Technical Note

Semitendinosus Autograft Transplant for Medial Meniscus

Amit Joshi, Bibek Basukala, Rajiv Sharma, Nagmani Singh, Rohit Bista, and Ishor Pradhan

Abstract: Treatment of meniscal tears has evolved over the last few decades, and preservation has now become the gold standard of treatment. Advancements in repair technique have extended the indication of repair. However, meniscectomy has to be performed in some situations. In these situations, meniscal allograft transplantation is considered the gold standard. But allografts are not available in every part of the world. Collagen implants and synthetic polymers are also advocated. But again, its limited research, availability, and high cost have restricted its widespread use. Many authors have advocated autograft transplantation, but there are no long-term results, and there is a lack of uniform surgical techniques. There is a technique described for lateral meniscus, but a medial meniscus autograft transplant technique is not very well elaborated. In this report, we aimed to describe a medial meniscus replacement technique using a hamstring autograft.

Over the past few decades, meniscus preservation has become the "gold standard" for treating meniscal tears to prevent the occurrence and progression of osteoarthritis.[1] However, there are certain conditions, such as complex irreparable tears, late presentation, absence of meniscal tissue, and failed meniscal repairs, where meniscus has to be sacrificed.[2] Management of these situations is often challenging, as limited options are available. Meniscus allograft transplant (MAT).[3] Collagen meniscus implants[4] and synthetic polymer meniscal implants[5] have been advocated for these scenarios. However, these options may not be available in centers with limited resources.

There has also been an attempt to replace the meniscus with autografts, including the quadriceps tendon, patellar tendon, peroneus longus tendon, and hamstrings.[6-8] Of which, meniscal transplants using semitendinosus (SemiT) tendon autograft have shown promising results.[6] However, most previous reports have used autografts for lateral meniscus replacement.[6,8]

Hence, this report aimed to describe a technique for medial meniscus replacement using a SemiT tendon (Video 1). This technique is described in the following steps.

Surgical Technique

Step 1: Diagnostic Arthroscopy and Meniscal Preparation

This is one of the most critical steps of surgery, during which the final decision of the meniscus transplant with a hamstring graft is taken. The first step of diagnostic arthroscopy is pie-crusting of MCL. Pie-crusting opens the medial joint line to assess meniscal substance and tear pattern thoroughly (Fig 1, B and C). If the meniscus were repairable, attempts were made to repair the meniscus. The decision of SemiT transplant is made only when meniscectomy is the only option, and a significant amount (subtotal or total meniscectomy) of the meniscus has to be removed. All of the flaps and unstable portions of the meniscus are removed (Fig 1, D-F). If anchors of the meniscal repair system are visible inside the joint, they are also removed (Fig 1G). Meniscectomy is performed up to the red-red zone, and the peripheral rim is preserved as much as possible (Fig 1H). Multiple fenestrations through the meniscus to the periphery are done to increase healing potential. Other associated pathologies were treated before the meniscus transplant.

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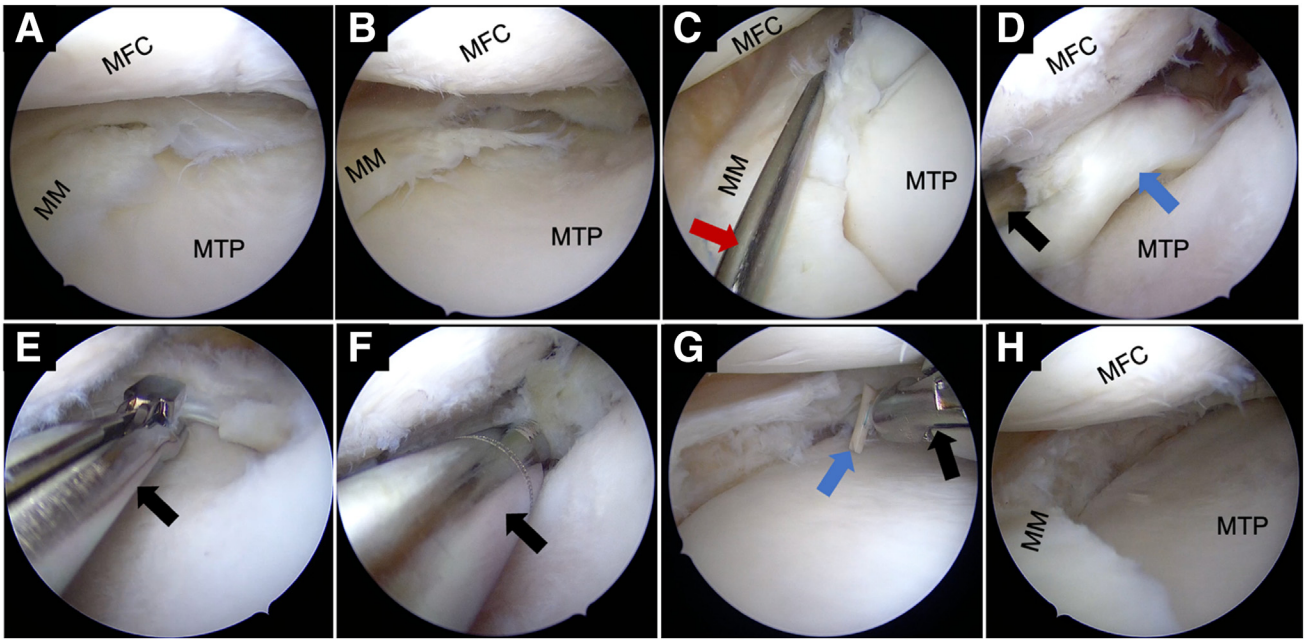

Fig 1. Diagnostic arthroscopy and meniscectomy. Arthroscopy view of the medial compartment of the left knee. A 30° arthroscope is in the anterolateral portal. (A) Picture showing the complex medial meniscus tear. (B) View of the meniscus after pie-crusting of medial collateral ligament. (C) Assessment of meniscal tear using an arthroscopic probe (red arrow). (D) The displaced flap tear of the posterior horn (blue arrow) is pulled into the joint using an arthroscopic grasper (black arrow). (E) Loose and unstable flaps are cut using punch forceps (black arrow). (F) The displaced posterior root flap is cut using an aggressive shaver (black arrow). (G) The Peek anchor of all inside repair devices (blue arrow) is removed using grasper (black arrow). (H) Final intra-articular view of medial meniscus depicting preserved peripheral rim of the meniscus. MFC, medial femoral condyle; MM, medial meniscus; MTP, medial tibial plateau.

Step 2: SemiT Harvest and Preparation

The hamstring is palpated over the medial aspect of the tibia. A 3-4-cm oblique incision is given at the center point between the posterior aspect of the tibia and the shin (Fig 2A). A sartorial flap (red arrow) is raised (Fig 2B). The SemiT (red arrow) is identified and tagged with a silk suture (black arrow) (Fig 2C). The SemiT is detached from the tibial insertion, and whip-stitch (red arrow) is applied (Fig 2D). The vinculae of the SemiT is identified and detached. A closed-end 7-mm stripper (yellow arrow) is used to harvest the graft (Fig 2E). The size of the harvested graft (yellow arrow) (Fig 2F) is essential to measure because if the graft is very thin and there is a negligible meniscal rim, one may need to double-fold the graft to achieve adequate width. The other end of the graft is also whipstitched (red arrow) (Fig 2G). The length of the prepared and whipstitched graft is measured, and a center point is marked. A no. 2 orthocord is applied at the center (red arrow) point, acting as a centralizing suture (Fig 2H). The tibial part of hamstringing is labeled as the leading end (L), and the other end is labeled as the trailing end (T).

Step 3: Tunnel Preparation

After the graft preparation, arthroscopy is resumed. An accessory anteromedial portal is made. First, a transtibial tunnel is made from the medial aspect of the tibia to the posterior root (Fig 3, A-H). A root repair jig (BIOTEK- Chetan Meditech Pvt Ltd., Ahmedabad, Gujarat, India) is used to make the tunnels. The anatomical site of the posterior root is marked using a radio frequency ablator (Fig 3, A and B). A meniscal root jig (BIOTEK- Chetan Meditech Pvt Ltd.) is set at 60 and introduced into the joint through the accessory anteromedial portal. The tip is placed at the center of the marking (Fig 3C). A beath pin is drilled in. The jig is removed, and a 4.5-mm Endobutton reamer is used to make a tunnel over the beath pin (Fig 3D). The debris and cartilage are removed from the intraarticular aperture (Fig 3E). A no. 1 Prolene suture loop is passed through the tunnel (Fig 3F) and retrieved through the accessory anteromedial portal using a suture retriever (Fig 3, G and H).

After the posterior root tunnel, the anterior tunnel is made in a similar manner. A radio frequency ablator is used to mark the footprint of the anterior root (Fig 4A). The root repair jig (BIOTEK- Chetan Meditech Pvt Ltd.) is set at 50 and introduced through an anteromedial portal (Fig 4B). Care is taken to space the tunnel at least 1.5- 2 cm in the anteromedial aspect of the tibia. The Beath pin is introduced, and a 4.5-mm Endobutton reamer is used to make a tunnel over the Beath pin (Fig 4C). The aperture is cleaned,

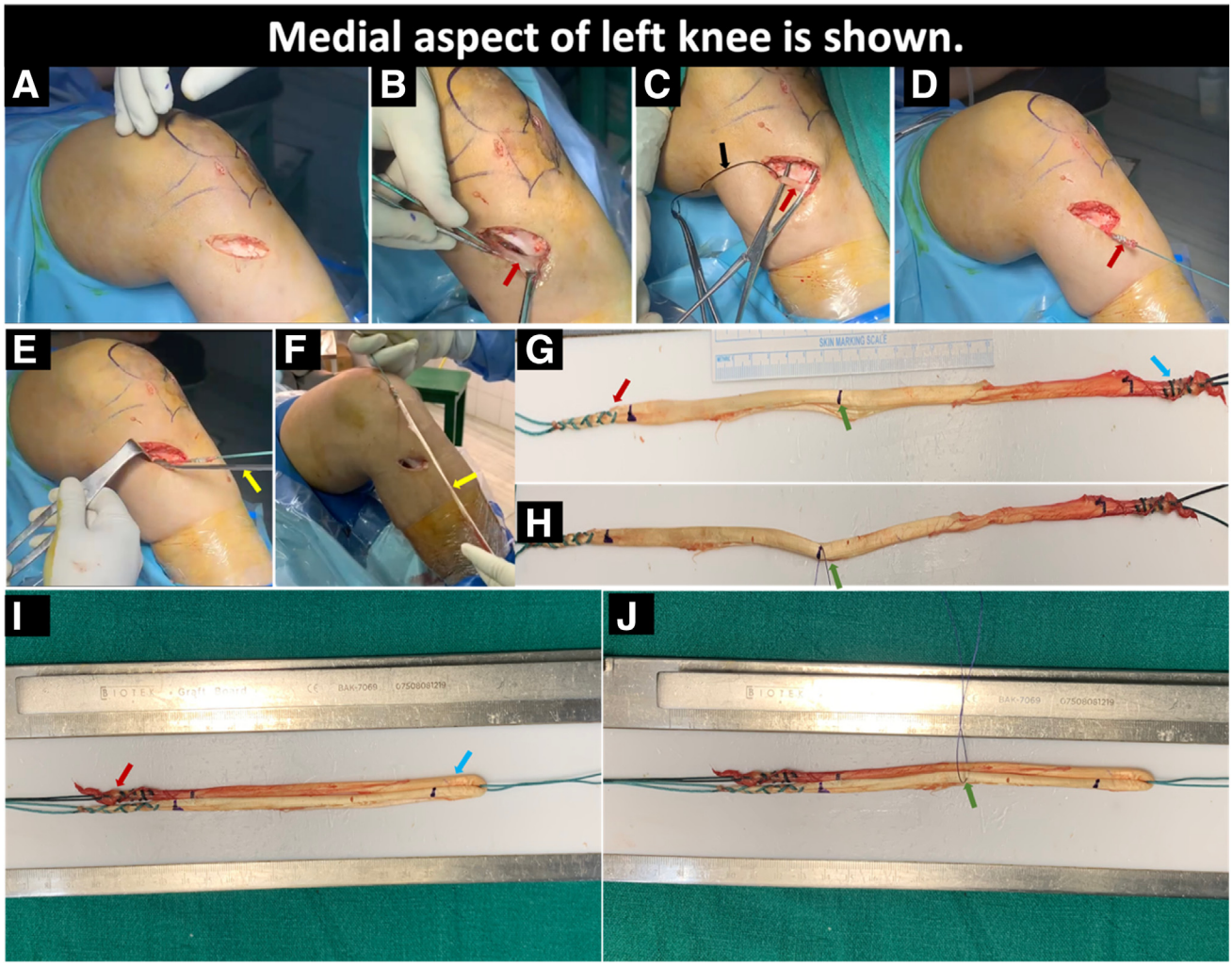

Fig 2. Steps depicting the steps of SemiT Harvest and preparation. (A) An oblique incision is given midway between the posterior tibia and the shin. (B) A sartorial fascia flap (red arrow) is raised. (C) the SemiT (red arrow) is identified and tagged with no. 1 silk (black arrow). (D) The tibial attachment of SemiT is detached and whipstitched (red arrow). (E) The SemiT is harvested using a closed-end 7-mm stripper (yellow arrow). (F) Figure depicting a 6-mm-thick hamstring graft. (G) The other end of the SemiT graft is also whipstitched (red arrow). (H) The center point of the graft is identified, and a centralization suture (no. 2 OrthoCord) is applied. Once the graft is prepared, it is wrapped with vancomycin-soaked gauge and safely parked on the back table.

and a no. 1 Prolene loop is passed through the tunnel using an initial puncture needle (Fig 4D). Now, the loop is retrieved through the anteromedial portal (Fig 4, E and F).

Step 4: Graft Passage

Using the Prolene in the anteromedial accessory portal, the surgeon now pulls the Ethibond-sutured hamstring graft into the posterior root tunnel. The Ethibond, which is applied to the graft's leading end, is looped into the Prolene Fig 5A), and the opposite end of the Prolene is pulled slowly to deliver the leading Ethibond to the anterior tibia through the PRT (Fig 5, B-D). The leading end Ethibond is then pulled to deliver the graft into the PRT until the trailing end Ethibond is visible in the joint (Fig 5E). The Prolene of the anterior root tunnel and the Ethibond of the trailing end are now extracted from the anteromedial portal using a suture manipulator (Fig 5F). Both sutures are pulled together, so that there is no soft tissue entanglement (Fig 5G). Now, the trailing end of the Ethibond is looped into the Prolene loop of the anterior root tunnel (Fig 5H), and the other end of the Prolene is pulled to deliver the trailing Ethibond through the anterior root tunnel into the anterior tibia (Fig 5, I and J). The trailing Ethibond is then pulled to deliver the graft's trailing end into the ART (Fig 5K). If the graft is long, both ends will emerge from the PRT and ART in the anterior tibia (Fig 5L). The trailing end of the graft is pulled, so that the centralizing suture is applied to the center of the graft and is positioned intra-articularly in the center.

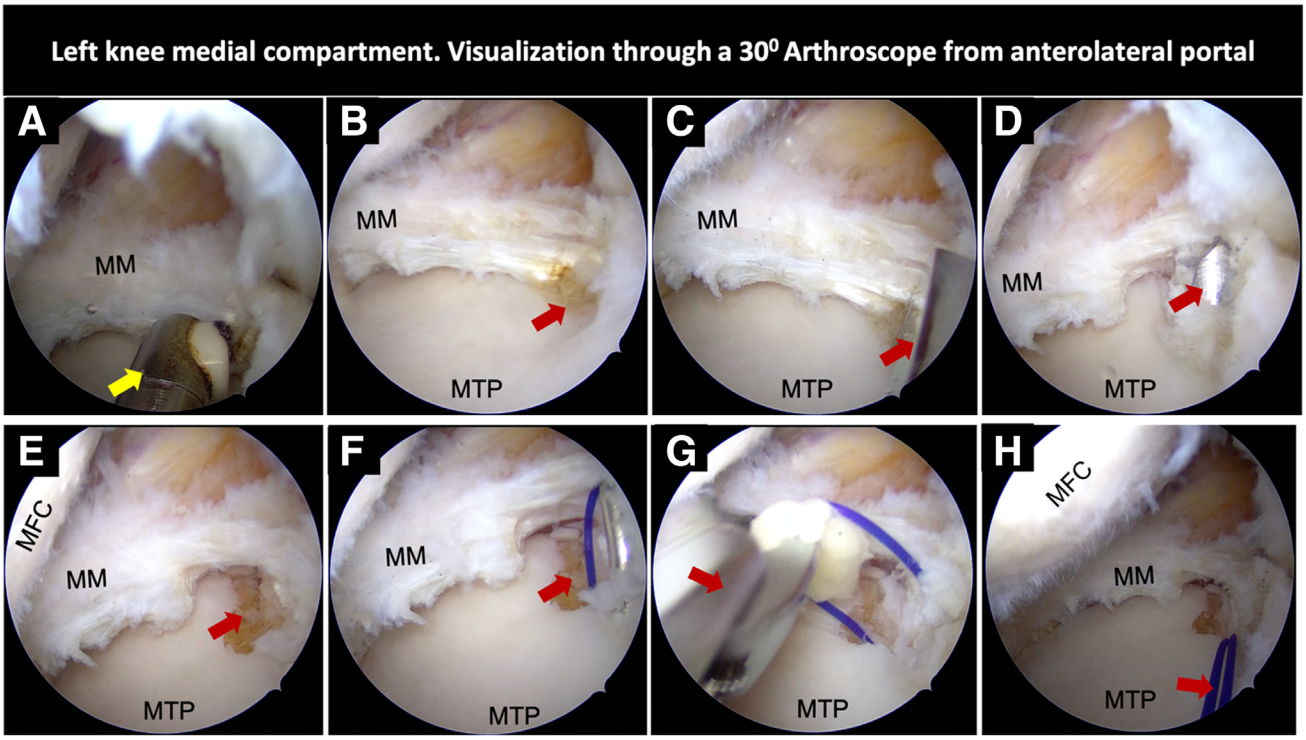

Fig 3. Posterior root tunnel preparation. The left knee medial compartment is visualized through an anterolateral portal using a 30° arthroscope. (A) The anatomical footprint of the posterior root is marked with a radio frequency ablator (yellow arrow). (B) The marking is confirmed. (C) Meniscal root repair jig (red arrow) is introduced and aimed at the center of the marking. (D) A tunnel was created over the beath pin using a 4.5-mm Endobutton reamer (red arrow). (E) Debris are removed to clear the aperture of the tunnel (red arrow). (F) A no. 1 Prolene suture loop is passed through the tunnel using an initial puncture needle (red arrow). (G) Using a suture retriever (red arrow), the surgeon retrieves the Prolene loop through the accessory anteromedial portal. (H) Arthroscopic picture depicting Prolene suture (red arrow) retrieved from posterior root tunnel to accessory anteromedial portal. MFC, medial femoral condyle; MM, medial meniscus; MTP, medial tibial plateau.

Step 5: Repair of SemiT Graft to the Meniscal Rim

This step is extensive and requires the availability of all types of meniscal repair systems. Because of economic constrain, we do outside-in meniscal repair (suture shuttle technique).[9] The first suture should be to fix the centralizing suture. An 18-gauze Tuohy epidural needle (red arrow) is passed from outside-in through the substance of the peripheral meniscal rim (Fig 6A). A no 1 Prolene (blue arrow) is introduced through the cannulation from outside in (Fig 6B). A soft tissue tunnel is made along the epidural needle from the skin to the capsule, as described in the suture shuttle technique. The Prolene is retrieved from an anteromedial portal using a suture manipulator (Fig 6, C and D). The Prolene and centralization suture are brought together to the accessory anteromedial portal, creating a virtual cannula (Fig 6E). Then the Prolene is pulled outside by pulling the superior limb of centralizing suture (Fig 6F). The second pass of the epidural needle was made through the same soft tissue tunnel made for the first pass and brought intra-articular through the meniscal rim inferior (red arrow) to the previous one (Fig 6F). No. 1 Prolene is passed from outside through the cannula (Fig 6G) and retrieved through the accessory anteromedial portal using a suture grasper (Fig 6, H and I). Using a suture manipulator, the surgeon pulls together both the sutures (Prolene and centralizing suture) through an accessory anteromedial portal, making a virtual cannula (Fig 6, J and K). Using the suture shuttle technique, the surgeons shuttles out the centralizing suture. This will pull the graft toward the meniscal rim and fixes the graft to the remaining meniscus (Fig 6L).

An adequate number of outside-in sutures (2/0 orthocord) is applied (at a distance of 5 mm) in the remaining part of the meniscal graft, fixing the graft to the peripheral rim of the meniscus (Fig 7, A- I). Outside-in suture shuttle technique is used to repair the graft, except in the root area of the graft.

It is crucial to repair the root area of the graft. All-inside meniscal repair system is most suitable for repairing this area. However, in this particular case, we repaired it with an anterograde suture passing device (first-pass mini). First, a bite is taken through the meniscal rim using the first-pass mini and 2/0 OrthoCord (Fig 8, A and B). Using the inferior limb, a surgeon

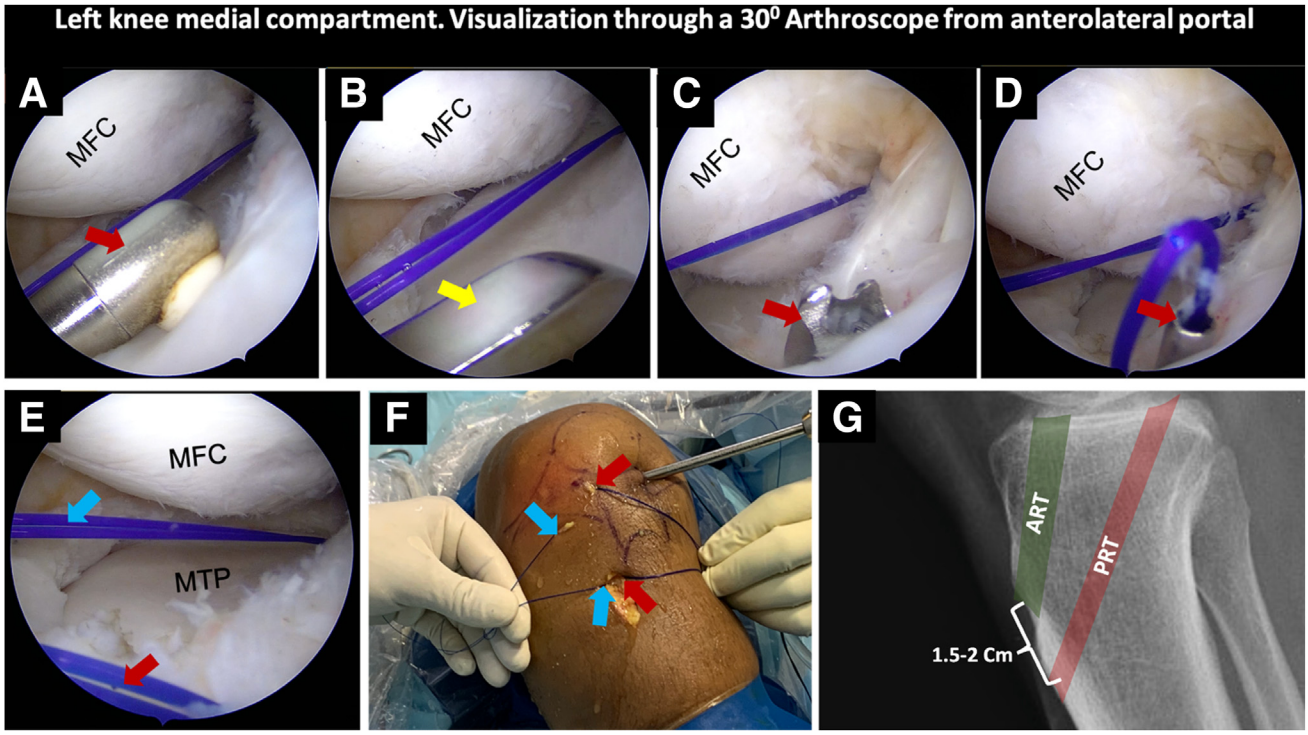

Fig 4. Anterior root tunnel preparation. The left knee medial compartment is visualized through an anterolateral portal using a 30° arthroscope. (A) The anatomical footprint of the anterior root is marked with a radio frequency ablator (red arrow). (B) meniscal root repair jig (yellow arrow) is introduced and aimed at the center of the marking. (C) A tunnel was created over the Beath pin using a 4.5-mm Endobutton reamer (red arrow). (D) A no. 1 Prolene suture loop is passed through the tunnel using an initial puncture needle (red arrow). (E) An arthroscopic picture showing Prolene from the posterior tunnel (blue arrow) is retrieved from the far anteromedial portal, and Prolene from the anterior tunnel (red arrow) is retrieved from the anteromedial portal. (F) Outside view of the left knee showing the Prolene suture loop exiting from accessory anteromedial (blue arrow) and anteromedial (red arrow) portal. (G) Diagrammatic representation of posterior root tunnel (PRT) and anterior root tunnel (ART), where PRT is directed inferior and posterior, compared to ART, which is directed superiorly and anteriorly. MFC, medial femoral condyle; MM, medial meniscus; MTP, medial tibial plateau.

makes a second bite is through the graft (Fig 8, C and D). Both the limbs of the 2/0 orthocord are pulled through the anteromedial portal, making a virtual cannula. An SMC knot is applied and delivered intra-articularly (Fig 8E), tightened and locked in the meniscal rim side using a knot pusher. The knot is cut (Fig 8F), and the final repair is checked (Fig 8G).

Since this was isolated hamstring transplantation, microfracture augmentation is done at the notch area (Fig 9A).

Step 6: Fixation of the SemiT in Tibia

If the grafts are long enough to make a knot, a simple knot is made over the bone bridge of PRT and ART. The hamstring knot is then secured with no. 2 orthocord by locking the knot. If the graft is short (usually when doubled), the Ethibond sutures of the leading and trailing ends are tied with each other over the bone bridge. In this case, a bone staple is used to fix the SemiT outside the tibial tunnel (Fig 9B). The portals and skin are closed in layers.

Discussion

Over the past few years, meniscal tear treatment has evolved a lot. Repair techniques and devices have evolved, making repair feasible with more predictable outcomes.[2] However, rarely there are situations in which subtotal or total meniscectomy becomes inevitable. Meniscectomy, when it is done in the younger age group, osteoarthritis is inevitable. Hence, in indicated cases, meniscal replacement is advocated.[1] Over the past few years, meniscus substitutes have become more popular. Synthetic polymer meniscal implants are still in the initial stage of testing, and only limited literature is available for their wider use.[5] Collagen meniscus implants are better studied and useful for total and partial replacement. But availability and high-cost limit its wider use.

MAT are, by far, the most popular and established method of meniscal substitute. Long-term results of MAT are now published with reasonable survival rates.[3] However, their uses are again limited to those places where allografts are available. The technical

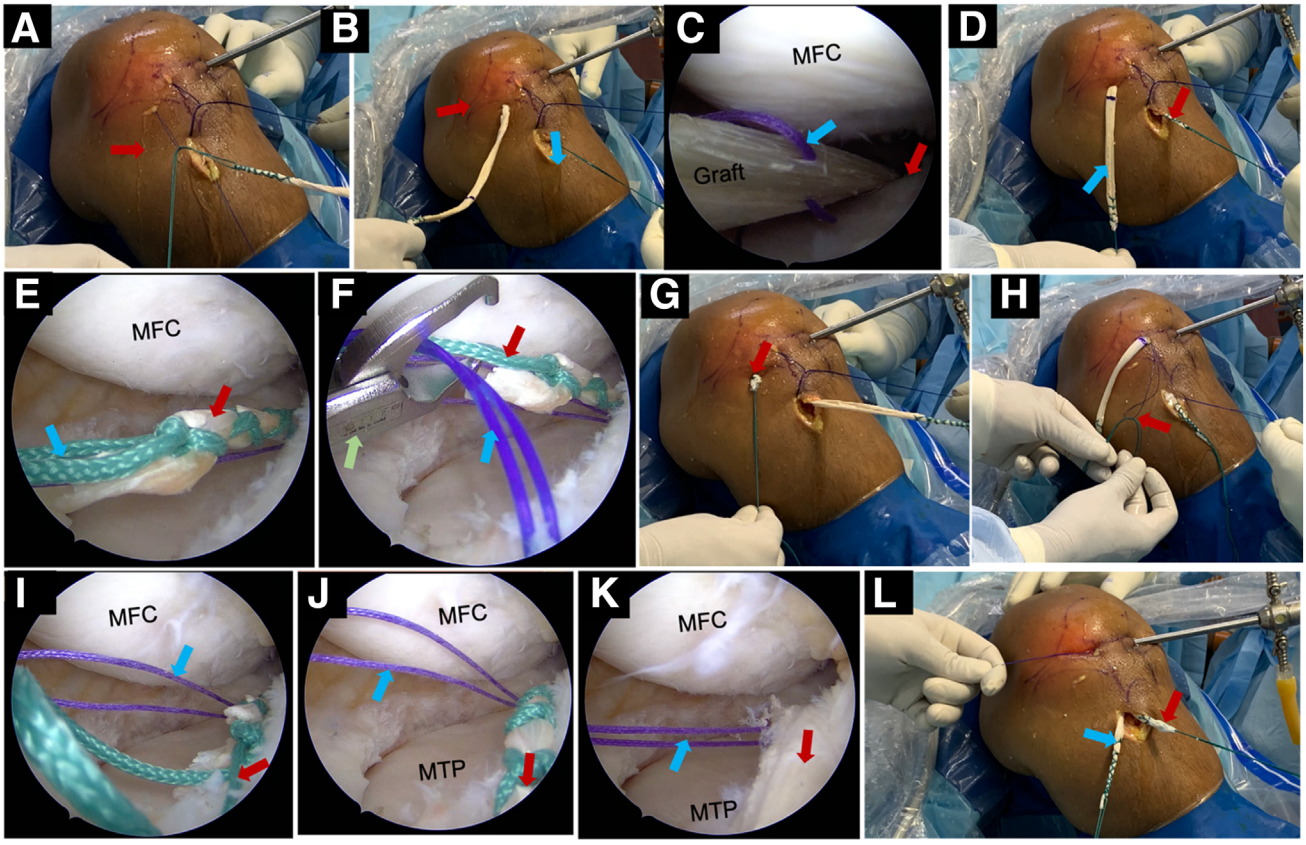

Fig 5. Steps of graft passage into the tunnel. (A) The anteromedial aspect of the left knee depicting the leading end Ethibond is looped around the Prolene loop (red arrow) in the accessory anteromedial portal. (B) The leading Ethibond (blue arrow) has been pulled to the anterior tibia through the PRT. The graft is already inside the joint (red arrow). (C) Arthroscopy picture showing graft inside the joint, and the leading end is inside the PRT (red arrow). The centralizing suture is visualized inside the joint (blue arrow). (D) Left knee anteromedial aspect. The leading end of the graft (red arrow) is in the anterior tibia through the PRT, and the trailing end is still in the accessory anteromedial portal (blue arrow). (E) Arthroscopic picture showing the trailing end of graft (red arrow) and trailing Ethibond (blue arrow) inside the joint. (F) A suture manipulator (green arrow) is used to pull the trailing Ethibond (green arrow) and Prolene (blue arrow) through the same anteromedial portal. (G) The outside picture demonstrates both the graft and the Ethibond are pulled through the anteromedial portal. (H) The trailing Ethibond is looped around Prolene in an anteromedial portal (red arrow). (I) The trailing Ethibond (red arrow) is pulled inside the ART. (J) The Ethibond of the trailing end is pulled to bring the graft (red arrow) into the tunnel, such that the centralizing suture is at the center. (K) Arthroscopy picture demonstrating graft across the tunnel (red arrow) and central suture (blue arrow at the center of the joint. (L) Outside picture of the medial aspect of the knee depicts both the ends of the graft exiting from the PRT (red arrow) and ART (blue arrow). ART, anterior root tunnel; MFC, medial femoral condyle; MM, medial meniscus; MTP, medial tibial plateau; PRT, posterior root tunnel.

challenges associated with MAT, e.g., surgical technique, adequate sizing, and cost, are also factors for its limited use.[3]

Autograft transplants for meniscus are not new in literature. In 1993, Kohn reported the first-ever autograft (quadriceps) transplant in 20 patients.[7] He reported good clinical and arthroscopic outcomes. However, their long-term results were not published. In 2000, Johnson et al. published their pilot study of 5 patients and reported inferior results.[6] However, there were several limitations of the study. It was done in patients with preexisting arthritis. Their surgical technique was inadequate, as the posterior root tunnels were not created. Milenin et al., in 2020, described the surgical technique of peroneus tendon transplant for lateral meniscus.[8] Rönnblad et al., in 2022, published their results of 7 cases of hamstring transplants.[10] Six out of seven of their patients were medial meniscus transplantation. However, the technique was not elaborative. In contrast, the present technical note is aimed to describe the detailed procedure of meniscal transplantation using SemiT tendon.

The details of advantages and disadvantages are elaborated In Table 1. Milenin et al. considered the SemiT size a disadvantage and used the peroneus longus tendon.[8] In contrast, we believe that SemiT is more adaptable, as it can be used as a single strand if sufficient meniscal rim is preserved and doubled if a larger

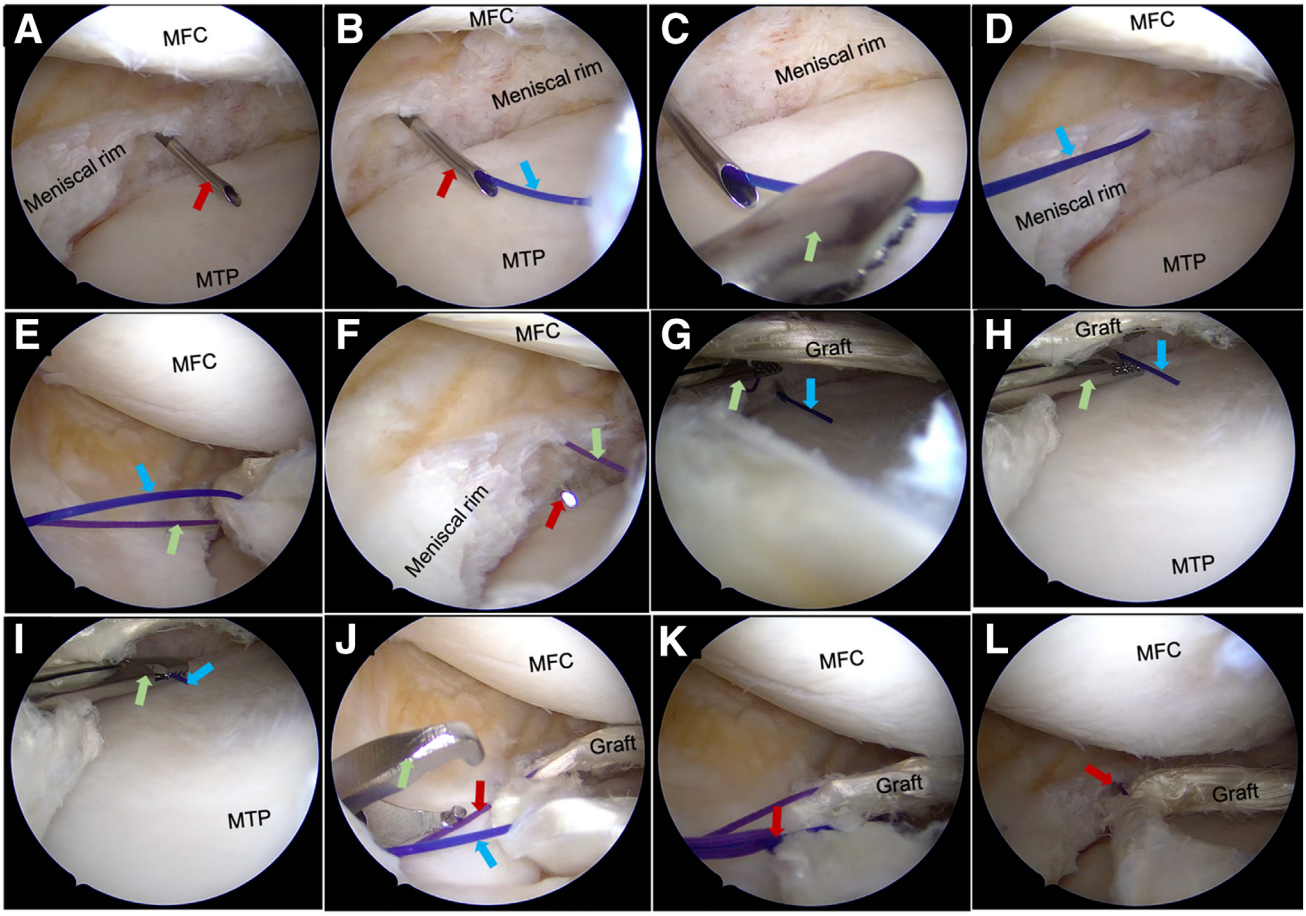

Fig 6. Steps of repair using the centralizing suture. Arthroscopic pictures demonstrate the medial compartment of the left knee joint through an anterolateral portal using 30° arthroscopes. (A) An 18-g Tuohy epidural needle (red arrow) is passed from the medial aspect of the knee to the center of the meniscus. (B) A no. 1 Prolene (blue arrow) is passed from outside-in through the cannulation of the epidural needle (red arrow). (C) the Prolene (blue arrow) is grasped by a grasper (green arrow) and pulled out from the accessory anteromedial portal. (D) The sutures (Prolene and centralizing suture) are pulled through the accessory anteromedial portal, making a virtual cannula. (E) The centralizing suture is then shuttled out on the medial side by tying over the loop of centralizing suture by the Prolene. (F) The epidural needle (red arrow) is again passed through the same soft tissue tunnel exiting through the meniscal rim just below the previous point. (G) Prolene is passed through the epidural needle and delivered under the graft. (H and I) Prolene is retrieved through the accessory anteromedial portal. (J) The sutures are pulled out together using a suture manipulator to make a virtual cannula. (K) Centralizing suture is shuttled out using the Prolene. (L) A sliding knot is made in the two limbs of centralizing suture, and the knot is delivered to the capsule through the soft tissue tunnel to complete the repair.

size is required. On top of that, SemiT is the most studied graft and has lesser donor site morbidities. SemiT graft has more evidence of its biomechanical superiority than other grafts.[11] Pearls and pitfalls are elaborated in Table 2.

Although the primary indications for this procedure are similar to those of allograft transplantation and meniscus scaffold implantation, we did not wait for medial pain syndrome after meniscectomy to develop. If a subtotal or total meniscectomy must be performed on a young patient (below 40 years of age), the SemiT is transplanted. Obesity, synovitis, inflammatory arthritis, and prior joint infections are contraindications for this procedure.[1]

This technique has several limitations. There is a lack of long-term results and no evidence to prove that the remodeled meniscus-like tissue will work as a meniscus and prevent future osteoarthritis. Long-term follow-up studies are required to suggest this surgery for regular use. The direction of fibers of SemiT is different than the meniscus, and there is no evidence yet of the formation of these fiber orientations. Moreover, the procedure requires a high degree of surgical skill.

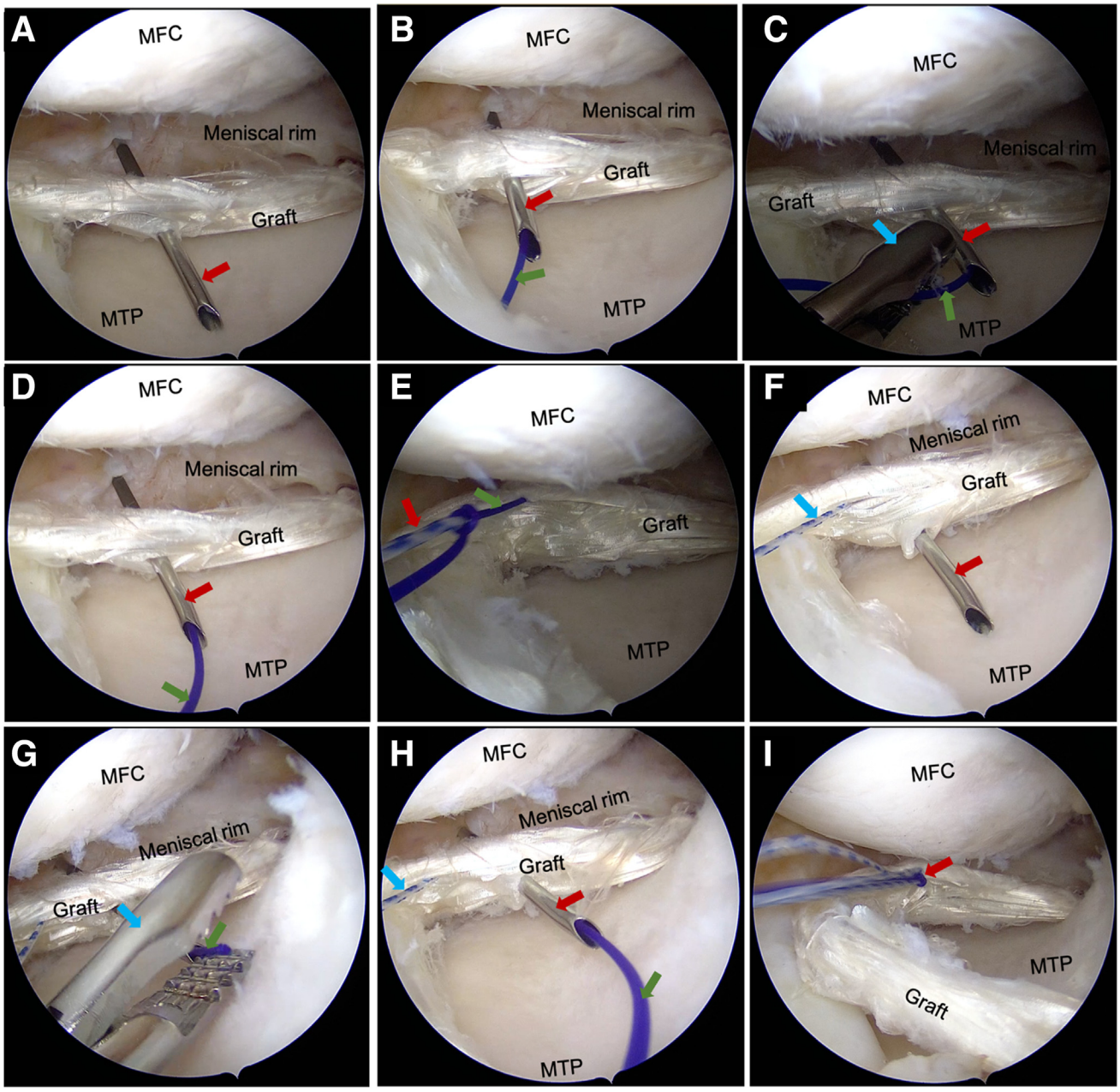

Fig 7. Application of outside-in sutures in transplant graft. Arthroscopic pictures demonstrate the medial compartment of the left knee joint through an anterolateral portal using 30° arthroscopes. (A) An 18-g Tuohy epidural needle (red arrow) is passed from the medial aspect of the knee, exiting midway between centralizing suture and posterior root through the graft. (B) A no. 1 Prolene (green arrow) is pushed in through the cannulation of the epidural needle (red arrow). (C) Prolene (green arrow) is retrieved through an anteromedial portal using a grasper (blue arrow). (D) Arthroscopic picture depicting epidural (red arrow) needle piercing the graft and Prolene (green arrow) pulled out from the anteromedial portal. (E) A simple knot of Prolene (green arrow) is tied over the loop of the OrthoCord (red arrow) outside and pulled to deliver the suture on the medial aspect of the knee. (F) The epidural needle (red arrow) is passed through the same soft tissue tunnel and pierced through the graft, creating a vertical mattress configuration with the previously passed OrthoCord (blue arrow). (G) Prolene (green arrow) is retrieved through the anteromedial portal using a grasper (blue arrow). (H) Arthroscopic picture of the medial compartment of left knee depicting epidural (red arrow) needle piercing the graft and Prolene (green arrow) pulled out from the anteromedial portal. (I) The second limb of the OrthoCord is pulled out by a knot tied over the loop of the OrthoCord (red arrow), creating a vertical mattress suture.

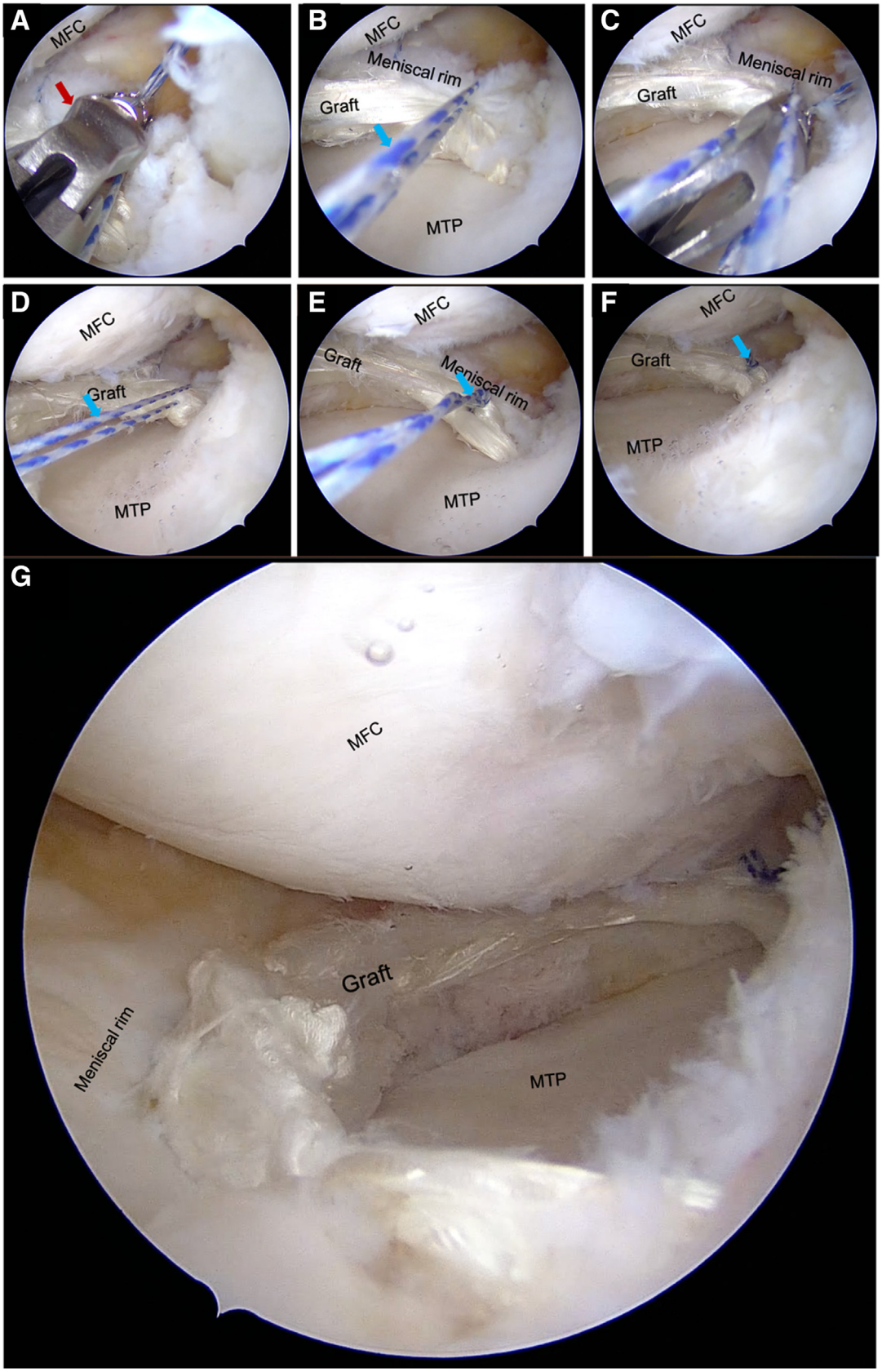

Fig 8. Application of all-inside sutures in the posterior root. Arthroscopic pictures demonstrating the medial compartment of the left knee joint through an anterolateral portal using 30° arthroscopes. (A) A first pass mini (Smith & Nephew) (red arrow) loaded with no. 2 OrthoCord is introduced from the anteromedial portal. A bite is taken at the peripheral meniscal rim. (B) Both the

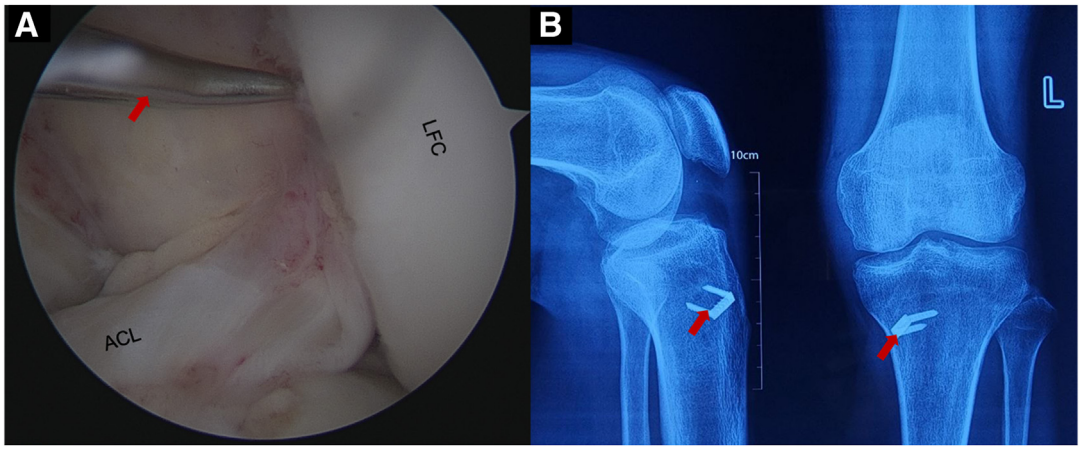

Fig 9. Microfracture and graft fixation. (A) Arthroscopic pictures demonstrating microfracture in the lateral femoral condyle, anterior to anterior cruciate ligament attachment using a 4-mm microfracture awl (red arrow). (B) Postoperative radiograph of left knee anteroposterior and lateral view demonstrates bone staple application (red arrows).

Table 1. Advantages and Disadvantages of this Technique

Advantages	Disadvantages
Cost effective	Requires a high degree of surgical skill
There is no need to size the meniscus, as excess meniscus can be accommodated in the tunnel or cut.	Need all types of meniscal repair skills (all inside, inside out and outside in).
Easily available	Partial replacement of meniscus is not possible.
Less donor site morbidities	The technique is still evolving.
All the advantages of autograft	
The entire meniscus can be replaced.	
No immunological reaction	
It can be used as a single or double strand.	
Have more biomechanical evidence of its strength[11]	

Table 2. Pearls and Pitfalls

Pearls	Pitfalls
Meticulous excision to preserve as much peripheral meniscal tissue as possible	Requires high skill level, especially when performing in conjunction with other reconstructions.
Creation of both the root tunnel as anatomical as possible	Long-term outcome of this technique is still not available.
Keep all shoulder instruments handy and available.	Indication of this technique has to be very stringent.
Need skills and implants for all types of meniscal repair (outside-in, inside-out and all inside)	
The graft must be repaired sequentially to the periphery, starting from the center and alternating posterior and anterior.	

Hamstring autograft transplantation for the medial meniscus can be an option in young patients when repair and other standard facilities are unavailable. The hamstring is a versatile graft, which can be used as a single- or double-strand based on the required size.

limbs (blue arrow) are pulled out through the anteromedial portal. (C) The inferior limb of the suture is then loaded into the first pass mini and introduced through the same anteromedial portal. The second bite was taken on the graft from inferior to superior. (D) Both of the limbs of the suture (blue arrow) are pulled out using a suture manipulator through the anteromedial portal, making a virtual cannula. (E) An SMC knot is applied, and the knot (blue arrow) is delivered toward the peripheral rim. (F) Sutures (blue arrow) are cut using a cord cutter. (G) Final arthroscopic picture of the graft transplantation after adequate suturing.

Disclosure

The authors report no conflicts of interest in the authorship and publication of this article. Full ICMJE author disclosure forms are available for this article online, as supplementary material.

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