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Case Series

Arthroscopic FiberWire Fixation for Anterior Cruciate Ligament Avulsion Fractures: A Case Series Report

Maziar Nafisi[1], Hossein Ahmadzadeh[1], Pouya Tabatabaei Irani[2], Mohammad Ayati Firoozabadi[3,*], Seyed Mohammad Javad Mortazavi[4]

[1] Knee Fellowship, Department of Orthopedic Surgery, Joint Reconstruction Research Center, Imam Khomeini Hospital Complex, Tehran University of Medical Sciences, Tehran, Iran
[2] Assistant Professor, Department of Orthopedic Surgery, Joint Reconstruction Research Center, Imam Khomeini Hospital Complex, Tehran University of Medical Sciences, Tehran, Iran
[3] Associate Professor, Department of Orthopedic Surgery, Joint Reconstruction Research Center, Imam Khomeini Hospital Complex, Tehran University of Medical Sciences, Tehran, Iran
[4] Professor, Department of Orthopedic Surgery, Joint Reconstruction Research Center, Imam Khomeini Hospital Complex, Tehran University of Medical Sciences, Tehran, Iran

[*]Corresponding author: Mohammad Ayati Firoozabadi; Joint Reconstruction Research Center, Tehran University of Medical Sciences, Tehran, Iran. Tel: +98-9123409462
Email: dr.mohammad.ayati@gmail.com

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Abstract

Arthroscopic fixation using FiberWire sutures with a suture disc is a reliable, cost-effective, and minimally-invasive technique for managing anterior cruciate ligament (ACL) avulsion fractures, also known as tibial spine fractures (TSFs), which are uncommon but significant knee injuries that can lead to joint instability if left untreated. This retrospective case series evaluated the clinical outcomes of this approach in six patients (four men, two women; mean age: 22 years) with fractures classified using the modified Meyers and McKeever system. All patients underwent arthroscopic fixation and were followed for 9 months with serial radiographic and clinical assessments. Fracture union was achieved in all cases within three months, and five patients demonstrated negative Lachman and pivot shift tests, while one exhibited grade 1 positivity. The mean International Knee Documentation Committee (IKDC) score was 91.16 ± 4.61, with five patients graded as excellent and one as good. No complications were observed, highlighting the efficacy and safety of this technique across different age groups.

Keywords: Anterior Cruciate Ligament Injuries; Tibial Spine Fractures; Arthroscopy; Suture Techniques; Knee

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Background

Anterior cruciate ligament (ACL) avulsion fracture, which is also called tibial spine fracture (TSF), was first described by Poncet in 1875 (1). The incidence is estimated at 3 per 100,000 persons per year and comprises 2-5 percent of knee injuries in adults and 14% of ACL injuries in pediatrics (2). However, the incidence is rising due to increased athletic activity of children such as skiing, soccer, and ever-increasing motor vehicle accidents (MVAs) in adults (3-5).

TSFs were initially classified according to Meyers and McKeever in 1959 into three types based on conventional radiography: type I, as simple non-displaced fragment, type II, as an avulsion with anterior lip elevation and posterior hinge attachment, and type III, as a complete displaced fragment without any hinge attachment (6). The classification was further modified by Zaricznyj in 1977 by adding type IV as a comminuted fragment (7). Subsequently, Green et al. proposed a complementary classification based on magnetic resonance imaging (MRI) for better interpretation of soft tissue entrapment which helps through decision-making on operative versus non-operative treatment (8).

The best treatment for TSFs is still a topic of debate. The displaced fragment could affect the mobility of the knee and may lead to joint instability; therefore, it is a good practice to consider surgical fixation when having displaced (> 2 mm) type 2 or any type 3 or 4 fractures according to the modified Meyers and McKeever classification (3, 9, 10).

Although numerous arthroscopic fixation techniques have been described for ACL avulsion fractures, there remains limited clinical evidence regarding the outcomes of FiberWire fixation using a suture-disc construct (10). Most available studies focus on technical descriptions, biomechanical investigations, or comparisons between screw and suture fixation, while clinical outcome data for this specific low-cost technique remain scarce (3, 11). Therefore, the purpose of this study was to evaluate the radiographic healing, knee stability, range of motion (ROM), and functional outcomes of patients treated with arthroscopic FiberWire fixation using a suture disc.

Surgical Technique

This is a case series report of 6 patients. The study was conducted after receiving approval from our institution's ethical committee at Joint Reconstruction Research Center, Tehran University of Medical Sciences, Iran. Informed consent was taken from all the participants.

Inclusion and Exclusion Criteria

Patients were eligible for inclusion if they had a displaced ACL tibial avulsion fracture (modified Meyers and McKeever type III or IV), underwent arthroscopic fixation using the described FiberWire and suture-disc technique, and completed a minimum follow-up of 9 months.

Patients were excluded if they had associated meniscal, chondral, or ligamentous injuries requiring additional surgical procedures, previous surgery on the affected knee, pathological fractures, chronic neglected injuries, or incomplete clinical and radiographic follow-up data.

There were 4 men and 2 women. The mean age of patients was 22 years old (range: 15-35). The mechanism of injury was MVA in 5 patients and knee twisting injury in sport activities in one. According to modified Meyers and McKeever classification, 4 patients had type 3 and 2 had type 4 TSFs. Four injuries were in the left knee and two in the right knee.

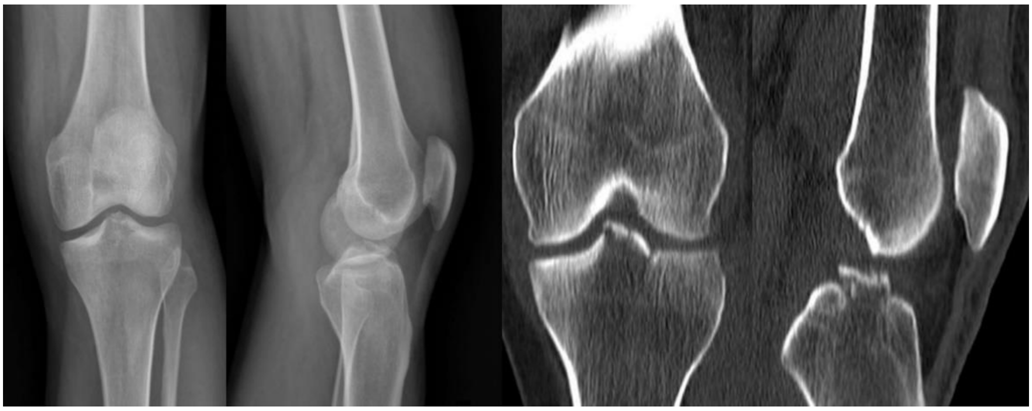

Figure 1. Pre-operative radiography and computed tomography (CT) scan showing a type IV tibial spine fracture (TSF)

All surgeries were done in 2 weeks after injury (ranged from 4 to 14 days) and by 2 senior surgeons with the same surgical technique (Figure 1).

We have previously represented our arthroscopic technique for fixation of ACL avulsion fracture by using FiberWire suture and suture disc (3). After spinal anesthesia, the patient was placed in supine position. After administration of 2 g cefazolin and 1 g tranexamic acid, an anteromedial working portal and an anterolateral visual portal were applied. Diagnostic arthroscopy was used in order to rule out any accompanying knee lesion.

Any hematoma at the fracture site was evacuated and interposed tissues obstructing the fragment reduction (i.e., intermeniscal ligament) were removed. The crater of the fracture fragment was debrided by arthroscopic shaver and was made ready for reduction. A cannula was inserted at the anteromedial portal. Two separated FiberWire sutures (Arthrex, Naples, FL) were selected. By means of Lasso (Arthrex) with wire loop, sutures were passed through the ACL around the fracture site (one through the lateral half and the other through the medial half of the ligament). Using the arthroscopic sliding knot, a FiberWire suture was tied over each border (lateral/medial) of the ACL. A longitudinal incision was made on the anteromedial side of tibia 4 cm below the joint line. Two 2.7 mm tibial tunnels were made by 2 Kirschner wires (K-wires) inserted through an ACL guide (ACUFEX ACL tibial guide, Smith and Nephew, Andover, MA) from the anteromedial side of the tibia to the tibial plateau (their proximal endings aimed at the lateral and medial side of the fractured fragment). The distal points of the tunnels were tuned to be 1 cm apart from each other, and then the pins were removed. A suture retriever was applied to pull out the 2 ends of the lateral suture through the lateral tunnel and the medial suture through the medial tibial tunnel. Following reduction of the fragment with a probe, the two FiberWires were tied together over a suture disc while the knee was flexed 20°. Finally, fixation stability was checked during the knee ROM, the joint was irrigated, and the surgical wounds were closed (Figure 2).

Postoperatively, the knee was immobilized by a hinged knee brace locked in full extension. Partial weight-bearing and knee ROM was started after 2 weeks with active knee flexion and passive extension, and was gradually increased to 120° of flexion within 6-8 weeks. The brace was discontinued at this point, and the patients started to bear full weight.

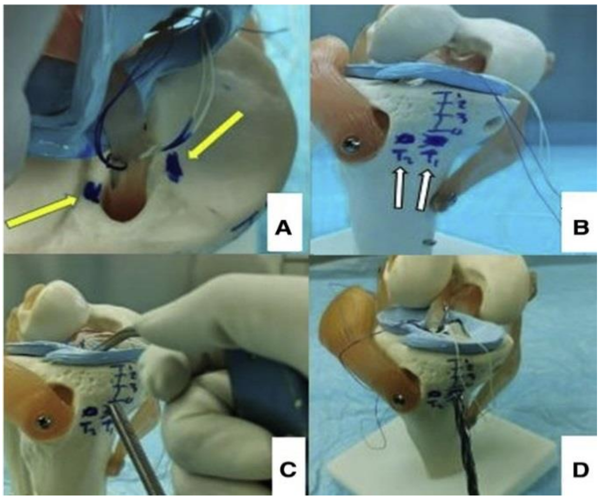

Figure 2. As represented in the model, 2 tunnels are drilled in anteromedial side of tibia aimed at the medial and lateral sides of tibial spine fragment (yellow arrows) (A), and their distal ends are 4 cm below the joint line and at least 1 cm apart just medial to the tibial tubercle (white arrows) (B), The anterior cruciate ligament (ACL) guide is used for passage of K-wires (C), and 2.7 mm tunnels are made at the desired point (D); (Adapted from our original technique paper).

All the patients were followed up at 2, 6, 12, 24, and 36 weeks after surgery. To assess the fracture healing, X-rays of the affected knee were done, one at six weeks and the other 3 months postoperatively. A comprehensive clinical examination was performed at 9 months after surgery assessing ACL laxity by pivot shift test grading and Lachman test (Table 1).

Table 1. Lachman test graded according to the difference in tibial translation in comparison to the contralateral side

Lachman translation grade	Difference to contralateral side
+1	< 5 mm
+2	5-10 mm
+3	> 10 mm

Knee function was assessed with the help of subjective International Knee Documentation Committee (IKDC) score (Table 2).

Table 2. International Knee Documentation Committee (IKDC) score

IKDC score	Functional definition
< 70	Poor
70-79	Fair
80-89	Good
≥ 90	Excellent

IKDC: International Knee Documentation Committee

Figure 3. Final X-ray at 3 months postoperatively demonstrating complete fracture healing

Active knee ROM was also evaluated with a goniometer. At each follow-up visit, any complications were assessed and recorded (Figure 3).

All 6 patients were followed for 9 months. No patient was lost during follow-up. There were no concomitant meniscal, chondral, or other ligamentous injury. Radiographs showed that the fractures were united within 3 months after surgery in all patients (Table 3).

Before surgery, under spinal anesthesia, 4 patients had a grade 1 and 2 patients had grade 2 positive pivot shift test. At the final follow-up, pivot shift test was negative in 5 patients, and grade 1 was positive in 1 patient.

Preoperatively, 4 patients had grade 2 positive Lachman test (between 5 to 10 mm anterior translation differences in comparison to contralateral knee), and 2 patients had grade 1 positive Lachman test (less than 5 mm anterior translation difference in comparison to contralateral knee). After surgery, at the last follow-up visit, Lachman test was negative in all patients except for 1. In this patient, Lachman test was grade 1 positive.

All patients had normal knee without any functional limitation before surgery. At 9 months after operation, subjective IKDC score [mean ± standard deviation (SD)] was 91.16 ± 4.61.

Five patients were graded as excellent (IKDC ≥90) and 1 patient as good (IKDC: 80-89).

The ROM was full in all patients except for 1. In this patient, there was 10° loss of terminal flexion in comparison to normal side.

There were no superficial or deep infections, wound problems, or other complications.

Discussion

There are many surgical techniques for treatment of ACL avulsion fractures. In 1982, McLennan stated that arthroscopic fixation was a viable option with less soft tissue damage compared with the conventional open surgeries (12).

Moreover, concomitant injuries to the meniscus or chondral lesions can be managed simultaneously. However, the ACL insertion site on the tibia is relatively small (18 × 19 mm); therefore, adequate reduction and fixation of the avulsed fragment through arthroscopic portals is technically demanding (13). Besides, there are many fixation devices to be used in arthroscopic surgery like screw, K-wire, high-strength suture (e.g., FiberWire, Arthrex), and anchor suture.

The theoretical advantage of a screw is its ability to provide the strongest purchase for fracture fixation, but we should consider that the proximal tibial bone is cancellous, and the strength of fixation may not be as rigid as expected. Screw may impinge the femur in extension and causes extension lag; therefore, a second operation would be inevitable to remove the screw after fracture healing. Additionally, an inserted screw may tear the ACL or create smaller bony fragments. Another disadvantage is that it is difficult to use screws in small or comminuted avulsed fragments.

K-wire can be used in avulsions with smaller fragments. Besides, it is safer in children and adolescents and is associated with less injury to the proximal tibial physis. In contrast, the rigidity of its fixation is limited; thus, the surgeon should immobilize the knee longer postoperatively, and this is associated with increased risk of ROM limitation and extension lag.

High-strength sutures and anchor sutures can be used as a fixation device for ACL avulsion fracture independent of the fragment size or the patient's age (11). They can be used for type 4 avulsion fractures. Moreover, there is no need for future device removal. Anchor sutures are expensive; therefore, especially in developing countries, FiberWire suture is a reasonable option.

In a retrospective study, Seon et al. compared clinical outcomes of 16 patients treated with screw fixation with 17 cases treated with suture fixation (14).

Table 3. Final assessment of patients' functional outcomes using subjective and objective criteria

Patient no.	Age (year)	Mechanism of injury	Side	ACL avulsion type	Subjective knee instability	Knee ROM	ADT	Pivot shift	Lachman	IKDC score
1	20	MVA	Left	IV	Negative	Full	Negative	+	+1	86.5
2	35	MVA	Right	III	Negative	Full	Negative	-	Negative	91.2
3	15	MVA	Left	III	Negative	Full	Negative	-	Negative	92.7
4	30	Twisting injury in sport	Right	III	Negative	0-125	Negative	-	Negative	90.7
5	16	MVA	Left	IV	Negative	Full	Negative	-	Negative	92.5
6	17	MVA	Left	III	Negative	Full	Negative	-	Negative	93.4

MVA: Motor vehicle accident; ACL: Anterior cruciate ligament; ROM: Range of motion; ADT: Anterior drawer test; IKDC: International Knee Documentation Committee

No clinically significant difference was noted in extension lag, Lysholm Knee Score, or anterior instability between 2 methods. On the other hand, in a biomechanical study, Bong et al. compared cannulated screw fixation with FiberWire fixation (15). They concluded that FiberWire fixation provided more ultimate strength than screws and was superior biomechanically. Their findings were similar to a systematic review by Bogunovic et al. who demonstrated that there was statistically significant greater anterior knee laxity following screw fixation compared with suture fixation (16). However, the percentage of patients needing further ACL reconstruction and cases who returned to sport was not significantly different between two methods (16).

The most common complications of arthroscopic ACL avulsion fixation are decreased ROM, remained anterior knee instability, and fracture nonunion. Removing any loose bodies is important to decrease the risk of knee motion limitation. Early aggressive rehabilitation further improves the post-operative knee motion (17). Irrigation and debridement of the fragment bed are essential for adequate reduction and preventing fracture nonunion. It is not recommended that the crater be deepened to allow the fragment to be sunk into it (18). Overreduction of the fragment causes excessive tension in ACL and may cause extension limitation.

This study has some limitations. First, the sample size was small, reflecting the relative rarity of ACL avulsion fractures. Second, the retrospective case-series design and absence of a comparison group limit the ability to draw definitive conclusions regarding superiority over other fixation methods.

Third, the follow-up duration was limited to 9 months and may not fully capture long-term functional outcomes or late complications.

Future prospective multicenter studies with larger patient cohorts, longer follow-up periods, and direct comparison with screw and other suture-based fixation techniques are warranted to further validate the effectiveness and durability of this technique.

Conclusion

ACL avulsion fractures can be treated with arthroscopic suture fixation and suture disc with good clinical outcomes. It is an inexpensive method with no need for future device removal, and can be used for all types of ACL avulsion fractures in all age groups.

Conflict of Interest

The authors declare no conflict of interest in this study.

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