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Original Article

Arthroscopic Dual-Tunnel Fixation of Anterior Cruciate Ligament Tibial Avulsion Fractures Using a Luggage-Tag FiberWire Configuration

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ABSTRACT

Background: Anterior cruciate ligament (ACL) tibial avulsion fractures represent detachment of the ligament from its tibial insertion rather than midsubstance rupture. Although more frequently reported in pediatric populations, displaced injuries are increasingly encountered in adults following high-energy trauma and sports activities[1]. Stable fixation is required to restore ACL tension and prevent residual knee instability.

Purpose: To evaluate radiological union and functional outcomes following arthroscopic fixation of displaced ACL tibial avulsion fractures using a luggage-tag FiberWire configuration with a dual-tunnel technique.

Methods: Ten adult patients with Meyers and McKeever Type II–IV tibial avulsion fractures underwent arthroscopic fixation using high-strength FiberWire sutures in a luggage-tag configuration. Two tibial tunnels were created maintaining a 1-cm cortical bone bridge. Sutures were secured over a tibial suture disc. Functional outcomes were assessed using Lysholm and IKDC subjective knee scores preoperatively and at minimum 12-month follow-up.

Results: All fractures achieved radiographic union within 12 weeks. Mean Lysholm score improved from 48.5 ± 6.5 preoperatively to 92.5 ± 4.5 at final follow-up. Mean IKDC score improved from 44.2 ± 7.5 to 89.0 ± 5.2. No revision surgery or persistent instability was observed.

Conclusion: Arthroscopic luggage-tag FiberWire fixation with a dual-tunnel technique provides reliable fracture union and excellent functional outcomes in ACL tibial avulsion fractures.

Keywords*: ACL tibial avulsion, arthroscopic fixation, FiberWire, luggage-tag suture, dual-tunnel technique.*

INTRODUCTION

Anterior cruciate ligament tibial avulsion fractures involve separation of the ACL from its tibial insertion while the ligament substance remains intact[1]. These injuries are relatively uncommon but are increasingly recognized following sports injuries, road-traffic accidents, and high-energy trauma[2].

The modified Meyers and McKeever classification categorizes these injuries based on the degree of displacement and comminution[1,3]. Type I injuries are minimally displaced and are typically treated conservatively. However, displaced fractures (Types II–IV) usually require surgical fixation to restore normal ACL tension and prevent residual anterior instability[4].

Historically, open reduction and internal fixation were used to treat these injuries. With advances in arthroscopic techniques, minimally invasive fixation methods have largely replaced open surgery due to better visualization of intra-articular structures, reduced soft-tissue trauma, and faster rehabilitation[5].

Several fixation techniques have been described including cannulated screw fixation, suture anchors, and transosseous suture techniques[6,7]. While screw fixation provides rigid compression, it may not be suitable in comminuted fragments and sometimes requires hardware removal[6]. High-strength suture constructs using modern materials such as FiberWire have demonstrated biomechanical strength comparable to screw fixation while avoiding hardware complications[8].

The present study evaluates the outcomes of arthroscopic fixation using a luggage-tag FiberWire configuration with dual tibial tunnels and suture disc fixation in adult patients with displaced ACL tibial avulsion fractures.

MATERIALS AND METHODS

Study Design: A prospective case series was conducted at a tertiary orthopaedic center between November 2024 and December 2025. Institutional approval was obtained prior to commencement of the study.

Sr No.	Parameter	Value
1	Total patients	10
2	Mean age	23
3	Gender: Male/Female	8/2
4	Side: Left/right	4/6

Patient Demographics:

Inclusion Criteria:

- Meyers and McKeever Type II–IV fractures
- Surgery performed within 3 weeks of injury

Exclusion Criteria:

- Multiligament knee injury
- Associated tibial plateau fracture
- Previous knee surgery
- Chronic avulsion fractures (>6 weeks)

Fracture Distribution

Fracture Type	Number of patients
Type 2	3
Type 3	5
Type 4	2

Surgical Technique:

Patient Positioning and Anesthesia: The procedure is performed under spinal or general anesthesia. A high-thigh pneumatic tourniquet is applied but inflated only after limb exsanguination.

The patient is placed supine on a radiolucent operating table with the operative leg in hanging leg position or secured in a leg holder allowing approximately 90° of knee flexion. The contralateral limb is positioned in an abduction stirrup.
The entire lower limb is prepared and draped in a sterile manner from mid-thigh to foot.

Portal Placement: Standard arthroscopic portals are established:
Anterolateral portal: Used as the primary viewing portal and placed just lateral to the patellar tendon at the level of the inferior pole of the patella.

Anteromedial portal: Created under direct visualization using a spinal needle to ensure appropriate trajectory toward the tibial eminence.

A Passport cannula is introduced through the anteromedial portal to facilitate suture management and prevent soft-tissue bridging.

Diagnostic Arthroscopy and Fracture Bed Preparation
1. Evacuate hemarthrosis
2. Evaluate ACL integrity
3. Assess menisci and articular cartilage
4. Identify interposed soft tissue

Soft-tissue structures such as the intermeniscal ligament or fibrous debris that prevent fragment reduction are removed using a shaver or radiofrequency probe.The fracture crater is gently debrided to expose fresh cancellous bone while preserving the size and morphology of the avulsed fragment.

Luggage-Tag FiberWire Configuration: High-strength nonabsorbable FiberWire suture is used.
First Stitch: A suture passer is introduced through the Passport cannula and passed through the ACL substance 5–7 mm proximal to the tibial insertion.
The free suture end is then passed through its own loop to create a self-cinching luggage-tag configuration.

This construct provides:
- ✓ Circumferential ligament capture
- ✓ Even load distribution
- ✓ Reduced risk of suture cut-through

Second Stitch: A second luggage-tag stitch is placed posteriorly within the ACL substance.

This step provides:
- ✓ Rotational stability
- ✓ Balanced force distribution
- ✓ Secure capture of both ACL bundles

Tibial Tunnel Preparation: An ACL tibial guide is introduced through the anteromedial portal and positioned at the medial margin of the fracture bed.

First Tunnel: A 2.7-mm guide pin is drilled from the anteromedial tibial cortex exiting at the medial aspect of the fracture crater.

Second Tunnel: The guide is repositioned laterally and a second tunnel is drilled while maintaining a 1-cm bone bridge between tunnels.

Preserving the bone bridge is essential to:
- ✓ Maintain cortical strength
- ✓ Prevent tibial fracture
- ✓ Provide a stable base for suture fixation

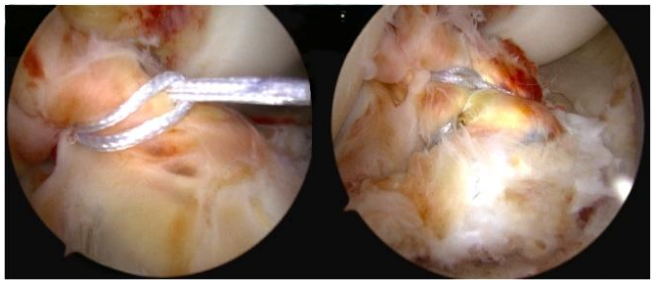
Suture Retrieval: Each luggage-tag suture limb is retrieved through its corresponding tibial tunnel using a suture retriever.
Care is taken to maintain medial-lateral orientation and prevent crossing of sutures.

Fragment Reduction: The avulsed fragment is reduced under arthroscopic visualization using a probe. Traction is applied to both sutures simultaneously.
Anatomic reduction is confirmed by:
- ✓ Restoration of tibial eminence contour
- ✓ Flush seating of the fragment
- ✓ Absence of step-off

Final Fixation With Suture Disc: With the knee maintained at approximately 20° flexion, sutures are tensioned sequentially.
A tibial suture disc is placed over the cortical entry site and sutures are tied securely using alternating half-hitches.
The suture disc:
- ✓ Distributes compressive forces
- ✓ Prevents cortical cut-through
- ✓ Enhances fixation durability

Intraoperative Stability Assessment following fixation:
- Knee is taken through full range of motion
- Lachman test is performed
- Impingement is checked in extension

Intra-op image:



Postoperative Rehabilitation:

- Hinged knee brace in extension for 2 weeks
- Passive ROM started on postoperative day 3 (0–90°)
- Partial weight bearing at 2 weeks
- Full weight bearing at 6 weeks
- Progressive strengthening after 8 weeks
- Early mobilization reduces the risk of arthrofibrosis[9].

Outcome Measures

Functional outcomes were assessed using Lysholm Knee Score[10] and IKDC Subjective Knee Score[11]. Clinical stability was evaluated using Lachman and anterior drawer tests.

RESULTS

Radiological Outcomes: All fractures demonstrated complete radiographic union within 12 weeks.

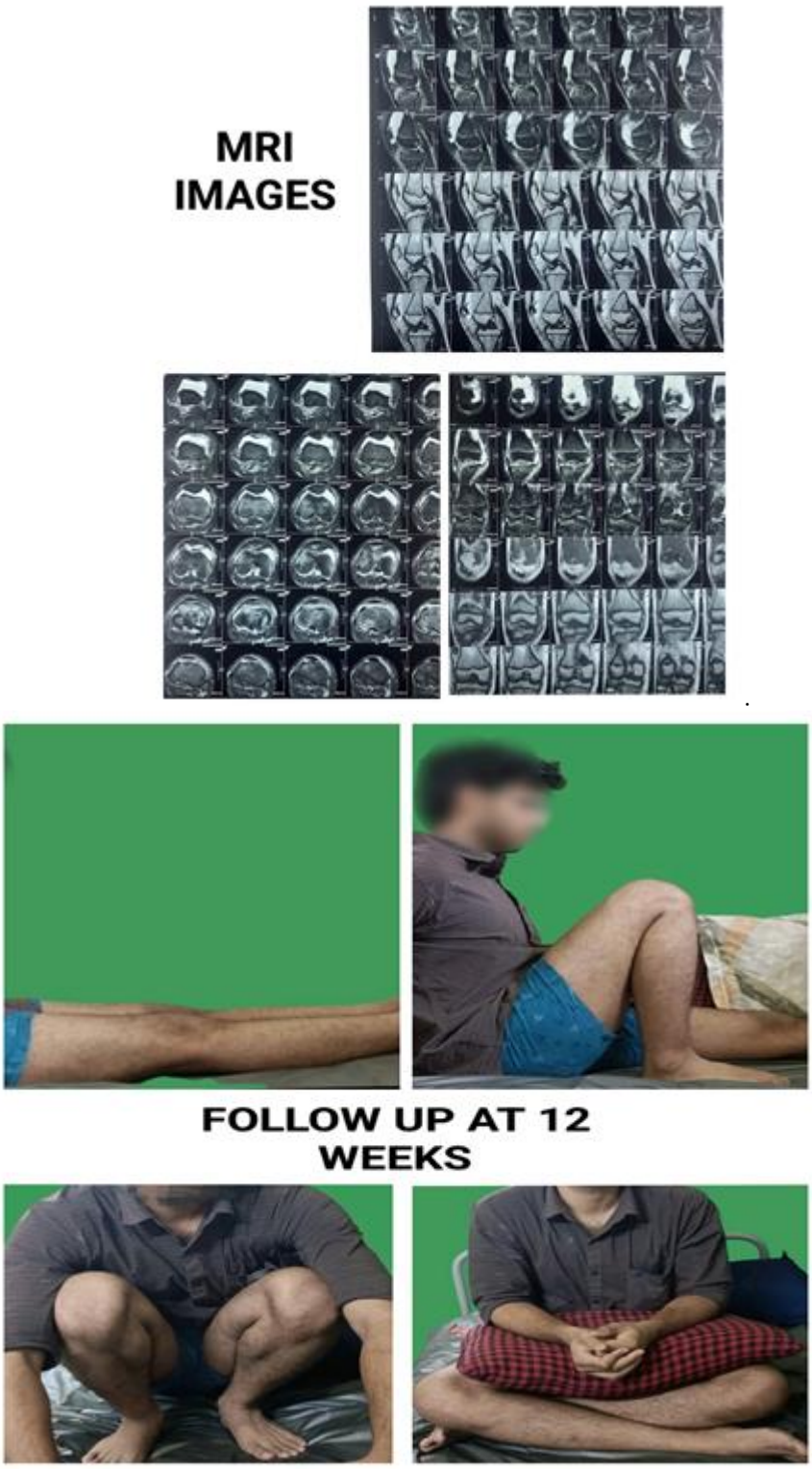
Functional Outcomes:

Score	Preoperative value	Final Follow-up value
Lysholm score	48.5 ± 6.5	92.5 ± 4.5
IKDC score	44.2 ± 7.5	89.0 ± 5.2

Eight patients achieved excellent Lysholm scores (>90), while two achieved good outcomes.

Complications

1 transient extension lag (resolved with physiotherapy). No persistent anterior laxity. No hardware irritation. No revision surgery required.



DISCUSSION

Stable fixation of ACL tibial avulsion fractures is essential to restore ligament tension and prevent persistent knee instability[4]. Arthroscopic management offers significant advantages over open surgery including improved visualization, reduced morbidity, and faster recovery[5].

While screw fixation provides rigid compression, it may not be suitable for comminuted fragments and may require hardware removal[6]. Biomechanical studies have demonstrated that high-strength suture fixation provides stability comparable to screw fixation[8].

Dual-tunnel constructs improve rotational control compared with single-tunnel techniques[12]. Additionally, the luggage-tag configuration provides circumferential ligament capture and improved force distribution.

The significant improvement observed in Lysholm and IKDC scores in this study supports the clinical effectiveness of this technique.

CONCLUSION

Arthroscopic fixation of ACL tibial avulsion fractures using a dual-tunnel luggage-tag FiberWire technique with suture disc fixation provides reliable fracture union and excellent functional outcomes.

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