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TECHNICAL NOTE • KNEE - ARTHROSCOPY

A novel suture technique to reduce the meniscus extrusion in the pullout repair for medial meniscus posterior root tears

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Abstract
The medial meniscus (MM) posterior root has important functions in preventing an excessive loading stress during knee motion and degeneration of the articular cartilage. Although the transtibial pullout repair has become the gold standard for MM posterior root tears (MMPRTs), MM extrusion remains. In addition, during knee extension to deep flexion, the MM posterior segment in the MMPRT knee has been shown to translate toward the posteromedial direction, causing a notable MM posterior extrusion. Thus, the reduction in the MM posteromedial extrusion is one of the important postoperative outcomes to restore the meniscal function and eventually prevent the progression of knee osteoarthritis. The present technical note describes an arthroscopic technique addition to the pullout repair, in which an all-inside suture is inserted into the posteromedial part of the MM to reduce the MM posteromedial extrusion.

Keywords Medial meniscus posterior root tear · Arthroscopy · Transtibial pullout repair · Meniscal extrusion · 3D MRI

Introduction

Medial meniscus posterior root tear (MMPRT) is defined as a radial tear at the posterior attachment zone of the medial meniscus (MM) [1]. MMPRT results in a notable MM extrusion (MME) when compressive loads are applied to the knee, representing the functional failure of load transmission into hoop strain [2, 3]. Costa et al. [4] detected MMPRTs in 42% of patients with a major medial extrusion > 3 mm on magnetic resonance imaging (MRI). An open MRI analysis also found that MMPRT caused pathological posterior extrusion of the MM posterior segment at 90° of knee flexion [5].

Several techniques have been recently developed for MMPRT repair [6–8]. We previously reported on MMPRT repair techniques that allow easy access to the tear site and strong grasping, especially in cases with a tight medial compartment [8, 9]. A meta-analysis reported that MMPRT repair results in significant postoperative improvements in clinical scores compared to preoperative values, even though the MME was not completely reduced [10]. Chung et al. [11] also stated that patients with decreased MME after MMPRT repair have more favorable clinical outcomes at the midterm follow-up. Therefore, the reduction of MME is an important indicator in restoring the anatomy and function of the meniscus.

The present technical note describes an arthroscopic technique to reduce medial and posterior extrusions of the MM as an additional method in the pullout repair for MMPRTs [12].

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Surgical technique

The pullout repair for MMPRTs is indicated for patients with a femorotibial angle < 180°, mild cartilage lesion (Outerbridge grade I or II), and Kellgren–Lawrence grade 0–II, confirmed with preoperative radiographs and MRI. The patient is placed in the supine position with a tourniquet. Standard anterolateral and anteromedial portals are created for arthroscopic visualization of the MM posterior root and its anatomical attachment using a 30° arthroscope. In cases with a tight medial compartment, we use the outside-in pie-crusting technique by using a standard 18-gauge (1.2 × 40 mm) hypodermic needle (TERUMO, Tokyo, Japan) [13]. The needle is inserted percutaneously through the medial collateral ligament while maintaining the knee valgus-extension position. After confirming that the medial compartment is opened, synovial tissues around the torn meniscus are gently debrided using a shaver to create a working space for the next procedure (Fig. 1a).

Suturing by two simple stitches (TSS) is performed by using a Knee Scorpion suture passer (Arthrex, Naples, FL, USA) to pass a No. 2 Ultrabraid and/or Ultratape (Smith & Nephew, Andover, MA, USA) vertically through the meniscal tissue (Fig. 1b). The first suture is inserted into the outer area of the MM posterior horn, and the second suture is inserted into the inner portion of the MM posterior horn (Fig. 1c). These sutures are retrieved through the anterolateral portal while maintaining moderate tension.

The next major procedure is started by switching the working portal from the anteromedial to the anterolateral portal. An all-inside suture device, such as the FasT-Fix repair system (Smith & Nephew), is inserted through the anterolateral portal using a metal slotted cannula. The purpose of this step is to facilitate the approach to the large MME point that lies in the posteromedial area of the MM [14]. The first needle of the device is inserted into the inferior surface of the MM posterior segment, toward the posteromedial direction (Fig. 1d). The second needle is inserted directly into the articular capsule via the area below the meniscus (Fig. 1e). The sliding knot of the inserted device is adequately fastened after delivery needle removal. Thus, the uncut free-end of the suture can be pulled while holding the MM and medial capsule to reduce the MM posteromedial extrusion (Fig. 1f).

After MM posterior root attachment is confirmed, a custom-made posterior root-aiming device (MMPRT guide, Smith & Nephew) [15] is placed at the center of the attachment area (Fig. 2a). A 2.4-mm guide pin is inserted, using the aiming device at a 45° angle to the articular surface, and a 4.0- or 4.5-mm cannulated drill is used to overdrill. After removal of only the inner guide pin, three sutures are pulled out through the cannulated drill using a suture

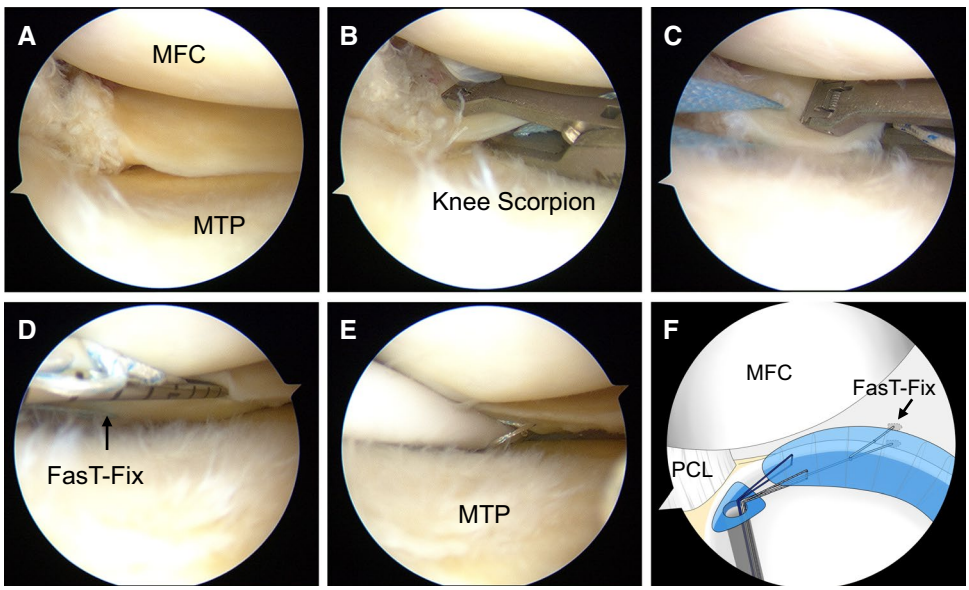

Fig. 1 Arthroscopic findings of the right MM in a 60-year-old male patient and schematic diagram. **a** A radial tear of the MM posterior root with fibrous tissues. MFC, medial femoral condyle; MTP, medial tibial plateau. **b** Grasping the MM posterior horn using a Knee Scorpion suture passer. **c** The first suture (Ultratape) is passed through the outer area of the MM posterior horn, and the second suture (No. 2 Ultrabraid) is inserted into the inner area, more than 10 mm from the torn area. **d** The anterolateral portal is the working portal and the anteromedial portal is the viewing portal. The first needle of the FasT-Fix is aimed at the inferior surface of the MM, toward the posteromedial direction. **e** The second needle is inserted into the medial capsule directly. **f** A modified two simple stitches suture configuration. PCL, posterior cruciate ligament

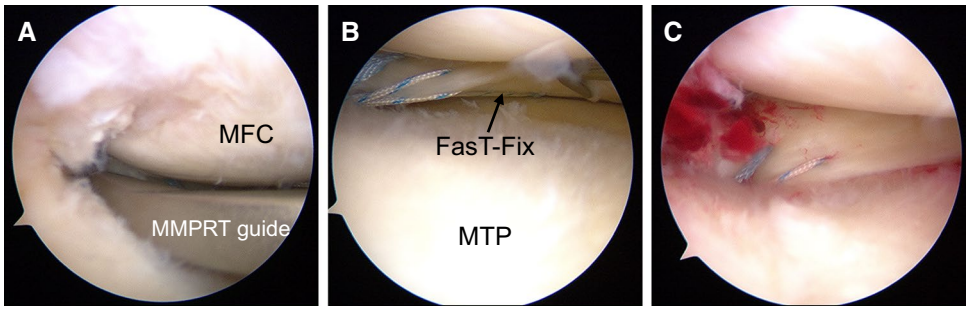

Fig. 2 Arthroscopic findings of the pullout repair for MMPRTs. **a** The tip of the MMPRT guide (Smith & Nephew) is placed at the anatomical insertion of the MM posterior root from the anteromedial portal. A tibial tunnel is created by a 4.0-mm-diameter cannulated drill with a guide pin. MFC, medial femoral condyle. **b** The FasT-Fix suture lying under the MM posterior segment is observed using a probe. MTP, medial tibial plateau. **c** After all sutures are adequately fixed with the expected initial tension, the FasT-Fix suture is hidden below the meniscus

retriever. Gentle tension is applied to these sutures under arthroscopy (Fig. 2b, c). After the expected tension (30 N) is applied by a spring tensioner at 20° of knee flexion, tibial fixation is performed using a bioabsorbable screw, as previously described [12].

Postoperative rehabilitation

Initially, no weight bearing is permitted; a knee immobilizer is used for 2 weeks after surgery. After 2 weeks, partial weight bearing is permitted with a progression to full weight bearing at 5 weeks. Knee flexion exercise is limited to 90° for 8 weeks. Deep knee flexion is permitted 3 months postoperatively. Athletic activities are allowed after 6 months.

MRI assessments in a representative case

The postoperative reduction in the entire MME was assessed using three-dimensional (3D) MRI at 10° and 90° of knee flexion. 3D MRI examinations were performed preoperatively and 3 months postoperatively. Figure 3 shows the 3D-reconstructed meniscus of the same patient as that in Figs. 1 and 2. We evaluated the 3D MRI-based MM medial extrusion (MMME), MM posterior extrusion (MMPE), and MM extrusion volume (MMEV) as described [14]. At 10° of knee flexion, the MMME and MMEV decreased postoperatively from 4.5 to 3.9 mm and from 1138 to 853 mm^3, respectively. At 90° of knee

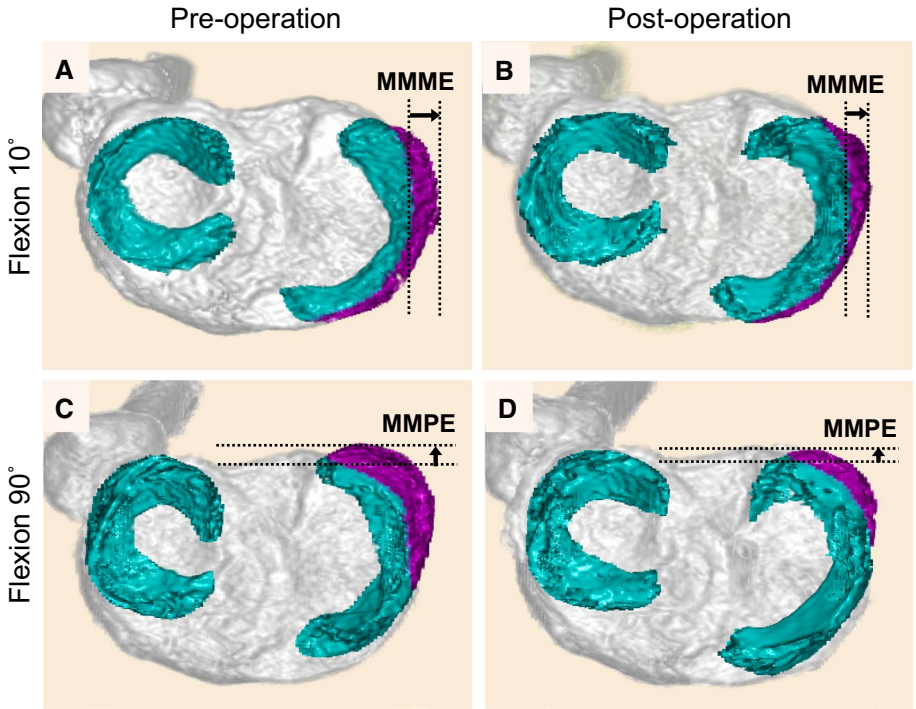

Fig. 3 3D-reconstructed MM at 10° and 90° of knee flexion. **a** At 10°, the MME area beyond tibial edge (purple area) is located along the medial side widely, with a large MMME. Dotted lines show the medial edge of the tibial plateau and outer edge of the MM. **b** Postoperatively, the MME area is slightly reduced. **c** At 90°, the MM posterior root is separated from the posterior attachment. The MME area spreads to the posteromedial direction with MMPE. Dotted lines show the posterior edges of the tibial and the MM. **d** Postoperatively, the MM posterior root is stabilized and the MME area is reduced, with a decrease in the MMPE and its volume

flexion, the MMPE and MMEV decreased greatly from 4.6 to 2.2 mm and from 1290 to 537 mm^3, respectively. Of note, the posteromedial extrusion of the MM was reduced after the pullout repair (Fig. 3c, d).

Discussion

The pullout repair for MMPRTs using a tibial tunnel has been widely accepted. We previously reported on repair methods involving the modified Mason–Allen suture technique and the TSS technique [9, 12], which result in favorable clinical outcomes [16]. A biomechanical study showed that the TSS technique reduces the medial joint contact pressure due to an increased tibiofemoral contact area [17]. However, a clinical study demonstrated that the TSS technique could not fully reduce the MME on postoperative MRI, even though it improved clinical outcomes [18]. Thus, we described a modified TSS technique for reducing the meniscus extrusion in MMPRTs. This novel technique can be easily accomplished with an additional simple suture.

MMPRTs lead to a failure of normal meniscal function in converting the axial load into hoop stress. The MM is then displaced externally and squeezed toward the unloaded outer joint, causing degeneration [14, 19]. As the extruded part of the MM has already lost its flexibility, the sutures at the MM attachment alone cannot move the MM to a reduced position. Koga et al. [20] described a centralization technique concurrent with the pullout repair, in which the midbody of the MM is centralized onto the tibial plateau using a suture anchor. They also reported that the MME was reduced by the centralization to restore the load-absorbing function of the MM, even though the procedure was technically demanding to some extent and might restrict the normal motion of the MM during knee flexion.

Previous MRI studies have shown that during knee extension to deep flexion, the MM posterior segment in the MMPRT knee is translated toward the posteromedial direction, with an increase in the MMPE and its thickness [5, 14]. Thus, we believe that it is important to prevent the posteromedial extrusion and reduce the extrusion volume during knee extension–flexion. The present technique facilitates the direct reduction of the MM posteromedial extrusion by inserting an all-inside device into the posteromedial part of the MM. Indeed, the postoperative MMPE and MMEV at 90° of knee flexion were decreased without a rigid restriction in MM motion, due to the combined effect of TSS and an additional suture that pulled the MM posterior segment and medial capsule together. However, this is a preliminary report, and further follow-up is necessary to determine the clinical benefit of this technique. Nevertheless, the present additional technique can be easily performed by many operators, simply by determining an insertion point and a pulling tension of the suture. Thus, this technique might be a good candidate for the arthroscopic repair of MMPRTs.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflicts of interest.

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