

Arthroscopic Reduction of Bicruciate Tibial Avulsion Fractures: Lever Push Technique



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Abstract: Combined anterior cruciate ligament and posterior cruciate ligament tibial avulsion fractures are rare knee injuries that are primarily seen in adults. Prompt surgical intervention is indicated for displaced fractures to restore knee stability. Arthroscopic techniques are now the preferred method for treating anterior tibial spine avulsion fractures with posterior cruciate ligament tibial avulsion fractures being treated arthroscopically or with open reduction and internal fixation methods. This Technical Note and accompanying video demonstrate an arthroscopically assisted repair of bicruciate tibial avulsion fractures using an arthroscopic lever push technique. Two sutures are passed through the anterior cruciate ligament and pulled down through two bone tunnels placed within the tibial fracture bed, and one suture is passed around the posterior cruciate ligament and pulled down through one bone tunnel passing from the anterior tibia to the tibial fracture bed. Our technique is simple and effective in reducing bicruciate tibial avulsion fractures to anatomic position.

Introduction

Combined anterior cruciate ligament (ACL) tibial spine and posterior cruciate ligament (PCL) tibial avulsion fractures (henceforth referred to as bicruciate tibial avulsion fractures, or BTAF) occur rarely and are not well reported on in the literature. They are primarily documented in adults after high-energy impacts, such as two-wheeler vehicle accidents and falls from a height.¹⁻⁵ Hyperextension of the knee from such injuries places strain on both the ACL insertion in the tibial spine and the PCL insertion in the posterior aspect of the tibial plateau and is a common mechanism of injury for adult ACL and PCL avulsion fractures.⁶

Similar to stand-alone cruciate ligament tibial avulsion fractures, BTAFs present with knee pain with weight bearing, antalgic gait, painful range of motion, and instability. Prompt surgical intervention is indicated with type II or above ACL and PCL avulsion fractures, as classified by Meyers and McKeever.⁷ Arthroscopic techniques are now considered the gold standard for treating tibial spine avulsion fractures, while the literature has yet to reach a consensus on the treatment of PCL avulsion fractures, with both open and arthroscopic fixation yielding satisfactory operative and clinical outcomes.^{8,9} However, in our literature review, no consolidated surgical technique has been presented for BTAF. The purpose of this Technical Note and accompanying video (Video 1) is to describe an arthroscopic approach to easily and effectively reduce BTAF using an arthroscopic lever push technique.

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Surgical Technique

Preoperative Evaluation

The diagnosis of bicruciate tibial spine avulsion fractures is established using the patient's history, clinical examination, and diagnostic imaging. Upon examination, the patient may present with diffuse swelling and pain of the knee, as well as inability to bear weight. Lachmann's test, the anterior drawer test, and posterior drawer test will be positive but may be difficult to assess if the patient is in severe pain due to guarding.

Radiographs may demonstrate avulsion fracture, but this may be difficult to visualize if minimally displaced. Advanced imaging such as computed tomography and/or magnetic resonance imaging would further describe the size of avulsion and associated injuries (Fig 1). Magnetic resonance imaging is recommended to evaluate for intact cruciate ligaments and concomitant soft tissue injuries such as meniscal lesions.

Patient Positioning

The patient is positioned supine on a standard operating table and the lower extremity is placed into an OSI leg holder. Perioperative antibiotics and a peripheral nerve block are administered. General anesthesia is induced. The head and body prominences are padded. The lower extremity is prepped and draped in the usual sterile fashion.

Arthroscopic Portal Placement

An anterolateral portal is created using a #11 blade with a vertical incision just lateral to the patellar tendon at the inferior pole of the patella. The joint is then entered with a blunt trocar and scope sheath. The trocar is removed, and a complete diagnostic arthroscopy is performed using a 30° 4.0-mm arthroscope to inspect for loose bodies, cartilage damage, and meniscus tears. An anteromedial portal is made in the standard fashion under needle localization.

Preparation and Reduction of the ACL Tibial Spine Avulsion

Upon probing, the ACL is lax and with intact femoral attachment (Fig 2A). The tibial footprint is inspected and found to be avulsed. The shaver is used to debride the scar tissue under the avulsed fragment, as well as tibial fracture bed to create a recess for anatomically reducing the fracture (Fig 2B). A 2-cm incision is made over the anterior proximal tibia and drill guide from the Arthrex RetroConstruction

set is used to guide 3-0 cannulated drill bit under the avulsed fragment (Fig 3A). Then a Scorpion suture passer (Arthrex) is used to pass a no. 2 FiberWire suture (Arthrex) around the ACL just above the avulsed fragment. A retriever is then used to grab the tails and pull them through the loop, cinching down around the ACL. A flexible nitinol suture passer is used to pull the tails through the anterior tibial tunnel. The fracture is found to be partially reduced. A second bone tunnel is then drilled laterally using the knee drill guide to guide the 3-0-mm cannulated drill bit under the avulsed fragment. An additional suture is passed and cinched in the same direction around the ACL and subsequently pulled through the anterolateral tibial tunnel (Fig 3C). Once the fracture is well reduced, a spade-tip drill is used to create a pilot hole for a 4.75-mm SwiveLock anchor (Arthrex). The drill hole is tapped and both sutures are loaded onto the SwiveLock, tensioned, and screwed into the tibial cortex. The ACL is probed and found to be taut, indicating successful performance of the lever push technique (Fig 3D).

Preparation and Reduction of the PCL Tibial Avulsion

Upon probing, the PCL appears incompetent. The tibial footprint is inspected and also found to be avulsed. Under arthroscopic visualization, a posterior drawer test is notable with shifting of the tibia. The arthroscope is moved to view the origin of the PCL, after which a posteromedial portal is made under needle localization, and a cannula is inserted. The arthroscope is then shifted into the new portal, and a grasper is inserted to further test the ligament. Upon further inspection, the ligament is found to be taut when the fragment is reduced, confirming that arthroscopic reduction of the fragment can be used. The shaver and electrocautery are introduced and used to debride along the PCL origin to better identify the origin of the fibers. A PCL tibial

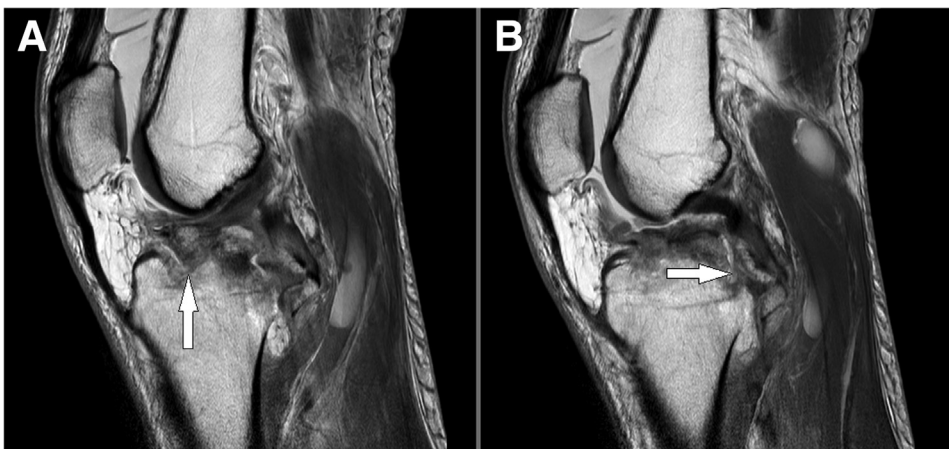
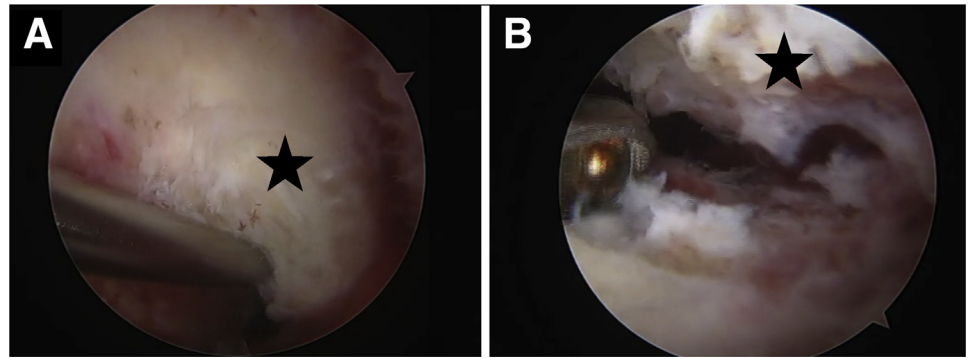


Fig 1. Preoperative lateral magnetic resonance imaging scans of the left knee showing type IV or comminuted avulsion fracture (arrow) (A) of the anterior cruciate ligament and type III or completely displaced avulsion fracture (arrow) (B) of the posterior cruciate ligament.

Fig 2. Intraoperative arthroscopic views of the left knee from the anterolateral portal. (A) The intact anterior cruciate ligament (star) is probed to confirm laxity. (B) The tibial fracture bed underneath the avulsed fragment (star) is debrided with a shaver.



tip-aiming guide is then positioned under the insertion of the PCL. A small incision is made over the lateral proximal tibia and 3.0-mm cannulated pin guide is fired through the tibia (Fig 4A). The Arthrex Knee Scorpion Suture passer is then used to pass a no. 2 FiberWire suture through the PCL, and a retriever is again used to pass the tails through the looped end to create a cinched knot around the PCL, allowing for manipulation of the avulsed fragment (Fig 4B). With the aid of a suture lasso, the suture tails are retrieved through the tibial drill hole and out of the anterior tibia. A pilot hole is drilled in the anterior tibia and prepared with a 4.75-mm SwiveLock anchor tap (Arthrex). Sutures are loaded onto the SwiveLock (Arthrex), tensioned, and

anchored into the tibia. The PCL fragment is found to be well reduced and the PCL taut upon probing (Fig 4D).

Final Examination and Postoperative Care

Postreduction, knee stability is confirmed arthroscopically. Knee examination reveals improved extension and flexion and elimination of excess ACL and PCL laxity. The incisions are closed in the standard fashion with 3-0 nylon. The knee is placed in a functional brace and locked in extension. The patient is advised to wear the brace for a total of 6 weeks. Non-weight-bearing is recommended for a total of 4 weeks postoperatively. Postoperative radiographic imaging will confirm proper reduction and routine healing of avulsion fractures (Fig 5).

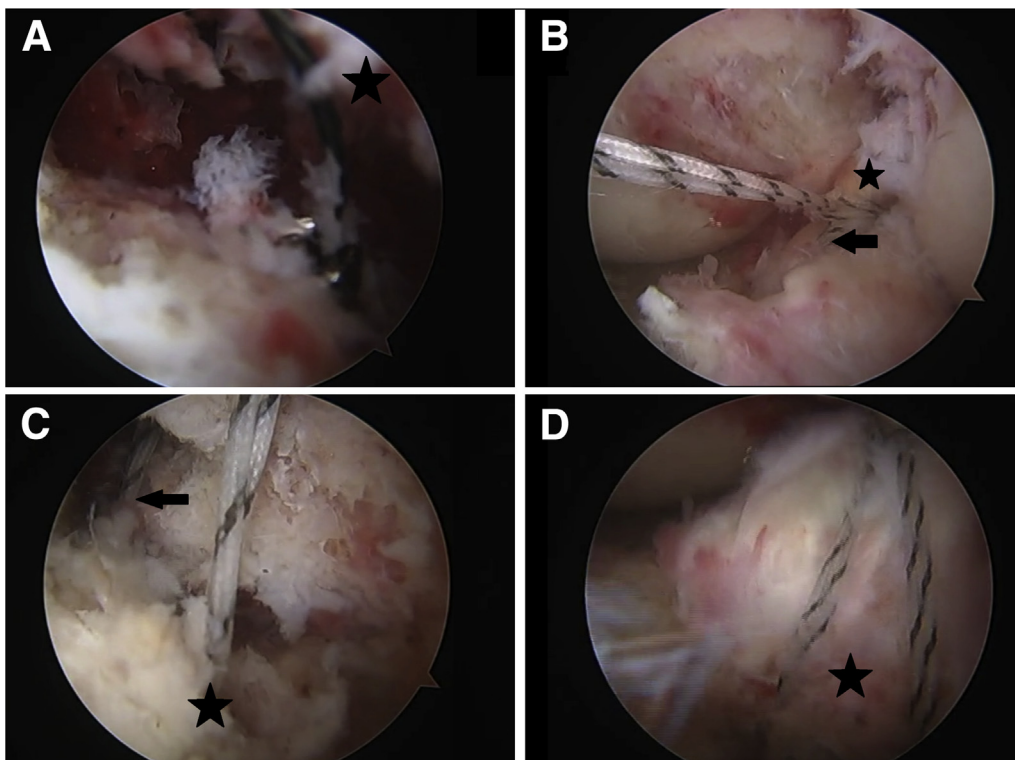


Fig 3. Intraoperative arthroscopic views of the left knee from the anterolateral portal. (A) The first bone tunnel is drilled underneath the avulsed fragment (star) and a suture wire retrieved. (B) The first suture (arrow) has been tied around the anterior cruciate ligament (star) in a cinch knot and pulled down the tunnel, while the second suture has been similarly tied around the anterior cruciate ligament (star). (C) The positioning of both sutures (star, arrow) after being pulled down their respective tunnels can be seen. (D) Finally, excellent reduction of the avulsed fragment (star) is confirmed.

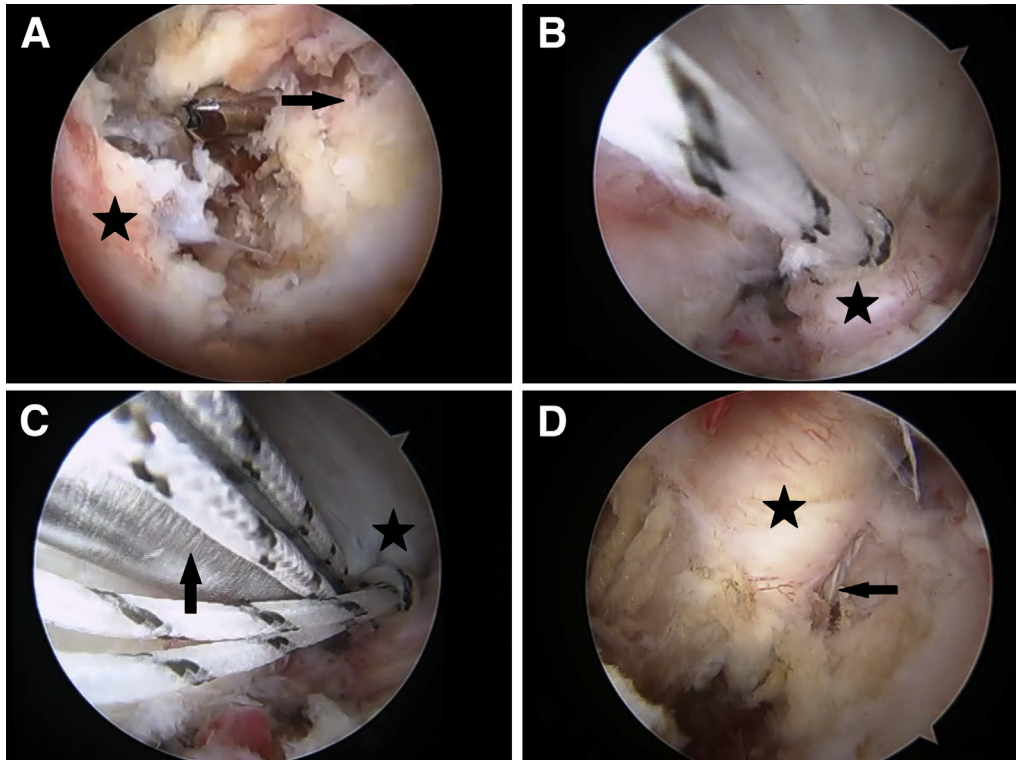


Fig 4. Intraoperative arthroscopic views of the left knee. (A) The view from the posteromedial portal shows the 3-0 cannulated drill bit created tunnel passing through the tibia (arrow) and aimed at the avulsion fragment (star). (B) The suture is tied around the posterior cruciate ligament (star) in a luggage tag cinch knot. (C) Then parked under the posterior cruciate ligament (star) in the posteromedial compartment with a Scorpio grasper (arrow). (D) The suture (arrow) is pulled down through the tibial tunnel and the avulsion fracture (star) is successfully reduced.

Discussion

Proper knee kinematics require both the ACL and PCL to be properly positioned and tensed, making BTAF doubly problematic due to the presence of bicruciate laxity. Surgery is indicated as long as either avulsion fracture is displaced and must be performed for both at the same time, as a full recovery cannot occur

otherwise with either cruciate ligament being compromised. While PCL tibial avulsions can be satisfactorily treated through either open or arthroscopic approaches, we recommend an arthroscopic approach for both ACL and PCL avulsions, in part, to simplify surgical equipment preparation and to minimize incision size and hardware required.⁹

Fig 5. Postoperative radiographic imaging of the left knee in the anteroposterior view (A) and lateral view (B) indicate well-reduced avulsion fractures (arrows).

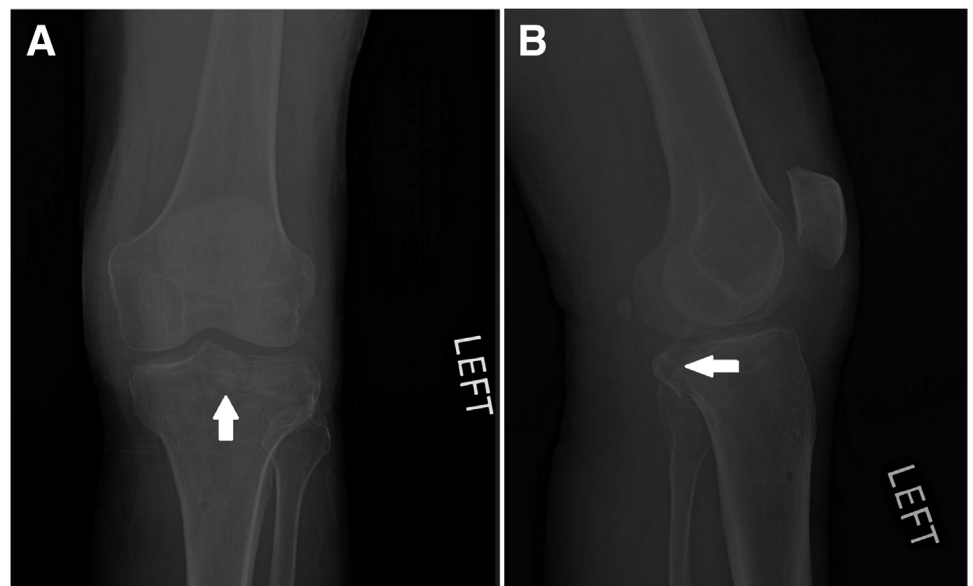


Table 1. Advantages and Disadvantages of Lever Push Technique

| Advantages |
|---|
| <ul style="list-style-type: none"> • Easy and effective reduction technique of double avulsion fractures without need for provisional fixation • Optimized points of fixation (two for ACL, one for PCL) while maintaining excellent anatomic reduction, strong fracture fixation, and subsequent knee stability • Eliminates risk of comminuting type II or type III fractures due to no need for drilling through avulsion fragments • Additional surgery for hardware removal not required • Ability to treat concomitant intra-articular pathology |
| Disadvantages |
| <ul style="list-style-type: none"> • Limited in clearest visualization of comminuted avulsion fractures • Arthroscopic entry to the posterior compartment of the knee requires experienced surgeon, due to complex anatomy • Increased chances of arthrofibrosis without aggressive rehabilitative protocol |

This report describes an arthroscopic technique using nonabsorbable suture fixation. Multiple arthroscopic methods have been described for tibial avulsion fractures, including K-wires, screws, suture fixation, and suture anchors, as well as less reported techniques, such as transtibial suturing with cerclage wire, staple fixation, and toothed plate fixation.^{3,8,10-13} Screws and nonabsorbable suture fixation are the most common techniques. Suture fixation using absorbable anchors is both minimally invasive, while achieving excellent anatomic reduction and stable fixation, as well as eliminating the risk of fragment comminuting^{8,14} (Table 1). One of the primary disadvantages of arthroscopic suture fixation for BTAF include technical complexity of arthroscopically accessing the posterior compartment of the knee and the deep-seated PCL tibial insertion^{1,15} (Table 2). This challenge is mitigated by using only one bone tunnel for the PCL tibial avulsion. In addition, higher rates of arthrofibrosis are reported after arthroscopic suture fixation compared to screws, which could potentially be rectified with earlier range-of-movement rehabilitation.^{14,16}

Our surgical technique used two bone tunnels for repair of the tibial spine avulsion fracture and one for repair of the PCL tibial avulsion fracture. This is the

Table 2. Pearls and Pitfalls of the Lever Push Technique

| Pearls |
|---|
| <ul style="list-style-type: none"> • Trial reduce fragments to ensure cruciate ligaments are intact and sufficiently taut. • Debride the tibial fracture beds to ensure proper anatomic reduction of the fracture. • Tibial aiming guides should be aimed so that the tunnels will end in the posterior and lateral sections of the tibial fracture bed for the ACL and aimed at the PCL avulsion fragment for the PCL. • Finish reduction and fixation of tibial avulsion first to have access to anterior viewing portals for assistance in creating posteromedial portal with needle localization. |
| Pitfalls |
| <ul style="list-style-type: none"> • Ensure that no other soft tissue or cartilage is entrapped while performing the final reduction of the avulsion fractures. |

least amount of fixation points so far found to be necessary for proper anatomic reduction of ACL and PCL avulsion fractures. Zhao et al. reported that at least three bone tunnels may be necessary to ensure anatomic reduction and to prevent avulsion fragments from sticking up on one side.¹ There appears to be no consensus on the optimal points of fixation. Points of fixation used for arthroscopic suture fixation of the tibial spine avulsion typically vary between two or three,^{1,2,16,17} while points of fixation used for arthroscopic suture fixation of the PCL tibial avulsion have been reported between one to three.^{1,15,18,19} It is possible that different numbers of points of fixation may potentially be necessary to achieve proper anatomical reduction for different Meyers and McKeever type of avulsion fractures. More clinical studies are necessary to evaluate this possibility. Our surgical technique provides proper reduction of the avulsed fragments with as few drill holes as possible leading to a less invasive surgery and, in turn, less postoperative pain and fewer complications.

Our surgical technique is an effective and concise way to reduce the fragments for BTAF, providing an adequate reduction without excessive drilling. It eliminates risk of comminuting avulsion fragments as is present in screw fixation, eliminates the need for provisional reduction, and is streamlined to address two serious disturbances of knee kinematics in one procedure. We conclude that our arthroscopic lever push technique is an easy and effective method for the repair of BTAF that produces excellent anatomic reduction and ligamentous stability.

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