Technical Note

Posterior Meniscal Root Repair: The Transtibial Double Tunnel Pullout Technique

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Abstract: Meniscal root tears are increasingly recognized as an important pathology. Failure to recognize this pathology could lead to early onset osteoarthritis of the ipsilateral knee joint compartment similar to a total meniscectomy. Therefore, surgical treatment is necessary to restore meniscal function and to normalize contact pressures, when there is joint overload and sufficient remaining articular cartilage. This article details our anatomic posterior root repair procedure using a transtibial double tunnel pullout technique.

Meniscal root tears, although previously underdiagnosed, are increasingly recognized as a significant pathology requiring surgical management in appropriate patients.[1] Meniscal root tears have been reported to account for 10% to 21% of all arthroscopic meniscal surgeries and often go unnoticed on magnetic resonance imaging (MRI) and arthroscopy in large part due to the lack of anatomic understanding.[2] If left untreated, meniscal root tears can lead to ipsilateral compartment osteoarthritis similar to a total meniscectomy where hoop stresses are no longer dissipated through the meniscus, thereby increasing contact pressures.[3] Meniscal root tears are classified by tear type: type 1 (partial stable root tears); type 2 (radial root tears, which are the most common), located 0 to <3 mm (2A), 3 to <6 mm (2B), and 6 to 9 mm (2C) from the root attachment, respectively; type 3 (bucket-handle tears with a complete root detachment); type 4 (complex oblique tears with complete root detachments extending into the root attachment); type 5 (bony avulsion fractures of the root attachments).[4]

Historically, meniscal root tears were treated nonoperatively or with partial meniscectomy. Recently, attention has turned to meniscal preservation for patients with sufficient remaining articular cartilage, using a variety of repair strategies to restore meniscal function.[2,5,6] The purpose of this technical note was to describe the procedure for posterior meniscal root repair using a transtibial double tunnel pullout technique.

Indications for Surgery

Patients who are poor surgical candidates (multiple comorbidities or advanced age) have severe osteoarthritis (grade 3 or 4 chondromalacia of the ipsilateral compartment), or nonsymptomatic chronic meniscal root tears are excluded from surgical repair. Patients with significant malalignment of the affected compartment should have the malalignment corrected concurrently or before the meniscal root repair. Otherwise, anatomical restoration of the meniscal root tear should be attempted (Fig 1).

Surgical Technique

Objective Diagnosis

The meniscal root tear can be visualized on axial, coronal, and/or sagittal MRI views. The classic MRI presentation of a meniscal root tear is represented by the presence of a "ghost sign"—the absence of an identifiable meniscus on the sagittal sequence or high signal replacing the normal dark meniscus. In addition, meniscal extrusion can be visualized on coronal sections (defined as a meniscal sagittal displacement of >3mm at the level of the medial collateral ligament).[2,7]

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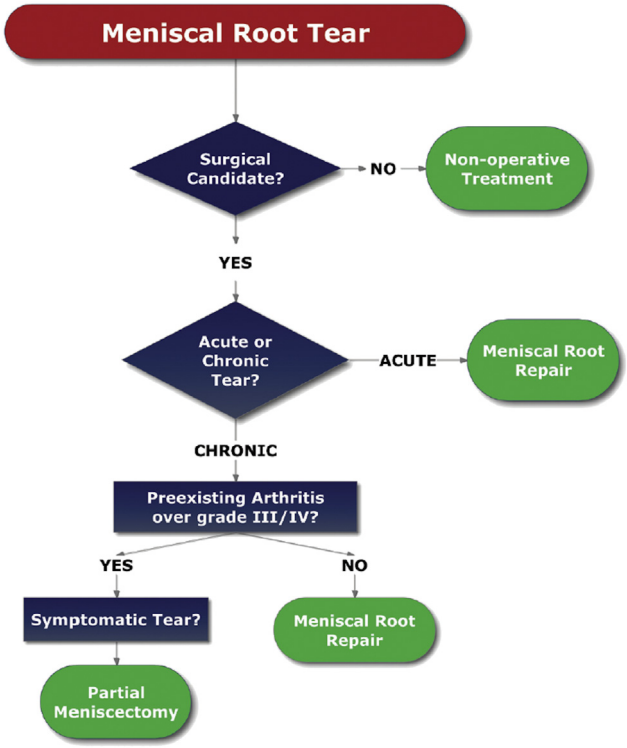

Fig 1. Treatment decision making for meniscal root tears. Appropriate indications for root repair are key to obtain successful outcomes. (Reproduced with permission from Bhatia et al.[2])

In an acute injury or in younger patients, a bony avulsion of the meniscal root attachment may be noted on radiographs. Arthroscopically, a meniscal root tear should be probed to verify that it is detached from its origin and is essentially nonfunctional.

Patient Positioning and Anesthesia

The patient is placed in the supine position on the operating table (Video 1). After induction of general anesthesia, a bilateral knee examination is performed to evaluate for any concurrent ligamentous instability, and to assess for knee range of motion. A well-padded high-thigh tourniquet is subsequently placed on the operative leg and then placed into a leg holder (Mizuho OSI, Union City, CA), whereas the contralateral leg is placed into an abduction stirrup (Birkova Product LLC, Gothenburg, NE). The foot of the operating table is then lowered, allowing for the surgeon to freely manipulate the knee as needed.

Surgical Technique

Standard anterolateral and anteromedial portals are made adjacent to the patellar tendon. The joint is insufflated with normal saline and visualized with a 30° arthroscopic camera (Smith & Nephew, Andover, MA). An arthroscopic shaver (Smith & Nephew) is inserted into the knee and any notable adhesions are removed. The damaged meniscal root should be probed to assess for severity and tear pattern.[4] An accessory arthroscopic portal (anteromedial or anterolateral) can be made to help access the posterior root. Thorough knowledge of the anatomy is essential to perform an anatomical repair and to avoid damaging other structures (Fig 2).

The location of the planned root repair on the tibial plateau should then be decorticated using a curved curette (Fig 3). A grasper can be used to position the torn meniscal root and determine the ideal location to perform the repair.

For a posterior medial root tear, an initial incision for the transtibial tunnels is made just medial to the tibial tubercle. For a posterior lateral meniscal root

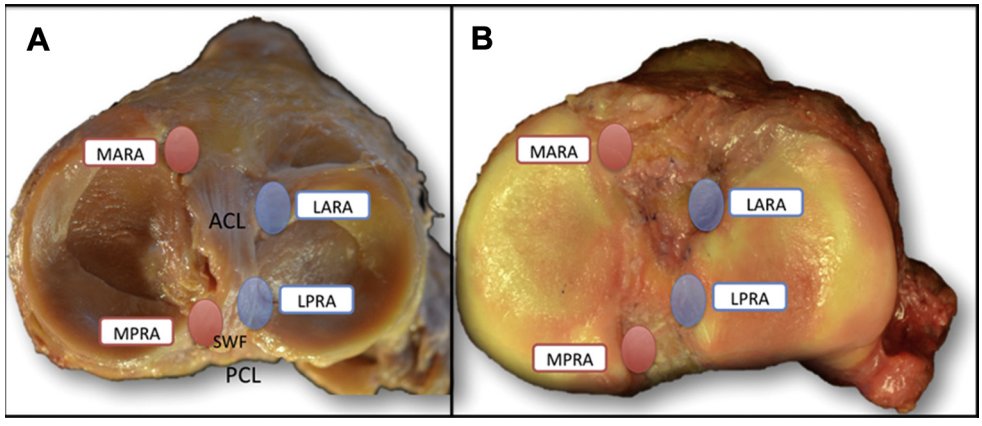

Fig 2. Photographs showing the relation of the 4 meniscal roots in a right knee (A) with menisci intact and both cruciate ligaments to better illustrate the anatomical relation between the structures. The location of the accessory shiny white fibers (SWFs) is labeled in relation to the MPRA. (B) Tibial plateau without menisci or cruciate ligaments. (LARA, lateral meniscus anterior root attachment; LPRA, lateral meniscus posterior root attachment; MARA, medial meniscus anterior root attachment; MPRA, medial meniscus posterior root attachment.)

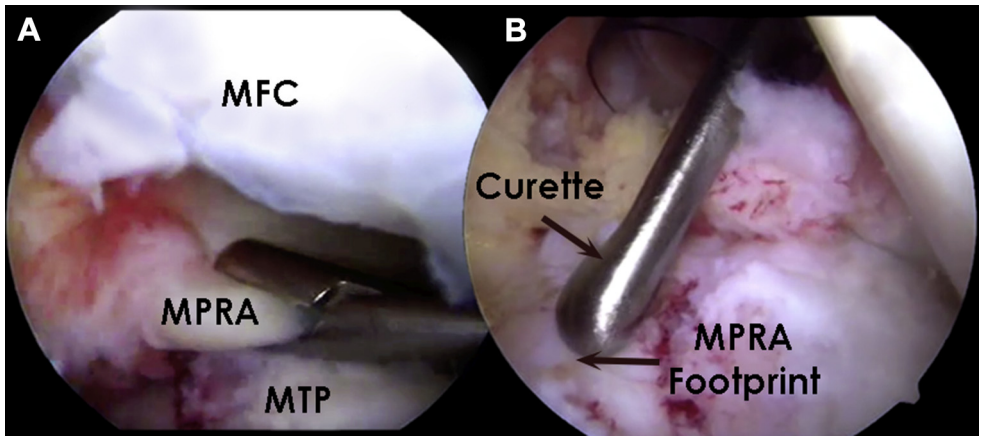

Fig 3. Arthroscopic images showing (A) mobility of the posterior meniscal root assessed with a grasper, and (B) preparing the repair bed (anatomical location of the meniscal root on the tibial plateau). It should be cleaned off down to bone with a curved curette until bleeding bone is observed. (MFC, medial femoral condyle; MPRA, medial meniscus posterior root attachment; MPT, medial tibial plateau.)

repair, the incision will be made on the anterolateral tibia, just distal to the medial aspect of Gerdy's tubercle. To best restore the footprint of the repair and increase the chance of biologic healing, 2 transtibial tunnels are created at the location of the root attachment. An aiming device with a cannulated sleeve (Smith & Nephew) is used to position a drill pin. A tibial tunnel guide (Smith & Nephew) is then used to ream the first tunnel (along the posterior aspect of the posterior root attachment site). The second tunnel is placed approximately 5 mm anterior to the first tunnel using an offset guide (Smith & Nephew). The tunnels are visualized arthroscopically to verify correct tunnel placement and the drill pins are removed leaving the 2 cannulas in place for passing the sutures (Fig 4).

An accessory anteromedial or anterolateral portal is created (if not done previously) for medial or lateral meniscal repairs, respectively, to allow an arthroscopic grasper to firmly hold the torn meniscal root and facilitate passing the sutures. An accessory posterior portal is created in cases when the surgeon is unable to pass the sutures into the root tear through the anterior portals, such as in cases of tight medial or lateral compartments.[2]

A suture-passing device (FirstPass, Smith & Nephew) is used to pass a simple suture through the far posterior portion of the detached meniscal root, approximately 5 mm medial to its lateral edge for the medial meniscus, or 5 mm lateral to its medial edge for the lateral meniscus, passing from the tibial to the femoral side. Most suture-passing devices have a

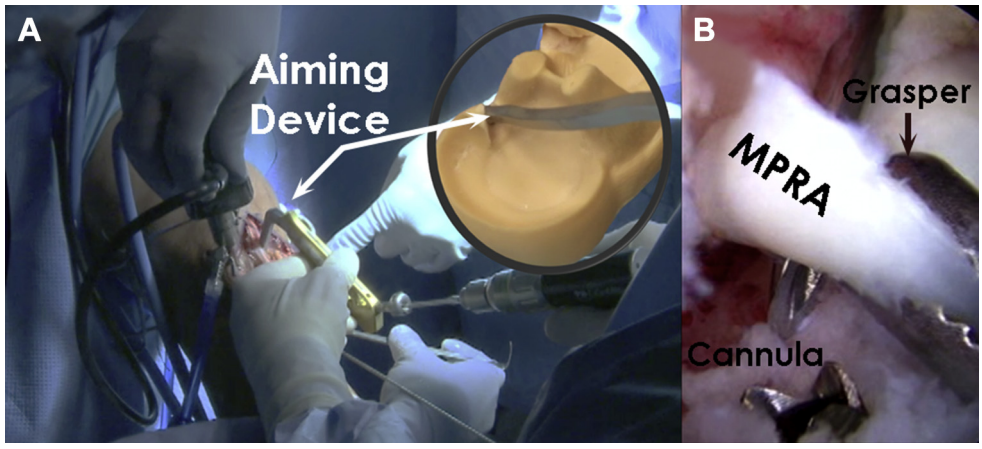

Fig 4. (A) An aiming device is used to position a guide pin in the anatomical attachment of the meniscal root on a left knee. (B) The drill pins are removed once they are in the correct position, leaving 2 cannulas in place for passing the sutures. The posterior cannula is seen here, with the meniscal root mobilized with a grasper to ensure proper positioning for the repair. A spinal needle is visualized entering through an accessory posterolateral portal, which will be used to pass the sutures. (MPRA, medial meniscus posterior root attachment.)

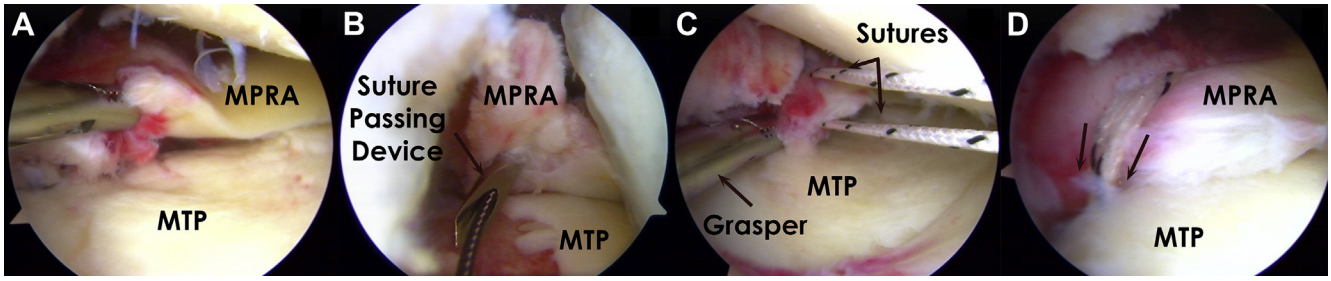

Fig 5. (A) After ensuring that the meniscal root will be able to achieve an anatomical placement (B) a suture-passing device is used to pass a simple suture through the far posterior portion of the detached meniscal root. (C) The sutures are then pulled out through the anteromedial portal (through a cannula) as the device is removed. (D) Lastly, the suture is shuttled down through the more posteriorly placed tibial tunnel. The process is repeated for the anteriorly placed suture. (MPRA, medial meniscus posterior root attachment; MTP, medial tibial plateau.)

suture retrieving mechanism, so the sutures can be pulled out through the anteromedial or anterolateral portal (through a cannula) as the device is removed. It is important to verify that there are no soft tissue bridges in the arthroscopic portal with the passing sutures because soft tissue bridges may result in tearing of the sutures through the meniscal root when the sutures are pulled down the tibial tunnel. Before passing the second suture through the meniscus, the first suture is shuttled down through the more posteriorly placed tibial tunnel to avoid intra-articular suture tangling. To accomplish this, a looped passing wire is placed up the posterior tunnel cannula and the posterior suture is shuttled down the posterior tunnel.

The steps are repeated with the second suture positioned through the midportion of the meniscal root, anterior to the first suture placed into the meniscus. The second suture is then pulled down through the anterior positioned tibial cannula (Fig 5). The sutures are tied down over a cortical fixation device (Endobutton, Smith & Nephew) on the anteromedial tibia for the medial meniscal root repair, or the anterolateral tibia for the lateral meniscal root repair, whereas the posterior root of the respective meniscus is visualized arthroscopically to confirm a secure repair (Fig 6). Pearls and pitfalls to this procedure are summarized in Table 1.

Postoperative Rehabilitation

After a meniscal transtibial pullout root repair, patients should remain non-weight-bearing for 6 weeks. Physical therapy should start as soon as possible after surgery, which should include early passive range of motion exercises in a safe zone of 0° to 90° of flexion for the initial 2 weeks. After 2 weeks, they can work on further increases in knee flexion as tolerated. Progressive advancement to full weight-bearing begins at 8 weeks. Deep leg presses and squats greater than 70° of knee flexion should be avoided for at least 4 months after surgery.

Discussion

The 2-tunnel transtibial root repair technique, based on restoring the native anatomy of the posterior root attachments, restores the contact areas and pressures to near normal values.[2,5,6,8] Several studies have reported

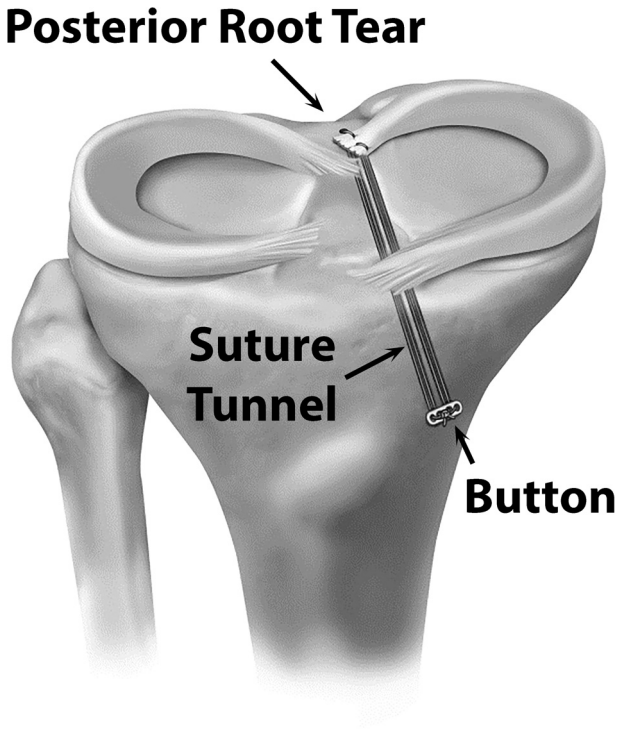

Fig 6. Illustration of the transtibial pullout repair technique for a tear of the posteromedial meniscal root of the right knee. A complete radial tear is located 3 mm from the bony attachment. The two-simple-stitches (TSS) method of suture fixation is shown. The anterior and posterior sutures are shuttled down their respective tunnels. The sutures are tied over a cortical fixation device (Endobutton, Smith & Nephew, Andover, MA) with the knee flexed at 90° to secure the root repair. The TSS method resists displacement better than single double locking loop or double-double locking loop.[8] (Reproduced with permission from LaPrade et al.[5])

Table 1. Pearls and Pitfalls

Pearls	Pitfalls
Clean the bed of the root repair location until bleeding healthy bone is observed.	Failure to repair the meniscal root in an anatomical position can lead to unfavorable results.
Place the more posterior of the tibial tunnels first. Space the 2 tunnels approximately 5 mm apart.	Soft tissue bridges in the arthroscopic portal may result in tearing of the sutures through the meniscal root when the sutures are pulled down the tibial tunnel.
Create an accessory anteromedial or anterolateral portal (for medial or lateral meniscal repairs, respectively) to allow an arthroscopic grasper to firmly hold the torn meniscal root and facilitate suture passing.	Intra-articular suture tangling may occur if both sutures are passed through the meniscus, instead of placing 1 and shuttling it through the posterior tibial tunnel before placing the second.
An accessory posterior portal is created in cases when the surgeon is unable to pass the sutures into the root tear through the anterior portals, such as in cases of tight medial or lateral compartments.	Deep leg presses and squats greater than 70° of knee flexion put stress on the posterior meniscal roots and can result in a failed repair, especially if performed before 4 months postoperatively.

on the outcomes of meniscal root repairs. A systematic review[9] of level III and IV studies concluded that arthroscopic transtibial pullout repair for posterior medial meniscal root repair yielded good to excellent functional outcome scores. However, complete healing and reduction of the meniscal extrusion were less predictable.

Kim et al.[7] published their results of 14 patients with a mean follow-up of 48.5 months and found significant radiological improvement (decrease in meniscal extrusion) on second look arthroscopy in patients who had a meniscal root repair compared with patients who had a partial meniscectomy. Jung et al.[10] reported no change in meniscal extrusion after suture anchor repair. Moon et al.[11] found an increase in meniscal extrusion with the transtibial pullout technique. However, the increased extrusion observed in their study may be in part explained by the inclusion of patients with severe osteoarthritis and the relatively high average age (59 years) of their study population.[12]

A prospective study[13] comparing arthroscopic suture anchors versus pullout suture repair reported significant functional improvement in both groups at 2-year follow-up. However, incompletely healed cases showed cartilage degeneration progression, regardless of the repair technique. Cho and Song[14] reported on 13 second-look arthroscopic assessments of root repairs at 7-month follow-up, finding 4 complete, 8 partial (lax or scar), and 1 failed healing.

Repairing the meniscal root with a transtibial pullout repair has been reported to restore contact pressures to those of the intact states and allow for the dispersion of hoop stresses across the meniscus, although outcomes studies are still needed.[1,6]

Lastly, some advantages and limitations should be mentioned for the transtibial double tunnel pullout technique. Biomechanical studies reported repetitive loading resulted in displacement of this repair complex.[5,15] Future clinical studies are needed to evaluate this concern in vivo. In addition, the most common root tear morphology according to a recent classification study,[4] a complete radial tear, does seem ideal for this technique, with previous biomechanical studies showing the ability of a similar single tunnel technique in restoring tibiofemoral contact mechanics in both posterior meniscal roots.[1,6] However, it should be noted that meniscal root tears are not uniform in their pathology; therefore, this particular technique may not be ideal for all root tear types.

Future level I and II randomized clinical trials are needed to investigate the comparative benefit of the transtibial repair technique. In addition, long-term outcomes studies are needed to investigate the longevity of the transtibial repair technique. We recommend our approach for posterior root tears and encourage further studies by other groups to evaluate our surgical technique.

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