

Arthroscopic Transosseous Suture-bridge Fixation for Anterior Cruciate Ligament Tibial Avulsion Fractures



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Abstract: Few cases of tibial spine avulsion injuries occur in adolescents. An open or arthroscopic surgical approach is indicated for displaced and nonreducible fractures, but evidence for a gold standard is insufficient. Various arthroscopic techniques are available. Suture fixation is popular and shows good results. The proposed technique is a modified suture-bridge fixation using 2 high-strength sutures tied through 2 transosseous tunnels. This simple and low-cost technique avoids the potential complications of hardware fixation within a joint. It represents an arthroscopic treatment option for anterior cruciate ligament tibial avulsion injuries.

Tibial spine fractures, tibial eminence fractures, and anterior cruciate ligament (ACL) bony avulsion injuries are uncommon in children or adolescents. Their annual incidence in children is 3 per 100,000 population.¹ The injury mechanism is axial loading of the knee coupled with hyperextension, causing external femoral rotation. Meyers and McKeever² classified avulsion fractures as follows: type I, non-displaced; type II, partially displaced with an intact posterior hinge; and type III, completely displaced. Zaricznyj³ added type IV for comminuted avulsed fragments. Conservative treatment is given for type I and minimally displaced type II fractures. However, surgery is indicated in the event of extension loss after treatment of types II, III, and IV. Various open and arthroscopic surgical approaches have shown satisfactory healing.⁴ Many arthroscopic techniques and devices have been used, such as Kirschner wires (K-wires),⁵ screw fixation,⁶ surgical steel,⁷ suture fixation,⁸

suture anchors,⁹ and EndoButton (Smith & Nephew, Andover, MA) fixation.¹⁰ To restore these injuries, we propose the use of an all-arthroscopic transosseous suture-bridge fixation within 2 tibial tunnels.

Surgical Technique

Patient Position and Portal Placement

Preoperatively, plain anteroposterior and lateral radiographs are obtained to determine the extent of the fragment and appropriate fixation options (Fig 1 A and B). The patient is placed in the supine position with a lateral post, with a pneumatic tourniquet applied to the upper thigh. A fully flexed knee motion is confirmed. With the patient under anesthesia, a complete knee examination is performed to find associated ligament injuries. A standard arthroscopic setup is used. An anteromedial (AM) working portal and a standard anterolateral viewing portal are created. Blood is evacuated from the joint, with a complete diagnostic knee arthroscopy undertaken to identify concomitant injuries (e.g. meniscal or chondral injuries).

Preparation of Tibial Spine Fragment and Fixation

The femoral and tibial footprints of the ACL and the intrasubstance of the ACL are evaluated for any lacerations or ruptures that may necessitate the use of another surgical procedure with a different post-operative rehabilitation protocol. The tibial spine fragment is carefully identified and debrided using a radiofrequency wand (Super Turbovac Coblation Wand; ArthroCare, Austin, TX). The hematoma at the fracture site is removed to clearly delineate the

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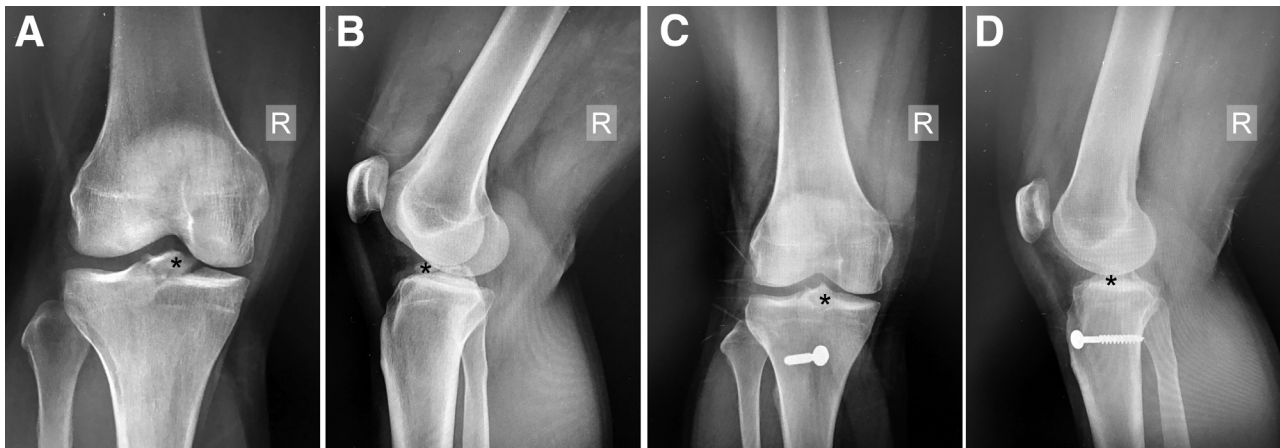


Fig 1. (A) Preoperative anteroposterior view of right knee. (B) Lateral view, showing a completely displaced tibial spine fracture, that is, type III according to the Meyers and McKeever classification.² (C) Postoperative anteroposterior view. (D) Lateral view of right knee at 6 months postoperatively, showing fracture union with anatomic reduction. The asterisks indicate the tibial spine avulsion fragment. (R, right.)

fragment (Fig 2A, Video 1). A periosteal elevator is used to reduce the fracture and assist by slowly extending the knee. Parts of the transverse intermeniscal ligament entrapped under the fragment are carefully retracted to aid in anatomic reduction. Next, a 45°, left-curved suture passer (Accu-Pass Suture Shuttle; Smith

& Nephew) loaded with a No. 1 polydioxanone suture (Ethicon, Somerville, NJ) is inserted through the AM portal. The suture passer is then pierced through the most fibrous portion of the ACL from its medial to lateral surface, as close as possible to the tibial footprint (Fig 2B, Video 1). One limb of a nonabsorbable No.

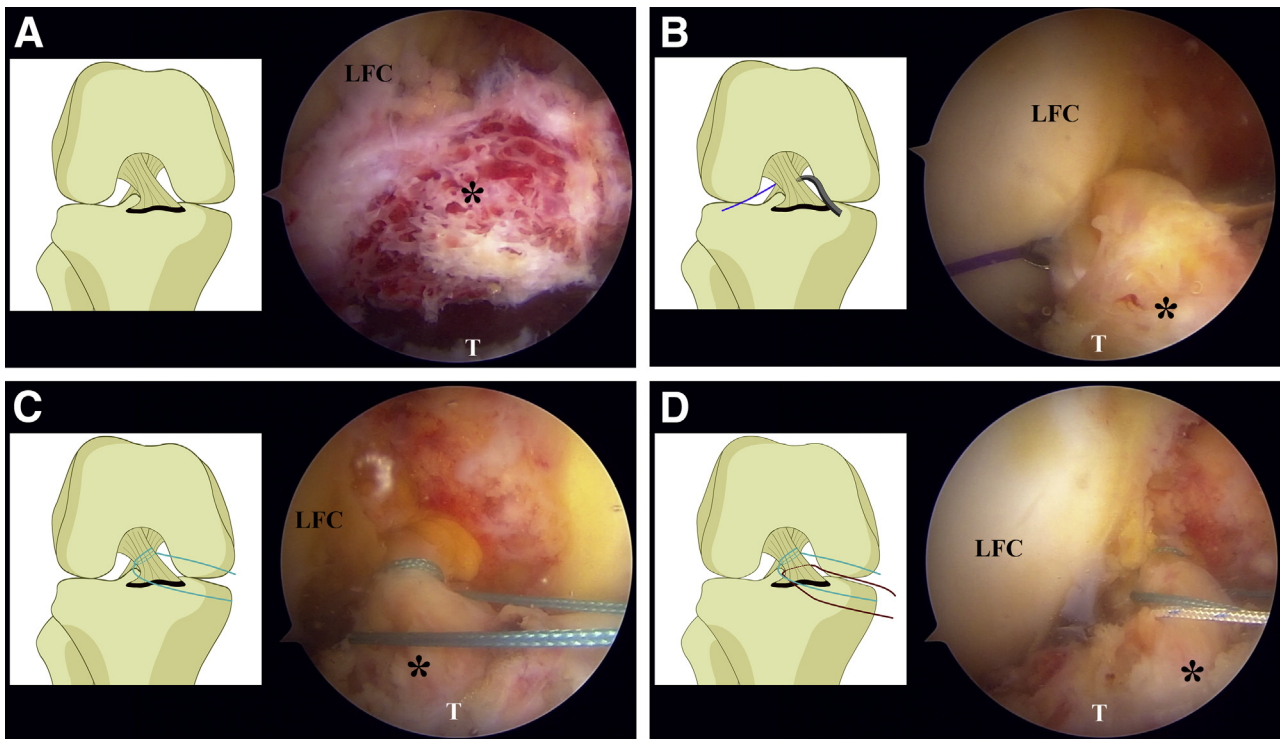


Fig 2. (A) Arthroscopic photograph and drawing of right knee (in supine position), viewed from standard anterolateral portal. The tibial spine avulsion fragment is shown after debridement and blood clot removal. (B) A 45°, left-curved suture passer loaded with a No. 1 polydioxanone suture is inserted through the anteromedial portal and pierced through the most fibrous portion of the anterior cruciate ligament from the medial to lateral side, as close as possible to the tibial footprint. (C) One limb of the No. 5 Ethibond is shuttled through the anterior cruciate ligament fiber. The 45°, left-curved suture passer is used to shuttle the medial limb of the No. 5 Ethibond suture, making a locking loop. (D) The same technique is repeated: One limb of the Ultrabraid suture is shuttled, making a simple loop. The asterisks indicate the tibial spine avulsion fragment. (LFC, lateral femoral condyle; T, tibia.)

5 Ethibond Excel polyester suture (Ethicon) is shuttled through the ACL fiber. The suture passer is subsequently used to shuttle the medial limb of the Ethibond suture, making a locking loop (Fig 2C, Video 1). The same technique is used for the second suture: One limb of an Ultrabraid suture (Smith & Nephew) is shuttled, making a simple loop (Fig 2D, Video 1). All 4 suture limbs are retrieved through the AM portal.

A tibial tunnel (2.5-mm diameter) is created using an Acuflex ACL tibial guide (Smith & Nephew), with the angle set at 45°, while aiming at the AM rim through the fracture site (Fig 3A, Video 1). The guide is removed once the K-wire's tip is visible at the anticipated site; the K-wire is left in situ, as with a temporary reduction. The technique is performed again at another tibial entry point—this time aiming at the anterolateral rim through the fracture site—with at least 1 cm of bone bridge between the 2 tibial tunnels (Fig 3B, Video 1). The K-wire is subsequently pulled from the lateral tibial tunnel and replaced by a No. 18 epidural needle loaded with a No. 1 polydioxanone suture. Two suture limbs (the medial limb of the No. 5 Ethibond and the lateral limb of the Ultrabraid) are retrieved through the polydioxanone suture loop and shuttled to the anterolateral tibial tunnel in a crossing-bridge pattern (Fig 4A, Video 1). The 2 remaining suture limbs are similarly shuttled to the AM tibial tunnel to complete the suture-bridge fixation system (Fig 4B, Video 1).

With both suture ends held under tension, the anatomic reduction is visually confirmed. While the knee is fully extended, the impingement of the ACL fiber and the fragment at the intercondylar notch are checked. The 2 suture limbs from the AM and anterolateral tibial tunnels are then tied separately over a screw and post using a 6.5-mm partially threaded cancellous screw with a washer 1 cm below the tibial tunnel aperture (Fig 4 C and D, Video 1).

Postoperative Management

Postoperatively, the patient's knee is immobilized while fully extended for 2 weeks. Isometric quadriceps exercises are allowed during the early postoperative period, with range-of-motion exercises commencing later. The patient is encouraged to ambulate with protected weight bearing (axillary crutches) before bearing some weight during postoperative week 4. Full weight bearing without crutches is permitted after complete fracture consolidation. The 6-month postoperative radiographs showed fracture union with anatomic reduction (Fig 1 C and D).

Discussion

The surgical treatment options for ACL tibial avulsion fractures are open or arthroscopic fixation. The main drawbacks of the open approach are difficulties in viewing the fracture and treating the associated meniscal or chondral injuries. However, there is insufficient evidence to support the superiority of the arthroscopic approach in terms of healing, motion deficit, or laxity.⁴ We prefer an arthroscopic technique because it is minimally invasive, allows concomitant intra-articular pathologies to be treated, and provides a faster recovery.

Despite there being numerous surgical techniques for the treatment of avulsion fractures,⁵⁻¹⁰ a gold standard does not exist.⁴ One biomechanical study found that the suture fixation system provides superior strength to 1- and 2-screw fixation systems.¹¹ Another study, comparing the biomechanical strength of high-strength sutures, EndoButtons (cortical suspension devices), and suture anchors, determined that the EndoButtons had a higher ultimate failure load than the sutures and anchors.¹² Moreover, the sutures showed a higher failure load than the suture anchors. However, the suture fixations in that study were tied over the bone bridge without any screws or instruments that would have

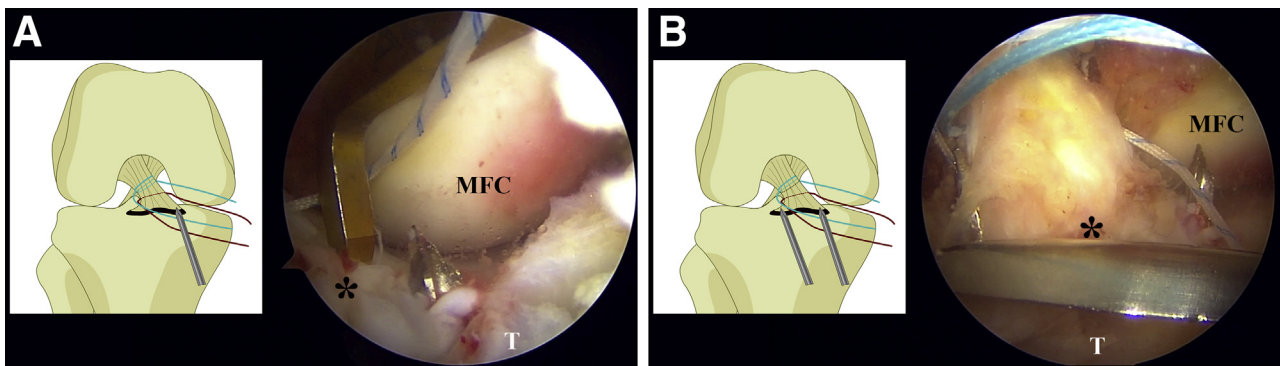


Fig 3. (A) Arthroscopic photograph and drawing of right knee (in supine position), viewed from standard anterolateral portal. Creation of a tibial tunnel (2.5-mm diameter) is shown, using an anterior cruciate ligament tibial guide with the angle set at 45° and aiming at the anteromedial rim through the fracture site. (B) The same technique is performed again—this time aiming at the anterolateral rim through the fracture site from a separate tibial entry point—with at least 1 cm of bone bridge between the 2 tibial tunnels. The asterisks indicate the tibial spine avulsion fragment. (MFC, medial femoral condyle; T, tibia.)

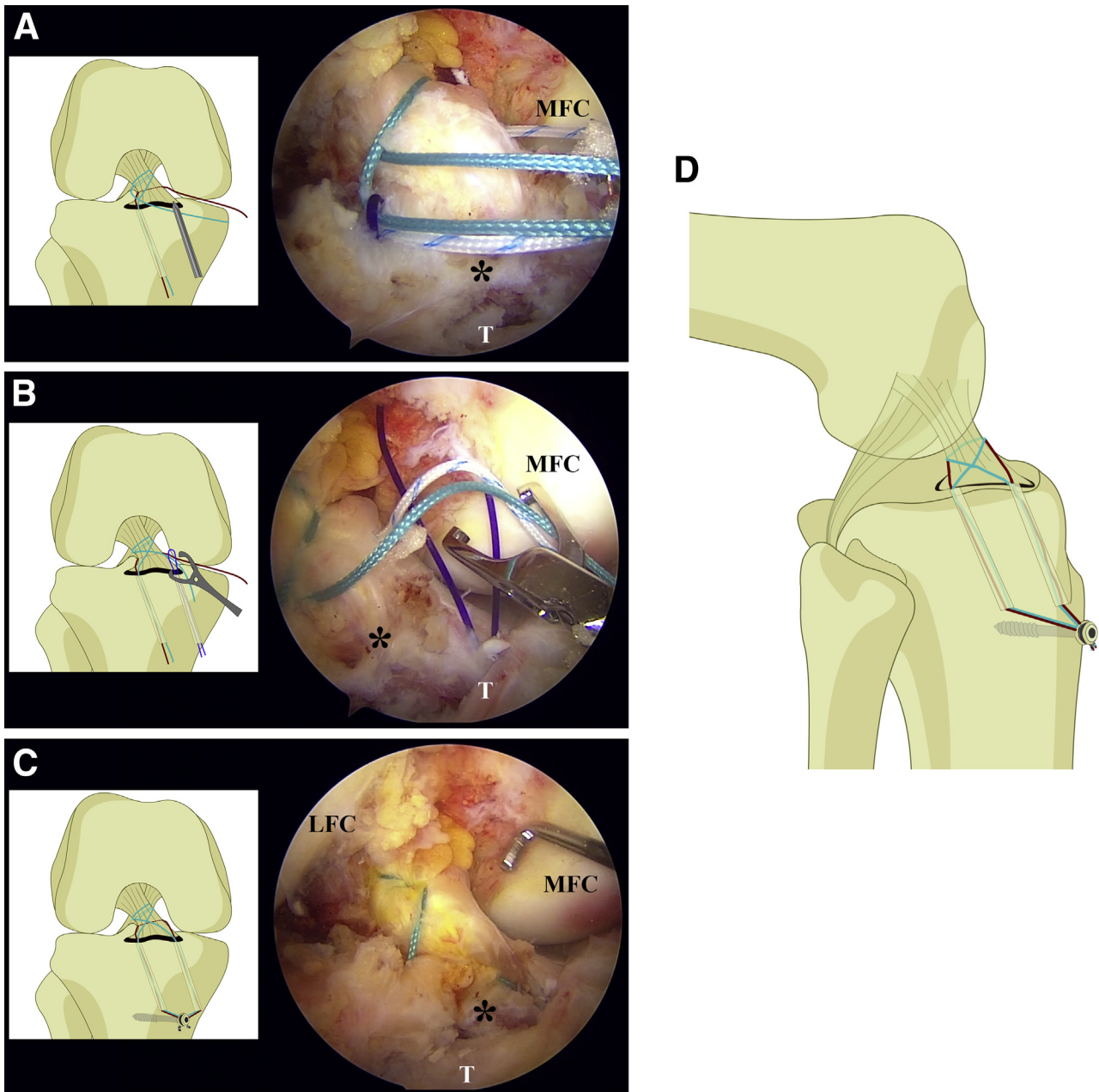


Fig 4. (A) Arthroscopic photograph and drawing of right knee (in supine position), viewed from standard anterolateral portal. Two suture limbs are shown: one limb of the No. 5 Ethibond and the opposite limb of the Ultrabraid. The 2 limbs are retrieved through the polydioxanone suture loop and shuttled to the anterolateral tibial tunnel in a crossing-bridge pattern. (B) The remaining suture limbs are shuttled to the anteromedial tibial tunnel in the same manner. (C) Two limbs of the sutures (one each from the anteromedial and anterolateral tibial tunnels) are tied separately over a screw and post, thereby completing the suture-bridge fixation system. (D) Drawing of right knee in lateral view, illustrating transosseous suture-bridge fixation technique. The asterisks indicate the tibial spine avulsion fragment. (LFC, lateral femoral condyle; MFC, medial femoral condyle; T, tibia.)

lessened the ultimate failure load. Many biomechanical studies have shown the advantages of suture-bridge fixation for the repair of rotator cuff and tibial eminence fractures. A suture-bridge technique using a PushLock anchor (Arthrex, Naples, FL) was found to provide a higher ultimate failure load than standard screws and suture fixation.¹³ Given its good ultimate

failure load, the suture-bridge fixation technique may therefore be one of the preferred options.

The proposed technique is a suture-bridge fixation using high-strength sutures that pass through 2 transosseous tunnels and are tied over a screw and post. The technique offers the advantages of a suture-bridge system without having instruments fixed inside the

Table 1. Technique Advantages, Disadvantages, and Special Cautions

Advantages
Simple technique
Strong fixation achieved owing to suture-bridge fixation technique
Cost savings
No intra-articular hardware fixation and avoidance of related complications
Tibial guide and K-wire may assist anatomic reduction of fragment
Disadvantages and special cautions
Possibility of iatrogenic fracture of fragment: Avoid drilling through small fragments
Potential for bone-bridge fracture
No clinical-outcome studies of technique currently available

joint. Two high-strength suture loops at the base of the ACL are tied in a suture-bridge configuration with the aim of compressing the fragment, increasing the contact area, and decreasing gap formation (Fig 4C). The advantages of this technique are listed in Table 1. As to the tibial preparation, the 2 tibial tunnels are positioned with at least 1 cm of bone bridge between them to prevent an iatrogenic fracture. The sutures are also tied in the fully extended position to prevent an extension deficit. Some studies have found a higher rate of arthrofibrosis with extension deficits over 10° for suture fixations than for screw fixations.⁴ We therefore used a partially threaded cancellous screw with a washer to achieve a strong fixation as well as prevent the suture cutting through the bone bridge.

The proposed technique should be used with caution for comminuted fractures or very small fragments that may cause an iatrogenic fracture. Such a fracture can be avoided by drilling the tibial tunnel at the rim of the fragment's base, not through the fragment. Because a bone-bridge fracture can occur, the 2 tibial tunnels should be over 1 cm apart. Potential disadvantages and special cautions are listed in Table 1.

The described surgical technique provides a simple and low-cost method of avoiding the potential complications arising from hardware fixation within a joint. We also consider it to be safe and show good anatomic reduction. It is therefore recommended as an arthroscopic treatment choice for ACL tibial avulsion injuries.

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