Technical Note

A Technique for Arthroscopic Fixation of Tibial Eminence Avulsion Fractures: A Physeal-Sparing Construct With All-Suture Anchor Bridge Fixation

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Abstract: Arthroscopic or open surgical treatment is indicated for displaced tibial spine fractures to obtain anatomic reduction and restore the functionality of the anterior cruciate ligament. Numerous open and arthroscopic techniques for the treatment of tibial spine fractures have been described. The purpose of this technical note is to describe a minimally invasive arthroscopic physeal- and ligament-sparing surgical technique using knotless all-suture anchors to provide stable bridge fixation over displaced tibial spine fractures.

Tibial eminence fractures occur in older children, generally aged 10 to 14 years.[1] The fracture is an avulsion of the insertion of the anterior cruciate ligament (ACL) off the tibia that can result in knee instability and subsequent joint degeneration. Associated injuries such as meniscus tears, collateral ligament tears, capsular damage, and osteochondral fractures can occur in up to 40% of these fractures.

The modified Meyers and McKeever classification system is used to guide treatment of these fractures. Closed, arthroscopic, and open treatment methods for these fractures require anatomic reduction of the tibial eminence fracture for union and functionality of the ACL. Type I and II fractures can usually be treated with aspiration of hemarthrosis, closed reduction of the fracture with extension and immobilization, and verification of reduction with radiographs and/or magnetic resonance imaging.

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Frequently, anatomic reduction cannot be obtained with closed methods in type II-V fractures due to interposed tissue or more severe fracture displacement. Therefore, arthroscopic or open treatment is indicated to obtain anatomic reduction. There are multiple open and arthroscopic operative techniques that have been described for displaced tibial spine fractures. Advantages of arthroscopic methods include smaller incisions and improved ability to visualize and treat other concomitant injuries such as meniscus tears and osteochondral damage.

Arthroscopic operative techniques have included suture, anchor, or screw fixation. Suture-fixation techniques have been described that include sutures being passed around and/or through the ACL and passed through tibial tunnels that are drilled across the growth plate on each side of the ACL and tied over a bony bridge on the tibia. The cons of this procedure include possible damage to the physis and technical difficulty of suture placement. Screw-fixation techniques include metal and bioabsorbable implants to reduce and maintain fracture reduction.[2-6] The cons of screw fixation include possible screw irritation, impingement, physeal damage, and potential need for hardware removal.

We describe a technique named the Skyway Suture Bridge Technique. The construct is an all-suture-knotless fixation, spares the physis, is performed completely arthroscopically with 3 small portals, and does not use metallic or absorbable implants.

Surgical Technique (With Video Illustration)

After administration of general anesthesia, the patient is positioned supine, a sterile tourniquet is applied, and the operative leg is placed in a thigh holder attached to

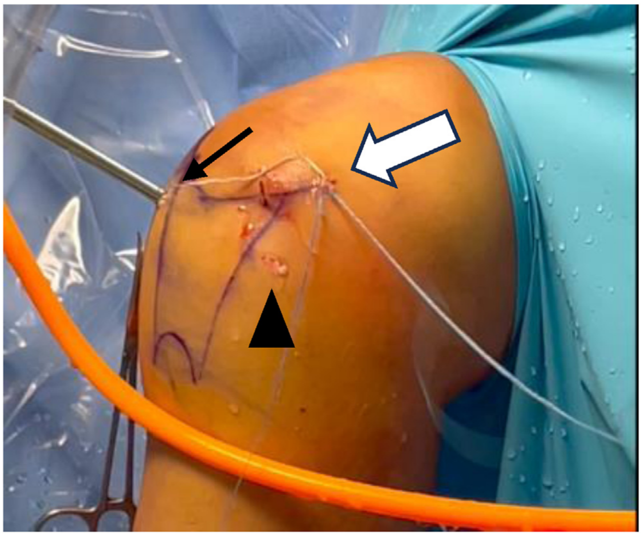

Fig 1. Clinical photograph of a right knee in 90° of flexion showing the standard anterolateral (thin black arrow) and anteromedial (white block arrow) portals along with the accessory portal (black arrowhead).

the operating room table. The contralateral leg is placed in a well-padded leg holder. The operative leg is prepped and draped in the usual sterile fashion.

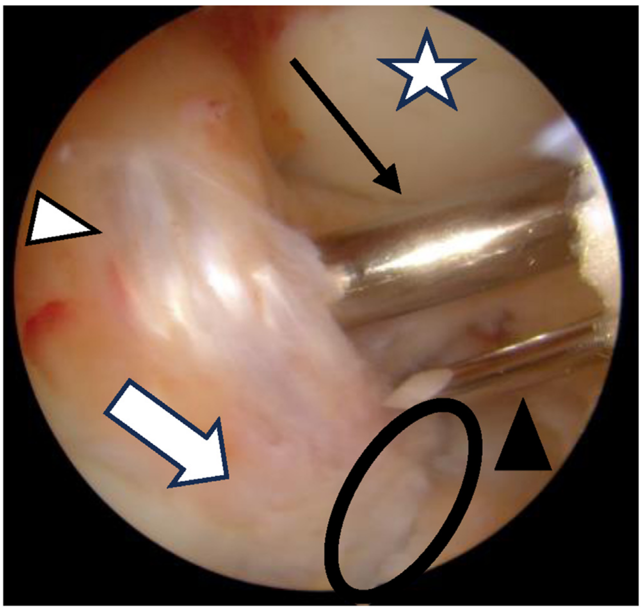

Fig 2. View from anteromedial portal of a left knee in 90° of flexion demonstrating a probe (thin black arrow) holding the fracture fragment (white block arrow) reduced as a K-wire (black arrowhead) is advanced into the joint to provisionally hold the fracture in place. The ACL is labeled with the white arrowhead and lateral femoral condyle is labelled with a star. Fracture line (black oval), ACL (white arrowhead), and lateral femoral condyle (star) are also visualized. (ACL, anterior cruciate ligament.)

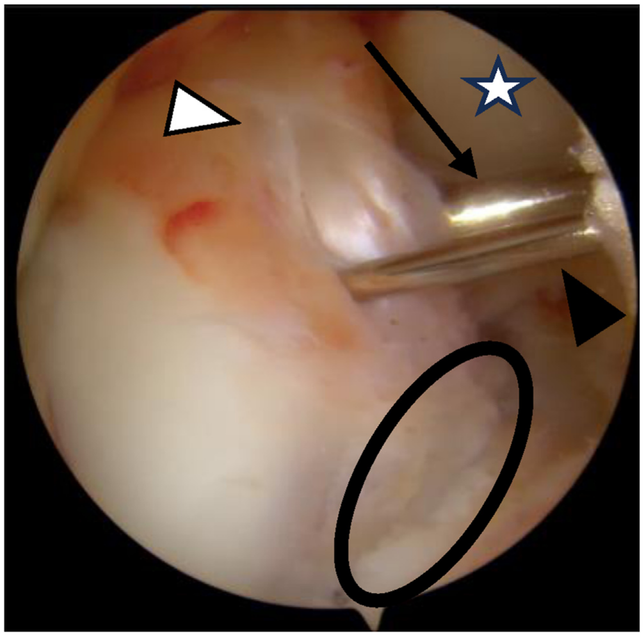

Fig 3. View from the anteromedial portal of a left knee in 90° of flexion demonstrating provisional fracture fixation with a k-wire (black arrowhead) through the accessory portal while the fracture is held in place with a probe (thin black arrow). Fracture line (black oval), ACL (white arrowhead), and lateral femoral condyle (star) are also visualized. (ACL, anterior cruciate ligament.)

A standard anterolateral and anteromedial portal are made and a diagnostic arthroscopy is performed to visualize the fracture and identify any other pathology

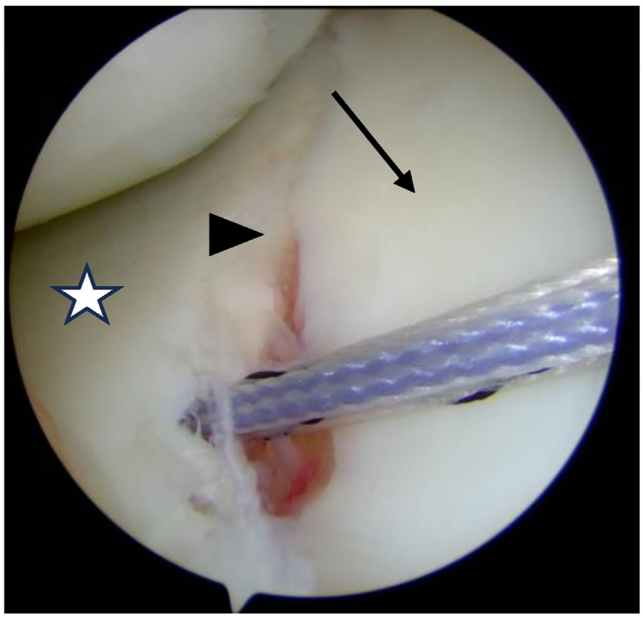

Fig 4. View from the anteromedial portal of a left knee demonstrating anchor placement medial to the fracture fragment. Anchor is placed just lateral to the medial tibial plateau articular surface. Fracture line (black arrowhead), medial tibial plateau (star), and fracture fragment (thin black arrow) are seen.

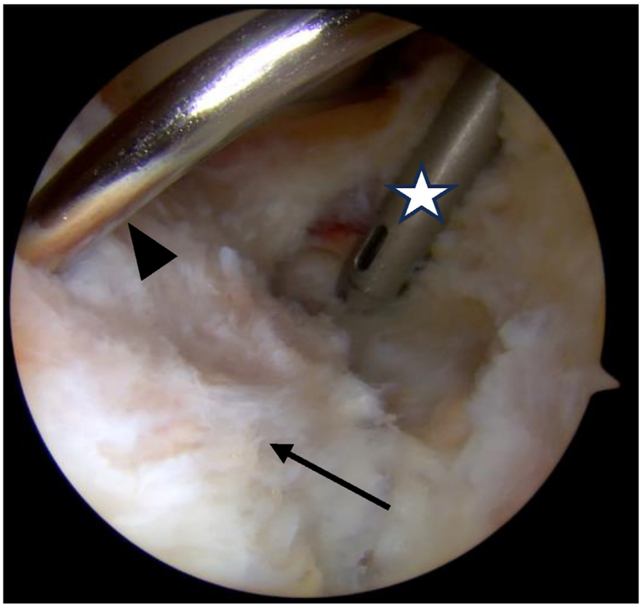

Fig 5. View from anteromedial portal of a left knee demonstrating guide (star) placement for lateral anchor as well as visible k-wire (black arrowhead) used for provisional fracture fixation. The lateral anchor is placed between the fracture fragment (thin black arrow) and the articular surface of the lateral tibial plateau.

in the knee (Fig 1). The ACL is probed to confirm that it is intact and attached to the tibial eminence fracture. Associated pathology such as meniscus tears are treated

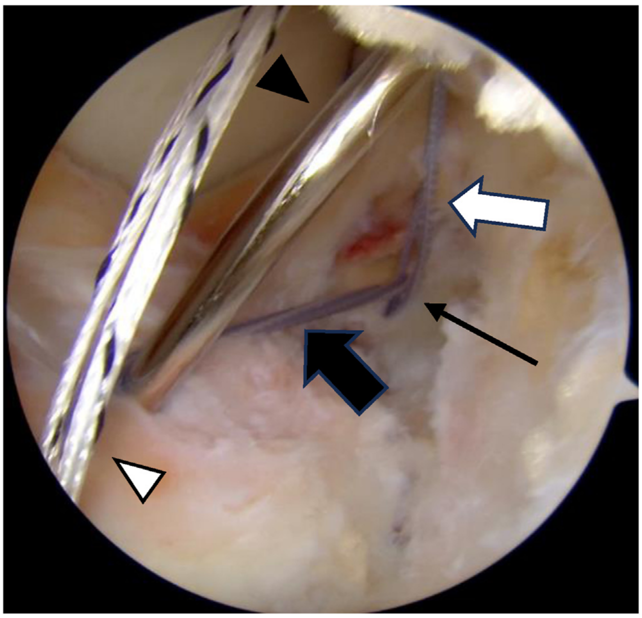

Fig 6. View from the anteromedial portal of the left knee demonstrating again that the fracture reduction is held provisionally with a k-wire (black arrowhead). Single suture bridge (black block arrow) has been already created and is passing over the fracture fragment from the medial anchor (off left/inferior aspect of frame) to the lateral anchor (thin black arrow). Visible blue repair suture (white block arrow) from lateral anchor and white looped shuttling suture (white arrowhead) from the medial anchor will be grasped next.

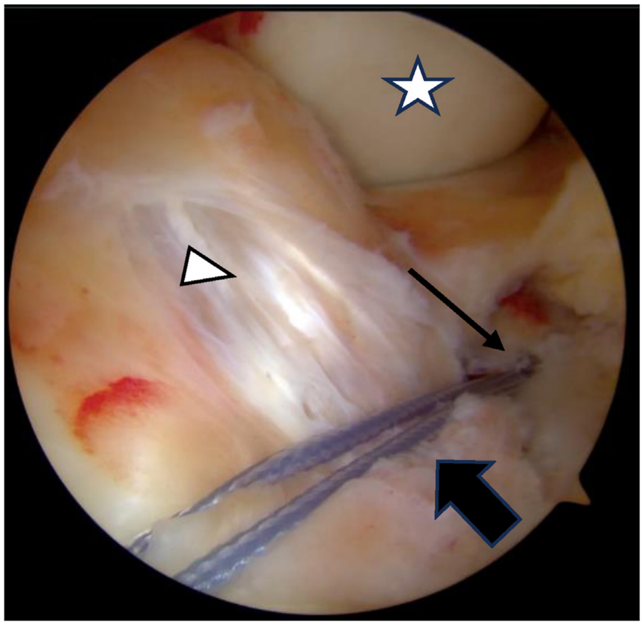

Fig 7. View from the anteromedial portal left knee of the final construct. K-wire has been removed. Two sutures are crossing the fracture fragment (black block arrow), fixated to the tibia by the medial anchor (not pictured) and lateral anchor (thin black arrow). Anterior cruciate ligament is also seen in the superolateral aspect of the view (white arrowhead), and the lateral femoral condyle is labeled with a white star.

at this time before fracture reduction. The fracture bed is debrided to remove any fracture hematoma, loose fragments of bone, and clearly visualize all edges of the fracture. Any meniscus is disengaged by various

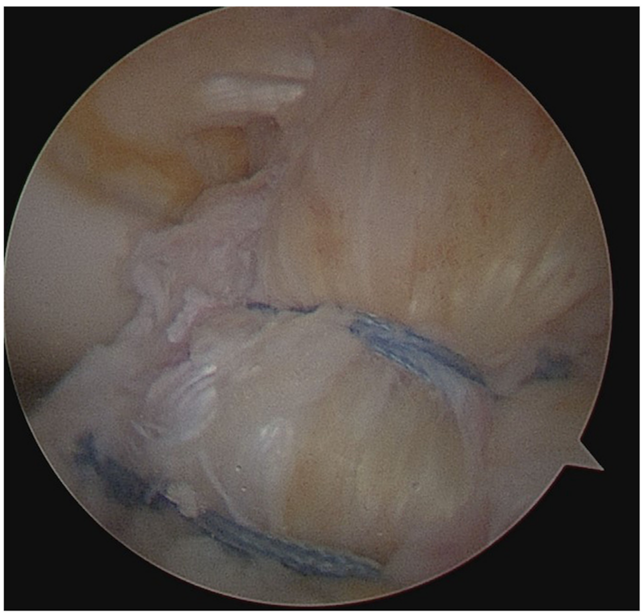

Fig 8. Example of another patient with fixation with four sutures crossing the fracture fragment from four separate anchors.

Table 1. Pearls and Pitfalls

Pearls	Pitfalls
Check fracture reduction frequently throughout the procedure.	Inadequate fracture-site debridement limiting anatomic reduction.
Ensure with spinal needle that accessory portal is able to access planned anchor sites.	Violating the weight-bearing plateau surface with anchor placement.
To prevent a soft-tissue bridge, place a nitinol wire through the drill guide after placement of the first anchor. Set the anchor, and then place the drill guide over the wire for placement of second anchor.	Placing anchors in positions that do not provide the largest area of fracture-fragment compression.

methods and a probe was then used to manipulate the fragment into the fracture bed to anatomically reduce the fracture (Fig 2). A probe maintains the reduction and provisional fixation is obtained by placing a Kirschner wire percutaneously through the patellar tendon across the fracture fragment and into the intact tibia (Fig 3).

With the knee in 90° of flexion, a third medial accessory patellar portal is made medial to the patella, 1 to 2 cm distal to the midline of the patella with needle localization to ensure access to the medial and lateral sides of the fracture. A number 11 blade scalpel is slid over the spinal needle vertically to create the portal and an arthroscopic shaver is used to create a smooth defined portal. Through the accessory portal, a curved anchor guide is used to place a 1.8-mm Arthrex all-suture FiberTak knotless anchor (Arthrex, Naples, FL) medial to the fracture fragment (Fig 4). A nitinol guide wire is then placed down the guide to maintain the portal. The curved anchor guide is removed and then reinserted over the nitinol guide wire to free the suture from the anchor guide. A second 1.8-mm Arthrex all-suture FiberTak knotless anchor (Arthrex is then placed lateral to the fracture fragment (Fig 5).

Once both anchors are placed, the looped end of the 2.0 shuttling suture from the medial anchor and the blue repair suture from the lateral anchor are retrieved. The blue repair suture is then loaded through the looped shuttling suture and passed through the knotless mechanism to create and tension the suture bridge, (Fig 6). This process is then repeated with the looped end of the 2.0 shuttling suture front the lateral anchor and the blue repair suture from the medial anchor, forming a second bridge. The tibial eminence is probed for stability. If additional stability is required a second bridge can be created by adding 2 additional anchors, anterior or posterior to the first bridge if additional stabilization is needed. The K-wire is then removed, and the loops can be retensioned if needed. The suture tails are then cut with a flush cutting guide (Fig 7). The final construct with four sutures crossing the fracture fragment from four separate anchors is demonstrated in Figure 8.

Postoperatively, the patient is placed in full extension for 4 weeks with a cylinder cast or a knee brace locked in zero degrees' extension. Following cast removal or knee brace range-of-motion adjustment at approximately 4 weeks, physical therapy is initiated using an ACL-reconstruction protocol.[7]

Discussion

Good surgical outcomes have been reported with numerous techniques, including transphyseal and physeal-sparing single and double-row bony bridge suture fixation, tibial spine fixation with suture anchors, bioabsorbable nail fixation through arthroscopic portals, and screw fixation through arthroscopic portals.[2-6] Several of these techniques pass the suture through the ACL, which could compromise the integrity of the ligament.[2-4] ACL rupture after fixation of a tibial spine avulsion fracture can occur, but it is unclear whether this is related to suture passing through the ligament.[4,5] Another technique includes passing the suture through the fracture fragment, which could result in comminution of the piece and compromise fixation.[4] The Skyway Suture Bridge Technique provides suture bridge fixation and avoids passing the suture through both the ligament and the fragment.

The technique described in this Technical Note provides knotless suture bridge fixation, uses 3 small arthroscopic portals, and avoids the physis. This technique is similar to transosseous suture bridge fixation, but is physeal-sparing, easier to perform, and creates smaller incisions. The technique has the additional benefit of limited artifact on magnetic resonance imaging should one be needed in the future. Pearls and pitfalls are cited in Table 1 and advantages and disadvantages are cited in Table 2.

All-suture knotless anchor bridge fixation of displaced tibial eminence fractures is a minimally invasive arthroscopic technique that is easy to perform. The

Table 2. Advantages and Disadvantages

Advantages	Disadvantages
Physeal-sparing	Specific anchor availability
ACL-sparing	Less effective for comminuted fracture fragments
Fragment sparing	
No metallic or hard implants	
Small incisions	
Easy technique to learn and use	

ACL, anterior cruciate ligament.

Skyway Suture Bridge Technique provides knotless suture bridge fixation similar to transosseous suture bridge fixation but uses 3 small arthroscopic portals and avoids the physis.

Disclosure

The authors report no conflicts of interest in the authorship and publication of this article. Full ICMJE author disclosure forms are available for this article online, as supplementary material.

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