Technical Note

Anterior Meniscal Root Repair Using a Transtibial Double-Tunnel Pullout Technique

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Abstract: The menisci are important structures within the knee and play a critical role in maintaining proper stability, load distribution, and joint lubrication. Injury to these structures can significantly alter the complex biomechanics of the knee and thus affect the health and longevity of the joint. Meniscal root tears are increasingly recognized as an important pathologic condition that results in a nonfunctional meniscus if not properly repaired. Whereas early treatment of meniscal tears traditionally focused on removal of the injured tissue, recent attention on the long-term consequences of partial or total meniscectomy has led to increased attempts at meniscal repair whenever possible. This article details our anatomic anterior root repair procedure using a transtibial double-tunnel pullout technique.

Historically, meniscal root tears have gone largely unrecognized. However, recent literature has increased awareness and understanding of this pathology, leading to surgical management of meniscal root tears in appropriately indicated patients.[1] Failure to repair meniscal tears can lead to overloading of the affected joint compartment over time, predisposing the knee to early degenerative changes.[2] Meniscal repairs have been reported to exhibit a higher reoperation rate than meniscectomy; however, they result in better long-term patient-reported outcomes, improved activity levels, and slower progression to osteoarthritis.[3]

Meniscal root tears are classified by tear type. Type 1 tears are partial stable root tears. Type 2 tears are radial root tears, which are the most common and are further subdivided based on their location from the root attachment: 0 mm to less than 3 mm (subtype 2A), 3 mm to less than 6 mm (subtype 2B), or 6 to 9 mm (subtype 2C). Type 3 tears are bucket-handle tears with a complete root detachment. Type 4 tears are complex oblique tears with complete root detachments extending into the root attachment, and type 5 tears are bony avulsion fractures of the root attachments.[4] Although the posterior meniscal root has recently gained significant attention, a paucity of literature exists surrounding pathology of the anterior meniscal root attachment.

Traditionally, meniscal root tears were treated nonoperatively or with partial meniscectomy. In the past several years, there has been an increasing trend toward meniscal preservation for patients with sufficient articular cartilage, using a variety of repair strategies to restore meniscal function.[5] The purpose of this technical note is to describe our procedure for anterior meniscal root repair using a transtibial double-tunnel pullout technique.

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Surgical Technique

Objective Diagnosis

Tears of the anterior meniscal roots are best visualized on axial, coronal, and/or sagittal magnetic resonance imaging views. The most reliable magnetic resonance imaging finding of a meniscal root tear is represented by the presence of a "ghost sign"—the absence of an identifiable meniscus on the sagittal or axial sequence.[5] This is represented by high signal replacing the normal dark meniscus on this view. Furthermore, extrusion of the meniscus can be visualized on coronal sections (defined as meniscal displacement outside of the joint of >3 mm) at the level of the medial collateral

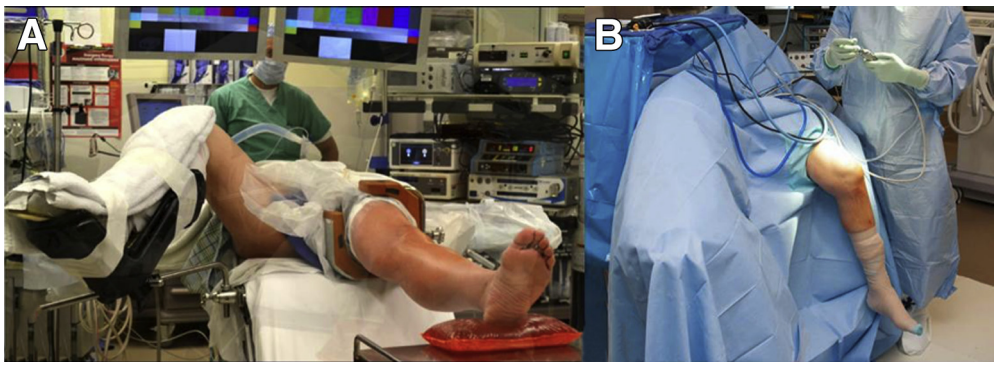

Fig 1. (A) Intraoperative photograph showing patient positioning in the operating suite. The patient is positioned supine on the operating table with the surgical limb (left) placed into a leg holder, allowing the surgeon to freely manipulate the knee during the procedure. The nonoperative (right) limb is kept in a well-padded abduction stirrup. (B) Intraoperative photograph of the patient supine on the operating table after sterile preparation and draping. The foot of the bed is lowered to allow the surgical (left) leg to hang free within the sterile surgical field.

ligament.[5,6] Uncommonly, a bony avulsion of the proximal tibia or tibial eminence may have an attachment to the anterior meniscal root, and this can be visualized on plain radiographs. At arthroscopy, the surgeon can verify the anterior meniscal root tear by carefully probing the anterior attachment site, noting a complete tear and meniscal instability.

Surgical Indications

Patients who have multiple comorbidities, have advanced osteoarthritis (Outerbridge grade 3 or 4 chondromalacia of the ipsilateral compartment), have chronic meniscal root tears and present as asymptomatic, or are advanced in age are not considered for surgical intervention. Furthermore, patients with significant varus or valgus malalignment of the affected compartment should undergo corrective osteotomy concurrently or before the meniscal root repair. In situations other than these, when a complete tear of the anterior meniscal root is noted either on preoperative imaging or on diagnostic arthroscopy, anatomic repair and restoration of the meniscal root tear should be attempted.

Patient Positioning

The patient is placed in the supine position on the operating table. After the induction of general anesthesia, a bilateral knee examination is performed to evaluate the injured knee, and abnormalities compared with the uninjured side are noted. A well-padded thigh tourniquet is placed on the operative leg, and the leg is placed into a leg holder (Mizuho OSI, Union City, CA), while the contralateral knee is placed into an abduction stirrup (Birkova Products, Gothenburg, NE). The foot of the operating table is lowered, allowing for the surgeon to freely manipulate the knee as needed. The operative extremity is then prepared and draped in the usual sterile fashion (Fig 1).

Diagnostic Arthroscopy

A detailed approach to our preferred technique for anterior meniscal root repair can be seen in Video 1. Surgical pearls for performing the procedure are noted in Table 1. An initial diagnostic arthroscopy is performed through standard anterolateral and anteromedial portals to confirm and evaluate the anterior meniscal root tear, as well as any additional concomitant intra-articular pathology.

Preparation for Planned Root Repair

The location of the planned root repair on the tibial plateau should be decorticated using a curved curette. If scarring of the root to the surrounding capsule is present, it may prevent adequate mobilization and anatomic repair. With the aid of an arthroscopic shaver, radiofrequency probe, and/or scissors placed through the contralateral portal, release of the scarring and mobilization of the anterior root can be accomplished (Fig 2), followed by use of a grasper to position the torn meniscal root to within its anatomic footprint.

For an anterior medial root tear, an initial incision for the transtibial tunnels is made just medial to the tibial

Table 1. Surgical Pearls

Adequate mobilization of the anterior root with release of surrounding scar tissue is necessary to allow proper fixation to its anatomic footprint.
A 5-mm offset guide can be used to accurately place the second drill tunnel in the desired location, preventing tunnel convergence or malpositioning.
Use of an arthroscopic cannula placed in the portal through which the sutures are passed can prevent inadvertent soft-tissue bridge formation.
The 2 sutures are tied over a bone block and cortical fixation device (i.e., EndoButton) to ensure robust fixation.
Postoperative rehabilitation focuses on early passive range of motion to reduce the risk of motion loss while protecting the root repair.

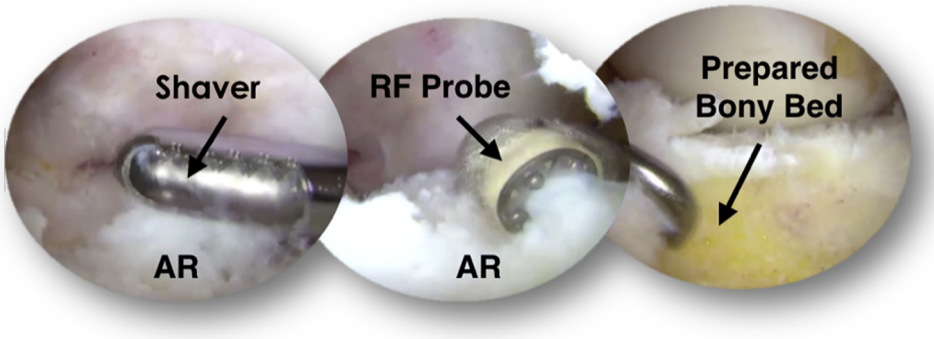

Fig 2. Arthroscopic images of a right knee with an anterior-lateral meniscal root tear as viewed through the anterolateral portal. Sequential release of scar tissue is performed with a combination of a mechanical shaver and radiofrequency (RF) probe placed through the anteromedial portal to mobilize the anterior meniscal root (AR). Once the root is adequately mobilized to allow repair to its native footprint, a bony bed at the location of the footprint is prepared for the site of tunnel placement.

tubercle, measuring approximately 2 to 3 cm in length. For an anterior-lateral meniscal root repair, the incision is made on the anterolateral tibia, just distal to the medial aspect of the Gerdy tubercle.

Anterior Meniscal Root Repair

To best restore the footprint of the repair and increase the chance of biological healing, 2 transtibial tunnels are created at the location of the root attachment. An anterior cruciate ligament aiming device with a cannulated sleeve (Arthrex, Naples, FL) is used to position a drill pin (Fig 3).

A tibial tunnel guide (Smith & Nephew, Andover, MA) is then used to ream the first tunnel along the posterior aspect of the anterior root attachment footprint. The second tunnel is placed approximately 5 mm anterior to the first tunnel by use of an offset guide (Smith & Nephew) to ensure accurate placement and avoid tunnel convergence. 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.

A suture-passing device (FirstPass; Smith & Nephew) is used to pass a simple suture through the posterior portion of the detached meniscal root. To ensure there is adequate meniscal tissue to avoid suture pull-through when securing the meniscus to its footprint at a later step, we recommend placing the suture approximately 5 mm medial to the lateral edge of the medial meniscus (or 5 mm lateral to the medial edge of the lateral meniscus). Most suture-passing devices have a suture-retrieving mechanism, so the sutures can be pulled

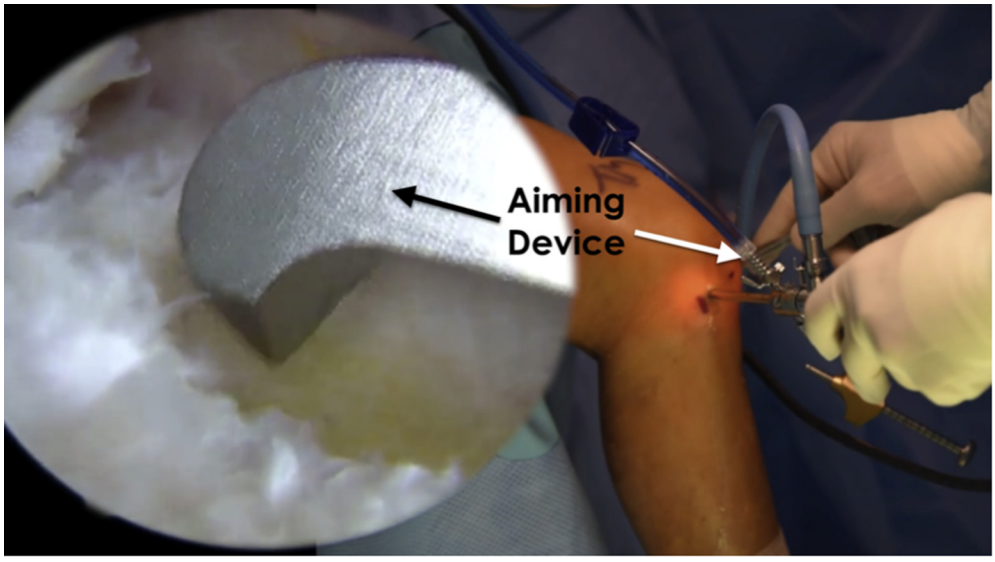

Fig 3. The arthroscopic image shows a right knee with an anterior-lateral meniscal root tear, as viewed through the anterolateral portal. An anterior cruciate ligament aiming device is placed through the anteromedial portal and used to accurately place the transtibial tunnels in the anatomic footprint of the meniscal root. The intraoperative photograph shows a right knee with the arthroscope placed in the anterolateral portal to view the meniscal tear. The anterior cruciate ligament aiming guide is passed into the anteromedial portal.

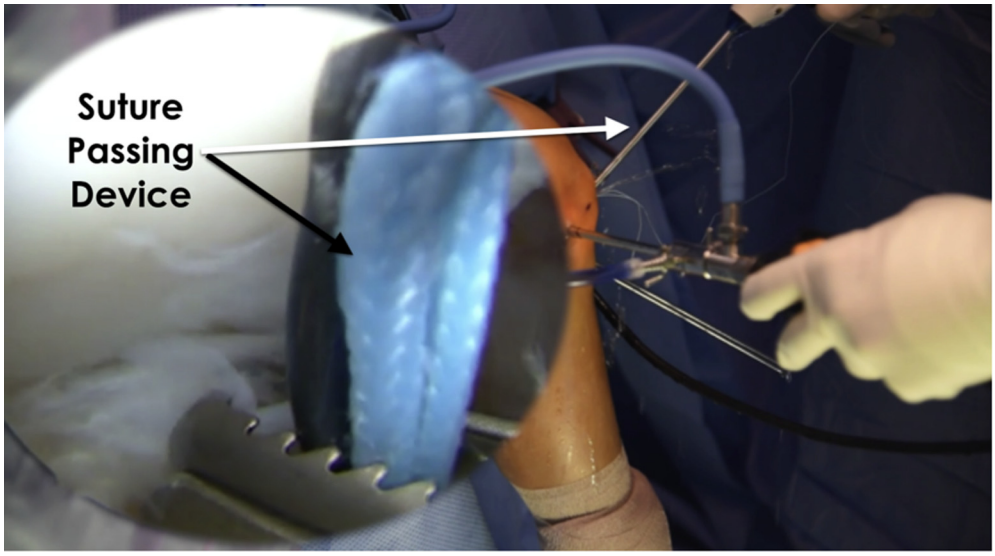

Fig 4. The arthroscopic image shows a right knee with an anterior-lateral meniscal root tear, as viewed through the anterolateral portal. A suture-passing device is used to pass suture through the anterior horn of the lateral meniscal root. The intraoperative photograph shows a right knee with the arthroscope placed in the anterolateral portal to view the meniscal tear. The suture-passing device is placed through the anteromedial portal to secure the torn meniscal root.

out through the anteromedial portal as the device is removed (Fig 4).

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. To help prevent soft-tissue bridges, we recommend passing the sutures through the portals with an arthroscopic cannula in place. Before the second suture is passed 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 (Fig 5).

The steps are repeated with the second suture positioned through the midportion of the meniscal root, placed anterior to the first suture into the meniscal root. The second suture is then pulled down through the anteriorly positioned tibial cannula. The sutures are tied down over a bony bridge with a cortical fixation device

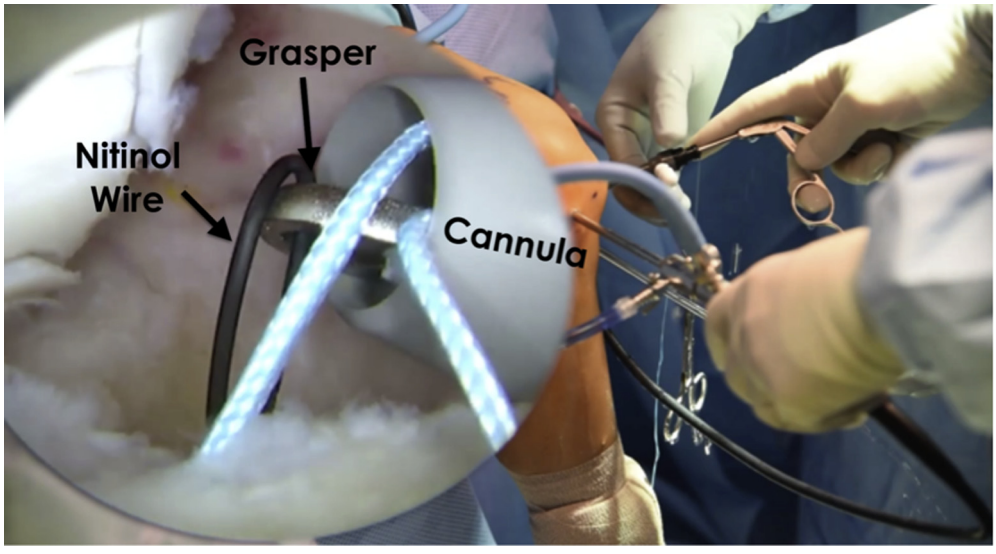

Fig 5. The arthroscopic image shows a right knee with an anterior-lateral meniscal root tear, as viewed through the anterolateral portal. Once the suture has been passed through the anterior meniscal root and pulled out through a cannula in the anteromedial portal, a nitinol wire is passed in a retrograde fashion up the transtibial cannula to retrieve the suture for passage through the tunnel. The nitinol wire is then grasped through the same cannula such that the suture can be passed antegrade down the tibial tunnel. The intraoperative photograph shows a right knee with the arthroscope placed in the anterolateral portal to view the suture and wire passage. The suture-grasping device is placed through the anteromedial portal cannula.

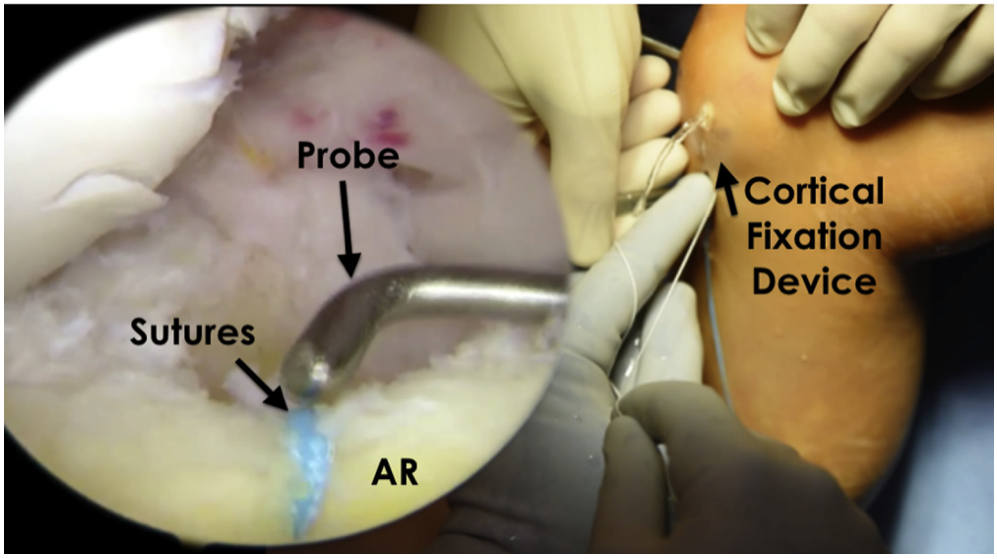

Fig 6. The arthroscopic image shows a right knee after repair of an anterior-lateral meniscal root tear, as viewed through the anterolateral portal. Arthroscopic confirmation of anatomic repair of the anterior meniscal root (AR) to its native footprint with proper tension is seen. The intraoperative photograph shows the anteromedial aspect of a right knee, with placement of a cortical fixation device anchoring the meniscal repair sutures against the anteromedial tibia.

(EndoButton; Smith & Nephew) on the anteromedial tibia for the medial meniscal root repair (or on the anterolateral tibia for the lateral meniscal root repair). This is visualized arthroscopically to ensure proper positioning and tension of the root to its native footprint (Fig 6).

Once the repair is complete, excess fluid is drained from the knee and the arthroscopic portals are closed with No. 4-0 Monocryl suture (Ethicon, Somerville, NJ). The tunnel incision is closed in a layered fashion with No. 2-0 Vicryl sutures (Ethicon) followed by a running No. 4-0 Monocryl suture (Ethicon) in the subdermal layer. Steri-Strips (3M, St. Paul, MN) are applied followed by a soft dressing.

Postoperative Recovery and Rehabilitation

After meniscal transtibial pullout root repair, the patient is placed in a knee immobilizer (Ossur, Reykjavik, Iceland) and should remain non–weight bearing for 6 weeks. Physical therapy is started on postoperative day 1 to begin working on early passive range-of-motion exercises. Knee flexion is limited to 0° to 90° for the first 2 weeks and then progressed as tolerated. Deep leg presses and squats with greater than 70° of knee flexion should be avoided for at least 4 months after surgery to protect the root repair.

Discussion

This article describes a transtibial pullout technique for repair of anterior meniscal root tears. Limited literature is available regarding management of these injuries, and this is particularly true as it relates to surgical techniques.

It has been reported that a meniscal root detachment leads to failure of the meniscus to convert axial loads into transverse hoop stresses. These changes in joint loading lead to cartilage degeneration, and biomechanical studies have reported that this situation can resemble a total meniscectomy state.[1,7,8] Although most of the reported literature refers to posterior meniscal root tears, it would stand to reason that anterior root tears will have the same fate if not anatomically repaired.

The aim of the 2-tunnel transtibial technique for the repair of the anterior root of the meniscus is to restore the anatomy, joint congruence, and joint loading. This

Table 2. Surgical Risks and Avoidance Strategies

Risks and Pitfalls	Avoidance Strategy
Scarring or contracture of the meniscal root to the surrounding joint capsule	Careful dissection and release of the anterior capsule from the meniscus to achieve adequate mobilization for anatomic repair
Improper placement of the bony tunnels in relation to the anatomic attachment site of the anterior root	Use of an intra-articular aiming device and offset guide to ensure accurate placement of the tunnels in the anatomic footprint of the anterior meniscal root
Stiffness and loss of knee motion postoperatively	Early gentle passive range of motion (0°-90°) with an experienced physical therapist
Deep venous thrombosis	Use of intraoperative and postoperative prophylaxis as determined by patient risk factors

technique has been biomechanically evaluated in posterior root tears and was found to restore contact areas and pressures to near native values.[9-12] Osti et al.[13] reported on an all-inside technique performed in 12 patients with a mean follow-up of 1 year. At the last control, the average Lysholm score improved from 48 ± 17 to 91 ± 7 ($P < .001$). At the last appointment, 8 of 9 active patients practiced sports at the same level as preoperatively and only 1 (8.5%) had changed to a lower level of activity.

The transtibial pullout technique can be advantageous in patients with poor bone quality in whom a suture anchor technique might not be desirable because of poor fixation. A limitation of this technique is that it is technically challenging, and nonanatomic repair of the root can lead to displacement and decreased meniscal biomechanical properties with cyclic loading. This displacement can be a cause for concern because nonanatomic repair of the posterior meniscus root was associated with altered joint contact areas and pressure.[11] Further surgical risks and avoidance strategies are shown in Table 2.

Further biomechanical studies and long-term clinical outcomes regarding anterior root tears are needed. We recommend the described technique for the repair of anterior horn meniscal tears and encourage other groups to evaluate our surgical technique.

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