

## Original article

# A clinico-radiological study of bicondylar tibial plateau fractures managed with dual locking plates



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## ABSTRACT

**Background:** Treatment of bicondylar intra-articular tibial plateau fractures due to high energy trauma is complex and highly prone to complications due to fracture patterns and extensive soft tissue damage.

**Aim:** The study's objective was to evaluate the clinical, radiological and functional outcome, including the complications in closed Schatzker type V and VI tibial plateau fractures managed with dual locking plates using less extensile approaches and indirect reduction techniques.

**Materials and methods:** Thirty-four patients of closed Schatzker Type V and VI treated with pre-contoured locking plates were evaluated clinically and radiologically. Dual plating was done using a less extensile anterolateral approach for lateral plate and medial/open posteromedial approach for medial plate. Functional results were evaluated using the Knee Society Score (KSS) and radiological results by the Modified Rasmussen score (MRS) for radiological assessment.

**Results:** The mean age of patients in our study was 45 years (range = 26–60 years) with a male predominance of 84.4%. The average time difference between trauma and surgery was 7.6 days (range = 5–14 days) with an average length of hospital stay of 8.5 days (range = 7–18 days). Autologous bone grafting from the iliac crest was done in 10 patients (29.4%) with a sizeable metaphyseal void. The study has a mean follow-up period of 22.6 months. The complete union was seen at an average of 17.4 weeks. The average knee ROM at the last follow-up was 110.75°. Three patients had complications, 2 with wound dehiscence and 1 with deep infection.

**Conclusion:** Internal fixation with dual locking plates is biomechanically strong and stable and gives excellent to good functional outcomes. However, the timing of internal fixation is essential in such complex injuries to prevent soft tissue complications and failure. The use of rigid fixation by less extensile approaches and indirect reduction techniques helps prevent wound healing problems and allows early knee mobilization.

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## 1. Introduction

Bicondylar intra-articular tibial plateau fractures represent a complex, high-energy injury associated with high complication rates. Schatzker type V and VI are intra-articular fractures of the tibial plateau involving condyles, causing articular comminution, metaphyseal-diaphyseal dissociation, severe soft tissue damage,

and joint instability.<sup>1–4</sup> Soft tissue damage is the primary concern even in closed fractures, and early definitive fixation can aggravate complications, making time for open reduction and internal fixation (ORIF) controversial and challenging.<sup>5–7</sup> There is no specific or ideal treatment protocol described for managing such fractures. Anatomic reduction with minimal soft tissue invasion and rigid fixation can achieve articular congruity and restore limb alignment while allowing full weight-bearing and early knee ROM.<sup>8–11</sup> However, early definitive fixation, specifically which compromises the soft tissue envelope, can cause significant wound complications.<sup>12</sup> Postoperative complications like wound dehiscence, knee stiffness, infection or septic arthritis, and eventually non-union or secondary osteoarthritis could compromise the

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outcomes of these complex fractures (see Table 1).

An external fixator has been developed as an alternative to avoid soft-tissue complications and obtain good results by spanning the fracture site until soft tissue condition improves.<sup>13-16</sup> However, it often leads to joint stiffness due to delayed knee mobilization.<sup>11</sup> Temporary external fixation followed by definitive internal fixation has been used to minimize such complications allowing restoration of joint congruency and limb alignment. An external fixator is usually applied by using the principle of ligamentotaxis and further stabilizing the comminuted fracture fragments with the help of K-wire and percutaneous screw.<sup>17</sup>

Many studies have been published in the literature comparing plate osteosynthesis and hybrid external fixator or ring fixator; however, very little is known regarding dual plating using limited open or less extensile approaches on the more severe Schatzker type V and VI fractures.<sup>18,19</sup> The objective of this study was to evaluate the outcomes in these complex types of fractures using less extensile approaches, indirect reduction techniques, and fixation with dual locking plates.

**2. Material and methods**

A prospective study of 34 patients (34 knees) with closed Schatzker type V or VI fractures operated in our tertiary care and research institute and followed up clinically and radiologically. Inclusion criteria include isolated high-velocity trauma resulting, closed Schatzker type V or VI tibial plateau fractures managed with two pre-contoured locking plates. Exclusion criteria were open fractures, neurovascular injury, other than Schatzker type V or VI, ipsilateral distal femur fractures, fracture. Antero-posterior (AP) and lateral x-ray and a CT scan with a 3D reconstruction of the involved knee joint were done in all cases for pre-operative planning. At admission, the injured limb was gently reduced by traction, immobilized with skeletal traction, and elevated on a Bohler-Braun splint. All patients were closely monitored for any deteriorating signs of peripheral circulation and neurological status of the limb. A single dose of prophylactic antibiotics was given to all patients on admission in the form of injectable ceftriaxone 1 gm and amikacin 500 mg, and the doses were repeated before giving incision.

The patients presenting with these complex fractures were planned for plate fixation only after a cautious and thorough examination, including the soft tissue and skin condition. Visible contusion and blisters indicated severely compromised underlying

soft tissues, and the surgery was deferred till the disappearance of tense and shiny skin and the wrinkling test was observed back. Occasionally, even after adequate waiting, the improvement in skin and soft tissue was not satisfactory. Such patients were managed using a ring fixator and were not included in the study group.

All patients were operated under general or spinal anesthesia by the same surgeon. Three-Column Classification was used for these complex fractures. Moreover, because of the significant comminution of these fractures, occasionally, Schatzker Classification alone was inadequate to classify the fracture pattern and needed to supplement with the CT-based Three-Column Classification, more so in fractures involving posterior column. CT-based classification assisted in identifying the number of columns involved and determining if the fracture line was in the coronal or sagittal plane. While planning, it's essential to get an X-ray/Ct scan on traction for better understanding the fracture pattern. Because of this simple ligamentotaxis, a very complex-looking fracture can be managed adequately as major fracture fragments fall back to alignment. Each fractured column thus identified needs individual fixation with a pre-contoured anatomic plate. The depressed fragments are elevated using a small periosteal elevator and subsequently be supported using a bone graft. The reduced fracture fragments were temporarily fixed using multiple Kirschner wires. Before applying the plates, the position, alignment, and articular congruity were confirmed using fluoroscopic guidance.

The surgeries were done in a supine/floppy lateral position under a tourniquet on a radiolucent table. These fractures were operated and reduced using less extensile approaches and indirect reduction techniques by two incisions. Direct manipulation and reduction of comminuted subarticular bone fragments were avoided. Limited open reduction was sometimes necessary where fracture reduction was not possible by ligamentotaxis and indirect methods alone. The medial column was fixed using medial plating with subperiosteal dissection limited to fracture margins. A small fragment plate was sometimes used for buttressing or as an anti-gliding plate. While fixing the medial column, it's paramount not to allow the plate's sliding posteriorly as it tends to loosen its buttress effect in this malposition. For lateral column fractures, the reduction was held with a clamp, and preliminary fixation of the articular surface was done using partially threaded cancellous lag screws. The locking plate was then glided under the periosteum along the shaft. An open posteromedial approach was used in cases with a large posteromedial fragment. While fixing the posterior column,

**Table 1**  
Comparison between Dual plating and External Fixator.

DESCRIPTION	ORIF WITH PLATING	EXTERNAL FIXATOR
GLOBAL ACCEPTABILITY	Gold Standard	Damage control
SKILL LEVEL	High skill level	Easy to apply
INVASIVENESS	Invasive requiring skin incision and superficial and deep soft tissue dissection	Minimally invasive
FRACTURE REDUCTION	Anatomic fracture reduction	Fracture alignment and stabilization. Anatomic reduction not always possible
BONE GRAFTING	Bone grafting can be augmented in severe comminution and bone loss	Bone grafting is not an option
INTER-FRAGMENTARY COMPRESSION	Inter-fragmentary compression is possible when applied in compression mode.	Does not provide much inter-fragmentary compression.
ASSOCIATED SOFT TISSUE INSULT OR TRAUMA	Using plates in an already compromised soft tissue might further strip off the blood supply	iatrogenic soft tissue damage is minimal
ASSOCIATED JOINT STIFFNESS	Early mobilization of the knee in immediate postoperative period thus preventing joint stiffness	Early mobilization not allowed and can lead to joint stiffness
POST OP CARE	Regular alternate day stitch line dressings	Daily pin site dressings
RISK OF OSTEOMYELITIS	Osteomyelitis uncommon	Osteomyelitis can occur
INFECTION RISK	Stitch line infections	Pin tract infections
ECONOMIC CONSIDERATION	Expensive	Inexpensive
USEFULNESS IN SEVERE SOFT TISSUE COMPROMISE	It cannot be applied in severe soft tissue compromise due to the risk of infection and skin and soft tissue necrosis	The application can also be done in severe soft tissue compromise around the knee

careful dissection is required to preserve the posterior tibial recurrent artery and the other neurovascular bundle in the popliteal region. Autologous bone grafting was done only in patients with significant metaphyseal defects.

All patients underwent the same postoperative protocol; static quadriceps, hamstring, and passive knee mobilization exercises were started postoperatively on day 2. Partial weight-bearing was allowed at 6–8 weeks and total weight bearing at 12–14 weeks once evidence of union was seen on x-rays. During each visit, the patients were evaluated clinically and functionally, using the Knee Society Score (KSS)<sup>20</sup> and radiologically, using the Modified Rasmussen Score (MRS) for radiological assessment.<sup>21</sup> Data collected on follow-up also included joint line restoration and maintenance, signs of infection, delayed union, non-union, and fracture collapse. Any depression of the articular surface >2 mm was considered as an articular step-off. Any secondary loss of alignment of >5° in the frontal or sagittal plane was considered as mal-alignment when compared with an immediate postoperative radiograph. Union was defined when at least three bridging cortices were seen on AP and lateral radiographs with painless full weight-bearing.<sup>22,23</sup>

Statistical analysis was made using SPSS version 17, categorical data were compared between two groups using chi-square/Fisher exact test, and quantitative data was analyzed by Student t-test. The p-value of <0.05 was taken as the level of significance.

### 3. Results

In this study, the most common cause of tibial plateau fracture was roadside accidents, and the average age of patients was 45 years (range = 26–60 years) with a male predominance of 84.4%. A total of 34 patients (34 knees) were classified as bicondylar intra-articular tibial plateau fractures, of which 22 (64.7%) were of Schatzker type V and 12 (35.3%) of Schatzker type VI. The average time difference between trauma and surgery was 7.6 days (range = 5–14 days). The average length of hospital stay was 8.5 days (range = 7–18 days). The average follow-up time was 22.6 months (range = 12–36 months). The iliac crest was harvested for autologous bone grafting, done for ten patients (29.4%) with a large metaphyseal void. All patients achieved full weight-bearing after 12 weeks. The average time seen for bony union and consolidation was 17.4 weeks. The average knee ROM at the final follow-up was 110.75° (See Fig. 1 and Fig. 2).

Out of thirty-four patients, twelve patients (35.3%) had excellent, nineteen patients (55.9%) had good, and three patients (8.8%) had fair, objective knee society score. The functional knee society score in this group was excellent in ten patients (29.4%), good in twenty patients (58.8%), fair in three patients (8.8%), and poor in

one patient (2.9%). Modified Rasmussen criteria for radiological assessment showed excellent results in twelve patients (35.3%), good in seventeen patients (50%), and fair in five patients (14.7%).

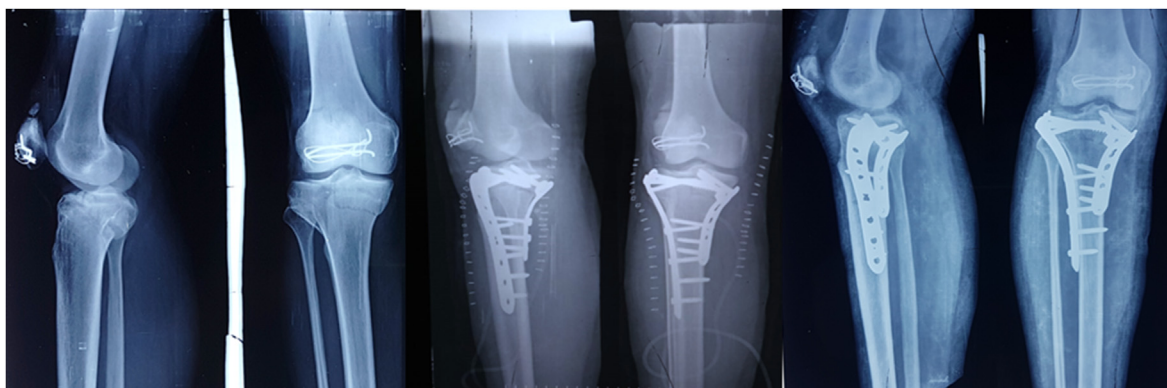
Postoperatively, knee stiffness was the most common complication seen among patients. Fixed flexion deformity of the knee >10° was seen in six patients (17.6%). The range of flexion was less than 90° in four patients (11.7%), 91°–120° in twenty patients (58.8%), and over 120° in ten patients (29.4%). There were two patients with wound dehiscence who healed with debridement and antibiotics. One patient had a deep infection that needed implant removal and revision surgery. Two patients had a secondary loss of reduction with malalignment due to articular comminution managed by a long leg cast and delayed weight-bearing.

### 4. Discussion

Bicondylar intra-articular tibial plateau fractures are high-energy complex fractures that require surgical treatment for anatomical reduction of the articular surface. However, these fractures are associated with high complication rates, including massive articular comminution and severe soft tissue injury resulting in increased chances of wound dehiscence and malalignment, further resulting in delayed complications like implant failures, the varus collapse of fracture, and post-traumatic osteoarthritis of the knee.<sup>6,23–25</sup> Various fixation methods have been described in the literature for these fractures, like plating through a single midline incision, dual buttress plating, external fixation, and a hybrid fixator.<sup>26–28</sup> But the timing and choice of the surgical option are essential and can be very challenging to obtain good knee ROM and prevent secondary osteoarthritis.

Open reduction and internal fixation using two incisions or dual plating poses a high risk of complications like infection, wound dehiscence, fracture collapse, non-union and secondary osteoarthritis.<sup>29,30</sup> The availability of anatomically contoured locking plates using minimally invasive techniques has reduced complications by minimizing surgical exposure, providing stable internal fixation without bone grafting.<sup>18</sup>

In our study, internal fixation was done with dual locking plates using less extensile/limited open reduction techniques in all patients. Only ten patients (29.4%) required bone grafting to fill the sizeable metaphyseal void, which was comparable to the studies by Gosling et al. and Jiang et al., who reported bone grafting needed in 19% & 29.3% of their patients, respectively.<sup>22,31</sup> The use of less extensile approaches with locking plates limits bone and soft tissue complications while providing stable fixation as the fracture site is minimally exposed. The plate is glided under the periosteum,



Case 1. Pre-operative, postoperative, and follow up x-ray.





**Case 2.** Pre-operative, postoperative, and follow up x-ray.

sparing the overlying tissues. With the use of c-arm image and indirect reduction techniques, reducing the articular fragments can be minimal without stripping off the blood supply to these small fragments. However, this surgical technique demands a competent surgeon. It requires indirect fracture reduction by skeletal traction, K-wires as joysticks, or preliminary fixation of the articular surface using cannulated screws.<sup>18</sup>

Bertrand et al., In a comparative study between two population groups, reported that the delay to surgery was more significant in the open reduction internal fixation (ORIF) group; average = 3.04 days compared to 1.9 days in the hybrid fixator group. However, the complication rates were higher in the hybrid fixator group. Similarly, in a comparative study by Bove et al., they reported an average surgical delay of 7 days in the plating group. In our study, the average surgical delay was 7.6 days (range = 5–14 days). We agree that a better policy would accept a further delay in definitive surgery to prevent soft tissue complications.<sup>17,18</sup>

The average time for healing and consolidation was 17.4 weeks which was similar to some other studies in the literature.<sup>11,23</sup> In our study, the overall length of hospital stay was between 7 and 18 days (mean 8.5 days). These findings were similar to the survey by Bertrand et al., who reported the length of stay to be 6.50 days.<sup>17</sup> The overall rate of operative site infection in tibial plateau fractures is 7.8% and was similar to our finding of 8.8% (3 out of 34 patients).<sup>32</sup> The incidence of deep infection in our study was very low despite including severe complex high energy Schatzker Type V and VI fractures, which we believe was due to delay in definitive surgery and the use of less extensile approaches with indirect reduction techniques and minimal periosteal stripping. The most common complication seen postoperatively among patients was knee stiffness, which stresses the importance of rigid fixation and early knee mobilization in the immediate postoperative period. However, the KSS was excellent or good in 88.2% of our patients. The Modified Rasmussen criteria for radiological assessment score was statistically significant postoperatively in all patients, and the score was maintained at the latest follow-up. On comparing, these scores were similar to studies in the literature.<sup>15,25,29,33</sup>

Our study was a prospective study with a few limitations. Randomization with a control group is necessary to eliminate bias impact on results. However, it was not done to minimize the potential risks of infection and soft tissue complications. A relatively small sample size and a short follow-up add to the limitation of this study. Consequently, the study could be undertaken to a more extensive sample set or population to reduce bias creeping in due to outliers.

## 5. Conclusion

Dual locking plates with less extensile/limited open reduction techniques are more competent and virtuous for managing high-energy, complex tibial plateau fractures associated with severe soft tissue damage and intra-articular comminution. It represents a more biologic approach with minimal soft tissue dissection and periosteal stripping at an acceptable complication rate. These locking plates provide a stable fixation with anatomical reconstruction while awaiting union. The postoperative complications might be further minimized by a well-planned surgery, less extensile approaches, and early knee mobilization.

## Informed consent

A well defined and informed consent was taken from all individual participants included in the study.

## Declaration of competing interest

All the authors in this study declare no conflict of interest. Moreover, the study was not funded by any source.

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