Technical Note

Arthroscopic Treatment of Chronic Tibial Spine Malunion

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Abstract: Reports of surgical resection and internal fixation for symptomatic tibial spine malunion are rare, and the reported techniques typically involve an open surgical approach. We present an all-arthroscopic technique of tibial spine malunion treatment, with selective arthroscopic bone resection below the tibial spine, preserving the anterior cruciate ligament attachment, followed by internal fixation of the tibial spine with a hybrid transtibial and suture—bridge construct using knotless anchors and tape sutures.

Tibial spine malunion, a potential sequela of a displaced tibial spine fracture, typically presents as an excessive bony prominence at the anterior notch, leading to impingement, limited extension, pain, and decreased activity tolerance. The anterior cruciate ligament (ACL) attachment on the tibial spine contributes to the mechanism and displacement of the initial fracture and also complicates subsequent malunion treatment: a direct excision of the bony prominence can compromise ACL attachment integrity.

Abundant reports and studies exist in the literature that describe the arthroscopic treatment of acute tibial spine fractures.[1-7] In contrast, tibial spine malunion treatment reports are rare, and internal fixation techniques described typically involve an open surgical approach.[8-13] We describe our all-arthroscopic bone resection and internal fixation treatment technique of tibial spine malunion, as an alternative, less-invasive approach.

Surgical Technique

Indications

Our technique is indicated for patients with knee dysfunction and discomfort secondary to the excessive prominence of the tibial spine malunion who remain symptomatic despite conservative measures (physical therapy, activity modifications).

Patient Evaluation and Imaging

Patients typically describe persistent anterior knee discomfort that impedes extension, and they may also report instability. On examination, terminal knee extension is limited, with reproduction of the anterior discomfort, and Lachman and other ACL-specific tests may show excess laxity. Preoperative radiograph and magnetic resonance imaging details to assess include ACL integrity, dimensions, and contour of the tibial spine prominence and other intra-articular pathology (Fig 1).

Patient Positioning, Initial Assessment

The patient is prepared in a standard supine position and setup for knee arthroscopy. After anesthesia and preoperative antibiotics, a knee examination is performed, with attention paid to extension deficit and knee stability. An arthroscopic evaluation of the knee through standard anteromedial and anterolateral portals is performed, followed by treatment of other pathology if found. The malunion prominence is visualized and anterior impingement with knee extension documented (Fig 2 A-C). A debridement of the retropatellar soft tissue is performed, particularly down below the prominence, to fully expose its anterior surface and define its medial and lateral borders (Fig 2D).

Arthroscopic Bone Resection

A 0.25-inch osteotome is introduced through the anteromedial portal to make 2 horizontal cuts in the bony prominence, both spanning the entire width,

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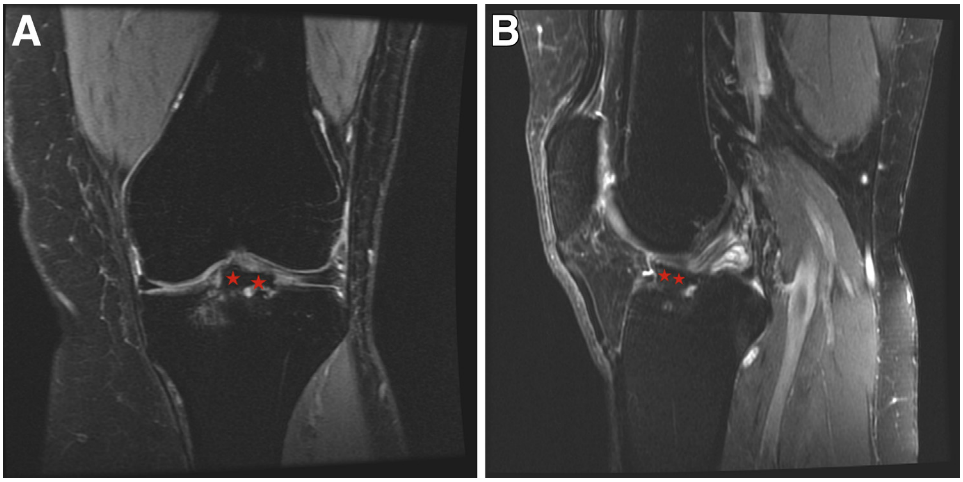

Fig 1. Preoperative magnetic resonance imaging scans of the left knee, with tibial spine malunion (red stars), shown on (A) coronal and (B) sagittal views.

the first starting about 10 mm below the superior border and with a slope that parallels the upper surface of the prominence, and the second, lower cut at the base of the prominence. These 2 cuts establish the boundaries of the initial resection and ultimately converge at the posterior extent of the prominence. A stepwise resection is performed, deepening the osteotome cuts incrementally, followed by bone clearance with graspers and shavers, then switching back to osteotome to further deepen the resection (Fig 3 A-D).

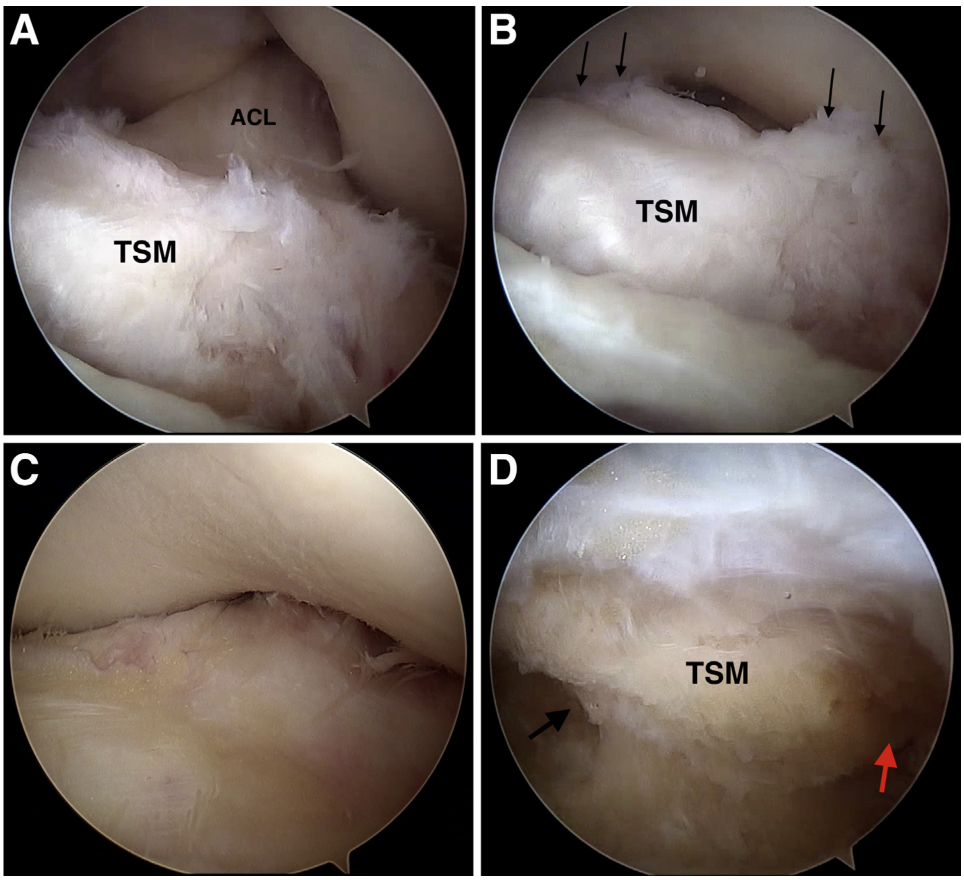

Fig 2. Arthroscopic assessment of the tibial spine malunion. Arthroscopic views through anterolateral portal of left knee with patient in supine position. (A) The knee is in 45° of flexion, demonstrating the TSM as a bony prominence at the anterior notch, with ACL in the background. (B) The knee is in maximum extension, demonstrating anterior impingement (arrows) of the TSM. (C) A comparison arthroscopic view through anterolateral portal of a normal left knee in full extension with patient in supine position. (D) Anterior surface of TSM exposed in preparation for bone wedge resection, including exposure to define its medial border (black arrow) and lateral border (red arrow). (ACL, anterior cruciate ligament; TSM, tibial spine malunion.)

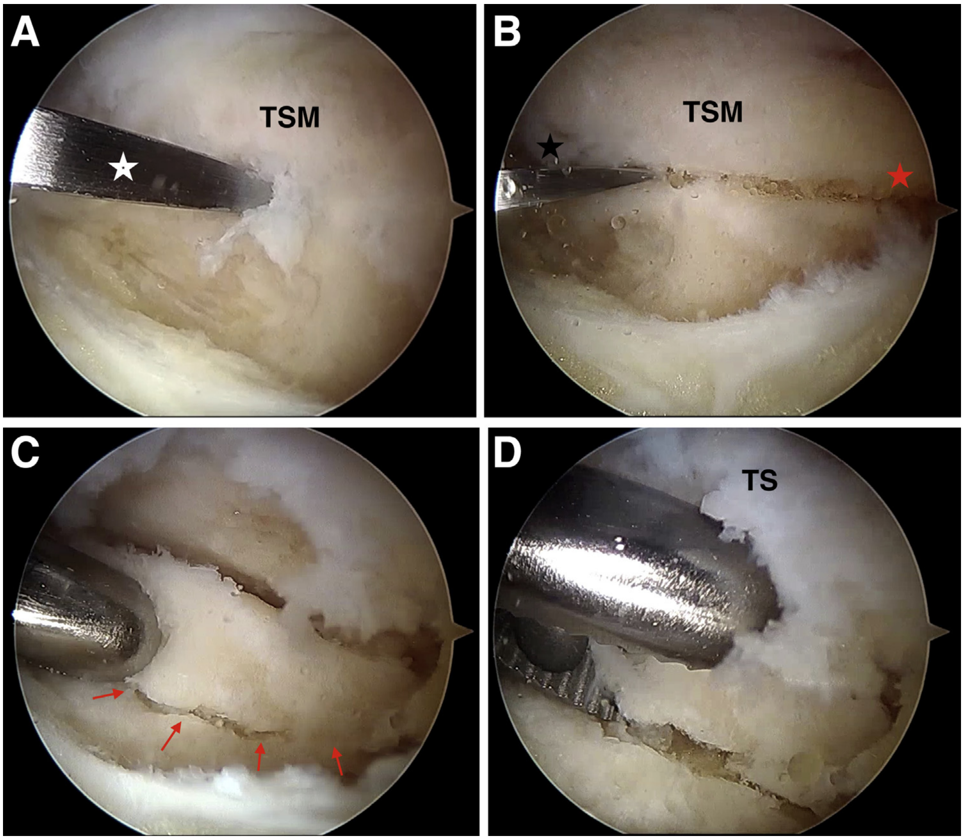

Fig 3. Arthroscopic bone resection beneath the TS. Arthroscopic views through anterolateral portal of left knee with patient in supine position. (A) Osteotome (white star) is introduced through the anteromedial portal to make a horizontal cut in the TSM, approximately 10 mm below the upper surface, with an anterosuperior-to-posteroinferior trajectory that parallels the upper surface, to preserve TS bone layer thickness. (B) The cut spans from the medial border (black star) to the lateral border (red star) of the TSM. (C) Another horizontal cut (red arrows) is made at the base of the prominence. (D) Bone is removed from between the cuts, with care to preserve the integrity of the TS layer above. Bone resection proceeds incrementally, and steps A-D are repeated, until the resection extends far enough posteriorly to undermine the entire TS. (E) Bone-cutting shaver is used to deepen the resection below, to allow for reduction of the TS. (F) Appearance after bone resection, with sufficient space below (TS) to allow for reduction. (G) The TS layer is intact after bone resection, with space created below for reduction (white stars). (H) TS provisionally reduced post-bone resection, compared with a view of a normal knee. (TS, tibial spine; TSM, tibial spine malunion.)

Once the bone resection clears enough room under the tibial spine, the underlying bone bed is deepened using a bone-cutting shaver, so that the tibial spine can be reduced into it, eliminating the prominence (Fig 3 E-G).

Suture Passage to Secure the ACL and Tibial Spine

Using a suture passing device (SutureLasso; Arthrex, Naples, FL) through a cannula, a reinforced suture is folded in half, creating 2 free ends and one loop, and the free ends are passed around the ACL at its base. A broad tape suture (FiberTape; Arthrex) is preferred for its tissue-holding properties. Once passed around, the free ends are fed through the loop end, and the loop is cinched down ("luggage tagged"), locking the doubled suture around the ACL just above the tibial spine. The aforementioned steps are repeated from the opposite portal with another tape suture to create a strong capture of the ACL and the tibial spine underneath, with 4 limbs of reinforced sutures for fixation (Fig 4).

Central Tunnel Drilling and Suture Passage for Transtibial Fixation

The tip of an ACL tibial guide is placed through the anteromedial portal and on the center of the ACL

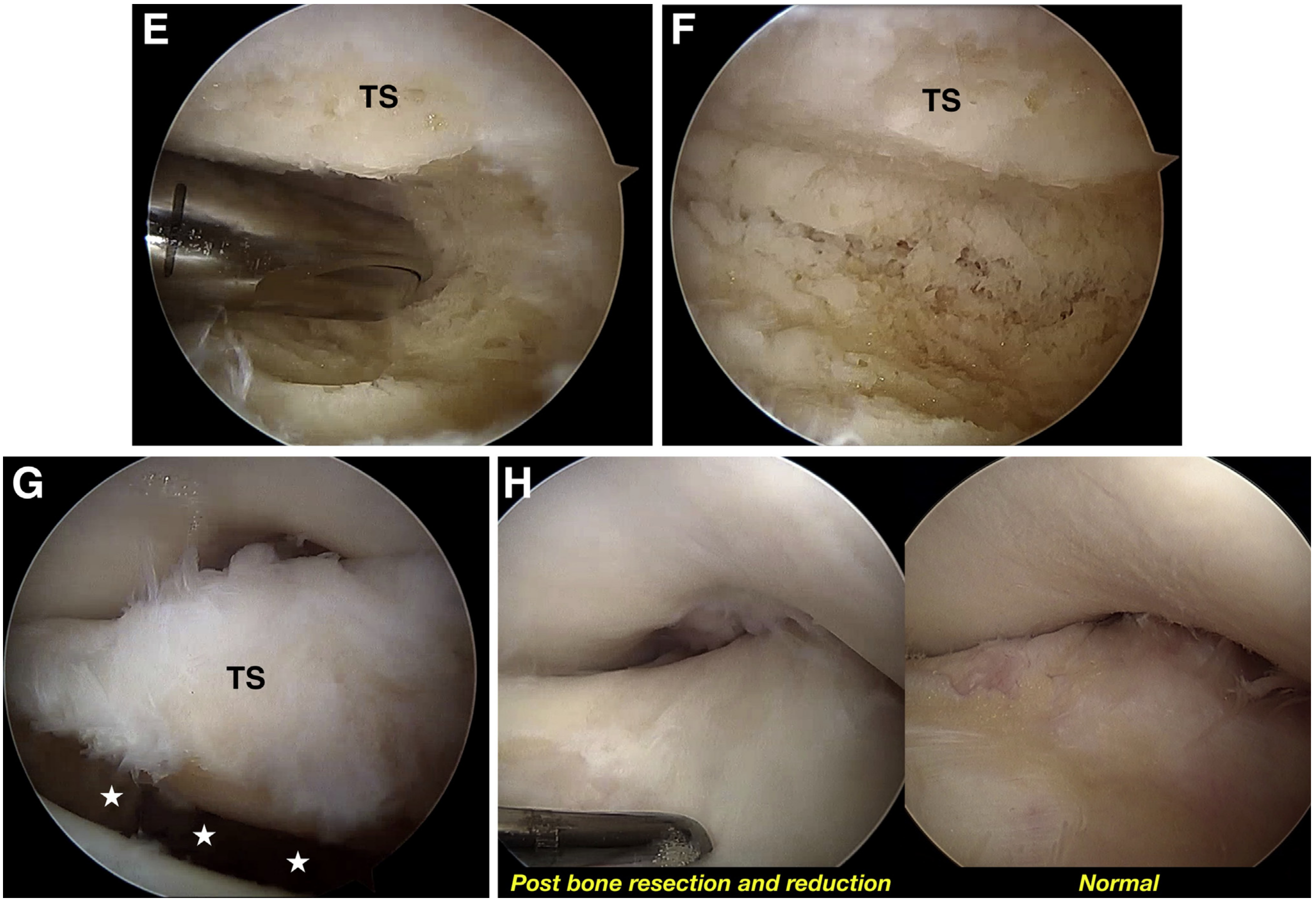

Fig 3. Continued.

attachment. Downward pressure is applied, reducing the tibial spine to the tibia. A small, 2-cm anteromedial leg incision is made for the drill sheath to be placed on the tibial cortex. A 2.4-mm drill-tip guidewire is advanced through both the tibia and the tibial spine held in reduction. A wire suture passer (Nitinol Suture Passing Wire; Arthrex) is passed up the tunnel, retrieved, then used to pass 2 tape suture limbs down the tunnel, one from each of the 2 sutures, exiting the small leg incision. These 2 limbs are secured into the tibial cortex under tension using a knotless anchor such as the 4.75-mm SwiveLock (Arthrex) (Fig 5).

Arthroscopic Anterior-Row Fixation

The remaining 2 tape suture limbs are used similar to the lateral row fixation technique in a double-row rotator cuff repair. The low anterior tibial plateau cortical surface, posterior to the patellar tendon and superior to the tibial tubercle, is arthroscopically exposed. A low anterior transtendinous accessory portal is made. One limb of the tape suture is secured with a 4.75-mm SwiveLock anchor (Arthrex) placed through the accessory portal, in the anteromedial aspect of the tibial cortex, with tension to reduce the tibial spine. The steps are repeated with the final tape suture limb, securing it under tension with a SwiveLock anchor placed in the anterolateral cortex of the tibia just distal to the tunnel (Fig 6).

Post-fixation, elimination of anterior impingement at full extension is confirmed arthroscopically. Knee examination demonstrates improved extension and elimination of the preoperative excess ACL laxity.

The surgical procedure is demonstrated in Video 1. The major steps of the procedure and surgical pearls are summarized in Table 1.

Rehabilitation

A knee immobilizer is worn during ambulation for approximately 2 to 3 weeks until quadriceps strength has returned sufficiently. Motion is gradually

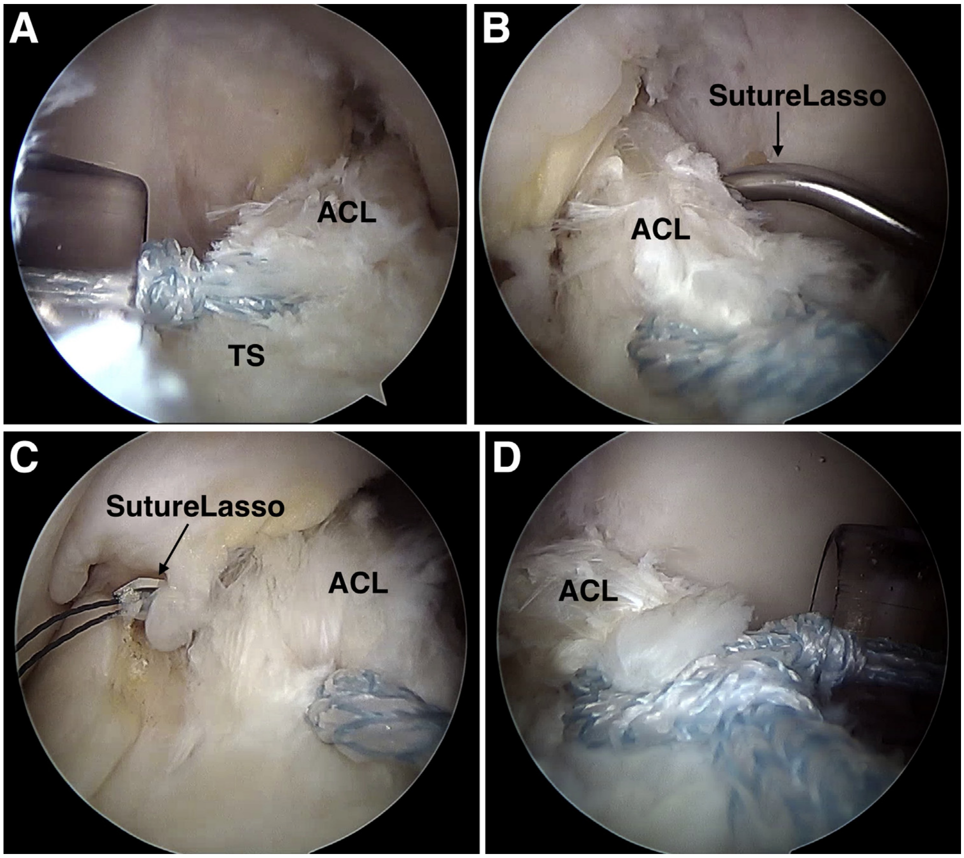

Fig 4. Suture passages to secure the ACL and tibial spine. Arthroscopic views of left knee with patient in supine position. (A) View from the anterolateral portal. A tape suture (FiberTape; Arthrex, Naples, FL) has been passed around and cinched down (in the "luggage-tag" fashion) at the base of the ACL just above the TS. (B-D) Views from the anteromedial portal. A suture passing device (SutureLasso; Arthrex) is used again, from the opposite direction, to penetrate the ACL just above the tibial spine, and another tape suture is passed around and cinched down in the same fashion. (ACL, anterior cruciate ligament; TS, tibial spine.)

increased over the first 6 weeks, aiming for early full extension, and 90° of flexion by 3 to 4 weeks. Weight-bearing is limited to toe-touch for the first 2 weeks, up to full by 6 weeks. Balance and strength exercises are emphasized after weight-bearing and gait normalization by 6 to 8 weeks, followed by dynamic activities, running, and agility routines starting about 12 weeks. Return to sports is permitted typically by 20 to 24 weeks after agility program completion.

Discussion

Compared with acute fracture treatment, a chronic malunion of the tibial spine presents an additional technical challenge for arthroscopic treatment: a careful bone resection below the tibial spine is necessary to correct the malunion deformity without compromising ACL attachment integrity.

Reported tibial spine malunion treatment techniques include debridement, femoral notchplasty, and open bone resection and fixation with implants.[8-13] Except for one report in which the malunion in a pediatric patient was treated arthroscopically with 8 absorbable screws,[12] reports of tibial spine malunion resection and internal fixation have typically been performed via an open approach.

Our experience demonstrates that the entire tibial malunion treatment, from bone resection to internal fixation, is achievable arthroscopically. The bone resection is performed using an osteotome to establish the superior and lower boundaries of the bone resection, followed by deepening of the lower surface to allow for tibial spine reduction. We feel that arthroscopic visualization improves the specificity of bone resection, allowing for precise elimination of excess bone while allowing frequent reduction checks to ensure a precise level of bone resection without excess removal.

Our fixation construct provides longitudinal stabilization with transosseous suture fixation distally in line

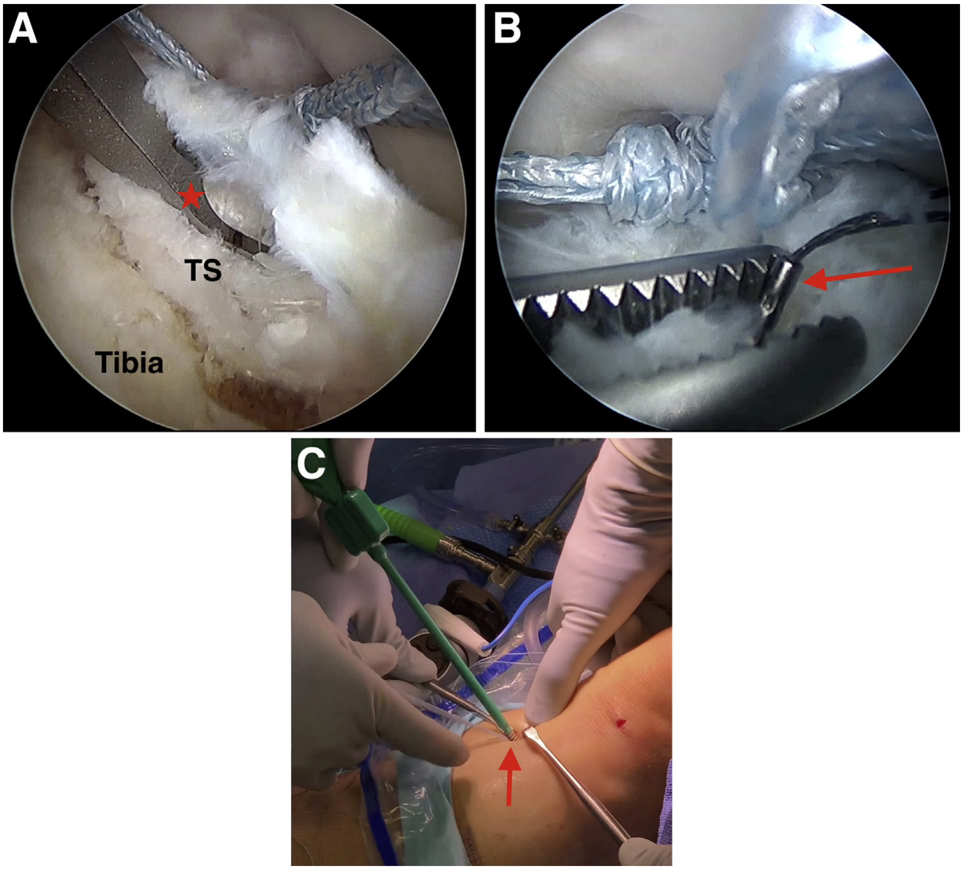

Fig 5. Central tunnel drilling and suture passage for transtibial fixation. Arthroscopic views through anterolateral portal of left knee with patient in supine position. (A) An ACL tibial drill guide tip (red star) is placed on the TS to reduce it to the tibia. (B) A guidewire is passed through the ACL drill guide to make a tunnel through the tibia and tibial spine. This is followed by a suture passing wire (red arrow) passed up through the tunnel, and then retrieved out the anteromedial portal, to pass 2 free limbs of the tape suture, one limb from each suture, down and out through the tibia distally. (C) The 2 suture tape limbs are secured under tension in the tibial cortex using a knotless anchor such as the 4.75 mm-SwiveLock (Arthrex) (red arrow). (ACL, anterior cruciate ligament; TS, tibial spine.)

with the ACL and a broad compression zone to stabilize the tibial spine with the anterior row fixation of tape suture limbs, similar to the double-row rotator cuff repair technique. The rationale of our construct is consistent with the results of a cadaveric biomechanical study by Li et al.[14] comparing several common tibial spine fracture fixation techniques. Our method combines the double "luggage tag" or "neckwear" transosseous suture technique and the "suture bridge" fixation construct, the 2 fixation methods shown to provide the greatest ultimate failure load and the lowest displacement, respectively, in the aforementioned study. The use of tape sutures and knotless fixation potentially increases tissue and bone capture stability over regular sutures[15] and decreases the likelihood of suture cut-out through bone or ACL or suture and knot breakage, 2 common modes of failure seen in the study.[14]

The main advantage of our technique is the potential decrease of morbidity with the minimally invasive approach.[2] Other benefits include improved visualization during bone resection; a more secure and less failure-prone fixation construct; and simplicity of a single central tunnel drilling instead of multiple parallel tunnels.

Disadvantages include possible tibial spine fragmentation and ACL attachment compromise during bone resection; secure final fixation requires careful tape suture tensioning; increased implant costs; and, as with any new technique, large studies with long-term follow-up are needed to fully evaluate the technique's efficacy.

The advantages and disadvantages are further detailed in Table 2. In summary, we present an all-arthroscopic treatment technique for the symptomatic tibial spine malunion, a minimally-invasive alternative to the more commonly reported open surgical techniques.

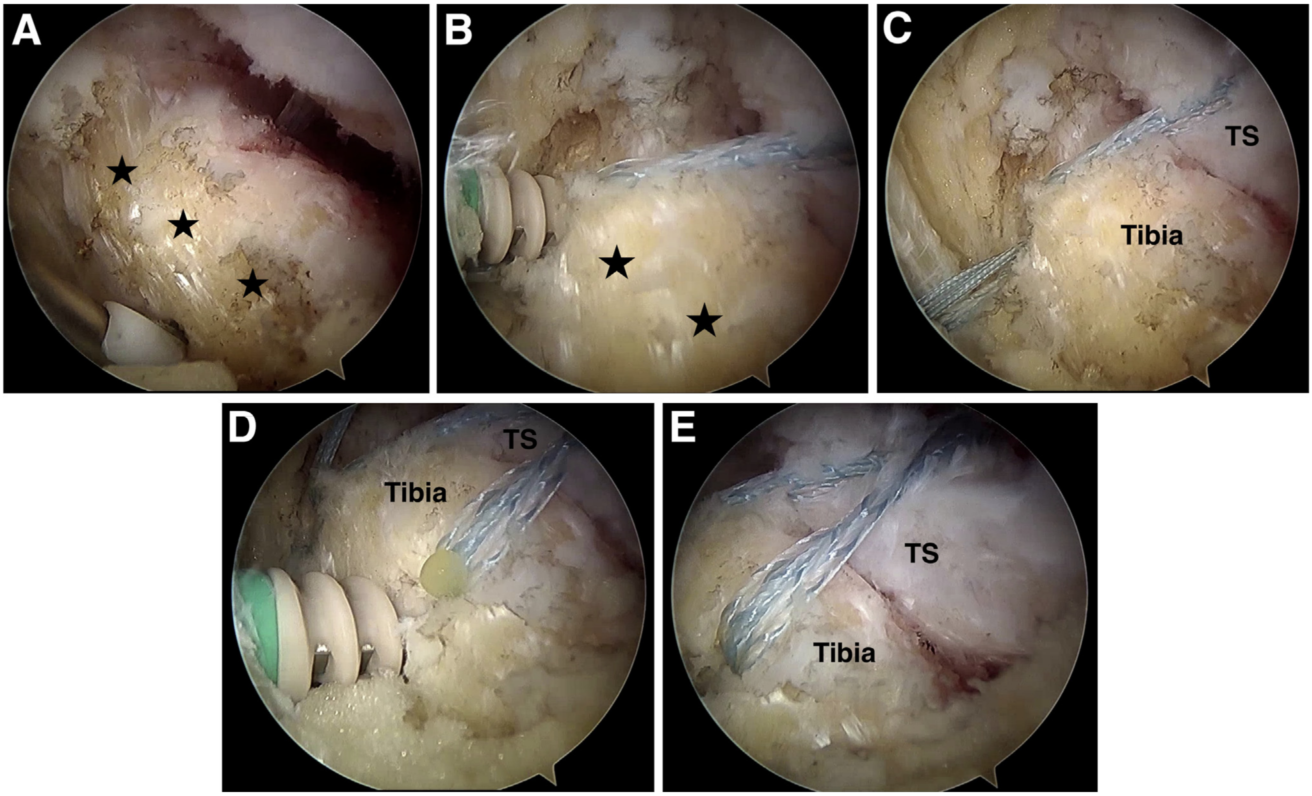

Fig 6. Arthroscopic anterior-row tibial fixation. Arthroscopic views through anterolateral portal of left knee with patient in supine position. (A) A low anterior transtendinous accessory portal is made, and lower anterior tibial cortical surface (black stars) is exposed. (B), (C) Tapping followed by fixation of 1 of the 2 remaining tape suture limbs under tension in the low anteromedial tibia (black stars), using a knotless anchor (SwiveLock; Arthrex), to reduce the TS to the tibia. (D) Tapping and fixation is repeated to fix the final tape suture limb under tension in the low anterolateral tibia. (E) Appearance at completion, with fixation of the TS to the tibia. (TS, tibial spine.)

Table 1. Major Steps in Procedure and Surgical Pearls

Tibial Spine Malunion Exposure
Ensure the entire width of the tibial malunion prominence is exposed medially and laterally to ensure the entire prominence is mobilized and to decrease the chance of tibial spine layer fragmentation.
Tibial Spine Bone Resection and Reduction
The top cut is made first, so the prominence is more stable, to help minimize premature breaking off of the bone if the lower cut destabilizes it.
When removing bone underneath to create the space for tibial spine reduction, check the reduction periodically to avoid excessive resection of bone, gap formation between the tibial spine and the underlying bone bed and possibly impaired healing.
Suture Passage to Secure the ACL and Tibial Spine
The free ends of the FiberTape (Arthrex, Naples, FL) are thinner than the middle loop end. When folded in half for passage, it is easier and less traumatic for the tissue to pass the free ends through the ACL first.
After completing the first tape suture “luggage tag,” use it to pull the ACL down and forward when passing the suture passer around the ACL again. This maneuver improves the reach of the second suture passage posteriorly, to ensure a broad capture of the ACL.
Central Tunnel Drilling and Suture Passage for Transtibial Fixation
After the central tunnel has been drilled with the 2.4 -mm guidewire, which typically enters the joint at the center of the tibial spine and within the ACL fibers, a thin but rigid suture passing wire such as the Nitinol Suture Passing Wire (Arthrex) is useful to push through the ACL fibers when entering the joint.
Arthroscopic Anterior-Row Fixation
When tapping or punching to prepare the tibia for the low anteromedial and anterolateral anchors, pay attention to the trajectory to avoid compromising the tape sutures already passed down the central tunnel. The use of a low transtendinous accessory portal helps, since it will by default diverge the directions of anteromedial and anterolateral anchors away from the center. Manual use of tap or punch to prepare for anchor placement will minimize tape suture damage if encountered. SwiveLock anchor (Arthrex) has no sharp tip or cutting threads to damage the tape sutures.

ACL, anterior cruciate ligament.

Table 2. Advantages and Disadvantages

Advantages
• All-arthroscopic procedure, with potential decrease of morbidity through a minimally invasive approach
• More thorough and precise bone resection due to improved arthroscopic visualization under the tibial spine
• Hybrid construct, with both transosseous and anterior-row suture fixation features, potentially improving ultimate failure load and minimizing fixation displacement
• Requires placement of only a single central tunnel, a step familiar to surgeons who perform ACL reconstructions, instead of drilling multiple parallel tunnels as in other suture pullout fixation techniques
• Tape suture and knotless cortical anchor fixation may minimize cut-out through bone or knot/suture breakage, 2 likely potential modes of failure
Disadvantages
• Care during bone resection is necessary to maintain tibial spine integrity to avoid fragmentation and ACL reattachment compromise
• Tape suture tensioning during final anterior-row anchor fixation may be challenging if not familiar with double-row rotator cuff repair techniques
• Increased costs, particularly for the anchors, compared to more traditional sutures-only techniques
• Large studies with long-term follow-up are needed to fully evaluate the technique's efficacy

ACL, anterior cruciate ligament.

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