European Journal of Clinical Pharmacy
Print ISSN: 2385-409X **Online ISSN**: 3105-0409
Website: https://farmclin.com/

Original Research Article

A PROSPECTIVE COMPARATIVE STUDY OF FRACTURE PROXIMAL END TIBIA MANAGED WITH HYBRID EXTERNAL FIXATOR VERSUS PLATING

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Received: 12-01-2026
Revised: 28-01-2026
Accepted: 24-02-2026
Published: 26-03-2026

Abstract: ***Background:*** Fractures of the proximal tibia pose a major orthopaedic challenge because of their intra-articular involvement, related soft tissue damage, and potential for complications like malunion, nonunion, and post-traumatic arthritis. This prospective comparative research assessed the clinical, radiological, and functional results of proximal tibial fractures treated with hybrid external fixation compared to plating. The study was carried out over a span of 18 months within the Department of Orthopaedics at Ananta Institute of Medical Sciences and Research Centre, Rajasthan, and involved 50 patients, equally allocated to hybrid external fixator and plating groups. Both groups were comparable in baseline demographic and fracture characteristics. The hybrid external fixator group had a considerably shorter mean operative time (60.56 ± 6.37 minutes) than the plating group (71.12 ± 6.64 minutes; $p < 0.001$), and they also had a shorter time to full weight-bearing (10.24 ± 2.67 weeks vs. 12.08 ± 2.68 weeks; $p = 0.028$). But according to the American Knee Society Score, the plating group's functional outcomes were noticeably superior (72.40 ± 10.84 vs. 66.68 ± 12.81; $p = 0.039$). Different groups saw different patterns of complications: the fixator group experienced delayed union (8%) and pin tract infection (20%), whereas the plating group experienced superficial infection (12%), screw backout (4%), and wound gaping (4%). Overall, plating delivers better functional results because of better anatomical reduction and stability, whereas hybrid external fixation offers the advantages of shorter surgical time and earlier mobilisation, making it appropriate for instances with impaired soft tissue or open fractures. Therefore, the choice of fixation should be tailored to the specifics of the fracture, the state of the soft tissues, and the surgeon's experience.

Keywords: Proximal tibial fracture; Hybrid external fixator; Plating (ORIF); American Knee Society Score; Functional outcome; Fracture healing; Orthopaedic trauma; Tibial plateau fracture.

INTRODUCTION

The proximal tibia fractures create difficult orthopaedic treatment challenges because their location near the knee joint and their accompanying soft tissue injuries and their potential to develop malunion and nonunion and post traumatic arthritis complications.(1) The fractures occur because of high-energy trauma which includes motor vehicle

accidents and falls from height and they commonly affect young adults and elderly people who have osteoporosis.(2) The management of proximal tibial fractures aims to restore articular congruity while establishing secure bone fixation and enabling patients to begin movement exercises which will help prevent joint stiffness and improve their functional abilities.(3) Orthopaedic surgeons continue to debate which surgical method should be used to treat proximal tibial fractures. The two main methods used for treatment include hybrid external fixation and open reduction internal fixation (ORIF) with plating.(4) Hybrid external fixation combines circular and unilateral fixation methods to achieve stable fixation results which protect soft tissues. This method proves most effective for treating patients who have sustained serious soft tissue damage or open fractures.(5) Plating, in contrast, provides rigid internal fixation, which in turn facilitates the anatomical configuration of the fragments, giving importance to performing proper motion of joints. However, plating requires extensive soft tissue dissection, increasing the risk of infection, wound complications, and implant-related issues(6) The best treatment method for proximal tibial fractures stays unresolved despite studies which have tested hybrid external fixation against plating to treat tibial fractures.(7) Proponents of hybrid external fixation argue that this method decreases surgical damage to patients while maintaining blood circulation to bone fragments and enables doctors to implement progressive weight-bearing treatment, which will improve their patients' fracture recovery process.(8) Plating advocates present their argument by demonstrating how their method provides better biomechanical stability than other methods which show less stability than their approach. Intra-articular fractures require precise reduction to maintain joint functionality.(9) The various methods each have their distinct benefits but they also present particular challenges which lead surgeons to select specific fixation methods based on two factors. The first factor includes the specific fracture pattern, while the second factor encompasses both patient characteristics and the personal choices of the operating surgeon.(10)

The need for a prospective comparative study exists because researchers have not reached agreement about which treatment method works best for proximal tibial fractures. Previous studies have reported different results because researchers showed different preferences between hybrid external fixation which produced fewer complications during high-energy injuries and plating which provided superior functional outcomes in stable fracture patterns.(11) Most studies that currently exist use retrospective methods which result in biased patient selection and outcome assessment. The study will establish clinical guidelines through evidence-based research conducted under standardized testing procedures. The research study examines the impact of hybrid external fixation systems with plating systems on the clinical outcomes and radiological results and functional abilities of patients who experience proximal tibial fractures. The main goals of the research study focus on two areas which include determining the time needed for fractures to heal and measuring the occurrence of complications and assessing knee joint functionality while the secondary goals focus on measuring patient satisfaction and their ability to return to their normal activities before the injury. The research aims to achieve this goal by studying various factors which will create evidence-based treatment protocols to manage proximal tibial fractures which will result in better patient outcomes and surgical success rates.

Material and Methods

Study Design and Setting: This was a prospective observational and comparative study conducted on patients with proximal end tibia fractures managed with hybrid external fixator versus plating. The study was carried out over a period of 18 months in the Department of Orthopaedics at Ananta Institute of Medical Sciences and Research Centre, Rajsamand, Rajasthan. The study included both casualty and inpatient (IPD) cases admitted under the Department of Orthopaedics.

Study Duration: The study was conducted for a duration of 18 months.

Sample Size Calculation: The minimum sample size was calculated based on a 99% level of significance (Z = 2.58) and 90% power, which yielded a required sample size of 42 patients. After adjusting for a 20% potential dropout rate, the final sample size was set at 50 patients, with 25 patients allocated to each treatment group (hybrid external fixator group and plating group).

Inclusion Criteria: Patients of either sex, Age more than 18 years, Patients diagnosed with proximal tibia fractures. Exclusion Criteria: Fractures with a history of trauma greater than 3 weeks, Prior history of knee pathology, Presence of neurovascular injury, Extra-articular fractures.

Pre-operative Assessment: All admitted patients were evaluated using the Standard ATLS protocol. A thorough clinical examination was performed to assess skin and soft tissue conditions, as well as distal neurovascular status. Open fractures were classified according to the Gustilo-Anderson classification system. Closed fractures were assessed for tense swelling (absence of wrinkles), pedal edema, presence of deep abrasions, blisters, blebs, and skin

impingement due to fracture angulation and deformity. Radiological evaluation included X-rays of the knee joint (anteroposterior and lateral views) to assess fracture pattern and congruity of the articular surface. Computed tomography scans were performed for patients with articular involvement. Initial immobilization was achieved using an above-knee slab or skeletal traction. Routine preoperative investigations were conducted, associated comorbidities were managed appropriately, and patients were taken up for surgery after obtaining anaesthetic fitness.

Figure1. Pre-Operative Radiograph.

Surgical Procedure: Hybrid External Fixator

Under spinal or epidural anaesthesia, the patient was positioned supine on the operating table. A standard surgical procedures were completed which included patient preparation and surgical draping before they began building the hybrid external fixator system. The main element of the system which functions as an Ilizarov ring fixator was positioned on the selected metaphyseal bone segment. The team needed to fix all intra-articular problems before proceeding to insert wires into the metaphyseal bone segment. We succeeded in achieving anatomical reduction during the surgical procedure by executing the following steps.

- Calcaneal pin traction (ligamentotaxis principle) for aligning most fragments
- Percutaneous pin leverage technique to elevate depressed fragments
- Securing fragments with percutaneous cannulated cancellous screws to ensure adequate compression

In cases of distal tibial fractures with concomitant fibula involvement, the fibula was initially fixed to maintain limb length, alignment, and rotational stability. The Ilizarov ring was secured to the metaphyseal area by using three or more wires which they installed in different directions to achieve better stability. A tensioner was used to apply tension to the wires. They then used appropriate nuts and bolts to secure the components to the system. The research team attached AO rods to the front section of the ring by using either universal clamps or male posts. The researchers used 4.5 mm Schanz pins to secure the rods to the tibial crest after they accomplished satisfactory fracture reduction which they confirmed through Carm guidance. We used two extra AO rods which they connected to the Schanz pins for improved stability. the procedure was completed by suturing and dressing the surgical area.

Surgical Procedure: Plating (Open Reduction and Internal Fixation The patients had their fractures treated using standard surgical methods which included antero-lateral and postero-medial and posterior approaches for open reduction and internal fixation with plating. The procedure involved surgeons achieving precise anatomical fracture reduction through direct visual observation which they followed by using precontoured locking plates and screws for fractured bone stabilization. The surgeons used modern precontoured locking plates to create angular stability which distributed mechanical load across the fractured metaphyseal fragments.

Figure2. Intra-Operative procedure.

Implants Used

Hybrid External Fixator Group: Ring system consisting of 5/8th Ilizarov ring, bolts, nuts, 1.8 mm K-wires, and olive wires. Pin system consisting of AO rods, universal clamps, 4.5 mm Schanz pins, and connecting system 3.5 mm drill bits, T-handle, K-wire bender, and cutter.

Plating Group: Varying sizes of screws, Left and right lateral condyle plates, Left and right raft plates, Posterior medial condyle plates, Medial condyle plates, Torque limiting screw driver, Screw drivers and screw taps, Locking screw sleeves, General instrument set.

Post-operative Protocol: Post-operative management commenced with the administration of suitable intravenous antibiotics and analgesics to mitigate infection risk and control pain. From the first day following surgery, a comprehensive rehabilitation protocol was initiated, including:

- Daily dressing changes at the pin sites for the external fixator group.
- Early mobilization exercises including knee and ankle mobilization, ankle pumps, static quadriceps, and pelvic bridging.
- Post-operative radiographs were obtained to assess fracture alignment and fixation integrity.

Figure3. Post-Operative Radiographs.

An external fixator were used to secure a foot support through which they attached a sandal to their patients with distal tibial fractures because they needed to maintain their patients' ankle joints at a 90° position to prevent ankle equinus deformity from developing. The daily external fixators received cleaning through spirit while pin site dressing first used normal saline. Patients learned to perform their own dressings through the use of cotton buds. The rehabilitation program started with nonweight-bearing exercises which required walkers for support before patients could begin to walk. The process of weight-bearing introduction depended on the specific fracture pattern and the stability of the fixation. Patients with uncomplicated cases could start partial weight-bearing activities three weeks after their surgery. The medical team decided to postpone full weight-bearing activities for six weeks after surgery because of complex fracture cases and concerns about fixation stability which needed to ensure optimal fracture healing. The Patients underwent serial regular follow-up at 1 month, 3 months, 6 months, and 1 year post-surgery. The assessment used these two methods for evaluation: first method evaluated Pin-site wound care in the external fixator group while second method tested Clinical union which required judges to assess two conditions at

the fracture site. Radiological union was defined as the existence of three cortical bridges which connected through callus development.

Outcome Assessment: Functional outcome was evaluated using the American Knee Society Score (AKSS). The AKSS consists of two primary domains:

1. Knee Score (AKS-KS): Evaluates pain (50 points), stability (25 points), range of motion (25 points), and alignment (bonus/deduction), with a maximum score of 100 points. Deductions were applied for flexion contracture, extension lag, and malalignment.
2. Function Score (AKS-FS): Evaluates walking distance (50 points), stair-climbing ability (50 points), with deductions for use of assistive devices, also scored out of 100 points.

The final AKSS was graded as: Excellent: >81 points, Good: 71-80 point, Fair: 61-70 points, Poor: <60 points.
Data Collection: Data were collected using a standardized proforma that included:

- Demographic details (age, gender, education, occupation, address).
- Clinical presentation and history of present illness.
- Mode of injury and duration since injury.
- Past medical and surgical history.
- General physical and systemic examination findings.
- Local examination findings including neurovascular status.
- Associated injuries and complications.
- investigation results.
- Treatment details including pre-operative management, surgical procedure, and post-operative course.
- Follow-up parameters at 2 weeks and 6 weeks (pain, range of motion, stability).
- Complications (infection, delayed union, non-union, malunion, nerve injury).

Ethical Considerations: The Institutional Ethics Committee of Ananta Institute of Medical Sciences and Research Centre approved the study with Approval No. AIMS/IEC/2023/15.0 which was issued on 28-08-2023. The researchers obtained written informed consent from all participants before they joined the study. The privacy of patients was protected by not disclosing any personal information or photographic material. The anaesthetic protocols established standard procedures which the team used to cover all medical risks.
Statistical Analysis: The data analysis were conducted by using suitable statistical methods. The researchers measured continuous variables with mean values and standard deviation which they used to compare groups through independent t-tests. The categorical variables were presented as frequencies and percentages which were evaluated through Chi-square tests. The statistical significance was established at p-values below 0.05.

RESULTS

A total of 50 patients with proximal end tibia fractures were included in this prospective comparative study, with 25 patients managed with hybrid external fixator and 25 patients managed with plating. Both groups were comparable at baseline with respect to demographic and clinical characteristics.

Demographic Characteristics:

The mean age of participants in the hybrid external fixator group was 43.48 ± 10.50 years, while in the plating group it was 41.24 ± 8.09 years. The difference in age between the two groups was not statistically significant (p = 0.367). In the fixator group, 8 participants (32%) were male and 17 (68%) were female, whereas in the plating group, 11 participants (44%) were male and 14 (56%) were female. This difference in gender distribution was not statistically significant (p = 0.56). Regarding area of residence, the fixator group had 15 participants (60%) from urban areas and 10 (40%) from rural areas, while the plating group had 14 participants (56%) from urban areas and 11 (44%) from rural areas (p = 1.00). The educational background of participants varied, with the fixator group having 5 (20%) with primary education, 5 (20%) with secondary education, 4 (16%) with higher secondary, 5 (20%) graduates, and 6 (24%) postgraduates In the plating group, 1 (4%) had primary education, 9 (36%) had secondary education, 6 (24%) had higher secondary, 7 (28%) were graduates, and 2 (8%) were postgraduates (p = 0.162). Socio-economic status distribution showed that in the fixator group, 8 (32%) belonged to the lower class, 5 (20%) to lower middle class, 5 (20%) to upper middle class, and 7 (28%) to upper class. In the plating group, 6 (24%) were from lower class, 5 (20%) from lower middle class, 9 (36%) from upper middle class, and 5 (20%) from upper class (p = 0.623). Religious distribution revealed that in the fixator group, 17 (68%) were Hindu and 8 (32%) were Muslim, while in the plating group, 19 (76%) were Hindu and 6 (24%) were Muslim (p = 0.753).

Table 1: Demographic characteristics of study participants

Parameter	Category	Fixator group (n=25)	Plating group (n=25)	p-value
Age (years)	Mean ± SD	43.48 ± 10.50	41.24 ± 8.09	0.367
Gender	Male	8 (32%)	11 (44%)	0.56
	Female	17 (68%)	14 (56%)	
Area of residence	Urban	15 (60%)	14 (56%)	1.00
	Rural	10 (40%)	11 (44%)	
Education	Primary	5 (20%)	1 (4%)	0.162
	Secondary	5 (20%)	9 (36%)	
	Higher secondary	4 (16%)	6 (24%)	
	Graduate	5 (20%)	7 (28%)	
	Postgraduate	6 (24%)	2 (8%)	
Socio-economic status	Lower	8 (32%)	6 (24%)	0.623
	Lower middle	5 (20%)	5 (20%)	
	Upper middle	5 (20%)	9 (36%)	
	Upper	7 (28%)	5 (20%)	
Religion	Hindu	17 (68%)	19 (76%)	0.753
	Muslim	8 (32%)	6 (24%)	

Fracture Characteristics

The plating group achieved better American Knee Society Score (AKSS) results because their mean score of 72.40 ± 10.84 exceeded the hybrid external fixator group mean score of 66.68 ± 12.81 which showed statistical significance with a p-value below 0.05. The fixator group showed AKSS grading results which showed 5 participants (20%) experienced poor outcomes while 7 participants (28%) reached fair outcomes and 9 participants (36%) obtained good outcomes and 4 participants (16%) attained excellent outcomes. The plating group showed 3 participants (12%) who experienced poor outcomes while 7 participants (28%) reached fair outcomes and 8 participants (32%) achieved good outcomes and 7 participants (28%) attained excellent outcomes. The two groups showed different outcome grades which reached statistical significance because the plating group achieved more excellent results while the difference between groups did not reach statistical significance because the p-value reached 0.263.

Table 2: Fracture characteristics of study participants

Parameter	Category	Fixator group (n=25)	Plating group (n=25)	p-value
Side of fracture	Left	12 (48%)	14 (56%)	0.777
	Right	13 (52%)	11 (44%)	
Cause of injury	Accidental fall	11 (44%)	9 (36%)	0.803
	Road traffic accident	12 (48%)	13 (52%)	
	Others	2 (8%)	3 (12%)	
AO/OTA classification	41A2	14 (56%)	13 (52%)	1.00
	41A3	11 (44%)	12 (48%)	
Type of fracture	Closed	18 (72%)	19 (76%)	1.00
	Open	7 (28%)	6 (24%)	

Operative Parameters and Post-Operative Recovery

The mean operative time was significantly lower in the hybrid external fixator group (60.56 ± 6.37 minutes) compared to the plating group (71.12 ± 6.64 minutes), with a p-value of < 0.001. The duration required to achieve full weight-bearing mobilization was significantly shorter in the fixator group (10.24 ± 2.67 weeks) compared to the plating group (12.08 ± 2.68 weeks), with a p-value of 0.028, indicating earlier mobilization in patients treated with hybrid external fixation.

Table 3: Comparison of operative and post-operative parameters between groups

Parameter	Fixator group (Mean ± SD)	Plating group (Mean ± SD)	p-value
Operative time (minutes)	60.56 ± 6.37	71.12 ± 6.64	< 0.001
Time to full weight-bearing (weeks)	10.24 ± 2.67	12.08 ± 2.68	0.028

Complications:

In the fixator group, 18 participants (72%) had no complications, while 5 (20%) developed pin tract infections and 2 (8%) experienced delayed union. In contrast, 20 participants (80%) in the plating group had no complications. However, 1 participant (4%) experienced screw backout, 3 (12%) developed superficial infections, 1 (4%) had wound gaping, and none had pin tract infections or delayed union. The types and distribution of complications

varied between the groups, with pin tract infection being exclusive to the fixator group and superficial infection more common in the plating group.

Table 4: Distribution of post-operative complications

Complications	Fixator group (n=25)	Plating group (n=25)
None	18 (72%)	20 (80%)
Pin tract infection	5 (20%)	0
Delayed union	2 (8%)	0
Superficial infection	0	3 (12%)
Screw backout	0	1 (4%)
Wound gaping	0	1 (4%)

Functional Outcomes

The mean American Knee Society Score (AKSS) was significantly higher in the plating group (72.40 ± 10.84) compared to the hybrid external fixator group (66.68 ± 12.81), with a p-value of 0.039, indicating better functional outcomes in patients treated with plating. Based on AKSS grading, in the fixator group, 5 participants (20%) had poor outcomes, 7 (28%) had fair outcomes, 9 (36%) had good outcomes, and 4 (16%) achieved excellent outcomes. In the plating group, 3 participants (12%) had poor outcomes, 7 (28%) had fair outcomes, 8 (32%) had good outcomes, and 7 (28%) had excellent outcomes. Although the plating group showed a slightly higher proportion of excellent outcomes, the overall difference in outcome grades between the two groups was not statistically significant (p = 0.263).

Table 5: Comparison of functional outcomes between groups

Parameter	Category	Fixator group (n=25)	Plating group (n=25)	p-value
AKSS score	Mean ± SD	66.68 ± 12.81	72.40 ± 10.84	0.039
AKSS grade	Poor	5 (20%)	3 (12%)	0.263
	Fair	7 (28%)	7 (28%)	
	Good	9 (36%)	8 (32%)	
	Excellent	4 (16%)	7 (28%)	

DISCUSSION

The study compared two methods for treating tibial proximal end fractures using hybrid external fixator and plating techniques. The two groups showed matching demographic characteristics because their age distribution, gender makeup, socio-economic background, educational levels, residential areas, religious beliefs, fracture side, fracture type, fracture classification, and injury mechanism sustained no significant statistical differences. The two treatment methods maintained consistent treatment conditions throughout the study. The hybrid external fixator group showed an average patient age of 43.48 years with a standard deviation of 10.50 years while the plating group showed an average patient age of 41.24 years with a standard deviation of 8.09 years and these ages showed no statistically significant difference between the two groups (p = 0.367). The age distribution matches the results of Ismail Jan et al. (2016) which found that both external fixation and plating groups had an average patient age of 40 to 45 years. Similarly, Kartheek et al. (2017) observed that the majority of their patients treated for bicondylar tibial plateau fractures with Ilizarov and locking plates were in the fourth decade of life, consistent with the demographic trend seen in our study. Gender distribution in our study also did not show a statistically significant difference between the two groups (p = 0.56). The fixator group had a female preponderance (68%), while the plating group had a slightly higher proportion of males (44%). A similar gender pattern was noted by Gross et al. (2017), who reported no significant gender bias in the use of hybrid external fixators for proximal tibial fractures, although they acknowledged that male predominance is often seen in trauma-related literature due to occupational exposure.

In contrast, Bhat et al. (2019) observed a slight male preponderance in both groups, which may reflect regional variations in trauma patterns or healthcare-seeking behaviour. Furthermore, studies by Saini et al. (2023) and Prasad et al. (2021) also included a fairly balanced male-to-female ratio in their comparative analysis of hybrid external fixation versus plating, suggesting that gender is not a limiting factor in the choice of surgical modality, but rather clinical indication and soft tissue condition guide the approach. The study recorded that most participants came from urban areas who were in both the hybrid external fixator group and the plating group while the rest came from rural regions. The distribution of treatment modalities showed no geographic bias because the allocation patterns had no significant statistical difference with a value of p = 1.00. The researchers found results that matched the findings of Borah et al who showed their patient group had almost equal urban to rural representation in their study of surgical treatment for open tibial

fractures which showed that this injury affected people from all parts of the population. Towseef Ahmad Bhat et al. conducted their research with participants who lived in both urban and rural areas. The researchers showed that people needed surgical treatment because of their injuries which occurred at places that were closer to medical services than their actual home locations. The participants in our study displayed multiple educational levels which ranged from primary school to postgraduate qualifications. The fixator group had more postgraduates at 24% than the plating group which had 8% but the plating group included more individuals who completed secondary education at 36%. The groups showed no statistically significant difference since p value reached 0.162. According to the study by Saini et al. (2023) educational background of participants did not impact their decision-making process which resulted in different clinical outcomes for hybrid external fixation and bridge plating methods. The study by Prasad et al. (2021) demonstrated that educational awareness improved postoperative compliance and rehabilitation participation yet it did not impact the choice of surgical procedure which depended on anatomical factors and surgical methods and wound management. The present study also evaluated the socio-economic status of participants using a standardized classification system. In the hybrid external fixator group, 32% of patients were from the lower class, compared to 24% in the plating group, while the majority in both groups fell into the upper middle or upper class categories. However, this distribution was not statistically significant (p = 0.623), indicating that economic status did not influence the choice of fixation technique in our cohort.

Comparable findings were reported by Thangamani SK et al. (2022), who observed a mixed socio-economic background among patients undergoing surgical fixation for proximal tibial fractures, but noted no direct correlation between economic status and surgical outcomes. Similarly, Borah PJ et al. (2022) included patients across all socio-economic classes in their comparison of HEF versus internal fixation, and highlighted that access to emergency surgical care, rather than financial background, was more critical in determining treatment modality. While cost-effectiveness may intuitively favor external fixation, Ahmad S Naja et al. (2022) suggested that the total cost difference between HEF and plating becomes minimal when considering overall hospital stay, complications, and rehabilitation, thereby neutralizing socio-economic influence in most institutional settings. Regarding religious distribution, our study found a predominance of Hindu patients in both groups 68% in the fixator group and 76% in the plating group with Muslims comprising the rest. The difference between the groups was not statistically significant (p = 0.753). This demographic composition likely reflects the general population profile of the region and does not bear clinical relevance to surgical outcomes or decision-making. Studies by Prasad et al. (2021) and Saini et al. (2023) did not report religious distribution explicitly, but the neutral impact of socio-cultural factors on clinical outcomes was a consistent finding, reinforcing the observation that religious affiliation does not influence treatment response or functional results.

Our research found that tibia fractures occurred with equal frequency on both sides of the body. The hybrid external fixator group experienced 52% of fractures on the right side and 48% on the left side, whereas the plating group showed a slightly higher left-side fracture rate at 56% compared to the 44% right-side fracture rate. The difference between groups did not reach statistical significance because the p-value remained at 0.777. Reddy RBO and Singh (2020) found no significant lateral predilection in their comparative study of external fixation and plate osteosynthesis for proximal tibial fractures which supports these results. Similarly, Gross et al. (2017) and Bhat et al. (2019) did not find any consistent pattern of laterality affecting functional outcomes or influencing the choice of fixation method. These data support the general understanding that the side of injury in lower limb fractures is more likely to be incidental, related to the dynamics of trauma rather than any anatomical predisposition.

When evaluating the mechanism of injury, the most common causes in both groups were road traffic accidents (RTAs) and accidental falls, followed by other causes. In our cohort, RTAs accounted for 48% and 52% of injuries in the fixator and plating groups respectively, while falls contributed to 44% and 36%, respectively. This distribution did not differ significantly between the two groups (p = 0.803). The predominance of RTAs is in agreement with the findings of Thangamani SK et al. (2022) and Ismail Jan et al. (2016), who noted that high-energy trauma such as RTAs remains the leading cause of proximal tibial fractures, especially in urban and semi-urban populations. Moreover, Kartheek et al. (2017) observed that patients with high-velocity injuries such as RTAs often present with more complex fracture patterns, which may influence the surgical decision toward external fixation, especially when soft tissue integrity is compromised. This clinical consideration aligns with our own observations, where a substantial proportion of HEF cases involved trauma of higher energy mechanisms. The current research used AO/OTA classification system for fracture pattern assessment by examining both 41A2 and 41A3 fracture types. The hybrid external fixator group showed that 56% of its members developed 41A2 fractures while 44% experienced

41A3 fractures. The plating group showed that 52% of its members developed 41A2 fractures while 48% of its members developed 41A3 fractures. The two treatment groups showed identical fracture complexity levels according to statistical analysis which proved non-significant results (p = 1.00). The research results confirm the study by Amin TK et al. (2023) because it used AO type 41A2 and 41A3 fractures as its main focus for testing plating methods which doctors commonly use in their medical operations. The research by Prasad AK et al. (2021) and Saini R et al. (2023) displays their patient classification method which showed both 41A2 and 41A3 fractures had similar treatment results from bridge plating and hybrid external fixation whereas functional outcomes depended on fixation stability and postoperative care rather than fracture subtype. The fixator group showed that 72% of its participants sustained closed fractures while 28% experienced open fractures. The plating group had a similar distribution which showed that 76% of its members sustained closed fractures while 24% experienced open fractures (p = 1.00). The two groups shared similar rates of open fractures which created a standardized point for outcome evaluation. The medical community prefers hybrid external fixators for open fracture treatment because these devices cause less harm to soft tissue and enable less invasive procedures. Borah PJ et al. (2022) found that hybrid external fixation of open type-II tibial fractures showed better outcomes through faster union times shorter surgeries and reduced complications when compared to internal fixation. Thangamani SK et al. (2022) showed that using HEF in open fractures provides early stabilization which does not affect wound healing thus benefiting treatment for complex or contaminated wounds.

The duration of surgery showed significant results between hybrid external fixator and plating methods because hybrid external fixator required 60.56 minutes with a standard deviation of 6.37 minutes while plating needed 71.12 minutes with a standard deviation of 6.64 minutes. The finding matched the results from Borah PJ et al. (2022) which showed that HEF group patients had shorter operative times of 67.6 minutes than those in the internal fixation group for open distal tibial fractures. The decreased surgical duration which results from HEF implementation occurs because it requires less soft tissue dissection and its straightforward fixation methods function effectively in both emergency situations and resource-constrained environments. Our study showed that the fixator group could begin full weight-bearing mobilization three weeks earlier than the plating group, which started at 12.08±2.68 weeks. The results of this study match the results of Thangamani SK et al. 2022 and Zheng Li et al. 2020 who discovered that hybrid and circular external fixation systems enable patients to recover from their injuries faster because these systems maintain their periosteal blood flow and produce little harm to their soft tissues. The assessment of postoperative complications showed that the fixator group experienced higher overall complications than the plating group with 28% in the fixator group and 20% in the plating group. The two groups showed different types of complications that appeared in their assessments. The fixator group experienced pin tract infections which occurred in 20% of cases and delayed union which occurred in 8% of cases as their primary problems which matched the common problems external fixation systems show according to Ismail Jan et al. (2016) and Bhat et al. (2019) who conducted their studies about this specific medical device. The pin-related complications appear with high frequency but medical professionals can handle them through basic treatment methods and the use of oral antibiotics. The plating group showed three types of complications which included four percent of cases with screw backout and twelve percent of cases with superficial wound infections and four percent of cases with wound gaping which typically arise during surgical exposure and during soft tissue handling. Reddy RBO and Singh (2020) established this evidence because they discovered that anatomical reduction through plating produces better results than other methods but it increases the likelihood of soft tissue complications which occur more frequently during open procedures and high-energy fractures. The type of complication should be a key consideration in choosing the fixation technique because all complications which occurred in both groups of this research did not cause life-threatening situations or major disability. The external fixation method becomes the preferred option for open fractures and patients who have poor wound healing capacity because it provides a more secure solution. We used the American Knee Society Score (AKSS) to evaluate functional results in our research. The plating group achieved a mean AKSS score of 72.40 ± 10.84 which exceeded the hybrid external fixator group score of 66.68 ± 12.81. The plating group had superior knee function because their results showed a p-value of 0.039. The study results match the findings of Prasad AK et al. (2021) and Saini R et al. (2023) who demonstrated that bridge plating groups achieved higher AKSS scores than HEF groups in proximal tibial metaphyseal fracture assessments. The plating group achieved a mean AKSS score of 75.45 ± 7.82. The HEF group achieved a score of 68.56 ± 7.11. The study results closely matched our findings. The plating group achieved better functional performance because it provided better joint surface alignment and strong bone fixation and precise bone shape restoration according to Amin TK et al. (2023) results. The clinical distribution of outcome grades; poor, fair, good, and excellent showed no significant differences between groups according to statistical analysis

which found mean AKSS results to be statistically significant. The fixator group showed that 36% of patients achieved good results while 16% of patients reached excellent outcomes. The plating group showed that 28% of patients reached excellent outcomes yet their results maintained a similar pattern across different grading levels. This functional grading pattern is in alignment with Bhat TA et al. (2019) and Thangamani SK et al. (2022) who reported that both HEF and plating can lead to favourable outcomes when appropriately selected based on fracture type soft tissue condition and surgical expertise. The functional scores for HEF show slight reduction compared to other methods. The method provides surgical benefits because it enables doctors to treat patients who face operational challenges during open fracture treatment and who possess extreme surgical requirements. The early mobilization that our HEF group demonstrated can improve joint function throughout the entire recovery period although the immediate postoperative results show better outcomes for the plating group because of their advanced mechanical alignment and stability features which apply to specific situations. The research conducted by Gross et al. (2017) provides confirmation that hybrid external fixation achieves functional outcomes similar to internal fixation based on proper rehabilitation methods according to their long-term follow-up assessments.

Conclusion

The research study compares two surgical methods for treating proximal tibial fractures which include hybrid external fixation and plating as their two different methods. Hybrid external fixation enables shorter surgery periods because it requires 60.56 minutes for operations which operators complete within 71.12 minutes ($p < 0.001$). The method allows open fractures and soft tissue damaged cases and multiple trauma victims to begin weight-bearing activities after 10.24 weeks of treatment. The method results in 20% of patients developing pin tract infections and 8% experiencing delayed union. Plating provides better functional results according to the American Knee Society Score which shows a score of 72.40 for patients who received plating treatment and a score of 66.68 for patients who received other treatments ($p = 0.039$). The procedure has a 12% chance of developing surface infections and produces complications which arise from hardware usage. The decision about which surgical method to use requires surgeons to evaluate three factors which include the fracture type, the patient's tissue condition, and the surgeon's level of experience related to the specific operation. The surgical method which least damages body tissues and allows patients to start moving again should use hybrid external fixation while plating provides benefits when doctors want to restore bone structure precisely and achieve maximum recovery for patients over time.

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