Technical Note

# Securing the Root: Meniscus Root Repair with Rip Stop and Cannulated Drilling

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**Abstract:** Meniscal root pathology has garnered increased attention over the past decade. Meniscal root tears are considered to essentially represent a meniscus-deficient state, which has led to a rise in the surgical fixation of this pathology. Meniscus root tears are classified as either radial tears within 1 cm of the root insertion, or a direct avulsion of meniscal root. These injuries are important to recognize because they contribute to impaired joint mechanics and rapid articular cartilage degeneration. Given this, there remains significant interest in identifying novel surgical techniques that may facilitate better surgical repair and enhance patient outcomes. The purpose of this technical note is to describe a surgical technique for a medial meniscus root ripstop repair with cannulated drilling. This technique is simple and reproducible, while also allowing for the augmentation of potentially poor tissue quality.

The menisci were once thought to be vestigial structures; however, it is now known that they play an essential role in the knee.[1] These crescent-shaped fibrocartilaginous structures confer joint congruity, shock absorption, load transmission, lubrication, proprioception, and stability to the knee joint.[1-5] Meniscus injuries are common knee injuries, with an estimated prevalence of 60 to 70 per 100,000 people.[6] Previous work demonstrates that meniscal injury initiates a pathway of altered knee kinematics, and increased peak contact stresses, which ultimately accelerates the risk of degenerative changes and early osteoarthritis.[7,8] As a result, there has been trend toward increased surgical repair of the menisci.[9]

Meniscal root injuries specifically are a subset of meniscus injuries that have been the focus of much attention recently. Meniscus root injuries are seen as radial tears within 1 cm of the root insertion or a direct bone or soft tissue avulsion of meniscal root from the tibia.[10,11] These are significant injuries because meniscal root integrity is a prerequisite for normal meniscal biomechanics. The meniscal roots contain supplemental fibers that improve the strength and stiffness of the meniscal attachment. Injury to the posterior meniscal attachment is associated with meniscus extrusion and an inability to convert axial loads into hoop stresses, which contributes to accelerated degenerative changes within the knee.[12,13] The significance of this injury is further highlighted by biomechanical work, which demonstrates no difference in peak tibiofemoral contact pressures after total medial meniscectomy, or posterior meniscus root tear.[14,15]

Current treatment options for patients with a meniscus root injury include nonoperative treatment, partial meniscectomy, or meniscus root repair. Nonoperative treatment fails to restore normal joint biomechanics, and thus, it is typically reserved for patients who are poor surgical candidates, elderly, or those with significant articular cartilage degeneration.[10,13] Historically, partial, or complete meniscectomy was a frequently employed surgical treatment for meniscus root tears; however, better understanding

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*The authors report the following potential conflicts of interest or sources of funding: C.N. reports royalties or licenses from Arthroscopy, consulting fees from Guidepost, speaker fees from Arthrex and Vericel; editorial board membership in* Arthroscopy*; board membership in AAOS, American Orthopaedic Society of Sports Medicine, and Arthroscopic Society of America; and other financial and nonfinancial interests from AO Foundation. Full ICMJE author disclosure forms are available for this article online, as supplementary material.*

*Received March 21, 2023; accepted May 27, 2023.*

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*2212-6287/23447*

*https://doi.org/10.1016/j.eats.2023.05.012*

regarding the function of the meniscus root has led to a shift away from this methodology. Today, meniscectomy is used sparingly and most often for patients with chronic meniscus injuries, and/or concomitant degenerative cartilage pathology.[10] The current paradigm suggests that the meniscus root should be repaired to convey symptomatic relief and to prevent the progression of articular cartilage injury whenever possible.

Current meniscal root repair methods include options that utilize suture anchors offering direct fixation into the plateau, or transtibial tunnel techniques with suture repair.[16-18] Overall, both techniques are associated with improved patient outcomes, with the suture anchor technique considered more technically challenging, as it may require an accessory posterior portal.[19] This technical note describes a reproducible arthroscopic meniscal root ripstop repair with transosseous cannulated drilling.

## Surgical Technique

### Patient Evaluation

Patients with a posterior root meniscus tear may present with or without a history of recent trauma with an associated audible "pop", typically occurring in deep flexion. Clinical diagnosis may prove challenging because clinical symptoms are highly variable. Patients may have some degree of knee effusion, posterior knee pain, pain with deep flexion, or a feeling of instability.

### Imaging

Radiographs are most often within normal limits (Fig 1, A and B), so magnetic resonance imaging (MRI) is the diagnostic imaging modality of choice. Patients should be evaluated for pre-existing osteoarthritis to ensure they are an appropriate candidate for meniscal repair. Extremity alignment radiographs should also be obtained, as they may demonstrate coronal plane deformity that may need to be considered when surgical treatment is indicated. (Fig 1C) MRI is the gold standard in the diagnosis of meniscal tears and T2-weighted sequences are often the best to identify meniscus root tears. (Fig 2A) Even with MRI, the diagnosis remains challenging, as meniscus root tears may present as fluid accumulation or degeneration signal without evidence of a visible tear. Meniscal extrusion is one sign that should increase clinical suspicion for a possible meniscal root injury (Fig 2B).

### Indications

As we continue to learn more about the importance of the meniscus root, surgical indications continue to evolve. But prompt surgical repair of the meniscus root is recommended for most patients with acute or chronic tears without evidence of articular cartilage disease to manage symptoms and potentially slow progression of degenerative changes. Patients with chronic injuries and persistent symptoms who have preexisting arthritis may benefit from limited partial meniscectomy. Nonoperative treatment is often reserved for patients who are poor surgical candidates, elderly, or those with grade III/IV chondromalacia in the ipsilateral compartment.[20] Additionally, patients who are unwilling, or unable to comply with the postoperative rehabilitation protocol are also poor operative candidates.

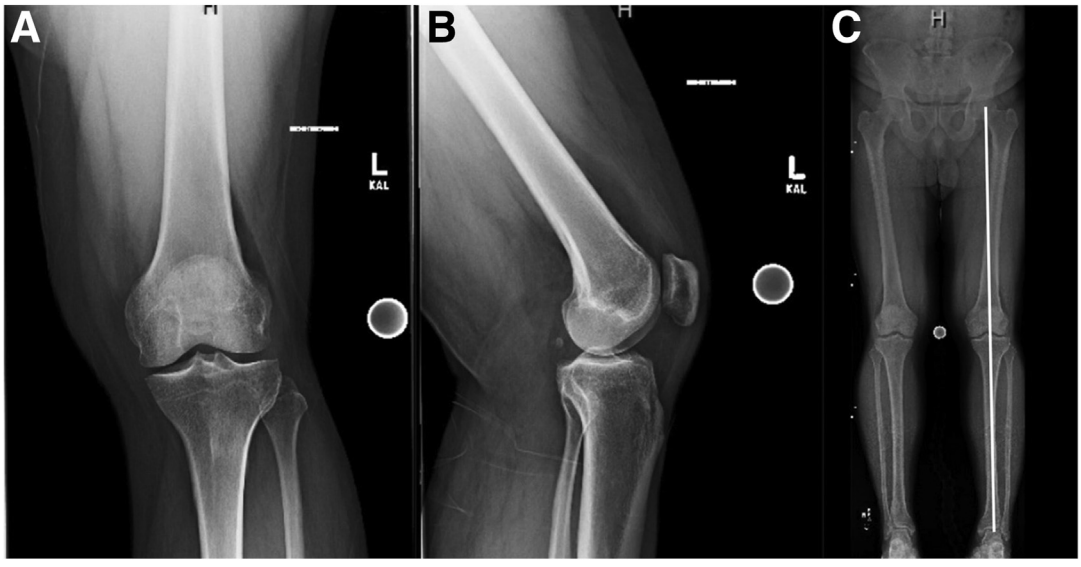


**Fig 1.** (A and B) Anteroposterior and lateral radiographs of the left knee. (C) Extremity alignment radiographs evaluating the alignment of the bilateral lower extremities demonstrating neutral mechanical alignment of the left lower extremity.

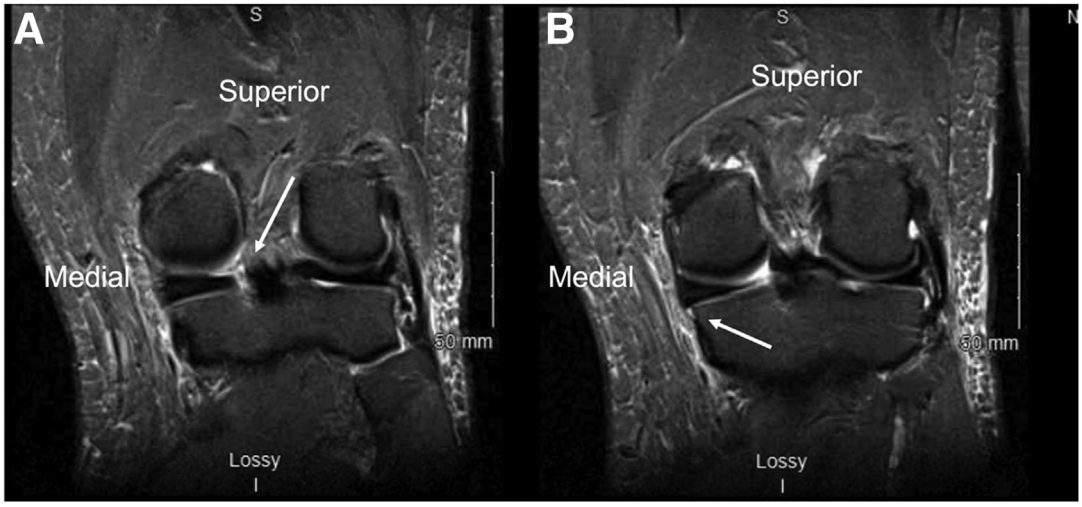


**Fig 2.** T2-weighted coronal MRI images demonstrating a posterior root medial meniscus tear (white arrow) (A), as well as associated meniscal extrusion (white arrow) (B).

## Patient Positioning

The ripstop medial meniscus root repair (Video 1, Table 1) can be performed under general anesthesia with a regional block. Patients are positioned supine with a lateral post of the surgeon's choosing. We elect to use a nonsterile tourniquet; however, in larger patients, this can impede visualization acting as a venous tourniquet and will not be used if this is the case. If used, the tourniquet is placed high on the operative extremity and the leg is exsanguinated to 250 mmHg.

## Meniscus Root Ripstop Repair Technique

A standard two-portal technique for the arthroscopy is performed. A 30° arthroscope with inflow and outflow is used in the anterolateral portal. A complete diagnostic arthroscopy is performed, and all findings are documented with intra-articular photography. Absence of grade 4 articular changes are confirmed. The knee is placed in ~30° of flexion with a valgus force, and an anteromedial portal is created under direct visualization. This portal is used to introduce instrumentation and probe the posterior root. Posterior root tear should be confirmed (Fig 3).

Depending on medial compartment viewing access, partial release of the MCL is often required to facilitate access and limit iatrogenic damage to the medial femoral condyle. The senior author's preferred technique for increasing visualization of the posterior root of the medial meniscus consists of a mini-open release of the anterior fibers of deep MCL through the same incision used for the tibial tunnel and has been previously reported.[21] This is repaired at the conclusion of the case. A 2-cm incision is made ~1-2 cm medial to the tibial tubercle. Dissection is carried to the sartorial fascia. The fascia is then carefully lifted and incised to avoid iatrogenic damage to the superficial MCL. Then bovie electrocautery and an elevator are used to subperiosteally release the deep MCL from the tibia as a sleeve for later repair.

The arthroscope is reintroduced to the joint via the anterolateral portal and the efficacy of the release is assessed. A passport (Arthrex Inc., Naples FL) cannula is placed in the AM portal to prevent any potential suture bridging during repair. A ring curette is used to remove cartilage from the meniscal root footprint. Fibrinous meniscal tissue is debrided as needed. Once the area is prepared, the root repair sutures are passed. First, an inverted mattress stitch using suture tape (Arthrex) is placed in the root. The suture tape is loaded

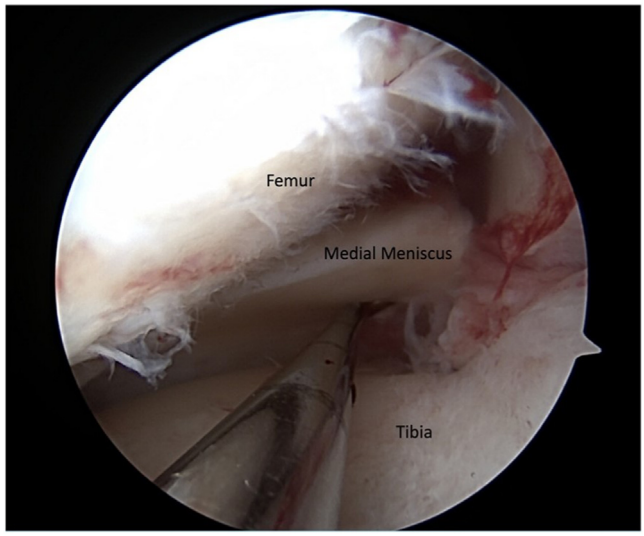


**Fig 3.** Arthroscopic image of a left knee with a 30° arthroscope viewing from a standard anterolateral portal. Evidence of medial meniscus posterior root tear is shown.

**Table 1.** Rip Stop Meniscus Root Repair Surgical Technique

| |
|---|
| 1. Patient is positioned supine with a lateral post, with or without tourniquet. |
| 2. A standard two-portal diagnostic arthroscopy is performed to confirm preoperative imaging findings. |
| 3. Knee is placed in ~30° of flexion with a valgus force, and an anteromedial portal is created under direct visualization. |
| 4. At this time, a partial release of the MCL may be performed to facilitate access and limit iatrogenic damage to the medial femoral condyle. |
| 5. An arthroscope is reintroduced into the joint via the anterolateral portal and a passport is introduced into the AM portal to prevent suture bridging. |
| 6. The meniscus footprint is debrided to remove cartilage and fibrinous debris. |
| 7. First an inverted mattress stitch using suture tape is placed in the root. The suture tape is loaded into the knee scorpion self-retrieval device and passed from the inferior surface of the meniscus to the superior surface. The suture tape is then reloaded and passed from superior to inferior on the meniscus close to the end of the root, using the self-passing device in an inverted fashion. |
| 8. Next 2 cinch sutures are placed between the 2 passes of the suture tape, and posterior to the horizontal limb. They are passed in a locking luggage tag configuration. |
| 9. A meniscal root guide is placed through the anteromedial portal and positioned on the footprint of the posterior root. |
| 10. The drill guide is set to 65° and pushed onto the anteromedial face of the tibia. |
| 11. A 2.4-mm guide pin is then drilled, and the position of the pin on the tibial plateau is evaluated before the pin is overreamed with a 4.0-mm cannulated reamer. |
| 12. The guide pin is then removed, and a nitinol passing wire is inserted through the cannulated reamer and retrieved out of the AM portal. |
| 13. The repair sutures are then passed through the nitinol passing wire and shuttled through the transosseous tibial tunnel. |
| 14. The knee is flexed to 90°, and the sutures are fixed to the anteromedial cortex of the tibia with a knotless biocomposite anchor. |

into the knee scorpion (Arthrex) self-retrieval device and passed from the inferior surface of the meniscus to the superior surface. This is done at a distance sufficient to allow additional suture passes lateral to this. The suture tape is then reloaded and passed from superior to inferior on the meniscus close to the end of the root, using the self-passing device in an inverted fashion. This pass is done with sufficient space from the first pass to allow for two additional suture passes between this spanning stitch, allowing it to effectively create a rip stop within the meniscus. Next 2 cinch sutures are placed between the 2 passes of the suture tape, and posterior to the horizontal limb. They are passed in a locking luggage tag configuration. This allows the cinch stitches to encompass both the meniscal tissue and the suture tape, helping to supplement potentially poor-quality or degenerative tissue, and prevent potential pullout (Fig 4).

Once satisfied with the suture configuration, a meniscal root guide (Smith and Nephew, London UK) is placed through the anteromedial portal and positioned on the footprint of the posterior root. The drill guide is set to 65° and pushed onto the anteromedial face of the tibia through the incision previously used to release the MCL. This may be malleted into the tibial cortex for increased stability of the guide position at the surgeon's discretion. A 2.4-mm guide pin (Arthrex) is then drilled, and the position of the pin on the tibial plateau is evaluated. Once the position is deemed anatomic, the pin is overreamed with a 4.0-mm cannulated reamer. The guide pin is then removed, and a nitinol passing wire is inserted through the cannulated reamer and retrieved out the anteromedial portal.

The repair sutures are then passed through the nitinol passing wire and shuttled through the transosseous tibial tunnel. The previously placed passport is critical in this step for preventing any soft tissue bridges. The sutures are used to reduce the root and assess its position. The two cinch sutures pull not only on the meniscal tissue, but against the rip stop-inverted mattress, which allows for greater repair strength in cases of compromised tissue quality. At this point, the knee is flexed to 90°, and the sutures are fixed to the anteromedial cortex of the tibia with a knotless biocomposite anchor (Arthrex). The joint is then again inspected via the arthroscope to ensure no iatrogenic injury and that the root repair is anatomic and well tensioned. (Fig 5) Additionally, the senior author will routinely perform a microfracture/marrow stimulation of the intercondylar notch to increase healing potential.

Following completion of the repair, the tourniquet is deflated. The deep MCL and sartorial fascia are reapproximated with a double loaded all suture anchor (Arthrex).[21] The wound is irrigated, and a layered closure is performed. A sterile dressing is applied, as well as a hinged knee brace locked in extension prior to patient awakening.

## Rehabilitation

Following the surgical procedure, the patient is seen postoperatively at the following intervals: 2 weeks, 6 weeks, 3 months, 6 months, and 1 year. Physical therapy is initiated within the first week after surgery, with the goal of controlling pain and swelling, increasing range of passive motion, and minimizing quadriceps atrophy. For the first 4 weeks, the patient maintains toe-touch weight bearing restrictions in a hinged knee brace locked in extension. Range of motion is restricted to 0-90° with therapy for the first

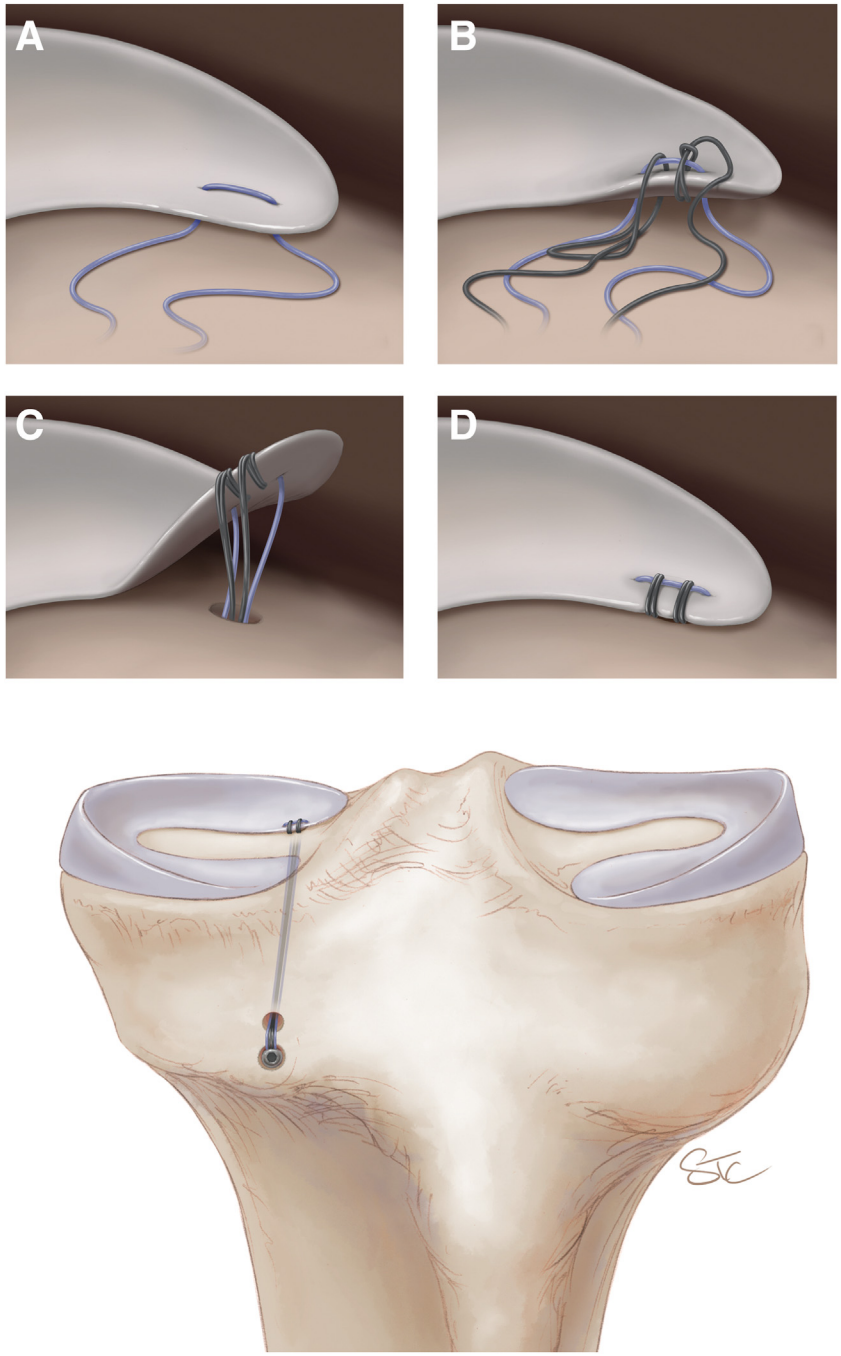


**Figure 4.** Illustrations demonstrating a rip stop meniscus root repair construct and technique. (A) The blue stitch is the inverted horizontal mattress rip stop. (B) Two black cinch stitches are placed through the meniscus and around the rip stop stitch. (C) A transtibial tunnel is drilled, and the sutures are shuttled into and through the tibia. (D) Final reduction with the sutures fixed on the anterior cortex of the anteromedial tibia with a suture anchor.

4 weeks. At 4 weeks, the patient can unlock their brace and advance to weight bearing as tolerated, with no weight bearing beyond 90°. From 6 weeks on, the range of motion is gradually increased, as tolerated. The brace is typically discontinued at 8-12 weeks. Jogging and running are begun at 3 months, as well as more aggressive strengthening and sport-specific activity. Patients are subsequently advanced through the physical therapy protocol with the goal of returning to full activity by 5-6 months.

## Discussion

The meniscal root plays a paramount role in preserving the function of the meniscus. Previous work demonstrates injury to the posterior meniscal root leads to meniscus extrusion, an impaired ability to convert axial loads into hoop stresses, and accelerated degenerative changes within the knee.[12,13] Further, biomechanical studies suggest that posterior root tears are clinically equivalent to total meniscectomy.[14,15] Meniscal root repair has been demonstrated to restore

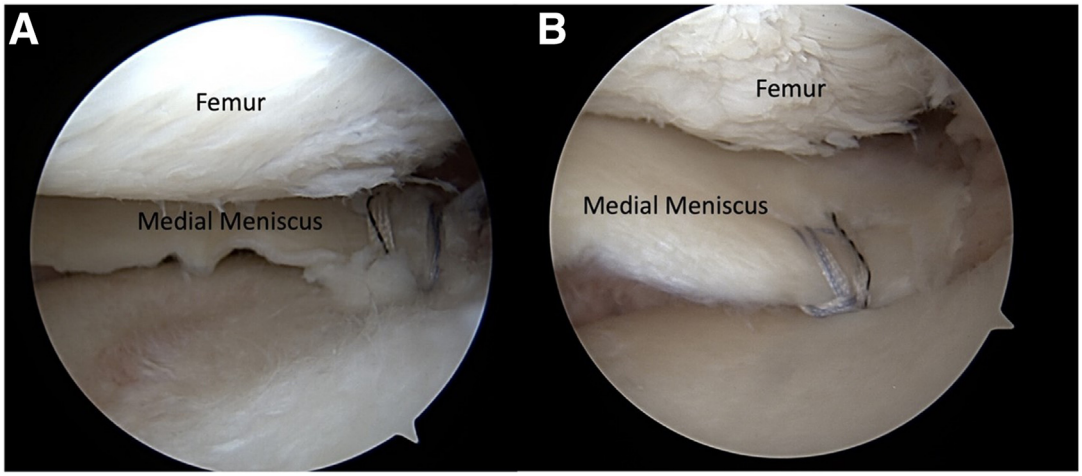


**Fig 5.** Arthroscopic image of a left knee with a 30° arthroscope viewing from a standard anterolateral portal. A and B demonstrate final configuration of a rip stop medial meniscus root repair.

**Table 2.** Pearls and Pitfalls of the Rip Stop Meniscus Root Repair Technique

| Pearls | Pitfalls |
|---|---|
| Mechanical alignment radiographs can be obtained preoperatively to evaluate for coronal plane deformity that may impact meniscal repair. | Failure to recognize clinical varus may lead to mechanical failure of the construct. |
| In patients with a tight medial compartment, a percutaneous pie crust or mini-open release of the deep MCL can be performed through the same incision used for the tibial tunnel. | Poor visualization can make this procedure technically challenging and lead to increased iatrogenic cartilage damage |
| Use of a passport cannula in the anteromedial portal may minimize the changes of soft tissue bridges during the repair. | Lack of a cannula may lead to suture tangling or soft tissue bridges during suture passage |
| Place 2 cinch sutures posterior to the inverted horizontal mattress rip stop stitch to enhance the strength of the repair. | Inadequate spacing of the sutures can lead to suture tangling, also failure to place the cinch stitch posterior enough, or placing the rip stop too posterior may lead to the rip stop stitch being pierced by the passing needle. |
| Careful attention to anatomic location of the tunnel will improve the biomechanics of the repaired meniscus. | Poor tunnel placement may lead to early failure. |
| Proper patient selection is essential to ensure predictable postsurgical outcomes. | Failure to adhere to postoperative protocol may lead to ongoing pain, stiffness, or otherwise poor clinical outcome. |

**Table 3.** Advantages and Disadvantages of the Described Techniques

| Advantages | Disadvantages |
|---|---|
| Anatomic technique for posterior root meniscus tear repair with smaller tunnel at footprint than other techniques. | Requirement for transtibial tunnel may be difficult in patients with concomitant ligamentous injuries and careful attention needs to be paid to tunnel convergence. |
| Use of the rip stop configuration minimizes chances of failure at tissue-suture interface. | Suture crowding can occur if surgeon is not precise and deliberate with suture passage. |
| Use of cannulated drill guide leads to increased repair precision and nitinol wire passing. | A skilled assistant is needed to ensure that the drill bit remains in place during wire passage. |
| The described technique does not require accessory posterior portal or costly implants. | Instrumentation used for this technique may not necessarily be available to all surgeons. |
| Self-retrieval device makes suture passage easy. | If adequate space is not afforded for suture passage the internal needle in this device can break against the bone of the femoral condyle or tibial plateau. |

peak contact forces to within normal levels and to minimize arthritic progression.[14,22,23] Given the significance of this injury pattern, there has been much interest in continuing to refine meniscal root repair strategies.

Current techniques can be classified as either transtibial tunnel pull-out repair or all-inside direct repair.[13] With transtibial techniques, various configurations of sutures can be passed through the meniscus root and subsequently shuttled through a tibial bone tunnel. The requirement for a transosseous tibial tunnel could be a negative in patients who require concomitant tunnels for other intra-articular pathology (e.g. multiligament reconstruction patients). With all-inside techniques, however, implants can be used to directly secure the meniscal root to the tibia. All inside techniques may be considered more technically demanding because they may require the use of an accessory posterior portal. Further, in some regions, there may be financial considerations associated with the use of these implants. Ultimately, both techniques have been associated with improved patient outcomes[22] therefore, repair technique is at the surgeon's preference.

This technical note presents a variant of a transtibial tunnel pull-out repair featuring a meniscal root ripstop repair with cannulated drilling and anteromedial tibial anchor fixation. Previous transosseous techniques have been described using various suture configurations, including a combination of simple stitches, a modified Kessler stitch, Mason-Allen, horizontal mattress, or a loop stitch.[24,25] The present technique is a rip stop repair configuration in which an inverted horizontal mattress suture is placed anterior to two meniscal repair cinch stitches. Placing the inverted horizontal mattress stitch anterior to the cinch serves to reinforce the two posterior repair stitches. The two cinch sutures pull not only on the meniscal tissue, but against the rip stop-inverted mattress, which provides greater repair strength. This technique offers utility in patients with poor tissue quality, as the horizontal mattress ripstop configuration minimizes the likelihood of suture pull out.[26] Previous work demonstrates that the addition of a vertical mattress rip stop is associated with a lower likelihood of suture pull-out.[24] There are several technical considerations with this technique of which the surgeon should be aware when performing this procedure (Table 2).

Meniscal root tears are significant injuries that require prompt attention to restore normal joint biomechanics and minimize joint degeneration. This technical note describes a transosseous medial meniscus root ripstop repair with cannulated drilling, which may prove useful in patients with poor tissue quality. There are numerous advantages of using this technique when considering meniscal root repair (Table 3).

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