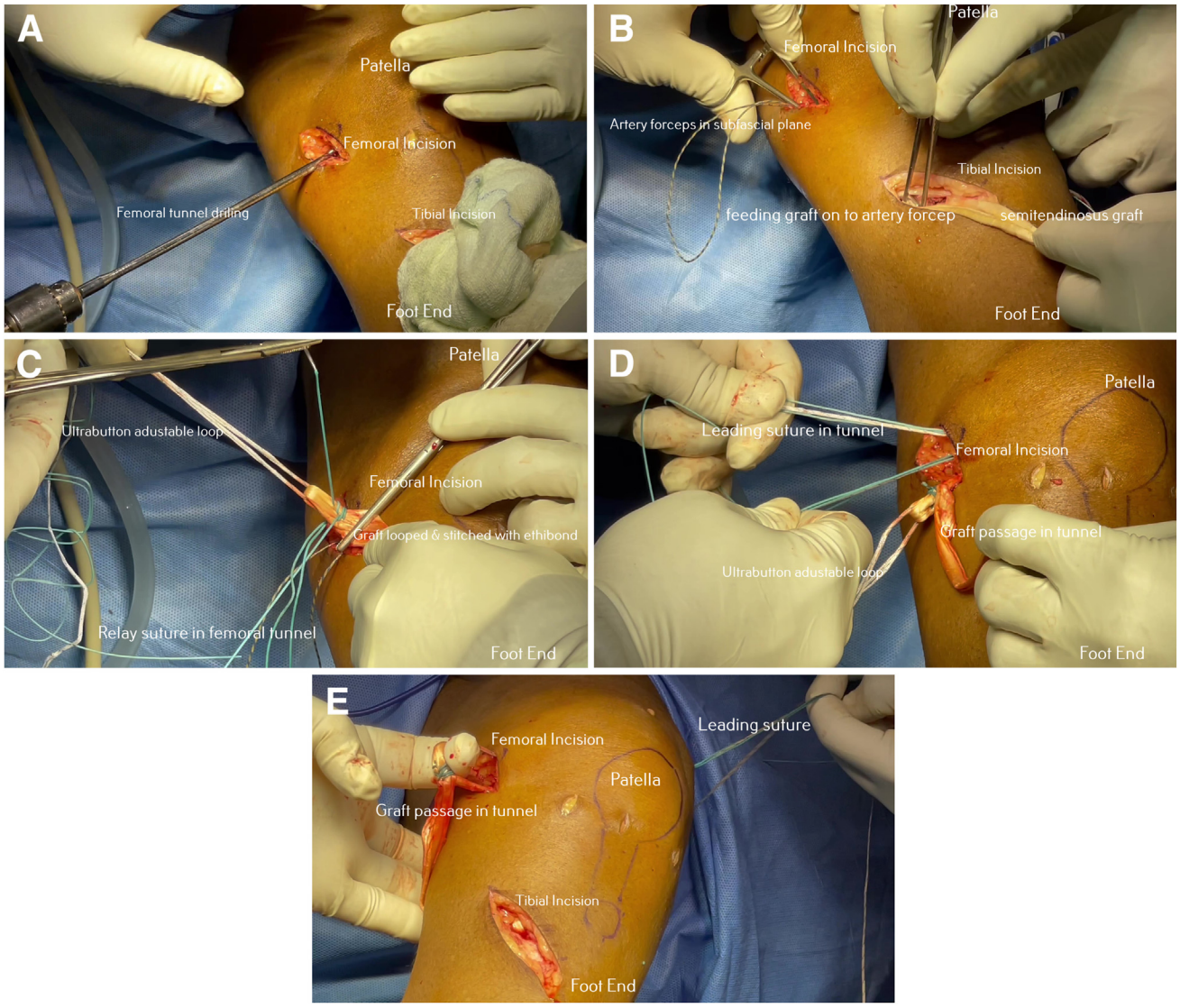

Fig 12. (a) With the left knee in the supine position, an incision over the femur with the guidewire is passed at an anatomic site of the femoral attachment proximal and posterior to the medial epicondyle. A 7 mm reamer is drilled over the guidewire up to a depth of 30 mm, after both cortexes are drilled with a 4.5 mm Endobutton. (b) With the left knee in the supine position, a long curved artery forceps is passed from the femoral incision to the tibial incision below fascia for transporting semitendinosus graft at the femoral incision. A relay suture is parked in the femoral tunnel for later passage of the graft. (c) With the left knee in the supine position, the semitendinosus graft strand is passed through 1 more UltraButton loop and stitched to make it double loop of up to a length of 20 mm. (d) With the left knee in the supine position, a relay suture is in the femoral tunnel. Over this relay suture loop, a leading suture of UltraButton previously mounted on a whipstitched semitendinosus graft is passed. (e) With the left knee in the supine position, a leading suture of UltraButton is passed through the lateral skin. this leading suture is pulled in such a way to keep UltraButton horizontal to pass through the 4.5 mm tunnel drilled previously. This is followed by flipping of the button and shortening of the adjustable loop to pass the graft through the femoral tunnel.

Discussion

Acute MCL injuries requiring surgery are treated with repair or repair with augmentation. The most common indications for reconstruction of the MCL are for chronic injury and multiligament injury.[7] For isolated sMCL reconstruction, a single-bundle technique is described. For MCL along with POL injury, double-bundle non-anatomic and anatomic techniques are described.[5] Yoshiya et al.[8] used autologous semi-T and gracilis tendons as free grafts in the anatomic reconstruction of the sMCL. In their series the graft was fixed proximally with screws and distally with extracortical fixation. For isolated MCL reconstruction, other grafts used are the partial-thickness quadriceps as described by Hetsroni and Mann[9] and the Achilles tendon allograft described by Marx and Hetsroni.[10]

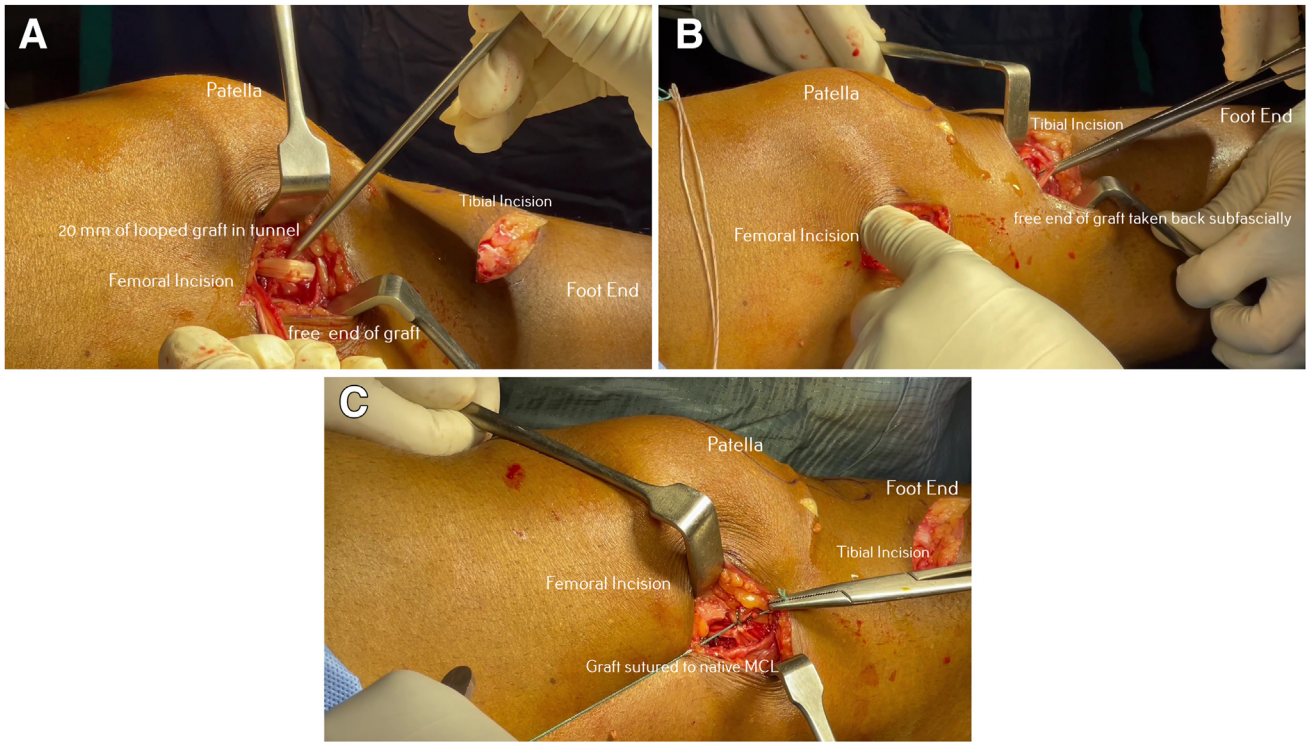

Fig 13. (a) With the left knee in the supine position, shortening is continued until 20 mm of graft is inside the tunnel, the free end of graft is held and in 20° flexion, varus-controlled shortening is done, and a blunt rod is used to check for appropriate tension. (b) With the left knee in the supine position, the free end of the graft is taken back at the tibial incision for reinforcement of the previous graft or for posterior oblique ligament reconstruction if needed. (c) With the left knee in the supine position, the femoral end of the reconstructed graft is stitched with a remnant of the native medial collateral ligament (MCL).

For combined MCL and POL injury, Borden et al.[11] and Dong et al.[12] described using allografts for both the MCL and POL. Laprade et al.[13] used 2 tunnels in the femur and 2 in the tibia for anatomic MCL and POL reconstruction. Although more anatomic, the techniques described previously used interference screw fixation, which led to problems like graft amputation while trying to put a screw into hard cortical tibial bone.

Lind et al.[6] described a technique for combined MCL and POL injuries in which the semitendinosus attachment is kept intact on the tibia, so not only is autologous graft readily available, but it also avoids a potential

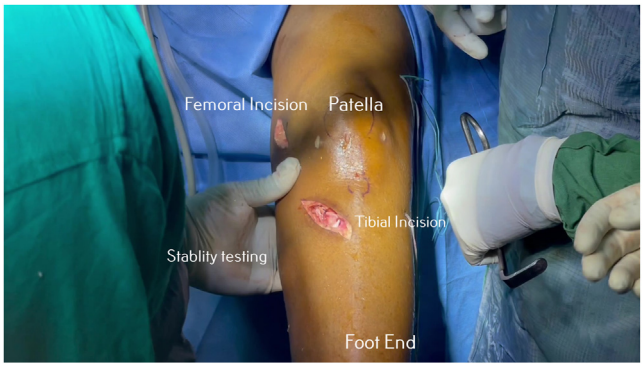

Fig 14. With the left knee in the supine position, a completed medial collateral ligament reconstruction is shown with the 2-incision double adjustable loop technique, and valgus stress at 0° and 20° is assessed to check for final stability.

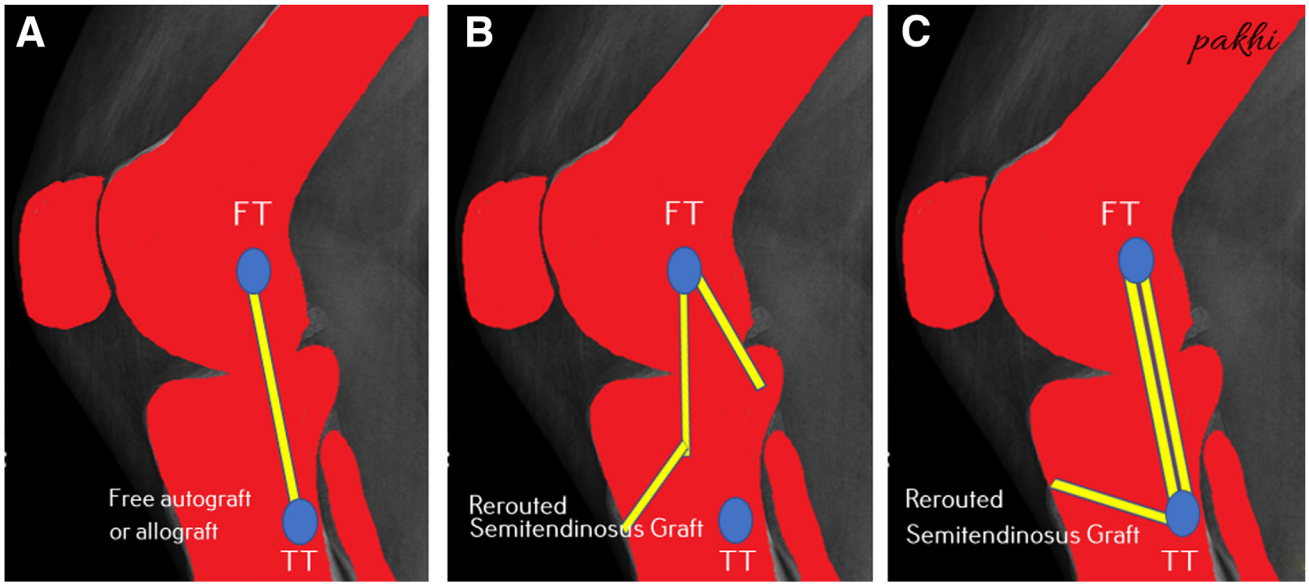

Fig 15. (a) A schematic representation of the free graft (autograft or allograft) technique with 2 tunnels, 1 each in the femur and tibia for the superficial medial collateral ligament (MCL) reconstruction. (b) A Schematic representation of the Danish technique with 1 tunnel in the femur and rerouting of the semitendinosus for superficial MCL reconstruction; a tibial tunnel is not made in the Danish technique. (c) A schematic representation shows our modified Danish technique with 2 tunnels, 1 each in femur and tibia with rerouting of the semitendinosus through the tunnel for superficial MCL reconstruction; a tibial tunnel is made in the modified Danish technique. (FT, femoral tunnel; TT, tibial tunnel.)

problem of screws on the tibial side. A drawback of their technique is that the semitendinosus is anterior to the MCL, which is non-anatomic and anisometric. So we developed this technique, modifying Lind's technique, by rerouting the semitendinosus anatomically, but following the principles of anatomic MCL reconstruction described by Laprade et al.[13] Also, our technique uses suspensory fixation, thus avoiding the use of an interference screw on the tibial tunnel. Rerouting the technique of the semitendinosus has been described previously by Deo and Getgood,[14] but they used staples, which have potential of causing underlying graft necrosis. Rerouting of the semitendinosus, also described by Joshi et al.,[15] uses a weave technique, but it cannot be used in cases of MCL rupture from the tibia side, and weaving is a less-secure fixation, with chances of soft tissue cut through after mobilization. Our technique is a modification of the Lind technique,[6] popularly known as the Danish technique, but it differs in several ways. In our technique the semitendinosus graft is rerouted and placed anatomically in the tibial tunnel and fixed with adjustable dual suspensory button fixation on both sides, which gives the advantage of better healing in the tunnel, fewer hardware problems, and a choice of differential tensioning on both the femur and tibia.

Wijdicks et al.[16] have proved that cortical suspensory fixation of soft tissue grafts is superior to interference screw fixation. Use of an adjustable loop for MCL fixation has also been described by Deo and Getgood,[14] but they have used it only in the femoral side. Watson et al.[17] better results with dual adjustable suspensory cortical fixation with better valgus stability because this technique helps to re-tension the graft after fixation, thus improving graft healing. Watson et al.[17] used allografts for MCL reconstruction with dual suspensory fixation, which has disadvantages in the form of poor healing and more cost. Ohliger et al.[18] described a technique with intact pes attachment and used suture anchors on the tibia and screws on the femur side. In our technique we used rerouted semitendinosus autografts in tunnels for MCL reconstruction, which is easily available, leads to better healing, and has no extra cost.

Our modification of the Danish technique benefits by strong fixation of the MCL by rerouting the autogenous semi-T graft with a cortical adjustable suspensory fixation device on either side of the knee at both the tibia and the femoral footprints. This fixation technique allows re-tensioning of the graft on both sides of the knee after fixation.

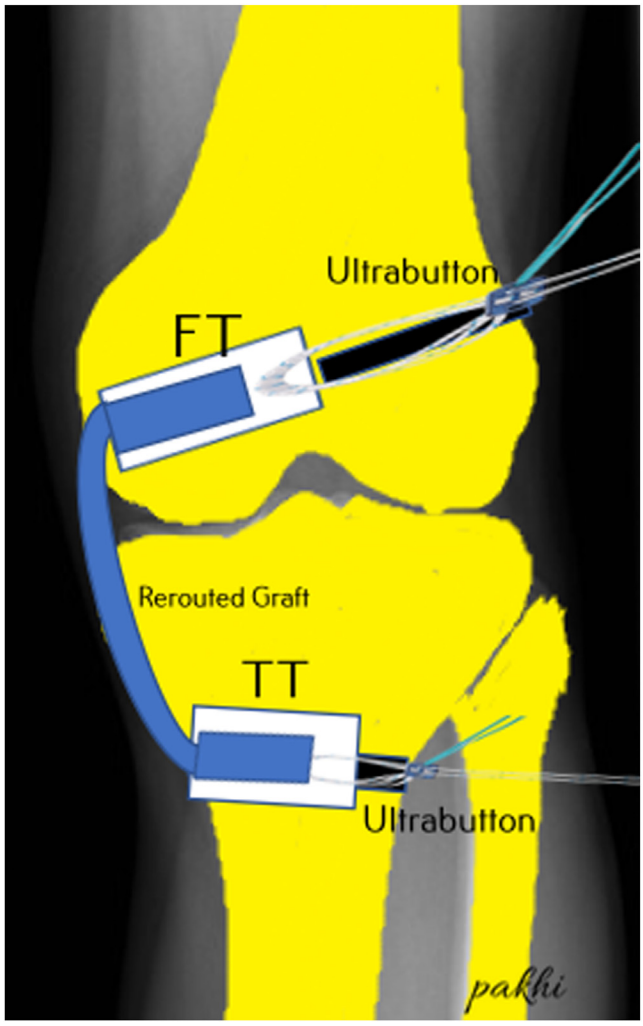

Fig 16. A schematic representation of the modified Danish technique with 2 sockets, 1 each in the femur and tibia with rerouting of the semitendinosus through it for superficial medial collateral ligament reconstruction and fixation with an UltraButton adjustable loop. (FT, femoral tunnel; TT, tibial tunnel.)

This technique alleviates disadvantages of earlier techniques, with more anatomic rerouting, no screw fixation on the tibia, better healing in the tibia, no hardware issues, and a readily available autogenous graft. The complications with this technique include cortical breach while reaming. Tension within the graft may be poor if proper length of the tunnel is not calculated. There are rare chances that both sides of the graft are bottomed out, with adjustable loops on both sides of knee. Pearls and pitfalls are summarized in Table 1, and the advantages and disadvantages of this technique are described in Table 2. Although described for MCL reconstruction, this technique can also be used for combined MCL and POL, in which a third adjustable loop can be used for POL.

Table 1. Pearls and Pitfalls for MCL Reconstruction Using a Modified Danish Technique With Dual Adjustable Loop Suspensory Fixation

Pearls
Valgus stress radiograph will quantify involvement of the POL with the MCL
Semitendinosus harvest is done by palpating under the Sartoris and cutting expansion onto the gastrocnemius to prevent premature amputation.
Anatomic footprint lies 6.5 cm below the joint line, and the tibial tunnel needs to be drilled at this point.
Chamfering of the corner prevents graft damage.
Because this is a 2-incision technique, the subfascial plane should be made correctly using a long artery forceps for smooth passage of the graft.
Always drill socket by more than 10 mm at the femoral side for tensioning of the graft.
Keep knee in 20° flexion and varus and then start synching gradually on the femoral and tibial side
Pitfalls
Wrong assessment on valgus stress can lead to residual laxity after surgery.
Distal attachment of the tendon should be kept intact while dissection on to tibia, or else rerouting cannot be done.
A shorter tunnel is a possibility at 6.5 cm below the joint line, and a minimum 30 mm tunnel is needed.
Excessive shortening of the adjustable loop may lead to more graft in the tibial tunnel and bottoming out of the graft in case re-tensioning is not possible.
Flipping the button of the femoral side may lie away from the cortex if the measurement is not proper. An image intensifier may be used to confirm proper sitting of button on to the cortex.

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

Table 2. Advantages and Disadvantages for MCL Reconstruction Using Modified Danish Technique With Dual Adjustable Loop Suspensory Fixation

Advantages
Use of rerouting autogenous graft without need of an expensive allograft
Rerouting via tunnel for better stability and healing of the graft
Avoidance of a screw in tunnel, so chance of graft amputation in hard cortical bone avoided
Suspensory adjustable loop on both femur and tibia allows for re-tensioning after fixation
Minimally-invasive procedure with passage of graft subfascial on femoral side
Remnant residual graft after femoral fixation can be used for reinforcement of reconstructed MCL or for POL
Disadvantages
Not described for combined MCL/POL, although a remnant graft can be used for it
Lateral cortex blow out may lead to loss of fixation
A short tunnel, particularly on tibial side, may not have a possibility of being re-tensioned
Bottoming out of the graft is possible if there is a mismatch between tunnel length and graft length
Overtensioning may happen if the loop is not adjusted gradually

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

Dual (femoral and tibial) adjustable-loop cortical suspensory fixation with a modified Danish technique uses the minimally invasive technique of graft placement, further allowing re-tension of the graft during surgery and preventing the complication of valgus instability, leading to better anatomic healing of the graft and restored knee kinematics.

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