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Original Article

Treatment of tibial eminence fractures with arthroscopic suture fixation technique: a retrospective study

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Abstract: Aims: The present study aims to investigate the clinical outcomes of arthroscopic suture fixation in treating tibial eminence fracture with a retrospective study design of two years' follow-up. Methods: A total of 33 patients with imaging evidence of tibial eminence avulsion fractures who underwent arthroscopic surgery between 2008 and 2012 were included in this study. The inclusion criteria for the study were a displaced tibial eminence avulsion fracture and anterior knee instability of grade II or higher inskeletally mature patients. These patients were treated with arthroscopic suture fixation and followed with a mean period of 24 months. Anteroposterior and lateral radiographs were obtained 3 months postoperatively to assess fracture healing. At 24 months after surgery, all patients were evaluated by an independent orthopaedic professor with clinical examination like anteroposterior laxity (Lachman-Noulis and anterior drawer tests) and Rolimeter knee tester (Aircast, Vista, CA). Knee range of motion was evaluated actively and passively with a goniometer. Knee function was evaluated by the Lysholm and International Knee Documentation Committee (IKDC) scores. Knee radiographs in standing anteroposterior, standing lateral, and Merchant views were examined for alignment, joint space narrowing, and degenerative knee changes. Results: No major complication like infection, deep venous thrombosis, or neurovascular deficit happened peri-operatively. At the final follow-up, there were no symptoms of instability and no clinical signs of ACL deficiency. Radiographs showed that all fractures healed 3 months post-operative, but at the last follow-up, there was one person with degenerative changes like joint space narrowing in radiographs. Anterior translation of the tibia was 0.47 mm on average (0 to 2.5 mm) compared with the uninjured side. Range-of-motion measurement showed a mean extension deficit of 1.5° (0° to 5°) and a mean flexion deficit of 2.7° (0° to 10°) compared with the unaffected side. The mean Lysholm score was 96 (85 to 100), and the mean IKDC score was 94 (80 to 100). Overall, the IKDC grade was A (normal) in 24 patients (58%), B (nearly normal) in 8 patients (33%), and C (abnormal) in 1 patient (8%). Conclusion: The present study demonstrated tibial eminence fractures in adults can be effectively treated with arthroscopic suture fixation.

Keywords: Arthroscopy, suture fixation, tibial eminence fracture

Introduction

Tibial intercondylar eminence fracture involves bony avulsion of the anterior cruciate ligament (ACL) insertion from the tibial spine, which is first reported in 1875. Knee extension, nonunion, malunion, and anterior instability of the knee are common complications if the tibial eminence is not well treated [1-3]. These are rare injuries with an incidence significantly less than that of the more common intraligamentous tear of the ACL. The majority of tibial eminence fractures occur in children and adolescents (age 8-14 years) [4], but these injuries can also be seen in adults and are equivalent to orbe a subtype of an acute rupture of the ACL. A fall from a bicycle was the traditional mechanism associated with this injury, but other common mechanisms include contact sports (soccer, rugby, and football) and motor vehicle accidents [5, 6]. Concomitant injury to the menisci, articular cartilage, and collateral ligaments can also be seen, and is more common in adults [4, 7, 8]. Forces responsible for fracture are also felt to strain the ACL and lead to permanent attenuation of the ligament.

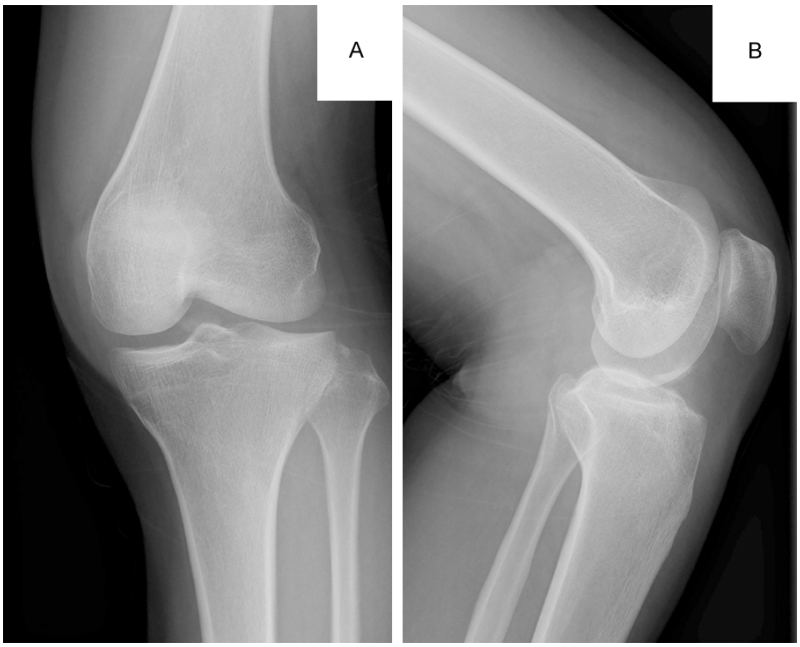

Figure 1. Anteroposterior (A) and lateral (B) radiographs of tibial eminence fracture.

Tibial eminence fractures are commonly classified and treated according to the criteria established by Meyers and McKeever [9]. Type I fractures are nondisplaced with complete bony apposition between the fracture fragment and tibial plateau. Type I (nondisplaced) fractures are commonly treated by conservative treatment, the limb is immobilized in near (~20 degrees) to full extension until radiographic evidence of bony union is seen (6-12 weeks) [4]. Type II fractures are mildly displaced with elevation of the anterior half of the fracture hinged off an intact posterior cortex. Type III fractures involve complete displacement of the avulsed fragment from its bony bed. Type IV fractures involve a displaced and comminuted fragment [10]. The ideal treatment for displaced fractures, especially minimally displaced McKeever Type II, remains unclear. Both operative and non-operative treatment protocols have been reported.

When operative treatment is utilized, an open reduction and internal fixation approach was traditionally utilized; however, it has dissipated with the evolution of arthroscopy though successful results have been reported with both methods [11-15]. The ability to arthroscopically evaluate the fracture pattern and address concomitant intra-articular pathology has allowed arthroscopic-assisted reduction and fixation to become the gold standard for fixation [4, 16]. Nowadays, multiple techniques for arthroscopic reduction and internal fixation have been developed, and as yet, there is no gold standard [17]. Suture and screw fixation are the most commonly described fixation techniques and both have yielded satisfactory results [4, 18, 19]. The results of biomechanical studies comparing suture and screw fixation are mixed [20-23], and few clinical studies directly compare these two methods of fixation [19, 24]. Furthermore, until now, no universal technique has been available that can be applied regardless of skeletal maturity, fragment size, or comminution. Arthroscopic suture fixation has also evolved over the years, including suture loop transporters, multiple drill tunnels, retrograde guides, and various tissue penetrators for suture passage [16, 25-28]. The present retrospective study reported the clinical outcomes of arthroscopic suture fixation for tibial eminence fracture with 2 years' follow-up.

Methods

This project was approved by the Institutional Review Board of the orthopaedic hospital of Henan Province. The present retrospective study enrolled 33 patients with imaging evidence of tibial eminence avulsion fractures who underwent arthroscopic surgery between 2008 and 2012. The inclusion criteria for the study were a displaced tibial eminence avulsion fracture and anterior knee instability of grade II or higher in skeletally mature patients. Avulsion fracture of the ACL is diagnosed by anterior instability on physical examination and radiographic evidence of bone fragmentation (**Figure 1**). Anterior instability was determined by performing the anterior drawer test and the Lachman test. The anterior drawer test was performed at 90° of knee flexion and was

Table 1. The characteristics of the tibial eminence fracture patients included

Age		34 (22 to 55)
Gender	Male	26
	Female	7
Injury mechanism	Traffic accident	29
	Sports	2
	Fall	2
Modified Meyers and McKeever classification	II	13
	III	16
	IV	4
Concomitant injury	Lateral meniscus tears	6
	Medial meniscus tear	5
	Medial collateral ligament injury	3
Anterior instability examination under anesthesia	Grade II	8
	Grade III	25
Follow-up		24 (20 to 27)

Table 2. Statistical analysis of Rolimeter measurement, extension deficit, flexion deficit, Lysholm score, and IKDC score

		Mean	Range	SD
Anterior translation		0.47 mm	0 to 2.5 mm	0.35
ROM	Extension deficit	1.5°	0° to 5°	1.10
	Flexion deficit	2.7°	0° to 10°	2.52
Lysholm score		96	85 to 100	7.2
IKDC score		94	80 to 100	8.7
IKDC grade	A (normal)		24	
	B (nearly normal)		8	
	C (abnormal)		1	
	D (severely abnormal)		0	

graded according to the extent of anterior translation (grade I indicated by translation <5 mm, grade II indicated bytranslation of 5 to 10 mm, and grade III indicated by translation >10 mm).

Operative procedure

All patients were operated on by the same surgeon. Patients were positioned supine on the operating table after general or epidural anesthesia. Standard knee portals for arthroscopy were made, including anteromedial, anterolateral, and lateral midpatellar knee portals. A fluid pump of 60 to 90 mmHg was set to control bleeding and improve visualization, so that the fracture pattern and concomitant intraarticular pathology can be exactly evaluated. An ACL tibial angle guide (Smith & Nephew Endoscopy, Andover, MA) was used to manipulate and anatomically reduce the displaced fracture fragment. A suture hook (Linvatec, Largo, FL) loaded with No. 2 polydioxanone (PDS; Ethicon, Somerville, NJ) was introduced through the anteromedial portal and pierced the fibers of the ACL as far anteriorly as possible. The PDS was then advanced into the joint and the suture hook was then removed. A suture grasper was used to shuttle the PDS through the anteromedial portal. The PDS was used as a guide suture to deliver a No. 2 Ethibond non-absorbable suture (Ethicon) through the base of the ACL. An additional suture were passed in the same fashion through the ACL posterior to the initial sutures. A longitudinal incision was made just medial and inferior to the tibial tuberosity, and by use of the ACL tibial drill guide, two bone tunnels were drilled from the proximal tibia to the fracture site. There was at least 1-2 cm bridge of metaphyseal cortex between the 2 tunnels. The sutures were then tied over the bony bridge with the knee in 30° of flexion. The tibial eminence avulsion fracture was reduced to the fracture bed with the probe, and the sutures were kept under tension until all sutures were tied to achieve anatomic reduction and restore normal position and tension to the ACL. The surgeon then re-examined the reduced fragment and ACL tension with the probe, checking the reduction and stability of the fragment throughout knee flexion and extension.

Post-surgery rehabilitation

Postoperatively, the knee is immobilized in full extension in a brace for 4 weeks. The brace was then adjusted to allow gradual flexion to regain complete range of movement. Partial weight bearing in the brace is allowed as tolerated with crutch support until the second week, and full weight bearing was allowed until 4 weeks. Isometric quadriceps muscle exercises were performed throughout the immobilization period to minimize disuse atrophy. Nonimpact activities are allowed at 8 weeks (e.g., swimming and cycling). Return to sports was permitted at 6 months postoperatively, after knee stability, range of motion, muscle strength, and proprioception were restored.

Clinical evaluation

The patients were followed up at 4 weeks, 2 months, 3 months, 6 months and 12 months and then 24 months. Those patients with a follow-up period of less than 20 months were considered lost to follow-up and thus excluded. Anteroposterior and lateral radiographs were obtained 3 months postoperatively to assess fracture healing. At 24 months after surgery, all patients were evaluated by an independent orthopaedic professor with clinical examination like anteroposterior laxity (Lachman-Noulis and anterior drawer tests) and Rolimeter knee tester (Aircast, Vista, CA). Knee range of motion was evaluated actively and passively with a goniometer. Knee function was evaluated by the Lysholm and International Knee Documentation Committee (IKDC) scores. Patients were also evaluated according to the IKDC knee examination form, and their knees were graded as normal (grade A), nearly normal (grade B), abnormal (grade C), or severely abnormal (grade D). Knee radiographs in standing anteroposterior, standing lateral, and Merchant views were examined for alignment, joint space narrowing, and degenerative knee changes.

Statistical analysis

The Statistical Package for Social Sciences software (SPSS, Inc., Chicago, IL, USA), version 16.0 for Windows was used for statistical analysis in this study. Descriptive statistics were presented for all continuous variables and frequencies were used to obtain descriptive statistics for all categorical variables.

Results

The present study included 26 male (78.8%) and 7 female (21.2%) patients, with the mean age of 34.2 years (range from 22 to 55 years). The injury mechanism was divided to traffic accident (29), sports (2), and fall (2). There were 13 type II fractures, 16 type III, and 4 type IV according to the modified Meyers and McKeever classification. Concomitant injuries like lateral meniscus tears were found in 6 patients, medial meniscus tear in 5 patients, and medial collateral ligament injury in 3 patients. All meniscal tears were treated with partial meniscectomy or meniscal repair, and 2 medial collateral ligament injuries were treated conservatively but 1 treated with surgery. Examination under anesthesia before surgery showed grade II anterior instability in 8 knees and grade III in 25. All of the patients were followed up with a median time of 24 months (range, 20 to 27 months). The characteristics of the tibial eminence fracture patients included are shown in **Table 1**.

No major complication like infection, deep venous thrombosis, or neurovascular deficit happened perioperatively. The patients were followed at 4 weeks, 2 months, 3 months, 6 months, and 12 months and then 24 months. At the final follow-up, there were no symptoms of instability and no clinical signs of ACL deficiency (Lachman-Noulis and anterior drawer tests) among all the patients. Radiographs showed that all fractures healed 3 months post-operative, but at the last follow-up, there was one person with degenerative changes like joint space narrowing in radiographs. This patient is 55 years old at surgery, with a type IV tibial eminence fracture and concomitant injury of medial meniscus tear treated with partial meniscectomy. However, only slight pain with moderate or strenuous activities was presented.

Anterior translation of the tibiawas 0.47 mm on average (range from 0 to 2.5 mm) compared with the uninjured side. Range-of-motion measurement showed a mean extension deficit of 1.5° (range, 0° to 5°) and a mean flexion deficit of 2.7° (range, 0° to 10°) compared with the unaffected side. The mean Lysholm score was 96 (range from 85 to 100), and the mean IKDC score was 94 (range, 80 to 100). Overall, the IKDC grade was A (normal) in 24 patients (58%), B (nearly normal) in 8 patients (33%), and C (abnormal) in 1 patient (8%) (**Table 2**).

Discussion

The present retrospective study reported the clinical outcomes of arthroscopic suture fixation for tibial eminence fracture with a follow-up of 24 months. The arthroscopic suture fixation in treating tibial eminence fracture is more and more common nowadays, but only a handful of studies have been performed reporting the outcomes, especially these studies were of low levels of evidence with regard to the small number of sample size and short follow-up period. This study included 33 patients and a follow-up period of 24 months, the conclusion may help to guide the decision of fixation technique.

Tibial eminence fractures are relatively rare injuries involving avulsion of the ACL insertion and the management of displaced fractures is somewhat controversial [4]. In 1982, McLennan reported the usefulness of endoscopic reduction with an arthroscope, and emphasized its advantages including less invasiveness than open surgery, and rapid recovery of knee functions [29]. Later, van Loon and Marti use a drill guide for knee ligament reconstruction in arthroscopic fixation for tibial intercondylar eminence fractures [30]. Moreover, various arthroscopic fixation techniques such as the pull-out method, and fixations using screw, K-wire and staple have been reported [31]. All these studies techniques aimed at more accurate approach to the fracture site and reducing surgical invasiveness, thus emphasize the advantages of arthroscopic fixation techniques for tibial intercondylar eminence fractures. However, on the other hand, some articles have also reported the postoperative complications like motion impairment and instability, raising concerns about the efficacy of arthroscopic fixation. For example, Berg et al. [2] reported 2 cases of postoperative arthrofibrosis and Montgomery et al. [32] reported 53% of patients had severe difficulty in regaining motion postoperatively. Another study reported a rate of post-surgery laxity of 30% along with fair or poor results [33]. The present study reported perfect results in patients treated with arthroscopic suture fixation, which suggest the effectiveness and security of arthroscopic techniques.

Though arthroscopic techniques is more and more commonly used, the ideal method of fixation, suture versus screw, has not been defined. Arthroscopic screw techniques include both retrograde and antegrade techniques and incorporate metal, absorbable, and non-absorbable materials [14, 30, 33, 34]. Retrograde and ante grade screws have been commonly used for fixation, but several potential problems exist: screw purchase with fragment comminution and stability, fixation pullout strength, posterior neurovascular injury, as well as the potential need for hardware removal and transphyseal fixation in the skeletally immature patient [4, 21].

Both suture and screw techniques have also been researched in cadavers. A previous study found there was significantly greater anterior translation with pullout suture fixation in comparison with antegrade screw fixation [23]. Same results were found in Eggers' study [35] which demonstrated suture fixation provides greater strength than screw fixation. However, Bong et al. [21] reported the initial ultimate strength was higher with Fiber Wire sutures than with cannulated screw. Also, other studies demonstrated no significant differences in outcomes between the two techniques [19]. In our mind, we prefer the arthroscopic suture fixation technique as it can be used in all types of fractures and the suture technique is more experienced to us.

Conclusion

The present study demonstrated tibial eminence fractures in adults can be effectively treated with arthroscopic suture fixation.

Disclosure of conflict of interest

None.

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