Technical Note

Meniscus Reconstruction Using Autologous Tendon Combined With Open-Wedge High Tibial Osteotomy: A Technique to Achieve Rigid Fixation and Avoid Interference Between Locking Screws and Tibial Bone Tunnel

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Abstract: Meniscal posterior root tears reportedly result in accelerated cartilage degeneration and spontaneous insufficiency fractures of the knee. While meniscus repair combined with open-wedge high tibial osteotomy is an optional method, the healing rate is not sufficiently high. Therefore, this Technical Note describes a technique for meniscal reconstruction combined with open-wedge high tibial osteotomy that may offer improvements in meniscal healing rates and clinical results.

The medial meniscus posterior root plays important roles in anchoring the medial meniscus to its tibial attachment site and distributing pressure through a hoop stress mechanism.[1] Various forms of meniscal posterior root tears (MMPRTs) have been reported, and those left untreated can result in accelerated cartilage degeneration,[2] which can cause spontaneous insufficiency fracture of the knee (previously termed knee osteonecrosis).[3,4]

In recent years, various treatment strategies for MMRPTs have been reported.[5-8] Generally, there are 2 methods: repairing the meniscus alone[9] and repairing the meniscus in combination with osteotomy.[10] Repairing the meniscus alone can suppress the progression of knee osteoarthritis (OA) in the short term; however, it cannot inhibit the progression of knee OA in the medium term.[5] A systematic review and meta-analysis showed that concurrent MMPRT repair during open-wedge high tibial osteotomy (OWHTO) for medial OA had little benefit on the clinical, radiologic, and arthroscopic outcomes in the short term.[6]

The healing rates of MMPRTs differ when MMPRT pull-out repair is used in combination with OWHTO; in approximately 50% of cases, the bone tunnel is created in a posterior anatomic position.[11]

Alternatively, the use of meniscal reconstruction using autologous tendons instead of pull-out repair for MMPRT has shown superior clinical outcomes and a higher meniscal root healing rate.[12,13] Therefore, this Technical Note describes a technique for meniscal reconstruction combined with OWHTO that allows rigid fixation, avoiding interference between locking screws and the tibial bone tunnel.

Surgical Technique

The surgical technique is demonstrated in Video 1.

Preoperative Assessment

Preoperative evaluation of lower limb alignment is necessary to determine whether meniscal reconstruction

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should be performed alone or in combination with osteotomy. If the preoperative weightbearing line is <50%, osteotomy is performed. The target weightbearing line is 55% to 62%, depending on the degree of medial cartilage damage; in cases of severe medial cartilage damage, the target weightbearing line is 62% (Fig 1).

Step 1: Patient Positioning, Incisions, and Approaches

The patient is placed in the supine position. After applying an air tourniquet to the proximal thigh, the affected limb is placed on the lateral side of the thigh with support. To perform the arthroscopy, the affected limb is flexed with a pillow under the thigh to gain space for the medial operative field (Fig 2).

A 4- to 5-cm incision is made obliquely at the medial portion of the anterior ridge of the tibia, and the gracilis tendon is harvested using a tendon stripper. The medial collateral ligament is completely released.

Step 2: Preparation of the Harvested Tendon and Arthroscopic Procedure

After removing the air tourniquet, knee arthroscopy is performed through the conventional anteromedial and anterolateral portals to diagnose the associated injuries (Fig 3).

The harvested tendon is trimmed to a width of approximately 3 mm to allow easy penetration into the meniscus. Krackow sutures are performed at both ends using No. 2 Ethibond (Smith & Nephew) (Fig 4A).

Using a special drill guide (Arthrex) at the attachment point of the posterior root medial meniscus, a 2.0-mm guide pin is drilled from the medial tibia under arthroscopic visual control (Fig 4b). The insertion point of the guide pin was within 40 mm of the articular surface; thus, the tibial tunnel is located at the proximal bone fragment after the osteotomy. An overdrill 6 mm in diameter is drilled through the guide pin to create a bone tunnel (Fig 4C). Next, a 2-0 FiberWire (Arthrex) is passed using a Knee Scorpio (Arthrex) 1 cm proximal to the rupture site of the posterior root medial meniscus (Fig 4D). Using the suture relay method, Ethibond No. 2 is shuttled to a 2-0 FiberWire to enlarge the hole in the posterior root medial meniscus (Fig 4E). While pulling the meniscus with Ethibond No. 2 and applying tension simultaneously, a bone pick is used to enlarge the hole (Fig 4F). Next, nylon No. 2 is passed through the bone tunnel using a suture passer (Smith & Nephew) (Fig 4G). The autologous tendon is passed

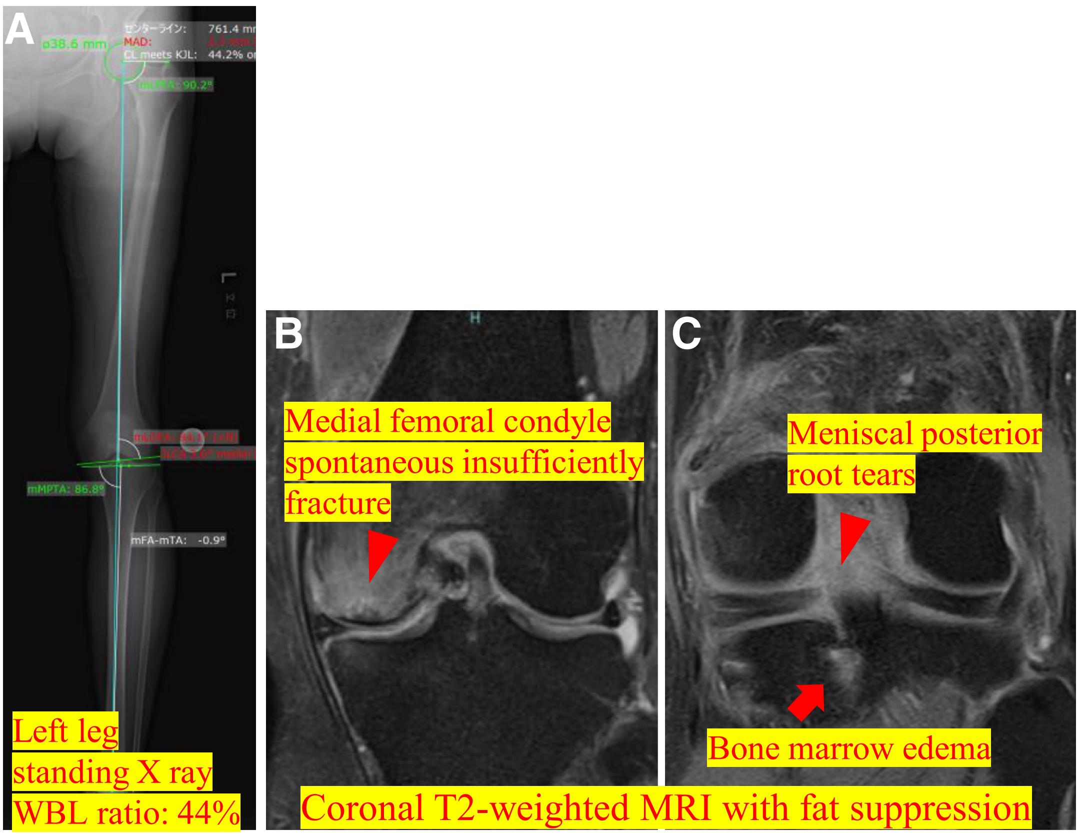

Fig 1. Preoperative left lower leg alignment in a standing anteroposterior x-ray (A) and coronal T2-weighted magnetic resonance imaging (MRI) of the left knee with fat suppression (B, C). (A) The weightbearing line (WBL) is 44%. (B) There is a spontaneous insufficiency fracture and bone marrow edema in the medial femoral condyle (arrowhead). (C) Meniscal posterior root tears (arrowhead) and bone marrow edema immediately below the attachment of the medial meniscal posterior root (arrow).

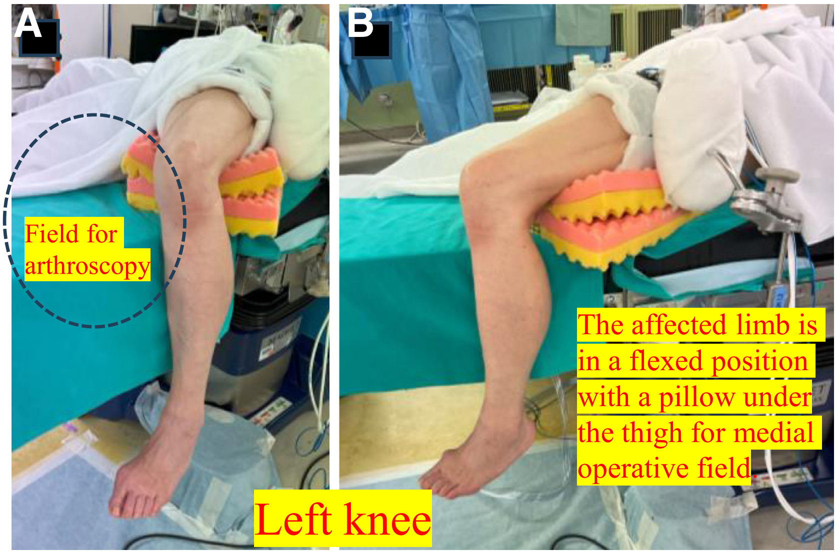

Fig 2. (A, B) Left knee. The patient is placed in a supine position and the affected limb is in flexed position with a pillow under the thigh for the medial operative field.

through the meniscus using the suture relay method (Fig 4H). Finally, the autologous tendon is shuttled into the tibial tunnel (Fig 4I).

With the knee joint positioned in slight flexion, the autologous tendon is pulled with a force of 20 N using a tensioner. An absorbable interference screw (Biosure; Smith & Nephew; diameter, 6 mm; length, 20 mm) (Fig 5B) is inserted under fluoroscopy just below the articular surface to fix the autologous tendon (Fig 5C).

Step 3: Osteotomy and Plate Fixation

The osteotomy line begins 40 mm distal to the medial tibial plateau and extends to the fibular head, which is the hinge point. This line is marked with 2 Kirschner wires with threaded tips (Mizuho Corporation) under fluoroscopy. To avoid interference between the interference and proximal screws using plate fixation, the distance from the articular surface is set at 40 mm instead of 35 mm.

Transverse and ascending osteotomies are performed using a reciprocating saw and chisels, leaving the lateral cortex intact as a hinge. The osteotomy site is then gradually opened and the medial opening gap is filled with 2 β-tricalcium phosphate spacers (Osferion60; Olympus Terumo Biomaterials). The β-tricalcium phosphate wedges are covered with the fascia of the pes anserinus.

The plate is then placed approximately 20 mm distal to the joint surface under fluoroscopy to avoid collisions between the inserted interference and locking screws. After chewing, there is no collision between the proximal screw hole Kirschner wire and the interference screw (Fig 5D). To avoid damaging the interference screw, only the front bone cortex is drilled, and the

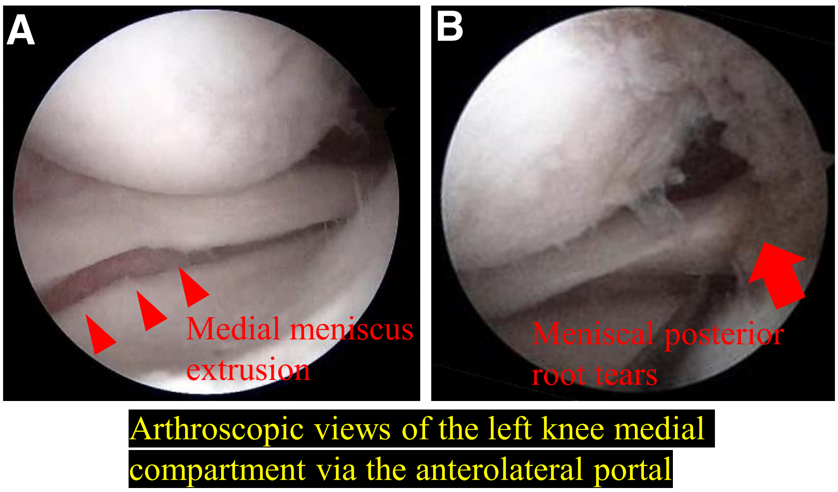

Fig 3. Arthroscopic views of the left knee via the anterolateral portal showing the medial meniscus extrusion (arrowhead, A) and meniscal posterior root tears (arrow, B).

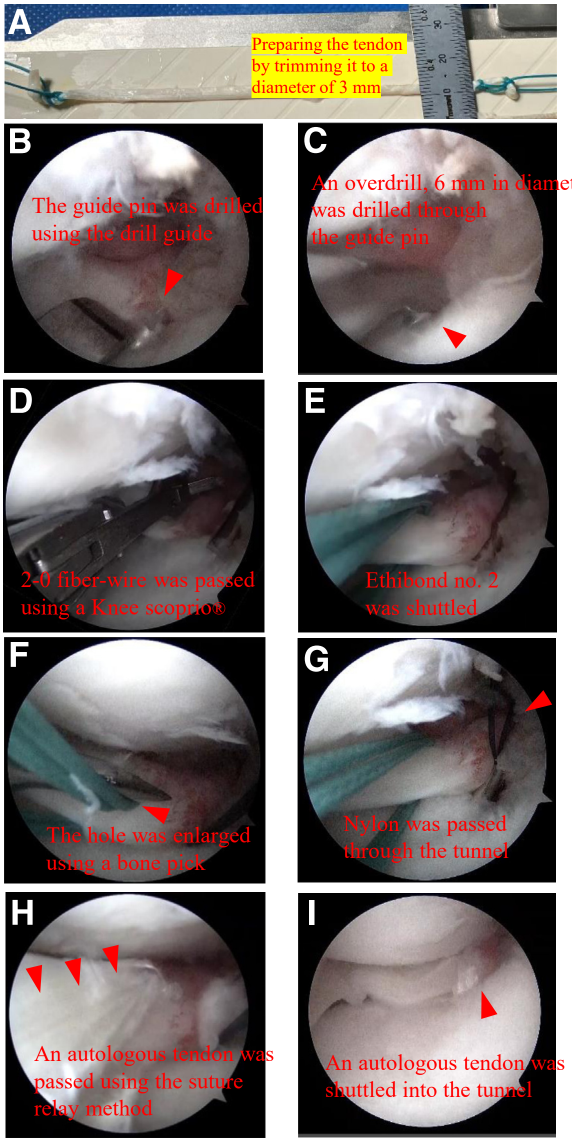

Fig 4. (A) Preparation of autologous tendon to a diameter of 3 mm. (B) Arthroscopic view in the left knee via the anterolateral portal showing a 2.0-mm guide pin (arrowhead), which was drilled from the medial tibia. (C) A cannulated drill (6.0 mm) (arrowhead) was inserted along with the guide pin. (D) A 2-0 FiberWire was passed through the anteromedial portal using a Knee Scorpio. (E) Ethibond No. 2 was shuttled to the 2-0 FiberWire to enlarge the hole in the posterior root medial meniscus. (F) The meniscus hole was enlarged using a bone pick, and pulling of the meniscus was performed with the Ethibond No. 2. (G) Nylon No. 2 was used for the final suture relay through the bone tunnel using a suture passer. (H) The autologous tendon was passed through the medial meniscus posterior root. (I) The autologous tendon was shuttled into the tibia tunnel.

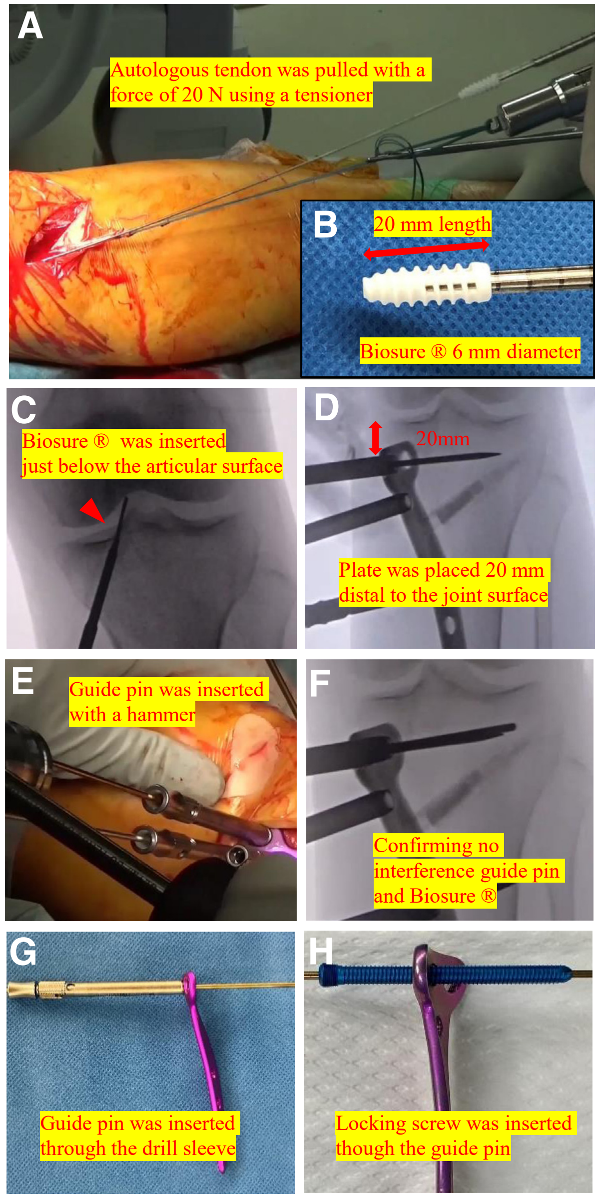

Fig 5. (A) Left knee. No. 2 Ethibond, which is attached to the autologous tendon, is pulled with a force of 20 N using a tensioner with the knee joint in a slightly flexed position. (B) The screw diameter was 6 mm and the long absorbable interference screw was 20 mm. (C) The autologous tendon was fixed just below the articular surface under fluoroscopy. (D) The locking plate was placed in the position of most proximal screws, which is 20 mm distal to the articular surface. The Kirschner wire was inserted and interference with the interference screw was checked. (E) To avoid damaging the interference screw, only the front bone cortex was drilled, and the guide pin was inserted with a hammer. (F) Fluoroscopy was used to confirm that the inserted guide pin did not collide with the interference screw. (G) Photograph of guide pin that was inserted through drill sleeve. (H) A cannulated locking screw was inserted through the guide pin.

guide pin is inserted with a hammer. After confirming that there is no interference, cannulated screws are inserted (Fig 5 E and F). The osteotomy site is fixed using a locking plate (Tris Medial HTO Plate System; Olympus Terumo Biomaterials) (Fig 6). Finally, we evaluate the reconstructed meniscus, which was

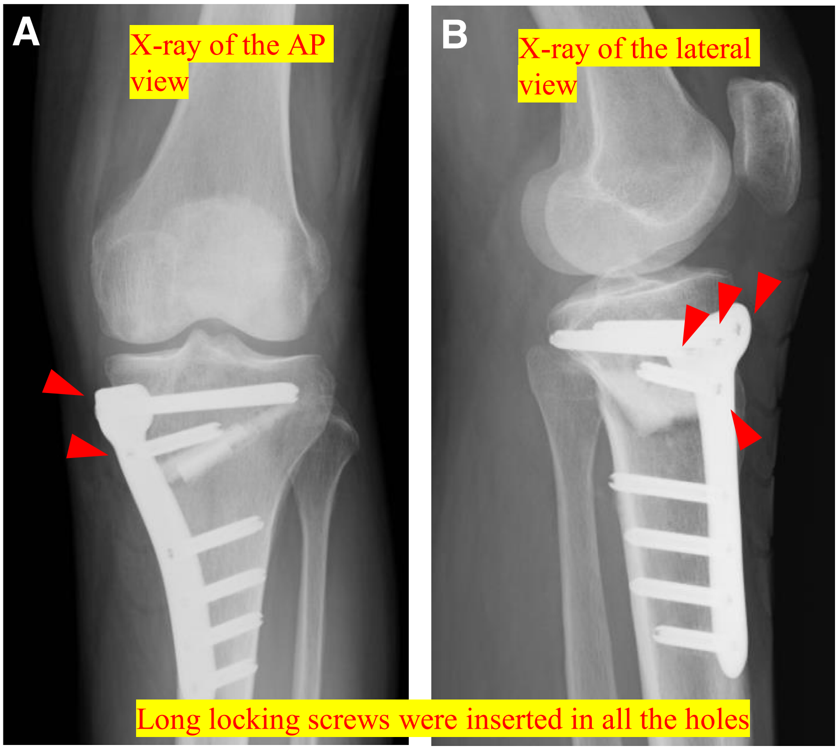

Fig 6. Postoperative x-ray of (A) anteroposterior view and (B) lateral view.

repaired using arthroscopy (Fig 7). The incisions are closed in a standard fashion.

Postoperative Rehabilitation

The knee is immobilized using a knee brace for 2 weeks postsurgically, and a range of exercises is given. Partial weightbearing with crutches is initiated at 1 week; full weightbearing is initiated after 4 weeks. Deep flexion motion with weightbearing is prohibited for 6 months.

Discussion

This Technical Note presents meniscal reconstruction and OWHTO for a case of spontaneous insufficiency fracture of the knee due to MMPRT.

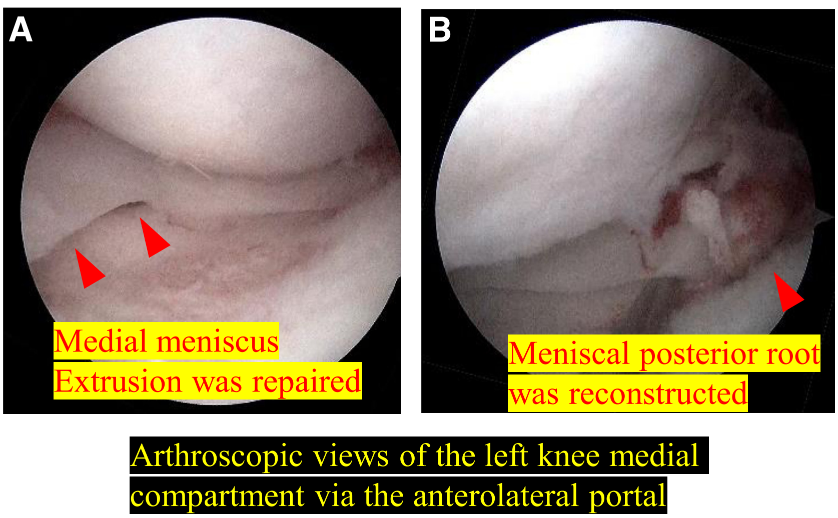

Fig 7. Arthroscopic views of the left knee via the anterolateral portal showing that the (A) medial meniscus extrusion was repaired and (B) meniscal posterior root was reconstructed after surgery.

Table 1. Advantages and Disadvantages of This Technique

Advantages
- Cartilage damage caused by MMPRTs can be treated
- Meniscus healing can be expected by using an autologous tendon
- Rigid fixation is possible without interfering with the bone tunnel

Disadvantages
- Not applicable in cases without varus deformity
- No consensus on simultaneous OWHTO and MMPRT repair
- More invasive compared with OWHTO alone
- Requires a larger diameter bone tunnel than that needed when using artificial ligament
- Pes anserinus requires resection for obtaining autologous tendon

OWHTO, open-wedge high tibial osteotomy; MMPRT, meniscal posterior root tear.

Cartilage damage rapidly progresses with MMPRTs[14]; thus, it is better to combine with OWHTO, which distributes the load stress on the medial compartment to the lateral compartment.[15] If surgery is performed immediately after MMPRT injury, repair of the meniscus alone may be reasonable. However, we occasionally encounter cases in which cartilage damage has already occurred because the acute stage has progressed to the subacute stage.

Methods using autologous tendons are more likely to improve the meniscal union rate and hoop function reconstruction than pull-out repair using artificial ligaments or sutures in the treatment of MMPRTs. For example, Li et al.[12] reported that the gracilis autograft reconstruction technique showed a superior meniscal root healing rate (82.7%) compared with the transtibial pull-out technique (51.4%),with similar findings for MMPRTs. Feucht et al.[16] reported that pull-out repair showed superior biomechanical properties compared with suture anchor repair under cyclic loading conditions and load-to-failure testing; however, pull-out repair was significantly weaker than the native posterior medial meniscus root in a cadaver study. Therefore, further improvements are required for MMPRT repair. Using the gracilis tendon, 3 mm in diameter in our case, which is thicker than an artificial ligament or sutures, may improve the fixation force.

Another advantage of combination with OWHTO is that the gracilis tendon can be harvested from the same incision site as that used for the procedure; therefore, there is nearly no increase in patient burden.

There are concerns regarding interference between the transtibial pull-out bone tunnel and locking screws when performing OWHTO and root reconstruction simultaneously, which could lead to suture damage in pull-out repair. However, if no screw or a short screw is inserted to avoid interference, the fixation force will decrease, leading to inferior stability of plate fixation, which could result in a lower union rate and correction loss.[17] This problem can be resolved by fixing an autologous tendon 20 mm from the articular surface using an interference screw. Furthermore, the interference screw may also be damaged during drilling. In this method, only the front bone cortex is drilled, the guide pin is inserted with a hammer, and, after confirming no interference, the cannulated screws are inserted safely. Additionally, cannulated screws are safer than self-drilling or pointed screws.

There are several disadvantages and pitfalls in the clinical application of meniscal reconstruction combined with OWHTO (Tables 1 and 2). First, the outcomes of autologous tendon reconstruction combined with OWHTO are unknown, and further studies are needed to evaluate the meniscal healing rate and medium- to long-term clinical outcomes.

Table 2. Pearls and Pitfalls

Pearls
- The medial collateral ligament was completely detached to obtain the working space of the medial joint space.
- By thinning the autologous tendon to 3 mm, it became easier to pass it through the meniscus and bone tunnel.
- Use of a tensioner to fix the meniscus to prevent fixation tension did not cause overtightening.

Pitfalls
- When the hole in the meniscus was too narrow, it was difficult to pass the autogenous tendon to the meniscus.
- When performing the suture relay method, it is necessary to perform sufficient abrasion to avoid interference with soft tissue.
- Strong traction on the autologous tendon may cause cheese-cut of the meniscus.
- The inserted interference screw could not be confirmed by fluoroscopy; absence of interference must be confirmed when drilling the screws.

Disclosures

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