

## Case Series

# Arthroscopic pull-through suture for tibial eminence avulsion fracture: a case series

Mario D. Simatupang, I. G. N. Wien Aryana, Hans K. Nugraha\*

Department of Orthopaedic and Traumatology, Sanglah Hospital, University of Udayana, Bali, Indonesia

**Received:** 14 October 2020

**Revised:** 22 October 2020

**Accepted:** 23 October 2020

### \*Correspondence:

Hans K. Nugraha,

E-mail: [hans.nugraha@yahoo.com](mailto:hans.nugraha@yahoo.com)

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### ABSTRACT

Fractures of the tibial eminence is commonly reported in adolescents and adults, due to traffic accident, sports injury, or any other mechanism. Case 1: a 12-year-old male complained knee pain after a traffic accident 2 months prior to visit. Case 2: a 31-year-old female complained knee pain which worsened with long-distance walking and sitting, after falling on her knees one month prior to visit. Case 3: a 27-year-old female complained a worsening knee pain after traffic accident 12 years ago. Although it has been extensively studied, controversies regarding the best fixation method still exist. Open technique was once popular, but some morbidity has been associated with this method. Therefore, a new approach using arthroscopic pull-through suture technique, albeit technically challenging, is currently being advocated as a treatment option for such fractures. The result in our series confirm that all of 3 patients have a good result based on international knee documentation committee (IKDC) scoring for evaluation the treatment, hence support the use of this novel technique for the patients with tibial eminence avulsion fracture.

**Keywords:** Arthroscopy, Avulsion, Suture, Tibia

### INTRODUCTION

Anterior cruciate ligament injury is a common athletic injury and one of the most commonly treated conditions of the knee. Estimated rates of anterior cruciate ligament reconstructions performed per year range widely from 60,000 to 175,000.<sup>1</sup> Tibial eminence fracture, a bony avulsion of the anterior cruciate ligament (ACL) from its insertion on the intercondylar eminence, also known as tibial spine fractures, account for 2% to 5% of knee injuries in the pediatric population<sup>4,5</sup> and 14% of ACL injuries, 6 and have an incidence of 3 per 100,000 children per year.<sup>2</sup>

Different authors have conducted study regarding methods of treatment. Type 1 fractures are universally treated with conservative method, while type 2 fractures treatment is still controversial, for type 3 and 4 fractures many surgeons recommend retrograde wires, cancellous

screws, suture anchors, suture bridging, k wire with tension band wire.<sup>3</sup> Although avulsion fractures of the tibial eminence have been well described and classified, disagreement remains concerning the indications and methods of fixation in displaced (type II and III) tibial eminence fractures. Open modes of reduction and fixation do cause some morbidity. Recently, arthroscopic techniques have been described in the management of tibial eminence fractures.<sup>4</sup> In this study, we are assessing arthroscopic pull out suture technique in ACL tibial avulsion.

### CASE SERIES

This study was conducted in accordance with the principles of the Declaration of Helsinki. Inclusion criteria are ability to walk and perform daily activities before the trauma resulting in tibial eminence avulsion fracture, and a minimum of 6 months follow-up.

Exclusion criteria are patients that has metabolic bone disease, and not willing to participate in the study. Using total sampling, there was a total of 3 patients (1 male, 2 females; mean age 23.3 years; range 12 to 31 years) who were operated in Sanglah Hospital between January 2018 and December 2018 because of tibial eminence avulsion fracture, and assessed prospectively. Diagnosis was made on the basis of clinical examination, plain x-ray and diagnostic arthroscopy. Informed consent regarding arthroscopic pull-through suture was obtained from all patients and parents. Those who agreed to undergo the procedure were documented and followed-up until six months after surgery.

Three patients were documented during the study period. Patient A (male, 12-year-old) complained a knee pain after a traffic accident 2 months prior to visit. Patient B (female, 31-year-old) complained a knee pain which worsened with long-distance walking and sitting, after falling on her knees one month prior to visit. Patient C (female, 27-year-old) complained a worsening knee pain after traffic accident 12 years ago. Tibial eminence avulsion fracture knee was diagnosed based on clinical findings and plain x-ray (Figure 1). Pull-through suture was done in all patients via arthroscopy.

#### **Operative technique**

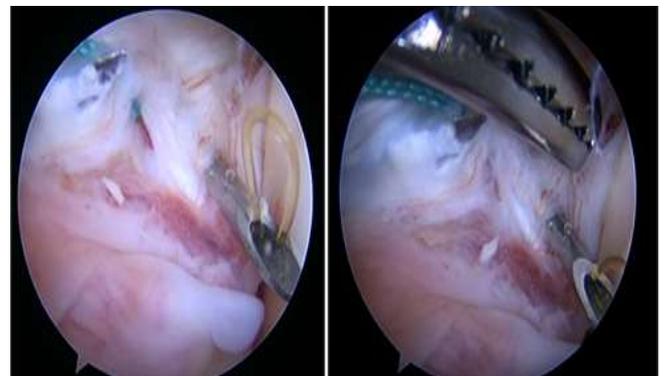
Arthroscopy was undertaken under spinal anesthesia in supine position, with a leg-free tourniquet control. Standard anterolateral and anteromedial ports were inserted and any intra-articular hematoma was evacuated. Standard diagnostic arthroscopy was performed using a 300 4.0-mm arthroscope to visualize and probe structures to assess the integrity. The avulsed fracture fragment is probed and elevated to evaluate the displacement, size, and comminution if any. The crater of the fracture fragment was debrided using a motorized shaver. A 2-3 cm vertical incision is made over the anteromedial aspect of the tibia approximately 3 cm below the joint line.

A pushlock anchor (Arthrex, Naples, FL) was used to pass a no. 2 K-wire suture around the ACL near the base of its insertion on the fragment. The suture was then retrieved from the anteromedial port and was tied to the ACL. A small incision was made medial and distal to the tibial tubercle and, using an ACL drill guide, a guidewire was drilled to exit the posterior half of the fracture bed without going through the fracture fragment. The suture was then shuttled anterior to the fracture fragment through the tibial tunnel, thus, levering down the fragment inferiorly and posteriorly to its anatomic position. Two additional sutures were passed around the ACL. Medial and lateral tunnels were drilled through both the tibia and the fracture. The knee was then extended, and a pilot hole was drilled to insert Arthrex 4.75 anchor. The lever suture was loaded into the anchor, tensioned, and screwed into the tibial cortex. The medial and lateral sutures were fixated to the anterior tibia using

arthrex 2.9 push lock anchors, resulting in 3 fixation points (Figure 2).



**Figure 1: Pre-operative x-ray showing tibial eminence fracture (arrows).**



**Figure 2: Intra-operative arthroscopic views.**



**Figure 3: Post-operative x-ray showing normal anatomy.**

The knee was flexed and extended to check its stability. Intra-articular structures were evaluated under direct arthroscopic visualization. A final intraoperative radiograph of the knee was taken to evaluate the anatomy (Figure 3). Wounds were closed in a standard fashion. The knee is immobilized using a functional brace. Patients were followed at 3 weeks post-surgery by using the scoring system based on international knee documentation committee (IKDC) form. The brace was worn for a total of 8 weeks and was held in extension position during the first week. The range of motion was then gradually increased, and non-weight-bearing was recommended for at least 5 weeks postoperatively.

### Outcomes

The surgery was successfully done in all patients. The method was technically feasible even in the case of neglected fracture (patient C). No significant morbidity was found during and after surgery. During follow-up period, subjective and objective parameters were unremarkable compared to the uninjured side. No long-term morbidity was reported.

### DISCUSSION

Avulsion fractures of tibial spine, leading to discontinuity of anterior cruciate ligament fibers has been well described in literature in both pediatric and adult population. These fractures are also called as tibial eminence fractures or ACL avulsion fractures. They represent a variant of anterior cruciate ligament injury. Poncet in 1895 was probably the first person to document these types of injuries. In 1959, Mayer and Mc Keevers was the first who described the method of classification based on degree of displacement of avulsed fragment: type I fracture is an undisplaced fracture of tibial eminence, where in the avulsed fragment is not displaced from the fracture crater; type II fracture is partially displaced fracture, in which the anterior part of the avulsed fragment is displaced superiorly from the bone bed and gives a beak like appearance on the lateral x-rays; type III fracture is completely displaced fracture and there is no contact of avulsed fragment to the bone bed; type IIIA involves only ACL insertion; type IIIB involves entire Intercondylar eminence; Type IV (was later added by Zaricznyj) include comminuted fractures of tibial spine.<sup>5</sup>

The ACL is the main static stabilizer against anterior translation of the tibia on the femur and accounts for up to 86 % of the total force resisting anterior draw. The cruciate ligaments are named for their attachments on tibia and are important to function of the knee joint. The cruciate ligaments act to stabilize the knee joint and prevent anteroposterior displacement of the tibia on the femur.<sup>6</sup>

The anterior cruciate ligament is attached medially to the anterior intercondylar area of the tibia partly blending

with the anterior of the lateral meniscus; it ascends posterolaterally, twisting on itself and fanning out to attach to the posteromedial aspect of the lateral femoral condyle. It is anterolateral to the posterior cruciate ligament. The cruciate ligaments consist of a highly organized collagen matrix, which accounts for approximately three fourths of their dry weight. The majority of the collagen is type I (90 %), and the remainder is type III (10%).<sup>6</sup>

Displaced avulsion fractures of the tibial attachment of the anterior cruciate ligament (ACL) can result in anteroposterior and rotational knee instability, nonunion, loss of extension, and entrapment of the anterior horn of the medial meniscus, making closed reduction impossible. Displacement of the avulsion fragment can lead to anterior impingement during knee extension.<sup>7</sup> This injury tends to manifest as an aching, flexed knee and signs of anterior instability, such as encountered by our patients. The mechanism often varies between children and adults.<sup>8</sup> Between the ages of 14 and 16, there is transformation of chondroepiphyseal junction which ossifies and fuses at the site of the ACL tibial insertion. Once this transformation occurs, the ACL typically lacks the tensile strength to avulse the skeletally mature tibial ACL attachment. After this age, high-energy forces applied to the knee will overcome the ultimate tensile strength; this applied tension results in disruption of the ACL fibers. In skeletally mature adults, overcoming the tensile bone strength at the ACL attachment requires high-energy trauma. The most common mechanism of injury is severe hyperextension, usually associated with high speed motor vehicle collisions. Consequently, adults with tibial eminence fractures have a higher prevalence of associated injuries, including “kissing” bone contusions and tears of the medial collateral ligament, meniscus, and posterior cruciate ligament.<sup>9,10</sup>

Standard imaging for tibial spine fractures include anteroposterior (AP) and lateral radiographs. Lateral radiographs should be true lateral radiographs which are particularly useful to assess degree of displacement and type of fracture. In skeletally immature patients the actual size of fragment may be significantly larger than what they appear on a radiograph owing to presence of cartilage in the fragment. A notch view is sometimes useful to better visualize the fragment in an AP plane.<sup>5</sup>

CT scan is useful in better assessment of fracture anatomy and degree of comminution. MRI is useful in outlining the non-osseous concomitant injuries like meniscal injury, cartilage injury and other ligamentous injury.<sup>5</sup> On MRI, the ACL is best visualized on sagittal images. Because of its oblique course the ACL should routinely be imaged on two or three sagittal sections. The appearance of a tiny bone fragment in the intercondylar notch with cortical irregularity of the adjacent tibial eminence suggesting a donor site for the fragment are the usual findings in this entity. MR imaging is useful to confirm that the fragment does in fact arise from the tibia

and that the entire substance of the ACL is intact, as well as assessing for associated injuries. Partial ACL tears may be imaged by increased signal, thickening or redundancy in the ligament.<sup>6</sup> It is imperative for the radiologist to accurately identify this injury, as classification of ACL avulsion fractures is important with regard to patient treatment.<sup>10</sup> However, accurate diagnosis of partial injuries remains challenging. Arthroscopic evaluation of the ACL remains the gold standard for assessing suspected partial and complete tears.<sup>6</sup>

In this study, tibial eminence avulsion diagnosis is made based on clinical findings, plain x-ray, and diagnostic arthroscopy. This diagnostic procedure is not always applicable in all patients. But, when the extent of injury is too difficult to determine using standard plain x-ray, diagnostic arthroscopy may be considered, without resorting to CT scan or MRI. Again, this policy would be different in every centres.

Treatment depends on type of fracture, entrapment of soft tissues at fracture site and associated knee injuries. Chief goals in treating tibial spine avulsion are: 1) anatomical reduction of displaced fragment and achieving continuity of ACL fibers, while removing any block to reduction like bone fragments, blood clots, intermeniscal ligament or meniscus; 2) adequate rigid fixation which allows early range of motion exercises; 3) eliminate the extension block and impingement due to displaced fragments.<sup>5,6</sup>

Type 1 fractures are treated with long leg cast immobilization for a period of 4-6 weeks. Radiographs are done immediately post immobilization to ensure that fragment is not displaced. Treatment of type II fractures has been controversial. In most cases closed reduction and immobilization may be attempted after aspirating knee hemarthrosis. If acceptable reduction is achieved conservative management should be continued.<sup>5</sup>

Treatment of displaced tibial spine avulsion fractures has evolved over a period of time from conservative management to open reduction and internal fixation to arthroscopic reduction and internal fixation. Various methods of fixation are used in operative treatment of these fractures varying from retrograde wires/screws, antegrade screws, sutures, and suture anchors.<sup>5</sup> Many factors including plastic deformation of the ACL, improper reduction of the fragment with resultant ACL complex lengthening, and insufficient fixation techniques resulting in dislocation of the fragment may lead to residual laxity seen after fragment fixation to the tibia.<sup>7</sup> Anatomic reduction, secure fixation, and early range of movement are recommended to prevent stiffness and restore full extension. If stiffness or arthrofibrosis occurs, arthroscopic debridement, screw removal, and/or manipulation under anaesthetic should be performed.<sup>11</sup>

Suture fixation is preferable for comminuted fractures. Some authors have recommended suture fixation for all cases due to less risk of neurovascular involvement and less problem of implant prominence.<sup>5</sup> It is also believed that displaced tibial spine fractures are best treated with fixation because the native ACL has mechanoreceptors for proprioception and neuromuscular control.<sup>12</sup> Suture fixation has the advantage of not entailing metalware removal, but the fixation must be secure enough for early mobilisation. Early results of arthroscopic fixation are excellent. Treatment outcomes in younger patients are generally better. This may be due to the lower liability to associated injuries.<sup>11</sup> Some techniques are described to achieve secure fixation which vary from Kirschner (K) wire, stainless steel wires, suture anchor, meniscal arrows, sutures or combination.<sup>12</sup>

Many studies emphasize the advantages of arthroscopic fixation techniques.<sup>13</sup> A wide variety of fixation methods have been used to secure tibial eminence fractures, and as yet, there is no gold standard. Fixation with screws and fixation with sutures are among the most common methods and have yielded satisfactory results. However, until now, no universal technique has been available that can be applied regardless of skeletal maturity, fragment size, or comminution. Comminuted fractures are not amenable to screw fixation, and there also exists the risk of fragment comminution, posterior neurovascular injury, the need for hardware removal, and extension block creation with screw fixation. All the described methods entail passage across the growth plate with a possible risk of physal damage.<sup>7</sup>

Functional outcomes of arthroscopic pull-through suture have also been studied. Sapre et al reported the outcome of ten patients (mean age 29.2 years). The mean follow-up period was 21.7 months. Radiographs showed that all fracture healed anatomically at an average duration of 3 months after surgery. At the final follow-up, all patients reported no symptoms of instability. All patients achieved their pre injury tegner activity levels. One patient had postoperative arthrofibrosis with the loss of terminal extension of 5° which responded to arthroscopic adhesiolysis and physiotherapy.<sup>14</sup> Similar results were also reported by Pandey et al.<sup>13</sup> In our set of patients, the technique was successfully done in all patients without any notable complication. Recovery was achieved, and no long-term morbidity was reported.

## CONCLUSION

Arthroscopic pull-through suture is an effective and safe procedure for patients with tibial eminence avulsion fracture. This technique allows early mobilization and rehabilitation for patients during their reproductive age. Careful examination should be carried to determine the extent of injury and to decide which patient will be benefited from arthroscopic pull-through suture fixation. Further study is needed to evaluate the benefit of this

technique on different settings, and to compare with other methods.

*Funding: No funding sources*

*Conflict of interest: None declared*

*Ethical approval: Not required*

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**Cite this article as:** Simatupang MD, Aryana IGNW, Nugraha HK. Arthroscopic pull-through suture for tibial eminence avulsion fracture: a case series. *Int J Res Med Sci* 2020;8:4471-5.