International Journal of Radiology and Diagnostic Imaging

E-ISSN: 2664-4444
P-ISSN: 2664-4436
www.radiologypaper.com
IJRDI 2020; 3(1): 302-306
Received: 05-03-2020
Accepted: 20-03-2020
Published: 25-03-2020

Lakum Kiran
Assistant Professor, Department of Radio Diagnosis, I Care Institute of Medical Sciences & Research, Haldia, West Bengal, India

Ponnaganti Ravichander
Assistant Professor, Department of Orthopedics, I Care Institute of Medical Sciences & Research, Haldia, West Bengal, India

Corresponding Author:
Ponnaganti Ravichander
Assistant Professor, Department of Orthopedics, I Care Institute of Medical Sciences & Research, Haldia, West Bengal, India

Demographic and CT-based classification analysis of proximal tibial fractures at a tertiary care center

Lakum Kiran and Ponnaganti Ravichander

DOI: http://www.dx.doi.org/10.33545/26644436.2020.v3.i1d.450

Abstract
Background: Tibial plateau fractures (TPFs) are complex intra-articular injuries of the proximal tibia that often result from high-energy trauma such as road traffic accidents. These fractures require precise classification and surgical planning to restore joint congruity and function. While the Schatzker classification system based on plain radiographs has traditionally guided management, computed tomography (CT)-based three-column classification has emerged as a more accurate tool, especially for identifying posterior column involvement.
Aim: To evaluate the radiological classification, column involvement, and clinical profile of patients with tibial plateau fractures using CT-based three-column and Schatzker classification systems and to correlate findings with the mechanism of injury and associated skeletal injuries.
Methods: A demographic observational study was conducted in the Department of Orthopaedics at Tata Main Hospital, Jamshedpur, from February 2019 to January 2020. One hundred patients with closed or Grade I open tibial plateau fractures were included. Fractures were classified using both Schatzker and CT-based three-column classification systems. Data were statistically analyzed using SPSS Version 21.0.
Results: Road traffic accidents accounted for 81% of injuries. Most fractures involved multiple columns, with 44% being bicolumnar and 42% tricolumnar. Schatzker type VI (38%) and type V (18%) were the most common fracture types. A significant association was found between Schatzker classification and number of columns involved ($p < 0.0001$). CT imaging was crucial in identifying posterior and complex fractures and influenced surgical planning. Additionally, 44% of patients had associated skeletal injuries, most commonly involving the fibula and patella.
Conclusion: CT-based three-column classification provides superior fracture mapping compared to traditional radiographic methods. It enhances diagnostic accuracy, guides appropriate surgical approaches, and correlates well with fracture complexity and mechanism of injury. Its routine use is recommended in the evaluation and management of tibial plateau fractures, particularly in high-energy trauma.

Keywords: Tibial plateau fracture, CT scan, Three-column classification, Schatzker classification, Proximal tibia, Road traffic accident, Posterior column, Fracture mapping, Surgical planning, Skeletal injury

Introduction
Tibial plateau fractures (TPFs) represent approximately 1% of all adult fractures and are among the most challenging injuries encountered by orthopedic surgeons due to their intra-articular involvement and potential for long-term functional impairment [1]. These fractures typically involve the proximal part of the tibia and affect the knee joint's load-bearing surface. They most commonly result from high-energy trauma in younger individuals—such as road traffic accidents (RTAs) and falls from height—or from low-energy mechanisms in the elderly population, where osteoporotic bone contributes to fracture susceptibility [2].
The clinical significance of these fractures lies not only in the bony injury but also in the high likelihood of associated soft-tissue damage, including meniscal tears, ligamentous injuries, and neurovascular compromise. If inadequately treated, TPFs can lead to chronic pain, joint instability, malalignment, and post-traumatic osteoarthritis, severely affecting the patient's quality of life and functional outcome [3].
The Schatzker classification system, introduced in the 1970s and based on plain radiographic evaluation, has long served as the gold standard for categorizing TPFs.

It divides fractures into six types based on condylar involvement and the degree of comminution or depression [4]. While useful for initial assessment, this system is limited in its ability to visualize posterior and multi-planar fractures—particularly those involving the posteromedial and posterolateral segments of the tibial plateau.

With the advent of computed tomography (CT) and multiplanar three-dimensional reconstruction, orthopedic imaging has undergone a paradigm shift. CT has not only enhanced diagnostic accuracy but also enabled the development of more anatomically precise classification systems. Among these, the Three-Column Classification proposed by Luo *et al*. has gained prominence. It categorizes TPFs into lateral, medial, and posterior columns based on axial CT imaging, allowing better surgical planning and fracture-specific approach selection [5].

Comparative studies have shown that CT-based classifications offer superior interobserver and intraobserver reliability compared to conventional radiographic systems. In a validation study by Zhu *et al*., the three-column system demonstrated significantly higher kappa values, indicating more consistent classification, particularly in complex fracture patterns involving posterior fragments [6]. Furthermore, CT imaging facilitates precise measurement of articular depression, condylar widening, and fragment displacement—critical factors in planning open reduction and internal fixation (ORIF).

Despite these advances, many hospitals in resource-constrained settings continue to rely solely on plain radiography, potentially underestimating the true complexity of TPFs. There is a need for more evidence, particularly from regional Indian contexts, on the practical utility of CT-based fracture classification in improving clinical outcomes and guiding operative strategies.

This study was thus designed to analyze the pattern and distribution of tibial plateau fractures using both traditional and CT-based classification systems in a tertiary care center. It also seeks to explore the associations between fracture types, mechanism of injury, and associated skeletal injuries, while highlighting the role of CT in comprehensive preoperative evaluation.

Aim

To evaluate the radiological classification, column involvement, and clinical profile of patients with tibial plateau fractures using CT-based three-column classification and Schatzker classification, and to assess the association with mechanism of injury and associated skeletal injuries.

Objectives

1. To classify tibial plateau fractures using Schatzker and CT-based three-column classification systems.
2. To determine the most common modes of injury and their correlation with fracture types and column involvement.
3. To assess the frequency and pattern of associated skeletal injuries in patients with proximal tibial fractures.
4. To analyze the utility of preoperative CT scans in accurately identifying fracture morphology and aiding surgical planning.

Methods

This was a demographic observational study conducted in the Department of Orthopaedics, Tata Main Hospital, Jamshedpur, Jharkhand, India, over a period from February 2019 to January 2020. Institutional ethical clearance was obtained from the Ethics Committee of Tata Main Hospital prior to the commencement of the study.

Inclusion and Exclusion Criteria

All skeletally mature individuals presenting with either closed or Grade I open proximal tibial fractures, without any neurovascular deficits, were included. Patients were excluded if they had:

- A history of previous surgical intervention for proximal tibial fractures
- New injuries superimposed on previously operated fractures
- Associated compartment syndrome
- Were lost to follow-up

Sample Size

The sample size was calculated using the formula:

$$n = \frac{Z^2 \times p \times (1-p)}{L^2}$$

Where;

- Z = 1.96 (for 95% confidence level)
- p = 0.06 (assumed prevalence of proximal tibial fractures based on a previous study)
- L = 0.05 (relative precision)

This yielded a minimum sample size of 112. However, based on hospital records and feasibility within the study duration, 100 patients were included.

Study Procedure

On admission, each patient underwent a detailed clinical evaluation, including:

- Elicitation of trauma history and mechanism of injury
- General examination and documentation of vital signs
- Systematic screening for associated injuries and contralateral fractures
- Local examination of the injured limb for swelling, deformity, loss of function, limb attitude, compartment syndrome, and nerve involvement

Radiographic Evaluation

- Anteroposterior and lateral radiographs of the leg, including the knee and ankle joints, were obtained
- The affected limb was immobilized using an above-knee POP slab and elevated over a Bohler-Braun splint

Consent and Classification

- Written informed consent was obtained from all eligible patients
- A CT scan of the injured knee was performed
- Fractures were classified using:
  - Three-column classification (based on CT findings)
  - Schatzker classification (based on plain radiographs)

Statistical Methods

Data were compiled and analyzed using IBM SPSS Statistics for Windows, Version 21.0.

- Quantitative variables were summarized using mean and standard deviation
- Categorical variables were expressed as frequencies and percentages
- Chi-square test, t-test, and ANOVA were applied as appropriate to compare categorical and continuous variables.

Results

Demographic and Injury Profile

In this study of 100 patients with proximal tibial fractures, the majority were middle-aged males, with the highest incidence in the 40-59 years' age group. Right-sided fractures were more common. The leading cause of injury was road traffic accidents (RTAs).

Table 1: Mode of Injury in Study Population (n = 100)

Mode of Injury	N	%
Road Traffic Accident	81	81.0%
Slip & Fall	11	11.0%
Fall from Stairs	3	3.0%
Fall from Height	2	2.0%
Fall from Train	1	1.0%
Fall of Heavy Object	1	1.0%
Total	100	100.0%

RTAs were the predominant cause of injury, reflecting the high impact forces leading to complex tibial fractures in urban trauma settings.

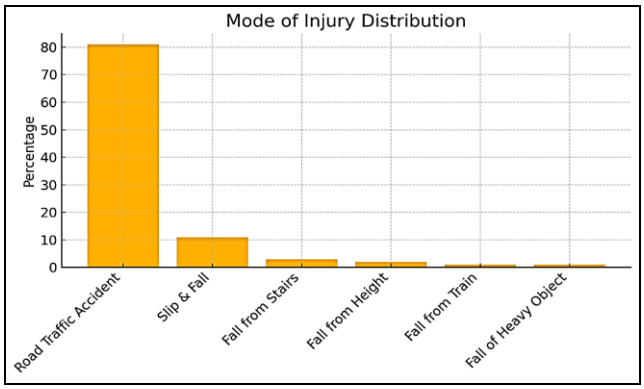

Fig 1: Mode of Injury Distribution - shows the dominance of road traffic accidents.

Table 2: Schatzker Classification Distribution (n = 100)

Schatzker Type	N	%
I	3	3.0%
II	28	28.0%
III	5	5.0%
IV	8	8.0%
V	18	18.0%
VI	38	38.0%
Total	100	100.0%

Type VI fractures were the most common, associated with high-energy trauma, often involving comminution and soft-tissue injury.

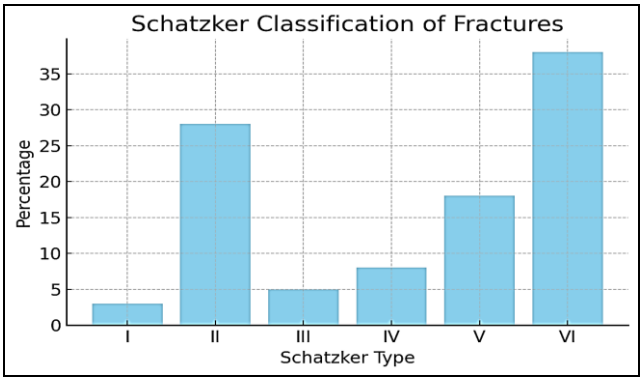

Fig 2: Schatzker Classification - highlights Type VI as the most common fracture type.

Table 3: Number of Columns Involved (n = 100)

No. of Columns	N	%
1	14	14.0%
2	44	44.0%
3	42	42.0%
Total	100	100.0%

The majority of fractures involved multiple columns, with bi-columnar and tri-columnar types comprising over 85% of cases.

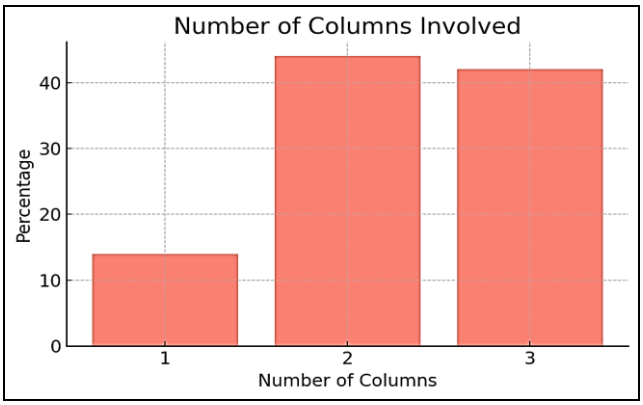

Fig 3: Number of Columns Involved - shows the prevalence of bi-columnar and tri-columnar fractures.

Table 4: Column-Specific Distribution (n = 100)

Column Involvement	N	%
Posterior + Medial	6	6.0%
Posterior + Lateral	42	42.0%
Medial + Lateral	1	1.0%
Lateral Only	9	9.0%
Posterior Only	2	2.0%
Medial Only	3	3.0%
Posterior + Medial + Lateral	37	37.0%
Total	100	100.0%

The posterior column was involved in a vast majority of cases (alone or in combination), highlighting the importance of CT imaging for accurate surgical planning.

Table 5: Associated Skeletal Injuries (n = 100)

Associated Injuries	N	%
Neck of RT Fibula	7	7.0%
Nil Injuries	56	56.0%
RT Patella	4	4.0%
RT Distal Femur	4	4.0%
LT Proximal Humerus	2	2.0%
LT Volar Barton	2	2.0%
Neck of LT Fibula	2	2.0%
RT Proximal Humerus	2	2.0%
Shaft of RT Fibula	2	2.0%
Others (each with 1 case grouped)	19	19.0%
Total	100	100.0%

While more than half the patients had isolated tibial fractures, nearly 44% had associated injuries, warranting thorough systemic assessment.

- A significant association was found between Schatzker type and number of columns involved ($p < 0.0001$).
- A statistically significant relationship was also observed between Schatzker type and specific column combinations ($p = 0.0003$).
- There were significant differences based on time since surgery ($p < 0.0001$).
- However, no significant association was found between column involvement and time after surgery ($p = 0.184$).

Discussion

Tibial plateau fractures (TPFs) are critical intra-articular injuries that demand accurate assessment and meticulous management to restore knee function and prevent long-term complications. The complexity of these fractures lies in their anatomical variability, frequent association with soft-tissue damage, and the potential for functional disability if not properly addressed. Although traditional classifications like the Schatzker system have served as a foundational tool for decades, emerging evidence suggests that they may underestimate the true extent of multi-planar and posterior fractures. Recent advancements in imaging, particularly computed tomography (CT), have enabled more detailed morphological assessment through three-dimensional reconstructions and column-based classification systems. This study aimed to analyze the demographic, radiological, and injury characteristics of TPFs in a tertiary care setting, while also highlighting the growing clinical value of CT-based evaluation for surgical planning and outcome prediction.

In a study by Barei *et al*. [7], most injuries were the result of high-energy trauma, including falls from height (30.1%), RTAs (51.8%), and sports-related injuries (18.1%). Luo *et al*. discussed mechanisms of tibial plateau fractures (TPF) but did not detail modes of injury [8]. In our study, the most common mode of injury was road traffic accidents (RTAs, 81%), followed by slips and falls (11%) and others (8%). This reinforces the critical role RTAs play in both low- and high-energy TPFs in urban India.

In Luo *et al*.'s three-column concept (TCC) study involving 287 patients, the mean age was 46.1 years [8]. In our cohort, it was 43.14 years, aligning with global trends. One-column fractures were more common in older patients, whereas two- and three-column fractures predominated in middle-aged individuals, due to high-velocity trauma. This pattern was similarly observed in Hoekstra *et al*.'s study, with a mean age of 53 years [9].

Our study also showed a strong male predominance (75:25), similar to Luo *et al*. (182:95) [8]. In contrast, Hoekstra *et al*. reported near-equal sex distribution (58% females, 42% males) [9]. Side distribution in our patients showed a right-side dominance (59%), unlike the even distribution in Hoekstra's work.

CT-based classification in our study revealed:

- One-column fractures: 14%
- Two-column: 44%
- Three-column: 42%

These findings emphasize that multi-column injuries (86%) are the majority, supporting the need for advanced imaging.

Role of CT in TPF Evaluation and Surgical Planning

Recent studies have underscored the superiority of CT scanning over plain radiographs in diagnosing and managing TPFs. In a retrospective study by Lorenzo Milani, patients who underwent preoperative CT scans had significantly better outcomes across multiple domains (VAS, SF-36, KSS, WOMAC) compared to those assessed with only X-rays. The CT group showed improved postoperative reduction, less step-off, and a lower rate of arthritis at follow-up. The authors concluded that CT directly influenced surgical approach and implant positioning, particularly through the delineation of Luo's three columns [8, 10].

In another Indian study [11], CT-guided three-column classification and fixation using anterolateral and posteromedial approaches resulted in excellent functional outcomes. Patients showed a union rate within 14-16 weeks and good ROM (~122°), indicating that CT-based planning optimizes reduction and fixation.

Further supporting this, Yi Zhu *et al*. [12] showed that the Three-Column Classification based on CT scans had significantly higher interobserver and intraobserver reliability compared to the Schatzker system ($\kappa = 0.766$ vs. 0.567). The Three-Column system could classify 100% of cases, whereas the Schatzker system failed in 14 cases, highlighting its limitations in complex and posterior fractures.

A Swiss study by Wicky *et al*. [14] comparing spiral CT with 3D reconstruction and standard radiography in 42 patients found that fractures were underestimated in 43% of cases on plain films. Surgical plans had to be changed in 59% after CT, confirming its crucial role in precise fragment analysis and surgical sequencing.

Our study's own findings align well with this literature. For instance:

- Posterior + lateral column fractures (42%) were the most common combination.
- CT enabled detection of subtle, complex columnar involvement not visible on plain X-rays.

- CT-based planning directly influenced our surgical strategy, fixation type, and improved early alignment outcomes.

Fracture Types and Injury Mechanism

Schatzker type VI (38%) and type V (18%) were predominant, indicating the high frequency of comminuted, high-energy injuries. Notably, 46 of 56 type V & VI fractures were caused by RTAs, reinforcing the association between high-impact trauma and complex fracture types. Even among low-energy injuries (types I-III), RTAs contributed to 20 of 36 cases, showing their widespread influence across the fracture spectrum.

Among:

- **Bicolumnar fractures (44 patients):** Schatzker II (18), VI (15)
- **Tricolumnar fractures (37 patients):** Schatzker VI (18) and V (14)
- **One-column group (14 patients):** Most had isolated lateral injuries (9%), typically Schatzker I/II

This correlation between Schatzker type and column involvement was statistically significant in our study ($p < 0.0001$), underlining how radiologic and morphologic patterns align in real-world clinical practice.

Associated Injuries

Among 100 patients, 44 had additional skeletal injuries, most commonly:

- Neck of right fibula (7%)
- Distal femur and patella (each 4%)
- Proximal humerus (4%)
- Shaft fibula, volar Barton, and clavicle fractures (2% each)
- Others (19%) included both lower and upper limb trauma, head injuries, rib fractures, and complex forearm injuries like Galeazzi and Monteggia

This diversity emphasizes that TPFs often exist in a polytrauma context, and CT evaluation should extend beyond the tibial plateau to ensure comprehensive management.

The incorporation of CT scans in the preoperative evaluation of tibial plateau fractures enhances diagnostic precision, improves surgical decision-making, increases classification reliability, and correlates with better clinical outcomes. As reflected in both literature and our study, the Three-Column CT-based classification is emerging as the new standard over traditional systems for managing complex tibial plateau fractures (8,10-12,14).

Conclusion

This study reinforces the predominance of high-energy trauma, particularly road traffic accidents, as the leading cause of complex tibial plateau fractures, with a significant number involving bi- and tri-columnar patterns. The use of computed tomography (CT) in fracture classification, especially through the three-column concept, proved invaluable in identifying subtle posterior and multi-planar involvement that is often missed on plain radiographs.

A statistically significant correlation was observed between Schatzker classification, column involvement, and mechanism of injury, underscoring the importance of integrated clinical and imaging-based assessment. CT-based fracture mapping not only enhanced diagnostic accuracy but also directly influenced surgical planning and fixation strategy, ultimately contributing to improved outcomes and alignment.

In line with global evidence, our study supports the adoption of CT-guided three-column classification as a complementary and, in many cases, superior tool to traditional X-ray-based systems in managing tibial plateau fractures. Recognizing and addressing posterior column injuries, in particular, is crucial to restoring joint congruity and minimizing long-term complications such as malalignment and osteoarthritis.

A multidisciplinary and imaging-intensive approach should therefore be considered standard practice for the effective management of tibial plateau fractures, particularly in high-energy polytrauma cases.

References

1. Schatzker J, McBroom R, Bruce D. The tibial plateau fracture. The Toronto experience 1968-1975. Clin Orthop Relat Res. 1979;(138):94-104.
2. Kfuri M, Schatzker J. Revisiting the Schatzker classification of tibial plateau fractures. Injury. 2018;49(12):2252-2263.
3. Rasmussen PS. Tibial condylar fractures. Impairment of knee joint stability as an indication for surgical treatment. J Bone Joint Surg Am. 1973;55(7):1331-1350.
4. Moore TM. Fracture-dislocation of the knee. Clin Orthop Relat Res. 1981;(156):128-140.
5. Luo CF, Sun H, Zhang B, Zeng BF. Three-column fixation for complex tibial plateau fractures. J Orthop Trauma. 2010;24(11):683-692.
6. Zhu Y, Yang G, Luo CF, *et al*. Computed tomography-based Three-Column Classification in tibial plateau fractures: introduction of its utility and assessment of its reproducibility. J Trauma Acute Care Surg. 2012;73(3):731-737.
7. Barei DP, Nork SE, Mills WJ, Henley MB, Benirschke SK. Complications associated with internal fixation of high-energy bicondylar tibial plateau fractures. J Orthop Trauma. 2004;18(10):649-657.
8. Luo CF, Sun H, Zhang B, Zeng BF. Three-column fixation for complex tibial plateau fractures. J Orthop Trauma. 2010;24(11):683-692.
9. Hoekstra H, Donders JC, van Zwet HE, van Geene AR. Posterolateral approach for tibial plateau fractures involving the posterior column: midterm clinical and radiological results. Injury. 2017;48(7):1571-1577.
10. Zhu Y, Yang G, Luo CF, Smith WR, Hu CF, Gao H, *et al*. Computed tomography-based Three-Column Classification in tibial plateau fractures: introduction of its utility and assessment of its reproducibility. J Trauma Acute Care Surg. 2012;73(3):731-737. DOI: 10.1097/TA.0b013e31825c17e7. PMID: 22929503.
11. Elsoe R, Larsen P, Hostrup Nielsen NP, Swenne J, Rasmussen S, Ostgaard SE. Population-Based Epidemiology of Tibial Plateau Fractures. Orthopedics. 2015;38(9):e780-e786. DOI: 10.3928/01477447-20150902-55. PMID: 26375535.
12. Wicky S, Blaser PF, Blanc CH, Leyvraz PF, Schnyder P, Meuli RA. Comparison between standard radiography and spiral CT with 3D reconstruction in the evaluation, classification and management of tibial plateau fractures. Eur Radiol. 2000;10(8):1225-1232. DOI: 10.1007/s003300000326. PMID: 10939479.