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Case Series

Does 4 column classification of upper tibia fracture gives you better idea of fixation and impact on clinical outcome-analysis of 50 cases?

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ABSTRACT

Background: The management of proximal tibia fracture has underdone significant changes in the recent years, while the main goals remain same i.e. to achieve a smooth articular surface, mechanical axis and joint stability. Recent advances in computed tomography and MRI based imaging have led to better understanding and classification of fracture and therefore better planning for treatment.

This is a prospective analysis of the proximal tibia fracture managed as per 4 column 10 segment concept in view of functional outcomes.

Materials and Methods: Radiological and functional outcomes using knee society score of the proximal tibia fractures operated and classified as per computed tomography based 4 column 10 segment concept were studied at 6 weeks, 3 months, 6 months and 9 months from year 2019 to 2022.

Results: Mean age of population sustaining proximal tibia fracture among males was 43.90 years and females was 48.71y with 86% predilection for male and 14% for female. Involvement of right tibia was 50 % in comparison to left tibia which was 46%, while 4% patients had involvement of both limbs. Distribution of proximal tibia fracture ; zero column -7.69%, one column- 55.77%, two column-21.15%, three column-15.38% average knee society score for proximal tibia fracture at the end of 9 months (knee score, function score) 87.65;79.54.

Single incident of superficial infection was encountered managed with debridement and parenteral antibiotics. Single incident of surgical site infection managed with implant removal, debridement and parenteral antibiotics as per culture sensitivity. Single incident of common peroneal nerve palsy was encountered repaired with extended Lobenhoffer approach.

Conclusion: Recent computed tomography based classification are very useful for fixation and deciding most suited surgical approach for proximal tibia fractures to achieve a smooth articular surface, mechanical axis and joint stability. Still, a long-term study with large study group is needed to confirm the usefulness of the same.

1. Introduction

Proximal tibia fractures are relatively common lower limb fractures and account for 1% of the total fractures[1] with an estimated annual incidence of 10 per 100,000 people. While these fractures are more common in men overall elderly females are more prone to experiencing them. Most proximal tibia fractures occur between ages 40 and 60 in both genders.[2]

In men, high-energy events like motor vehicle accidents are the primary cause of proximal tibial fractures. On the other hand, women often sustain these fractures through low-energy incidents such as falls during walking or cycling.[2] Low-energy injuries typically lead to one-

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sided depression-type fractures, while high-energy incidents can result in more complex comminuted fractures with significant damage to bone, soft tissues, and nerves.[3]

Fractures involving the proximal tibia can occur from various forces, including medial, lateral, or axial impacts. Medially directed forces, like a valgus forces are associated with classic "bumper fractures" seen in motor vehicle versus pedestrian accidents.[4] More complex mechanisms involve combination of axial, varus, or valgus forces. In many cases, both shearing and compressive forces act on the underlying tibial plateau through the femoral condyle, either medially or laterally.[5] Classification of proximal tibia fractures as per mechanism of injury has been provided below. (Table 1)

Over the years management protocols of proximal tibia fractures have undergone significant changes but the main goal remains the same i.e. to maintain articular congruity, mechanical axis and joint stability.

Recent advances in the field of radiology with 3d computed tomography scans and MRI have helped to better classify the complex fracture patterns and associated soft tissue injury and also decide the plan of treatment and surgical approach to be taken.

Following paper documents, a case series of 50 cases managed as per classification and functional outcomes obtained in the form of knee society score.

2. Management of proximal tibia fractures

2.1. Classification

Classification system of proximal tibia has changed significantly over the years since the advent of modern radiological investigations. Below are the classification systems commonly used.

1. Schatzker et al.[5]
2. The Ao/ Ota classification
3. Moore classification
4. Tscherne et al.[6]
5. Three-column concept of Luo and co-workers,[7] later modified by Hoekstra et al[8] (Figure 1)
6. The 10- segment concept of Krause et al[9] (Figure 2)

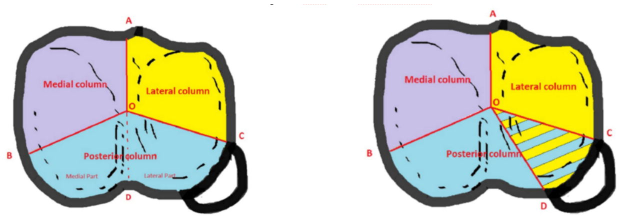

Figure 1: Three-column concept of Luo and Hoekstras's modification

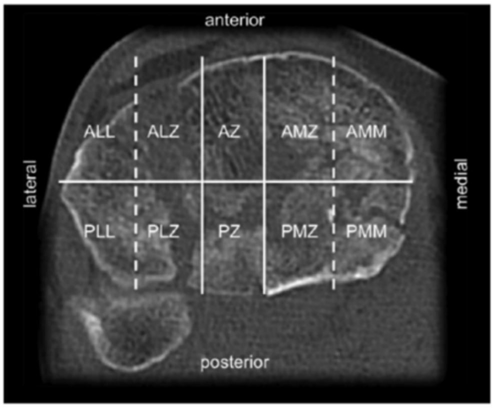

Figure 2: 10 segment classification according to Krause et al[9] ALL, Anterolaterolateral; ALZ, Anterolaterocentral; AZ, Anterocentral, AMZ, Anteromediocentral; AMM, Anteromediomedial; PLL, Posterolaterolateral; PLZ, Posterolaterocentral; PZ, Posterocentral; PMZ, Posteromediocentral; PMM, Posteromediomedial

2.2. Diagnosis

An essential diagnostic step involves assessing soft tissue damage, classified by Tscherne and Oestern,[6] crucial for planning further treatment. For open fractures, Gustilo and Anderson's Classification is widely used.[10] Special attention is needed for compartment syndrome and potential harm to neurovascular structures, particularly in the popliteal region.

Proximal fibula involvement may affect the peroneal nerve. Compartment syndrome, especially when the fracture extends into the tibial shaft, requires immediate attention.

Conventional x-rays quickly evaluate the fracture type, while computed tomography provides detailed 2d and 3d reconstructions for complex fractures, thereby helping in classification and planning treatment. In knee dislocations with suspected arterial lesions or low ankle-brachial index (ABI), angiography is essential. MRI aids in recognizing ligament trauma and assessing intra- and extraarticular structures, enhancing diagnostic precision.

2.3. Treatment options

Various treatment options available as per fracture patterns are listed below

1. Conservative treatment
2. Arthroscopic assited reduction and internal fixation(fracturoscopy)
3. Closed reduction and percutaneous fixation
4. Definative treatment with external fixation
5. Open reduction internal fixation

A pictographic representation of the management of the different case scenarios encountered has been listed below.

Table 1: Classification of proximal tibia fracture as per mechanism of injury

Classification				
Varus(VR)	1. Mild varus	Medial condyle fracture with/without coronal split		Valgus
	2. Severe varus	Medial condyle fracture with/without coronal split	Lateral condyle fracture	Valgus
	3. Varus+Axial compression	Medial condyle fracture with/without coronal split	Lateral condyle subluxation with depression/split depression	Valgus +traction
Varus flexion (VRF)	1. Mild varus	Postero-medial condyle fracture		Valgus + extension
	2. Severe varus	Postero-medial condyle fracture	Lateral condyle fracture	Valgus + extension
	3. Varus+Axial compression	Postero-medial condyle fracture	Lateral condyle subluxation with depression/split depression	Valgus + extension + traction
Varus hyperextension(VRE)	1. Mild varus	Antero-medial condyle fracture		Valgus + flexion
	2. Severe varus	Antero-medial condyle fracture	Lateral condyle fracture	Valgus + flexion
	3. Varus+Axial compression	Antero-medial condyle fracture	Lateral condyle subluxation with depression/split depression	Valgus +flexion + traction
Valgus(VL)	1. Mild valgus	Lateral condyle depression/split depression		Varus
	2. Severe valgus	Lateral condyle depression/split depression	Medial condyle fracture	Varus
	3. Valgus+Axial compression	Lateral condyle depression/split depresion	Medial condyle subluxation	Varus + traction
Valgus flexion(VLF)	1. Mild valgus	Postero-lateral condyle fracture		Varus + extension
	2. Severe valgus	Postero-lateral condyle fracture	Medial condyle fracture	Varus + extension
	3. Valgus+Axial compression	Postero-lateral condyle fracture	Medial condyle subluxation	Varus + extension + traction
Valgus hyperextension(VLE)	1. Mild valgus	Antero-lateral condyle fracture		Varus + flexion
	2. Severe valgus	Antero-lateral condyle fracture	Medial condyle fracture	Varus + flexion
	3. Valgus+Axial compression	Antero-lateral condyle fracture	Medial condyle subluxation	Varus + flexion + traction

Pre-op X ray Pre-op MRI films 9 month follow up X ray

Figure 3: Case 1: Case of ACL avulsion fracture managed with arthroscopic assisted pull through technique with biofibre wire

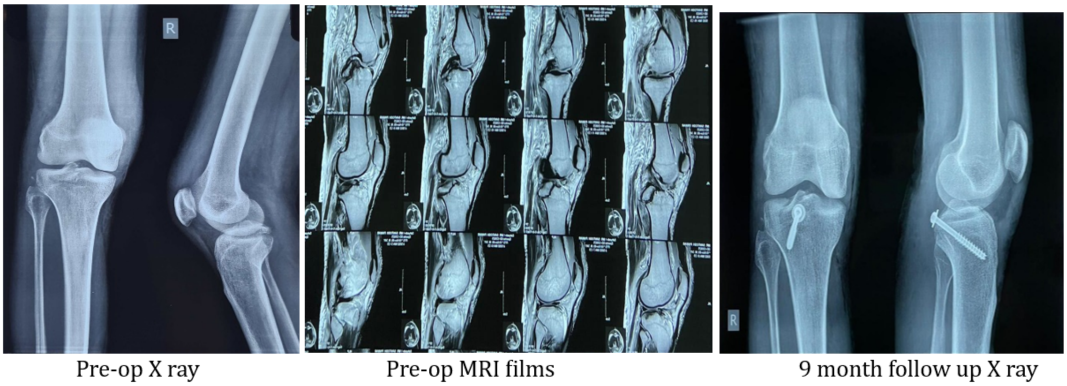

Figure 4: Case 2: Case of PCL avulsion fracture managed with open reduction internal fixation with cc screw

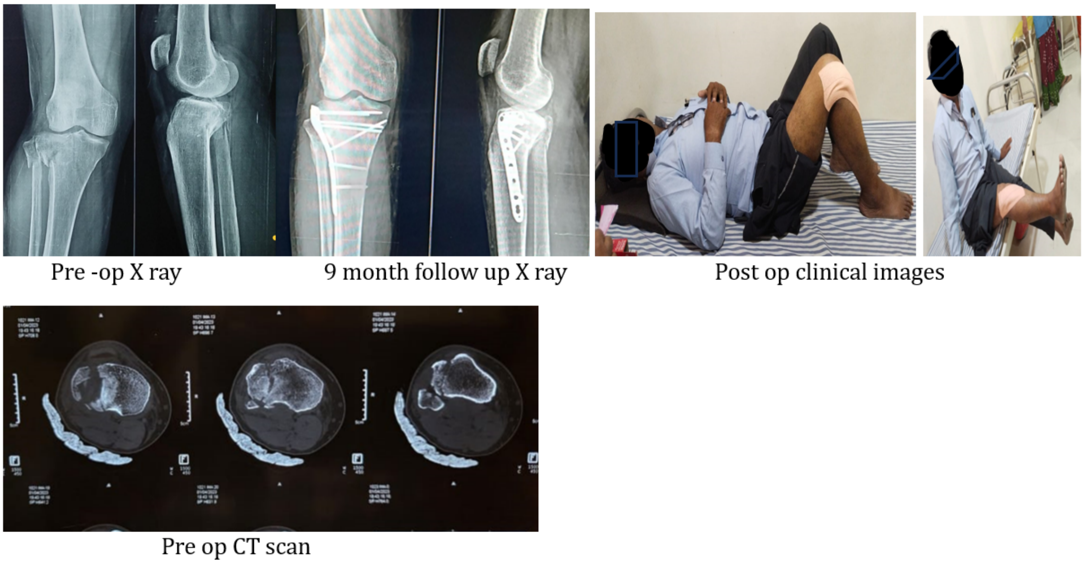

Figure 5: Case 3: Case of lateral column proximal tibia fracture managed with open reduction internal fixation

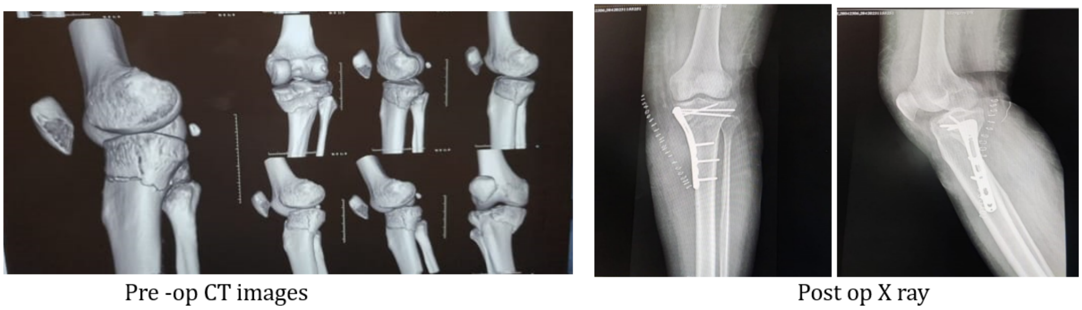

Figure 6: Case 4: Case of medial column proximal tibia facture managed with open reduction internal fixation

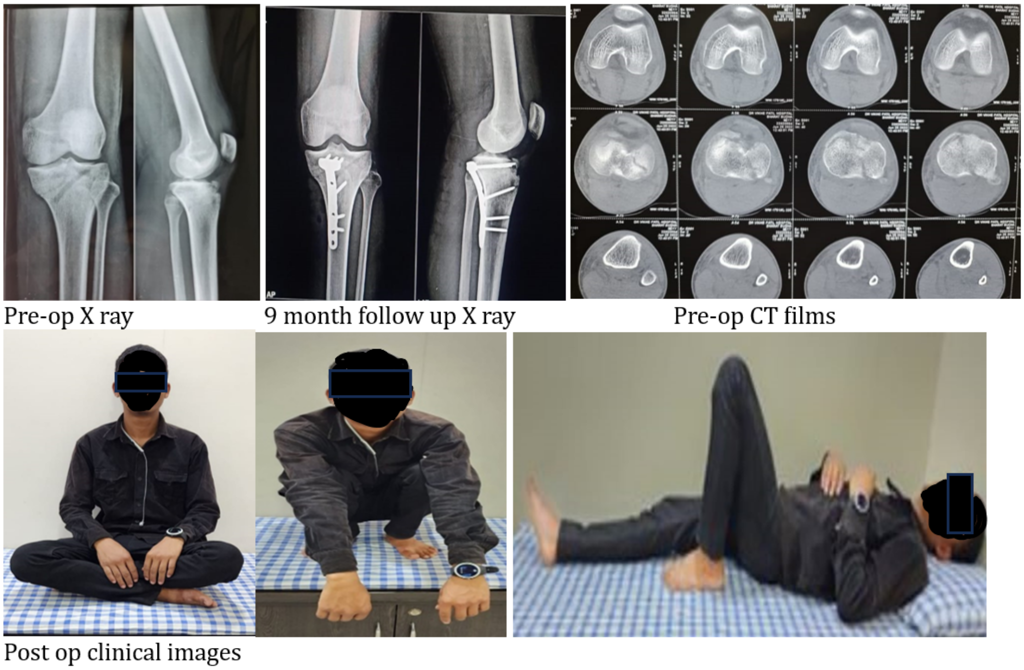

Figure 7: Case 5: Case of posterior column tibia fracture managed with open reduction internal fixation

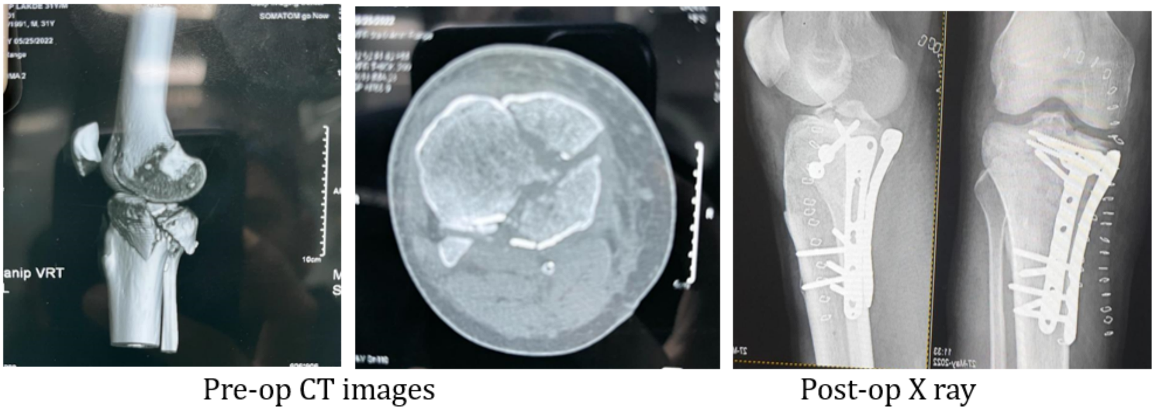

Figure 8: Case 6: Case of medial and posterior column tibia fracture managed with open reduction internal fixation

Figure 9: Case 7: Case of lateral and posterior column tibia fracture managed with open reduction internal fixation

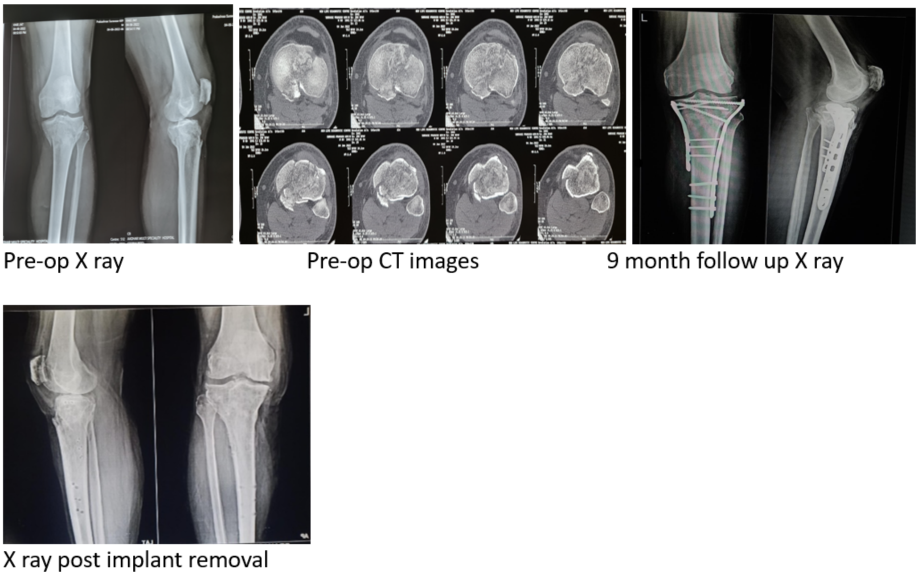

Figure 10: Case 8: Case of medial and lateral column tibia fracture managed with open reduction internal fixation

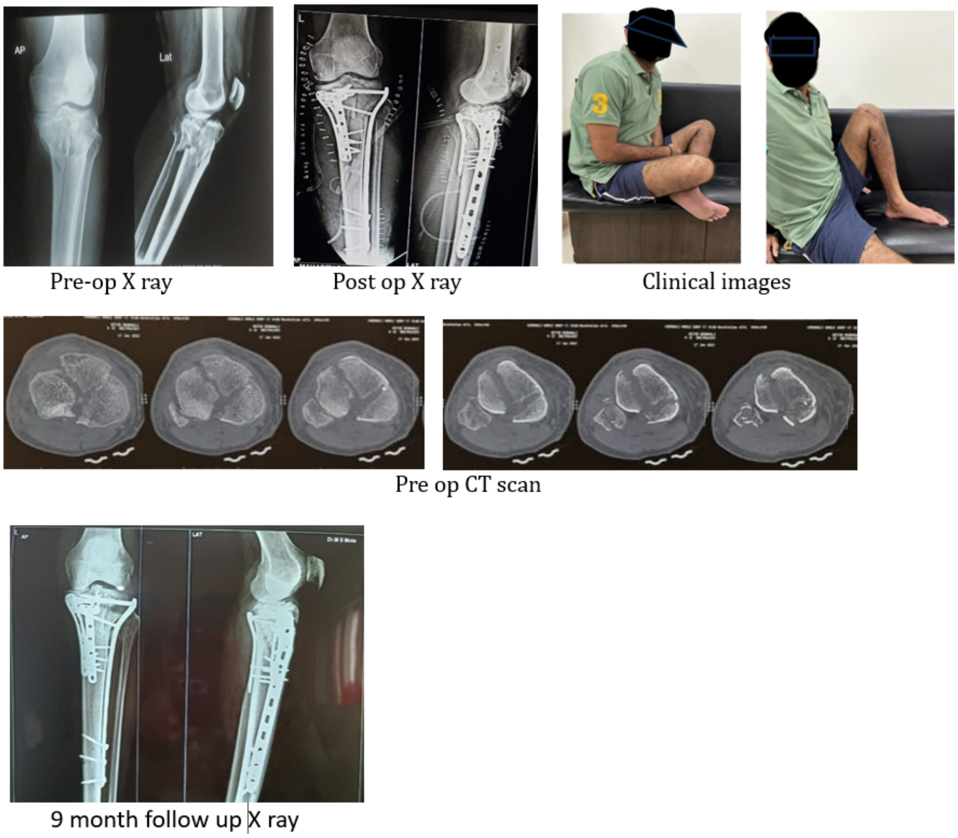

Figure 11: Case 9: Case of medial, lateral and posterior column tibia fracture managed with open reduction internal fixation

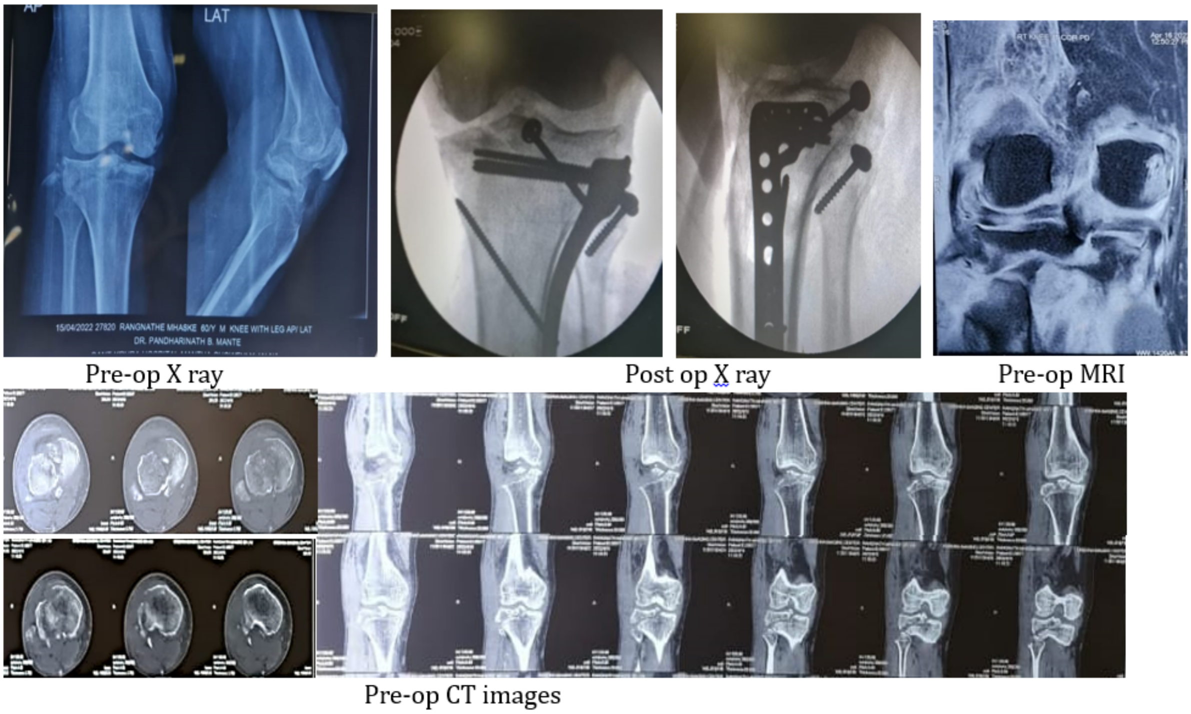

Figure 12: Case 10: Case of lateral column fracture with posterior cruciate ligament avulsion fracture and lateral collateral ligament injury

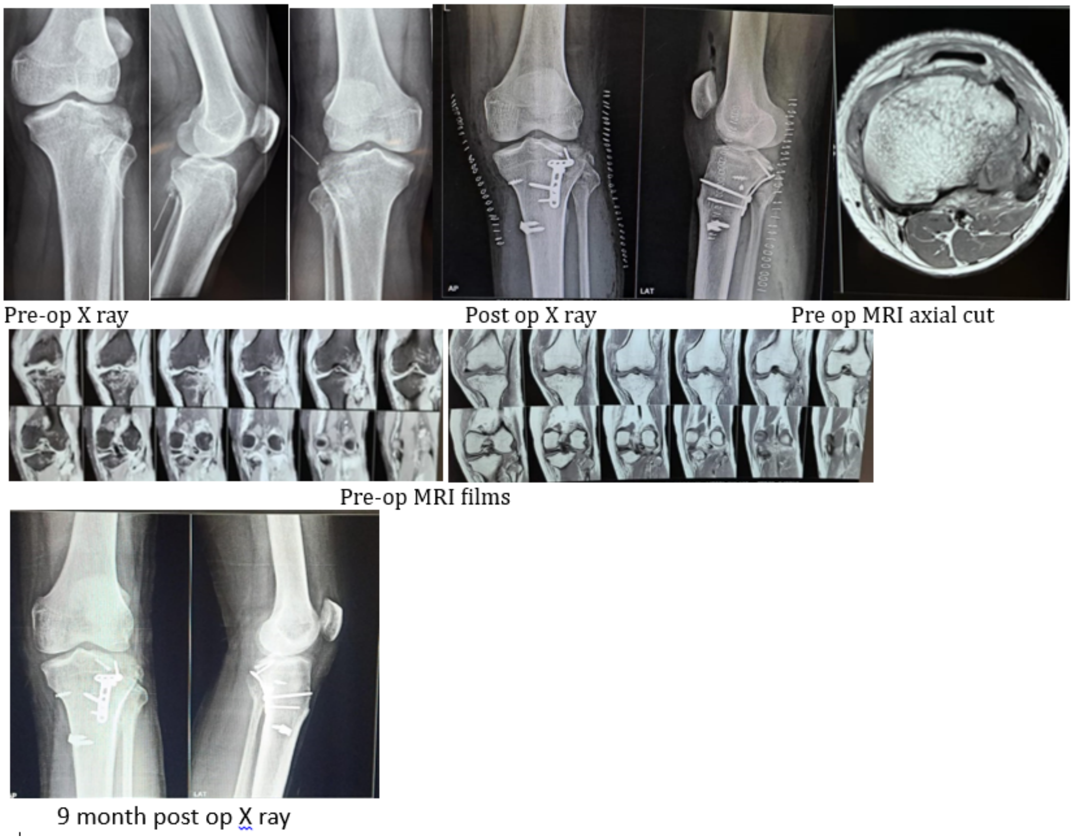

Figure 13: Case 11: Case of posterior column fracture with medial collateral ligament tear

3. Materials and Methods

3.1. Patient selection

All the cases of proximal tibia fractures managed surgically from year 2019 to 2022 as per 4 column and 10 segment classification irrespective of age, gender and nature of fracture.

3.2. Data collection

All proximal tibia fractures were classified as per 4 column and 10 segment classification following x-rays and 3d ct. All the possible surgical and conservative intervention possible were told to the patient and written and informed consents were taken for the same.

All the patients went through similar rehabilitation protocol. Patient related outcomes were measured at 6 weeks, 3 months, 6 months and 9 months with knee society score.

3.3. Surgical technique

The surgical approach and patient position were determined as per fracture geometry and column involvement. (Table 2)

Table 2: Position and surgical technique as per column involvement

Classification	Column involved	Position	Surgical approach
Zero column fracture	None	Supine	Minimally invasive surgery
One-column fracture	Lateral	Supine	Anterolateral approach
	Medial	Supine	Anteromedial approach
	Posterior (lateral part)	Prone	Lobenhoffer approach
	Poaterior (medial part)	Supine	Posteromedial approach
Two-column fracture	Lateral + medial	Supine	Anteromedial and anterolateral approach
	Lateral + posterior (lateral part)	Floating	Anterolateral + posterior reversed l shaped approach
	Lateral + posterior (medial part)	Supine+ prone	Anterolateral + posteromedial approach
	Medial + posterior (lateral part)	Prone	Posterior reversed l shaped approach
	Medial + posterior (medial part)	Supine	Posteromedial approach
Three-column approach	Medial + lateral + Posterior	Floating	Posterior reversed l shaped and anterolateral approach

4. Results

Mean age of population sustaining proximal tibia fracture among males was 43.90 y and females was 48.71y with 86% predilection for male and 14% for female. Involvement of right tibia was 50% in comparison to left tibia which was 46%, while 4% patients had involvement of both limbs. Distribution of proximal tibia fracture; zero column -7.69%, one column- 55.77%, two column-21.15%, three column-15.38% (Table 3). Average knee society score(knee score, function score) at 9 months; zero column-94.25;90, one column-92.10;82.75, two column-86.63;77.28, three column-77.63;68.13. (Table 4)

Average time for union in weeks was around 12 weeks for 21 patients and 12 to 24 weeks for 29 patients. (Table 5)

Single incident of superficial infection was encountered managed with debridement and parenteral antibiotics. Single incident of deep infection was encountered managed with implant removal, debridement and parenteral antibiotics. Single incident of common peroneal nerve palsy was encountered repaired with extended Lobenhoffer approach.(Table 6)

5. Discussion

Proximal tibia fractures are usually a result of high velocity trauma i.e. road traffic accident and therefore seen mostly among young adults.[11] In our study mean age was 46.3 years with males being predominantly affected.

Taking into consideration the associated soft tissue before planning the management of these fractures is of utmost importance. Staged management should be done as per literature with external fixator followed by definitive fixation as it provides time for the soft tissue to recover and improves the overall output of the surgery by decreasing chances of infection.[12,13] In our study, staged management was done by giving elevation on Bohler Braun splint and Mgso4 dressing or external fixator application considering the wound and skin condition of the patient. Skin over the proposed incision site was observed for wrinkles and the decision to proceed with surgery was made. Mean interval between injury and surgery was 7.2 days. Previous studies have reported a mean time to surgery of 9.2 days[14] and 8.5 to 9 days.[15]

The four-column classification is a recent development in managing complex intra-articular tibial plateau fractures, particularly beneficial for multiplanar fractures involving the posterior column. Posterior column fractures often result

Table 3:

General details	No of cases	Percentage
Gender distribution		
Male	43	86%
Female	07	14%
Side of Fracture		
Right	25	50%
Left	21	42%
Bilateral	04	08%
Age Group		
<50 years	31	62%
>50 Years	19	38%
Classification		
Zero column	04	7.69%
One column	29	55.77%
Two column	11	21.15%
Three column	08	15.38%
Fracture Morphology		
AL	21	
AM	01	
PM	02	
PL	02	
PM+PL	02	
AM+AL	06	
AL+PM	02	
AM+PM	02	
AL+AM+PM	08	

Table 4: Average knee society score

Classification	Knee score	Function score
Zero column	94.25	90
One column	92.10	82.75
Two column	86.63	77.28
Three column	77.62	68.13

Table 5: Time for union of fracture

Fracture union in weeks	No of Patients
12 weeks	21
12-24 weeks	29
>24 weeks	0

Table 6: Complications

No complication	47
Superficial infection	01
Deep infection	01
Common peroneal nerve palsy	01

from valgus-varus stress shear, typically seen in a partially to completely flexed knee when the femoral condyles impact the posterior half of the tibial plateau. This specific fracture pattern is challenging to visualize on plain radiographs alone, leading to potential oversight in diagnosis.

Despite its prevalence in complex tibial fractures, this injury pattern lacks recognition in existing classification systems like AO/OTA or Schatzker. Compression in the lateral posterior condyle and splitting in the medial posterior condyle are common features of these fractures. It is therefore very important to study the exact configuration of the medial column in complex proximal tibia fractures through axial CT cuts to define whether the fracture line is in coronal i.e. posteromedial fragment or sagittal plane. Molenaars et al. found posteromedial fragment to be prevalent in 81% of type V and 95 % of type VI fractures in a CT based morphological study.[16] Other studies have also found the presence of posteromedial fragment in 59%[17] and 74%[18] of bicondylar fractures. In our study prevalence of posteromedial fragment was 62.5% among cases of bicondylar fractures making it of immense importance to address the fragment separately as failure to do so might result in varus collapse and articular incongruity. Previously it was believed that a laterally placed locking plate would effectively buttress the medial fragment however it was found to be false in various clinical studies.[15]

Utilizing computed tomography with 3d reconstruction enhances recognition of proximal tibial fracture fragments, aids in column classification, and facilitates surgical planning. For bicondylar and complex patterns, combined anterolateral and posteromedial approaches offer biomechanical and clinical advantages. The most intricate cases involve three-column fractures, requiring a combination of a reversed l-shaped posterior approach and anterolateral approach for optimal fixation. This comprehensive approach ensures better outcomes in challenging tibial plateau fractures.

The conventional anterolateral approach is typically employed for simple tibial plateau fractures, specifically corresponding to the exclusive lateral column, as seen in Schatzker type i, ii, and iii fractures. However, for complex patterns resulting from a ramified fracture line, a combined approach becomes necessary. Achieving adequate reduction and stabilization in posterior column fractures proves challenging with traditional techniques, prompting the use of modified posterior approaches tailored to different fracture patterns.

Various approaches, such as the modified posterolateral approach for posterolateral shearing fractures and the inverted l-shaped posterior approach for posterolateral fractures, have been advocated by different authors. However, these approaches may encounter challenges like exposure difficulties or secondary loss of anatomic reduction. Additional techniques, like partial or total excision of the fibular head, may aid in reduction and fixation of the posterior and lateral columns but come with potential drawbacks, such as compromising normal lateral knee stability.

The choice of approach is crucial, and in practice, a combination of anterolateral and posteromedial approaches is often used for comprehensive management. The surgical approaches used in our study, with respect to fracture morphology has been stated in table 2. However, intraoperative considerations, such as neurovascular injury, surgical exposure challenges, and the need for altering patient and limb positioning, must be carefully navigated during posterior column stabilization for complex fractures.

Chen et al. Advocated the use of screws, reconstruction plates, or t-shaped plates based on fracture morphology, while Zeng et al. recommended posterior t-shaped anti-glide plates for split fractures, providing improved biomechanical stability. The application of newer anatomical locking plates for the posterior column proves effective in preventing bony collapse and secondary loss of reduction. The three-column concept serves as a valuable tool for diagnosing and meticulously planning pre-operatively in multiplanar intra-articular tibial plateau fractures, especially those involving the posterior column.

In our approach, we utilized column-based anatomical locking plates for the medial and lateral columns. The stabilization of the posterior column involved the use of various plates such as recon plates, distal radius plates, small fragment plates, and screws, tailored to the complexity of the fracture.

The rate of infection in our study was significantly low due to stringent aseptic precautions and adequate assessment of soft tissue injury.

Secondary loss of reduction- In our study, there were no instances of secondary loss of reduction in the form of medial collapse measured with medial proximal tibial angle (≥5 degrees). Table 7 compares the incidence of secondary loss of reduction during healing as reported in literature. Before 3 column classification little weightage was given to the idea of loss of reduction and varus collapse in bicondylar fractures treated with single lateral plate in comparison to dual plating. A study conducted by Weaver MJ in 2011 evaluated relationship between fracture geometry, fixation construct and secondary loss of reduction. It was found that lateral construct alone does well only in cases of bicondylar tibial plateau fractures with sagittal fracture line. While in cases with coronal split lateral construct alone shows higher incidence of secondary loss of reduction. Our study also supports the above stated statement. Therefore, 3 d CT scans are indicated to delineate exact fracture geometry as plain radiographs provide limited information.

In our study, through our column-based operative management and early rehabilitation, we achieved average knee score of 87.65 and function score of 79.54 as per knee society score which were comparable to study by Nikolaou et al.

Table 7: Literature review comparing incidence of secondary loss of reduction

Study	No. of patients	Varus collapse (no. of patients)
Cong Feng Luo et al.[19]	287	Nil
Florence Unno et al.[20]	101	3(2.9%)
Hong Wei Chen et al.[21]	39	Nil
Barei et al.[18]	83	2(2.4%)
Devdutta Neogi et al.[15]	61	5(8.2%)
Gosling et al.[22]	68	9(13.2%)
Jiang et al.[23]	84	3(3.57%)
Our Study	50	Nil

6. Conclusion

Recent computed tomography-based classification is very useful in understanding fracture topography, preoperative planning, fixation technique and deciding most suited surgical approach for proximal tibia fractures to achieve a smooth articular surface, mechanical axis and joint stability. Certain fracture fragments which could be missed on radiographs are taken into consideration and fixed with fragment specific approach which in turn, helps in early rehabilitation resulting in good functional and radiological outcome, reduced instances of secondary loss of reduction. One thing that has to be taken into consideration is the soft tissue condition as using more hardware increases the chances of infection and wound dehiscence, though it can be easily avoided by following staged fixation. Still, a long-term study with large study group is needed to confirm the usefulness of the same.

7. Source of Funding

None.

8. Conflict of Interest

None.

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