e-ISSN: 0975-9506, p-ISSN: 2961-6093

Available online on www.ijpqa.com doi: 10.25258/ijpqa.16.2.27

International Journal of Pharmaceutical Quality Assurance 2025; 16(2); 191-196

Original Research Article

Functional Outcomes Following Arthroscopic Suture Pull-Out Fixation for Displaced Tibial Spine Avulsion Fractures: A Single-Centre Prospective Study

Manish Raj[1], Raveendra Kumar[2], Avinash Kumar[3]

[1]Senior Resident, Department of Orthopaedics, All India Institute of Medical Sciences, Patna, Bihar, India

[2]Senior Resident, Department of Orthopaedics, All India Institute of Medical Sciences, Patna, Bihar, India

[3]Associate Professor, Department of Orthopaedics, All India Institute of Medical Sciences, Patna, Bihar, India

Received: 10-12-2024 / Revised: 15-01-2025 / Accepted: 25-02-2025

Corresponding Author: Dr. Raveendra Kumar

Conflict of interest: Nil

Abstract:

Background: Tibial spine avulsion fractures, though uncommon, are functionally significant injuries that disrupt anterior cruciate ligament (ACL) continuity and knee joint stability. These fractures occur more frequently in adolescents and young adults and are often the result of high-energy trauma or sports-related injuries. Arthroscopic fixation techniques have emerged as the preferred modality due to their minimally invasive nature and ability to achieve stable reduction.

Objective: To evaluate the functional outcome of patients undergoing arthroscopic suture pull-out fixation for displaced tibial spine avulsion fractures at a tertiary care center using standardized clinical scoring systems.

Methods: This prospective study was conducted at All India Institute of Medical Sciences (AIIMS), Patna, Bihar. Patients with displaced tibial spine avulsion fractures (Meyers and McKeever type II–IV) treated with arthroscopic suture pull-out fixation using non-absorbable sutures were included. Clinical and functional outcomes were assessed using the Lysholm Knee Score and IKDC (International Knee Documentation Committee) Score at regular follow-up intervals over a period of six months.

Results: A total of 25 patients were enrolled. The majority were adolescents with a mean age of 16.4 years. All patients achieved satisfactory fracture union with restoration of knee stability. At the final follow-up, the mean Lysholm Score was 91.6, and the mean IKDC Score was 87.8. No case of fixation failure, infection, or arthrofibrosis was reported. Most patients resumed pre-injury activity levels within 3 to 4 months.

Conclusion: Arthroscopic suture pull-out fixation is a safe, effective, and functionally rewarding technique for displaced tibial spine avulsion fractures. It facilitates early rehabilitation, excellent joint stability, and high patient satisfaction with minimal complications.

Keywords: Tibial spine fracture; arthroscopic fixation; suture pull-out technique; knee instability; ACL avulsion; Lysholm score; IKDC score; adolescent knee trauma; minimally invasive surgery; functional outcome.

Introduction

Tibial spine avulsion fractures represent a unique subset of intra-articular injuries, characterized by the avulsion of the bony attachment of the anterior cruciate ligament (ACL) from its tibial insertion. Though traditionally considered an injury of the pediatric and adolescent population due to the relative weakness of the apophyseal region, recent evidence shows increasing incidence among young adults engaged in athletic or high-energy activities. These injuries mimic ACL tears in terms of biomechanical instability and are classified as ligamentous equivalent injuries requiring prompt diagnosis and appropriate intervention [1,2].

The Meyers and McKeever classification remains the most widely used system for grading these injuries, ranging from non-displaced type I fractures to completely displaced and rotated type IV injuries. While type I injuries are typically managed conservatively with immobilization, displaced injuries (type II–IV) frequently require surgical fixation to restore knee stability, prevent chronic instability, and reduce the risk of arthrofibrosis and degenerative changes [3].

Open reduction and internal fixation were historically the mainstay of treatment for displaced tibial spine avulsions. However, the evolution of

arthroscopic techniques has significantly transformed the management landscape [4]. Arthroscopic reduction and fixation offer the advantage of superior visualization, accurate anatomical reduction, minimal soft tissue trauma, and early postoperative mobilization. Among the various fixation techniques, the suture pull-out method using non-absorbable sutures has gained popularity for its versatility, cost-effectiveness, and biomechanical stability [5].

Suture pull-out techniques avoid the complications associated with hardware such as screw breakage, implant impingement, or the need for secondary implant removal. Moreover, they allow multiple points of fixation and are suitable even in small or comminuted fragments. These advantages make arthroscopic suture fixation especially attractive in the adolescent and young adult age group, where preservation of growth plates and joint function is critical [6,7].

Despite its increasing adoption, data on functional outcomes following arthroscopic suture fixation of displaced tibial spine avulsion fractures remain limited, especially in the Indian population. Most existing literature is derived from small case series or retrospective studies with variable follow-up and inconsistent outcome reporting. Standardized functional scores such as the Lysholm Knee Score and IKDC Subjective Score are essential tools for objectively evaluating postoperative recovery and long-term knee function [8].

This prospective study was conducted at All India Institute of Medical Sciences (AIIMS), Patna, with the primary objective of evaluating the functional outcome of arthroscopic suture pull-out fixation in patients with displaced tibial spine avulsion fractures. The study aims to provide evidence-based support for the technique by documenting recovery in terms of pain, stability, range of motion, and return to activity using validated clinical scores.

Materials and Methods

This prospective observational study was conducted in the Department of Orthopaedics at All India Institute of Medical Sciences (AIIMS), Patna, Bihar, India for 11 months. The study included patients presenting with displaced tibial spine avulsion fractures who underwent arthroscopic suture pull-out fixation. The aim was to assess clinical and functional outcomes over a defined follow-up period using standard scoring systems.

Inclusion criteria were patients with radiologically confirmed tibial spine avulsion fractures classified as Meyers and McKeever type II, III, or IV; age between 10 and 40 years; and presentation within three weeks of injury. Patients with associated multi-ligamentous injuries, open fractures, previous knee surgery, or any pre-existing neuromuscular disorder affecting gait or joint mobility were excluded.

All patients underwent a detailed clinical evaluation including mechanism of injury, time since trauma, swelling, hemarthrosis, and knee instability tests such as Lachman and anterior drawer test. Radiographic imaging (anteroposterior and lateral X-rays of the knee) was used to identify fracture type and displacement. Magnetic resonance imaging (MRI) was done in all cases to assess associated soft tissue injuries and confirm the integrity of the ACL and menisci.

Arthroscopic fixation was performed under spinal or general anesthesia with the patient in supine position and tourniquet applied. Standard anterolateral and anteromedial portals were used. After joint lavage and hematoma evacuation, the avulsed fragment was identified, debrided, and reduced using probe manipulation. A tibial tunnel was created using an ACL tibial guide, and non-absorbable No. 2 Fiber Wire sutures were passed through the ACL base and retrieved through the tunnel using a shuttle technique. The sutures were then tied over an anterior tibial bony bridge or secured with a suture disc. Anatomical reduction was confirmed arthroscopically and on fluoroscopy. Postoperative rehabilitation included early quadriceps exercises, non-weight-bearing mobilization for 2–3 weeks, followed by gradual weight-bearing and return to full activity over 12 weeks.

Clinical outcomes were assessed using the Lysholm Knee Score and the International Knee Documentation Committee (IKDC) Subjective Knee Evaluation Score at 6 weeks, 3 months, and 6 months postoperatively. Stability tests were repeated at each follow-up visit. Complications such as infection, fixation failure, hardware irritation, or arthrofibrosis were also noted.

All data were compiled and analyzed using standard statistical software. Continuous variables were expressed as mean ± standard deviation and categorical variables as percentages. Pre- and postoperative functional scores were compared using paired t-test or Wilcoxon signed-rank test based on data distribution. A p-value less than 0.05 was considered statistically significant.

Results

A total of 25 patients with displaced tibial spine avulsion fractures underwent arthroscopic suture pull-out fixation and were followed up for six months. The majority of patients were adolescents and young adults, with a male predominance. All fractures were classified as Meyers and McKeever type II, III, or IV. Functional outcomes were evaluated using Lysholm and IKDC scoring systems. Range of motion, knee stability, time to

return to activities, and postoperative complications were also recorded.

Table 1: Age Distribution of Patients (N = 25)

Age Group (years)	Number of Patients (n)	Percentage (%)
10–15	7	28.0
16–20	9	36.0
21–25	5	20.0
26–30	3	12.0
>30	1	4.0
Total	**25**	**100.0**

Table 2: Gender Distribution (N = 25)

Gender	Number of Patients (n)	Percentage (%)
Male	18	72.0
Female	7	28.0
Total	**25**	**100.0**

Table 3: Classification of Tibial Spine Fractures (N = 25)

Fracture Type	Number of Patients (n)	Percentage (%)
Type II	7	28.0
Type III	14	56.0
Type IV	4	16.0
Total	**25**	**100.0**

Table 4: Mechanism of Injury (N = 25)

Mechanism of Injury	Number of Patients (n)	Percentage (%)
Sports injury	13	52.0
Road traffic accident	8	32.0
Fall at home	4	16.0
Total	**25**	**100.0**

Table 5: Lysholm Knee Score Over Follow-up

Follow-up Interval	Mean Score	Standard Deviation	p-value (vs baseline)
6 weeks	71.4	6.2	<0.001
3 months	84.8	5.3	<0.001
6 months	91.6	4.7	<0.001

Table 6: IKDC Subjective Score Over Follow-up

Follow-up Interval	Mean Score	Standard Deviation	p-value (vs baseline)
6 weeks	66.3	6.5	<0.001
3 months	79.2	5.7	<0.001
6 months	87.8	4.9	<0.001

Table 7: Time to Return to Pre-injury Activity (N = 25)

Return Time (months)	Number of Patients (n)	Percentage (%)
<3	4	16.0
3–4	15	60.0
5–6	6	24.0
Total	**25**	**100.0**

Table 8: Range of Motion at 6 Months (N = 25)

ROM Category	Number of Patients (n)	Percentage (%)
Full (0°–135° or more)	23	92.0
Mild restriction (up to 110°)	2	8.0
Moderate/severe restriction	0	0.0

Table 9: Anterior Stability Assessment at 6 Months (Lachman Test)

Stability Outcome	Number of Patients (n)	Percentage (%)
Grade 0 (Normal)	21	84.0
Grade I (Mild)	4	16.0
Grade II or higher	0	0.0

Table 10: Postoperative Complications (N = 25)

Complication	Number of Patients (n)	Percentage (%)
Superficial infection	1	4.0
Arthrofibrosis	0	0.0
Suture failure	0	0.0
Hardware-related issues	0	0.0
None	24	96.0

Discussion

Tibial spine avulsion fractures, although relatively rare, have significant clinical implications due to their functional equivalence to anterior cruciate ligament (ACL) injuries. These fractures are most commonly encountered in adolescents and young adults following sports-related trauma or high-velocity falls **[9]**. If left untreated or inadequately managed, they may lead to persistent knee instability, reduced athletic performance, or early degenerative changes. This prospective study evaluated the clinical and functional outcomes of arthroscopic suture pull-out fixation in displaced tibial spine avulsion fractures using standardized scoring systems and follow-up assessments [10].

In the present series, the majority of patients were in the second decade of life, with a mean age of 16.4 years, reflecting the typical epidemiology of this injury pattern. Male predominance (72%) is in agreement with existing literature, often attributed to higher participation in contact sports and outdoor physical activities among male adolescents [11].

Fracture classification revealed type III injuries to be most common (56%), followed by type II and type IV. This pattern underscores the need for prompt surgical management in a majority of cases, as non-operative treatment may lead to non-union or residual laxity in displaced fractures. All patients in this study underwent arthroscopic suture pull-out fixation using non-absorbable sutures—a technique that offers strong fixation without the complications of metallic hardware or the need for secondary implant removal [12].

Functional outcome evaluation demonstrated progressive and statistically significant improvement in both Lysholm and IKDC scores across all follow-up intervals. At six months, the mean Lysholm score was 91.6 and IKDC score was 87.8, indicating excellent functional recovery and patient satisfaction. These results are comparable with prior studies by Seon et al. and Ahn et al., who reported similarly favourable outcomes using suture-based fixation methods [13].

Early rehabilitation played a vital role in restoring range of motion and muscle strength. More than 90% of patients achieved full flexion and extension by six months. Only two patients showed mild flexion restriction (up to 110°), and no cases of significant arthrofibrosis or loss of motion were observed. The structured rehabilitation protocol, combined with stable fixation, likely contributed to this outcome [14].

Anterior knee stability, as assessed by the Lachman test, was found to be normal in 84% of patients and minimally lax in the remaining cases. None demonstrated clinical signs of graft insufficiency or instability severe enough to warrant revision. These results confirm the biomechanical efficacy of the suture pull-out technique in maintaining ACL continuity and restoring functional stability of the joint [15].

Return to pre-injury activity levels was achieved in 76% of patients within four months, reaffirming the benefit of early mobilization made possible by arthroscopic fixation. No patients reported re-injury or reinjury anxiety, indicating both objective and subjective satisfaction with the surgical outcome.

Complication rates were minimal. One patient developed a superficial wound infection, which resolved with oral antibiotics. No case of suture breakage, implant irritation, deep infection, or hardware-related issue was noted. These findings support the safety of the technique and its feasibility in both adolescent and young adult populations [16].

A key advantage of the arthroscopic approach lies in its minimal invasiveness, better joint visualization, reduced soft tissue disruption, and the ability to simultaneously address associated intra-articular injuries. Although some studies have raised concerns about the technical demands and learning curve, this was not a limitation in the present study as all procedures were performed by experienced arthroscopic surgeons.

Limitations of this study include a relatively small sample size and follow-up restricted to six months. Long-term follow-up is essential to assess the risk of

residual laxity, growth disturbances in skeletally immature patients, and post-traumatic arthritis. Additionally, objective measures such as KT-1000 arthrometer testing or MRI-based healing assessments were not employed.

Nonetheless, this study adds valuable prospective evidence to support the role of arthroscopic suture pull-out fixation in managing displaced tibial spine avulsion fractures. The favourable outcomes and low complication rates observed suggest that this technique should be considered the standard of care in appropriately selected cases.

Conclusion

Arthroscopic suture pull-out fixation is a safe, reliable, and effective method for managing displaced tibial spine avulsion fractures, particularly in adolescents and young adults. It offers excellent functional outcomes with high union rates, minimal complications, and early return to activity. The technique facilitates anatomical reduction, restores knee stability, and supports rapid postoperative rehabilitation. Given its minimally invasive nature and favourable results, arthroscopic suture fixation should be considered a preferred surgical option in displaced ACL avulsion injuries.

References

1. Pandey V, Cps S, Acharya K, Rao SK. Arthroscopic Suture Pull-Out Fixation of Displaced Tibial Spine Avulsion Fracture. J Knee Surg. 2017 Jan;30(1):28-35. doi: 10.1055/s-0036-1579682. Epub 2016 Mar 10. PMID: 26963070.
2. Ramakanth R, Silvampatti Ramasamy S, Muhammed S, D Souza T, Arumugam P, Rajasekaran S. Augmented suture pull-out with suture-button (triple fixation) yields less radiological residual laxity than suture pull-out technique-for Arthroscopic reduction and internal fixation of posterior cruciate ligament avulsion fractures. J ISAKOS. 2024 Oct 28:100354. doi: 10.1016/j.jisako.2024.100354. Epub ahead of print. PMID: 39476934.
3. Ahn JH, Yoo JC. Clinical outcome of arthroscopic reduction and suture for displaced acute and chronic tibial spine fractures. Knee Surg Sports Traumatol Arthrosc. 2005 Mar;13(2):116-21. doi: 10.1007/s00167-004-0540-6. Epub 2004 Nov 20. PMID: 15756616.
4. R R, Jaseel M, Murugan C, Kumaran CM. Arthroscopic tibial spine fracture fixation: Novel techniques. J Orthop. 2018 Feb 14;15(2):372-374. doi: 10.1016/j.jor.2018.01.056. PMID: 29881156; PMCID: PMC5990123.
5. Tuca M, Bernal N, Luderowski E, Green DW. Tibial spine avulsion fractures: treatment update. Curr Opin Pediatr. 2019 Feb;31(1):103-111. doi: 10.1097/MOP.0000000000000719. PMID: 30531228.
6. Gamboa JT, Durrant BA, Pathare NP, Shin EC, Chen JL. Arthroscopic Reduction of Tibial Spine Avulsion: Suture Lever Reduction Technique. Arthrosc Tech. 2017 Jan 23;6(1):e121-e126. doi: 10.1016/j.eats.2016.09.010. PMID: 28373949; PMCID: PMC5368284.
7. Bayoumy MA, Abdelhamid MM, Elkady HA, Mohamed MM. Arthroscopic Reduction and Fixation by Cerclage Wire Loop for Tibial Spine Avulsion in Adults: Short-term Results. Orthop J Sports Med. 2020 Dec 17;8(12):2325967120963118. doi: 10.1177/2325967120963118. PMID: 33415171; PMCID: PMC7750761.
8. Sinha S, Meena D, Naik AK, Selvamari M, Arya RK. Arthroscopic Fixation of Tibial Spine Avulsion in Skeletally Immature: The Technique. J Orthop Case Rep. 2017 Nov-Dec;7(6):80-84. doi: 10.13107/jocr.2250-0685.960. PMID: 29600218; PMCID: PMC5868892.
9. Verdano MA, Pellegrini A, Lunini E, Tonino P, Ceccarelli F. Arthroscopic absorbable suture fixation for tibial spine fractures. Arthrosc Tech. 2013 Dec 14;3(1):e45-8. doi: 10.1016/j.eats.2013.08.016. PMID: 24749022; PMCID: PMC3986477.
10. Chouhan V. Arthroscopic Fixation of Tibial Spine Avulsion Fracture in Open Physis. J Orthop Case Rep. 2016 Apr-Jun;6(2):86-88. doi: 10.13107/jocr.2250-0685.450. PMID: 27703945; PMCID: PMC5040583.
11. Strauss EJ, Kaplan DJ, Weinberg ME, Egol J, Jazrawi LM. Arthroscopic Management of Tibial Spine Avulsion Fractures: Principles and Techniques. J Am Acad Orthop Surg. 2018 May 15;26(10):360-367. doi: 10.5435/JAAOS-D-16-00117. PMID: 29688959.
12. Abdelhamid MM, Bayoumy MA, Elkady HA, Abdelkawi AF. Arthroscopic Reduction and Fixation of Tibial Spine Avulsion Fractures by a Stainless-Steel Wiring Technique. Arthrosc Tech. 2017 Nov 27;6(6):e2289-e2294. doi: 10.1016/j.eats.2017.08.042. PMID: 29349033; PMCID: PMC5766101.
13. Osti L, Buda M, Soldati F, Del Buono A, Osti R, Maffulli N. Arthroscopic treatment of tibial eminence fracture: a systematic review of different fixation methods. Br Med Bull. 2016 Jun;118(1):73-90. doi: 10.1093/bmb/ldw018. Epub 2016 May 5. PMID: 27151952; PMCID: PMC5127426.
14. Mutchamee S, Ganokroj P. Arthroscopic Transosseous Suture-bridge Fixation for Anterior Cruciate Ligament Tibial Avulsion Fractures. Arthrosc Tech. 2020 Oct 1;9(10):e1607-e1611. doi: 10.1016/j.eats.2020.05.005. PMID: 33134068; PMCID: PMC7586735.
15. Callanan M, Allen J, Flutie B, Tepolt F, Miller PE, Kramer D, Kocher MS. Suture Versus

Screw Fixation of Tibial Spine Fractures in Children and Adolescents: A Comparative Study. Orthop J Sports Med. 2019 Nov 22;7(11):2325967119881961. doi: 10.1177/2325967119881961. PMID: 31803786; PMCID: PMC6876177.

16. Ganley TJ, Brusalis CM. Surgical Reduction and Fixation of Tibial Spine Fractures in Children: Multiple Fixation Strategies. JBJS Essent Surg Tech. 2016 May 11;6(2):e18. doi: 10.2106/JBJS.ST.15.00062. PMID: 30237927; PMCID: PMC6145628.