Technical Note

# Arthroscopic Lateral Meniscus Root Repair With Reverse Suture Anchor Technique

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**Abstract:** The stability of the knee joint is crucially dependent on the integrity of the lateral meniscus posterior root, which is often accompanied by anterior cruciate ligament injury. Anchor suture repair for lateral meniscus posterior root injury not only achieves better biomechanical effects but also ensures favorable prognosis. However, the placement of anchors often requires the establishment of a posterior approach, and the insertion of an anchor is a technical challenge. In light of this, we have applied the technique of reverse anchor fixation for repairing the lateral meniscus posterior root, which not only simplifies the procedure but also effectively reduces the "bungee effect."

Posterior lateral meniscus root tears (PLMRTs) typically occur simultaneously with injury of the anterior cruciate ligament (ACL). It has been reported that nearly 17% patients with ACL tears have PLMRTs,[1] while in cases without ACL tears, the incidence of PLMRT is less than 1%.[2] The posterior lateral meniscus root plays a significant role in stability of knee. Combined with ACL tear, PLMRT is associated with high-grade laxity including 3+ Lachman and 3+ pivot shift.[1,3] In addition, repair of PLMRT can restore stress distribution and reduce the pressure load.[4] Thus, the repair and functional rehabilitation of PLMRTs are of utmost importance. The methods of repairing PLMRTs include all-inside suture, anchor suture, and transtibial pullout repair.[5,6] The methods depend on different tear types and specific conditions. Transtibial pullout repair has been widely used, while a study demonstrated that all-inside repair resulted in better functional outcomes compared to transtibial pullout repair, both clinically and radiologically.[7] Besides, anchor sutures can achieve more favorable biomechanical properties, so for PLMRT, they might be beneficial for healing of the repaired posterior meniscus root and restoration of meniscus function compared with transtibial pullout repair.[8] Nevertheless, anchor sutures always need more portals and may pose operational challenges. Several studies have proposed effective repair methods.[9-11] To address this issue, we proposed a set of methods, that is, reverse anchor insertion, to achieve the repair of PLMRT.

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## Surgical Technique

### Patient Positioning, Surgical Approach, and Arthroscopic Examination

The patient is placed in a supine position and the knee flexed at 90°. A 30° scope (Smith & Nephew) is used and a standard arthroscopic approach is adopted through the medial and lateral portals of the knee joint (Table 1). If a posterolateral portal is needed, it is placed above the short head of the biceps tendon. Then, an arthroscopic examination is performed (Video 1). A type 2 tear according to the Christopher classification is identified, which involves a complete radial lateral meniscus tear extending 0 to 9 mm from the root attachment[12] (Fig 1). The Christopher classification is shown in Table 2.

**Table 1.** Technical Pearls and Pitfalls

| Pearls | Pitfalls |
| --- | --- |
| The use of an equal-length needle to measure the distance to the articular surface. | If encountering difficulties with Mason-Allen suturing, simpler mattress sutures can be a feasible alternative. |
| Elevating the distal end of the affected limb in a 4-point position for better exposure. | When tying knots, using a Tennessee loop technique may lead to cutting the suture, so it is recommended to use a standard surgical knot for securing. |
| Suitable for type 2, 3, and 5 tear classifications. | |
| A posterior approach can be established if necessary to complete the suturing process. | |
| The use of a spinal needle can assist in the introduction of the PDS line into the joint cavity. | |
| Usually, when using a 2.0-mm Kirschner wire to create a bone tunnel, the length is approximately 5.5 cm. Therefore, when preparing the coarse bone tunnel, a drilling distance of 4 to 4.5 cm can achieve a tunnel depth of 1.5 cm from the cartilage surface. | |

## Suture Anchor Placement

The technique of anchor repair is similar to the reported technique of transtibial pullout repair in terms of positioning and suturing.[7] The location of the posterior root attachment point is determined, and a bone curette (Smith & Nephew) or plasma scalpel (Smith & Nephew) can be used to create a fresh cartilage surface for better healing (Fig 2). Subsequently, a tibial targeting device of the ACL reconstruction instrument (Smith & Nephew) is positioned at the site of the torn attachment point with the affected limb while maintaining the knee in flexion, raising the foot position, and having a guide angle of 55°, and the attachment point can be determined through grasping the torn meniscus to the footprint with relatively low tension (Fig 3).[13] A 2-cm incision is made on the medial aspect of the tibia, followed by the insertion of a 2.0-mm Kirschner wire (Wego; Fig 4). The length of the 2.0-mm bone tunnel is measured using an equivalent-length Kirschner wire (Fig 5, Table 1). Subsequently, a 4.5-mm drill bit (Smith & Nephew) is used to create a larger bone tunnel. The drilling is stopped approximately 1 to 1.5 cm away from the articular cartilage surface with the guide of the equivalent-length Kirschner wire (Table 1). The spinal needle (Qionghua) is inserted through the bone tunnel into the joint cavity. Then, the PDS suture (Ethicon; Johnson & Johnson) is passed through the spinal needle into the joint cavity (Fig 6, Table 1). The spinal needle is removed and a knot is tied at the distal end of the PDS suture to secure the 3.0-mm anchor (Johnson & Johnson) with suture tails (Fig 7). The anchor is inserted through the PDS suture in a reverse direction into the bone tunnel, and the anchor is fixed at the junction of the broad and narrow bone tunnels (Fig 8).

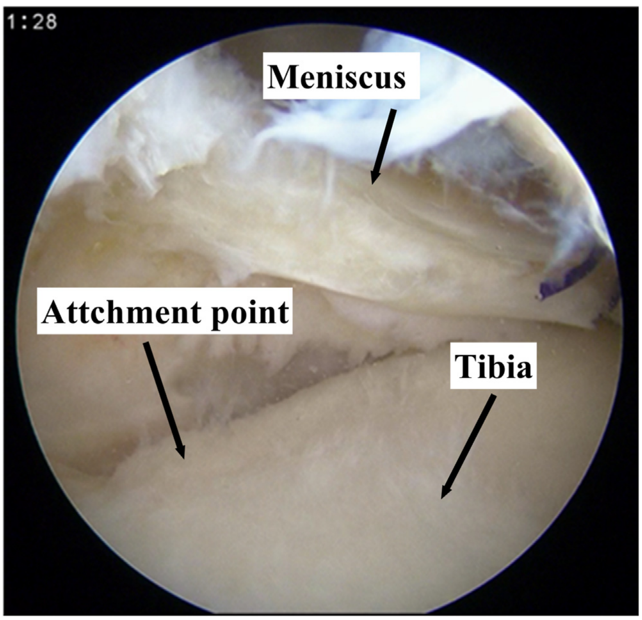


**Fig 1.** The patient is placed in a supine position and underwent arthroscopic surgery on the left knee. The affected limb was placed in a 4-point position with the knee flexed at 90°. A 30° scope (Smith & Nephew) is used and a standard arthroscopic approach is adopted through the medial and lateral portals of the knee joint. The lateral portal was the observation portal. The posterior lateral meniscus root also floated from the attachment point.

**Table 2.** Classification of Christopher

| Type | Description |
| --- | --- |
| 1 | Partial stable meniscal tear 0 to 9 mm from root attachment |
| 2 | Complete radial meniscal tear 0 to 9 mm from root attachment |
| 3 | Bucket-handle tear with meniscal root detachment |
| 4 | Complex oblique meniscal tear extending into the root attachment |
| 5 | Avulsion fracture of the meniscal root attachment |

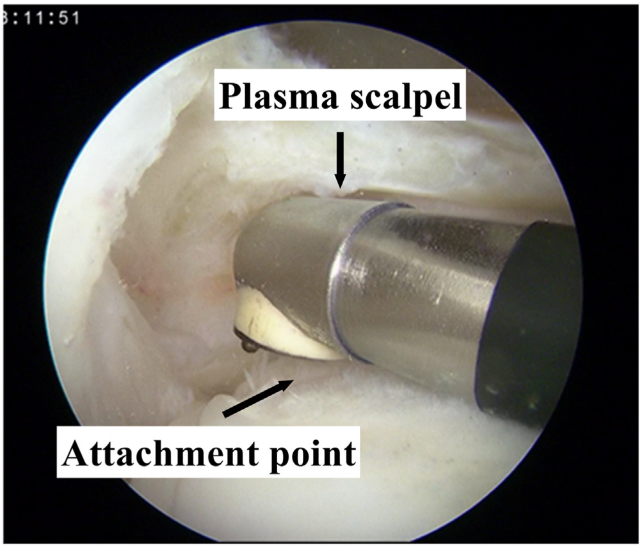


**Fig 2.** Plasma scalpel can be used to create fresh cartilage surface at the attachment, which is determined through grasping the torn meniscus to the footprint with relatively low tension. The patient is placed in a supine position and the knee flexed at 90° underwent arthroscopic surgery on the left knee. The affected limb was placed in a 4-point position with the knee flexed at 90°. The medial portal was the observation portal.

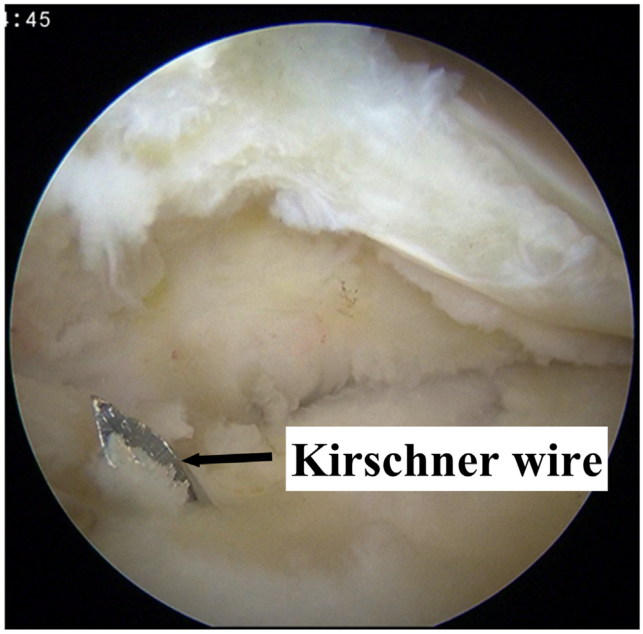


**Fig 4.** The patient is placed in a supine position and the knee flexed at 90° underwent arthroscopic surgery on the left knee. The affected limb was placed in a 4-point position with the knee flexed at 90°. The lateral portal was the observation portal. A 2.0-mm Kirschner wire is inserted into the articular cavity at the center of attachment.

### Suture Passage and Knotting

After the introduction of the anchor tail wires, a conventional mattress suture technique can be used to secure the 4 anchor wires by making pairwise knots through the posterior meniscus. To achieve improved biomechanical performance, a modified Mason-Allen suture technique can be employed (Fig 9, Table 1). To facilitate this, a posterior lateral approach is established for easier suturing (Table 1). To secure the posterior root of the meniscus at the insertion point, knots are tied to fix them in place. A standard surgical knot for securing is enough, while the Tennessee loop technique may lead to cutting the suture. The stability of the repaired posterior root of the meniscus is then confirmed (Fig 10). A diagram of our technique is shown in Figure 11. Of course, a modified Mason-Allen suture is not necessary, so the posterior lateral approach is no longer needed.

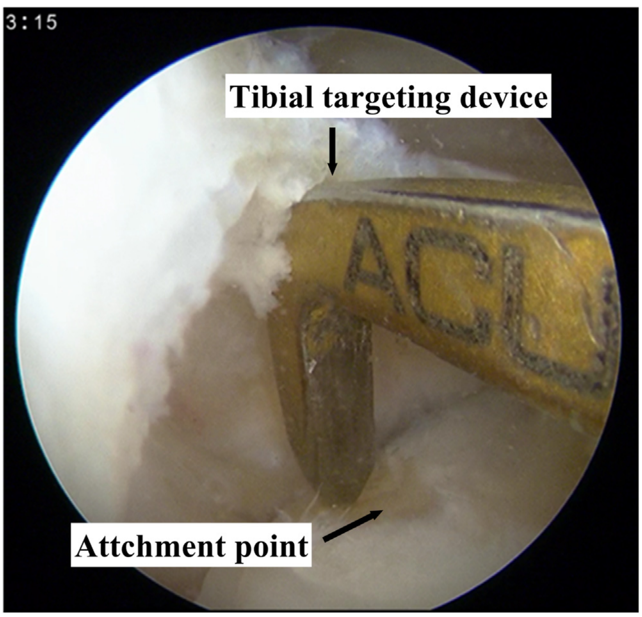


**Fig 3.** The patient is placed in a supine position and the knee flexed at 90° underwent arthroscopic surgery on the left knee. The affected limb was placed in a 4-point position with the knee flexed at 90°. The lateral portal was the observation portal. Tibial targeting device is positioned at the site of the torn attachment point with the affected limb maintained in the quadruped position.

### Postoperative Rehabilitation

Postoperatively, a brace is used to immobilize the knee joint for 4 weeks. In addition, for cases involving ACL reconstruction, the brace is kept on for 3 months. Partial weightbearing is initiated at 4 weeks postoperatively, and full weightbearing is allowed at 8 weeks postoperatively. At 4 weeks postoperatively, joint range of motion exercises begin, and the degree is limited to within 90°. At 6 weeks postoperatively, the range of motion can exceed 90 degrees, and gradually, exercises are performed to achieve full range of motion.

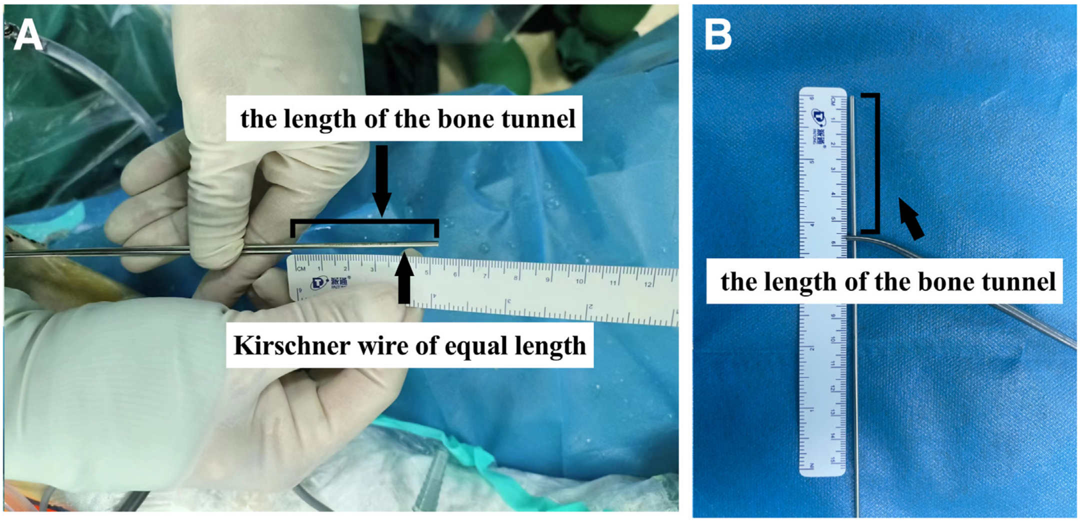


**Fig 5.** (A, B) The length of the 2.0-mm bone tunnel is measured using an equivalent-length Kirschner wire. When the tip of the Kirschner wire is just penetrating the articular surface, another Kirschner wire of equal length is placed at the same entry point without entering the bone's interior. The length of the exposed portion of the Kirschner wire is measured with a ruler, which represents the length of the bone tunnel (indicated in parentheses, A). Alternatively, a hemostat is clamped at the proximal end of the Kirschner wire with an equal length of protrusion, and the distance between the hemostat and the end of the Kirschner wire represents the length of the bone tunnel (B). The length of the bone tunnel is about 55 mm.

## Discussion

The barrier of using anchor sutures for PLMRT lies in the need for an additional posterior approach for the insertion of the anchor.[14] Moreover, even this approach carries the difficulty of inserting the anchor. In contrast, our reverse anchor technique eliminates the need for an additional approach when inserting the anchor, thereby making it easier to insert the anchor. We built an additional posterior approach to suture the meniscus so that better biomechanical performance could be achieved. In addition, when 2 simple stitches were performed, an additional posterior approach was no longer used. A technique incorporating a soft suture anchor for PLMRT repair has been previously described.[9] However, this technique relies on specialized anchors that are not widely available, whereas our technique achieves PLMRT repair using a commonly used 3.0-mm anchor. It has been reported that the anchor can be inserted through the femoral tunnel in cases requiring ACL reconstruction.[15] While this method is effective, it cannot be performed in cases without an ACL tear. Furthermore, our technique is applicable to medial meniscal root repair as well. Special attention should also be given to the repair constructs. A biomechanical study has demonstrated that the locking loop stitch exhibits the highest load to failure and stiffness among the 4 fixation methods, which include single suture, double suture, loop stitch, and locking loop stitch.[16] In our technique, we used the modified Mason-Allen method to suture the meniscus. However, for medial meniscus posterior root repair, it has been shown that the modified Mason-Allen technique does not yield superior clinical outcomes compared to simple sutures.[17] Recent studies have even revealed that 2 simple stitches for medial meniscus

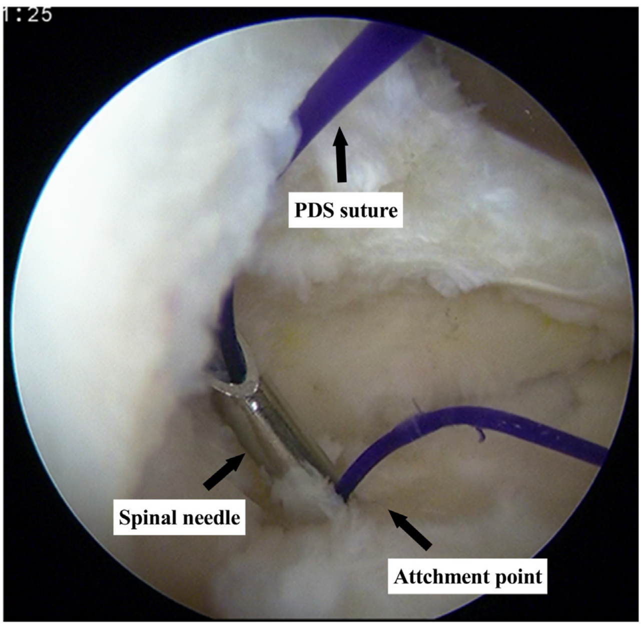


**Fig 6.** The patient is placed in a supine position and the knee flexed at 90° underwent arthroscopic surgery on the left knee. The affected limb was placed in a 4-point position with the knee flexed at 90°. The lateral portal was the observation portal. The spinal needle is inserted into the joint cavity along the direction of the bone tunnel. Subsequently, the spinal needle is used to introduce the PDS suture into the joint cavity to pull the anchor into the bone tunnel.

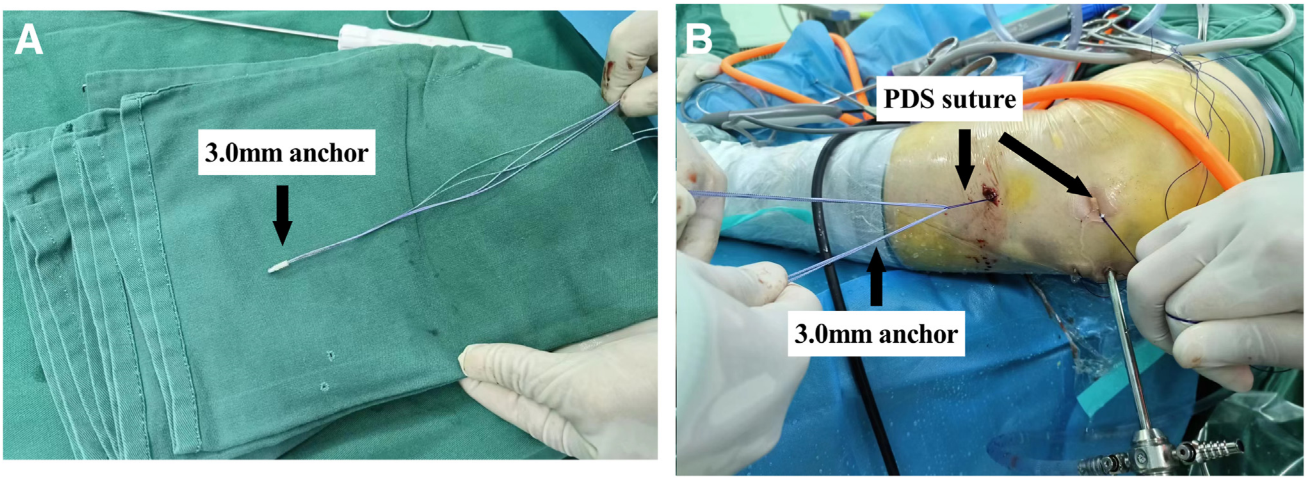


**Fig 7.** (A) A 3.0-mm anchor is used in this technique. (B) After removing the spinal needle, the tail sutures of the anchor pin are threaded through the loop formed at the distal end of the PDS suture. The proximal end of the PDS suture is then pulled to reverse-insert the anchor into the bone tunnel.

posterior root repair are more effective in preventing meniscal extrusion and reducing intrameniscal signal intensity compared to modified Mason-Allen sutures.[18,19] Nevertheless, certain studies argue in favor of the benefits of the modified Mason-Allen technique. It has been found that the modified Mason-Allen suture can prevent the progression of cartilage degeneration on the loading surface of the medial compartment.[20] Furthermore, a study has shown that, compared to simple stitches, the repaired root tends to heal better in the modified Mason-Allen stitch group, although the 2 different suture techniques did not exhibit differences

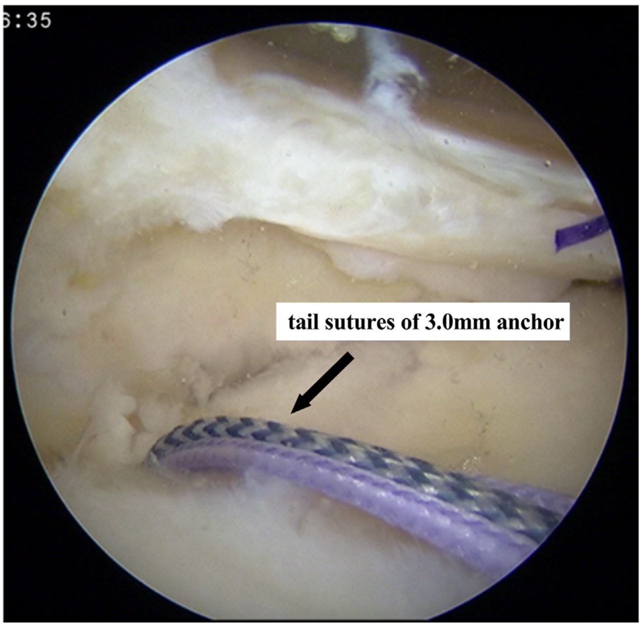


**Fig 8.** The patient is placed in a supine position and the knee flexed at 90° underwent arthroscopic surgery on the left knee. The affected limb was placed in a 4-point position with the knee flexed at 90°. The lateral portal was the observation portal. Insert the anchor through the PDS suture in a reverse direction into the bone tunnel and fix it at the junction of the broad and narrow bone tunnels.

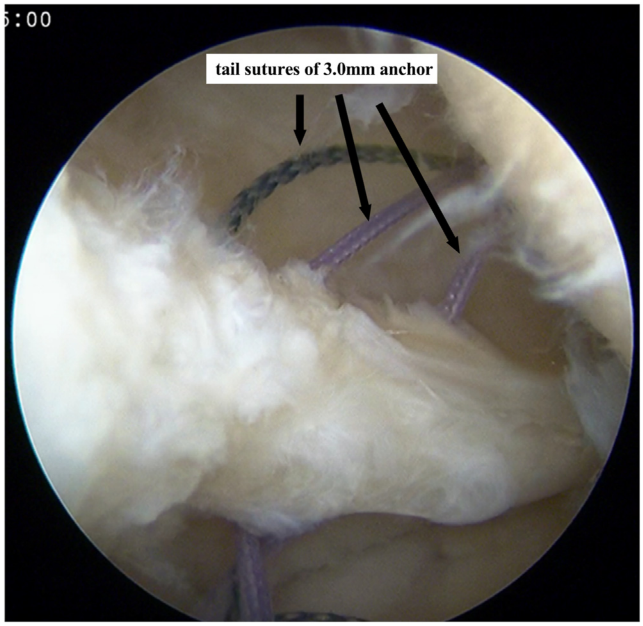


**Fig 9.** The patient is placed in a supine position and the knee flexed at 90° underwent arthroscopic surgery on the left knee. The affected limb was placed in a 4-point position with the knee flexed at 90°. The lateral portal was the observation portal. A modified Mason-Allen suture technique is applied to achieve better biomechanical performance. First, the suture hook is used to insert through the front part of the meniscus and passed through it, allowing the PDS thread to pull out an anchor wire. Then, near the midline, the suture hook is passed through the back part of the meniscus, pulling out another anchor wire. Near the midline again, the suture hook is used to insert through the front part of the meniscus and passed through it, allowing the PDS thread to pull out another anchor wire of the same color as the first stitch.


**Fig 10.** The patient is placed in a supine position and the knee flexed at 90° underwent arthroscopic surgery on the left knee. The affected limb was placed in a 4-point position with the knee flexed at 90°. The lateral portal was the observation portal. The repaired posterior root of the meniscus. The posterior root of the meniscus is repaired well and fixed at the attachment site.

in short-term clinical outcomes.[20] Moreover, a systematic review has suggested that the modified Mason-Allen suture configuration is superior to a simple suture configuration in transtibial pullout repair.[21] However, there have been limited studies investigating the use of the modified Mason-Allen suture in PLMRT. Therefore, we have employed the modified Mason-Allen suture to achieve the desired effect of preventing cutting and ensuring adequate biomechanical performance.

The management options for meniscus posterior root encompass nonoperative management, partial meniscectomy, transtibial pullout technique, anchor suture repair, and all-inside suture repair.[5,21-23] Currently, meniscus root repair leads to significantly less arthritis progression and subsequent knee arthroplasty compared with nonoperative management and partial meniscectomy.[24] However, the optimal method of repair remains a subject of debate. Transtibial pullout repair has been widely used, and this technique could achieve favorable outcomes.[25] Nevertheless, a study indicated that all-inside repair yielded improved functional outcome scores compared to transtibial pullout repair in the treatment of meniscus posterior root tears.[7] Moreover, biomechanical evaluation of transtibial pullout meniscal root repair highlighted the importance of recognizing the bungee effect, as there

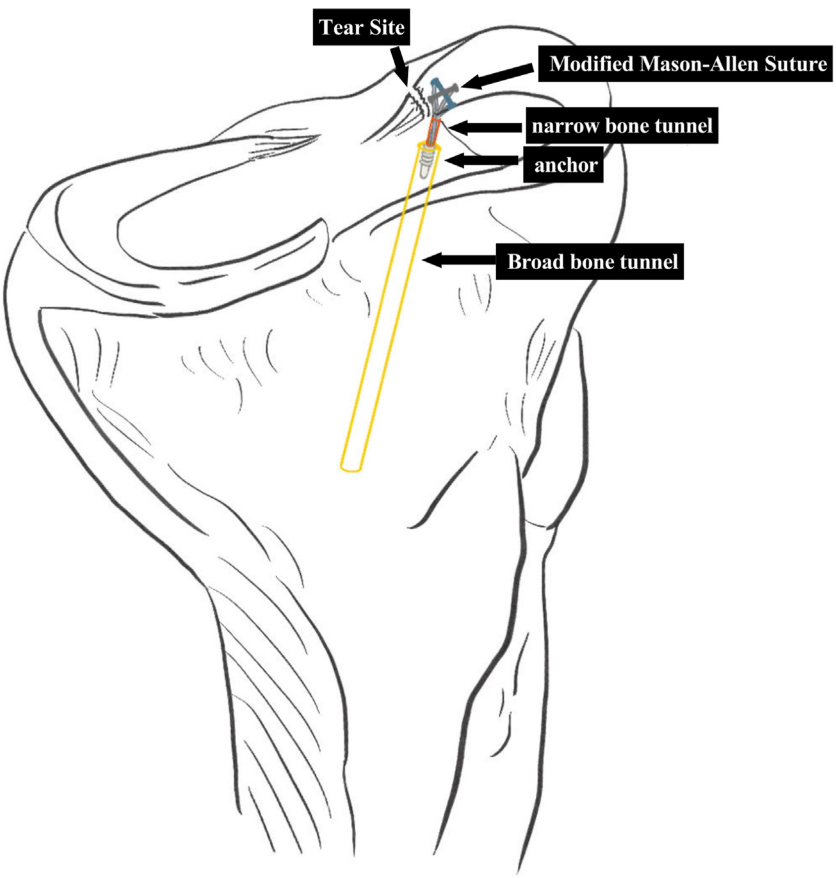


**Fig 11.** A diagram of technique. The yellow site represents the broad bone tunnel, and the red site represents the narrow bone tunnel.

**Table 3.** Advantages and Disadvantages

| Advantages | Disadvantages |
|---|---|
| The use of anchor insertion can avoid additional portals and is a simple and feasible technique.<br>It reduces the "bungee effect." | Reverse insertion of the anchor without screwing it into the bone. |

was substantial displacement of the posterior medial meniscal root repaired using the transtibial pullout technique under a cyclic loading protocol simulating postoperative rehabilitation.[26] Additionally, a biomechanical comparison between suture anchor and transtibial pullout repair for posterior medial meniscus root tears suggested that the suture anchor technique offers superior biomechanical properties compared to the transtibial pullout repair technique.[8] On the basis of these findings, we implemented the reverse suture anchor technique to mitigate the bungee effect and achieve more favorable biomechanical properties. Moreover, the creation of a tunnel during the procedure facilitates the provision of additional mesenchymal stem cells, thereby promoting meniscal healing.[27]

Meniscal root tears are commonly classified using the systems proposed by LaPrade et al.,[12] Forkel et al.,[28] and Ahn et al.[29] We mainly use the Christopher classification. Among these, we primarily employ the Christopher classification. Our technique is suitable for addressing type 2, type 3, and type 5 tears. For type 1 tears and radial tears (type 4) with a substantial amount of meniscal tissue remaining at the posterior root attachment, we recommend meniscal suture repair (Table 1). It is worth noting that our technique does not involve directly screwing the anchor into the bone, which necessitates further biomechanical analysis. The tunnels created in our technique are smaller compared to those in the transtibial pullout repair technique, potentially facilitating earlier bone healing and achieving superior biomechanical properties. The effectiveness of this method will be confirmed through future biomechanical tests and other relevant examinations. The advantages and disadvantages are shown in Table 3. In conclusion, this technique represents a straightforward and efficient approach to repair meniscal posterior root tears.

## Disclosure

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