Technical Note

Tibial Spine Avulsion Repair With FiberRing Suture and Anterior Cruciate Ligament Repair TightRope

Nicholas R. Williams, B.S., Sophia Yin, B.S., Alvarho J. Guzman, B.A., Patrick Waldron, D.O., Ethan Vallelanes, B.S., Caleb Shin, M.D., and James L. Chen, M.D., M.P.H.

Abstract: Tibial spine avulsion fractures occur predominantly in children and young adults and are an uncommon type of knee injury. To ensure knee stability and preserve range of motion with minimal knee laxity, it is essential to restore anterior cruciate ligament length through surgical reduction and fixation of the fracture. Achieving anatomic reduction of tibial spine avulsion fractures with an arthroscopic approach is a technically complex procedure. In this Technical Note and accompanying video, we describe a unique fixation repair of tibial spine avulsion fractures using Arthrex FiberRing sutures and an Arthrex ACL Repair TightRope. The technique presented is an effective method to reduce tibial spine avulsion fractures to anatomic position with a variable tensioning system that allows for a strong and secure fixation method.

Tibial spine avulsion fractures, or tibial eminence fractures, are rare and primarily occur in children and adolescent patients, comprising only 2% to 5% of all pediatric knee injuries.[1] In skeletally immature patients, the anterior cruciate ligament (ACL) is stronger than the incompletely ossified tibial plateau, and direct trauma or hyperextension and simultaneous rotation of the knee can cause an eminence fracture.[1] Tibial spine avulsions are classified using the Meyers and McKeever classification system. Literature demonstrates that type I fractures are best treated nonoperatively and type III and IV fractures necessitate surgical management. Type II fractures should be managed surgically if closed reduction is unsuccessful.

The most common methods of fracture fixation include sutures and screws. Each have their pros and cons, but both yield similar patient outcomes. Many different suture-fixation methods have been described in the literature, with varying degrees of technical ease and reliability. The purpose of this Technical Note and accompanying video (Video 1) is to describe a method of tibial spine avulsion fracture repair using an Arthrex ACL Repair TightRope (Arthrex, Naples, FL).

Surgical Technique (With Video Illustration)

Preoperative Evaluation

The diagnosis of tibial spine avulsion fracture is established using a combination of patient history, clinical findings, and diagnostic imaging studies. History will usually reveal a young, athletic patient who hyperextends the knee while participating in a sporting activity. On physical examination, the patient may present with edema, pain, and the inability to bear weight on the affected leg. A Lachman's or anterior drawer test may be positive, but these tests may be difficult to perform due to pain. Plain radiographs can reveal the tibial avulsion fragment, although advanced imaging studies such as computed tomography and magnetic resonance imaging can further assess osseous, meniscal, and ligamentous integrity of the knee. The patient's preoperative magnetic resonance imaging is shown in Figure 1.

Patient Setup

The patient is placed in the supine position on a standard operative table and anesthetized under general anesthesia. The operative knee is examined and a

From Advanced Orthopedics and Sports Medicine, San Francisco, California, U.S.A.

Received June 27, 2023; accepted August 13, 2023.

Address correspondence to Nicholas Williams, Advanced Orthopedics and Sports Medicine, 450 Sutter St., Suite 400, San Francisco, California, 94108, U.S.A. E-mail: williamsnr17@gmail.com

2212-6287/23908
https://doi.org/10.1016/j.eats.2023.08.008

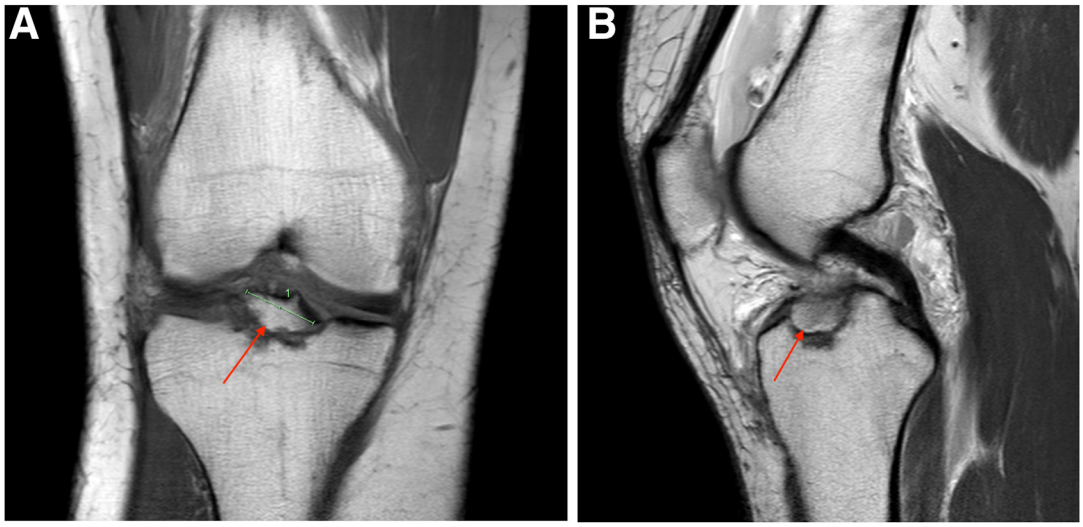

Fig 1. Preoperative coronal (A) and sagittal (B) T1 magnetic resonance imaging of the right knee showing a displaced tibial spine avulsion fracture (arrow).

positive Lachman's test is confirmed. Perioperative antibiotics and a peripheral nerve block are administered. The operative extremity is placed into a leg holder. The head and bony prominences are well padded and the operative extremity is then prepped and draped in usual sterile fashion.

Arthroscopic Portal Placement

A No. 11 blade is used to create a vertical incision just lateral to the patellar tendon at the joint line. The knee joint is entered with a blunt trocar and scope sheath. The trocar is removed, and a 30° 4.0-mm arthroscope is used for standard diagnostic arthroscopy. Complete diagnostic arthroscopy is performed, inspecting for chondral damage, loose bodies, and meniscus tears. A No. 11 blade is then used to create the anteromedial working portal in standard fashion with needle localization.

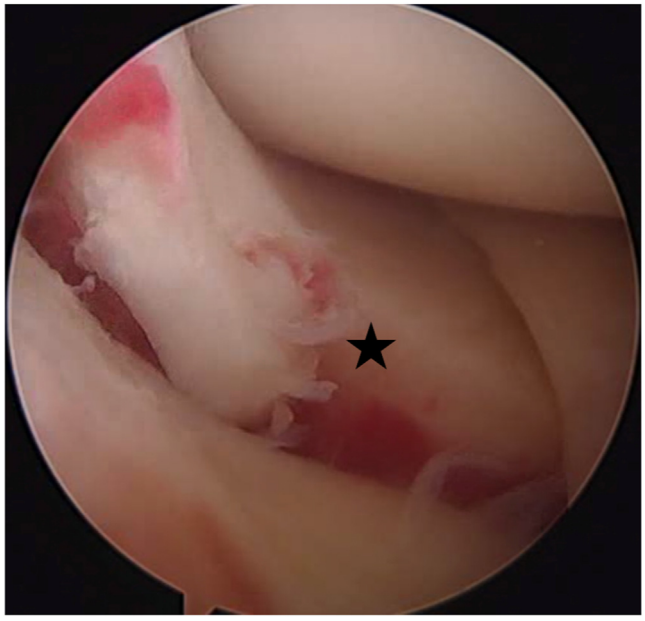

Fig 2. Intraoperative arthroscopic view of the right knee viewed through the anterolateral portal demonstrating a step-off in the tibial cartilage (star) caused by the avulsion fragment.

Preparation of the Tibial Spine Avulsion

The ACL is probed to ensure the femoral attachment is intact. Upon probing the ACL, anterior laxity is confirmed and the tibial footprint is inspected confirming an avulsed fragment (Fig 2). A 4-0 shaver is used to debride clots and loose fragments under the avulsed tibial fragment and create a recess to anatomically reduce the fracture.

Tibial Spine Avulsion Repair

To perform repair of the avulsed tibial spine fragment, 2 PassPort Cannulas (Arthrex) are placed in the anteromedial and anterolateral portals. A 2-cm incision is then made over the anterior proximal tibia and a tibial drill guide is used to pass a guide pin followed by a 3.0-mm cannulated drill bit under the avulsed tibial spine fragment. A nitinol wire is passed through the drill bit and retrieved through the anteromedial portal for later use. A scorpion suture passer is used to pass two No. 2 FiberRing suture (Arthrex) through the ACL in a luggage-tag configuration just above the avulsed tibial spine fragment (Fig 3).

Two #0 FiberLink suture (Arthrex) are passed through the end of the nitinol wire and shuttled through the tibial tunnel. The lead suture from the ACL Repair TightRope (Arthrex) is passed up through the tibial tunnel and out of the anteromedial portal. It is

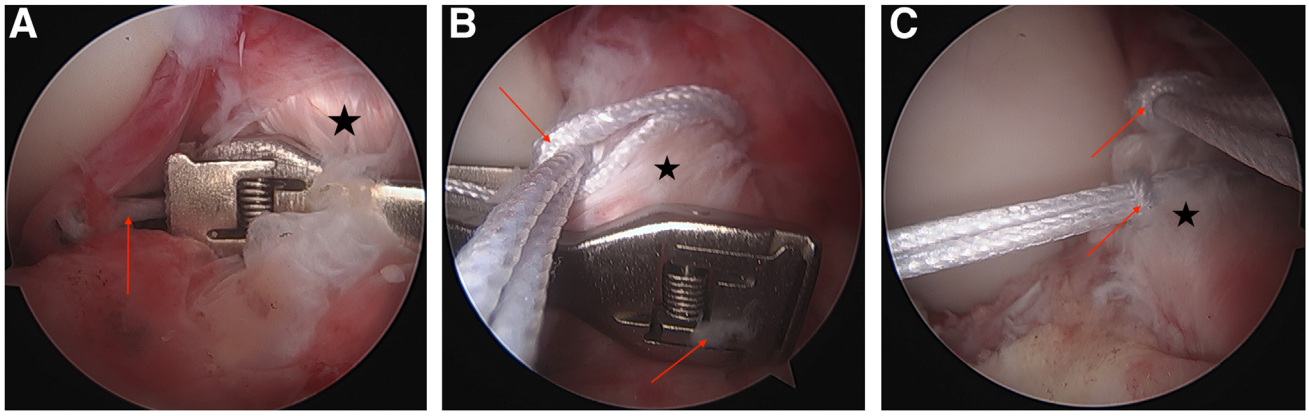

Fig 3. Intraoperative arthroscopic views of right the knee viewed through the anteromedial portal demonstrating the use of a knee scorpion (A and B) to fire 2 sequential FiberRing sutures (arrows) through the ACL (star), and the final luggage-tag configuration (C).

shuttled through each loop of the FiberRing sutures sequentially, using the #0 FiberLink sutures, then exits back through the tibial tunnel and the cortical button is loaded (Fig 4). The cortical button is secured onto the anterior tibial cortex using a needle driver as the knee is extended to ensure complete fracture reduction. The knee is cycled and the system is retensioned to remove any creep. The ACL is then probed and deemed taut completing the tibial spine repair.

Final Examination and Postoperative Care

Range of motion and stability of the knee are examined to check for any impingement or laxity. A final intraoperative radiograph is taken to ensure that the tibial spine avulsion remains anatomically reduced and that the button is flush on the cortex of the anterior tibia (Fig 5). Incisions are closed and dressed in standard fashion and local anesthetic is injected into the knee joint for postoperative pain control. The operative knee is placed in a functional brace and locked in extension for the first week, with gradually increasing range of motion. The patient should be non–weight-bearing for 8 weeks postoperatively. The patient's 8-week postoperative radiographs are shown in Figure 6.

Discussion

Correctly repairing tibial spine avulsion fractures is important for preserving anatomy and function of the knee, especially in patients with higher-grade fractures. Arthroscopic procedures are becoming the standard of care, as studies have shown superior results compared with open procedures. Repairs have been described using a variety of fixation methods, including but not limited to screws, anchors, sutures, and button systems. Screw fixation allows for earlier mobilization and weight-bearing but frequently requires an additional surgery for removal of the hardware.[2-4] Bong et al.[5] compared the strength of sutures versus cannulated

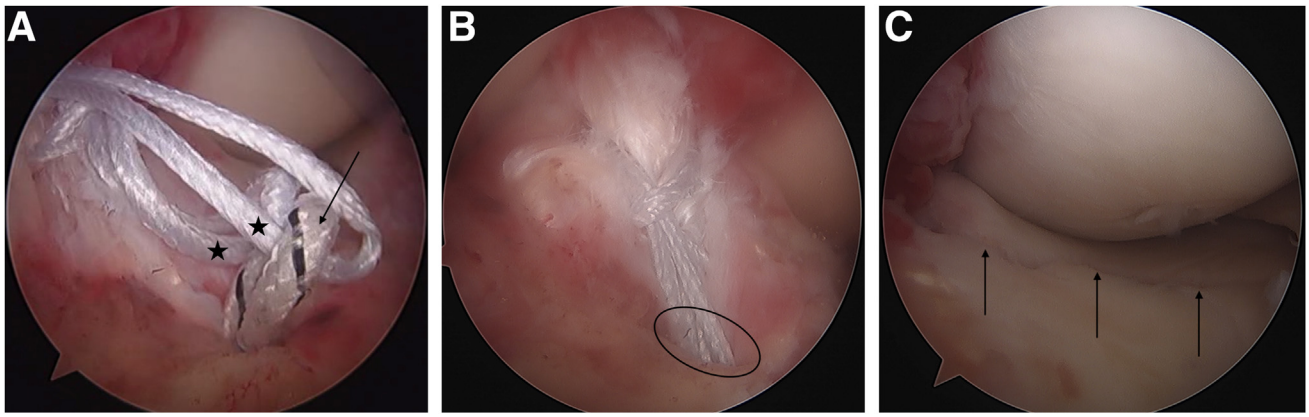

Fig 4. Intraoperative arthroscopic views of the right knee viewed through the anteromedial portal demonstrating how the ACL Repair TightRope (arrow) is shuttled through the 2 FiberRing sutures (star) (A), then the ACL Repair TightRope is passed through the tibial tunnel (oval) (B), and the final reduction (arrows) of the avulsion tibial spine fragment (C).

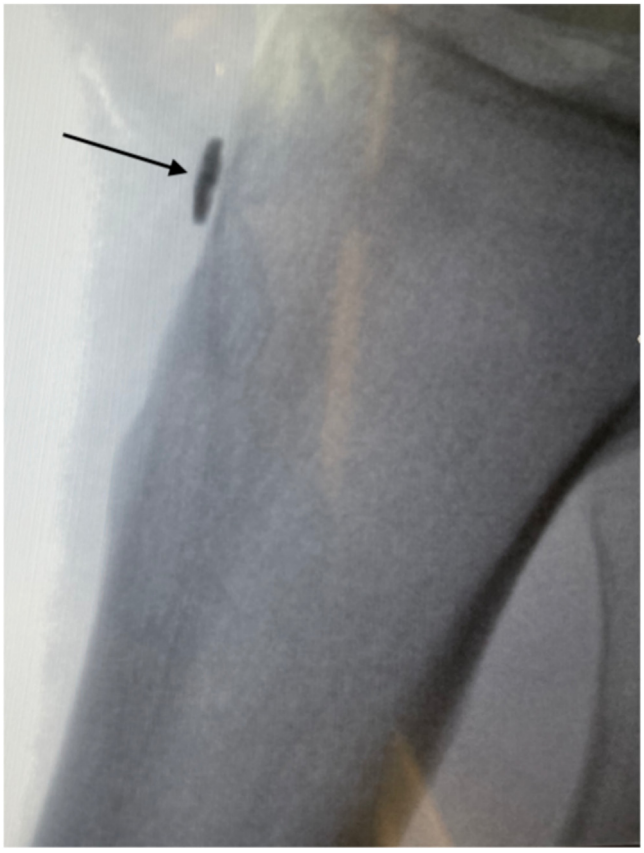

Fig 5. Final intraoperative lateral radiograph of the right knee demonstrating anatomic reduction of the avulsed tibial spine fragment and confirming that the ACL Repair TightRope button (arrow) is sitting flush against the cortex of the anterior tibia.

screw fixation in cadaveric specimens and found that the strength of FiberWire suture fixation was greater than screw fixation under a constant load. Most systematic reviews and meta-analyses have similarly found that suture fixation is superior or noninferior to screw fixation.

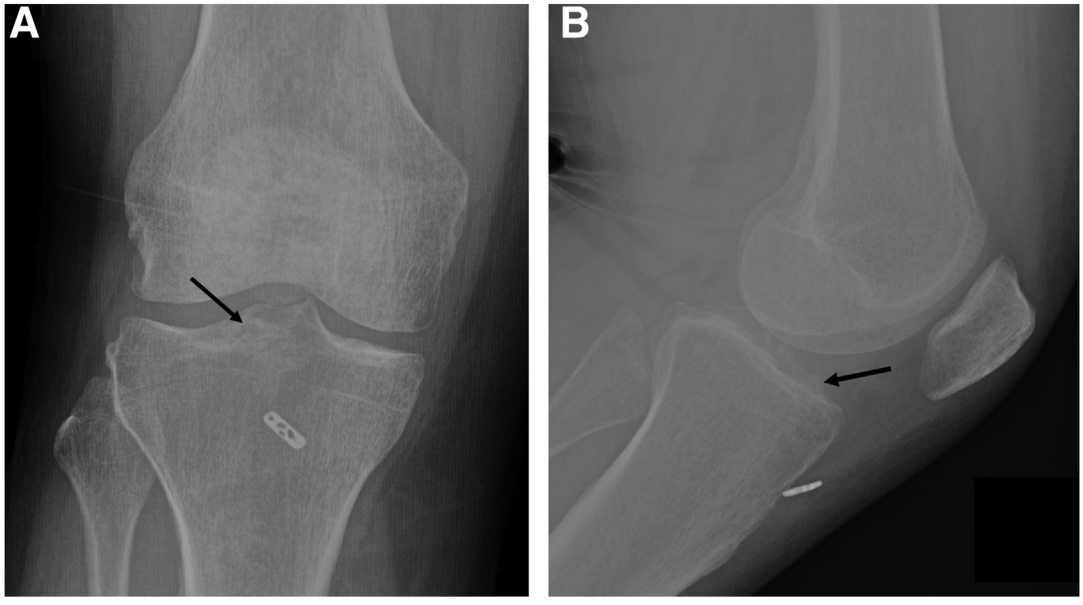

Fig 6. Radiographs of the right knee in AP (A) and lateral (B) views 8 weeks' postoperatively demonstrating anatomic reduction of the avulsed tibial spine fragment (arrow).

Table 1. Pearls and Pitfalls of Tibial Spine Avulsion Repair With FiberRing Sutures and ACL Repair TightRope

Pearls	Pitfalls
Debride the tibial fracture bed to remove clots and loose fragments in the recess to anatomically reduce the fracture	Avoid comminuting the avulsion fragment when drilling the tibial tunnel
Pass one FiberRing suture through the ACL using the anteromedial portal and one using the anterolateral portal just above the avulsion fragment	
Cycle the knee to remove any creep and then retension the ACL Repair TightRope	

ACL, anterior cruciate ligament.

Table 2. Advantages and Disadvantages of Tibial Spine Avulsion Repair With FiberRing Sutures and ACL Repair TightRope

Advantages	Disadvantages
Easy and effective reduction technique of the avulsion without the need for provisional fixation	Technically complex knee arthroscopy procedure
Variable tensioning system allows for better reduction after the knee is cycled to remove creep	
Decreased chance of reoperation compared with procedures that use a screw for fixation	
Minimal morbidity and risk of wound-healing complications	

ACL, anterior cruciate ligament.

Kelly et al.[6] recently published a similar technique, using Arthrex suture tape and a cortical button for avulsion fragment reduction. Their method uses 2 tibial tunnels, with one tail from each suture tape being shuttled through each tunnel. The tails of the suture tape are secured to the cortical button with a modified Tuckahoe sliding knot followed by 3 alternating half hitch knots. This technique also allows for re-tensioning after performing range of motion, but it relies on the quality of hand-tied knots to maintain an adequate reduction. Our proposed technique only requires one tibial tunnel to be drilled, and using the ACL Repair TightRope allows for retensioning without relying on hand-tied knots.

The primary benefit of our repair with ACL FiberRing sutures and an ACL Repair TightRope is the variable tensioning system which theoretically translates to superior reduction and tension of the repair. The ACL Repair TightRope locks itself securely in place and can then be retensioned after cycling the knee to remove excess creep from the system. In addition, our technique eliminates the need for provisional reduction of the avulsed fragment, which carries the risk of splitting the fragment as it is drilled into. The sutures are passed through the ACL and then through the tibial tunnel, reducing the fragment into anatomic alignment inferiorly and posteriorly as tension is applied. Finally, the use of an all-suture construct decreases the potential of reoperation for the removal of hardware compared with fixation methods that use a screw. However, the cortical button on the anterior tibia may still be irritating to the patient and occasionally requires removal. In general, arthroscopic procedures are associated with decreased postoperative pain and wound-healing complications compared with open procedures. A full list of the pearls and pitfalls of this procedure can be found in Table 1.

The main drawback of this procedure is its technically complex nature. It requires passing multiple sutures through the knee and shuttling them sequentially in the proper order. Once the surgeon is familiar with the use of each implant and the steps of the procedure have been memorized, the aforementioned technique is an effective method for the anatomic reduction and fixation of tibial spine avulsion fractures, with excellent ligamentous stability. A full list of the advantages and disadvantages of this procedure can be found in Table 2.

References

1. Tuca M, Bernal N, Luderowski E, Green DW. Tibial spine avulsion fractures: Treatment update. *Curr Opin Pediatr* 2019;31:103-111.
2. Osti L, Buda M, Soldati F, Del Buono A, Osti R, Maffulli N. Arthroscopic treatment of tibial eminence fracture: A systematic review of different fixation methods. *Br Med Bull* 2016;118:73-90.
3. Sawyer GA, Anderson BC, Paller D, Schiller J, Eberson CP, Hulstyn M. Biomechanical analysis of suture bridge fixation for tibial eminence fractures. *Arthroscopy* 2012;28:1533-1539.
4. Lubowitz JH, Elson WS, Guttmann D. Part II: Arthroscopic treatment of tibial plateau fractures: Intercondylar eminence avulsion fractures. *Arthroscopy* 2005;21:86-92.
5. Bong MR, Romero A, Kubiak E, et al. Suture versus screw fixation of displaced tibial eminence fractures: A biomechanical comparison. *Arthroscopy* 2005;21:1172-1176.
6. Kelly S, DeFroda S, Nuelle CW. Arthroscopic assisted anterior cruciate ligament tibial spine avulsion reduction and cortical button fixation. *Arthrosc Tech* 2023;12:e1033-e1038.