Arthroscopic Reduction of Tibial Spine Avulsion: Suture Lever Reduction Technique

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Abstract: Tibial spine avulsion fractures are uncommon knee injuries that predominantly occur in children and young adults. Restoration of anterior cruciate ligament length through surgical reduction and fixation of the fracture is necessary to ensure stability of the knee with suitable range of motion and minimal knee laxity. Arthroscopic repair of tibial spine avulsion fractures is a technically complex procedure, specifically when performing and maintaining the initial anatomic reduction. We describe in this technical note and accompanying video a unique 3-point fixation repair of tibial spine avulsion fractures using an arthroscopic assisted suture lever reduction technique. Our technique is both simple and efficacious in the reduction of tibial spine avulsion fractures to anatomic position by passing the first suture through the anterior cruciate ligament, and subsequently anterior to the avulsion fragment, and then beneath the fragment through a posteriorly placed bone tunnel within the tibial fracture bed.

Tibial spine avulsion fractures, also known as intercondylar eminence fractures, are most often encountered in young patients between 8 and 14 years of age.[1,2] These fractures in pediatric patients are rare injuries, accounting for 14% of all anterior cruciate ligament (ACL) injuries.[3] The mechanism of injury occurs when a patient hyperextends the knee with simultaneous rotation of the knee on the tibia, such as while playing soccer, falling off a bicycle, or participating in other forceful sporting activities.[4] Hyperextension of the knee places significant tension on the ACL, which originates on the lateral femoral condyle and inserts onto the anterior tibial spine, thus resulting in an avulsion fracture of the latter site (Fig 1). Concomitant injury to the ACL, meniscus, or other surrounding structures can also occur, and should be evaluated.[5]

Prompt operative reduction and fixation of Meyers and McKeever[6] type II and III tibial spine fractures is crucial to minimization of the risks of fracture nonunion, symptomatic knee laxity, and loss of range of motion in the patient.[1,7] The use of arthroscopy for tibial spine fracture repair has been well described, and it has replaced the traditional open approach because of its decreased morbidity. Different reduction and fixation methods have been described with varied technical ease and reliability.[8] The purpose of this technical note and accompanying video (Video 1) is to describe a modified arthroscopic approach to easily and effectively reduce tibial spine avulsion fractures using an arthroscopic suture lever technique.

Surgical Technique

Preoperative Evaluation

The diagnosis of a tibial spine avulsion fracture is determined using a combination of the patient's history, clinical examination, and radiographic evaluation. The history entails a young athletic patient who hyperextends the knee while running, playing soccer, or participating in another vigorous sporting activity.[1,2] Patients with a tibial spine avulsion will present with a swollen and painful knee with an inability to bear weight on the affected extremity. Lachman or anterior drawer tests may be positive, such as in an ACL tear, but the pain can make it difficult for the clinician to perform a proper physical examination of the affected knee. Radiographs typically reveal an avulsion fragment off the tibia. Diagnosis can be made

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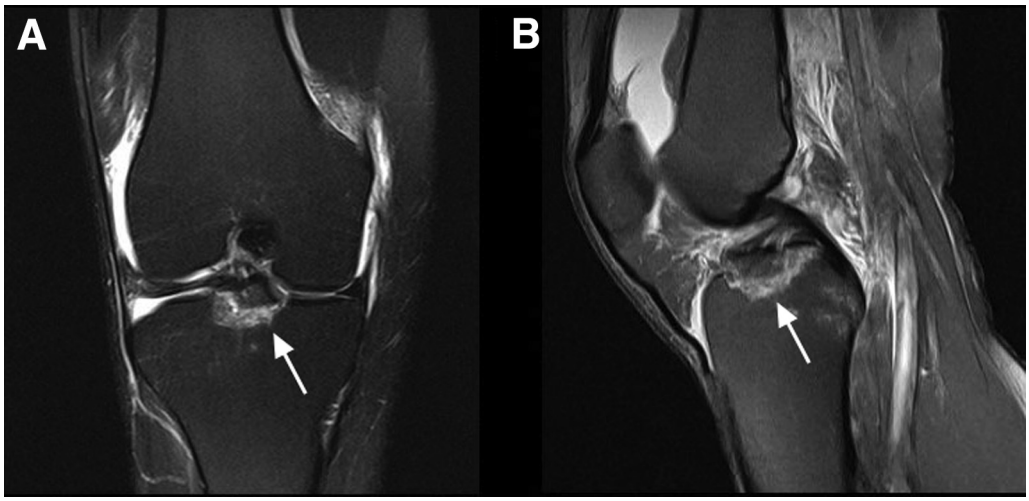

Fig 1. Preoperative (A) anteroposterior and (B) lateral magnetic resonance imaging scans of the right knee showing a displaced tibial spine avulsion of the anterior cruciate ligament (arrows).

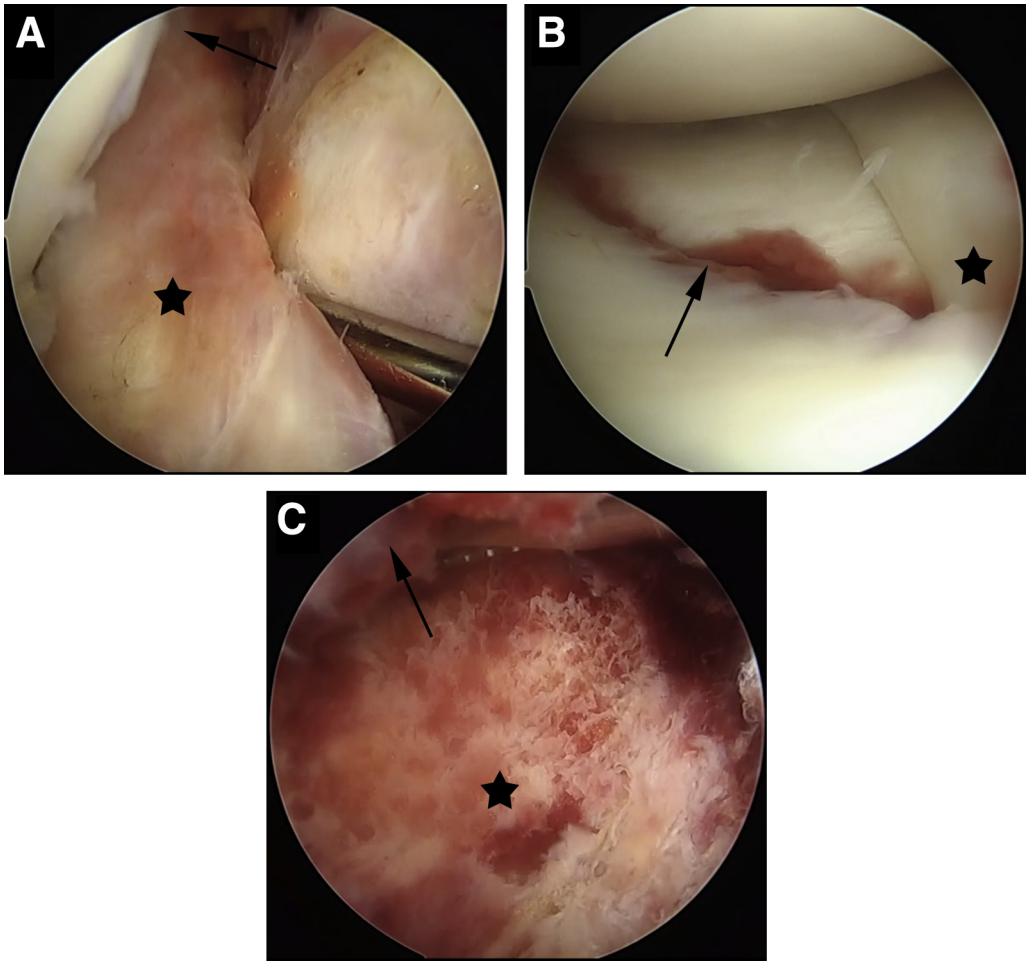

Fig 2. Intraoperative arthroscopic views of the right knee viewed from the anterolateral portal. (A) A probe is used to ensure tension in the anterior cruciate ligament (star) and an intact femoral attachment (arrow) with forward subluxation. (B) The medial compartment is then examined, which shows the fracture (arrow) with the meniscus (star) trapped under the avulsed fragment. (C) A shaver is used to debride underneath the fragment (arrow) and create a recessed cavity (star) in which to reduce the fragment.

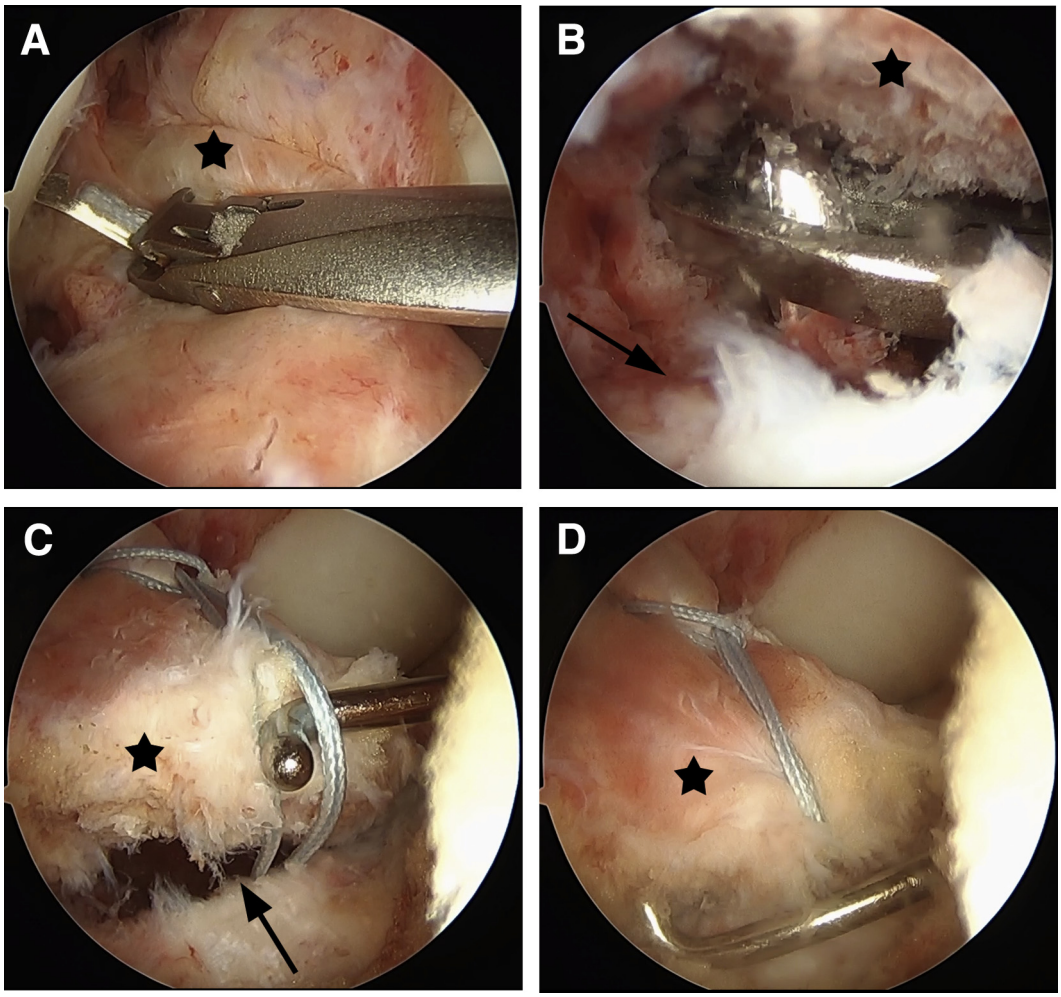

Fig 3. Intraoperative arthroscopic views of the right knee viewed from the anterolateral portal. (A) The anterior suture is first passed around the anterior cruciate ligament (star) and (B) a tunnel is drilled through the tibia (arrow) underneath the fragment (star). (C) The suture is then passed through the bone tunnel to (D) reduce the avulsed fragment (stars) inferiorly and posteriorly.

with radiographs alone, or with advanced imaging such as computed tomography and/or magnetic resonance imaging, as these are useful to describe the size of the fragment and any associated injuries.[1]

Patient Setup

The patient is placed in the supine position on a standard operative table and anesthetized using general anesthesia. The lower extremity is placed into a holder, and a tourniquet is applied around the proximal thigh to minimize blood loss and maximize visualization. The operative leg is prepared proximally from the foot to the mid-thigh below the tourniquet, and is draped in a sterile fashion.

Arthroscopic Portal Placement

Standard knee arthroscopy is performed using a 30° 4.0-mm arthroscope. To establish the anterolateral portal, a vertical incision is made using a No. 11 blade, hugging the border of the lateral patellar tendon at the level of the inferior pole of the patella. The knee is then entered with a blunt trocar and scope sheath, and these are gently guided up to the suprapatellar pouch. Complete diagnostic arthroscopy is performed, inspecting for chondral damage, loose bodies, and meniscus tears. A spinal needle is used to create the working anteromedial portal under arthroscopic visualization, and an incision is made in the same vertical fashion.

Preparation of the Tibial Spine Avulsion

The ACL is probed to ensure that the femoral attachment is intact (Fig 2A). The tibial spine avulsion is identified and inspected. A 4-0 shaver is used to aggressively debride the tibial fracture bed to remove clots and loose fragments, as well as to create a recess to anatomically reduce the fracture. A probe is used for a trial reduction of the avulsed fragment.

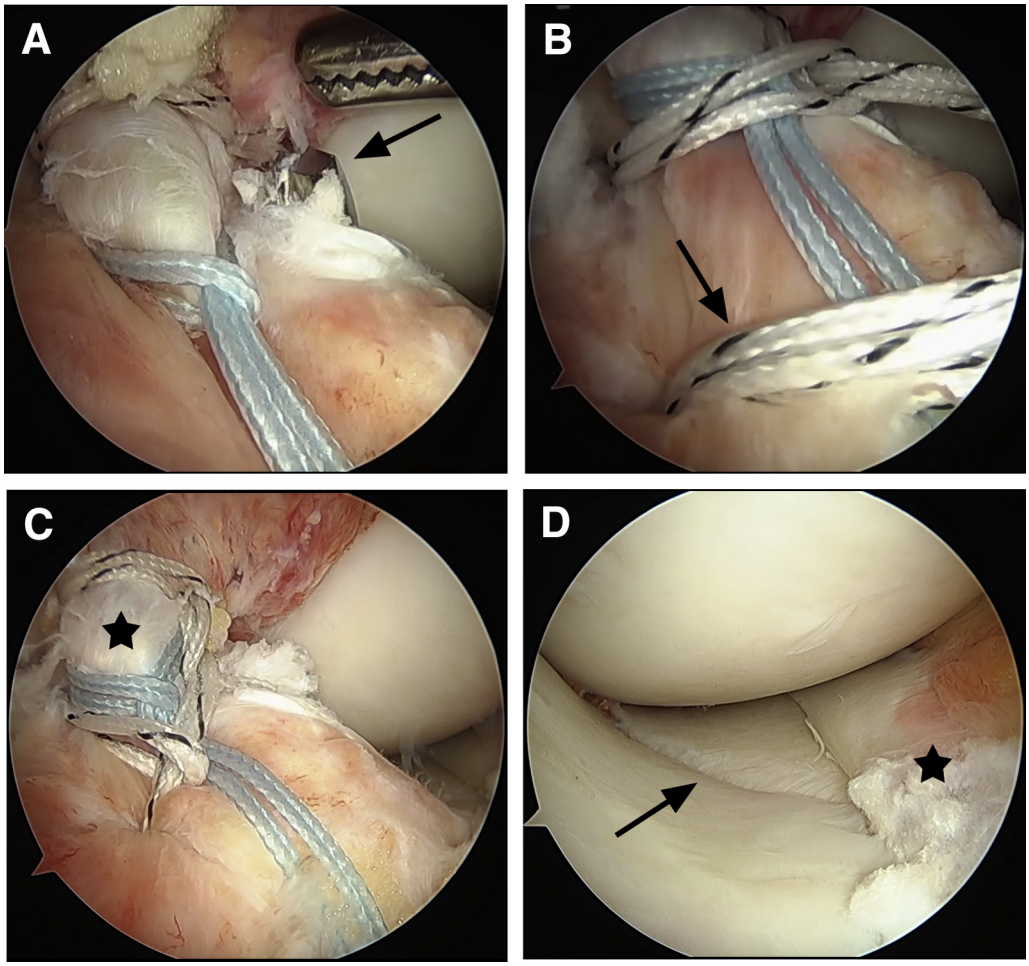

Fig 4. Intraoperative arthroscopic views of the right knee viewed from the anterolateral portal. (A) A second suture is passed around the anterior cruciate ligament (ACL) and through the medial bone tunnel (arrow) drilled through the tibia and fracture. (B) The procedure is repeated with a final suture (arrow) passed around the ACL and through the lateral bone tunnel drilled through the tibia and fracture. (C) The anterior, medial, and lateral sutures around the ACL (star) are then tensioned until (D) a successful anatomic reduction (arrow) of the tibial spine avulsion is achieved with the meniscus (star) no longer trapped under the fragment.

Performing the Suture Lever Reduction Technique

To perform the suture lever reduction technique, a Scorpion suture passer (Arthrex, Naples, FL) is used to pass a No. 2 FiberWire suture around the ACL near the base of its insertion on the fragment (Video 1). The suture is then retrieved from the anteromedial portal and tied to the ACL. A small incision is made medial and distal to the tibial tubercle and, using an ACL drill guide, a guidewire is drilled to exit the posterior half of the bony fracture bed of the tibia without drilling through the fracture fragment. The technical pearl is then to shuttle the suture anterior to the fracture fragment, and then through the tibial tunnel, thus "levering" down the fragment inferiorly and posteriorly to an anatomic reduction (Fig 3C). Once the fracture fragment is reduced anatomically, 2 additional sutures are passed around the ACL, and 1 medial and 1 lateral tunnel are drilled through both the tibia and the fracture (Fig 4A). The knee is then extended, and a pilot hole is drilled for an Arthrex 4.75 SwiveLock anchor. The lever suture is loaded into the SwiveLock, tensioned, and screwed into the tibial cortex. The medial and lateral sutures are each fixated to the anterior tibia with Arthrex 2.9 PushLock anchors, resulting in 3 points of fixation (Fig 5A).

Final Examination and Postoperative Care

The knee is flexed and extended to check for stability, and re-examined under direct arthroscopic visualization. A final intraoperative radiograph of the knee is taken to ensure that the tibial spine avulsion remains anatomically reduced (Fig 6). The wounds are then closed in the standard fashion. The knee is placed in a functional brace locked in extension. The brace is worn for a total of 8 weeks and held in extension during the first week, with gradually increased range of motion. Non-weight-bearing is recommended for at least 5 weeks postoperatively.

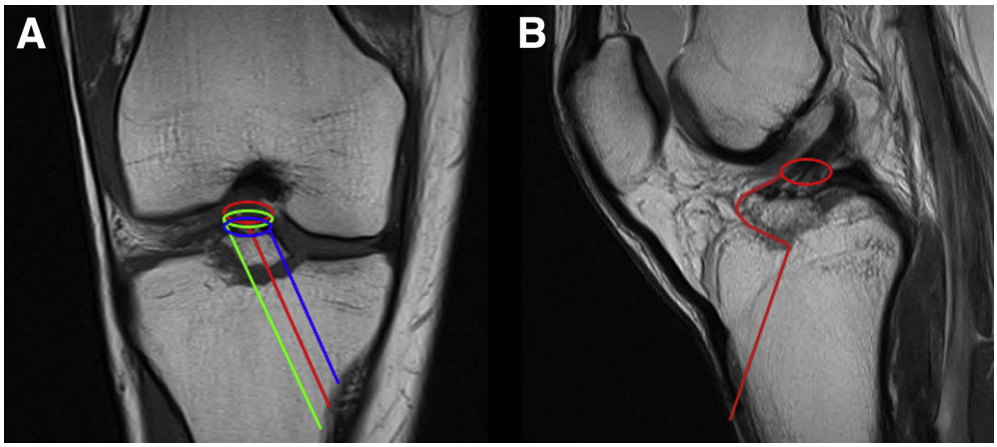

Fig 5. Preoperative magnetic resonance imaging scan of the right knee. (A) The anteroposterior image shows the suture attachments around the anterior cruciate ligament (ACL) and the medially directed tibial bone tunnels through which the anterior "lever" suture (red), medial suture (blue), and lateral suture (green) pass. (B) The lateral image shows the "lever" suture (red) attachment around the ACL, passing anterior to the fragment, and through the tibial bone tunnel, thereby reducing the avulsed fragment inferiorly and posteriorly.

Discussion

Fractures of the tibial spine are a rare occurrence and most often occur in pediatric and adolescent athletes.[1] The optimal approach to maintain good range of motion and prevent symptomatic knee laxity is surgical management of these fractures, particularly in cases when the articular surface is disrupted.[5] This repair has been previously described using open and arthroscopic approaches, with the latter having a decreased risk of soft tissue complications and postoperative pain.[9,10] The avulsion fracture is repaired to the tibia using a variety of methods including the use of screws, button systems, anchors, and sutures.

Screws and sutures are the primary surgical modalities for tibial spine fracture repair, both having exhibited very good clinical and radiographic outcomes.[8] Cannulated screws have shown good fracture repair with almost immediate weight bearing postoperatively, but a second surgery is frequently necessary for removal of the hardware.[1,8] The benefit of arthroscopic reduction and fixation with sutures and absorbable anchors is that an additional surgery is not required for hardware removal (Table 1). Bong et al.[11] performed a biomechanical study using cadaveric knee specimens and compared the strength of sutures versus cannulated screw fixation under a constant load. The study authors reported that the strength of FiberWire suture fixation was greater than that of screw fixation.[11]

Another question with tibial spine fracture repair is the number of fixation points. There appears to be no

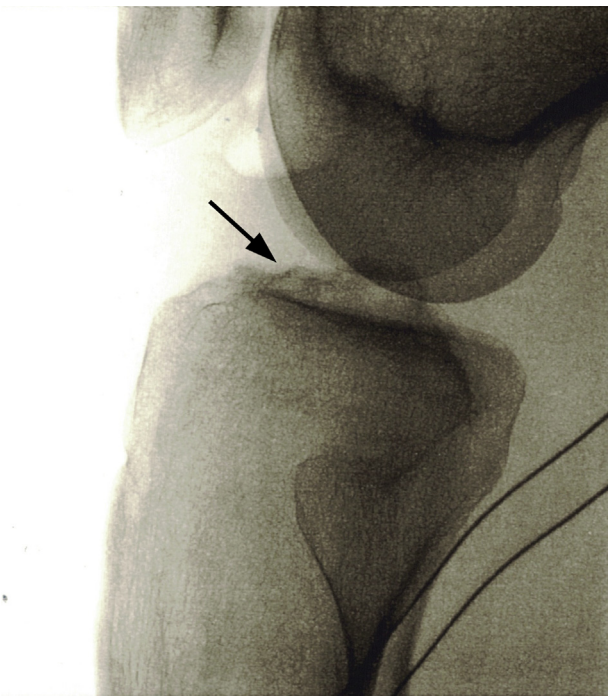

Fig 6. Final intraoperative lateral radiograph of the right knee confirming a successful reduction of the anterior cruciate ligament tibial spine avulsion (arrow).

Table 1. Advantages and Disadvantages of the Suture Lever Reduction Technique

Advantages:
Suture passing instrument can easily pass sutures through the anterior cruciate ligament
Easy and effective reduction technique of the avulsion without the need for provisional fixation
Three points of fixation with an excellent anatomic reduction, strong fracture fixation, and knee stability
Does not require additional surgery for hardware removal
Minimal morbidity and risk of wound healing complications
Disadvantages:
Technically challenging knee arthroscopy procedure

Table 2. Pearls of the Suture Lever Reduction Technique

Debride the tibial fracture bed to remove clots and loose fragments in the recess to anatomically reduce the fracture
Use a suture passing instrument to pass the suture around the anterior cruciate ligament (ACL) near the base of its insertion on the fragment
Using an ACL drill guide, drill a guidewire so as to exit the posterior half of the bony fracture bed of the tibia without drilling through the fracture fragment
Pass the suture anterior to the fracture fragment and through the tibial tunnel to lever the fragment inferiorly and posteriorly to an anatomic reduction
Flex and extend the knee after an anatomic reduction and fixation to check for stability and re-examine under direct arthroscopic visualization

consensus within the literature on the optimal number of points of fixation. The number of fixation points ranges from 1 to 4, largely depending on the suture device and overall technique.[12,13] Our technique is unique that uses 3 points of fixation with an excellent anatomic reduction (Table 2). We showed strong fracture fixation and knee stability with additional fixation compared with a 1- or 2-point fixation technique. In addition, our technique requires less suture material compared with the 4-point fixation technique described by Boutsiadis et al.[13] Further investigation into the optimal points of suture fixation is needed.

The primary and unique benefit of our method is the ease of fracture reduction using the suture lever technique without the need for provisional fixation that can split the fragment. Our technique eliminates the need for provisional fixation by drilling a tunnel underneath, but not into, the fragment. The suture around the ACL is then passed anterior to the bony fragment, through the bone tunnel, and then tensioned to reduce it down into anatomic alignment. We conclude that our arthroscopic suture lever reduction technique is an easy and effective method for the repair for tibial spine fractures, with an excellent anatomic reduction and ligamentous stability.

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