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Case Report

Arthroscopic treatment of tibial spine fracture in adult with a simple modified suture fixation technique

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Abstract: Objectives: Extreme tensile force to the anterior cruciate ligament (ACL) can cause an avulsion of the tibial eminence which may lead to malunion or nonunion resulting in pain, flexion deformity, and instability of the knee. Since the injury is generally regarded as something equivalent to the ACL injury, the treatment requires anatomic reduction of the fragment and preservation of the stability of the knee. The aim of this study was to test our experience in the treatment of displaced tibial eminence fractures with a simple modified suture fixation technique. Methods: Between January 2012 and June 2014, five adults with Type II or Type III anterior tibial eminence fractures were treated surgically. All patients were twice evaluated not only before the surgical treatment but also two years after the surgery, including clinical and radiographic outcomes. Results: Two years after the surgery, we did not find instability in any of the patients by physical examination. The average scores of Lysholm functional scale and the International Knee Documentation Committee (IKDC) subjective score were improved greatly after the surgery. The range of motion (ROM) of the injured knees also was identical to healthy sides two years later. Conclusions: The findings indicate that the presented arthroscopic technique provides good stability and preserves the function of the injured knee in the mid-term.

Keywords: Arthroscopy, tibial spine fracture

Introduction

Tibial spine or anterior cruciate ligament (ACL) bony avulsion fracture was once thought as uncommon injury [1]. The prevalence of this injury continues to rise as people are increasingly involved in athletic activities. This injury was believed to be more common in skeletally immature adolescent since the intercondylar eminence is not fully calcified in children and it can be exposed to injuries more frequently than the ACL itself, but recently, it has been reported in literatures that they may occur just as frequently in adults [2, 3]. The mechanism of the injury has not yet been fully understood. It results from injuries such as falls, skiing, football injuries or injuries due to vehicle accidents [4].

The tibial eminence fracture was first reported by Poncet in 1875. Meyers and McKeever had developed a very practical radiologic classification system classified these fractures into three types: Type I as minimal or non-displaced fractures, Type II as elevation of one-third or one-half of the eminence with intact posterior hinge, and Type III as completely displaced fractures [5]. Later Zaricznyj proposed a fourth category (Type IV) to better describe comminuted fractures [6]. Type I fractures are recommended managed by conservative therapy [7]. Type II fractures with greater than 2 mm displacement as well as type III and type IV injuries are advocated for surgical treatment because of disastrous complications and unsatisfactory results from conservative treatment [8]. Beyond all these, other surgical indications include patients presenting diminished motion range of knee or a locked knee during activities.

A wide variety of fixation methods had been reported to fix tibial eminence fractures including open reduction and internal fixation or arthroscopically assisted internal fixation. However, arthrotomy had some complications such as increasing surgical time, significantly prolonged recovery time and arthrofibrosis after surgery [9]. Successful arthroscopically assisted reduction and internal fixation (ARIF) techniques was first reported in 1982 by McLennan [10]. Proved to have high rates of success, ARIF techniques had been widely accepted by arthroscopic surgeries in the treatment of tibial eminence avulsion fractures [11, 12]. Although many successful ARIF techniques using a variety of fixation methods had been presented in the literatures, fixation can be most commonly classified as using pull-out sutures or screws [13-15]. However, until now, there is no gold standard available for the treatment of tibial eminence avulsion fractures. The goal of the study was to introduce and evaluate a new method of fixation of Type II and III eminence avulsion fractures in adults using double endobutton plates under arthroscopy assist. We hypothesized that this new techniques provides enough stability and enables early rehabilitation without the need of long term cast fixation. And it is also a good supplement to the existing treatment methods.

Patients and methods

All of the injured adult patients as research subjects were consecutively recruited between January 2012 and June 2014 from the orthopedics center of Changzhou First Peoples' Hospital, Jiangsu, China. On admission physical examinations, conventional X-rays (antero-posterior and lateral views), Computed Tomography (CT) and Magnetic Resonance Imaging (MRI) were performed. On most occasions, the fracture could be observed only on one X-ray view, mostly on lateral views. The CT scan and MRI of the injured knee help confirm the diagnosis. The fractures were classified on the basis of the Meyers and McKeever system. Data including demographics, fracture type, mechanism of injury and complications were collected. Undisplaced fractures (Type I) were managed conservatively. Surgical intervention was performed only in the cases of Type II, Type III fractures. Nevertheless Type IV (comminuted) fractures were not suitable for our method. All patients completed a follow-up of two years and three months postoperatively. All follow-up examination was performed by only one orthopedic surgeon who was not involved in the initial surgery. Stability test of the knee was performed using Lachmann, anterior drawer and pivot shift test. The functional outcome was evaluated by using the International Knee Documentation Committee (IKDC) subjective score and the Lysholm functional score [16, 17]. Range of motion (ROM) of the knee was measured with a goniometer with patient in supine position. Postoperative radiographs including anteroposterior and lateral films of the knee were also taken at the follow up time. A fracture union was defined as no presence of visible fracture line on the radiograms.

The patient was placed in the supine position under general anesthesia. The tourniquet was placed on the upper third of the thigh to facilitate visualization during operation. After prepping and draping in the normal, sterile fashion, diagnostic arthroscopy is performed. Standard anterolateral and anteromedial portal was established, and the hemarthrosis was thoroughly washed out. Assessment of accompanying injuries like meniscus tear and so on was performed and managed as per established guidelines before the treatment of ACL bony avulsion fracture. The anterior patellar fat pad was removed. Anterior horn of the meniscus and transverse intermeniscal ligament sometimes may impede reduction. It should be retracted with probe before the reduction of the fractured tibial spine. An arthroscopic shaver (Dyonics 4.5 mm Incisor Plus, Smith & Nephew Andover, US) was used for debridement of the bed of the fractured tibial spine for any blood clot or fibrous tissue. Curettage of the fracture bed was necessary, allowing to slightly over-reduce the fracture to provide a retightening of the ACL. The reduction of the avulsion fracture fragment is performed by probe temporarily. After that, the ACL drill guide was pressed upon the fragment through anteromedial portal which help and maintain over-reduction of the fragment. A 3-cm longitudinal incision was made parallel to the tibial tuberosity and was deepened up to the subcutaneous tissue and fascia. After the guided bullet was placed against the tibia, a guide pin (2.3-mm) was drilled from the incision through the fracture fragment, just at the insertion site of the ACL. The endobutton plate is loaded with #2 Ultra-Braid (Smith & Nephew, Andover, MA) and #2 Polydioxanone II (Ethicon, Somerville, NJ) suture in shown pattern (**Figure 1**). The pin was pulled out and an epidural needle loaded with #2 looped PDS suture was pushed into the tibial tunnel. Once the tip of the epidural needle was visualized, the PDS loop suture was pushed

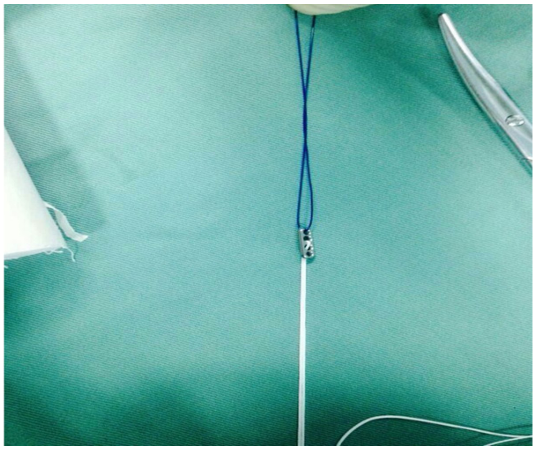

Figure 1. The endobutton plate is loaded with #2 UltraBraid (Smith & Nephew, Andover, MA) and #2 Polydioxanone II (PDS; Ethicon) suture in shown fashion.

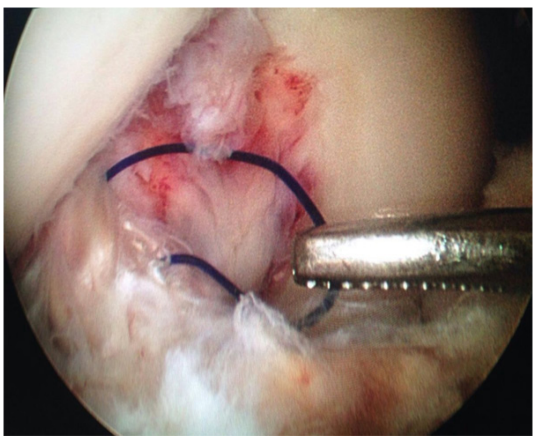

Figure 2. The PDS loop is grabbed using the arthroscopic grasper or vascular clamp through anteromedial portal.

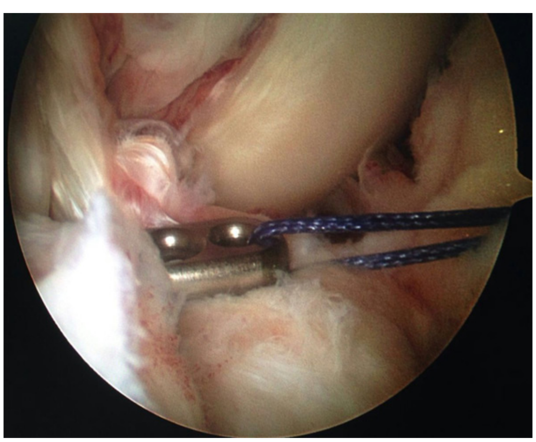

Figure 3. The avulsion fracture fragment was reduced with the help of endobutton plate pre-loaded UltraBraid and PDS.

Figure 4. Antero-posterior view X-ray of the knee one week after the surgery.

forward into the joint space. The PDS loop was grabbed using the arthroscopic grasper or vascular clamp through anteromedial portal (**Figure 2**) and loaded with a #2 UltraBraid suture outside the knee, which had already been loaded in the endobutton plate. Now, the epidural needle was withdrawn from the tibial tunnel and then the PDS in the tunnel was pulled down which carries the UltraBraid suture out of the tunnel together. The endobutton plate was flipped and tensioned down on the joint side to reduce and fix the avulsion fracture fragment with the help of pre-loaded UltraBraid and PDS suture which was now kept in tension (**Figure 3**). After that the knee was cycled through a full range of motion several times. Then the probe was used to check the over-reduction of the fragment and the tension of ACL. The UltraBraid suture was then tied one by one over another endobutton plate on tibia keeping the knee in 20-degree flexion and tibia pushed anteriorly. Finally, the knee was extended to look for any impingement in the intercondylar notch. In this study the author found no impingement in any case. After all have been done, the #2 PDS suture was removed and the wounds were closed in routine fashion. Conventional X-rays including antero-posterior and lateral views were taken one week after the surgery to confirm the reduction of the avulsion fragment (**Figures 4**, **5**).

Figure 5. Lateral view X-ray of the knee one week after the surger.

Postoperative rehabilitation

Following operation, the patients remained non-weight bearing with the leg in a brace at full extension and started on isometric quadriceps exercises for 4 weeks. Range of motion angle was allowed at 0° to 90° after 4 weeks and then adjusted to 0° to 120° from 6 weeks. Light strengthening exercises could be performed 6 weeks after the surgery. However, the full weight bearing of the operated joint was allowed only eight weeks after the operation.

Results

A total of five patients underwent the surgery with a median age of 40 years (range, 31 to 47 y) less than two weeks since the injury. All patients were female. According to the Meyers and McKeever classification, there were 2 type II and 3 type III subjects. Mechanisms of injury were various. In three cases the injury was caused by car accident, in two cases falling from a certain height.

All of the operations were performed as described above and the median operating time was 80 minutes (range, 55-120 minutes). The clinical examinations prior to the operations showed that anterior drawer +, Lachmann + and Pivot shift 0 deviations were observed in all the two cases who suffered Type II fractures. Among the three patients suffering Type III fractures, two severe cases demonstrated anterior drawer +++, Lachmann +++ and Pivot shift ++, while the other case presented as anterior drawer ++, Lachmann ++, and Pivot shift + (**Table 1**). The follow-up physical examinations performed two years after the surgery did not demonstrate instability in any of the patients (**Table 1**). At the same time the median Lysholm knee score was 94.8 (range, 94-95) and the median IKDC subjective score of patients was 93.8 (range, 93-96) in the study group (**Table 1**). The extension or flexion deficit was not observed in any of the patient during the follow-up period. The range of motion (ROM) of the injured knee joint was almost the same as healthy side two years after the surgery (**Table 2**). All patients were able to return to their daily life six months after the surgery, the time when the follow-up X-rays showed bony union of fractures. No complications such as secondary fracture dislocation or delayed fracture healing were observed during the follow-up time.

Discussion

Surgical treatment of displaced intercondylar eminence fractures is essential to preserve the normal knee function. Many methods including arthroscopic and open techniques had been described so far [6, 18, 19]. McLennan first presented the advantages of arthroscopic treatment for tibial eminence fractures in 1982 [10]. Arthroscopic fixation of eminence fracture now has become very common because of excellent visualization, accurate reduction, rigid fixation, accompanied joint injuries management, limited surgical time, and also decreased hospital cost. It also avoids the complications and morbidity of arthrotomy. There are various arthroscopic methods including the usage of staples, screws, Kirschner wires, and sutures [20-22]. The staple may be too bulky to repair the fracture, and it could crush the bone fragment or block the extension of the knee [23]. Commonly used screws may also crush bony fragments, cut ligaments, and most importantly require a second procedure to remove the hardware [24]. Currently, arthroscopic suture fixation technique has become a popular method as it is a rigid method of fixation, MRI compatible and no need to remove the hardware. Suture fixation methods can fundamentally be

Table 1. Comparison of the stability and function of different types of eminence fractures assessed prior to treatment, 12th week, and 1 year follow-up

Type of injury/number of patients/(treatment)	Drawer			Lachmann			Pivot-shift			Lysholm		IKDC	
	pr. treatm.	3 months	2 years	pr. treatm	3 months	2 years	pr. treatm.	3 months	2 years	3 months	2 years	3 months	2 years
Type II/	+	0	0	+	0	0	0	0	0	93	95	91	94
	+	0	0	+	0	0	0	0	0	94	95	92	96
Type III/	+++	0	0	+++	0	0	++	0	0	92	94	91	93
	+++	0	0	+++	0	0	++	0	0	92	95	92	93
	++	0	0	++	0	0	+	0	0	93	95	93	93

Table 2. Comparison of the range of motion of injured knees and counterparts assessed at the 3 months and 1 year follow-up examinations

Type of injury/number of patients/(treatment)	ROM healthy side	ROM injured side prior to surgery	ROM healthy side 3 months	ROM operated side 3 months	ROM healthy side 2 years	ROM operated side 2 years
Type II/	0-150	0-80	0-150	0-140	0-150	0-150
	0-145	0-75	0-145	0-140	0-145	0-140
Type III/	0-150	15-75	0-150	0-135	0-150	0-145
	0-145	20-75	0-145	0-140	0-145	0-145
	0-155	20-80	0-155	0-145	0-155	0-150

divided into 2 classes. One is based on the ACL itself (ligament suture methods), and the other is based on the avulsed bone fragment (avulsed bone fragment suture methods) [25, 26]. Ligament suture methods require special instruments which are very expensive and require complex maneuvers. Avulsed bone fragment suture methods using suture fixation with 2 drilled holes through the reduced fragment may not be always possible due to technical difficulties or comminution of the fragment.

This essay introduced a new method for the treatment of the displaced intercondylar eminence fractures. The technique presented here is fairly safe and reproducible. The results in this study are as good as what have been published in literatures before [20-26]. Compared to other arthroscopic techniques, the use of the Endbutton system allows surgeons to cut down steps for fracture fixation and simplifies the procedure. The most difficult step during the surgery is the placement of the guide pin which determines the rest of operating time. This fixation technique used only one drilled hole to pass the UltraBraid suture and the arthroscopic grasper is only used one time to pull out the suture. Some authors believe that during the trauma leading to tibial spine fracture, the intersubstance of the anterior cruciate ligament undergoes a stretching which may be responsible for further anteroposterior instability. Noyes *et al.* found that prior to the intercondylar eminence fracture, the ligament elongated more than 50% and maintained continuity [27]. The lengthening of the ligment may be caused by sequential failure of fibers. In support of slight over-reduction, the long-term follow up of well reduced tibial spine fractures have revealed subtle increases in anteroposterior laxity [28]. But even in this study functional difference is not found probably because the follow-up of the studies is still not long enough to observe meniscus injury or wear of articular cartilage. The author believes that the slight over-reduction of the fragment tends to compensate the ACL elongation but could be insufficient to some extent. Our study had found that at the time of follow-up, the operated knee had significant improved IKDC and Lysholm knee score. All patients showed radiologic bone union at 3 months postoperatively, supporting the excellent clinical data collected. The author did not find any anteroposterior laxity or functional difference at the last follow up time probably because the time was not long enough. Long-term follow up is needed in future. The removal of the plates was not found to be necessary because the author did not find any complication at the last follow-up time. It could be argued that the hardware may cause difficulties in the case of possible surgeries, such as ACL-reconstruction in future. To say the least, even if there is any need to perform the ACL reconstruction surgery, the remove of the hardware will not be hard. The method introduced here incorporates many of the previously described techniques to facilitate a simplified, reproducible method of treating this injury.

One of the potential limitations of our study is the fact that the number of patients studied is limited. However, it is known that tibial spine fractures are rare types of injuries. A prospective multi-centered trial would be of benefit to further elucidate the efficacy of this technique.

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Disclosure of conflict of interest

None.

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