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Original Research Article

Study of functional outcome in proximal tibia fracture fixation using three column concept

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ABSTRACT

Background: Proximal tibia fractures are complex intra-articular injuries often resulting from high-energy trauma. Traditional classification systems like Schatzker and AO/OTA rely on anteroposterior radiographs and may overlook posterior column injuries. The Three-column classification, introduced by Luo et al, utilizes computed tomography (CT) to address multiplanar fractures, particularly those involving the posterior column.
Methods: A prospective study was conducted on 80 patients with closed tibial plateau fractures at a tertiary care centre from January 2021 to January 2022. Fractures were classified using the Three-column concept. All patients underwent Open reduction and internal fixation (ORIF) using column-specific approaches. Functional outcomes were assessed after a minimum follow-up of 6 months using the modified Rasmussen clinical score.
Results: The mean age was 37.88±8.79 years, with a male preponderance (86.2%). Road traffic accidents were the most common mode of injury (88.7%). Two-column fractures were the most frequent (46.2%), followed by three-column fractures (32.5%). Functional outcomes were excellent in 17.5%, good in 68.7%, fair in 11.3%, and poor in 2.5% of cases. The mean Rasmussen score was significantly higher for one-column medial fractures (28±0) compared to two-column (24.05±1.54) and three-column fractures (24.80±1.35). Complications included superficial infection (11.3%), knee stiffness (8.7%) and screw pull-out (7.5%).
Conclusions: The Three-column concept provides a comprehensive understanding of fracture morphology, facilitating precise surgical planning for complex multiplanar injuries. Fixation based on this concept yields satisfactory functional outcomes, although multi-column injuries inherently carry a prognosis of lower functional scores compared to isolated column fractures.

Keywords: Proximal tibia fracture, Three-column classification, Rasmussen score, Posterior column, Functional outcome

INTRODUCTION

Proximal tibia fractures, accounting for approximately 1% of all fractures and 8% of fractures in the elderly, represent a significant challenge in orthopedic trauma.[1] These injuries are frequently caused by high-energy mechanisms such as road traffic accidents and falls from height, leading to complex intra-articular comminution and soft tissue compromise.[2] The primary goals of management are anatomical restoration of the articular surface, maintenance of limb alignment, and stable fixation to allow early mobilization.[3] Historically, the Schatzker classification has been the gold standard for surgical planning. However, its reliance on two-dimensional (2D) anteroposterior radiographs limits its ability to identify coronal plane fractures, particularly those involving the posterior tibial plateau.[4,5] Recent literature suggests that failure to address posterior column fragments can lead to poor functional outcomes and instability.[6] To address these limitations, Luo et al introduced the Three-column

classification system based on Computed Tomography (CT), which divides the tibial plateau into medial, lateral and posterior columns.[7] This 3D conceptualization has revolutionized the surgical approach, advocating for column-specific fixation strategies.[8]

Despite the growing adoption of the Three-column concept, prospective data quantifying functional outcomes in specific fracture patterns remain valuable, particularly in developing countries with a high burden of vehicular trauma.[9] Recent studies in 2024 and 2025 continue to debate the optimal fixation methods for complex Schatzker IV and bicondylar fractures.[10,11] This study aims to evaluate the functional outcomes of proximal tibia fractures managed using the Three-column concept and to analyze the complications associated with this approach.

METHODS

Study design and setting

This prospective observational study was conducted at the Department of Orthopedics, Tirumala Hospitals, Vizianagaram, from January 2021 to January 2022. The study protocol was approved by the Institutional Ethics and Scientific Committee.

Participants

We included 80 patients aged 15 to 60 years with closed tibial plateau fractures. Patients were selected using purposive sampling.

Inclusion criteria

Skeletally mature patients (15-60 years) with closed proximal tibia fractures; willing to give informed consent.

Exclusion criteria

It includes open fractures, pathological fractures (excluding osteoporosis), neurovascular injuries, and concomitant ipsilateral lower limb fractures.

Preoperative assessment

All patients underwent standard radiographic evaluation (AP and Lateral views) and CT scans with 3D reconstruction. Fractures were classified according to the Three-column classification.[7]

Surgical technique

Surgery was performed under spinal or general anesthesia. The surgical approach was dictated by the column involvement: The lateral column is typically addressed using an anterolateral approach, with lateral rafting or L-buttress plating as needed. The medial column is managed through a medial or posteromedial approach with buttress plating. For the posterior column, either a posteromedial (PM) or posterolateral (PL) approach is used depending on the fragment location; these cases often require specific patient positioning such as prone or floating, and may involve combined approaches in multi-column injuries. Commonly used implants include Locking Compression Plates (LCP), T-buttress plates, and 6.5 mm or 4.0 mm cancellous screws.

Postoperative care and follow-up

Mobilization was started based on fracture stability. Follow-up was conducted at 3 weeks, 6 weeks, 3 months and 6 months. Radiological union and functional outcomes were assessed. The primary outcome measure was the Modified Rasmussen clinical score at 6 months, graded as excellent (28-30), good (24-27), fair (20-23), or poor (<20).

Statistical analysis

Data were analyzed using SPSS Version 16. Quantitative variables (age, scores) were expressed as Mean±SD. Qualitative variables were expressed as frequencies and percentages. The Chi-square test and unpaired t-test were used for comparisons, with a $p<0.05$ considered statistically significant.

RESULTS

Demographics

The study included 80 patients with proximal tibia fractures. The mean age of the study population was 37.88±8.79 years, with the highest incidence observed in the 31–40 years age group (47.5%) (Table 1). A clear male predominance was noted, with males accounting for 86.2% of cases (Table 1).

Table 1: Demographic and injury characteristics of patients with proximal tibia fractures.

Variables	Details
Mean age (years)	37.88±8.79
Highest incidence age group	31-40 years (47.5%)
Gender distribution	Male: 86.2%
Mechanism of injury	Road traffic accidents: 88.7%
	Falls from height: 11.3%

Inference

The data indicates that trauma predominantly affects middle-aged adults, particularly those in the 31-40 years age group.

There is a marked male predominance, suggesting that males are at significantly higher risk, possibly due to greater exposure to high-risk activities and occupations.

Road traffic accidents emerge as the leading cause of injury, highlighting them as a major public health concern, while falls from height contribute to a smaller yet notable proportion. Overall, the findings emphasize the need for targeted preventive measures, especially focusing on road safety and risk reduction among the male working population.

Fracture morphology (three-column classification)

Table 2: Distribution of fracture morphology according to three-column classification.

Fracture type	Percentage (%)	Number of cases (n)	Remark
Two-column fractures	0.462	37	Most common
Three-column fractures	0.325	26	
One-column medial	0.113	9	
One-column lateral	0.1	8	

Inference

The CT-based evaluation reveals that complex fracture patterns are more prevalent, with two-column fractures being the most common, followed by three-column fractures. This indicates that a majority of cases involve multi-column involvement, suggesting high-energy trauma as a likely cause. In contrast, isolated one-column fractures (both medial and lateral) are relatively less frequent, reflecting a lower incidence of simpler injury patterns. Overall, the findings highlight the importance of detailed CT assessment for accurate classification and management planning, as most fractures require comprehensive surgical consideration due to their complexity.

Surgical management

Fixation strategies varied by injury pattern

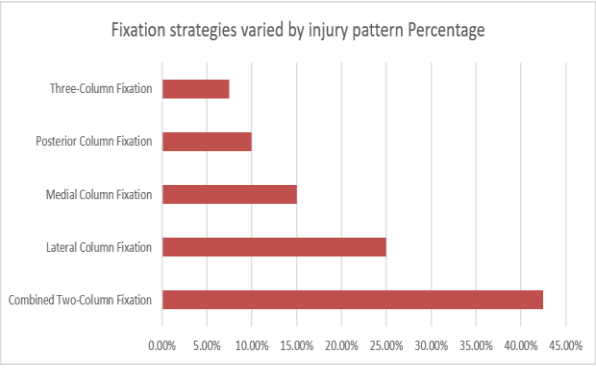

Figure 1: Fixation strategies varied by injury pattern percentage.

Functional outcomes

At the 6-month follow-up, the mean Modified Rasmussen Score varied significantly by fracture type (Table 3).

Table 3: Functional outcome based on modified Rasmussen score.

Fracture type	Mean score (mean±SD)	Clinical grade (majority)
One-column medial	28.00±0.00	Excellent
One-column lateral	26.50±2.07	Good
Two-column	24.05±1.54	Good
Three-column	24.80±1.35	Good

Overall clinical results showed that 86.2% of patients achieved excellent or good outcomes. Statistical analysis revealed that one-column fractures had significantly better outcomes compared to multi-column fractures ($p<0.0001$).

Complications

Most patients (72.5%) had no complications. The observed complications were:

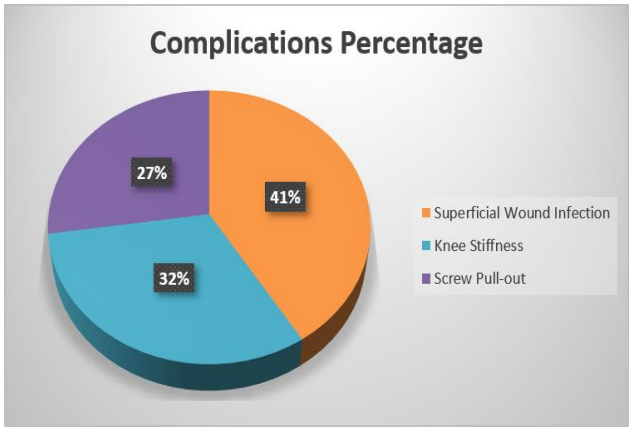

Figure 2: Complications percentage.

DISCUSSION

The management of tibial plateau fractures has evolved from a 2D understanding to a 3D perspective. Our study reinforces the utility of the Three-column classification in managing these complex injuries. The demographic profile of our study (mean age 37.8 years, male predominance) mirrors recent epidemiological trends in developing nations where young males are high-risk candidates for high-energy trauma.[13,14]

Fracture patterns and fixation

We found that two-column fractures were the most prevalent (46.2%). This aligns with findings by Van den Berg et al and recent 2025 data indicating that multi-planar fractures are more common than isolated column injuries

in high-energy trauma.[15,16] The identification of posterior column fragments, which were present in a significant portion of our two- and three-column injuries, is critical. Munde et al recently demonstrated that CT-based classification significantly alters surgical planning compared to Schatzker classification alone, leading to improved reduction of posterior fragments.[10]

Functional outcomes

Our study achieved excellent/good results in 86.2% of cases. This is comparable to contemporary studies; for instance, Selçuk et al reported superior KOOS scores in fractures managed with column-specific fixation.[17] We observed a statistically significant difference between isolated column fractures (mean score 28) and multi-column fractures (mean score ~24). This "prognostic gap" is supported by Gahr et al, who noted that increasing column involvement correlates with higher energy transfer and soft tissue damage, negatively impacting functional recovery.[3]

Complications

Our infection rate (11.3%) was slightly higher than some international series but comparable to studies involving high-energy trauma in similar settings.[18] Jiang et al observed lower infection rates but emphasized that soft tissue handling during dual-plating is the primary determinant.[14] The incidence of knee stiffness (8.7%) highlights the importance of stable fixation that permits early rehabilitation, a core tenet of the Three-column concept.[19]

Limitations

The study was limited by a modest sample size (n=80) and a relatively short follow-up (6 months), which may not capture long-term post-traumatic osteoarthritis. Future research should focus on long-term biomechanical outcomes of novel hybrid fixation techniques.

CONCLUSION

The Three-column classification is an essential tool for the preoperative evaluation of proximal tibia fractures. It allows for a precise understanding of fracture morphology, particularly regarding posterior column involvement. While single-column fractures yield excellent functional results, multi-column injuries managed with this concept still achieve good functional outcomes in the majority of patients. We recommend the routine use of 3D-CT and column-specific fixation for all intra-articular proximal tibia fractures.

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Ethical approval: The study was approved by the Institutional Ethics Committee

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