Technical Note

Improved Medial-Internal Approach to Repair Posterior Root of Medial Meniscus by All-Suture Anchor Combined With Opening Wedge High Tibial Osteotomy

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Abstract: Medial meniscus posterior root tears often occur in patients with lower limb varus malalignment, which leads to mechanical overloading of the medial compartment and premature cartilage wear. Such injuries are often treated by the pullout technique or the suture anchor technique. In this context, the technique of repairing the posterior root of the medial meniscus using all-suture anchors combined with an opening wedge high tibial osteotomy has been proposed. In this technique, we describe a simple maneuver to repair medial meniscus posterior root tears. This technique repairs the posterior root of the medial meniscus by percutaneous puncture through a medial-internal approach with all-suture anchors in combination with opening wedge high tibial osteotomy. This technique has the advantages of simplicity, avoidance of the "bungee effect," and reduction of wear and is worthy of clinical dissemination.

In recent years, medial meniscus root tears (MMPRTs) have been paid more and more attention by surgeons because of its specificity. MMPRTs can lead to loss of circumferential tension of the meniscus and cause pathologic meniscal extrusion, resulting in loss of function.[1] Previous biomechanical studies have found that MMPRTs are equivalent to a total medial meniscectomy.[2] It is important to note that MMPRTs can increase the contact pressure of the femorotibial joint and accelerate the damage to the articular cartilage, which eventually leads to osteoarthritis.[3] Therefore, the integrity of the posterior root of the medial meniscus is critical to the function of the knee joint in buffering pressure and dissipating stress.[4]

Studies have shown that lower limb varus malalignment is one of the risk factors for MMPRTs. Opening wedge high tibial osteotomy (OWHTO) can treat medial compartment osteoarthritis with lower limb varus malalignment by reducing the pressure of the medial compartment. Some studies have found that it promotes articular cartilage remodeling. Performing the MMPRT repair alone often results in failure for patients who have MMPRTs combined with a knee valgus deformity greater than 5°.[5] Therefore, for these patients, MMPRT repair combined with OWHTO is an effective surgical technique that can improve articular cartilage and clinical outcomes.[6]

At present, there is no uniform surgical technique for repairing the medial meniscus posterior root. The transtibial pullout technique has achieved good clinical results.[7,8] However, when combined with OWHTO, the sutures are often interrupted by the OWHTO osteotomy line or screws, which can easily lead to breakage. In addition, the "bungee effect," with suture wear and suture creep, has often confused doctors.[8,9] Other scholars have used the suture anchor technique to repair the MMPRTs, which avoids suture interference in combined OWHTO surgery, but it requires more skilled surgical maneuvers[10] because it needs the

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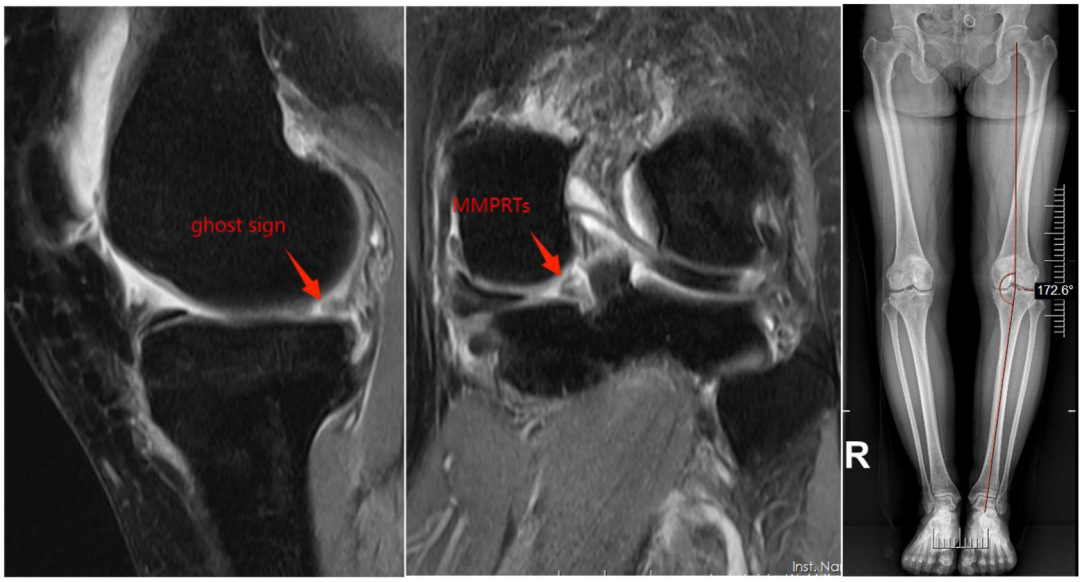

Fig 1. Sagittal and coronal MRI of the left knee showed the meniscus posterior root tears, and full-length x-ray of the lower limb showed an inversion deformity greater than 5°. (MMPRT, medial meniscus posterior root tear.)

creation of an additional posterior medial approach, yet there are many important blood vessels and nerves in the posterior aspect of the knee joint. In addition, both of these techniques are more complicated to maneuver through the conventional anteromedial approach when suturing the medial meniscus posterior root (MMPR). Sometimes, both of these techniques need special equipment such as the knee scorpion and require a longer learning curve.

Therefore, to solve the abovementioned problems, we propose a technique of repairing the MMPRs by all-suture anchors through the media-internal approach combined with OWHTO. In this case, the surgical technique we propose is simple to perform and easy to repair the MMPR, which can greatly reduce the operation time. This technique not only reduces the possibility of "bungee effect," suture wear, and iatrogenic femoral condylar cartilage injury but also avoids interference with OWHTO and the risk of injury to the posterior nerves and vessels. It is easy to operate and has a shorter learning curve when repairing the MMPR. We believe this surgical technique is worth popularizing because of these advantages.

Surgical Technique

According to magnetic resonance imaging and full-length x-ray of the lower limbs, we determine that the patient has MMPRT combined with a knee valgus deformity greater than 5° (Fig 1). We mark the body before the operation (Fig 2). The patient is placed in the supine position, with routine sterilization. Using an aseptic sterile technique, the operative site is prepared, draping is done, and a tourniquet is inflated. The anteromedial and anterolateral portals are established. Throughout the procedure, the knee is located between 0° and 30° while valgus stress is gently applied. The knee meniscus, ligaments, and cartilage are routinely explored. The arthroscope is placed into the anterolateral portal to visualize the MMPR. If the medial compartment space is too small, we can use the pie-crusting technique to release the posterior medial bundle of the medial collateral ligament, which can reduce medically derived femoral condylar cartilage injuries (Fig 3). MMPRTs are defined as posterior roots of the medial meniscus that can be easily lifted or pulled out by a probe (Fig 4).

The MMPR is then freshened using a planer, and the cartilage at the posterior root attachment is scraped

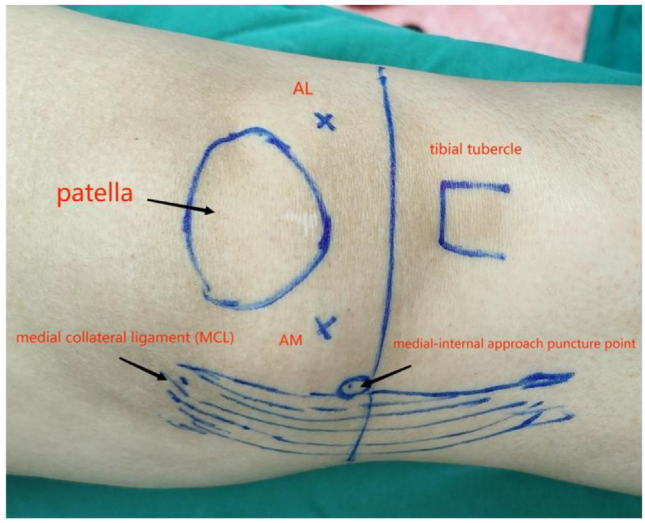

Fig 2. Marking the surgical approach before surgery. (AL, anterolateral; AM, anteromedial.) Patient in supine position.

using a bone curette to the subchondral bone to an extent of approximately 0.5 × 0.5 cm (Fig 5). The arthroscope is turned into an anteromedial portal. Then we place an anterior cruciate ligament reconstruction instrument into the joint cavity through the anterolateral portal, bypass the intercondylar fossa, and localize to the well-established bone bed. This step perfectly avoids the impingement of the medial intercondylar fossa and the shelter of the MMPR. The tunnel exit is positioned on the lateral aspect of the tibial tuberosity, where there is less fat and it is easy to find the bone tunnel (Fig 6). A 2.4-mm Kirschner wire is used to drill into the joint cavity (Fig 7). To facilitate the entry of the spinal needle into the joint, the tibial cortex can be enlarged by a 4.5-mm drill bit. A spinal needle with a polydioxanone (PDS) 1-gauge wire is passed along the tibial tunnel into the joint cavity (Fig 8).

We turn the scope into an anterolateral portal again to observe the MMPR. Then we pull the PDS wire out of the anteromedial portal after removing the spinal needle, noting that the PDS wire cannot be gashed by the spinal needle. We remove the all-suture anchor pin twisted at the base and thread it into the PDS loop. On the screen, the PDS line is used as a traction line to pull the all-suture anchor wire knot into the bone cortex (Fig 9). When the all-suture anchor is completely submerged in the bone cortex, the tail of the suture can be pulled back to retract the all-suture anchor and secure it below the bone cortex. Then we remove the retracted PDS wire.

In order to more easily suture the MMPRTs, we need to establish a medial-internal approach. The puncture point is at the junction of the joint line and the anterior border of the medial collateral ligament. Be careful not to damage the medial collateral ligament. Then, using a spinal needle as a guide, puncture at this point into the joint, passing posteriorly over the medial meniscus body to the attachment of the MMPR. After that, a 90° suture hook with a PDS wire is punctured from this point into the joint cavity (Fig 10). The suture hook can easily reach the attachment. Rotate the hook to suture the MMPR at approximately 5 mm to the margin. Use a push knotter to tie and secure the knot and a wire cutter to cut the tail line. Repeat at 3 to 5 mm of the first stitch to form a simple stitch and a loop stitch. The MMPR is seen to be firmly sutured and nonliftable by the probe test (Fig 11).

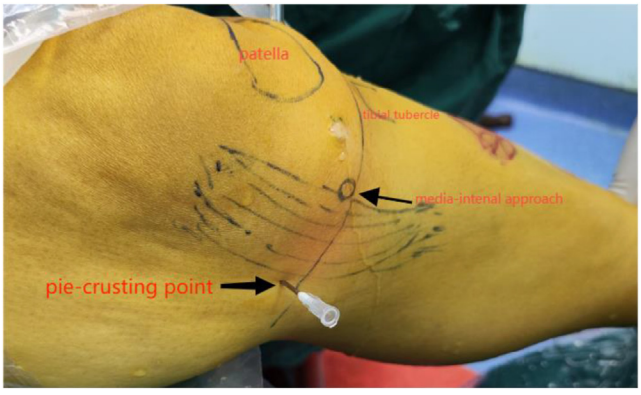

Fig 3. We use the pie-crusting technique to release the posterior medial bundle of the medial collateral ligament to reduce medically derived femoral condylar cartilage injuries. Patient in supine position with 45° knee flexion.

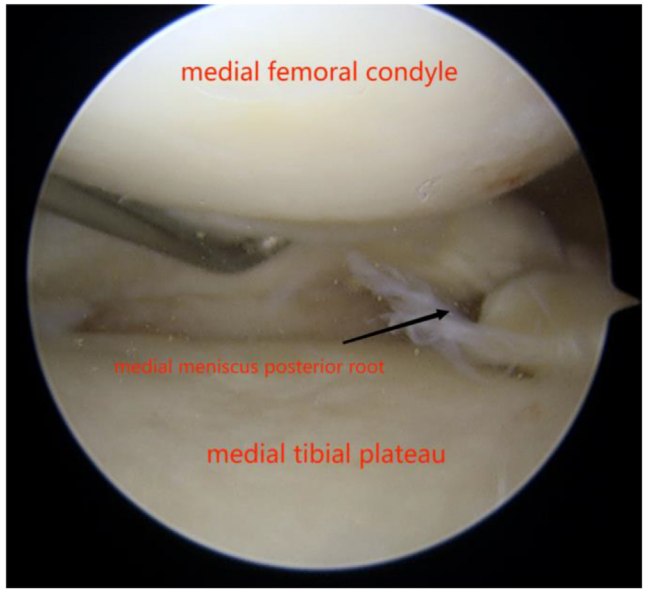

Fig 4. We observe the medial meniscus posterior root is easily lifted through the anterolateral approach. We can confirm the medial meniscus root tears. Observed through anterolateral approach.

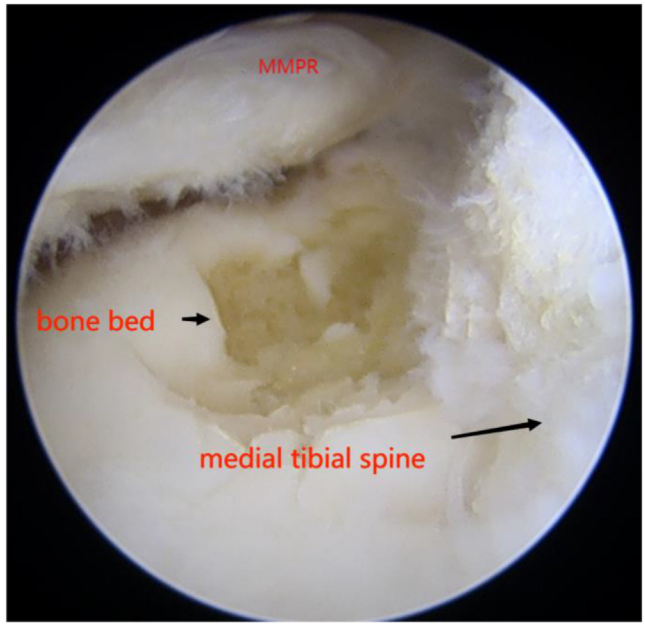

Fig 5. We use a bone curette to establish a bone bed for posterior root healing. The extent is approximately 0.5 × 0.5 cm. (MMPR, medial meniscus posterior root.) Observed through anterolateral approach.

Fig 6. We observe the medial meniscus posterior root tears through the anteromedial portal. The anterior cruciate ligament locator is positioned around the intercondylar fossa in the established bone bed and exits lateral to the tibial tuberosity. (AL, anterolateral; AM, anteromedial.) Patient in supine position with 45° knee flexion and observed through anterolateral approach.

Then perform the OWHTO operation. Extend the incision approximately 7 cm distally along the anteromedial approach. The pes anserinus tendon is preserved, and the superficial medial collateral ligament is completely released during exposure. The horizontal oblique osteotomy, aiming toward the tip of the fibular head, is established just above the insertion of the pes anserinus tendon and parallel to the tibial slope. An oblique coronal osteotomy is performed 110° to the horizontal oblique osteotomy (Fig 12). After completing the biplane cut, angle spacers are placed off to the rear to minimize the change in slope. The osteotomy site is increased until the mechanical axis of the limb passes through 50% to 62.5% of the tibial plateau width from the medial margin, and the final mechanical axis is confirmed by fluoroscopy. The target mechanical axis is determined based on degeneration of the lateral compartment. Correct the mechanical axis to the medial margin of the tibial plateau to 50% to 55% for mild cartilage injuries and to Fujisawa's point for knees with severe cartilage injuries. For a gap opening less than 10 mm, no filler is applied. For a gap greater than 10 mm, allogenic bone grafts are inserted at the gap. The plate (Tomofix) and screws are then fixed to the medial aspect of the proximal tibia (Fig 13). Then flush the joint cavity and suture the wound (Video 1).

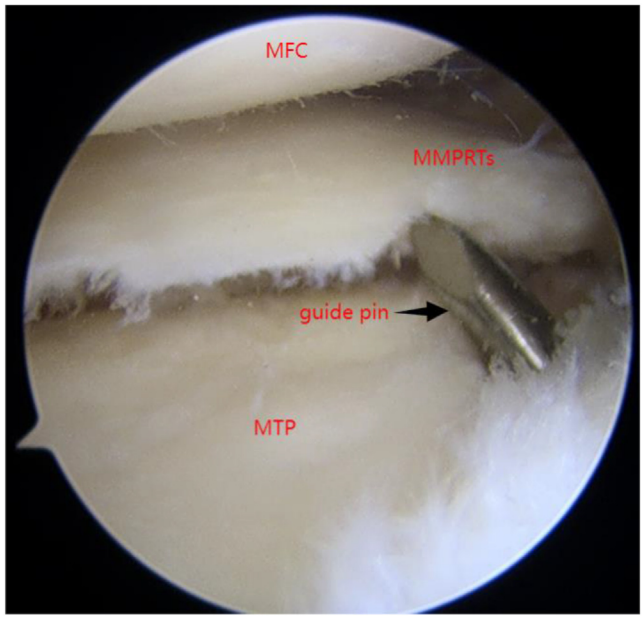

Fig 7. Drill the 2.4-mm guide pin into the bone bed via the anterior cruciate ligament locator. (MFC, medial femoral condyle; MMPRT, medial meniscus posterior root tear; MTP, medial tibial plateau.) Observed through anterolateral approach.

Postoperative Rehabilitation

Quadriceps isometric training and straight-leg raising are performed immediately after surgery. After surgery, patients can use crutches, but they should avoid weightbearing on the affected limb. The knee flexion angle is less than 90° for 4 weeks after surgery, partial weightbearing is allowed for 4 to 6 weeks after surgery, full weightbearing is allowed for 6 weeks after surgery, and squatting is prohibited for 3 months after surgery.

Discussion

According to a long-term comparative study of MMPRTs undergoing partial medial meniscectomy or repair (with at least a 10-year follow-up), the repair group is more effective in clinical outcomes and long-term survival, with less postoperative total knee arthroplasty.[11] However, the most likely cause of the MMPRTs is lower limb varus malalignment,[12,13] which results in loss of annular tension, as well as leads to wear and tear of the articular cartilage and further aggravation of the knee inversion. Therefore, repair of MMPRTs alone may not be sufficient in the patients with lower limb varus malalignment.[5] In a previous study, Outerbridge grade 3 or more and varus deformity greater than 5° were found to be risk factors for repair of MMPRTs.[14] Current research also suggests that for every 1° increase in preoperative involution angle, the risk of clinical failure increases by 1.5 times.[5] Ke et al.[15] showed that in patients with MMPRTs and varus malalignment, the rate of complete healing after

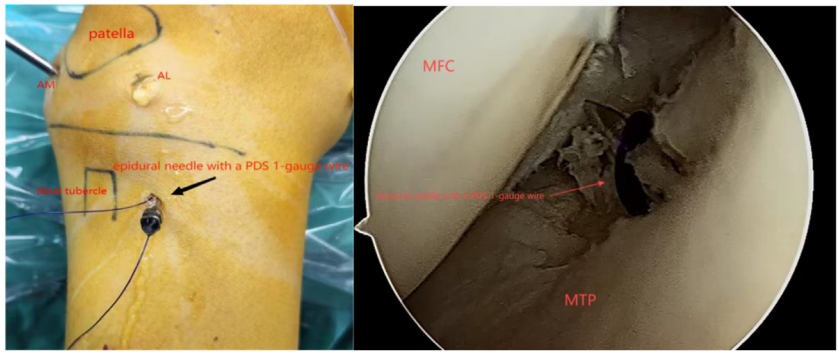

Fig 8. We observe the joint through the AM portal and pass an epidural needle with a polydioxanone 1-gauge wire along the tibial tunnel into the joint cavity. (AL, anterolateral; AM, anteromedial; MFC, medial femoral condyle; MTP, medial tibial plateau.) Patient in supine position with 45° knee flexion and observed through anterolateral approach.

OWHTO alone was only 5.9%. Lee et al.[16] reported that the complete healing rate of MMPRTs was 40.6% in 32 patients with MMPRTs who had lower limb varus malalignment and underwent OWHTO only, compared with 76% in 25 patients who underwent combined MMPRT repair. More studies have reported that MMPRT repair combined with OWHTO has superior posterior meniscal root healing rates (12.5%-64.7%) than OWHTO alone.[16-21] Choi et al.[17] demonstrated in the recent literature an improved MMPRT healing rate and cartilage regeneration in femoral condyles in patients undergoing OWHTO combined with MMPRT

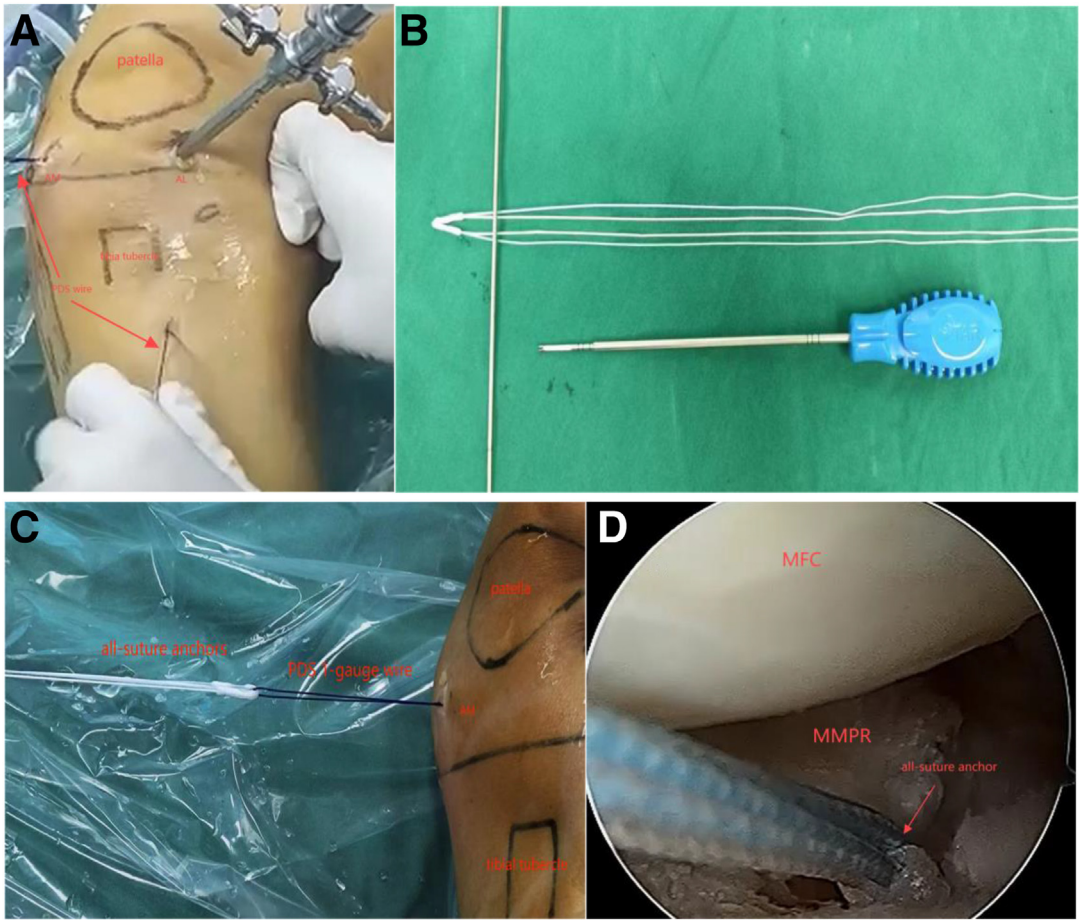

Fig 9. (A) We observe the joint through AL and pull the PDS wire out through AM. (B) Removing the all-suture anchor pin twisted at the base. (C) Threading the all-suture anchor into the PDS loop. (D) The PDS wire is used as a traction line to pull the all-suture anchor wire knot into the bone cortex. (AL, anterolateral; AM, anteromedial; MFC, medial femoral condyle; MTP, medial tibial plateau; PDS, polydioxanone.) Patient in supine position with 45° knee flexion and observed through anterolateral approach.

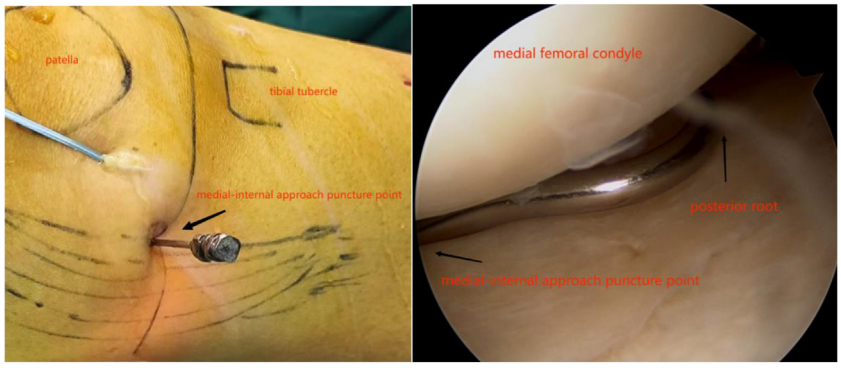

Fig 10. We inserted a spinal needle into the medial-internal approach as a guide. The medial-internal approach allows the suture hook to easily reach the meniscus posterior root. Patient in supine position with 45° knee flexion and observed through anterolateral approach.

repair surgery. Therefore, we recommend repair MMPRT combined with OWHTO to improve patient clinical outcome.

The pullout technique is favored by scholars. The pullout technique often leads to the "bungee effect," the risk of suture wear and creep and mutual interference when combined with OWHTO.[8,9] The suture anchor fixation technique, on the other hand, is more demanding on the operator's maneuvering, requires an additional posterior medial approach, is prone to injuring posterior blood vessels and nerves, and makes it difficult to place the suture anchor nails smoothly into the vicinity of the posterior root attachment.[10] In addition, both procedures require a learning curve when suturing the posterior root, as the conventional anteromedial approach is complicated to maneuver. Therefore, we propose a technique for repairing the MMPRTs by percutaneous puncture through a medial-internal approach with all-suture anchors in combination with OWHTO. The pearls and pitfalls of this procedure are shown in Table 1.

First, we use all-suture anchors to repair MMPRTs, which avoids interaction with the osteotomy line or screw and reduces the risk of a "bungee effect," suture wear, and creep, as well as the risk of injury to the posterior vascular nerves. Second, we suture the posterior root through the medial-internal approach, which makes it easy to suture the MMPRTs. This avoids the medical source of cartilage injury of the femoral condyle due to the narrowing of the medial gap and the difficulty of operation. At the same time, in patients with lower limb varus malalignment, the OWHTO technique can correct the patient's lower extremity force line, which decreases the medial interstitial compartment pressure, providing a favorable environment for the healing of the MMPR. The limitation of this procedure is the ability of the all-suture anchors to be securely anchored below the cortex of the bone over the time. This needs to be determined by longer-term

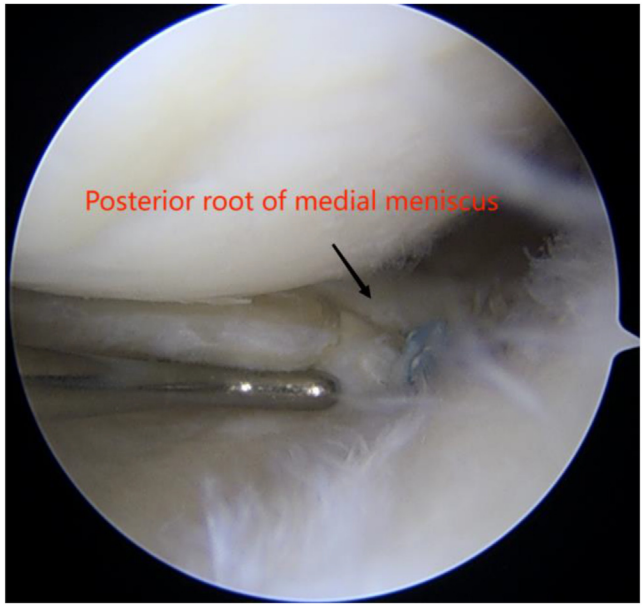

Fig 11. Suturing the posterior root of the medial meniscus to form a simple stitch and a loop stitch. The posterior root of the medial meniscus cannot be lifted or pulled out. Observed through anterolateral approach.

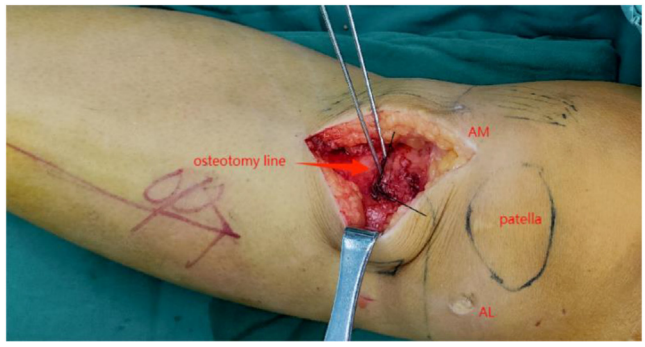

Fig 12. Extending the incision approximately 7 cm distally along the anteromedial approach, with a 110° biplane osteotomy guided with 2 guide pins. Correcting the mechanical axis to the medial margin of the tibial plateau to 50% to 55% for mild cartilage injuries and to Fujisawa's point for knees with severe cartilage injuries. The plate and screws are then fixed to the medial aspect of the proximal tibia. (AL, anterolateral; AM, anteromedial.) Patient in supine position.

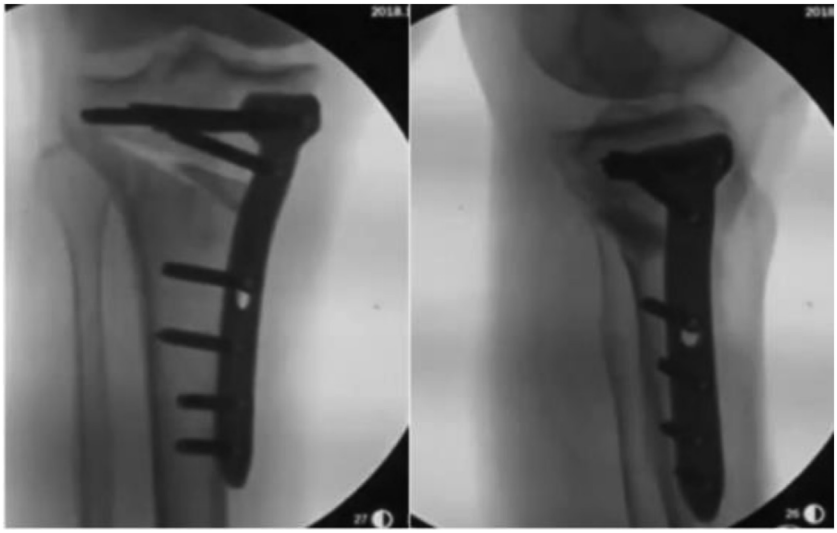

Fig 13. Postoperative x-ray shows well-adjusted mechanical axis of the lower limbs.

Table 1. Pearls and Tips and Pitfalls in the Posterior Root Medial Meniscus Tear With Medial Opening Wedge High Tibial Osteotomy

Surgical Technique	Pearls and Tips	Pitfalls
1. Pie-crusting technique	1. Increased medial femorotibial joint space. 2. Reduces the possibility of medically induced cartilage damage to the femoral condyle and facilitates maneuvering	Excessive loosening of the medial collateral ligament tends to cause injury to the medial collateral ligament, which in turn leads to knee instability.
2. Posterior root attachment positioning technique	1. Accurate creation of tunnels for anatomic fixation of the posterior root of the medial meniscus 2. Perfect avoidance of impingement of the intercondylar fossa and occlusion of the posterior root of the medial meniscus 3. The reconstruction instrument is placed on the lateral aspect of the tibial tuberosity, which is low in fatty tissue and can be used to insert the spinal needle into the joint cavity without the need to expand the bone tunnel with a 4.5-mm drill bit, preserving the amount of bone.	Skillful handling is required to avoid damage to the surrounding cartilage.
3. All-suture anchor technique	1. Reduced risk of suture wear 2. No "bungee effect" 3. With combined HTO, the bone tunnel does not interact with the osteotomy line or screws. 4. Even if the fix fails, it can be changed to a pullout technique.	Overdrawn all-suture anchors are prone to failure.
4. Percutaneous puncture suture technique in a medial-internal approach	1. Less trauma, faster recovery after surgery 2. The suture hook is closer to the posterior root and is easy to operate. 3. Effective in minimizing the potential for medically induced injury to the cartilage of the femoral condyles 4. Avoids injury to the medial collateral ligament 5. No special equipment	Too large an incision can easily damage the medial collateral ligament and saphenous nerve.
5. OWHTO technique	1. Reduces pressure on the medial femorotibial joint 2. Increased healing opportunities for posterior root medial meniscus repair	Avoid hinge point breakage.

HTO, high tibial osteotomy; OWHTO, opening wedge high tibial osteotomy.

follow-up and second look. In conclusion, the surgical technique we propose is worthy of clinical dissemination.

Disclosures

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: J.D. reports article publishing charges were provided by the Third Hospital of Hebei Medical University. All other authors (X.Z., Y.Z., Y.N., Z.Z., Z.S., Z.C.) 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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