Technical Note

An Arthroscopic Pull-Out Suture Technique to Repair Incomplete Radial Tears of the Lateral Meniscus Posterior Horn Adjacent to the Root Attachment Combined With Anterior Cruciate Ligament Reconstruction

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Abstract: Radial tears of the lateral meniscus posterior horn are one of the most common lateral meniscal injuries accompanied by acute anterior cruciate ligament disruption. Meniscus-preserving therapy is recommended in the case of a radial lateral meniscal tear to preserve its dynamic behavior. We introduce an arthroscopic pull-out technique for repairing incomplete radial tears of the lateral meniscus posterior horn combined with anterior cruciate ligament reconstruction. In this technique, a ring hoop is made through which the tear ends of lateral meniscus on both sides are tightened by adjusting tension of stitches, providing annular and downward tension for lateral meniscus, both of which are critical to the stability of the lateral meniscus. The resident part of lateral meniscus adjacent to the posterior root is not subject to much tension in this technique because of the pull-out fixation of lateral meniscus posterior horn, thus providing support for healing and restoring the hoop action of the lateral meniscus.

Posterior horn tears of the lateral meniscus commonly occur concurrently with acute anterior cruciate ligament (ACL) tears.[1] A radial tear of the lateral meniscus posterior horn (LMPH) is one of the most common lateral meniscal injuries accompanied by an acute ACL disruption,[2] usually leading to cartilage damage or osteoarthritis change.[3] It is well known that the lateral meniscus plays important roles in weight-bearing, load transmission, shock absorption, and lubrication of the articular surface. Moreover, the lateral meniscus is a secondary stabilizer of the knee under pivot–shift loading and has an influence on knee laxity according to biomechanical studies.[4,5] For the aforementioned reasons, there is an increasingly urgent demand for the LMPH repair.

However, repair of LMPH is challenging and requires extra caution.[6] First, there is a risk of iatrogenic lesions such as neurovascular damage during repair procedures for inside-out or outside-in repair techniques.[7-10] Second, repeated puncture is not allowed if there is not much left of the posterior horn adjacent to the posterior root of the lateral meniscus; otherwise, the meniscus will be fragmented. Here, we introduce an arthroscopic pull-out technique for repairing incomplete radial tears of the LMPH combined with ACL reconstruction, making good use of the remaining part of the posterior horn adjacent to the posterior root and avoiding repeated puncture, thus providing support for healing and restoring the hoop action of the lateral meniscus.

Surgical Technique (With Video Illustration)

The patient is placed in the supine position after spinal anesthesia. A tourniquet is applied with the pressure

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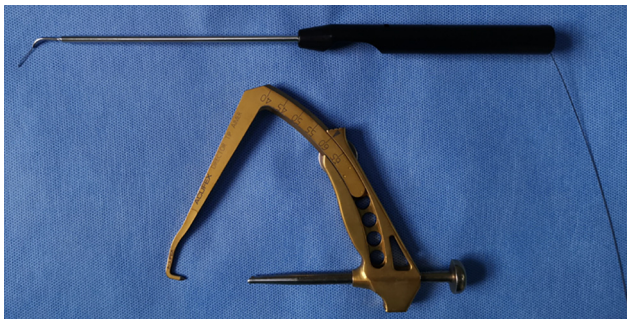

Fig 1. Surgical instruments used for the suture and fixation of LMPH. Arthrex suture lasso device (upper device) and ACUFEX ACL tibial drill guide (lower device). (ACL, anterior cruciate ligament; LMPH, lateral meniscus posterior horn.)

maintained at 260 mm Hg. An oblique skin incision on the upper edge of the pes anserinus is made to harvest the semitendinosus and gracilis tendons as an autograft of the ACL. Anterolateral, anteromedial, and medial portals are established for ACL reconstruction and LMPH repair. A SutureLasso device (Arthrex, Naples, FL) and ACUFEX ACL tibial drill guide (Smith & Nephew, Andover, MA) are 2 main instruments used in the suture and fixation of LMPH (Fig 1).

A routine arthroscopic examination is first conducted to determine the existence of ACL rupture and radial tears of LMPH (Fig 2). A shaver is used to refresh the broken ends of the LMPH. Then, we grab the outboard end of the lateral meniscus and pull it to the resident part adjacent to the posterior root to observe whether the normal meniscus morphology can be restored. Next, the LMPH is sutured using ORTHOCORD stitches (DePuy Mitek, Raynham, MA) by a lasso device (Fig 3). Briefly, the Arthrex suture lasso device is used to introduce the ORTHOCORD stitches through the meniscus from bottom to top and then from top to bottom; thus, a ring is created. The 2 ends of the ORTHOCORD stitches are guided to pass through the resident part of lateral meniscus adjacent to the posterior root from bottom to top and then cross the aforementioned ring (see Video 1).

After suturing LMPH, we perform single-bundle ACL reconstruction with remnant preservation as previously described[11] with LMPH fixation (Fig 4). Briefly, the central point of I.D.E.A.L femoral tunnel[12] is located with a 5.5-mm femoral guide (DePuy Mitek) using the apex of the deep cartilage[13] as the landmark at 120° of knee flexion through the anteromedial portal. The tibial tunnel is located at the anatomical central portion of the remnant ACL using an ACUFEX tip-to-tip drilling guide (Smith & Nephew) set at an angle of 55°. Both the tibial and femoral bone tunnels are drilled according to the graft diameter. After femoral and tibial tunnels of ACL reconstruction are made, we drill a tibial tunnel for LMPH fixation with the help of an ACUFEX tibial drill guide set at an angle of 60°. The intra-articular aperture of the tibial tunnel is placed at the tibial attachment of the posterior root of the lateral meniscus.[14] A 16-gauge trocar is used to introduce the double-stranded PDS line into the articular cavity and draw the ORTHOCORD stitches out from the tibial tunnel. After the graft is passed through the tibial tunnel to the femoral tunnel, an ENDOBUTTON (Smith & Nephew Endoscopy) suspensory system is flipped to establish femoral fixation. The tibial side of the graft is secured with a supplementary staple made of Kuntscher wire in the knee straight state. The tail end of the ORTHOCORD stitches are fixed at 90° of knee flexion using the same

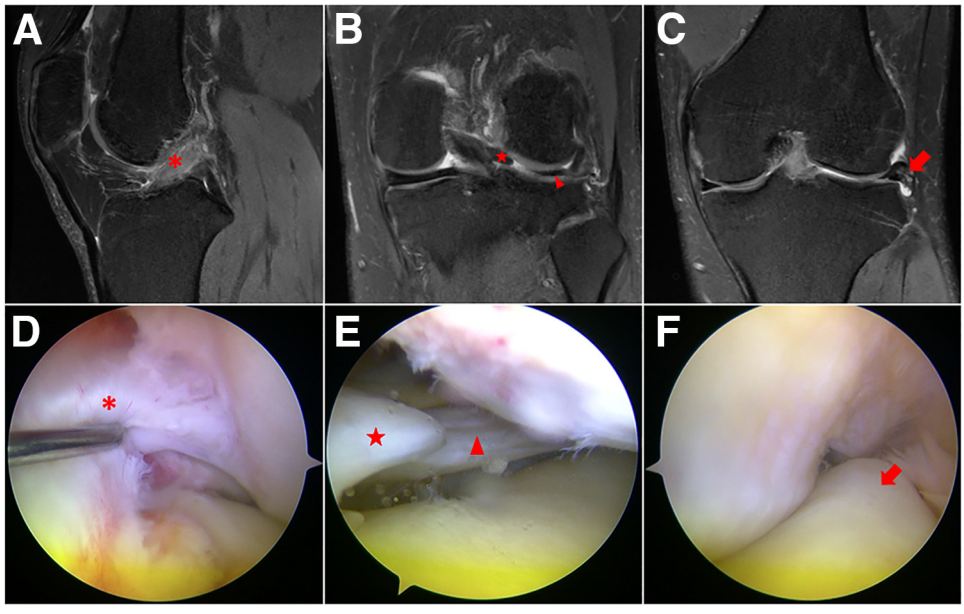

Fig 2. Magnetic resonance images and arthroscopic manifestation of ACL rupture and radial tear of LMPH. (A) and (D) show the remnant of the ACL (red asterisk) without normal tension, (B) and (E) present the radial tears of the LMPH (red five-pointed star indicates the broken end of LMPH adjacent to the posterior root, red triangle indicates the other end), and (C) and (F) are signs of lateral meniscus extrusion (red thick arrow). (ACL, anterior cruciate ligament; LMPH, lateral meniscus posterior horn.)

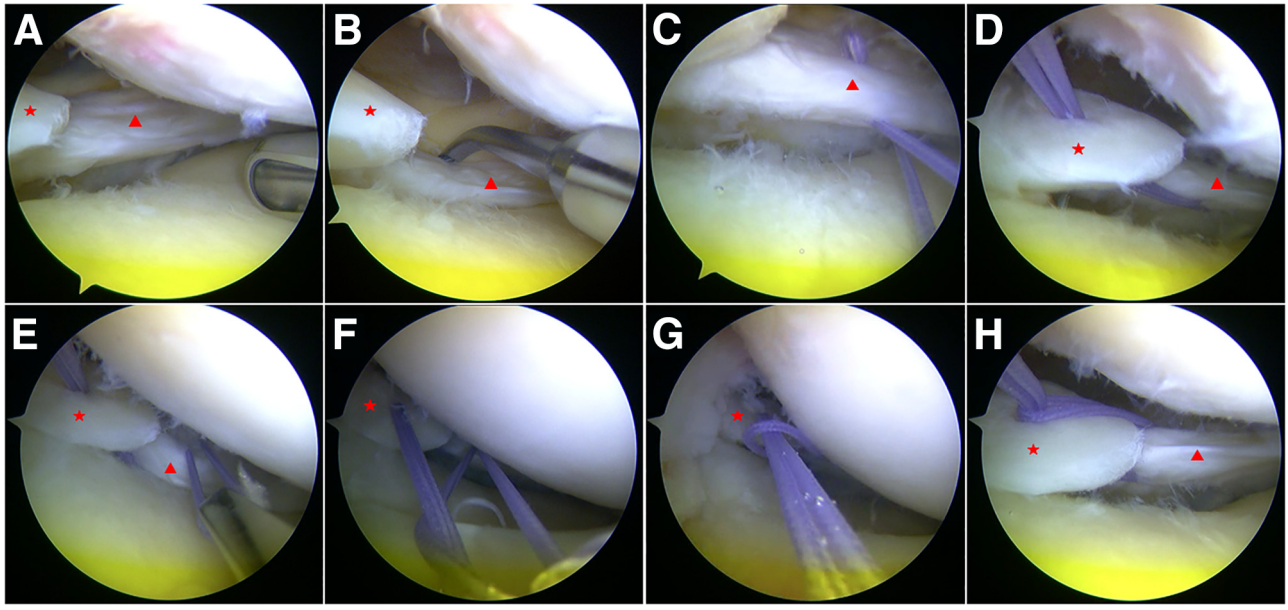

Fig 3. Suture process of LMPH. (A) Refresh the broken ends of LMPH using shaver. (B) Puncture the broken end of LMPH with the lasso device. (C) Introduce double-stranded ORTHOCORD stitches through the broken end of the LMPH by 2 points with the formation of a ring on the top of LMPH. (D) The tail ends of the ORTHOCORD stitches cross the broken end of LMPH adjacent to the posterior root from bottom to top. (E) Lengthen the ring created at the first suture. (F) The tail ends of the ORTHOCORD stitches cross the ring. (G) Tighten the ring gradually. (H) Two broken ends of LMPH are closely pasted together after tightening the ring. Red five-pointed star indicates the broken end of LMPH adjacent to the posterior root and red triangle indicates the other end. (ACL, anterior cruciate ligament; LMPH, lateral meniscus posterior horn.)

Kuntscher wire. Arthroscopic evaluation is then performed to ensure the absence of impingement between the graft and notch and whether the lateral meniscus extrusion is corrected (Video 1).

Rehabilitation Protocol

The knee is immobilized with a functional brace in a fully extended position after the operation with immediate weight-bearing within the first 2 weeks

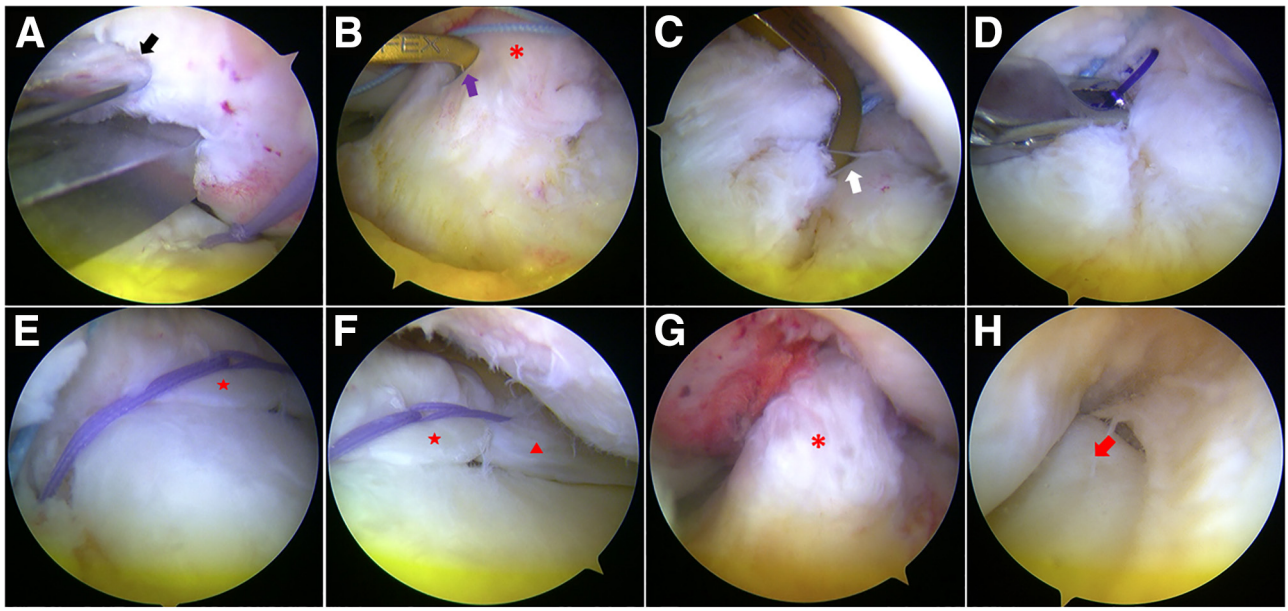

Fig 4. Single-bundle ACL reconstruction with remnant preservation with LMPH fixation. (A) The location of the central point of I.D.E.A.L. femoral tunnel (black thick arrow). (B) The location of the tibial tunnel (purple thick arrow). (C) The location of the tibial tunnel for LMPH fixation (white thick arrow). (D) The PDS line is introduced into the articular cavity through the tibial tunnel for LMPH fixation. (E) Draw the ORTHOCORD stitches out from the tibial tunnel, f-status of LMPH after tightening the ORTHOCORD stitches. (G) Performance after ACL reconstruction. (H) Lateral meniscus extrusion (red thick arrow) is corrected. Red * indicates the remnant of the ACL, red five-pointed star indicates the broken end of LMPH adjacent to the posterior root, red triangle indicates the other end. (ACL, anterior cruciate ligament; LMPH, lateral meniscus posterior horn.)

Table 1. Pearls and Pitfalls

Pearls	Pitfalls
The points of suture through the meniscus should be about 5 mm away from the tearing edge of lateral meniscus posterior horn	If the points of suture through the meniscus is less than 5 mm away from the tearing edge of lateral meniscus posterior horn, the meniscus tissue may be torn by sutures
The intra-articular aperture of the tibial tunnel is placed at the tibial attachment of the posterior root of the lateral meniscus with the help of an ACUFEX tibial drill guide set at an angle of 60°	If the angle of ACUFEX tibial drill guide is less than 55°, the tibial tunnels for the fixation of lateral meniscus posterior horn and anterior cruciate ligament may be converged

postoperatively. Then, range-of-motion exercises are performed gradually with the goals of achieving 90° knee flexion within the next 2 weeks and 120° knee flexion within 6 weeks postoperatively. Straight-leg raises and isometric quadriceps contractions are performed immediately after surgery. The patient undergoes home-based rehabilitation after discharge with the goals of recovering exercises of daily living level within 3 months, participating gradually in sports activities 6 months and returning to sports 10 months after operation. The pearls and pitfalls of this technique are shown in Table 1.

Discussion

The hoop effect is crucial to maintain the normal physiological function of the meniscus, whereas radial tears of LMPH usually destroy the hoop effect and cause the lateral meniscus to be in a state of dysfunction.[3] Radial tears adjacent to the root attachment of the lateral meniscus significantly increase contact stress in the lateral compartment compared with corresponding areas with intact lateral meniscus,[15] which was supposed to lead to pathologic meniscal extrusion and degenerative knee arthritis.[16,17] More importantly, clinical evidence supports the superior healing ability of radial tears in the posterior segment of the lateral meniscus compared with other radial tears.[18,19] Therefore, meniscus-preserving therapy is recommended in the case of a radial lateral meniscal tear to preserve its dynamic behavior, and the clinical results are satisfactory.[17,20]

We adopt the pull-out suture technique to repair radial tears of LMPH, as this method significantly improves lateral compartment joint contact pressures.[16] The difficulty of repair of radial tears of LMPH depends on the size of the remaining tissue adjacent to the root attachment. Repeated puncture is not allowed if there is not much left of the posterior horn adjacent to the posterior root of the lateral meniscus; otherwise, the meniscus is fragmented (Table 2). In the future, more sophisticated meniscus puncture instruments should be developed to reduce the damage to meniscus tissue.

As shown in the Figure 4F, after tightening the tail end of the suture, the 2 broken ends of the lateral meniscus are in close contact under the action of tension, which is conducive to the recovery of the hoop effect. In this technique, we fix the tail end of the ORTHOCORD stitches at 90° of knee flexion and the lateral meniscus extrusion is corrected under arthroscopic observation. There is no consensus on which knee joint position is optimal for the fixation of ORTHOCORD stitches, and biomechanical studies are needed in the future to determine the appropriate knee flexion angle for fixation (Table 2).

Postoperative rehabilitation needs to comprehensively consider repair of radial tears of LMPH and ACL reconstruction. For this technique, accelerated rehabilitation is implemented including weight-bearing, straight-leg raises, and isometric quadriceps contractions immediately after the operation. Two weeks after the operation, range-of-motion exercises are performed gradually, as we assume that there is no significant adverse effect on meniscal healing at this time.[21]

Table 2. Advantages and Limitations of the Technique

Advantages	Limitations
This technique manufactures a ring hoop through which the tear ends of lateral meniscus on both sides are tightened by adjusting tension of ORTHOCORD stitches thus providing support for healing and restoring the hoop action of the lateral meniscus	Although the suture lasso device is widely used in clinical practice, unskilled use of this device may result in failure of meniscus repair
In this technique, the ring hoop of stitches provides annular tension and the pull-out technique provides downward tension for lateral meniscus, both of which are critical to the stability of the lateral meniscus	Repeated puncture of lateral meniscus is not allowed in this technique because the resident part of lateral meniscus adjacent to the posterior root is small, otherwise, the meniscus tissue will be fragmented
The resident part of lateral meniscus adjacent to the posterior root is not subject to much tension in this technique because of the pull-out fixation of lateral meniscus posterior horn	It is still uncertain which angle fixation of lateral meniscus posterior horn works best for alleviating lateral meniscus extrusion and further clinical follow-up studies are needed

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