Technical Note

Arthroscopic Transtibial Pull-Out Repair of Medial Meniscus Posterior Root Tear With a Whip Running Suture Technique

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Abstract: Medial meniscus posterior root tear is a disruptive injury causing significant sequelae. Several techniques to repair and maintain the native function of the medial meniscus have been introduced, but limitations have been reported in terms of their results. In this current note, the authors introduce the arthroscopic transtibial pull-out repair with whip running suture technique, which may not only avoid the potential risk of meniscus cut-through by the suture material but also optimize the reduction of the extruded meniscus. By suturing the posteromedial capsule and peripheral meniscus, more medialization force can be directly applied to the extruded part of the meniscus, and normal hoop tension can be restored.

Medial meniscus posterior root tear (MMPRT) is a type of radial tear occurring within 10 mm of the posterior tibial attachment. The transection of the posterior root can weaken tensile strength, which may cause meniscal extrusion and the so-called total meniscectomy status.[1,2] Consequently, this can lead to the progression of a medial-compartment degenerative arthritis.[3-5]

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The authors report the following potential conflicts of interest or sources of funding: this research was supported by Basic Science Research Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Science and ICT (NRF-2017R1A2B3007362). Full ICMJE author disclosure forms are available for this article online, as supplementary material.

Received September 3, 2020; accepted November 24, 2020.

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2212-6287/201525

https://doi.org/10.1016/j.eats.2020.11.016

Many investigators have reported various techniques to repair MMPRT; however, concerns about residual meniscal extrusion persist.[6,7] In addition, due to the degenerative nature of the MMPRT, it is considered much more difficult to restore and maintain the posterior root attachment.

To overcome such limitations, this Technical Note introduces the arthroscopic transtibial pull-out repair using the whip running suture technique. By suturing the posteromedial capsule and peripheral meniscus, more medialization of the extruded meniscus can be achieved, and normal hoop tension can be restored. This technique can reduce the meniscus extrusion effectively, avoiding the risk of the meniscus cut-through by suture strand (Fig 1).

Surgical Technique (With Video Illustration)

Patient Positioning

Under general anesthesia, the patient is placed in a lithotomy position with the operated leg hanging to the side of the operation table. A pneumatic tourniquet is applied to the proximal thigh. After scrubbing and painting, routine draping is done for the lower extremity.

Arthroscopic Portal Placement

Standard anterolateral and anteromedial portals are used for the initial inspection. After confirming the diagnosis arthroscopically, posteromedial and posterolateral portals are made using the transillumination

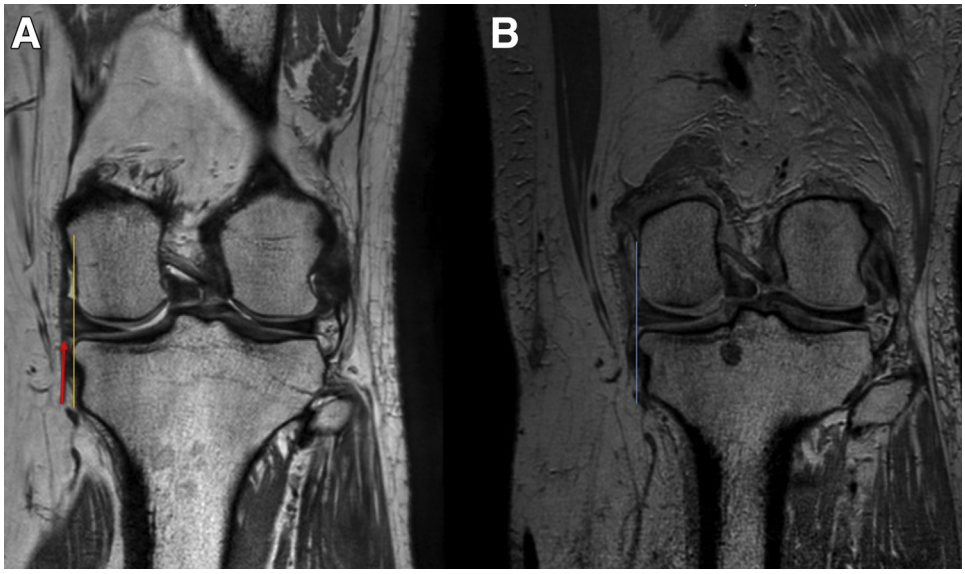

Fig 1. (A) Preoperative MRI of the right knee, coronal view. Significant meniscal extrusion can be seen on the posterior horn of the medial meniscus (arrow). (B) Postoperative MRI of the same patient. Appropriate reduction of the extruded meniscus was achieved. (MRI, magnetic resonance imaging.)

technique.[8] Posterior trans-septal portal formation is done with the previously described technique[9] (Fig 2). The instruments for the repair procedure are listed in Fig 3.

Tibial Tunnel Formation for the Pull-Out Suture

The arthroscope is introduced through the trans-septal portal, and the posteromedial compartment is inspected. To visualize the uncovered tibial plateau and the root stump of the medial meniscus (MM), peripheral synovial tissues surrounding the posterior cruciate ligament are minimally resected using arthroscopic punch forceps inserted through the posteromedial portal. During this stage, the resection of the peripheral tissue should be done minimally to avoid iatrogenic instability (Fig 4). To prepare a healing bed to anchor the posterior horn, cartilage and cortical bone are removed from the posteromedial edge of the medial tibial plateau, and the cancellous bone is thus exposed. Under visualization through the trans-septal portal, the ACL drilling guide (110° setting; Arthrex, Naples, FL) is inserted through the posteromedial portal, targeting the anatomical footprint of the meniscal root insertion (Fig 5). Then, the sleeve of the guide is fixed on the anteromedial cortex of the proximal tibia. A 2.4-mm guide pin is then inserted through the guide. After checking that the pin is placed on the right location, this pin is withdrawn just beneath the cartilage level.

Fig 2. Gross photo of the trans-septal portal formation. The operated (left) knee is positioned on the operation table, which allows it to be flexed about 80° at a neutral state. After making the posteromedial and posterolateral portal, the posterior septum is inspected through the posteromedial portal. A switching stick is introduced through the posterolateral portal, pushing the septum medially. A motorized shaver is introduced through the anteromedial portal and the intercondylar notch. While pushing the septum medially, the posterior trans-septal portal is made by using the aforementioned motorized shaver.

Pull-Out Repair With Whip Running Suture Technique

Under visualization through the trans-septal portal with a 30° scope, a 45° curved suture hook loaded with a no. 2 polydioxanone (PDS) II suture material is inserted through the posteromedial portal (Fig 6). First, the peripheral capsule and the MM posterior horn on the posteromedial corner are penetrated by the suture hook. The sharp tip of the suture hook is advanced from the posteromedial capsule into the femoral surface of the MM. The suture strand is advanced through the suture hook until approximately half of its length is inserted. Then, the suture hook is withdrawn, and both ends of the strands are retrieved out of the posteromedial portal with a suture retriever. At the point

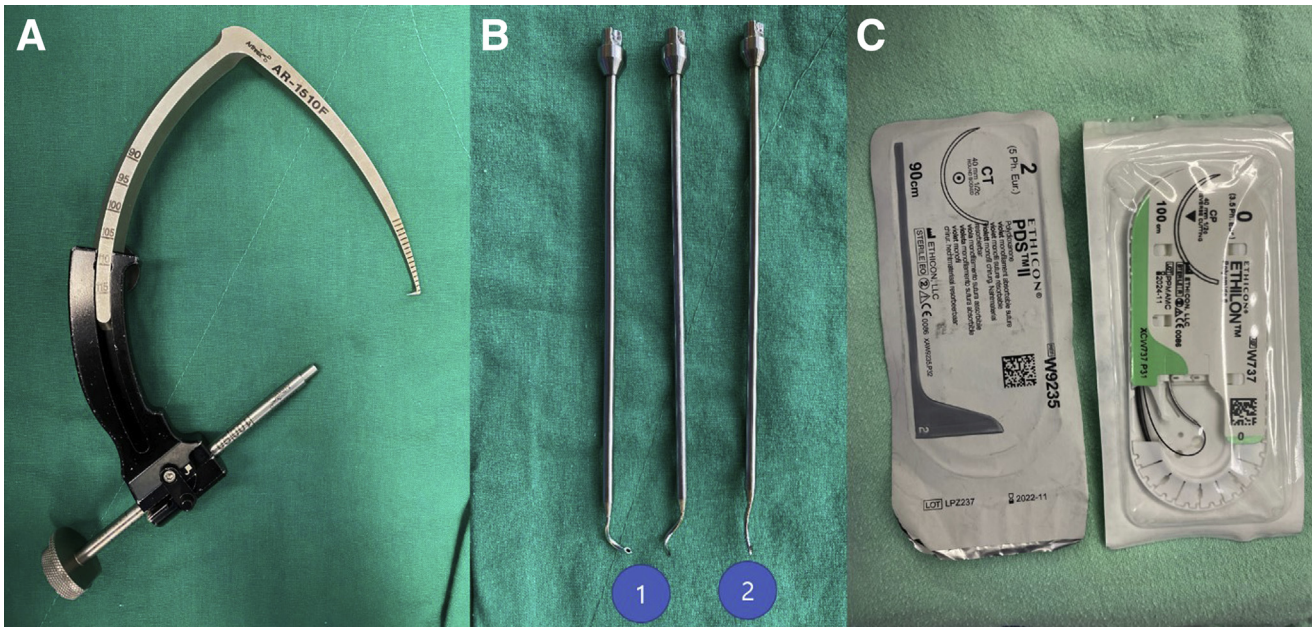

Fig 3. (A) the femoral footprint anterior cruciate ligament drilling guide (110° setting; Arthrex, Naples, FL), (B) (1), a 45° curved suture hook and (2), a crescent suture hook. (C) Suture materials for the whip running suture. The no. 2. PDS II is used for the running suture, and simple vertical sutures. The no. 0 ETHILON (Ethicon, Cornelia, GA) is used for the shuttle relay technique. (PDS, polydioxanone.)

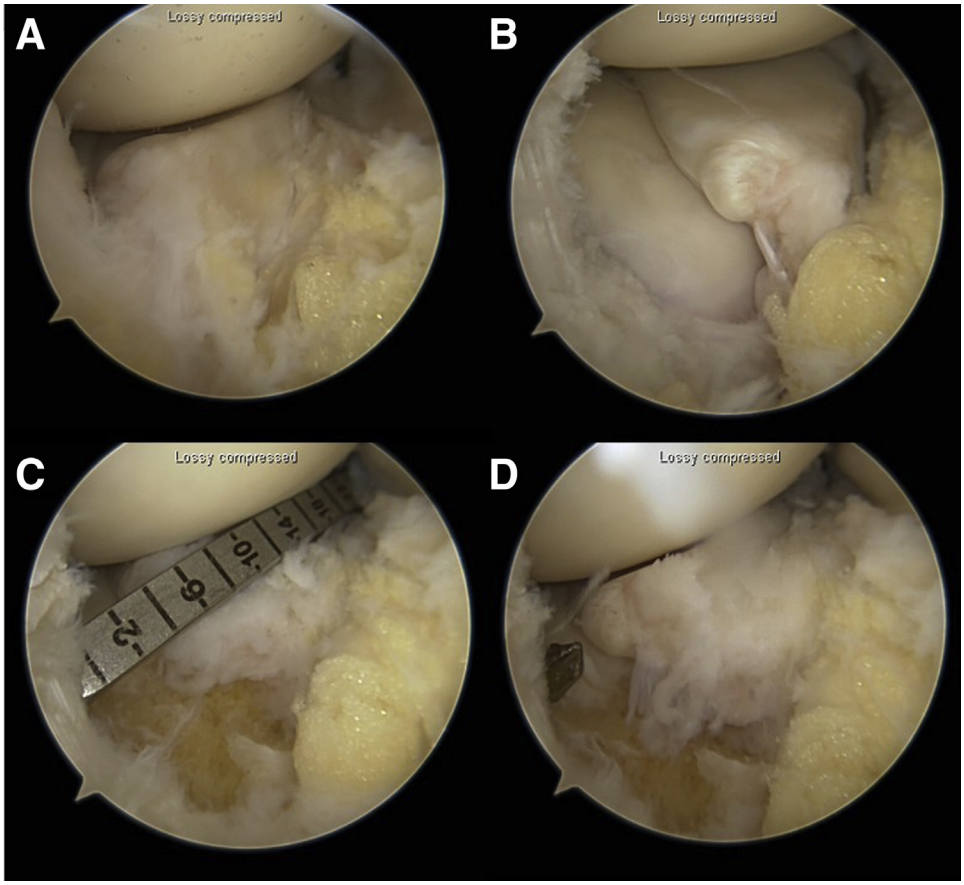

Fig 4. Arthroscopic view from the posterior trans-septal portal of the left knee. (A) Right after introducing the 30° scope, the meniscal root stump and medial tibial plateau are hidden behind the peripheral synovial tissue and the posterior cruciate ligament. (B) After the resection of the peripheral synovial tissue surrounding the posterior cruciate ligament (2-3 mm in extent), the uncovered tibial plateau and root stump are directly visualized. (C) Curettage for the bone healing bed is achieved, and the anterior cruciate ligament drilling guide is introduced through the posteromedial portal. (D) Anatomical footprint can be observed through the trans-septal portal. At the aimed tunnel site, the guide pin is inserted. Then, the pin is withdrawn just beneath the cartilage level.

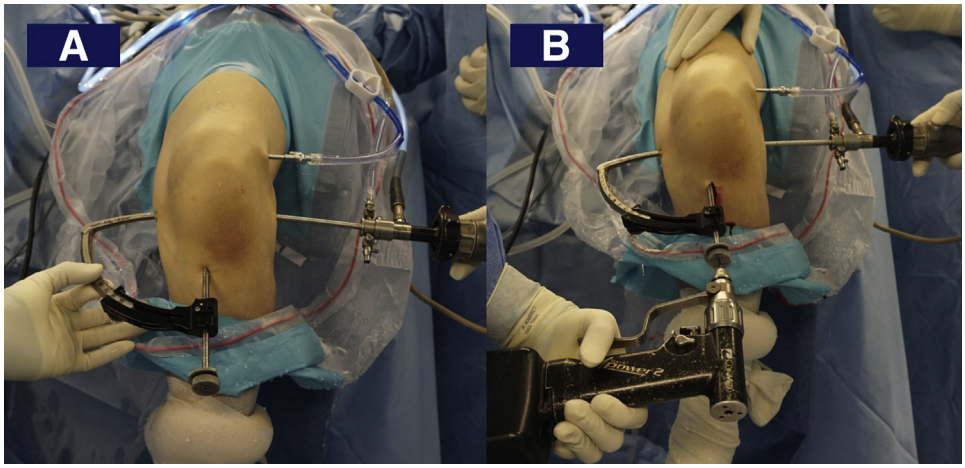

Fig 5. (A) Under visualization through the trans-septal portal, the anterior cruciate ligament drilling guide (110° setting; Arthrex) is inserted through the posteromedial portal of the left knee, targeting the anatomical footprint of the meniscal root insertion. Then, the sleeve of the guide is fixed on the anteromedial cortex of the proximal tibia. (B) A 2.4-mm guide pin is then inserted through the guide.

5 mm lateral to the first site of penetration, the posterior horn of the MM is penetrated by the same suture hook loaded with a no. 0 nylon suture material from the tibial side to the femoral side in a vertical direction. Then, both ends of the nylon strand are retrieved through the posteromedial portal. Using the shuttle-relay technique, the second suture of the nylon is exchanged with the first suture of the PDS. At this

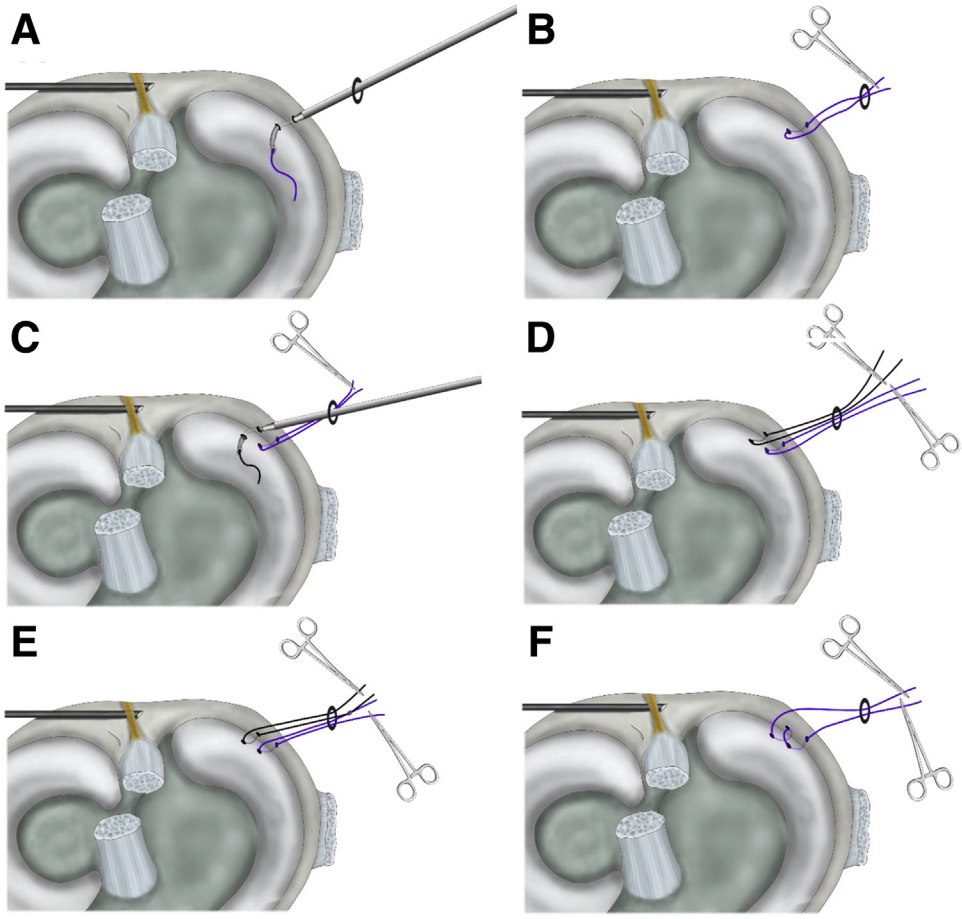

Fig 6. (A) Under visualization through the trans-septal portal with a 30° scope, a 45° curved suture hook loaded with a no. 2 PDS II suture material is inserted through the posteromedial portal. The posterior capsule and the medial meniscus posterior horn on the posteromedial corner are penetrated by the suture hook. The sharp tip of the suture hook is advanced from the posterior capsule into the femoral surface of the medial meniscus. (B) The suture hook is withdrawn, and both ends of the strands are retrieved out of the posteromedial portal with a suture retriever. (C) At a point 5 mm lateral to the first penetration, the posterior horn of the medial meniscus is penetrated by the same suture hook loaded with a no. 0 nylon suture material from the tibial side to the femoral side in a vertical direction. (D) Both ends of the nylon strand are retrieved through the posteromedial portal. (E-F) Using the shuttle-relay technique, the second suture of the nylon is exchanged with the first suture of the PDS. At this stage, the whip running stitch involving the posteromedial capsule is completed. (PDS, polydioxanone.)

stage, the whip running stitch involving the posteromedial capsule and peripheral meniscus is completed. Using a crescent suture hook loaded with a no. 2 PDS II, the simple vertical suture is made penetrating the posterior horn at the point 5 to 10 mm medial to the stump end. The crescent hook is advanced from the femoral surface to the tibial surface of the MM vertically. After advancing about half of the total length of the PDS, the suture hook is withdrawn, and both ends of the strand are retrieved out of the posteromedial portal. At the point 5 mm apart from the previous suture, a third suture is done using the same crescent hook and the suture material. In this stage, 1 whip running suture and 2 simple vertical sutures are completed. All 6 strands of the PDS are retrieved out of the posteromedial portal.

After completing the sutures, a tibial tunnel is made through the guide pin using a 4.5 cannulated reamer (Fig 7). While reaming, the guided pin is blocked by a straight bone curette to avoid iatrogenic damage to the posterior neurovascular bundle. The guide pin is withdrawn after reaming, and the cannulated reamer is left in place to pass a wire loop. Through the cannulated reamer, the wire loop is advanced into the intra-articular space, after which the reamer is removed. The suture retriever is then inserted via the posteromedial portal, with which the wire loop is retrieved.

After checking that both limbs of the 3 sutures are engaged properly within the wire loop, the wire is withdrawn through the tibial tunnel (Figs 8 and 9). By pulling the ends of the suture material under adequate tension, the reduction and stabilization of the meniscus can be checked. (Fig 10). While maintaining adequate tension, the PDS strands are post-tied and fixed with a 3.5-mm cortical screw and washer on anterior cortex of the tibia. Detailed pearls/pitfalls of the procedure are further described in Table 1.

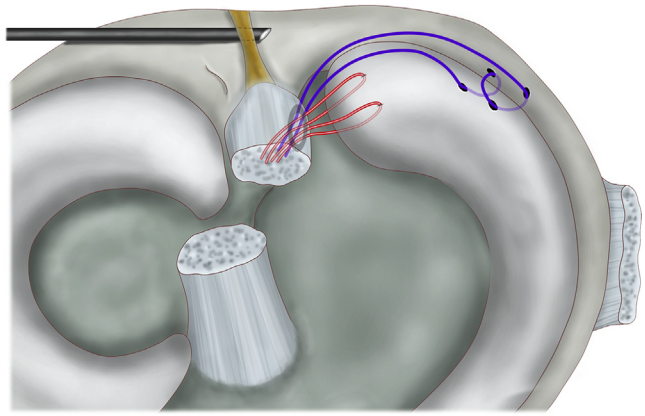

Fig 8. One whip running suture at the posteromedial capsule and 2 simple vertical sutures at the root stump are completed. These strands of the sutures are withdrawn through the tibial tunnel.

Postoperative Care and Rehabilitation

After the surgery, patients are allowed to mobilize, under nonweight-bearing, toe-touch ambulation with crutches for 4 weeks. Gradually, increased weight-bearing is allowed for the next 4 weeks. For the first 2 weeks after the surgery, a cylinder splint is applied with the knee at full extension. After that period, active knee range of motion exercise is allowed starting at 60°, and the range of motion is increased by 30° every 2 weeks until full range is achieved.

Fig 7. (A) The coronal image of the postoperative MRI of the operated knee (left). (B) The sagittal image of the postoperative MRI. The aimed tunnel position was achieved (arrow). (MRI, magnetic resonance imaging.)

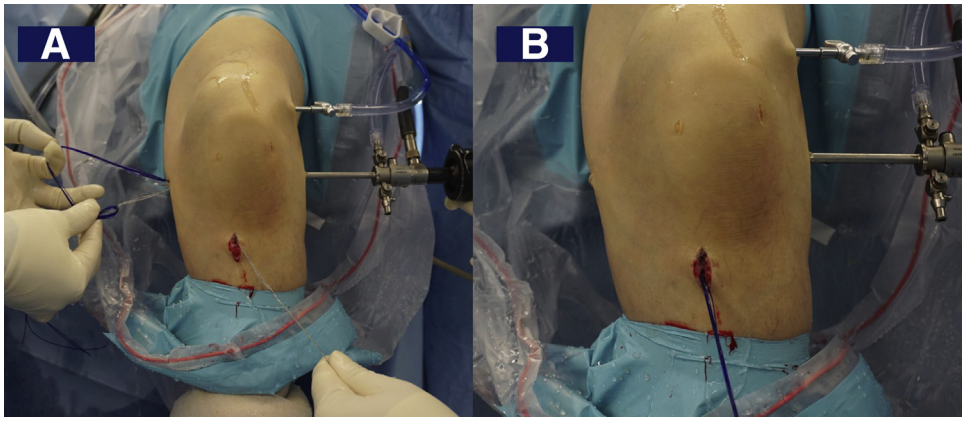

Fig 9. Gross photo of the suture passing the tibial tunnel using a wire loop. (A) The wire loop is passed through the tibial tunnel and retrieved through the posteromedial portal of the left knee. The suture strands are then engaged within the wire loop. (B) The wire is withdrawn through the tibial tunnel, thus retrieving the previously engaged suture strands with it.

Discussion

Several authors have reported favorable clinical outcomes of the arthroscopic transtibial pull out repair of MMPRT.[3-5,7,10,11] However, previous studies report various healing rates after repair of MMPRT.[11,12] Also, there are still concerns about residual extrusion of MM after the repair procedure.[6,7,12,13] This unsuccessful restoration of MMPRT can result in not only unfavorable biomechanical consequences[2] but also worse clinical outcomes.[7]

In contrast, the adequate reduction of the extruded meniscus is considered as a potential indicator of the successful outcomes of the repaired MMPRTs.[7,11] From the perspective of the meniscus extrusion, a landmark study pointed out that the amount of suture cutting-out at the suture–meniscus interface might be a major suspect of the displacement of the repaired MMRTs.[14] Therefore, it is our main concern to minimalize meniscus extrusion, prevent incomplete or lax healing, and optimize the medialization force introduced by the pull-out repair.

A number of techniques have been introduced to reduce the residual meniscal extrusion after the MMPRT repair.[15-21] Koga et al.[17] reported a novel technique using centralization suture. Those investigators introduced a suture that stabilizes the peripheral capsule onto the rim of the medial tibial plateau. However, this technique has limitations that could limit the normal motion of the MM, and the normal hoop tension could not be restored.

This current technique introduces the whip running suture, which modifies the previously reported pull-out repair techniques.[22] The advantages of this technique are as follows (Table 2). First, we believe that this suture technique can apply more reduction force directly to the posteromedial capsule and the MM. As a result,

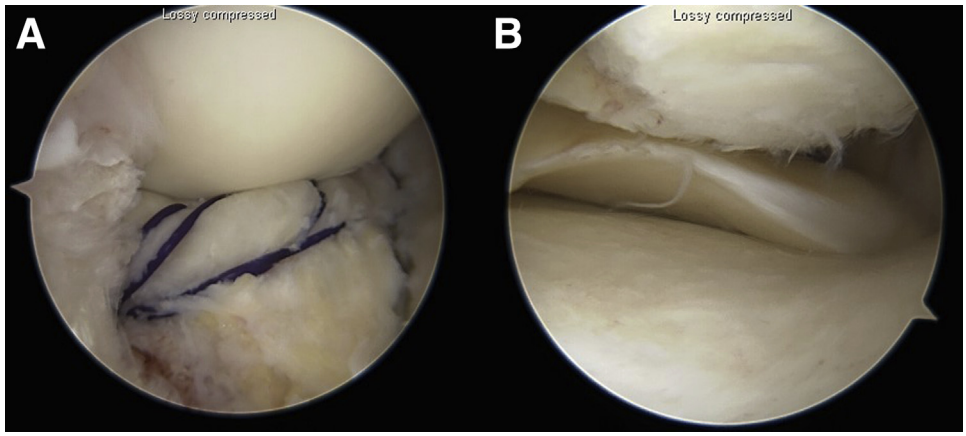

Fig 10. (A) Arthroscopic view from the posterior trans-septal portal of the left knee. Adequate reduction of the meniscus can be observed with the tibial plateau well-covered. (B) Arthroscopic view from the anterolateral portal.

Table 1. Pearls and Pitfalls

Pearls	Pitfalls
Use the transillumination technique to make the posterior portals, avoiding the nervous structure.	Excessive debridement of the meniscus root stump should be avoided.
Prepare the bone bed at the posterolateral edge of the medial tibial plateau to provide more contact area for the root healing.	Avoid too much resection of the synovial tissue surrounding PCL, which can result in iatrogenic instability while visualizing the root stump.
To avoid posterior neurovascular injury, use a straight bone curette to block the tibial reamer during the tunnel formation.	Forceful reaming over the guide pin can cause instrument breakage, which will waste time and cause more damage to the knee joint.
If surgeons do not use cannulas during repair, be sure all the suture ends are brought out through the portal to avoid soft tissue bridge.	Too much curettage for the tibial tunnel site can cause excessive cartilage damage. Make it just sufficient for the healing bed.
After the suture, it might be difficult to insert the tunnel reaming guide through the posteromedial portal, because several strands are retrieved out of the portal. Insert the tunnel guide pin before the suture.	Too much or less tension of the suture material can result in an inappropriate repair.
After reaming the tibial tunnel, leave the cannulated reamer to use it as a passage for a wire loop.	
After the post tie fixation, recheck the reduction status of the meniscus, and the tibial plateau coverage through the posterior trans-septal portal.	

PCL, posterior cruciate ligament.

the extruded part of the MM can be reduced effectively. Also, this running suture shares weight-load with sutures in the stump, thus minimizing suture-cutting through at the stump. This suture does not immobilize the MM and the peripheral capsule and does not interfere with the circumferential fibers of the MM. As a result, normal hoop tension can be restored. In addition, as previous investigators have mentioned, the anatomical foot print for the root of the MM can be easily visualized using trans-septal and posteromedial portal, enabling more accurate repair.

Some limitations that should be considered are as follows (Table 2). Suture abrasion and micromotion in the tibial tunnel may potentially result in the failure of the repair. In addition, the risk of suture cutting through the meniscus with multiple penetration may have undesirable effects. However, by suturing adequate amount of the meniscus tissue and keeping appropriate intervals between the sutures, we believe that such shortcomings can be overcome. Furthermore, it is vital that every precaution is taken not to injure the posterior neurovascular structure. Finally, further research will be needed to support whether this technique will result in improved clinical outcomes, better root healing, and ultimately be beneficial in the prevention of arthritic progression.

Table 2. Advantages and Disadvantages

Advantages	Disadvantages
By using the additional whip running suture, meniscal extrusion can be reduced effectively. Medialization force can be applied directly to the extruded part of the MM.	Technical demands using the posterior portals.
Weight-load can be shared by the posteromedial running suture. Therefore, suture-cutting through at the root stump can be minimalized	Potential bungee cord effect, micro-motion, and the danger of the suture abrasion in the tibial tunnel.
Direct visualization of the anatomical foot print of the MM root and the uncovered tibial plateau though the trans-septal portal.	The transtibial tunnel can interfere with concomitant procedures such as the high tibial osteotomy.
Using absorbable suture material, potential complication of the nonabsorbable suture could be avoided.	

MM, medial meniscus.

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