Technical Note

Posterior Meniscus Root Repair Using a Retensionable Knotless All-Suture Anchor

Daniel J. Stokes, M.D., Tyler R. Cram, D.O., Renzo A. Laynes, M.D., Adam Peszek, M.D., Kevin K. Shinsako, P.A.-C., and Rachel M. Frank, M.D.

Abstract: Meniscus root injuries lead to increased tibiofemoral contact pressures and rapid progression of osteoarthritis. Early recognition and treatment with a meniscal root repair can restore biomechanics and help preserve the joint. The transtibial pullout repair and suture anchor repair are the most commonly used techniques to achieve anatomic fixation of the meniscal root. Still, each method presents distinct advantages and disadvantages. This Technical Note aims to describe a vastly simplified, more efficient, and reproducible posterior lateral meniscal root repair using a retensionable knotless all-suture anchor.

It is well understood that a properly functioning meniscus is essential to a healthy knee joint. One of the primary functions of the meniscus is to transmit axial loads into circumferential hoop stresses.[1,2] When the posterior root is damaged, either by an acute injury or chronic degeneration, the altered tibiofemoral contact mechanics can lead to the progression of osteoarthritis (OA).[3,4] The posterior horn of the meniscus is particularly at risk of injury due to its robust attachments to the tibia at the meniscal root, making it less mobile in the setting of trauma. Injuries to the meniscal root have been shown to lead to a significant increase in tibiofemoral contact pressures similar to that of a total meniscectomy.[4] Given the importance of its function, the standard of care for meniscal root tears remains to restore native function and normalize tibiofemoral contact pressures.[5-7] Surgical candidates for meniscal root repair include younger (<50 years old) active patients without significant cartilage damage, joint space narrowing, or malalignment.[8,9]

Two popular techniques for meniscal root repair include the transtibial pullout repair and suture anchor repair. The transtibial method involves reaming 1 to 2 transtibial tunnels over a guide pin positioned arthroscopically, exiting at the site of the anatomic tibial attachment of the meniscal root. Sutures are placed through the meniscus, passed through the tunnel, and fixated to the anteromedial tibial cortex. Several types of fixation methods have been described, including fixation of the knot over a cortical bridge, cortical button, or tying over post with a washer.[2,10]

A suture anchor also can be used to fix a meniscal root injury. In this method, the surgeon typically will use a posteromedial portal, in addition to the standard parapatellar portals, for placement of a suture anchor within the transtibial tunnel at the site of native anatomic attachment of the posterior meniscal root. Sutures are then attached to the anchor, passed through the substance of the root, tied, and tensioned appropriately to achieve repair.[11]

Although both of these methods achieve similar clinical outcomes, they differ in rates of healing and displacement of the graft with loading.[11,12] Although suture anchor placement through the accessory portal can provide direct repair, this can be technically challenging and, in some cases, impossible. Some of these challenges are alleviated through the transtibial technique. However, fixation at the tibial cortex increases the length of repair, leading to the "windshield wiper effect," potentially introducing creep or suture pullout. In addition, once these sutures are tied over the anterior tibia, there is no ability to retension the repair. The aim of this Technical Note is to describe a posterior lateral

From the Department of Orthopaedic Surgery, University of Colorado School of Medicine, Aurora, Colorado, U.S.A.

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Address correspondence to Rachel M. Frank, M.D., UCHealth CU Sports Medicine — Colorado Center, 2000 S. Colorado Blvd., Tower 1, Suite 4500, Denver, Colorado 80222, U.S.A. E-mail: Rachel.Frank@cuanschutz.edu

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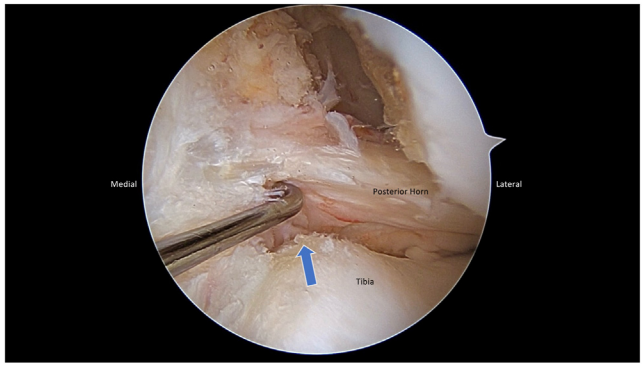

Fig 1. Arthroscopic view from the inferolateral portal of a left knee identifying the posterior lateral meniscus root tear (blue arrow).

meniscal root repair technique using a retensionable knotless all-suture anchor with fixation at the joint line.

Surgical Technique

Patient Evaluation, Imaging, and Indications

A thorough preoperative evaluation is required for patients undergoing meniscal root repair. A complete history, physical examination, and imaging workup are used to identify meniscal root tears and other associated pathology. Age, activity level, previous knee surgery, identification of concomitant injuries, and treatment goals are essential in the surgical decision-making process. Surgical candidates include active patients without significant cartilage damage, joint space narrowing, or malalignment, as these are poor prognostic indicators in meniscal root repairs.[9] Anteroposterior, lateral, merchant (or sunrise) views, and weight-bearing long leg alignment films are necessary imaging studies evaluated for each patient during the workup. Advanced studies such as magnetic resonance imaging (MRI) or computed tomography of the knee also may be useful in treating meniscal root tears. MRI can help better characterize the exact location of the lesion. Meniscal root tears also are often associated with extrusion from the joint, which is best evaluated on coronal sequence.[13] Axial cuts with a high signal may indicate disruption of the posterior meniscal root.[14] A "ghost sign," or the absence of an identifiable meniscus within a single sagittal cut, is pathognomonic for a posterior root tear.[15] MRI is also helpful in identifying commonly associated pathology, such as concomitant anterior cruciate ligament tears, found in tangent with root tears or osteochondral defects.[16] Any additional pathology identified during the workup should be appropriately addressed if a repair of the posterior meniscal root is planned.

Surgical Positioning

The patient is placed supine on the operating table. General anesthesia is induced, and an examination under anesthesia is performed. A tourniquet is applied to the thigh of the operative leg, and care is taken to ensure all bony prominences are well padded. A lateral post is positioned on the operative side at the level of the distal femur for valgus stress of the knee, and a foot stop is placed to hold the knee flexed at 90°. The operative leg is prepped and draped in the usual standard fashion. The leg is elevated, exsanguinated, and the tourniquet inflated.

Diagnostic Arthroscopy

The surgery begins with a standard diagnostic knee arthroscopy using standard inferolateral and inferomedial portals. Evaluation of the lateral compartment reveals a full-thickness, unstable lateral meniscus posterior root tear amenable to repair (Fig 1, Video 1). In some cases, an arthroscopic release of adhesions and meniscotibial ligaments may be required for meniscus mobilization posteriorly to allow for anatomic reduction of the retracted meniscal root (Table 1). In this scenario, the senior author prefers to use curved arthroscopic scissors for gentle release to ensure the root can easily be reapproximated to the anatomic position. Additional intra-articular pathology is assessed and, if indicated, addressed at this time.

Drilling Tibial Tunnel

With the knee in the figure-four position, a Point-to-Point Meniscal Root Marking Hook (Arthrex, Naples, FL) is placed through the inferomedial portal with the precision aiming guide directly over the lateral meniscal

Table 1. Pearls and Pitfalls of Posterior Meniscus Root Repair Using a Retensionable All-Suture Anchor

Pearls	Pitfalls
Minimize deflection as the pin is inserted into the tibia by using a 3.5-mm drill sleeve with a 2.4-mm insert and choking up on the drill pin	Adhesions may limit meniscus mobilization, preventing anatomic reduction of the retracted meniscal root
Remove bone fragments from the tip of the 2.4-mm drill after drilling the tibial tunnel, by tightly screwing the trocar back into the drill pin	Lasso wire prone to breaking during shuttling the SutureLoc implant
Load the SutureLoc implant proximal to the tensioning suture to easily shuttle the suture limbs through the tibial tunnel	Avoid pulling the SutureLoc anchor out of the tibial tunnel.
Keep the first suture conversion loose to help pass the second suture limb through the meniscus	

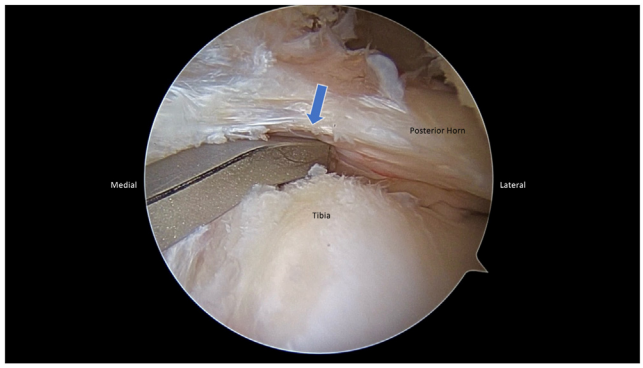

Fig 2. Arthroscopic view from the inferolateral portal of a left knee positioning the aiming guide of the meniscal root marking hook directly over the meniscus root footprint (blue arrow) working through the inferomedial portal.

root footprint (Fig 2). The senior author prefers to use the 3.5-mm drill sleeve with a 2.4-mm insert, which helps minimize deflection as the pin is inserted into the tibia (Table 1). To do this, the 3.5-mm drill sleeve is reduced down until it meets the anterior tibia. The 2.4-mm insert is required to accommodate the 2.4-mm cannulated pin, which is introduced through the insert and used to create a transtibial tunnel. To further minimize deflection, choke up on the drill pin so it is approximately 1 cm from the guide (Table 1). As the drill pin passes through the cancellous bone and approaches the tibial plateau cortex, advance it slowly until it reaches the tip of the marking hook. Once in position, remove the aiming guide, insert, and trocar to advance the drill pin completely through the cortex. After drilling, bone fragments often will be caught at the end of the drill, which can be extracted by tightly screwing the trocar back into the drill pin, pushing out any residual bone (Table 1). Remove the trocar from the cannulated drill pin, pass the looped end of a nitinol lasso wire into the joint, and retrieve it through the inferomedial portal (Fig 3A). Due to the increased risk of the lasso wire breaking during shuttling, the senior author prefers to exchange it for a FiberLink (Arthrex) suture (Fig 3B, Table 1). Finally, carefully remove the cannulated drill from the tibia.

Anchor Placement

The distal end of the SutureLoc implant (Arthrex) is loaded into the FiberLink passing suture. Loading the SutureLoc implant proximal to the tensioning suture is important to ensure easy passage of all the suture limbs for shuttling through the tibial tunnel (Table 1). The SutureLoc implant is passed in a retrograde fashion through the inferomedial portal and into the transtibial tunnel until the loop on the SutureLoc implant is near the tibial plateau (Fig 4A). Discard the FiberLink suture. Passing the SutureLoc loop in a controlled fashion is essential to prevent pulling the anchor through the tibial tunnel (Table 1). A click is typically felt as the SutureLoc implant passes deep to the tibial plateau, signifying the correct position (Fig 4B). The anchor is then set by pulling on the tensioning suture loop. To ensure the anchor is appropriately seated, pull on the suture limbs through the inferomedial portal assessing for any implant slippage. Next, a safety hemostat is used to clamp and secure the main anchor sheath at the anterior tibia to prevent premature pulling of the conversion suture tails.

Knotless Meniscus Root Repair

The provided 8-mm × 3-cm PassPort (Arthrex) can be inserted through the inferomedial portal to facilitate suture passage. Similarly, for suture management, the arthroscope can be switched to the inferomedial cannula, and the 2 solid repair sutures (white and blue) and the 2 striped conversion sutures (white/blue and white/black) can be shuttled through the inferolateral portal so that only one repair suture is through the anteromedial working portal at a time. Alternatively, this can be completed without these steps, as demonstrated in Video 1.

Using a Knee Scorpion (Arthrex) suture passer, the first repair suture, in this case, the blue suture, is loaded (outside of the knee) and passed through the meniscal root tissue using the inferomedial portal (Fig 5). After a solid bite of the posterior meniscus root, the blue repair suture slack is removed as it is shuttled back through the inferomedial portal. The blue repair suture is loaded into the loop end of the blue/white conversion suture. A purple ink-mark indicator on the repair suture is aligned with the conversion suture loop, and the repair suture tail is folded here. Remove the safety hemostat used to secure the main anchor sheath and shuttle the repair-conversion suture construct through the transtibial tunnel by pulling the tail of the blue/white striped conversion suture at the anterior tibia. It is worth noting the first suture conversion should remain loose to aid with passing the second suture limb through the meniscus (Table 1). With the safety hemostat reapplied, these steps are repeated with the second repair and conversion sutures. Working through the inferomedial portal, the solid white repair suture is loaded into the Knee Scorpion suture passer outside the knee, passed through the posterior meniscus root, and shuttled back outside the knee. The white repair suture is loaded through the loop of the white/black conversion suture until the ink-mark indicator overlays the loop (Fig 6). Remove the safety hemostat and pull the white/black conversion suture tail through the suture sheath to shuttle the repair suture into the knotless mechanism.

Retension the Meniscus Repair Sutures

The SutureLoc implant repair sutures are then retensioned down to the anchor. After achieving

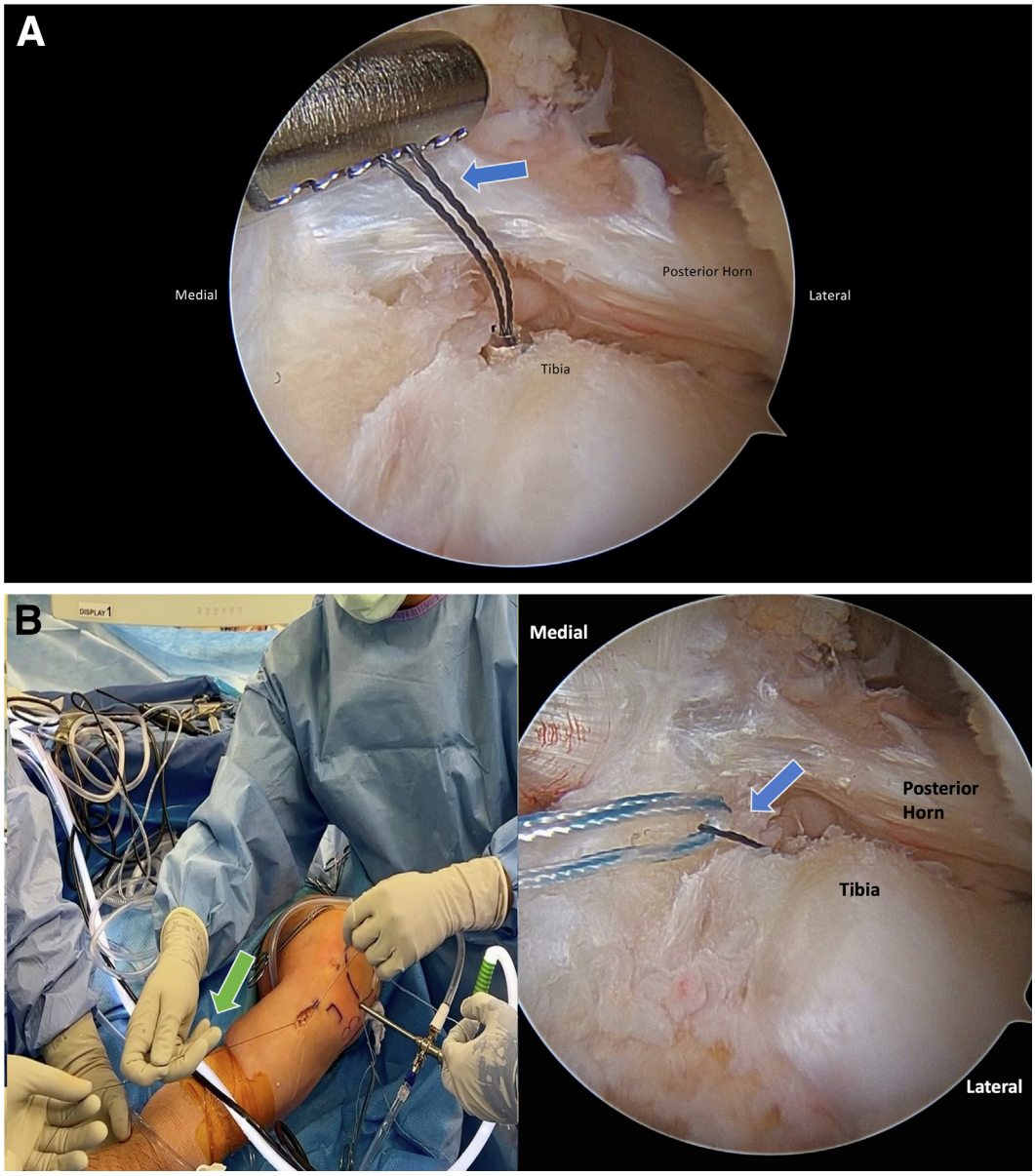

Fig 3. (A) Arthroscopic view from the inferolateral portal of a left knee retrieving the nitinol lasso wire from the cannulated drill pin through the inferomedial portal (blue arrow). (B) To avoid fortuitous lasso wire breakage while shuttling the SutureLoc implant, a FiberLink suture is passed through the inferomedial portal into the joint (blue arrow, right) and back out the transtibial tunnel by pulling the lasso wire at the anterior tibia (green arrow).

sufficient tension on the tibia, the knee is cycled. Differentially retension the repair sutures until a robust repair is achieved using a probe to confirm appropriate tension under direct visualization (Fig 7 A-C). Finally, cut the implant suture limbs flush at the anterior tibial aperture (Video 1).

Closure

The knee is cleared of loose debris, the tourniquet is let down, the wounds are copiously irrigated, and the incisions are closed in standard fashion. Sterile dressings are applied, followed by a hinged knee brace locked in full extension.

Rehabilitation Protocol

Postoperatively, patients remain toe-touch weight-bearing until approximately four weeks, followed by gradual progression to full weightbearing by 6 weeks. The hinged knee brace should remain locked in full extension with flexion permitted to 90° to work on passive range of motion (ROM) during the first 2 weeks, after which the brace can be unlocked until

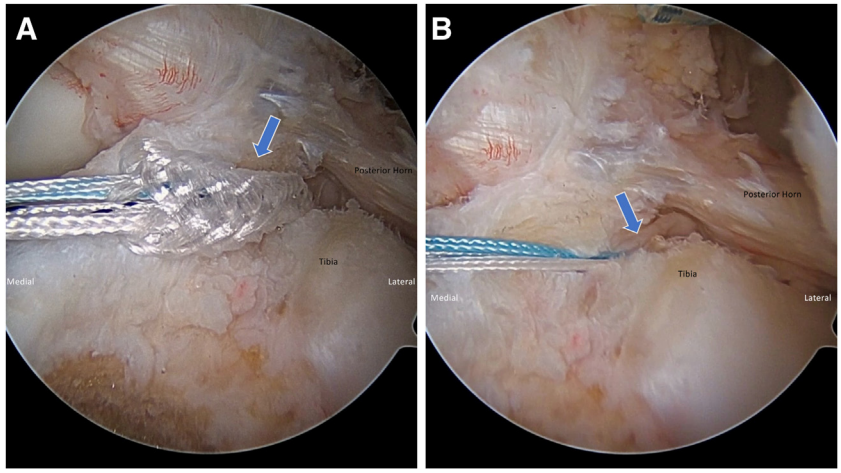

Fig 4. (A) Arthroscopic view from the inferolateral portal of a left knee shuttling the SutureLoc implant retrograde from the inferomedial portal into the transtibial tunnel with the loop anchor mechanism at the transtibial tunnel aperture (blue arrow). (B) In a controlled fashion, the anchor is advanced and set deep to the tibial plateau (blue arrow).

week 6 when it is discontinued. After 6 weeks, patients should work on obtaining full ROM. A stationary bicycle also can be initiated to promote ROM and strengthening. Resistive exercises starting with closed-chain strengthening begin at 6 weeks and slowly progress to include proprioceptive activities and running by 12 weeks. Gradual return to athletic activity is permitted at 16 weeks, and patients are expected to return to sport during the ensuing 8 weeks. A functional return to sport performance test is recommended to ensure a safe transition back to full activity.

Discussion

The importance of early recognition and treatment of meniscal root tears is increasingly recognized due to the rapid progression of OA.[1,17] In the past, meniscal root tears were treated nonoperatively or with partial or total meniscectomy.[18] However, recent literature has led to a better understanding of the ensuing biomechanical consequences of these management options.[19-21]

Currently, meniscal root repair is the treatment of choice to restore kinematics and preserve the joint in patients without significant cartilage damage, joint space narrowing, or malalignment.[22,23] Meniscal root repair has demonstrated superior outcomes to meniscectomy.[24-26] Faucett et al.[27] suggested meniscus root repair not only delays the progression of OA but is also a cost-saving intervention compared with nonsurgical management or total meniscectomy. In a matched cohort based on patient characteristics, Bernard et al.[28] reported significantly decreased OA progression and subsequent knee arthroplasty in meniscal root repair compared with nonoperative management and partial meniscectomy. Moreover, LaPrade et al.[29] reported improved patient-reported outcomes, pain, function, activity levels, and high patient satisfaction with posterior meniscal root repairs.

Various meniscal root repair techniques have been described, but transtibial pull-out and suture anchor repair are the most common. Both methods allow for meniscal preservation through anatomic fixation of the meniscal root.[8] In a recent systematic review, Jiang et al.[30] reported anatomical repairs with 2 sutures resulted in better fixation and improved contact mechanics using either technique.

The transtibial pull-out repair uses tibial tunnels to anchor the meniscal root to the tibial plateau. Sutures

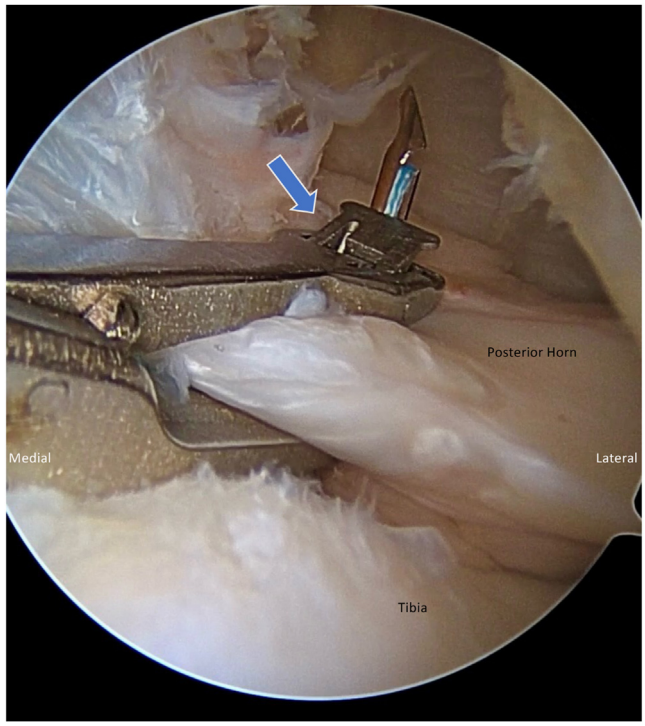

Fig 5. Using the inferomedial working portal in a left knee, the first repair suture is passed through the posterior lateral meniscal root tissue (blue arrow) using a Knee Scorpion suture passer device.

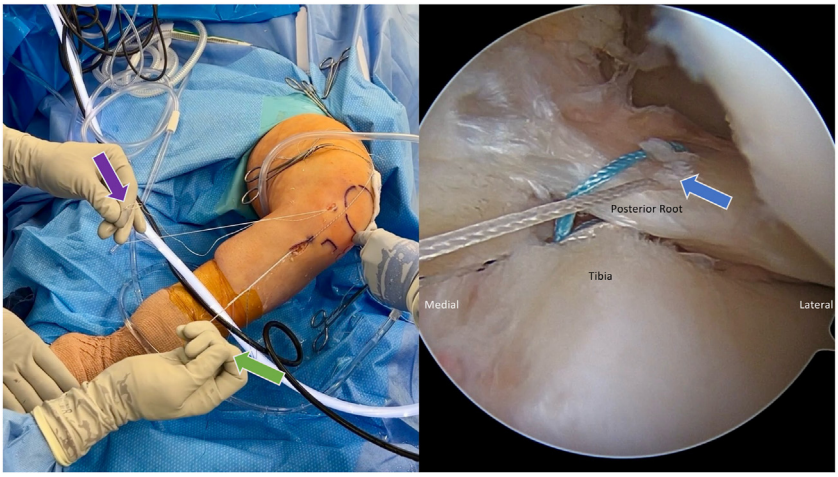

Fig 6. The white repair suture is loaded through the conversion suture loop and folded at the ink-mark indicator (purple arrow, left). The white/black conversion suture tail is pulled at the left knee anterior tibia (green arrow, left), shuttling the repair suture through the inferomedial portal (blue arrow, right) to convert it into the knotless mechanism.

are shuttled through the tibial tunnel and tied over a cortical bridge, cortical button, or post with a washer on the anterior tibial cortex, providing additional fixation and stabilization for the repair.[31] In addition, drilling the transtibial tunnels may contribute to a biologics component that can augment the meniscal root repair healing.[31] Traditionally, the transtibial pull-out repair technique utilizes a single tibial tunnel, but newer iterations incorporate a second transtibial tunnel.[31] The proposed benefit of adding a second tibial tunnel is the ability to restore more of the posterior meniscal root with a wider footprint to resist displacement and facilitate healing.[20,31,32] However, this is also considered a limitation, as 2 tunnels necessitate significant bone removal. In addition, this technique commonly utilizes a posterior portal, which is technically demanding and

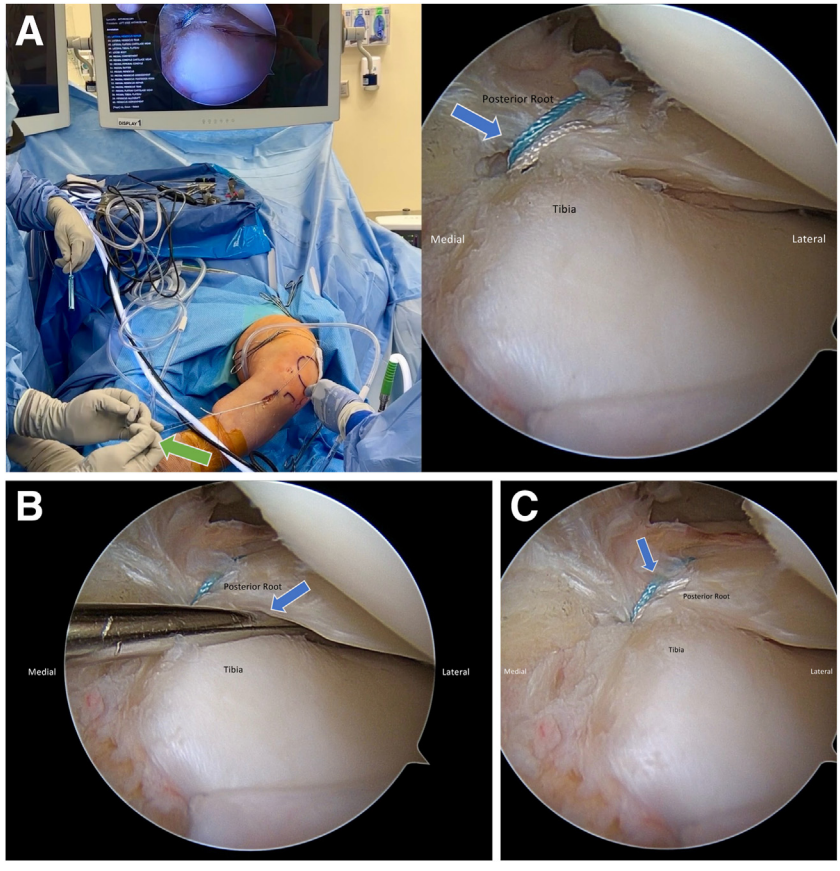

Fig 7. (A) The blue and white repair sutures are differentially retensioned under direct visualization through the inferolateral viewing portal (blue arrow, right) by pulling the suture tails at the left knee anterior tibia (green arrow, left). (B) With a probe through the inferomedial portal, appropriate tension is confirmed. (C) The final posterior lateral meniscus root repair is visualized from the inferolateral portal.

Table 2. Advantages and Disadvantages of Posterior Meniscus Root Repair Using a Retensionable All-Suture Anchor

Advantages	Disadvantages
Low-profile retensionable knotless all-suture implant	Learning curve
Eliminates posterior knee portals, reducing steps and simplifying the procedure	Implant cost
Direct tibia to meniscus fixation restoring the anatomic position	Absence of larger clinical studies that compare efficacy with existing methods
Minimal bone removal	
Inline conversion of the repair sutures eliminates the potential for sutures to cut into bone	

increases the risk of iatrogenic injury to the posterior neurovascular structures.[33] Similarly, accessory portals are often used to pass sutures, increasing the susceptibility for wound issues. The transtibial pull-out technique also may be less effective at restoring contact area than the suture anchor repair technique with increased extrusion detected on follow-up MRI.[34,35] Lastly, there is a concern for incomplete healing regardless of fixation type.[6,35]

We describe a lateral meniscus posterior root repair technique using the SutureLoc implant. The advantages of this technique include (1) low-profile soft, all-suture knotless implant; (2) eliminates the need for posterior knee portals; (3) direct tibia to meniscus fixation in an anatomic position; (4) 2 repair sutures with only one anchor pass; (5) minimal bone removal due to the smaller cannulated drill pin; (6) easy deployment of the anchor seated just below the tibial plateau; (7) inline conversion of the repair sutures eliminating the potential for sutures to cut into bone; and (8) the ability to dial in the repair under direct visualization with the retensionable technology (Table 2). Although this technique is simplified and more efficient overall, the learning curve associated with this technique may be considered a disadvantage. Additional disadvantages include the implant cost and the absence of extensive clinical studies comparing its efficacy with existing methods (Table 2). Despite these limitations, a retensionable all-suture anchor provides a vastly simplified, more efficient, reproducible option to achieve a robust anatomically positioned meniscal root repair.

Disclosures

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: R.M.F. reports a relationship with the American Academy of Orthopaedic Surgeons, American Orthopaedic Society for Sports Medicine, American Shoulder and Elbow Surgeons Arthroscopy Association of North America, International Cartilage Regeneration & Joint Preservation Society, International Society of Arthroscopy Knee Surgery and Orthopaedic Sports Medicine, *Journal of Shoulder and Elbow Surgery*, and *Orthopedics Today* that includes board membership; a relationship with AlloSource that includes consulting or advisory and speaking and lecture fees; a relationship with Arthrex that includes consulting or advisory, funding grants, and speaking and lecture fees; a relationship with JRF Ortho that includes consulting or advisory and speaking and lecture fees; and a relationship with Ossur that includes: speaking and lecture fees. All other authors (T.R.C., R.A.L., A.P., D.J.S., K.K.S.) declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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