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Original Research Article

FUNCTIONAL OUTCOMES OF BICOLUMNAR PLATING IN BICONDYLAR TIBIAL PLATEAU FRACTURES

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ABSTRACT

Background: Bicondylar tibial plateau fractures are high-energy intra-articular injuries associated with significant morbidity. Bicolumnar plating via dual incisions provides independent stabilisation of medial and lateral columns; however, prospective functional outcome data remain limited. The objective is to evaluate the clinical, radiological, and functional outcomes of bicolumnar plating in patients with Schatzker type V and VI bicondylar tibial plateau fractures.

Materials and Methods: A prospective observational study was conducted at Narayana Medical College & Hospital, Nellore (January 2024 to December 2025). Twenty patients with Schatzker type V and VI tibial plateau fractures underwent open reduction and internal fixation with bicolumnar plating. Outcomes assessed included fracture union, range of motion, Rasmussen functional score, Knee Society Score (KSS), and complications at 6-week, 3-month, and 6-month follow-up.

Results: Mean age was 46.8 ± 11.2 years; 75% were male. Road traffic accidents accounted for 65% of injuries. Mean operative time was 108 ± 20 minutes with mean blood loss of 130 ± 30 mL. Radiological union was achieved at a mean of 16 ± 3 weeks. Knee flexion greater than 120° was attained by 60% of patients. By Rasmussen criteria, 85% achieved excellent or good outcomes; KSS was excellent or good in 80%. The complication rate was 20%, with no implant failure or non-union.

Conclusion: Bicolumnar plating is a reliable technique for bicondylar tibial plateau fractures, yielding satisfactory union, favourable functional recovery, and an acceptable complication profile. Staged soft-tissue management and early rehabilitation are critical to outcome.

Keywords: Tibial plateau fracture; Bicondylar fracture; Bicolumnar plating; Dual-incision; Schatzker classification; Rasmussen score; Knee Society Score.

INTRODUCTION

Tibial plateau fractures are complex intra-articular injuries of the proximal tibia that involve the weight-bearing surface of the knee joint. They account for approximately 1% of all fractures and up to 8% of fractures in the elderly, with a bimodal age distribution—high-energy trauma in young adults and low-energy osteoporotic injuries in older patients.[1,2] The tibial plateau plays a crucial role in knee stability, alignment, and load transmission; fractures in this region therefore pose significant challenges in management and functional recovery.

The mechanism of injury typically involves axial loading combined with varus or valgus stress, producing depression, split, or comminuted fracture patterns.[3] High-energy trauma such as road traffic accidents often generates complex bicondylar fractures associated with metaphyseal comminution, metaphyseal-diaphyseal dissociation, and extensive soft-tissue injury.[4] Inadequate treatment may result in joint instability, malalignment, post-traumatic osteoarthritis, stiffness, and chronic pain.[5]

The Schatzker classification remains the most widely used system for categorising these fractures.[6] Bicondylar injuries (Schatzker types V and VI) are inherently unstable, involving both medial and lateral

columns of the proximal tibia, and frequently demand operative stabilisation.[7] Single lateral locking plate fixation, though minimally invasive, may be insufficient to control medial column instability, thereby risking varus collapse and loss of reduction.[8,9] Recognising the biomechanical importance of the medial column has led to bicolumnar fixation strategies that independently stabilise both columns through dual incisions.[10]

Several biomechanical and clinical studies have demonstrated the superiority of dual plating over single-plate constructs in preventing secondary collapse, maintaining alignment, and facilitating early mobilisation.[11,12] Nevertheless, prospective data from centres in developing countries—where road traffic accidents predominate—remain limited. The present study was therefore undertaken to prospectively evaluate fracture union, knee function, range of motion, and complications in patients with Schatzker type V and VI fractures managed with bicolumnar plating.

MATERIALS AND METHODS

Study Design and Setting: This prospective observational study was conducted in the Department of Orthopaedics, Narayana Medical College & Hospital, Nellore, Andhra Pradesh, India, from January 2024 to December 2025. Institutional Ethics Committee approval was obtained before commencement (Reference No: [IEC Ref – to be added]), and written informed consent was obtained from all participants. The study is reported in accordance with the STROBE guidelines for observational research.

Inclusion and Exclusion Criteria

Patients were eligible if they were aged 18 years or older, presented with closed Schatzker type V or VI tibial plateau fractures or Grade I/II open fractures, and were able to provide informed consent.

Patients were excluded if they were aged under 18 years, had Grade III open injuries, presented more than four weeks after injury, or had extensive soft-tissue injury requiring a healing period of more than three weeks.

Pre-operative Assessment: All patients were initially assessed and resuscitated following Advanced Trauma Life Support principles. Clinical evaluation included assessment of soft-tissue status, neurovascular integrity, ankle-brachial pressure index (values below 0.9 prompted angiographic evaluation), and ligamentous stability (Lachman test). Standard anteroposterior and lateral radiographs, a 10° caudal-tilt view, and computed tomography with three-dimensional reconstruction were obtained in all cases to define fracture morphology and guide surgical planning. Fractures were classified according to the Schatzker system.

Surgical Technique: Definitive fixation was deferred until resolution of soft-tissue oedema, typically five to seven days following injury. All procedures were performed under spinal or general anaesthesia with the patient in the supine position. Bicolumnar fixation was performed through anterolateral and medial/posteromedial approaches. Articular reduction was achieved under direct visualisation and fluoroscopic guidance. Metaphyseal voids were filled with autologous bone graft or bone substitute where indicated. Wound closure was performed in layers after meticulous haemostasis.

Post-operative Protocol: Prophylactic antibiotics were administered according to institutional protocol. Early quadriceps strengthening exercises and knee range-of-motion physiotherapy commenced within 48 hours of surgery. Non-weight-bearing ambulation was initiated as tolerated; progressive weight-bearing was guided by serial radiological evidence of fracture union.

Outcome Measures: Patients were followed up at six weeks, three months, and six months. Primary outcomes were radiological fracture union and functional recovery assessed by the Rasmussen Functional Scoring System (graded Excellent 27–30, Good 20–26, Fair 10–19, or Poor below 10); the Knee Society Score (graded Excellent 80–100, Good 70–79, Fair 60–69, or Poor below 60); knee flexion range of motion (categorised as greater than 120°, 90–120°, or less than 90°); and complication rate, including infection, stiffness, malunion, non-union, and implant failure.

Statistical Analysis: Data were entered in Microsoft Excel and analysed using SPSS version 26.0 (IBM Corp., Armonk, NY). Continuous variables are expressed as mean ± standard deviation. Categorical variables are presented as frequencies and percentages. Continuous variables were compared using Student's t-test or one-way ANOVA; categorical variables were analysed using the Chi-square test. A P value less than 0.05 was considered statistically significant.

RESULTS

Demographic, Injury, and Fracture Profile: Twenty patients were enrolled. The mean age was 46.8 ± 11.2 years (range 21–68 years). Male patients predominated (n=15; 75%), consistent with the higher exposure to high-energy trauma in this demographic. Road traffic accidents were the predominant mechanism of injury, accounting for 65% of cases; falls from height and sports injuries constituted the remaining 25% and 10% respectively. All fractures were bicondylar, with Schatzker type V fractures slightly more prevalent (55%) than type VI (45%). Full details are presented in [Table 1].

Operative Details and Hospital Course: Surgical and perioperative parameters are summarised in [Table 2]. The mean injury-to-surgery interval of 5.2 ± 2.3 days reflects intentional delay to permit soft-tissue recovery. Mean operative time was 108 ± 20 minutes. Intraoperative blood loss was well controlled (mean 130 ± 30 mL). The mean hospital stay was 11 ± 3 days.

Table 1: Baseline demographic, injury, and fracture characteristics (n=20).

Characteristic	Number of Patients	Percentage (%)
Age group (years)		
21–30	3	15%
31–40	4	20%
41–50	5	25%
51–60	6	30%
>60	2	10%
Gender		
Male	15	75%
Female	5	25%
Mechanism of injury		
Road traffic accident	13	65%
Fall from height	5	25%
Sports injury	2	10%
Schatzker classification		
Type V	11	55%
Type VI	9	45%

Table 2: Perioperative parameters (n=20).

Parameter	Mean ± SD
Injury-to-surgery interval	5.2 ± 2.3 days
Operative time	108 ± 20 minutes
Intraoperative blood loss	130 ± 30 mL
Duration of hospital stay	11 ± 3 days
Time to radiological union	16 ± 3 weeks

Fracture Union and Complications: Radiological fracture union was achieved in all 20 patients. The mean time to union was 16 ± 3 weeks; 65% of patients achieved union between 15 and 18 weeks. Delayed union (beyond 18 weeks) was observed in 15% of cases, all of which eventually united without additional intervention. The overall complication rate was 20%. Knee stiffness was the most frequent complication (10%; n=2), followed by superficial infection (5%; n=1) and malunion (5%; n=1). No patient sustained implant failure or non-union [Table 3].

Table 3: Postoperative complications (n=20).

Complication	Number of Patients	Percentage (%)
Superficial infection	1	5%
Knee stiffness	2	10%
Malunion	1	5%
Implant failure	0	0%
Non-union	0	0%

Functional and Radiological Outcomes: Knee flexion greater than 120° was attained by 60% of patients (n=12); 30% achieved flexion between 90° and 120°, and 10% had flexion less than 90°. By Rasmussen functional grading, 40% of patients achieved an Excellent result and 45% a Good result, giving a combined Excellent/Good rate of 85%; Fair and Poor results were recorded in 10% and 5% respectively. Overall KSS grading showed Excellent results in 45% and Good results in 35%, yielding a combined Excellent/Good rate of 80%; Fair and Poor outcomes were noted in 15% and 5% respectively [Table 4].

Table 4: Functional and radiological outcomes (n=20).

Outcome Measure	Number of Patients	Percentage (%)
Knee flexion (range of motion)		
>120°	12	60%
90–120°	6	30%
<90°	2	10%
Rasmussen functional score		
Excellent	8	40%
Good	9	45%
Fair	2	10%
Poor	1	5%
Knee Society Score		
Excellent	9	45%
Good	7	35%
Fair	3	15%
Poor	1	5%

DISCUSSION

This prospective study demonstrates that bicolumnar plating via dual incisions provides satisfactory fracture union, favourable functional recovery, and an acceptable complication profile in patients with bicondylar tibial plateau fractures. The key findings—a combined Excellent/Good Rasmussen rate of 85%, KSS Excellent/Good rate of 80%, 100% union, and zero implant failure or non-union—compare favourably with contemporary literature.[15-20]

Patient Demographics and Injury Pattern: The predominance of middle-aged males sustaining high-energy road traffic accidents reflects the epidemiological profile of bicondylar tibial plateau fractures reported across the literature.[15-18] Road traffic accidents accounted for 65% of injuries in the present study, consistent with their status as the principal cause of complex tibial plateau fractures in developing nations. A slight preponderance of Schatzker type V over type VI fractures was observed; both fracture types share the common feature of bicondylar involvement, mandating fixation of both columns for biomechanical stability.

Timing of Surgery and Soft-Tissue Management: The mean injury-to-surgery interval of 5.2 days reflects deliberate staging to allow soft-tissue recovery, consistent with the protocol advocated by Shah and Karunakar,[16] and Eggli et al.[17] These authors demonstrated that early surgery in the presence of significant oedema substantially increases the risk of wound dehiscence and deep infection. In the present series, the superficial infection rate of 5% is within the range reported for staged bicolumnar plating in the literature (0–14%).[16,17]

Operative Parameters: The mean operative time of 108 minutes is comparable with that reported by Shah and Karunakar,[16] and reflects proficiency with the dual-incision technique when meticulous preoperative planning is performed. Mean intraoperative blood loss of 130 mL indicates that targeted column-specific approaches minimise unnecessary soft-tissue dissection. The mean hospital stay of 11 days is consistent with stable fixation facilitating early mobilisation and discharge.[16,17]

Fracture Union: All fractures achieved radiological union at a mean of 16 weeks, consistent with the healing timeline reported by Eggli et al,[17] and Mahadeva et al.[18] The absence of non-union reflects the biological advantage of the proximal tibia, which has an abundant blood supply, and the mechanical benefit of rigid bicolumnar fixation. Stable construct loading conditions are known to promote secondary bone healing and callus formation.[18,20]

Functional Outcome: The Rasmussen Excellent/Good rate of 85% and KSS Excellent/Good rate of 80% are consistent with previously published series. Higgins et al,[15] demonstrated biomechanically that dual-plate constructs provide significantly greater resistance to axial loading and articular subsidence than isolated lateral locked plating, a mechanical advantage that directly translates into superior functional recovery. Shah and Karunakar,[16] and Musahl et al,[20] similarly reported excellent functional results following dual-incision bicolumnar plating when combined with early rehabilitation.

Knee flexion exceeding 120° was achieved by 60% of patients, a result concordant with early mobilisation protocols and rigid fixation allowing safe initiation of physiotherapy.[16,17] The 10% incidence of knee stiffness underscores the importance of aggressive, supervised postoperative rehabilitation.

Biomechanical Rationale for Bicolumnar Fixation: The fundamental biomechanical principle underpinning bicolumnar plating is the independent stabilisation of medial and lateral columns. Higgins et al,[15] showed that isolated lateral locking plate constructs fail to control medial column instability in bicondylar fractures, predisposing to varus collapse. The present findings—65% of patients with anteroposterior stability less than 5 mm and 65% with mediolateral laxity less than 5°—reflect effective restoration of both sagittal and coronal plane stability through dual plating.

The posteromedial fragment, identified by Eggli et al,[17] and Weil et al,[19] as a critical determinant of stability, was addressed in all relevant cases through the posteromedial approach with antiglide plating. This strategy prevents posterior shear displacement and maintains the integrity of the medial column throughout the rehabilitation process.[17,19]

Complication Profile: The overall complication rate of 20% compares favourably with the 25–42% reported for earlier techniques and is consistent with the 10–22% range observed in contemporary dual-plating series.[15-20] Meticulous soft-tissue handling, delayed definitive fixation, and perioperative antibiotic prophylaxis contributed to the low infection rate. The absence of implant failure or non-union affirms the mechanical competence of bicolumnar constructs in sustaining reduction until biological healing is complete.

Limitations: The study has several limitations that should be acknowledged. The sample size of 20 patients is relatively small, limiting statistical power and generalisability of the findings. The maximum follow-up period of six months does not capture late complications such as post-traumatic osteoarthritis or implant-related issues. The single-centre, non-randomised design and absence of a control arm preclude definitive causal inference. Future multicentre randomised controlled trials with longer follow-up are required to confirm these findings.

CONCLUSION

Bicolumnar plating through dual incisions is an effective and reliable surgical technique for the

management of bicondylar tibial plateau fractures. It achieves anatomical restoration of the articular surface, provides stable bicolumnar fixation, and facilitates early knee mobilisation. In this prospective series, 85% of patients achieved Excellent or Good functional outcomes by Rasmussen criteria, with a 100% union rate and no implant failure. Staged surgical management with appropriate soft-tissue recovery prior to definitive fixation and a structured postoperative rehabilitation protocol are critical to optimising outcomes. These findings support bicolumnar plating as a standard-of-care approach for Schatzker type V and VI tibial plateau fractures.

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