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

Supamongkol Mutchamee, M.D., and Phob Ganokroj, M.D.

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.

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 postoperative 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

From the Department of Orthopaedic Surgery, Khon Kaen Hospital, Khon Kaen, Thailand (S.M.); and Department of Orthopedic Surgery, Faculty of Medicine, Siriraj Hospital, Mahidol University, Bangkok, Thailand (P.G.).

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.

Received February 28, 2020; accepted May 14, 2020.

Address correspondence to Phob Ganokroj, M.D., Department of Orthopedic Surgery, Faculty of Medicine Siriraj Hospital, Mahidol University, 2 Prannok Road, Bangkok 10700, Thailand. E-mail: phob.gan@mahidol.ac.th

© 2020 by the Arthroscopy Association of North America. Published by Elsevier. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).
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 $45^\circ$, 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.
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 Acufex 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 4C 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 1C 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.)
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. 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...

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.)
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. Advantages include simplicity, strong fixation achieved owing to suture-bridge fixation technique, cost savings, no intra-articular hardware fixation and avoidance of related complications, and use of a Tibial guide and K-wire to assist in anatomic reduction of the fragment. Disadvantages include potential for iatrogenic fracture of the fragment, potential for bone-bridge fracture, and no clinical-outcome studies of technique currently available.

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.

Acknowledgment

The authors gratefully acknowledge Mr. Wacharapol Tepa for data collection, Miss Waraporn Chalermsuk for graphic materials, and Mr. David Park for English-language proofreading.

References

1. Skak SV, Jensen TT, Poulsen TD, Sturup J. Epidemiology of knee injuries in children. *Acta Orthop Scand* 1987;58:78-81.

2. Meyers MH, McKeever FM. Fracture of the intercondylar eminence of the tibia. *J Bone Joint Surg Am* 1970;52:1677-1684.

3. Zaricznyj B. Avulsion fracture of the tibial eminence: Treatment by open reduction and pinning. *J Bone Joint Surg Am* 1977;59:1111-1114.

4. Gans I, Baldwin KD, Ganley TJ. Treatment and management outcomes of tibial eminence fractures in pediatric patients: A systematic review. *Am J Sports Med* 2014;42:1743-1750.

5. Furlan D, Pogorelic Z, Biocic M, Juric I, Mestrovic J. Pediatric tibial eminence fractures: Arthroscopic treatment using K-wire. *Scand J Surg* 2010;99:38-44.

6. Wiegand N, Naumov I, Vamhidy L, Not LG. Arthroscopic treatment of tibial spine fractures in children with a cannulated Herbert screw. *Knee* 2014;21:481-485.

7. Oohashi Y. A simple technique for arthroscopic suture fixation of displaced fracture of the intercondylar eminence of the tibia using folded surgical steels. *Arthroscopy* 2001;17:1007-1011.

8. Koukoulias NE, Germanou E, Lola D, Papavasiliou AV, Papastergiou SG. Clinical outcome of arthroscopic suture fixation for tibial eminence fractures in adults. *Arthroscopy* 2012;28:1472-1480.

9. Sawyer GA, Hulstyn MJ, Anderson BC, Schiller J. Arthroscopic suture bridge fixation of tibial intercondylar eminence fractures. *Arthrosc Tech* 2013;2:e315-e318.

10. Sekiya H, Takatoku K, Kimura A, Kanaya Y, Fukushima T, Takeshita K. Arthroscopic fixation with EndoButton for tibial eminence fractures visualised through a proximal superomedial portal: A surgical technique. *J Orthop Surg (Hong Kong)* 2016;24:417-420.

11. Eggers K, Becker C, Weimann A, et al. Biomechanical evaluation of different fixation methods for tibial eminence fractures. *Am J Sports Med* 2007;35:404-410.

12. Hapa O, Barber FA, Suner G, et al. Biomechanical comparison of tibial eminence fracture fixation with high-strength suture, EndoButton, and suture anchor. *Arthroscopy* 2012;28:681-687.

13. Sawyer GA, Anderson BC, Paller D, Schiller J, Eberson CP, Hulstyn M. Biomechanical analysis of suture bridge fixation for tibial eminence fractures. *Arthroscopy* 2012;28:1533-1539.