Technical Note

# Combined Rip-Stop and Transtibial Pull-out Technique for Lateral Meniscus Radial Repairs

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**Abstract:** Radial tears of the meniscus disrupt circumferential fibers that allow for the dispersion of axial tibiofemoral forces. Both nonoperative treatment and meniscectomy carry increased risk of early-onset degeneration of the joint because of decreased contact surface area and increased point-loading of the chondral surfaces. Radial type tears are also notable for the relatively high failure rate associated with repair. The purpose of this technical note is to demonstrate our surgical technique for a radial lateral meniscus repair construct that allows for good apposition and anatomic reduction of the meniscus with less risk of residual postoperative extrusion through use of a combination inside-out rip-stop and transtibial pull-out suturing repair.

Intact menisci maintain the joint contact surface area and allow dispersion of axial loads via hoop stresses through circumferentially oriented fibers (Figs 1, 2).[1] Disruptions of the menisci, especially to their circumferential integrity (such as radial and root tears), are concerning for the increased risk of increased point-loading to tibiofemoral cartilaginous surfaces resulting in early accelerated osteoarthritis (Fig 3).[1-3] Studies report that patient-reported outcomes improve after surgical repair of radial meniscal tears, and there is a strong body of evidence to support concurrent meniscal repair with anterior cruciate ligament procedures.[4-6]

Biomechanical and clinical studies have shown several advantages for both inside-out rip-stop and transtibial pull-out repair techniques for the treatment of radial meniscus tears. Advantages include better preservation of meniscal apposition under continued cyclic loading compared to other techniques, and the transtibial pull-out repair significantly normalizes tibiofemoral contact pressures.[2,7-13] Therefore we present our technique for repair of lateral meniscus

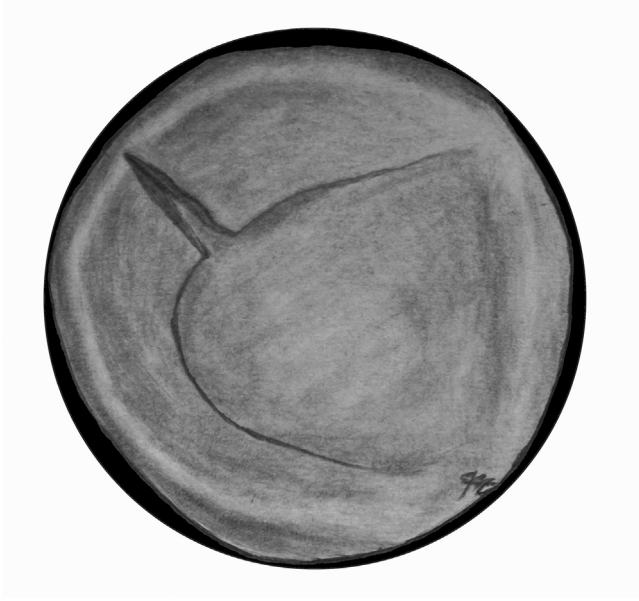

**Fig 1.** Illustration depicting a radial tear (as seen from above) disrupting circumferential meniscal integrity near the junction of the body and posterior horn. Artwork by MDH.

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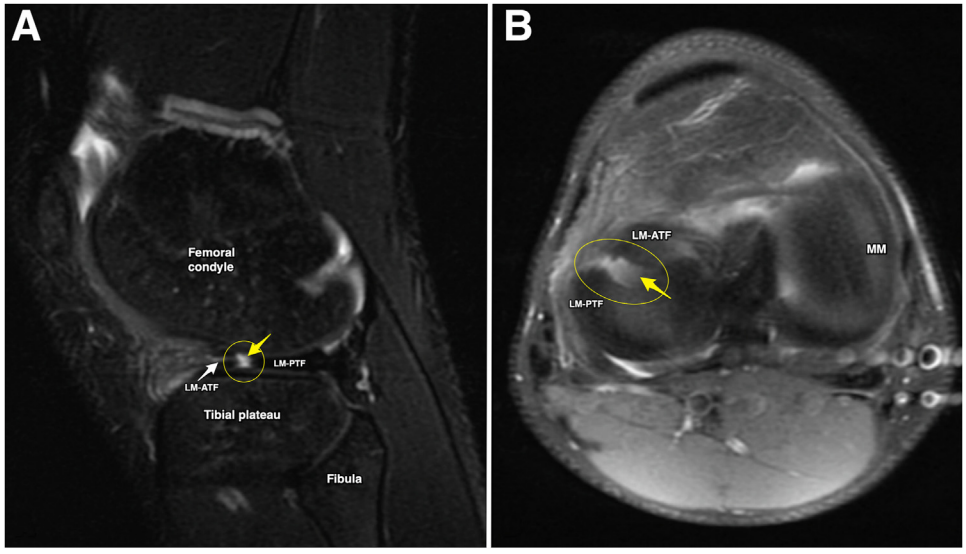


**Fig 2.** Magnetic resonance imaging sagittal T2-weighted (A) and axial FS-PD (B) sections depicting a complete radial tear of the lateral meniscus in a right knee near the junction of the anterior horn and body. Fluid is visible (yellow circles and arrows) between the lateral meniscus anterior tear flap (LM-ATF) and lateral meniscus posterior tear flap (LM-PTF). MM, medial meniscus.

radial tears, using a combined inside-out rip-stop suture technique with transtibial pull-out repair.

## Surgical Technique

The technique is detailed in Video 1. Pearls and pitfalls and advantages and disadvantages of this approach are discussed in Tables 1 and 2, respectively.

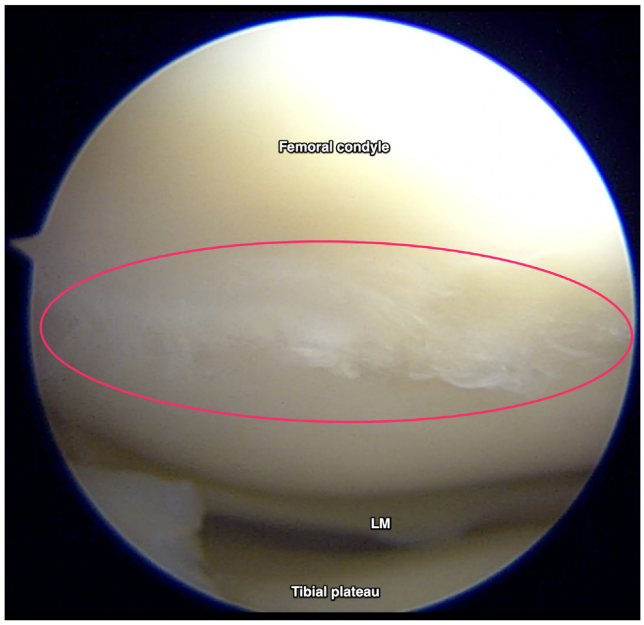


**Fig 3.** Arthroscopic view of a right knee lateral compartment depicting development of chondromalacia on the lateral femoral condyle (circled in red). In a healthy, 17-year-old athlete with a 2-month history of complete radial tear of the lateral meniscus (LM); this is most likely due to increased point loading on the tibiofemoral cartilage.

### Patient Positioning

The patient is positioned supine on the operating table. After induction of general anesthesia, the patient is examined bilaterally for knee range of motion, ligamentous stability, and mechanical symptoms. A well-padded high-thigh tourniquet is applied, and the surgical limb is placed in a leg holder (Mizuho OSI, Union City, CA). The nonsurgical extremity is placed in a leg abduction stirrup (Birkova Products, Gothenburg, NE).

**Table 1.** Pearls and Pitfalls

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| Pearls |
| Meniscocapsular release may be used to achieve satisfactory reduction and apposition with tears that have scarred out of the joint in an extruded position. |
| Use of rip-stop–type vertical mattress sutures on either side of the tear allows for the horizontal mattress sutures to pull against suture material rather than meniscus alone. This decreases risk of pull through. |
| The transtibial pull-out suture should be tied over the tibia using a surgical button to allow secure fixation and postoperative radiographic visualization of the cortical button location. |
| Postoperative rehabilitation focuses on early limited range of motion to reduce motion loss while protecting the repair. |
| A lateral unloader brace may be considered to help protect the repair, especially when genu valgum exists. |
| Pitfalls |
| Inadequate reduction before fixation requires increased suture tension across the tear site to achieve apposition, increasing the risk of suture cutout and residual meniscal extrusion. |
| Improper placement of the internal tunnel aperture may result in residual meniscal extrusion (too peripheral), over-reduction of the meniscus (too central), or inadequate meniscal apposition (not centered with tear). |
| Placement of the horizontal sutures too far away from the vertical "rip-stop" sutures negates their ability to resist suture cutout and may result in gapping of the repair if there is cutout. |
| Improper tunnel orientation may lead to tunnel convergence during concomitant or follow-up procedures. |
| Inadequate rehabilitation protocols may lead to violation of the repair before the tissue has healed. |

**Table 2.** Advantages and Disadvantages

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| Advantages |
| The repair is an anatomic technique that both reduces and anchors the meniscal tear site to better restore tibiofemoral contact mechanics. |
| Two vertical mattress sutures with four spanning horizontal sutures, 2 superior and 2 inferior, provide a cutout strength of >250 N. |
| Drilling of a transtibial tunnel allows for localized release of biologic factors that may aid the healing response. |
| Disadvantages |
| An additional transtibial tunnel and suture fixation device are needed. This may lead to increased postoperative irritation at the fixation site. |
| Requires additional sutures and an additional lateral incision and is more technically challenging. |
| The addition of a transtibial tunnel necessitates careful preoperative planning to avoid tunnel convergence with concomitant procedures. |

## Surgical Approach

Standard anterolateral and anteromedial arthroscopic portals are created. The joint is insufflated with normal saline solution, and a 30° arthroscopic camera (Smith & Nephew, Andover, MA) is inserted. An arthroscopic shaver (Smith & Nephew) is used to debride any significant adhesions. After a general diagnostic assessment, the site of the tear is probed thoroughly to assess tear flap mobility and orientation (Fig 4). The meniscocapsular ligaments are assessed, and an arthroscopic grasper (Alligator grasper; Smith & Nephew) is used to assess mobility and reducibility of the tear flaps (Fig 5). If necessary, arthroscopic rotary scissors (ACUFEX; Smith & Nephew) may be used to perform a peripheral release by cutting along the meniscocapsular junction (both superior and inferior but leaving the midbody attached) to the extent necessary for an anatomic reduction without excessive tension (Fig 6).

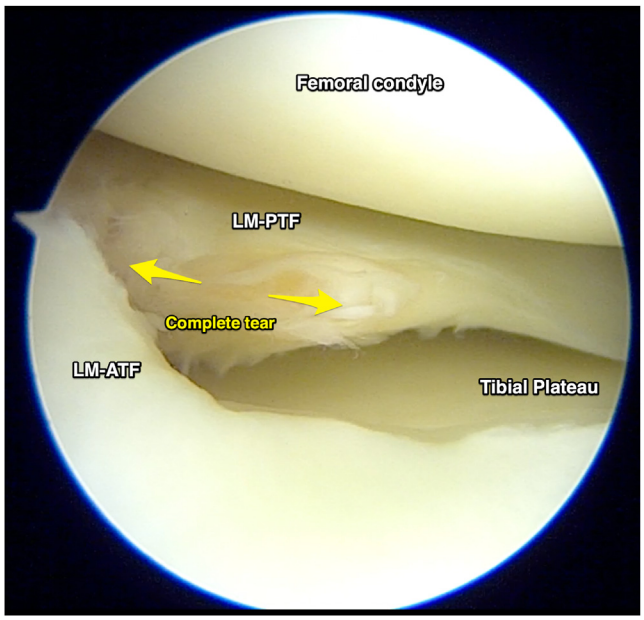


**Fig 4.** Arthroscopic view of a right knee lateral compartment depicting a complete lateral radial meniscal tear (yellow arrows). LM-ATF, lateral meniscal anterior tear flap; LM-PTF, lateral meniscal posterior tear flap.

## Transtibial Pull-Out Tunnel and Fixation

A skin incision for the transtibial tunnel is made approximately 5 cm distal to the joint line just medial to the tibial tubercle (Fig 7). After sharp dissection down to the periosteum, a Cobb elevator is used to elevate the periosteum so a surgical button may be later fitted directly against the bone. A tibial drill guide (Smith & Nephew) is used to establish the trajectory and to drill a pin from the anteromedial tibia to a point centered at the radial repair and 2 mm central to the peripheral edge of the tibial cartilage (Fig 8). A 2.4 mm cannula remains in place for suture passage when the drill pin is removed. A suture passing device (Mini FirstPass; Smith & Nephew) is used to pass suture tape in a vertical mattress configuration along the tear site of the posterior flap. A suture wire passer (Smith & Nephew) is used to withdraw the suture tape through the tibial cannula. Tension is applied to the suture while visualizing the posterior tear flap to ensure it reduces appropriately. The suture tape is tied down over a cortical fixation device (Endobutton; Smith & Nephew) on the anteromedial tibia (Fig 9) while visually assessing for reduction and proper tension.

## Inside-Out Rip-Stop Repair

The lateral joint capsule is exposed exteriorly via an incision made along the inferior border of the iliotibial band (Fig 10). Using the suture passer, a vertical mattress "rip-stop" suture is placed through the anterior tear flap and passed through the lateral capsule and tied in place. Two horizontal mattress sutures spanning the defect are placed superiorly just outside the vertical mattress rip-stop sutures and similarly passed through the joint capsule and tied outside. Two additional horizontal spanning sutures are placed from the inferior aspect of the meniscus for a total of four horizontal sutures. The final construct is visualized and probed for stability (Fig 11).

## Postoperative Protocol

Biomechanical studies provide evidence that early loading of transtibial pullout repairs before healing may cause loosening of the repair.[14] To avoid damaging the construct, the patient is made non-weightbearing in an immobilizer brace for 6 weeks after surgery. Physical therapy starts on postoperative day 1 with an early focus on pain control, reduction of edema, and knee motion. Knee range of motion is limited to 0° to 90° flexion for the first 2 weeks, after which it may be increased as tolerated. At 6 weeks after surgery, the

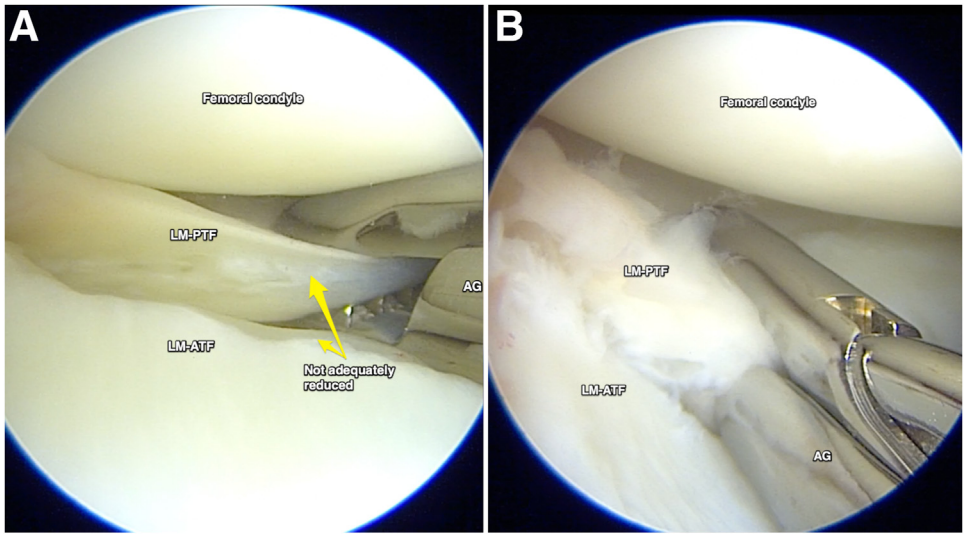


**Fig 5.** Arthroscopic views of a right knee lateral compartment depicting an arthroscopic grasper (AG) mobilizing the lateral meniscal posterior tear flap (LM-PTF) both before (A) and after (B) peripheral release of the meniscocapsular and meniscotibial ligaments, demonstrating increased reducibility of the LM-PTF after peripheral release. LM-ATF, lateral meniscal anterior tear flap.

patient may begin a partial protected weightbearing plan and wean off crutches slowly over several weeks until they can ambulate without a limp. When weightbearing is initiated, a lateral unloader brace may be used, especially if the patient has some degree of genu valgum. The brace may be worn until 4 months after surgery. The patient should avoid squatting, squatting and lifting, sitting cross-legged, and crossing their legs for the first 4 months after surgery to avoid excess stress on the repair. At our facility, patients may begin a gradual return to activity at 5 months after surgery in alignment with the level of their rehabilitation regime. Ultimate clearance for return to all activities is determined after patients pass a series of functional sports tests, clinical examination, and evaluation of radiographs. Return to all activities typically occurs around 6 to 7 months after surgery.

## Discussion

Repair is preferable to meniscectomy for complete radial tears of the meniscus, particularly in a young, athletic patient and when the defect is large, causes mechanical symptoms, or significantly disrupts normal meniscal function. Professional athletes who underwent lateral meniscectomy had a roughly 40% chance of not returning to play, and this was significantly worse for positions requiring high speed.[15] Because of the high risk of failure of meniscal repairs in general, a repair technique with increased strength is desirable. The rip-stop technique detailed herein was shown to

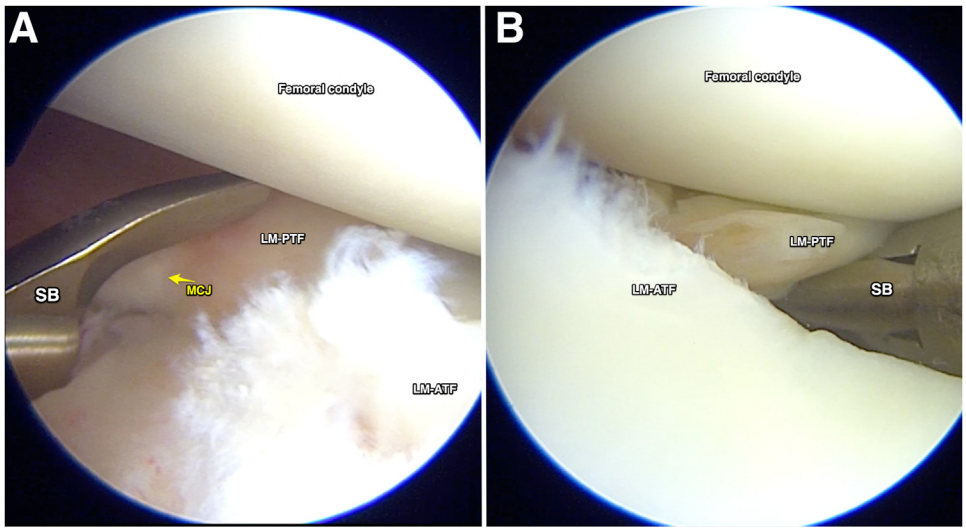


**Fig 6.** Arthroscopic view of a right knee lateral compartment demonstrating peripheral release of the lateral meniscal posterior tear flap (LM-PTF) both at the meniscocapsular attachments (A) and the meniscotibial attachments (B). SB, scissor biter; MCJ, meniscocapsular junction; LM-ATF, lateral meniscal anterior tear flap.

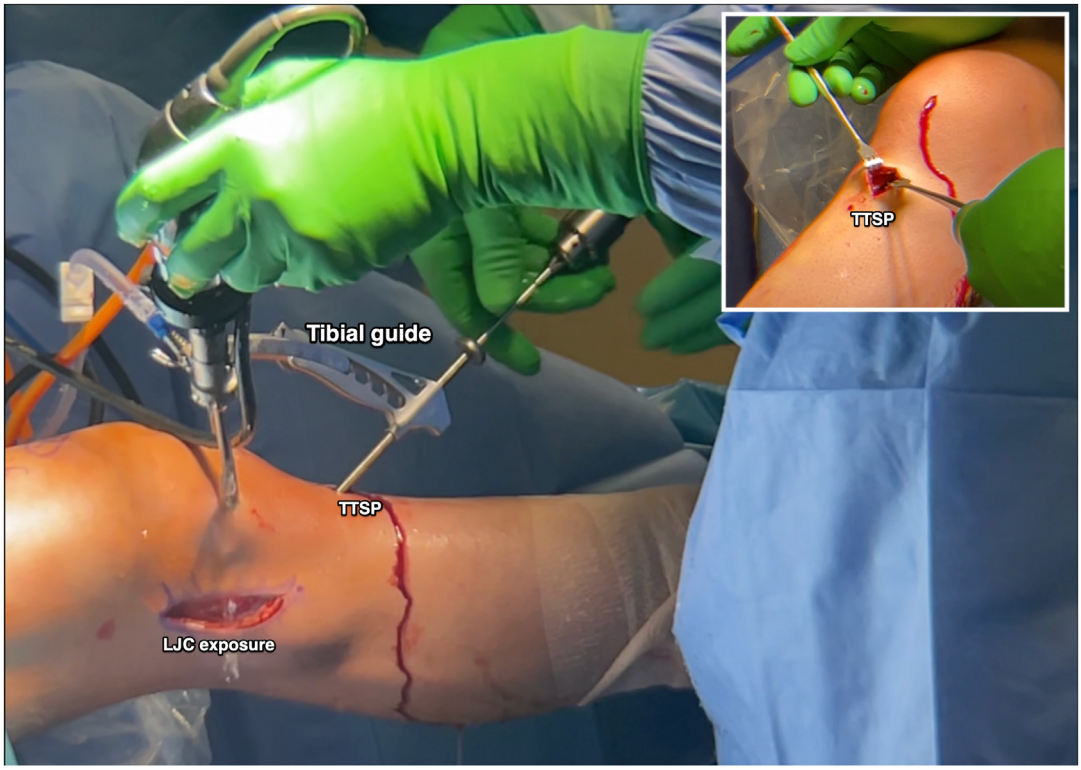


**Fig 7.** Intraoperative image of a right knee demonstrating the external location of the tibial tunnel starting point (TTSP) and orientation of the tibial guide and drill. LJC: lateral joint capsule.

have a >250N ultimate failure load, more than doubling the average ultimate failure load in a classic horizontal hashtag or cross-tag repair, likely because of the increased number of sutures.[10] Direct comparison in controlled biomechanical studies between transtibial pull-out, rip-stop, and combined procedures has not

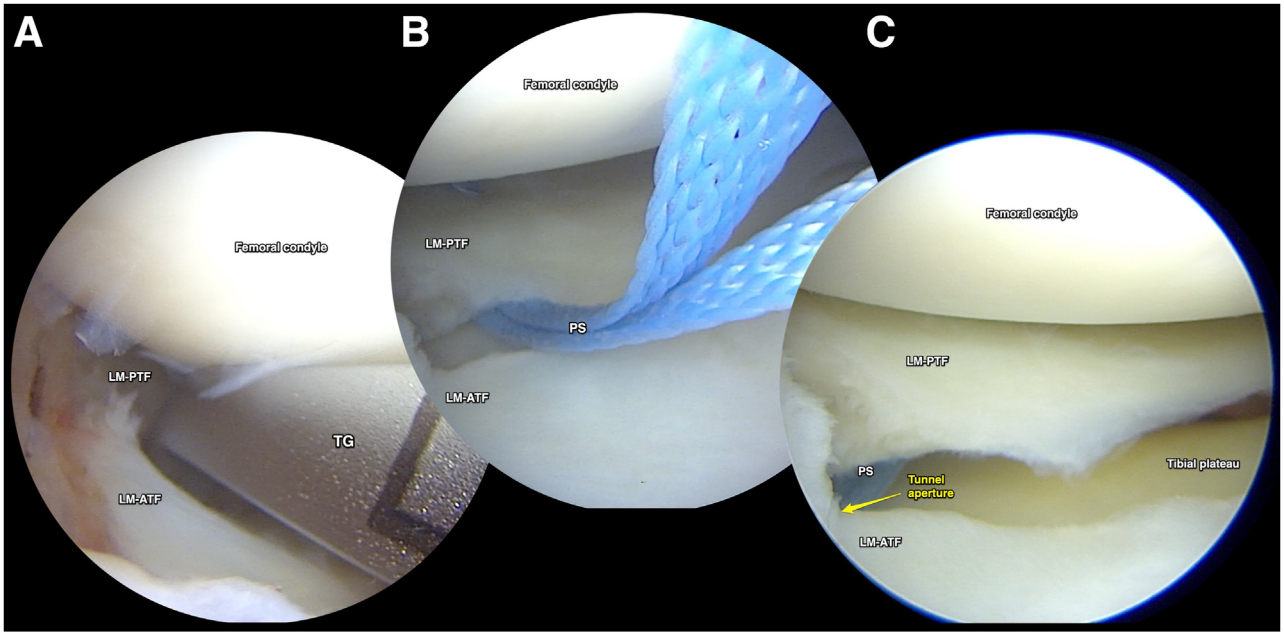


**Fig 8.** Arthroscopic views of a right knee lateral compartment depicting (A) tibial guide (TG) placement, (B) vertical mattress configuration of the pullout suture (PS) in the peripheral meniscus, and (C) the location of the internal aperture of the tibial tunnel (~2 mm central to edge of tibial cartilage, yellow arrow). LM-PTF, lateral meniscus posterior tear flap; LM-ATF, lateral meniscal anterior tear flap.

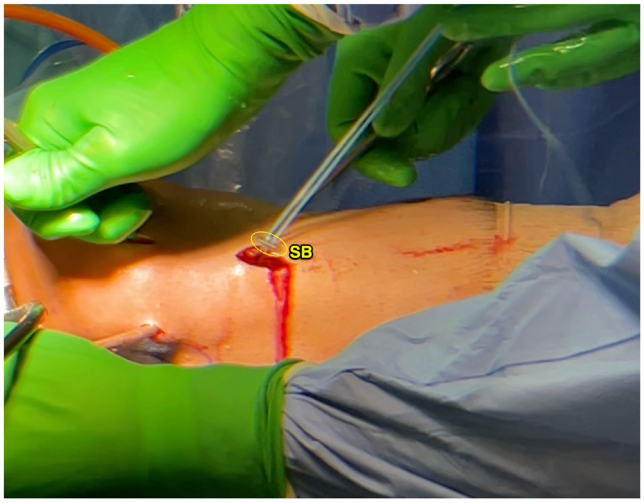


**Fig 9.** Intraoperative image of a right knee demonstrating application of the surgical button (SB, circled in yellow) for fixation of the pullout repair over the anterior tibia.

uncovered significant differences in ultimate failure loads when tested with cyclic loading followed by pull to failure; however, the rip-stop configuration decreases meniscal cutout.[10] The addition of the transtibial pull-out repair may not be strictly necessary according to the current evidence, but it serves two important functions. First, it helps reduce the meniscal tear site, holding one or two meniscal flaps in place during suture passage, and reducing tension on the rip-stop repair after surgery. Second, analogous to concomitant anterior cruciate ligament reconstruction, biologic factors that theoretically increase the healing response are released from the tunnel directly at the site of meniscal repair.


**Fig 10.** Intraoperative image depicting dissection through the iliotibial band (ITB) to the lateral joint capsule for inside-out rip-stop repair.

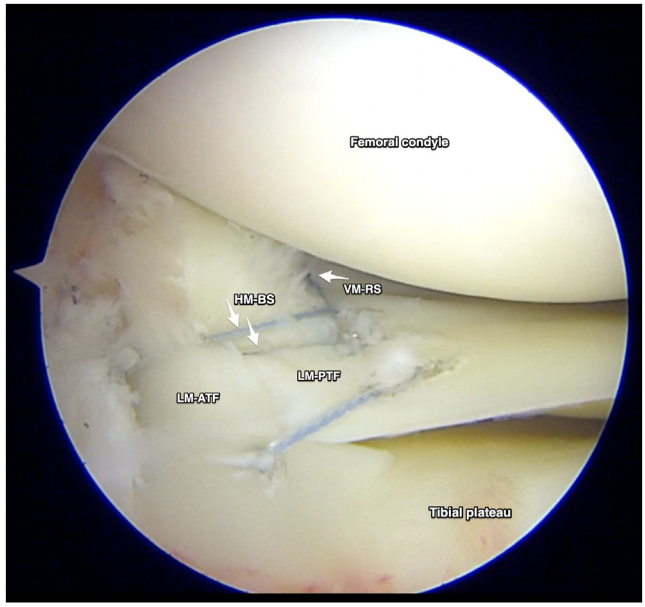


**Fig 11.** Arthroscopic view of a right knee lateral compartment demonstrating the final combined inside-out rip-stop and transtibial pullout repair of a lateral meniscus radial tear. LM-ATF, lateral meniscal anterior tear flap; LM-PTF, lateral meniscus posterior tear flap; HM-BS, horizontal mattress bridging suture; VM-RS, vertical mattress rip-stop suture.

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