Technical Note

Arthroscopic Assisted Anterior Cruciate Ligament Tibial Spine Avulsion Reduction and Cortical Button Fixation

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Abstract: Tibial spine avulsion fractures, or tibial eminence fractures, are intra-articular knee injuries that affect the bony attachment of the anterior cruciate ligament (ACL). It is commonly seen in children and adolescents aged 8 to 15 years old and can be caused by noncontact pivot shift injuries or by traumatic hyperextension knee injuries, as seen in adult ACL patients. A thorough history and physical exam is important in these patients alongside proper imaging that will confirm the diagnosis of a tibial spine avulsion. Proper imaging may also demonstrate other associated conditions or injuries to the cartilage, meniscus, or ligamentous structures. Following diagnosis, treatment can be both nonoperative versus operative, depending upon the degree of displacement and reducibility of the fragment, as well as other concomitant injuries. For nondisplaced or minimally displaced, and reducible injuries, the patient can be immobilized in full extension for several weeks. For displaced fragments that are unable to be reduced by closed methods, open reduction internal fixation or arthroscopic fixation is recommended. In this Technical Note, we describe an arthroscopy-assisted reduction and internal fixation with suture tape through 2 transtibial tunnels with a cortical suture button fixation technique.

Introduction

Tibial spine avulsions are rare injuries that are most commonly found in children and adolescents aged 8-14 years old, but can be seen in older individuals as well.[1] They account for 2-5% of all pediatric knee injuries and up to 14% of pediatric anterior cruciate ligament (ACL) injuries and are more commonly seen in males.[2-4] The mechanism of injury can be due to a noncontact pivot shift motion or a traumatic hyperextension of the knee joint.[5] In skeletally immature patients, the tibial eminence may fail at lower tensile forces than the ACL due to incomplete ossification and will lead to the equivalent of an adult ACL injury.[6,7]

There are several classification types that describe tibial spine fractures, which are based upon fracture displacement and rotation. The first classification was described by Meyers and McKeever and was then modified by Zaricznjy.[8-10] Type I injuries are nondisplaced, tibial avulsion fractures. Type II injuries are those with minimal fracture displacement and an intact posterior hinge. Type III and IV injuries are completely displaced fractures with varying degrees of rotation and comminution (Fig 1).

Tibial spine avulsions graded as Type I or Type II fractures that are reducible can be treated conservatively with immobilization of the knee in full extension. In a recent epidemiologic study evaluating over 876 cases of pediatric tibial spine fractures, over 71% of them were treated conservatively, with less than 3% of them going on to having residual ACL laxity or requiring ACL reconstruction.[4] Type II fractures that are unable to be reduced adequately in full extension or completely displaced Type III and Type IV fractures are recommended for surgical intervention, as these patterns have a higher risk of laxity, knee stiffness, and fracture nonunion associated with nonsurgical

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Fig 1. Computed tomography scan sagittal view of a right knee demonstrating a completely displaced tibial spine avulsion fracture (red arrow).

management.[11,12] Even though surgical intervention leads to clinical improvements, a recent study noted that at 5-year follow-up 10.6% of patients undergoing tibial spine avulsion repair suffered an ipsilateral ACL tear and 21% required an additional procedure.[13]

Techniques for surgical fixation of tibial spine avulsions can be open or arthroscopic with either suture or screw fixation. Decision making on the proper technique will depend upon a variety of factors, including: size of fracture and comminution, injury to the ACL tissue proper, associated injuries, tissue entrapment preventing reduction, and surgeon preference/experience. Open procedures can provide direct visualization of the fragment but have been shown to be associated with higher morbidity and longer hospital stay versus an arthroscopic approach.[14] Additionally, open fixation may require subsequent removal of hardware if performed with screws. On the contrary, arthroscopy-assisted reduction and internal fixation can be more technically demanding but affords the surgeon excellent visualization of fracture reduction, the ability to address any other intra-articular pathology, with less soft tissue dissection. Arthroscopic fixation has also been shown to lead to significant improvements in patient-reported outcomes, with low complications rates and high patient satisfaction at short-term follow-up.[15]

The purpose of this Technical Note is to describe the senior authors' preferred arthroscopic technique for tibial eminence repair using a dual transtibial tunnel, cortical suture button technique.

Surgical Technique

Patient Setup and Diagnostic Arthroscopy

The patient is positioned supine on the operative table with a standard knee arthroscopy set up, using a lateral post per preference of the surgeon. A standard anterolateral portal is created followed by an anteromedial portal through needle localization. A diagnostic knee arthroscopy is then performed to evaluate for associated injuries and the extent of the tibial spine avulsion. Special attention should be made to address any concomitant chondral or meniscal injuries.

Preparation of the Tibial Spine Avulsion

The tibial spine avulsion is evaluated and fracture fragments are identified noting their relationship to the attachment of the medial and lateral meniscus and the footprint of the tibial ACL (Fig 2, Video 1). The bony bed of the tibial spine avulsion, including the undersurface of the fracture, are thoroughly debrided using a motorized oscillating shaver to stimulate bony bleeding, in addition to helping visualize the fracture edges for a proper reduction (Table 1).

Passage of Suture and Tibial Tunnel Drilling

With the camera in the anteromedial portal, a suture lasso is then used through the anterolateral portal to pass a nitinol wire through the posterior fibers of the ACL in a lateral to medial direction, to allow for shuttling of a 1.8-mm suture tape (Arthrex, Naples, FL) (Fig 3, Video 1). The camera is then switched to the anterolateral portal, and the suture tape is then pulled out through the anteromedial portal. Following this, an incision is made over the anteromedial tibia centered over the medial tibia, and an ACL guide is used to drill a tibial tunnel through the avulsion site and into the lateral most aspect of the avulsion fragment. A 2.4-mm cannulated drill and subsequent nitinol wire are used to pass a shuttle suture through the tibial tunnel (Fig 4, Video 1). A suture lasso (Arthrex) is then used again to

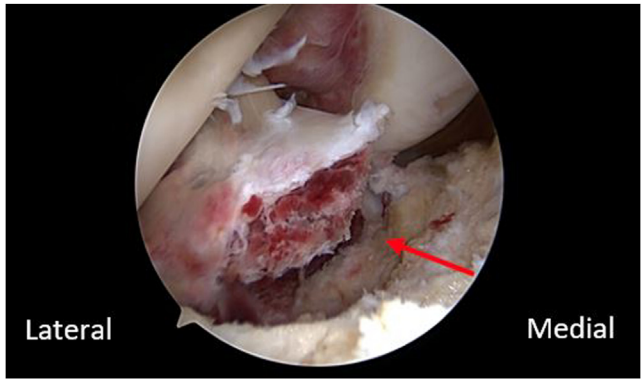

Fig 2. Arthroscopic image of a right knee viewing from the anterolateral portal with a 30° scope demonstrating a displaced tibial spine avulsion fracture (red arrow).

Table 1. Pearls and Pitfalls

Pearls	Pitfalls
• Prepare the tibial fracture bed and remove any small boney fragments and clot, in order to obtain anatomic reduction. • Use a suture lasso or other passing device to pass suture through the anterior and posterior ACL fibers. • Use an ACL guide, cannulated drill, and nitonil wire for precise position of each tunnel and simple shuttling of the sutures. • Place the knee through gentle range of motion and retension the sutures until adequate reduction and fixation is obtained.	• Make sure there is no other soft tissue, boney fragments, or meniscus tissue that are blocking your reduction. • Intermeniscal ligament or fracture hematoma can block reduction.

place a nitinol wire and subsequent suture tape through the anterior, inferior fibers of the ACL. After being passed, the ends of the anterior suture tapes are crossed over one another for improved tensioning and reduction and are pulled out the anteromedial and anterolateral portals (Fig 5, Video 1). Finally, a second tibial tunnel is drilled medial to the avulsion fragment using an ACL guide and a cannulated drill. The same shuttling technique is used as previously described for the medial tunnel (Fig 6, Video 1).

Suture Fixation and Tensioning

One end from each suture tape previously placed within the ACL fibers is then shuttled through the medial and lateral tibial tunnels to allow for anatomic reduction of the avulsion fracture and is tensioned over a 4-hole button in full knee extension. There are 2 separate tapes (4 total strands), and the corresponding suture tape ends are tied over the button using the following technique: a modified Tuckahoe sliding knot is utilized to initially tension the fixation while the tibial avulsion fragment reduction is maintained with an arthroscopic probe, then 3 alternating half hitch knots are placed after the sliding knot to secure the fixation. This is repeated for both suture tapes that were exiting the tibial tunnels. The knots are tied over the suture button with the knee is 60° of flexion, so as not to overtension the ACL. Once the proper tension and fixation are obtained, the knee is taken through a gentle range of motion to ensure anatomic reduction. The final knots are placed over the top of the suture button, and anatomic reduction of the tibial spine avulsion is maintained.

Final Intraoperative Examination

The knee is then taken through a final range of motion under arthroscopic visualization, confirming appropriate tensioning of the fixation throughout range of motion (Fig 7, Video 1). The sutures are then cut flush, and the wounds are irrigated and closed in a standard, layered fashion. A soft dressing is placed followed by a hinged knee brace locked in full extension. The above-mentioned technique is demonstrated in Video 1.

Postoperative Protocol and Rehabilitation

The patient is placed in a hinged knee brace at the conclusion of the procedure. Postoperative radiographs

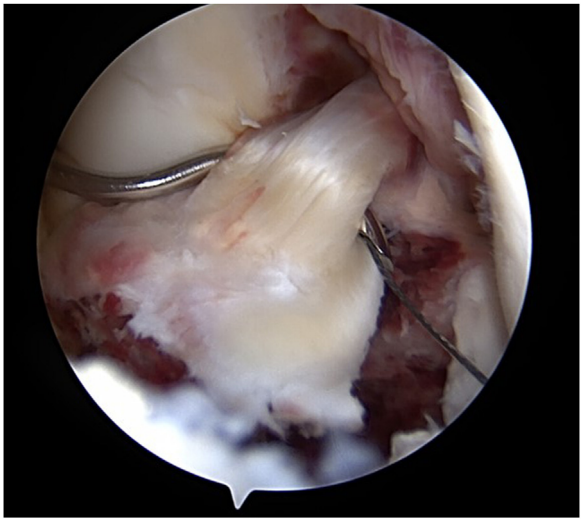

Fig 3. Arthroscopic image of a right knee viewing from the anteromedial portal demonstrating suture lasso passage of a nitinol wire through the posterior fibers of the anterior cruciate ligament.

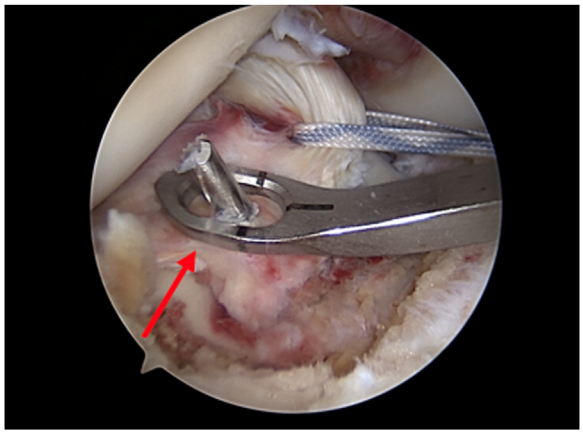

Fig 4. Arthroscopic image of a right knee viewing from the anterolateral portal demonstrating an anterior cruciate ligament drill guide and cannulated drill (red arrow) placed through a tibial spine avulsion fracture fragment to create a lateral tibial tunnel for fragment fixation.

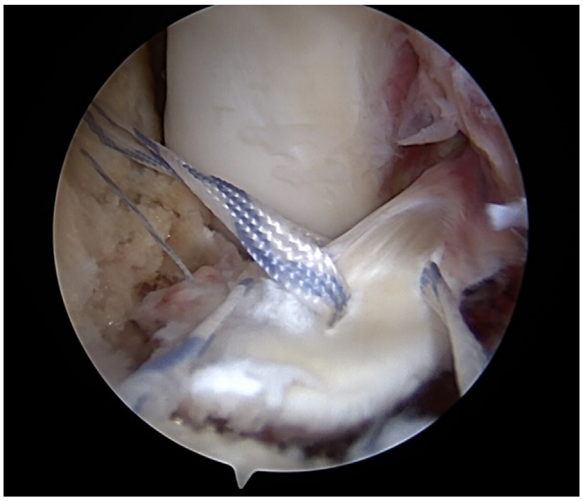

Fig 5. Arthroscopic image of a right knee viewing from the anteromedial portal demonstrating 2 suture tapes placed through the anterior and posterior fibers of the anterior cruciate ligament (ACL).

demonstrate anatomic reduction of the tibial spine avulsion fracture (Fig 8). The initial range of motion restrictions are 0-60° for the first 2 weeks and advanced to 0-90° for the first 6 weeks. The patient is toe-touch weight bearing to the right lower extremity to protect the fracture repair for 4 weeks' time.

Discussion

The fixation of tibial spine avulsion fractures can be technically challenging to ensure proper reduction, fixation, and tensioning of the fracture fragment. One of the most common complications following surgery for tibial spine avulsion fragments is knee arthrofibrosis, with rates reaching as high as 60%.[16,17] Risk factors for arthrofibrosis include malunion, nonunion, prominent hardware, prolonged operative time, delayed surgery, revision surgery, and length of postoperative immobilization.[17-19] Whether a surgeon chooses to perform the surgery open versus closed, it is important to have a simple, efficient technique that will provide anatomic reduction.

The technique described uses commonly used arthroscopic devices for suture fixation of a tibial spine avulsion fracture. Although we chose suture fixation, another option is the use of screw fixation when the fragments are large enough to accept screw fixation. Although screw fixation can provide strong fixation of the fracture fragment, previous biomechanical studies have shown that suture fixation had an even greater strength than cortical screws.[20,21] When comparing clinical outcomes, most studies have not shown a difference between screw and suture fixation, but have noted a higher risk for repeat surgery and need for hardware (screw) removal.[12,14-22]

Although this technique is efficient and reproducible, it is not without limitations. One limitation is that although we used common devices used for sports medicine arthroscopic surgeries, orthopedists outside of sports medicine may not be as familiar with these devices or have access to them. It is also important to take into consideration the risks of drill tunnels and injury to the physis when performing this procedure in skeletally immature patients. Another limitation to this technique is the use of a suture button and the risk for hardware prominence or irritation over the anterior proximal tibia requiring subsequent surgery for removal.

The primary benefits of this technique are the use of small tibial bone tunnels that are incorporated through the fracture fragment with subsequent tensionable

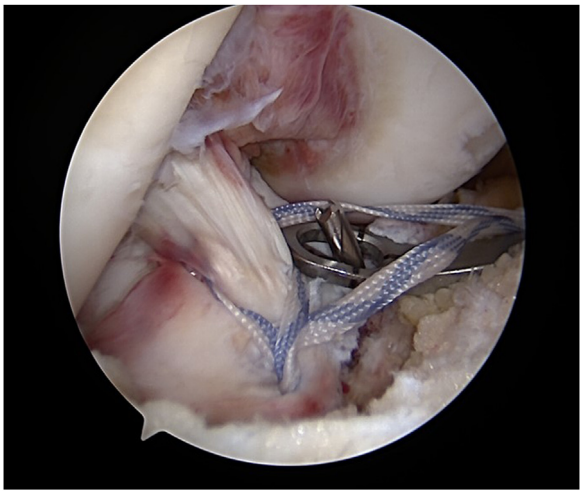

Fig 6. Arthroscopic image of a right knee viewing from the anterolateral portal demonstrating an anterior cruciate ligament drill guide and cannulated drill to create a medial tibial tunnel for fragment fixation.

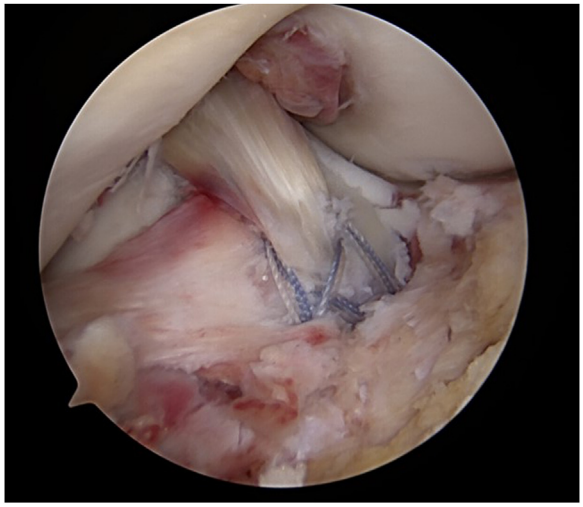

Fig 7. Arthroscopic image of a right knee viewing from the anterolateral portal demonstrating final tension and fixation of a tibial spine avulsion fracture.

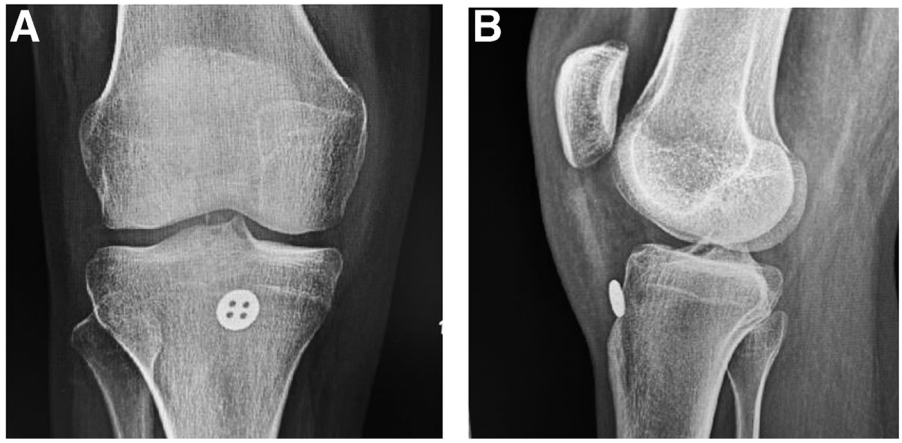

Fig 8. (A) Postoperative. (B) Anterior-posterior. Lateral radiographs demonstrating tibial cortical button fixation of a tibial spine avulsion fracture in a right knee.

Table 2. Advantages and Disadvantages of the Technique

Advantages	Disadvantages
• Arthroscopy allows complete visualization of any associated intra-articular injuries. • Less invasive approach for pediatric patients than an open procedure. • No intra-articular screws or hardware • Ability to tension and retension fixation and to visualize the ACL during tensioning with the arthroscope • Visualization of the fracture reduction through range of motion	• Access to arthroscopic devices, suture tape, and suture-passing materials • Hardware prominence of cortical tibial button • Drilling through the avulsion fragment to pass sutures may be difficult depending on the fragment size. • Potential drill tunnel through the physis in skeletally immature patients

fixation over a distal suture button and no intra-articular hardware (Table 2). Drilling and passing the suture tapes through the fracture fragment itself afford excellent fixation strength and an anatomic fracture reduction. The technique allows easy tensioning of the ACL fibers in connection with the bone fragment without the need for complex suture passage underneath or around the fracture fragment. It also allows for appropriate tensioning over the suture button prior to final fixation without the risks of screw removal. We conclude that this technique using tibial tunnel drilling through the tibial spine avulsion fragment and suture button, suspension fixation provides straightforward, tensionable, anatomic reduction of a tibial spine avulsion fracture.

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