Long-term outcomes of arthroscopic suture fixation for anterior cruciate ligament tibial avulsion fracture

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Summary

Introduction: Anterior cruciate ligament (ACL) tibial avulsion fracture is one of the most common knee injury. There are many classical procedures to be available for fixation ACL tibial avulsion fracture. Nowaday, arthroscopic suture fixation for ACL tibial avulsion fracture has many advantages and limits complications effecting knee joint. *Objective:* To evaluate long-term outcomes of arthroscopic suture fixation for anterior cruciate ligament tibial avulsion fracture. *Subject and method:* Thirty six patients with ACL tibial avulsion fracture (types II, III, IV), mean age of 33.8 years (range from 22 to 46 years) were prospectively followed up after arthroscopic suture fixation for anterior cruciate ligament tibial avulsion. Along with clinical examination, radiographs, Lysholm score, IKDC classification were used to evaluate the patients. Anteroposterior knee laxity was measured with a KT-1000. *Result:* Patients were followed up for a mean of 14.46 months (range, 6 to 24 months). At final follow-up, the mean Lysholm score was 92 (range, 81 to 100). 34 patients (94.5%) were classified by IKDC score as normal or nearly normal (grade A or B). The IKDC classification was abnormal (grade C) in 2 patients (5.6%). Anterior translation of the tibia, measured with the KT-1000, was 1.69mm on average (range, 0 to 6mm) compared to the healthy side. All 36 fractures achieved union within 3 months. *Conclusion:* Treating ACL avulsion fracture with arthroscopic suture fixation can restore ACL length, stabilize fragments, promote early motion.

Keywords: ACL tibial avulsion, suture fixation.

1. Background

Avulsion fracture of the tibial attachment of the anterior cruciate ligament (ACL) is more common in children and adolescents than in adults, these avulsion fractures account for only 1% to 5% of ACL injuries in adults [1]. Meyers MH and McKeever FM classified avulsion fractures into three types. Type I as undisplaced, type II as partially displaced with intact posterior hinge, and type III as completely displaced. Zaricznyj B. proposed a fourth category (type IV) for comminuted avulsed fragment [2]. Surgical intervention is indicated for Meyers MH. and McKeever FM types II, III, and IV because displaced fractures may cause nonunion or malunion as well as loss of knee extension or instability [1].

Previously, treatment techniques were surgical open reduction and internal fixation with screws and wires. Open modes of reduction and fixation have particular disadvantages and morbidities, including arthrotomy with soft tissue dissection, postoperative pain, delayed rehabilitation, prolonged hospitalization, and the need for subsequent implant removal [3].

***Received**: 29 September 2021, **Accepted:** 15 October 2021*

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Currently, arthroscopic suture fixation with high-strength suture is the most common technique which can restore ACL length, stabilize fragments, promote early motion [4]. In addition, patients with suture fixation typically have lower rates of secondary surgery because no hardware is left in place.

The aim of this study is to report the long-term outcomes of arthroscopic suture fixation for anterior cruciate ligament tibial avulsion fracture.

2. Subject and method

A retrospective, descriptive cross-sectional study was conducted in 36 patients who had isolated ACL tibial avulsion fracture and underwent arthroscopic suture fixation, performed by a group of surgeons. These surgical operations were perfomed at the Department of Joint Surgery – 108 Military Central Hospital from December 2017 to March 2019.

Inclusion criteria:

Patients with isolated ACL tibial avulsion fracture type II, III, IV (Meyers MH and McKeever FM classification).

Time from injury to surgical intervention less than 6 weeks.

Exclusion criteria:

Having any deformity or prior surgery at the injured extremity.

Having any bone fracture around knee or combined ACL, MCL, LCL and PCL injury.

Bilateral ACL lesions.

2.1. Surgical technique

Spinal anesthesia was administered to the patient, who was placed in the supine position. A thigh tourniquet was used.

Through a high anterolateral portal (portal were at the level of the patella tip, near the patellar tendon) and anteromedial portal, the joint was fully examined.

After a comprehensive arthroscopic examination has been performed, a hook probe is used to lift the avulsed fragment to allow access to the fracture bed. A mechanical shaver is used to carefully prepare the fracture site by debriding hematoma and removing smaller fracture fragments.

Once reduction of the fracture is performed, a superior percutaneous 2.0mm K-wire may be used to obtain provisional fixation.

A SutureLasso (Arthrex) is passed through the base of the ACL just proximal to its tibial insertion site on the fracture fragment and retrieved through the anteromedial portal. A FiberWire Suture (Arthrex) is then shuttled through the base of the ACL with the SutureLasso.

The tibial aiming device for ACL reconstruction (Arthrex) was inserted through the anteromedial portal. Then a 2-cm longitudinal incision was made at the medial side of the tibial tubercle. Through this incision, two 3.0mm wide tunnels were made from the medial side of the tibial tubercle, respectively, to the anteromedial and the anterolateral edge of the fracture bed. A bone bridge of more than 5mm in width was left for suture fixation over it. Next, the K-wires were pulled out and replaced by cannula needles loaded with looped 2.0mm PDS in medial and lateral tibial tunnels. The FiberWire sutures were crossed just at the anterior side of the ACL, above the bony fragment. Then the suture ends from the medial side of the ACL were pulled out the joint through the lateral tunnel, and those from the lateral side of the ACL were pulled out the joint through the medial tunnel using looped PDS.

FiberWire sutures were tied over the bone bridge keeping the knee in 30-degree flexion. The K-wire used for a temporary reduction was removed, and ACL probed for adequate tension. Finally, the knee was completely extended to check for intercondylar notch roof impingement with the fixed avulsed tibial spine. Furthermore, surgical incisions were closed in layers.

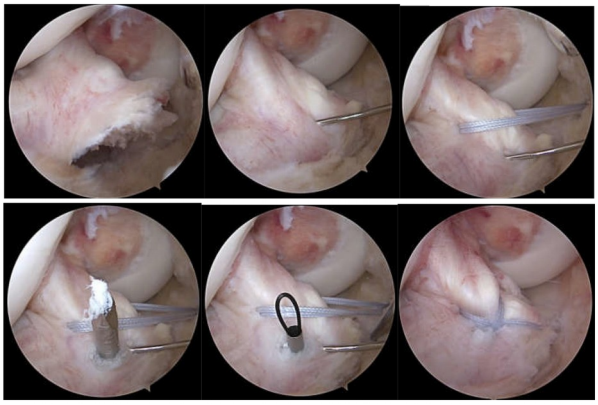

Figure 1. Suture fixation technique

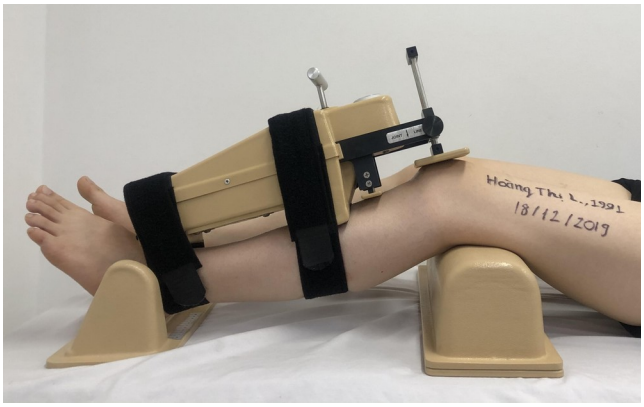

Figure 2. Assessment of knee stability by KT-1000 arthrometer.

2.2. Rehabilitation

During the first postoperative week, each patient was immobilized with a full-extension knee brace. Full weight-bearing, quadriceps-strengthening, and isometric exercises were encouraged along with straight-leg raises. From week 2 to 4, the range of motion (ROM) was 0° to 60° in flexion. From week 4 to 8 , ROM was 0° to 120° in flexion, and closed-chain kinetic exercise was encouraged. From week 8 to 12, stationary bicycling and straight-leg stance were encouraged. After 6 months, all patients could fully resume sports activity.

2.3. Follow-up evaluation

Descriptive characteristics of subject: Age, causes of injury, time from injury to surgical intervention, follow-up time.

Evaluation of long-term outcome (6 months postoperative).

Clinical features:

Assessment of knee stability: Anterior translation of the tibia, measured with KT-1000 arthrometer compared to uninjuried side.

Evaluation of knee function based on Lysholm scoring system and International Knee Documentation Committee (IKDC) classification.

Radiographic: A fracture was considered to be united if no fracture line was visible radiographically.

2.4. Statistical analysis

The χ^2 test was used to compare categorical data by comparing IKDC changes in groups A and B to that in groups C and D (normal or nearly normal and abnormal or severely abnormal) between preoperative and final follow-up assessments. The Mann-Whitney U test was applied for ranking continuous data (Lysholm scores), and the unpaired Student t-test was used to analyze continuous data (KT-1000 arthrometer comparison). $p<0.05$ was considered statistically significant. Statistical analysis was performed by use of SPSS software, version 22.0.

3. Result

3.1. Descriptive characteristics of subjects

Thirty six patients with ACL tibial avulsion fracture (types II, III, IV), mean age of 33.8 years (range from 22 to 46 years) were prospectively followed up after arthroscopic suture fixation for anterior cruciate ligament tibial avulsion fracture. The majority of 33 patients, or 91.6%, was injuried in traffic accident. When this study started, 20 patients had their injuries present for less than 3 days, and only 6 of them had injuries for 21 days. Patients were followed up for a mean of 14.46 months (range from 6 to 24 months).

Table 1. Pathological characteristics of patients

Parameter		No of cases	Percent
Activity at	Traffic	33	91.6

injury	accident Work accident Daily activities accident Sports injuries	1 1 1	2.8 2.8 2.8
Timing of surgery	< 3 days 3 - 7 days 7 - 21 days	20 10 6	55.5 27.7 16.8
Involved knee	Right side Left side	23 13	63.9 36.1

3.2. Clinical and radiographic features

Clinical: All patients had swelling, pain and lost of knee range motion, in which there were 6 cases having skin abration in front of the knee. Patients who arrived less than 7 days had more swelling and limited knee motion than those who arrived post 7 days.

Radiographic: 3/36 patients had type II fracture, 31/36 patients had type III fracture and 2/36 patients had type IV fracture.

3.3. Arthroscopic features

Table 2. Characteristics of lesion in arthroscopy

Meyers MH and McKeever FM classification of ACL alvusion fracture	Type II Type III Type IV	3 31 2	8.3 86.1 5.6
Concomitant injuries	Partial ACL rupture	1	2.8

3.4. Outcome

3.4.1. Lysholm Knee Score

The Lysholm knee scoring system was used to analyze subjective symptoms. The mean preoperative Lysholm score in the 36 knees was 36 (range, 30 to 52), the mean postoperative Lysholm score was 92 (range, 81 to 100). After a minimum of 6 months' follow-up, 32 of 36 patients (88.8%) had achieved excellent outcomes and 2 patients (5.6%) had achieved good outcomes. The 2 remaining patients achieved fair outcomes. No patient had a poor outcome. Lysholm scores significantly differed between preoperative evaluation and final follow-up.

Table 3. Comparison of Lysholm Knee Scores preoperatively and at final follow-up

Lysholm knee score	Preoperatively		Final follow-up	
	No. cases	Percent	No. cases	Percent
Excellent (95 - 100)	0	0	32	88.8
Good (84 - 94)	0	0	2	5.6
Fair (65 - 83)	0	0	2	5.6
Poor (< 65)	36	100	0	0
Mean ± SD	36 ± 10		92 ± 7	
Range	30 - 52		81 - 100	

**p<0.05 with Mann-Whitney U test.*

3.4.2. IKDC evaluation

Before surgery, all patients had moderate to severe knee effusion. At the last evaluation, there was one case having mild knee effusion.

Before surgery, 17 patients (47.2%) had a 15° difference in flexion defect between 2 sides. Of the patients, 11 (30.5%) had an extension defect exceeding 10°. At review, 35 patients (97.2%) whose normal and reconstructed limbs had a 3° or smaller

difference in full extension or a 5° or smaller difference in full flexion were given a normal rating. A rating of abnormal was found in 1 patients (2.8%) with 20° deficits in flexion. No patient had a severely abnormal rating.

KT-1000 arthrometer data at 89 N were available for all 36 patients. Postoperatively, 28/36 patients (77.8%) had side-to-side differences of less than 3 mm (grade A), 7 patients (19.4%) had side-to-side differences of 3 - 5mm (grade B) and 1 patient had side-to-side differences of 6mm at final follow-up. The mean difference at final follow-up was 1.69mm (range, 0 to 6mm). There was no statistically significant difference in postoperative KT-1000 scores compared to the contralateral uninjured limb data ($p>0.05$ with unpaired Student t-test).

Table 4. IKDC rating preoperatively and at final follow-up

Rating	Preoperatively		Final follow-up	
	No. cases	Percent	No. cases	Percent
A (normal)	0	0	27	75
B (nearly normal)	0	0	7	19.4
C (abnormal)	10	38.4	2	5,6
D (severely abnormal)	26	61.6	0	0

*$p<0.05$ (χ^2 test) for final rating in those with a normal or nearly normal rating versus those with an abnormal or severely abnormal rating.

3.4.3. Radiographic

All fractures were united in all cases within 6 months after surgery.

4. Discussion

4.1. Knee joint function outcome

Loss of motion and arthrofibrosis are concerns after tibial eminence fracture. It has been reported that stiffness may occur in as many as 60% of knees that are treated surgically for tibial eminence fracture [5]. Huang T.W. reported 2 patients (1 type III and 1 type IV) with 16° and 25° deficits in flexion [1]. whereas Montgomery KD, despite the use of an unrestricted rehabilitation regimen, found that 53% of the patients treated with arthroscopic suture fixation had severe difficulty regaining motion postoperatively [6]. Loss of motion may occur because of mechanical impingement of the displaced fracture or arthrofibrosis. Koukoulias E. reported 1 case of a 2mm superior fracture displacement in a patient who, at final follow-up, showed a 5° extension deficit [7].

Postoperatively, our patients were advised to follow a conservative rehabilitation regimen. We allowed immediate during week 2 to 4, the range of motion was 0° to 60° in flexion. At week 8, range of motion was 0° to 120° in flexion. In contrast, other authors who treated tibial eminence fractures in adults applied cast for 4 weeks after surgery. In our study, 35 patients (97.2%) had no difficulties in regaining satisfactory knee motion, and at final follow-up, range of motion measurement was satisfactory. We had 1 case of arthrofibrosis (20° deficit in flexion) after surgery 7 months, however this patient returned to daily activities, playing sport and satisfied with the treatment outcome. This patient was diagnosed type III ACL avulsion fracture at the cottage hospital and was treated with a long leg cast for 2 weeks. After surgery, this patient had to apply long leg cast for 4 weeks continuously so it was difficult to regain motion. Previous studies have shown that immobilization of the knee joint post surgery more than 4 weeks which would have high rate of stiffness and limited range of motion. We

found that treating ACL avulsion fracture by arthroscopic suture fixation can stabilize fragments, promote early motion, reduce the risk of stiffness post surgery.

The main goal of tibial eminence fracture treatment is to restore ACL competence. Nevertheless, continued laxity and instability have been reported in 10% of skeletally mature patients treated surgically and in 22% managed [5]. Moreover, positive anterior drawer and Lachman tests were commonly found in patients who were satisfied with the clinical result and had functional stability [7]. Two factors are likely responsible for the residual laxity and instability. Imperfect reduction may result in malunion and ACL lengthening, and plastic deformation of the ligament before ultimate avulsion fracture may also be responsible for ACL incompetence. The ACL does not have the ability to remodel. Despite the fact that skeletal growth has been shown to compensate for some laxity of the ACL in an animal model, this hypothetically protective mechanism has no effect in skeletally mature patients. Osti L. reported that 30% of their patients had a positive Lachman test and side to side difference greater than 3mm (4.5mm, 7mm, and 8.5mm) recorded with the KT-1000 manual maximum test. These patients had fair/poor clinical outcomes. Interestingly, a partial ACL tear (50% of fibers) was detected intraoperatively in these cases. Montgomery KD had 1 patient with instability (7%) and 3 patients (20%) with knee laxity (side to side difference 3mm) [6]. Koukoulias E. reported 1 case with a 3mm side to side difference; this occurred in the patient with the superiorly healed fracture [7].

In our study, no signs or symptoms of instability were detected. Objective measurement of knee laxity showed 1 case (2.8%) with a 6mm side to side difference: This occurred in the patient with the partial ACL tear (posterolateral bundle tear). Anterior translation of the tibia, measured with the KT-1000, was 1.69mm on average (range, 0 to 6mm) compared to the healthy side. Our results are in accordance with other authors who found normal laxity and stability in their series [1], [6], [7].

4.2. Assessment scale

In total, the final outcome was satisfactory, with 34 of 36 patients' knees being graded as normal or nearly normal and 2 patient's knee as abnormal because of a 20° flexion deficit in 1 case and 1 case with a Lachman positive (2+) (anterior translation of the tibia was 6mm side to side difference). IKDC grading was used only in 3 other studies with similar results [1], [7], [8].

Of the 36 subjects in this study, 34 (94.4%) had excellent or good, 2 remaining patients achieved fair outcomes. No patient had a poor outcome. Our Lysholm outcome had no diffirence compared with Koukoulias E (98 points with 92.1% excellent and good), Kuang S (93.4 points with 96.2% excellent and good) with the same technique [7], [9].

5. Conclusion

Our study had all fractures anatomically healed and 34/36 patient (94.4%) had excellent, good outcome so we found that indication to treat ACL avulsion fracture type II, III, IV by arthroscopic suture fixation was appropriate, this technique can restore ACL length, stabilize fragments, promote early motion, minimize morbidity and no need for hardware removal later.

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