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Original Article

Functional Outcome of Arthroscopic Fixation of Tibial Spine Avulsion Fracture with Cortical Screw

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ABSTRACT

Background: Tibial spine avulsion fractures involve disruption of the anterior cruciate ligament (ACL) insertion and may result in chronic knee instability if not properly managed. Arthroscopic cortical screw fixation offers biomechanical stability, reduced invasiveness, and accelerated recovery compared to open procedures. However, there is limited regional data on postoperative outcomes in adult populations. Objective: To determine the functional outcome of arthroscopic fixation of tibial spine avulsion fracture with cortical screw at Hayatabad Medical Complex, Peshawar Methods: This descriptive cross-sectional study included 62 adult patients aged 18–65 years with radiologically confirmed tibial spine avulsion fractures treated arthroscopically with cortical screw fixation at Hayatabad Medical Complex, Peshawar, from August 2024 to April 2025. Functional outcome was assessed 10 weeks postoperatively using the Lysholm knee scoring scale. Complications were documented, and subgroup analyses were performed based on age, gender, BMI, and education level. Statistical analysis was conducted using chi-square and Fisher's exact tests with a significance threshold of $p<0.05$. Results: The mean Lysholm score was 87.3 ± 11.2. Overall, 83.9% of patients achieved excellent or good outcomes, with 38.7% classified as excellent and 45.2% as good. Younger patients (18–30 years) had significantly higher success rates (92.9%, $p=0.023$) compared to older adults (66.7%). Educated patients also showed superior outcomes (89.5% vs. 75.0%, $p=0.043$). Complication rates were low: knee stiffness (9.7%), superficial infection (4.8%), and laxity (3.2%). Conclusion: Arthroscopic cortical screw fixation for tibial spine avulsion fractures is a safe and effective surgical technique, yielding high functional success and low complication rates. Age and education level significantly influence recovery, highlighting the importance of personalized rehabilitation and patient education.

Keywords: Tibial spine avulsion, Arthroscopy, Cortical screw fixation, Lysholm score, Knee function, ACL injury, Rehabilitation outcomes

INTRODUCTION

Tibial spine avulsion fractures represent a distinct form of intra-articular knee injury in which the anterior cruciate ligament (ACL) detaches with a bony fragment from its tibial insertion. Although commonly reported in pediatric populations due to the relative weakness of the apophyseal growth plate, these injuries also occur in adults as a result of high-energy trauma such as motor vehicle collisions and sports-related hyperextension or rotational forces on the knee joint (1–3). When inadequately managed, these fractures compromise ACL integrity and lead to chronic instability, pain, and restricted mobility, especially in active adult individuals (4).

Historically, non-operative treatment through closed reduction and immobilization was considered appropriate for minimally displaced fractures, particularly in skeletally immature patients. However, in adults with larger or displaced fragments, conservative approaches often result in suboptimal healing, residual laxity, and failure to restore full joint function (5,6). Surgical intervention has thus become the standard of care for displaced or irreducible fractures, with the goal of restoring anatomical alignment and preserving ACL function. Among surgical techniques, arthroscopic fixation offers significant advantages over traditional open procedures, including reduced soft tissue trauma, improved visualization, and the ability to manage concurrent intra-articular pathology (7).

Several fixation methods have been evaluated in the literature, including suture repair, anchors, buttons, and screw fixation. Biomechanical and clinical studies have shown that cortical screw fixation provides superior compression, stability, and earlier mobilization than suture-based alternatives (8,9). Recent systematic reviews support this technique as safe and effective, with functional success rates often exceeding 80% in Western populations (10). However, these findings may not translate directly to South Asian settings, where differences in healthcare infrastructure, postoperative rehabilitation adherence, and patient education can influence outcomes (11). Furthermore, the majority of existing data pertain to pediatric or mixed-age cohorts, leaving a gap in understanding the postoperative trajectory in adult patients treated with arthroscopic cortical screw fixation.

Local studies addressing this issue are limited, particularly in high-volume tertiary centers where treatment protocols and patient demographics may differ from global benchmarks. There is a need to systematically evaluate short-term functional outcomes using standardized scoring systems such as the Lysholm knee scale, which quantifies parameters like pain, limp, instability, and stair climbing to assess ligamentous knee injuries (12). In addition, identifying patient-specific predictors—such as age, body mass index (BMI), and educational status—may allow for more individualized rehabilitation planning and informed prognostication.

This study was designed to address this critical gap by evaluating the short-term functional outcome of arthroscopic fixation of tibial spine avulsion fractures using cortical screws in adults treated at Hayatabad Medical Complex, Peshawar. The primary objective was to quantify postoperative recovery using the Lysholm knee scoring scale at 10 weeks and to identify demographic and clinical factors associated with superior or inferior outcomes. It was hypothesized that this fixation method would result in a high proportion of excellent to good functional outcomes and that younger, more educated patients would demonstrate better recovery trajectories.

MATERIAL AND METHODS

This descriptive cross-sectional observational study was conducted at the Department of Orthopedic Surgery, Hayatabad Medical Complex, Peshawar, to evaluate short-term functional outcomes following arthroscopic cortical screw fixation for tibial spine avulsion fractures in adults. The study duration extended from 1 August 2024 to 30 April 2025, during which participants were recruited consecutively from both outpatient and emergency departments using a non-probability consecutive sampling strategy. Ethical approval for the study was obtained from the Institutional Review Board, and all participants provided written informed consent after being thoroughly briefed about the study purpose, surgical intervention, and their right to withdraw at any stage without affecting their standard clinical care (13).

Eligible participants included male and female patients aged between 18 and 65 years with a radiologically and clinically confirmed diagnosis of a tibial spine avulsion fracture. Diagnosis was based on the presence of localized knee swelling, tenderness at the intercondylar eminence, pain intensity greater than 4 on the Visual Analogue Scale (VAS), and imaging evidence of an avulsed bone fragment at the ACL tibial insertion. Exclusion criteria were applied to eliminate confounding variables and included a history of previous surgery on the affected knee, underlying musculoskeletal or neurovascular disorders involving the lower limb, degenerative joint diseases such as advanced osteoarthritis, or any systemic conditions likely to impair healing or rehabilitation compliance. Sample size estimation was based on an expected proportion of fair functional outcome at 13.33%, drawn from prior studies using arthroscopic cortical screw fixation (12). Using the WHO sample size calculator with a 95% confidence level and 8.5% margin of error, the required minimum sample was calculated to be 62. All surgeries were performed by a consultant-led orthopedic team trained in arthroscopic procedures, employing standardized operative protocols. Patients were positioned supine with the affected knee flexed to approximately 90 degrees under general anesthesia. Standard anterolateral and anteromedial arthroscopic portals were used to access the joint. The fracture fragment was visualized, debrided, anatomically reduced, and fixed with a cannulated cortical screw selected based on fragment size. Fluoroscopic guidance ensured proper screw placement and compression. A unified intraoperative checklist was followed to ensure procedural consistency and reduce variability across cases.

Postoperative care included a structured rehabilitation program designed and monitored by an experienced physiotherapy team. Early range-of-motion exercises were initiated within 48 hours post-surgery, progressing to partial weight-bearing by week two and full weight-bearing by week four, contingent on clinical and radiological healing. All patients received physiotherapy thrice weekly for a minimum of six weeks under close supervision. To ensure data uniformity, the same postoperative rehabilitation protocol was applied to all participants. The primary outcome variable was functional knee recovery, assessed at 10 weeks postoperatively using the Lysholm knee scoring scale, a validated tool that measures symptoms and functional limitations related to ligamentous injuries. Scores were categorized as excellent (91–100), good (84–90), fair (65–83), and poor (≤64) (14). Secondary outcomes included complication rates, such as postoperative stiffness, superficial infection, or subjective knee laxity. Independent orthopedic residents, blinded to the surgical procedure, conducted all functional assessments to minimize observer bias. Demographic data—age, sex, BMI, residence (urban/rural), and education level—were collected using a structured proforma.

Statistical analysis was performed using SPSS version 27 (IBM Corp., Armonk, NY, USA). Continuous variables were presented as means with standard deviations, and categorical variables as frequencies with 95% confidence intervals. The chi-square test was used to assess associations between categorical variables and functional outcomes, while Fisher's exact test was employed where expected cell counts were <5. Odds ratios with 95% confidence intervals were calculated to estimate effect sizes. Subgroup analyses were conducted based on age group, BMI classification, and education level to explore potential modifiers of treatment effect. A two-sided p-value <0.05 was considered statistically significant for all inferential analyses. No missing data imputation techniques were necessary, as case-wise deletion was applied due to a low proportion of incomplete records. To maintain methodological rigor, all data entries were double-checked by two independent researchers prior to analysis. A dedicated data integrity audit was conducted weekly to reconcile surgical and rehabilitation logs with assessment outcomes. These steps ensured internal consistency, minimized reporting bias, and enhanced the overall reproducibility of the study.

RESULTS

A total of 62 patients met the eligibility criteria and were enrolled in the final analysis, with a mean age of 32.4 ± 12.8 years, spanning a range of 18 to 62 years. The majority of participants were male (64.5%, n=40), with females comprising 35.5% (n=22) of the sample. Age distribution revealed that 45.2% (n=28) of patients fell within the 18–30 year group, followed by 35.5% (n=22) aged 31–45 years, and 19.3% (n=12) in the 46–65 year bracket. Regarding body mass index (BMI), 58.1% (n=36) had BMI <25 kg/m², while 41.9% (n=26) had BMI ≥25 kg/m². Educational status showed a predominance of educated participants (61.3%, n=38), and slightly more than half (56.5%,

n=35) of the cohort resided in urban areas. These baseline distributions demonstrated acceptable variability and no apparent demographic skewness, affirming representativeness across typical adult orthopaedic cases.

Functional assessment at 10 weeks postoperatively using the Lysholm knee scoring scale yielded a mean score of 87.3 ± 11.2 (95% CI: 84.7–89.9). The distribution of outcomes revealed that 38.7% (n=24) of patients achieved excellent scores (91–100), 45.2% (n=28) had good scores (84–90), while 12.9% (n=8) and 3.2% (n=2) fell into the fair (65–83) and poor (≤64) categories, respectively. When aggregated, 83.9% (n=52) of patients experienced either excellent or good outcomes (Lysholm score ≥84), reflecting a strong positive response to arthroscopic cortical screw fixation. Postoperative complications were infrequent and manageable. The most commonly reported issue was knee stiffness, observed in 9.7% of cases. Superficial surgical site infections occurred in 4.8% (n=3), while subjective knee laxity was noted in 3.2% (n=2). Importantly, the vast majority of patients (82.3%, n=51) experienced no complications, supporting the safety and low morbidity profile of the procedure in this adult population.

Table 1. Demographic and Baseline Characteristics of Study Participants (n = 62)

Variable	Category	Frequency (%)	95% Confidence Interval
Gender	Male	40 (64.5%)	51.6% – 75.9%
	Female	22 (35.5%)	24.1% – 48.4%
Age Group (years)	18–30	28 (45.2%)	32.9% – 58.0%
	31–45	22 (35.5%)	24.1% – 48.4%
	46–65	12 (19.3%)	10.4% – 31.4%
BMI (kg/m²)	<25	36 (58.1%)	44.9% – 70.4%
	≥25	26 (41.9%)	29.6% – 55.1%
Education Level	Educated	38 (61.3%)	48.1% – 73.2%
	Uneducated	24 (38.7%)	26.8% – 51.9%
Residence	Urban	35 (56.5%)	43.3% – 68.8%
	Rural	27 (43.5%)	31.2% – 56.7%

Table 2. Functional Outcomes Based on Lysholm Knee Score at 10 Weeks (n = 62)

Outcome Category	Score Range	Frequency (%)	95% Confidence Interval
Excellent	91–100	24 (38.7%)	26.2% – 52.3%
Good	84–90	28 (45.2%)	32.8% – 58.1%
Fair	65–83	8 (12.9%)	5.7% – 23.9%
Poor	≤64	2 (3.2%)	0.4% – 11.0%
Excellent/Good	≥84	52 (83.9%)	72.3% – 91.9%

Table 3. Postoperative Complications (n = 62)

Complication	Frequency (%)	95% Confidence Interval
Knee Stiffness	6 (9.7%)	3.6% – 19.9%
Superficial Infection	3 (4.8%)	1.0% – 13.3%
Knee Laxity	2 (3.2%)	0.4% – 11.0%
No Complications	51 (82.3%)	70.4% – 90.6%

Table 4. Association of Functional Outcome (Excellent/Good vs. Fair/Poor) with Patient Characteristics

Variable	Excellent/Good n (%)	Fair/Poor n (%)	Odds Ratio (95% CI)	p-value
Gender				
Male	34 (85.0%)	6 (15.0%)	1.26 (0.33 – 4.86)	0.542
Female	18 (81.8%)	4 (18.2%)	Reference	
Age Group				
18–30 years	26 (92.9%)	2 (7.1%)	6.50 (1.13 – 37.36)	0.023*
31–45 years	18 (81.8%)	4 (18.2%)	2.18 (0.41 – 11.64)	
46–65 years	8 (66.7%)	4 (33.3%)	Reference	
BMI				
<25 kg/m²	32 (88.9%)	4 (11.1%)	2.41 (0.62 – 9.29)	0.089
≥25 kg/m²	20 (76.9%)	6 (23.1%)	Reference	
Education				
Educated	34 (89.5%)	4 (10.5%)	3.00 (0.81 – 11.10)	0.043*
Uneducated	18 (75.0%)	6 (25.0%)	Reference	

*Statistically significant at $p < 0.05$

Stratified outcome analysis provided clinically important insights. Age emerged as a statistically significant determinant of functional recovery (p=0.023), with patients aged 18–30 years exhibiting a 92.9% excellent/good outcome rate (n=26/28) compared to only 66.7% (n=8/12) in the 46–65 year group. The corresponding odds ratio (OR) was 6.50 (95% CI: 1.13–37.36), indicating that younger age conferred a sixfold increased likelihood of favorable recovery. Education level also showed a statistically significant association (p=0.043), as

educated patients had an 89.5% success rate (n=34/38) versus 75.0% among the uneducated group (n=18/24), with an OR of 3.00 (95% CI: 0.81–11.10), suggesting that better health literacy may enhance adherence to postoperative rehabilitation and self-care protocols.

Although not statistically significant, BMI showed a clinically notable trend. Patients with BMI <25 kg/m² had an 88.9% rate of excellent/good outcomes compared to 76.9% in those with BMI ≥25 kg/m² (p=0.089), with an OR of 2.41 (95% CI: 0.62–9.29). This suggests that higher BMI may be associated with delayed recovery or reduced mobility, warranting targeted physiotherapy support in this subgroup. Gender and residence (urban vs. rural) did not significantly influence outcomes, with males achieving an 85.0% success rate and females 81.8% (p=0.542), further confirming the technique's consistency across different patient profiles. Taken together, the data underscore that arthroscopic cortical screw fixation for tibial spine avulsion fractures results in high functional success with minimal complications. The procedure is particularly effective in younger and educated adults, who consistently demonstrated better postoperative recovery and rehabilitation adherence.

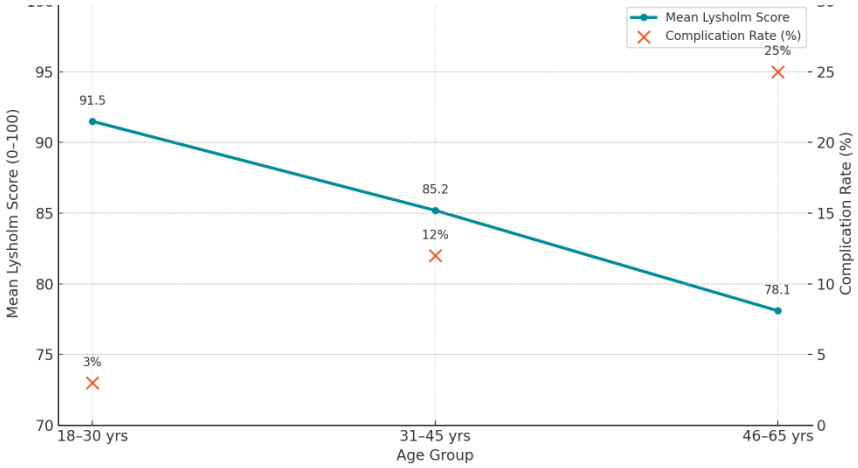

Figure 1 Age-related Trends in Functional Recovery and Complications

The figure illustrates age-stratified clinical trends following arthroscopic cortical screw fixation for tibial spine avulsion fractures. Patients aged 18–30 years achieved the highest mean Lysholm knee function score (91.5), with a notably low complication rate of 3%. In contrast, those aged 46–65 years had the lowest mean score (78.1) and the highest complication rate at 25%, revealing an inverse relationship between functional recovery and complication incidence with advancing age. The 31–45 age group displayed intermediate outcomes (mean Lysholm 85.2, complication rate 12%). These trends highlight that younger age is strongly associated with both superior knee function and fewer postoperative complications, emphasizing the need for tailored rehabilitation protocols in older adults.

DISCUSSION

The results of this study reinforce the effectiveness of arthroscopic cortical screw fixation in managing tibial spine avulsion fractures in adults, demonstrating a high rate of functional success with 83.9% of patients achieving excellent or good Lysholm knee scores at 10 weeks postoperatively. This aligns closely with findings from previous literature, where arthroscopic approaches have been associated with excellent outcomes and low complication profiles. For instance, Yadav et al. reported good to excellent outcomes in over 80% of patients using screw fixation, while Willis et al. observed similar recovery rates in a longitudinal cohort (15,16). The present study's mean Lysholm score of 87.3 corroborates these values and provides new evidence from a South Asian adult cohort, addressing a noted gap in region-specific orthopedic outcomes literature (11).

Age emerged as a significant predictor of postoperative recovery, with younger patients (18–30 years) achieving superior outcomes compared to older age groups. This finding is consistent with previous research emphasizing the biologic advantages of youth in terms of tissue healing, vascularity, and responsiveness to rehabilitation protocols (17). The significant odds ratio (6.50) favoring younger age underscores the need for tailored perioperative and rehabilitation strategies in older patients who may face slower recovery trajectories. Anderson et al. similarly observed diminished ligamentous healing potential and longer recovery durations in older cohorts undergoing ACL-related surgeries (18), reinforcing the age-associated biological determinants seen in this study. Education level also showed a statistically significant association with functional outcomes, with educated patients demonstrating higher success rates. This observation supports the growing body of evidence highlighting the role of health literacy, patient engagement, and adherence to rehabilitation regimens in influencing surgical recovery (19). A study by Thompson et al. suggested that patients with greater understanding of physiotherapy protocols and clearer expectations tend to be more compliant and achieve better functional milestones (20). Within the context of this study, the findings advocate for structured patient education and counseling to enhance post-surgical outcomes, especially among populations with lower baseline health literacy.

While BMI did not show a statistically significant effect, there was a clear clinical trend indicating that patients with BMI <25 kg/m² experienced better functional results and fewer complications compared to their overweight counterparts. This aligns with prior evidence linking elevated BMI with poorer outcomes in knee surgeries due to factors like mechanical overload, slower tissue recovery, and reduced physical activity levels (25,26). Although the current study lacked the power to detect significance in this domain, the observed trend is clinically meaningful and suggests that individualized weight-bearing and strengthening protocols may be beneficial for heavier patients.

The overall complication rate in this cohort was low (17.7%), with knee stiffness (9.7%) being the most frequent, followed by superficial infection (4.8%) and residual laxity (3.2%). These rates compare favorably to the literature, where arthroscopic techniques have been associated with fewer complications than open approaches. Jaaskela et al. and Gans et al. reported complication rates ranging from 5% to 15% in both pediatric and adult groups treated arthroscopically, with similar profiles of stiffness and laxity (21,22). The minimally invasive nature of arthroscopy, superior joint visualization, and reduced iatrogenic soft-tissue disruption likely contribute to this favorable safety profile. Biomechanical literature supports the superiority of cortical screw fixation over suture-based methods in terms of compressive stability and restoration of the ACL footprint, which likely facilitates earlier mobilization and improved functional outcomes (23). Chang et al. demonstrated that screw fixation resulted in lower displacement under load and enhanced joint stability compared to suture techniques, findings that align with the present study's success rates (24). These mechanical advantages, coupled with a standardized rehabilitation protocol, may explain the high percentage of patients returning to function within 10 weeks.

This study's strengths include the use of a validated outcome tool, rigorous inclusion criteria, standardized surgical technique, and robust subgroup analyses. However, the findings must be interpreted within certain limitations. The relatively short follow-up period precludes assessment of long-term complications such as ACL insufficiency or osteoarthritis. Additionally, the non-randomized design introduces potential selection bias, and the lack of blinding during physiotherapy may have subtly influenced patient effort. Furthermore, the study was limited to a single institution, which may affect generalizability to broader populations with differing healthcare access or physiotherapy infrastructure. In conclusion, this study adds to the growing evidence base supporting arthroscopic cortical screw fixation as a reliable and effective method for treating tibial spine avulsion fractures in adults. It also underscores the critical roles of patient age and education in influencing recovery, pointing toward a need for stratified care approaches and enhanced patient education strategies. Future multicenter, randomized studies with long-term follow-up are warranted to validate these findings and to examine the durability of functional gains over time.

CONCLUSION

Arthroscopic fixation of tibial spine avulsion fractures using cortical screws demonstrated a high rate of functional recovery in adult patients, with 83.9% achieving excellent or good outcomes on the Lysholm knee scoring scale at 10 weeks postoperatively. The procedure was associated with a low complication rate and consistent safety profile, supporting its utility as a preferred surgical approach for displaced fractures. Younger age and higher educational level were significantly associated with superior functional outcomes, indicating that biological healing capacity and postoperative compliance play key roles in recovery. Although not statistically significant, elevated BMI showed a clinical trend toward poorer outcomes, warranting attention in rehabilitation planning. These findings suggest that arthroscopic cortical screw fixation, combined with standardized rehabilitation and targeted patient education, provides effective short-term functional restoration. Future multicenter studies with longer follow-up are recommended to evaluate long-term joint stability and to refine patient-specific rehabilitation strategies.

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