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A study of complications and their associated factors in the management of high-energy tibial plateau fractures treated by open reduction and internal fixation

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ABSTRACT

Background: Tibial plateau fractures are one of the leading causes of joint dysfunction in major weight-bearing joints. Maintained articular surface, uniform plateau level, and a near-normal range of knee joint motion can all be preserved following the appropriate surgical guidelines. **Aims and Objectives:** The objectives of the study are as follows: (1) To study the complications and their associated factors in the management of high-energy tibial plateau fractures treated by open reduction and internal fixation. (2) To assess radiological parameters pre-operative and post-operative and their relation to fracture pattern. (3) To assess factors, such as fracture patterns, those influence the loss of reduction. **Materials and Methods:** Statistical analysis was done by expressing the data in frequency, percentage, mean, and standard deviation. Repeated measures ANOVA test or Friedman test or Wilcoxon signed-rank test will be used to compare radiological parameters from pre-operative to opposite side of the limb, and immediate post-operative to 6 weeks and 3 months. **Results:** Thirty-one cases of proximal tibial plateau fractures were studied between January 2021 and September 2022. The joint width has reduced in the immediate post-operative and has almost remained the same at 45 days and 3 months. The articular step off was noted to have a reduction of 0.3 mm in particular depression which is not significant. In the comparison of tibial offset preoperatively to the immediate post-operative and the 45-day and 12-week follow-up values, there was decrease in the values from the pre-operative to immediate post-operative radiographs and the reduction in the values noted in the further follow-ups is not significant. **Conclusion:** There was statistical significant difference noted between the pre-operative and immediate post-operative radiological parameters such as joint space width, tibial offset, and medial tibial plateau angle. Further radiological assessment done at 6-week and 3-month post-operative, there was no statistically significant loss of reduction.

Key words: Tibial plateau; Complications; High-energy injury; Internal fixation; Articular step; Reduction criteria

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INTRODUCTION

Tibial plateau fractures are one of the leading causes of joint dysfunction in major weight-bearing joints. The major objectives of treating these fractures are to keep the normal knee joint functions, maintain joint stability, reduce malalignment and deformity in the lower limbs, and avoid knee osteoarthritis. Maintained articular surface, uniform plateau level, and a near-normal range of knee joint motion can all be preserved following the appropriate surgical guidelines.[1] Various problems, including wound dehiscence, severe comminution leading to malalignment, and delayed

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consequences such as varus collapse, implant failure, and knee joint arthritis, are brought on by high energy intra-articular fractures involving the tibial plateau.[1] Osteoarthritis incidence increases with Schatzker's Grades V and VI. If the articular reduction and limb alignment are preserved, people with radiological arthritis can nonetheless function well clinically.[2] Both fracture-dislocations and fractures presenting with vascular damage should be managed on emergency basis. Regardless of the planned ultimate care, complications like compartment syndrome are emergencies that necessitate an immediate four-compartment fasciotomy. Evaluation for compartment syndrome should be done at every stage of management. Open fractures with severe contamination that are more likely to get infected also call for emergency treatment with widely accepted guidelines.[2] After open reduction and internal fixation (ORIF) of a tibial plateau fracture, patients with open fractures, compartment syndrome, prolonged surgery, tobacco use, and initial management with external fixator application are at risk of developing surgical site infection as shown in Table 11. Considering these hazards, proper pre-operative planning is important.[3] Elderly patients without significant comorbidities such as diabetes, hypertension, and cardiovascular diseases can also be considered as appropriate candidates for ORIF of tibial plateau fractures. Alternative treatment options, such as non-operative management or less invasive surgical treatments, should be considered in patients who are elderly and have major comorbidities (diabetes, hypertension, and cardiovascular disorders).[4] Even in closed proximal tibial plateau fractures, particularly, those of Schatzker's Types V and VI are associated with significant soft tissue injury. With careful patient selection and minimal soft-tissue dissection, the complications associated with treating these fractures can be minimized.[1] Because it is difficult for fixation of fracture fragments precisely with medial or lateral plate fixation for the tibial plateau fractures that involve coronal fractures, it can be better approached through posteromedial, posterolateral, or posterior approach.[3] When dual plate fixation is performed, the majority of patients with bicondylar tibial plateau fractures perform well. However, when lateral locked plating is used alone, those with a medial coronal fracture line typically have a higher rate of subsidence and loss of reduction. If the soft tissues permit, dual plating may be a preferable option for treating these fractures.[3] The goal of this study is to study complications and their associated factors in the surgical management of high-energy tibial plateau fractures.

Aims and objectives

The objectives of the study are as follows:

(1) To study the complications and their associated factors in the management of high-energy tibial plateau fractures treated by open reduction and internal fixation.
(2) To assess radiological parameters pre-operative and post-operative and their relation to fracture pattern.
(3) To assess factors, such as fracture patterns, those influence the loss of reduction.

MATERIALS AND METHODS

This was an observational study done to assess the complications and their associated factors in the management of high-energy tibial plateau fractures treated by ORIF. The study also assessed if fracture patterns can influence loss of reduction. All skeletally mature patients with proximal tibial plateau fractures and coming to Justice K. S. Hegde Charitable Hospital a unit of Nitte (Deemed-to-be) University, Deralakatte, Mangaluru – 575018 (Hospital-based study) were included in the study. The study was done during the January 2021–September 2022. Statistical analysis was done by expressing the data in frequency, percentage, mean, and standard deviation. Repeated measures ANOVA test or Friedman test or Wilcoxon signed-rank test will be used to compare radiological parameters from pre-operative to opposite side of the limb, and immediate post-operative to 6 weeks and 3 months. All patients with Schatzker's Type V and VI tibial plateau fracture after attaining skeletal maturity to 70 years were included in the study. Patients with a previous history of injury/surgery to the affected knee joint, patients with low energy injury leading to fracture of the tibial plateau (Schatzker's Type I-IV), presence of neurovascular injury in the lower limb to be assessed (Open GA Type 3b and 3c injuries), and patients with a contralateral knee injury were excluded from study. The patients are further evaluated with a CT scan. The surgical management is dependent on the fracture type, the amount of displacement, and articular depression of the tibial plateau. The patients underwent surgery at the earliest possible time depending on their medical condition, skin condition, and the amount of swelling. All fractures are openly reduced and fixed with medial, lateral, or posterior plate fixation. The surgical site is inspected in the immediate post-operative period and up to 3 months for soft-tissue complications such as wound infection and wound dehiscence. Radiographs are evaluated for adequacy of reduction, collapse, and implant failure in the immediate post-operative period and up to 3 months.

The radiological parameters that were assessed are Joint space width for medial and lateral compartment, Articular step off, Tibial offset and Medial tibial plateau angle.

The joint space width for the medial and lateral compartments was measured between the tibial and femoral surfaces at the midpoints of the lines depicting each compartment and parallel to the long axis of the tibia

as shown in Figure 1.[5] Articular step-off is measured by, a1=draw a reference line from extension of the medial plateau parallel to the joint line, a2=line parallel to a1 drawn from the maximum lateral plateau depression as shown in Figure 2. Articular depression is the distance between a1 and a2. b1=perpendicular to line a1 and tangent to the lateral femoral epicondyle, b2=line which corresponds to the lateral part of the lateral tibial plateau which is parallel to b1. Tibial plateau offset or condylar widening is the distance between line b1 and b2.[6]

As in Figure 3, measurement of the depression of articular surface (A and alignment of the articular surface to the anatomical axis of tibia (medial tibial plateau angle).[7]

A. Sagital split separates the medial and lateral plateau of tibia
B. Oblique fracture line across the medial articular surface
C. Medial articular fragment which is split by a coronal fracture line[8]
D. 3D image which depicts postero medial fragment of the same coronal section.[8]

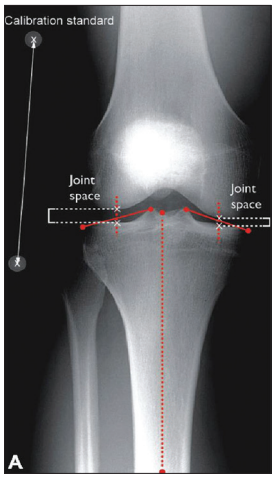

Figure 1: Joint space width

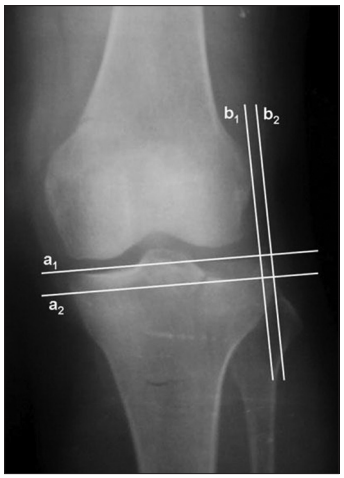

Figure 2: Articular step-off and tibial offset

RESULTS

Thirty-one cases of proximal tibial plateau fractures were studied between January 2021 and September 2022. This study is being carried out to study the complications and their associated factors in the management of high-energy tibial plateau fractures treated by ORIF and to evaluate the factors that influences the loss of reduction like fracture patterns. Of the 31 subjects in the study group, maximum number of patients were in the age group between 31 and 40 years, that is, 10 (32.3%) and 9 in each 41–50 years and >50 years. Of the total 31 patients, 25 (80.6%) were male and 06 (19.4%) were females. Among the 31 subjects, 6 (19.4%) of them are having comorbidities among which three are having diabetes and three hypertensions. Among the study group 19 (61.3%) of them sustained Schatzker's Type 5 fracture and 12 (38.7%) sustained Schatzker's Type 6 fracture. The study groups were also classified based on the Lou's CT scan classification and details are mentioned in Table 1.

Among the 31 subjects, 5 (16.1%) were operated within 1–3 days, 14 (45.2%) were operated within 4–7 days, 9 (29.1%) within 8–10 days and 3 after 10 days. Among the 31 study subjects for 13 patients (41.9%), external fixator was applied and for 18 patients (58.1%), it was not used. Among the 31 subjects, single plate and triple plate fixations were done for 4 (12.9%) each of the patient and dual plate fixations were done for 23 (74.2%) subjects. Out of the 31 cases complications were seen in 5 cases (16.1%) as shown in Table 2.

Table 1: Distribution of study subjects based on computed tomography scan classification

Type of fracture	Number of patients (%)
3-column fracture	18 (58.1)
3-column fracture with coronal fracture line	13 (41.9)
Total	31 (100.0)

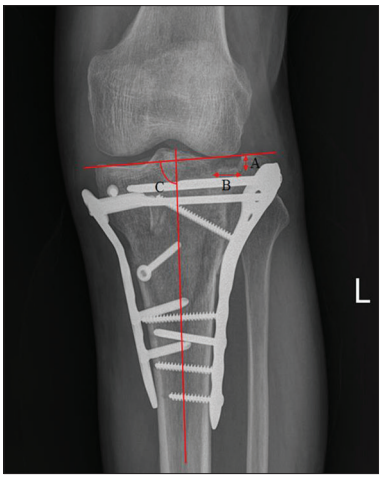

Figure 3: Medial tibial plateau angle

The mean joint width of the affected limb (7.58) was compared with the unaffected limb (6.3) and it was noted that the increased joint width in the affected limb than the normal limb as shown in Table 3.

The joint width in the affected limb preoperatively from the mean value of (7.58) has reduced to mean value of (6.26) in the immediate post-operative and has almost remained the same in the 45-day follow-up (6.30) and 3-month follow-up (6.44) as in Figure 4.

In the comparison of joint width from the at 3-month post-operative joint width (6.4) to the unaffected limb (6.3), it was noted that we could attain the near normal value as same as the unaffected limb as shown in Table 4.

The articular step off is compared to the immediate post-operative radiograph (6.5) to the 45-day (6.894) and 12-week (6.823) follow-up radiographs and it was noted that there was a reduction of 0.3 mm in particular depression which is not significant (Figure 5).

The tibial offset is compared between preoperative affected limb (1.272) and unaffected limb (0.516) and there was significant difference noted as in Table 5.

The comparison of tibial offset of the affected limb pre-operative value (1.272) to the immediate post-operative value (0.751) and the 45-day (0.69) and 12-week (0.673) follow-up values, there was a decrease in the values from the pre-operative to immediate post-operative radiographs and the reduction in the values noted in the further follow-ups is not significant as in Figure 6.

Table 2: Distribution of postoperative complications in subjects

Post operative complications	Number of patients (%)
None	26 (83.9)
Complications seen	5 (16.1)
Total	31 (100.0)
Details of post-operative complications	
Foot drop	1 (3.2)
SSI	4 (12.9)

Table 3: Comparison of joint width between affected and unaffected limb among study participants

Joint width	Mean (mm)	SD	P
Affected limb	7.58	0.279	0.027*
Unaffected limb	6.30	0.169	

SD: Standard deviation

Table 4: Comparison of joint width between affected and unaffected limb after 3-month post-operative

Joint width	Mean (mm)	SD	P
Affected limb	6.44	0.135	0.565
Unaffected limb	6.30	0.169	

SD: Standard deviation

Table 5: Comparison of tibial offset between affected and unaffected limb among study participants

Tibial offset	Mean (cm)	SD	P
Affected limb	1.272	0.637	<0.001*
Unaffected limb	0.516	0.161	

SD: Standard deviation

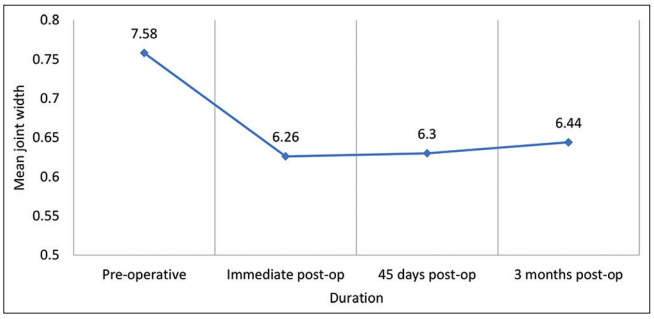

Figure 4: Comparison of joint width in affected limb

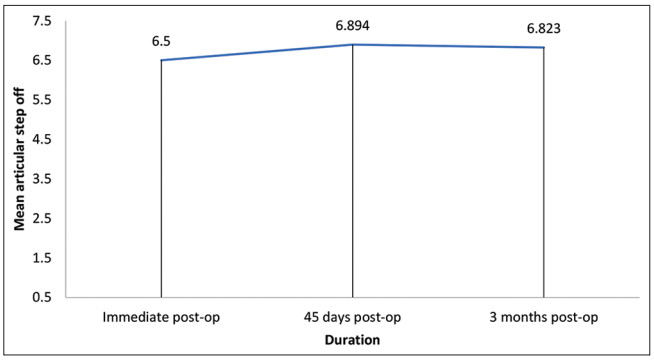

Figure 5: Comparison of articular step-off in affected limb in the immediate post-operative and follow-up X-rays

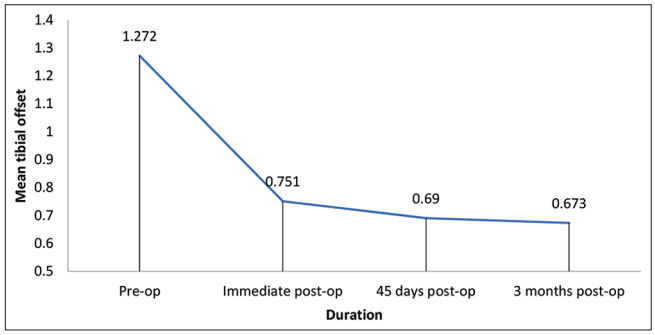

Figure 6: Comparison of tibial offset in affected limb in pre-operative, immediate post-operative, and follow-up radiographs

The mean medial tibial plateau angle among the affected and unaffected limb was 74.8 and 89.48, respectively as shown in Table 6.

Compared to the pre-operative medial tibial plateau angle (74.8) postoperatively, it was possible to achieve the angle of 88.71 in the immediate post-operative and in the subsequent follow-ups at 45 days (88.81) and 12 weeks (88.32), there was not much difference noted as in Figure 7. The 3-month post-operative medial tibial plateau angle (88.32) was compared with unaffected limb (89.48) and there was no significant difference noted.

Table 7 shows the distribution of complications among different age group that is no complication seen among <30 years age group and two subjects among each of the age group between 31 and 40 years and 41–50 years had surgical site infections and in one of the subject complications was seen in >50 years age group.

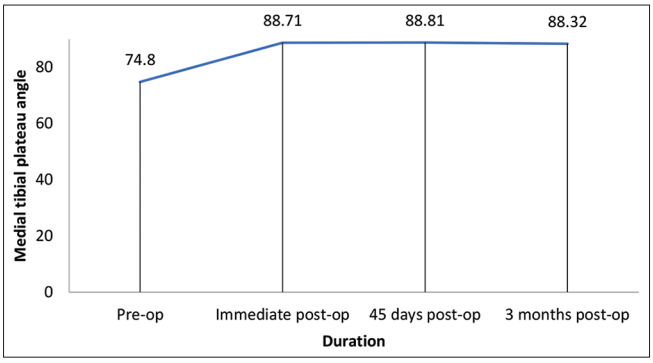

Figure 7: Comparison of medial tibial plateau angle in affected limb in pre-operative, immediate post-operative, and follow-up radiographs

Table 6: Comparison of medial tibial plateau angle between affected and unaffected limb among study participants

Medial tibial plateau angle	Mean	SD	P
Affected limb	74.80	4.65	0.026*
Unaffected limb	89.48	1.85	

SD: Standard deviation

Table 7: Age group-wise distribution of post-operative complications among study participants

Age group	Number of cases (%)		
	No complications	Complications present	Total
≤30 years	3 (100)	0	3 (100)
31–40 years	8 (80.0)	2 (20.0)	10 (100)
41–50 years	7 (77.8)	2 (22.2)	9 (100)
>50 years	8 (88.9)	1 (11.1)	9 (100)
Total	26 (83.9)	5 (16.1)	31 (100)
χ^2	1.037		
P	1.000		

Among the subjects who are not having any comorbidities 23 (92%) of them did not develop any complications and 2 (8%) of them developed complications. Moreover, in the study group who are having comorbidities 3(50%) did not develop and 3 (50%) developed complications as shown in Table 8.

Among the 19 Schatzker's Type 5 fractures, 15(78.9%) did not develop complications and 4 (21.1%) developed complications. Among the 12 Schatzker's Type 6 fractures, 1 (8.3%) of them developed complication as in Table 9.

Post-operative complications were most seen in the study group for whom external fixator was used for temporary stabilization that is among 13 subjects 3 (23.1%). In 2 (11.1%) of the study subjects for whom external fixator was not used post-operative complications were seen as seen in Table 10.

Table 8: Co-morbidities and occurrence of post-operative complications among study participants

Co-morbidities	Number of cases (%)		
	No complications	Complications present	Total
None	23 (92.0)	2 (8.0)	25 (100)
Present	3 (50.0)	3 (50.0)	6 (100)
Total	26 (83.9)	5 (16.1)	31 (100)
χ^2	6.310		
P	0.038*		

Table 9: Occurrence of post-operative complications among study participants in V and VI Schatzker classification

Schatzker classification	Number of cases (%)		
	No complications	Complications present	Total
Type 5	15 (78.9)	4 (21.1)	19 (100)
Type 6	11 (91.7)	1 (8.3)	12 (100)
Total	26 (83.9)	5 (16.1)	31 (100)
χ^2	0.880		
P	0.624		

Table 10: Occurrence of post-operative complications among study participants among whom external fixator application done

External fixation	Number of cases (%)		
	No complications	Complications present	Total
Not used	16 (88.9)	2 (11.1)	18 (100)
Used	10 (76.9)	3 (23.1)	13 (100)
Total	26 (83.9)	5 (16.1)	31 (100)
χ^2	0.799		
P	0.625		

Among the 23 subjects who underwent dual plate fixation 3 of them had surgical site infection and 1 foot drop (probably due to impending compartment syndrome) due to total of 4 (17.4%) and 1 (25%) among the three subjects who underwent single plate fixation had developed surgical site infection.

DISCUSSION

One of the most frequently occurring intra-articular fractures, tibial plateau fractures are caused by road traffic accidents, falls from heights, assault, etc. Due to the wide range of fracture patterns and soft-tissue complications, there has long been debate regarding how to manage these fractures. The complexity of the fracture patterns, ligament injury, and significant soft-tissue injuries has all been linked to high-energy tibial plateau fractures. Dual plating is preferable to single plating for the treatment of bicondylar fractures because it allows for better anatomical reduction and rigid fixation but with increased likelihood of soft-tissue complications. There are numerous methods for treating tibial plateau fractures, and each one has its own advantages and disadvantages. For improved clinical and radiological outcomes, the choice of treatment and fixation for tibial plateau fractures is still up for debate.

Posteromedial and posterior fractures in high-energy tibial plateau fractures often cannot be stabilized with an anterolateral plate alone. Particularly in high-energy trauma, fractures of the posterior tibial plateau are not uncommon. Luo's 3 column fixation method is the best method for planning and assessing displaced tibial plateau fractures and posterior tibial fractures.[9] In high energy tibial plateau fractures, fixation of the posteromedial and posterolateral fractures is also crucial for achieving satisfactory clinical and radiological outcomes. Failure to fix the posteromedial fragment results in varus collapse and limited range of motion. In addition to better visualization of the fractures and assisting in better reduction and fixation, posteromedial or posterior approaches, whether performed in prone or supine positions, also have the advantage of causing less soft-tissue complications as it has the advantage of better wound healing and lesser chances of wound dehiscence and skin necrosis that is more seen in the dual incisions due to close proximity of the two incisions. In addition to providing accurate reduction of the articular surfaces and rigid fracture fixation, posterior column fixation through these approaches and medial and lateral column fixation with screws or lateral locking plates also has the advantages of early mobilization, reduced soft-tissue complications, reduced secondary loss of reduction, varus collapse, better range of motion, and earlier mobilization than other modes of fixation.

Table 11: Comparison of type of surgical fixation and post-operative complications among study participants

Type of surgical fixation	Number of cases (%)		
	No complications	Complications present	Total
Single plate	3 (75.0)	1 (25.0)	4 (100)
Dual plate	19 (82.6)	4 (17.4)	23 (100)
Triple plate	4 (100)	0	4 (100)
Total	26 (83.9)	5 (16.1)	31 (100)
χ^2	1.029		
P	1.000		

In this study, high-energy tibial plateau fractures were assessed for post-operative complications and factors associated with it. Tibial plateau fractures were assessed with radiographs and CT scan and classification done to plan for approach and plate osteosynthesis using three columns and Schatzker's classification. Post-operative complications and radiological parameters causing secondary loss of reduction were assessed using articular step-off, joint space width, tibial offset, and medial tibial plateau angle. In this study, tibial plateau fractures were more commonly seen in the productive age group between 31 and 40 years, that is, 10 (32.3%).

It is extremely important to regain articular congruity, adequately visualize the fragments, reduce the fracture, and obtain stable rigid fixation. In our series, majority of patients were male (80.6%) as they were involved mostly in road traffic accidents. The more active lifestyle and higher risk of road traffic accidents in men, which is also the most frequent injury, can be ascribed to male preponderance. In their study, Zhang et al. found that 89.9% of cases had RTA injuries[10], while Kumar et al. found that all cases (100%) had RTA.[11] Studies conducted by Ghani et al. also corroborate the male preponderance.[12]

In this study, 19 (61.3%) of them were Schatzker Type V fracture and 12 (38.7%) were Schatzker Type VI fracture and based on the Lou's CT scan classification of proximal tibial plateau fractures all are under 3-column fracture with 13 (41.9%) among them having coronal fracture line. In this study, most of them 14 (45.2%) were operated within 4–7 days, with the mean duration of time interval between the injury and surgery being 7 days. In their study, Zhang et al. found that 89.9% of cases had RTA injuries[10], while Kumar et al. found that all cases (100%) had RTA.[11] Studies conducted by Ghani et al. also corroborate the male preponderance.[12]

The average time between an accident and surgery in a study by Devdatta et al. was 8.5 days,[13] whereas a study by Kumar et al. revealed an average delay in definitive surgery of 7.5 days.[11] The timing of internal fixation is essential in such complex injuries to prevent soft tissue complications and failure.[14]

In this study for 13 patients (41.9%), external fixator was used and for 18 patients (58.1%), it was not used. It was considered important to span the fracture site with an external fixator application until the soft-tissue conditions such as severe edema, blisters, compartment syndrome, internal degloving, and ecchymosis improves, considered crucial when selecting an initial external fixation. All of the patients received treatment with definitive internal fixation with plating as soon as the soft tissues were thought to have recovered successfully (depending on the clinical signs of resolving of edema and appearance of skin wrinkling). Metcalfe et al in their study which compared the management of complex tibial plateau fractures between external fixator application like Hybrid fixator or Ilizarov fixator and ORIF found an increased incidence of infections in external fixation which can be attributed to pin site infection.[15] However, because the knee mobilization is delayed, external fixator application frequently results in joint stiffness.[3] In our study, external fixator application was done because of the swelling and among them, three were having impending compartment syndrome and all of them were taken up for fasciotomy. Care should be taken to avoid the insertion of pins of external fixator is well away from the site of surgical incision of definitive procedure to avoid infection rate.

After studying the fracture patterns patients were taken single, dual, or triple plate fixation. In our study, single plate fixation done for 4 (12.9%) subjects, triple plate fixation done for 4 (12.9%), and dual plate fixation was done for 23 (74.2%) subjects. Post-operative complications related to soft tissue and neurovascular injury were seen among the 5 (16.1%) subjects out of which 1(3.2%) foot drop which had occurred at the time of injury due to impending compartment syndrome and 4 (12.9%) surgical site infection. Superficial wound infection was the most common complication. Infections of the subcutaneous tissues were considered superficial, while any infections that required surgical debridement were considered deep.[5] All cases were successfully treated with local wound care and antibiotics. The foot drop was managed conservatively with regular physiotherapy. Steven's analysis revealed 17% infection;[16] however Lee et al study reported 15% infection rate.[8] Our study's rate of complications was comparable to that of previous studies. Even though our study included severe complex high energy Schatzker's Type V and VI fractures, the incidence of deep infection was remarkably low. We attribute this to the use of less invasive approaches, indirect[5] reduction techniques, and minimal periosteal stripping, as well as the delay in definitive surgery. According to Weaver et al, there is a strong correlation between a high reduction loss rate and the fixation type and fracture pattern.[17] According to Ali et al, there may be a relation between early weight-bearing, larger preoperative displacement, more comminuted fracture and severe osteoporosis and the secondary loss of reduction.[18] When compared to immediate post-operative radiographs, secondary loss of reduction was defined as intra-articular step-off >3 mm, plateau widening higher than 5 mm, and malalignment increasing by 5° (TPA ≥95°/≤80°) It was observed that patients with fewer differences with uninjured limbs on plain radiographs showed a tendency to have better clinical outcomes.[8]

There was a significant difference in the mean joint width from the affected limb to the unaffected limb which was restored to near anatomical value in the immediate post-operative radiographs and which was statistically significant with P=0.01 and there was no statistically significant difference noted in the joint width in the subsequent follow-up radiographs. The comparison of 3-month post-operative limb joint width to the unaffected limb joint width, we were able to restore the near anatomical value but it was not statistically significant and as 3-month follow-up duration is too early to assess for the post-traumatic osteoarthritis. In our study, the articular step off which was compared between the immediate post-operative value to the (6.5) to the 45-day (6.894) and 12-week (6.823) follow-up values and the P-value for the same is 0.33 which is not statistically significant and suggests that there was no loss of reduction in the follow-up radiographs.

In the study by Durakbasa et al[19] it was noted that increase in the condylar widening was associated with distortion of the normal anatomy of the lateral tibial plateau and lateral meniscus injury and the more chances of lateral bowing. The P-value is significant between the tibial offset measured in the immediate post-operative and the pre-operative radiograph. P-value in the subsequent follow-up radiographs was not statistically significant. There was a significant difference between the pre-operative and unaffected limb medialtibial plateau angle with the P-value being 0.03. P<0.001 when compared between the pre-operative radiograph and immediate post-operative radiograph which is statistically significant whereas the subsequent follow-ups P-value being insignificant. To evaluate varus/valgus malunion postoperatively, MPTA measurement was done. MPTA typically ranges between 87±5°. At the end of the 3-month follow-up period, the average value in our series was 88.32. As a result, in our study, we discovered that following bicolumnar fixation, the natural proximal tibial joint orientation is maintained.[11] The occurrence of complications in a particular age group was not statistically significant which can be attributed to the small sample size. All the complications that occurred in our study were in male subjects and can also be due to a greater number of male subjects in the study group. In our study, it was noted that among six of the patients who had comorbidities, three (diabetes) of them developed post-operative complications which accounts to 50% and the P=0.038 being significant that implies that patients with comorbidities (like diabetes) are more prone for complications. Two of the patients who did not

have comorbidities also developed complication which accounts to 8%. There was no statistically significant association noted in the occurrence of complications in either Schatzker's Type V or VI types or in the patients among whom the external fixator was applied initially as temporary stabilization.

SUMMARY

A total of 31 patients were studied who had proximal tibial plateau fractures and who underwent ORIF of the same, maximum number of patients were in the age group between 31 and 40 years with 80.6% of them being male. Nineteen of the subjects were diagnosed to have Schatzker's Type V and 12 were Schatzker's Type VI fractures. All the subjects were found to have 3-column fractures according to Luo's CT classification and 13 among them were having coronal fracture line. The mean duration between the injury and surgery is 7 days. Thirteen of the patients were initially stabilized with external fixator application. Patients were then taken up for definitive fixation with four of them undergoing single plate fixation, 4-triple plate fixation and 23 of them dual plate fixation based on fracture pattern. Five of the patients developed complications out of which four were superficial infections which were managed conservatively and one was foot drop who had impending compartment syndrome. There was statistical significant difference noted between the pre-operative and immediate post-operative radiological parameters such as joint space width, tibial offset, and medial tibial plateau angle. The articular step off was found to be more than 3 mm in 3 of the fracture which also had coronal fracture line and 1 who did not have coronal fracture line, which suggests that with the presence of coronal fracture line the risk of secondary loss increases but it was not statistically significant. Further radiological assessment done at 6-week and 3-month post-operative, there was no statistically significant loss of reduction.

Limitations of the study

The limitations in this study are short follow-up, small sample size, and single-center study.

CONCLUSION

In our study, it is suggested that internal fixation with dual locking plates is biomechanically strong and stable fixation. To avoid soft-tissue complications, the timing of surgical intervention is crucial in such complex injuries. Rigid fixation achieved by less extensile approaches and indirect reduction techniques reduces the wound healing problems and allows early knee mobilization. Most bicondylartibial plateau fractures without medical coronal fracture involvement can be adequately fixed with lateral single locked plating. However, when lateral locked plating is used alone, fractures with a medial coronal fracture line have a higher likelihood of loss of reduction, and dual plating may be preferable in such cases if the soft tissues permit. The surgical intervention should be tailored to the unique fracture pattern since, most notably, not all bicondylartibial plateau fractures are similar to obtain the good outcomes. In bicondylartibial plateau fractures, staged treatment with a temporary external fixator produced positive clinical and radiographic results. Fluoroscopy should be used by surgeons during surgery to assess the reduction status.

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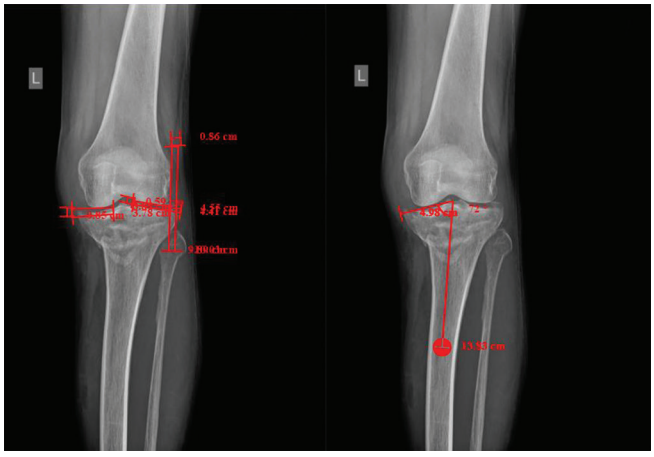
SCOPE FOR FUTURE WORK

- The study can be expanded to a larger population with multicentric involvement with long-term follow-up.

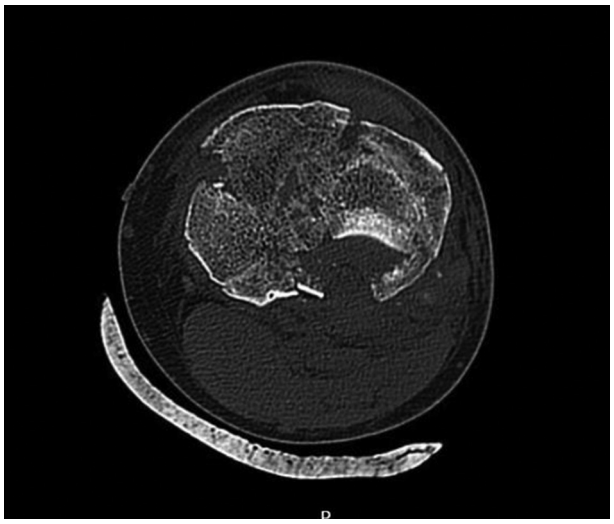
CASE EXAMPLES

Example 1 Schatzker type VI fracture.

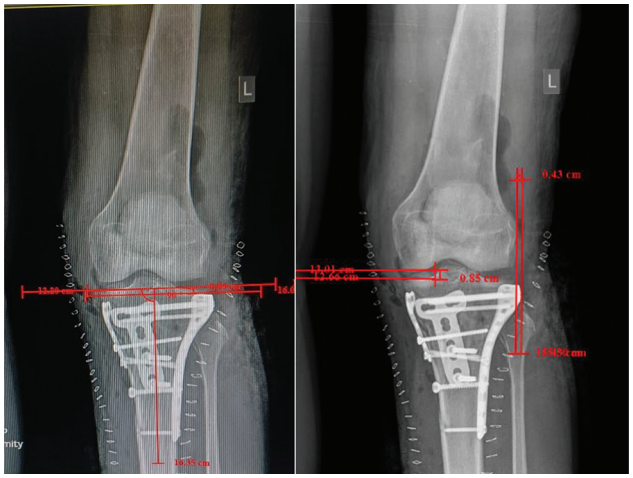
Pre-operative measurements



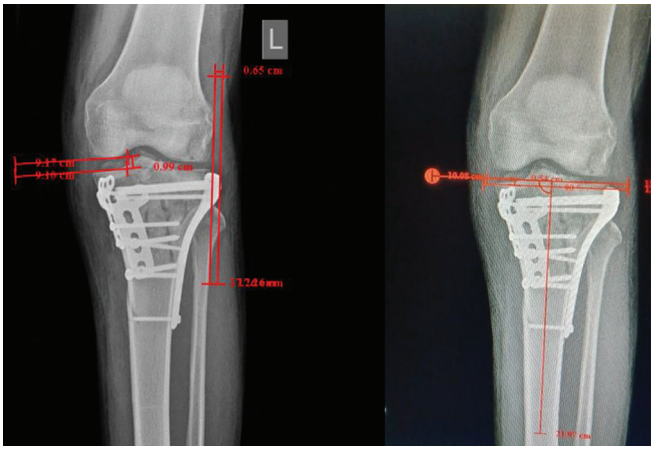
CT scan with coronal fracture line



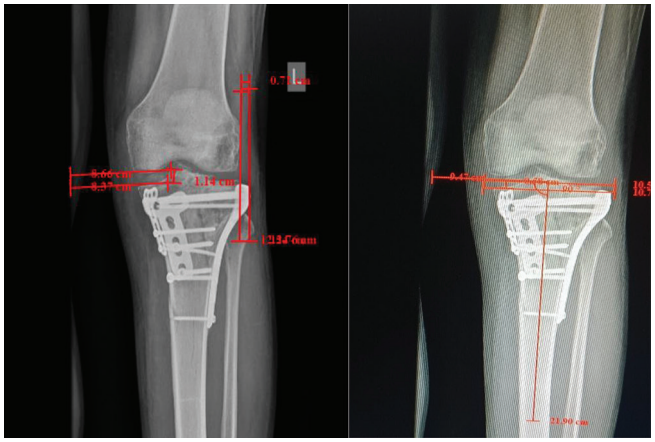
CASE 1: Immediate post-operative measurements



CASE 1: 6-week follow-up measurements

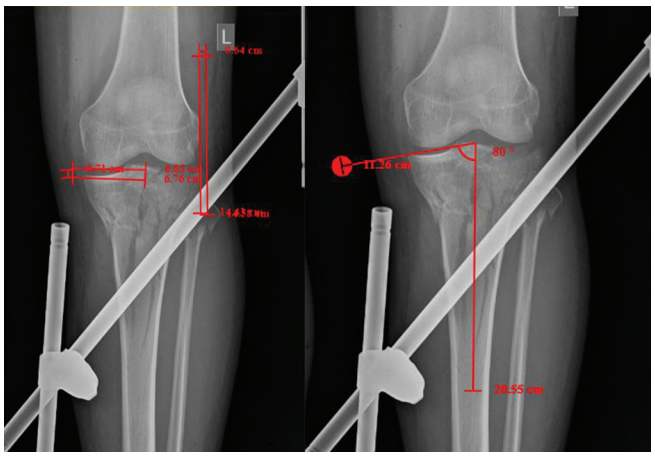


CASE 1: 3-month follow-up measurements

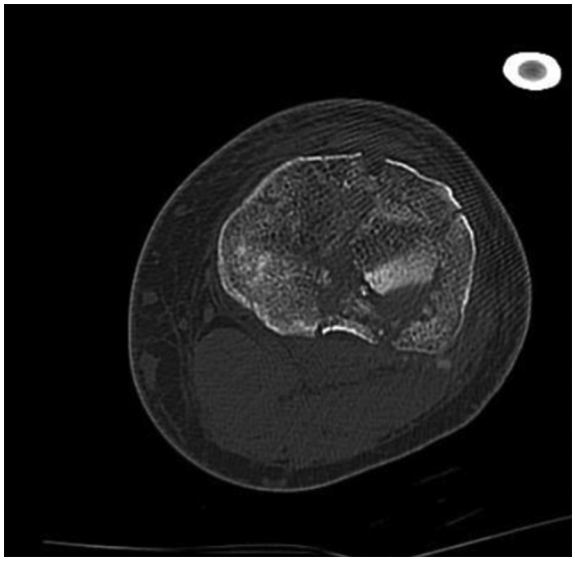


Example 2: Schatzker Type VI fracture

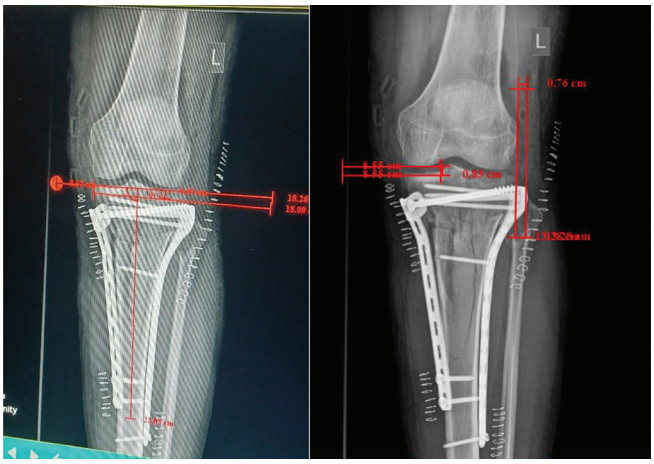
Pre-operative measurements



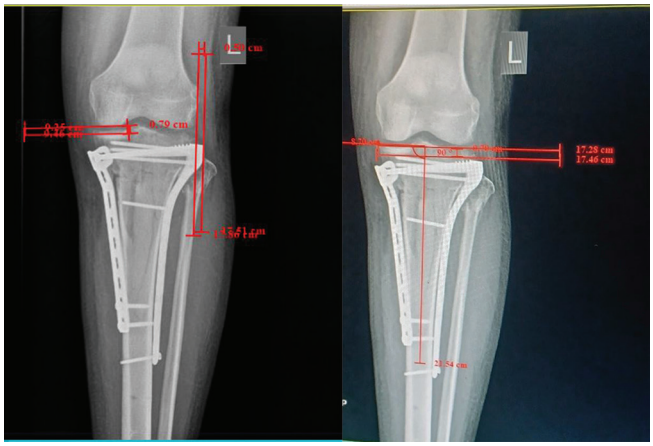
CT scan



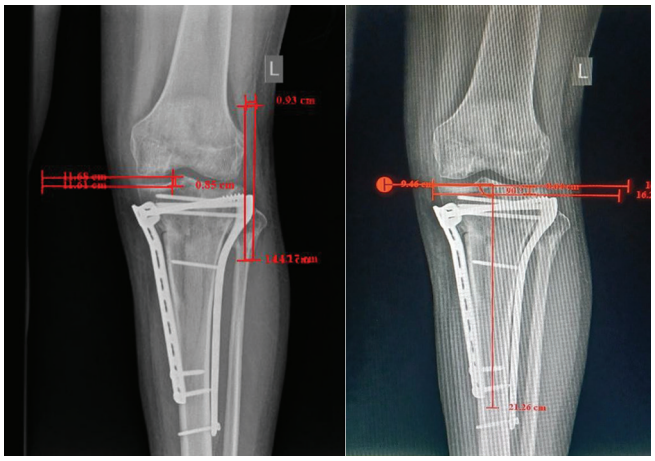
CASE 2: Immediate post-operative measurements



CASE 2: 6-week follow-up measurements

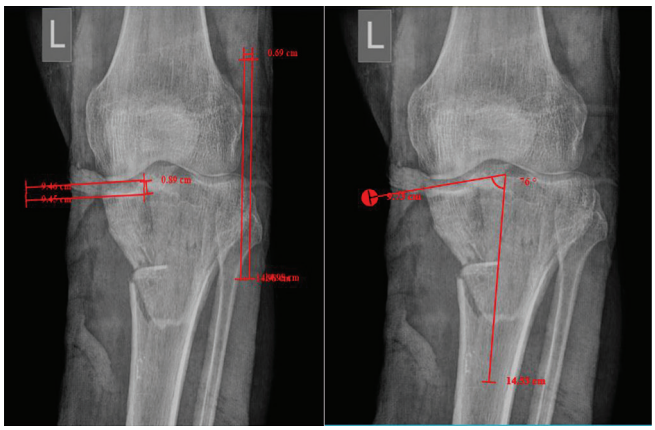


CASE 2: 3-month follow-up measurements

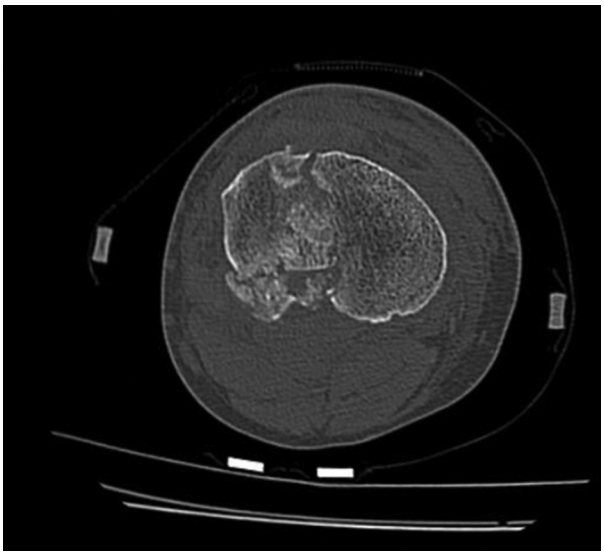


Example 3: Schatzker Type V fracture

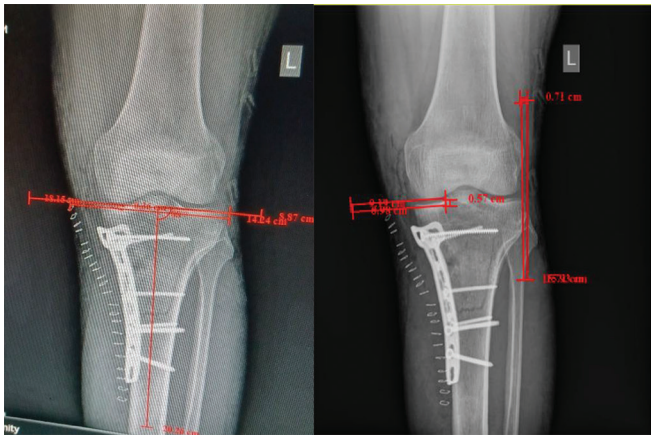
Pre-operative measurements



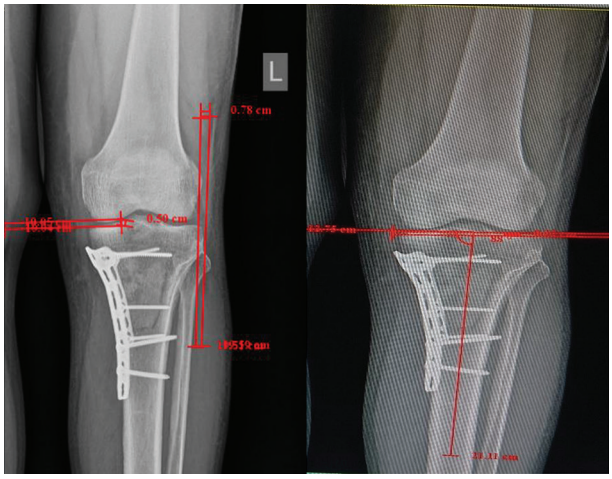
CT scan



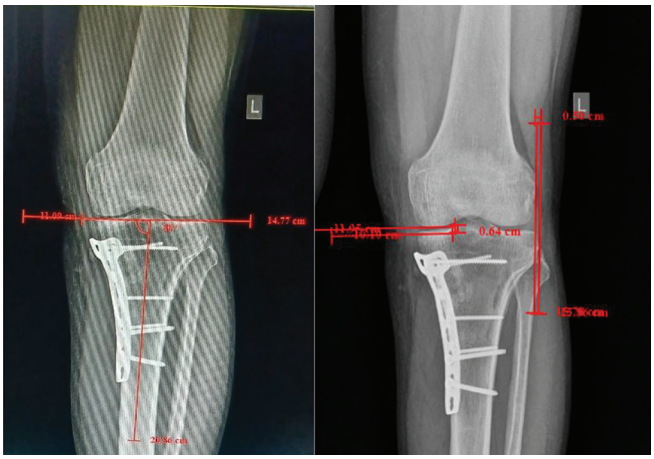
CASE 3: Immediate post-operative measurements



CASE 3: 6-week follow-up measurements



CASE 3: 3-month follow-up measurements



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LM- Definition of intellectual content, literature survey, prepared first draft of manuscript, implementation of study protocol, and manuscript revision;
AS- Manuscript preparation, editing, and manuscript submission; and **VS-** Definition of intellectual content, literature survey, prepared first draft of manuscript, implementation of study protocol, data collection, data analysis, and manuscript preparation.

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