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Functional and radiological outcome of surgical management of tibial plateau fracture

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Abstract
Introduction: Fractures of the tibial plateau range from simple lateral condyle fractures to severe comminuted metaphyseal fractures associated with varying degrees of articular depression. Management of these complicated fractures remains challenging. The objective in treating displaced fractures is to restore the articular surface anatomy and achieve stable internal fixation, thereby obtaining a painless and stable knee joint with a normal range of motion. This study aims to assess the functional and radiological outcome of surgical management of tibial plateau fractures
Methods: A total of 30 patients with tibial plateau fractures who met the inclusion criteria underwent operative intervention over twelve months and were followed for 6 months. The functional and radiological outcomes were measured using Modified Rasmussen Criteria at last follow-up.
Results: The mean age in the study was 38.93(Range 16-65) years. The most common mode of injury was road traffic accident (66.67%), followed by fall from height (20%). Schatzker type 2 (33.33%) was the most common fracture type, followed by type 4 (26.67%). The mean duration from injury to the time of operation was 6.63 days. The mean Modified Rasmussen clinical assessment score was 25.47, with excellent, good, and fair results in 15, 11, and 4 patients, respectively. Whereas the mean Modified Rasmussen radiological assessment score was 7.47, with excellent, good, and fair results in 7, 21, and 2 patients, respectively.
Conclusion: The treatment goal of tibial plateau fractures should be anatomical reduction, stable fixation, and early joint motion to prevent stiffness and the reduction of complications. These fractures treated with different modalities at our institute have been associated with excellent and good functional outcomes at the end of short-term follow-up.

Keywords: Tibial plateau, fracture, Modified Rasmussen criteria, Schatzker, functional outcome, radiological outcome

Introduction
The knee joint is one of the most robust and vital weight-bearing joints in the human body, allowing movement of the lower leg relative to the thigh while supporting the body's weight. Functional knee motion is essential for daily activities such as walking, running, sitting, and standing; thus, the proper management of fractures involving this joint is critical to reduce morbidity and disability from post-traumatic arthritis [1, 2].
Proximal tibial fractures are broadly classified into articular and non-articular types. Articular fractures, also called tibial plateau or tibial condylar fractures, involve the joint surface [3]. Intra-articular fractures of the proximal tibia are serious and complex injuries that account for approximately 1.2% of all adult fractures [4]. These injuries usually result from high-energy trauma, including road traffic accidents—historically termed "fender's" or "bumper's" fractures—sports injuries, or falls from height. Low-energy variants are frequently linked to osteoporotic bone and reduced bone quality [5, 6].
The tibial plateau is a crucial load-bearing structure contributing to knee stability, alignment, and range of motion. Fractures may range from minimally displaced lateral depression patterns to complex bicondylar injuries often accompanied by severe soft-tissue damage and complications [7, 8]. The region's intricate anatomy—including extensive articular cartilage, multiple ligamentous and meniscal attachments, and its role in transmitting high axial loads—makes reconstruction particularly challenging [9].
The primary goals of managing tibial plateau fractures are to restore joint stability, alignment,

and congruity while maintaining a pain-free range of motion and function [10]. The management of displaced fractures remains debated, requiring careful evaluation of fracture morphology and soft-tissue status [11, 12]. The timing of surgery and meticulous soft-tissue handling are essential for reducing complications and optimizing functional outcomes [13].

Recent decades have seen significant advances in fixation techniques, including smaller-diameter screws, locking plates, and osteobiologic implants [14]. Newer methods introduced in the 1990s have improved outcomes in high-energy fractures with complex patterns and soft-tissue compromise [15]. While surgical intervention is generally preferred for such high-energy injuries, treatment approaches for low-energy fractures still vary widely among surgeons [16].

Methods

This was a hospital-based prospective longitudinal study conducted at Gandaki Medical College and Teaching Hospital (GMCTH), Pokhara, over 12 months (July 2024 to June 2025). A total of 30 patients with tibial plateau fractures were included in our study.

Patients aged less than 18 years, open fractures, pathological fractures, associated fractures of the lower limb, pelvis, or spine, and patients with neuromuscular disorders and tumors were excluded from our study. Cases with duration of trauma >2weeks, without sufficient post-operative information, and those lost to follow-up, were also excluded from the study.

Ethical approval was taken from the Institutional Ethical Review Committee of GMC (Ref: 95/080/081-F). Junior residents and a consultant orthopedic surgeon evaluated patients at the emergency and outpatient clinic of GMCTH. Informed consent was obtained in the prescribed form/format from the patients selected for the study after an explanation of the details of the study and the procedure to be performed. Relevant history, clinical examination of patients, and other information were filled in a printed case report form. Plain anteroposterior and lateral view X-Ray of the involved knee and proximal leg was done to evaluate the fracture pattern. Computed tomography scans were done for complex fractures, and magnetic resonance imaging was done for assessment of soft tissue injury. Fractures were classified according to Schatzker. All fractures were managed using the standard techniques of exposure, open reduction, and stable internal fixation. Surgery was performed in fluoroscopic control, either under general or spinal anesthesia, on a standard radiolucent operating table. The involved joint was exposed either through a medial incision or through a lateral incision. Joint reduction was achieved under direct visualization using manual traction, a femoral distractor, or reduction clamps. Depressed fragments of the joint surface were elevated, and bone graft was used to fill bony voids as necessary to support elevated fragments. In relatively simpler fracture patterns, percutaneous cancellous screws were used for fixation. In more complex fracture patterns, lateral, medial, or dual plating with locking implants was utilized, as necessary, to achieve adequate fracture reduction and stabilization. Immediate postoperative radiographs (AP and lateral) were analyzed to determine the quality of reduction.

Post-operative observation of patients was done at 2 weeks, 6 weeks, 3 months, and 6 months follow-up. Physiotherapy was started postoperatively as soon as pain subsided or was bearable by the patient. Patients were assessed for pain, articular depression, condylar widening, angulation, stability, and range of movements at the knee joint, along with any complications. The results were evaluated with Modified Rasmussen criteria at 6months of follow-up visit.

Results

In this study, a significant association of fracture was found in the age group 30-45 years, with 46.67% of patients; the mean age was 38.89 years, 56.67 % were male patients, and 43.33 % were female patients. 53.33 % of the patients sustained an injury on the left side and 46.67 % on the right side. In our study, there was left-sided predominance. In this study, the most common mode of injury is highly associated with road traffic accidents which accounts for about 66.67% and fall injury which accounts for 33.33%. The majority of fractures were found to be type II fractures. 10 cases were managed with percutaneous cannulated screws, 4 with a Locking Compression plate, 7 with a medial Buttress plate, 7 with dual plating, and 2 cases with a locking compression plate along with bone graft. The mean time patients had to wait for surgery was 6.63 days, with minimum and maximum times being 3 days and 12 days, respectively. The mean time taken for the fracture to unite was 14.57 weeks. The minimum time taken was 12 weeks, and the maximum time was 18 weeks. All the cases achieved good union, with no evidence of non-union. The mean Rasmussen Functional score at the final follow-up was 25.37 (range 17-30). Out of 30 cases treated with surgical procedures, 15 cases had excellent results, 11 cases had good results, and 4 cases had fair results.

Table 1: Rasmussen Functional score at the final follow-up

Clinical result	No. of cases	Percentage
Excellent	15	50 %
Good	11	36.67 %
Fair	4	13.33 %
Total	30	100 %

The mean Rasmussen Radiological score at the final follow-up was 7.47 (range 5-9). Out of 30 cases treated with a surgical procedure, 7 cases had excellent results, 21 cases had good results, and 2 cases had fair results.

Table 2: Rasmussen Radiological score at the final follow-up

Radiological evaluation	No. of cases	Percentage
Excellent	7	23.33 %
Good	21	70 %
Fair	2	6.67 %
Total	30	100%

Excellent results were observed in Schatzker types 1-4, predominantly in type 2 fractures. Good results were observed in Schatzker type 2-6, while fair result was observed in Schatzker type 4 & 6.

Case Illustrations

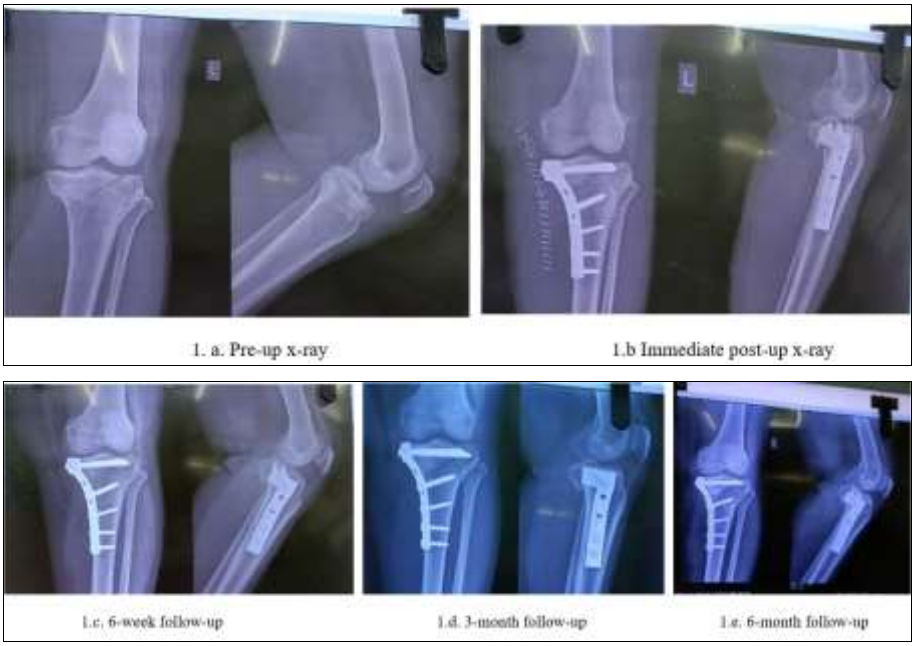

Fig 1a-e: pre-operative and post-operative X-ray images

Discussion:

Tibial plateau fractures are among the most common intra-articular injuries and frequently result from high-energy mechanisms such as road traffic accidents (RTAs) or falls from height. These injuries often involve associated soft tissue or osseous trauma and, due to the critical weight-bearing role of the knee, can lead to considerable morbidity and impaired quality of life if inadequately treated [3-4]. Fractures with intra-articular extension present a significant challenge to orthopedic surgeons due to the complexity involved in achieving stable and anatomical joint reconstruction.

The present study assessed both functional and radiological outcomes in 30 surgically managed cases of tibial plateau fractures using the Modified Rasmussen criteria. Variables such as age, sex, mechanism of injury, Schatzker fracture classification, surgical technique, complications, and outcomes were analyzed.

Males constituted the majority of our cases (56.67%), which is in line with the findings of Moore *et al*., who reported that approximately 62% of tibial plateau fractures occurred in men [14]. This may be attributed to greater participation of males in physically demanding and outdoor activities.

Consistent with other published data, fractures occurred most frequently in the active adult population, particularly between 30 and 45 years of age, with a mean of 38.9 years in our cohort. This reflects the higher exposure of this demographic to high-energy trauma. Conservative treatment has shown limited success in managing displaced or depressed intra-articular fractures, highlighting the necessity for surgical intervention to restore joint function and range of motion [15].

The leading mechanism of injury in our study was RTAs (66.67%), followed by falls (33.33%). This trend is comparable to the findings of Rademakers *et al*., who reported RTAs as the cause in 55% of their 109 cases [16].

According to Schatzker classification, Type II fractures (split with depression) were the most prevalent (33.33%) in our series, while Type I was the least common (3.33%). The distribution pattern observed here reflects the greater occurrence of low-energy injuries (Types I–III) compared to complex high-energy variants (Types IV–VI), as noted in several earlier studies [6, 13, 19, 20].

Schatzker Type	Honkonen	Ebraheim *et al.*	Mytatt *et al.*	Present Study
I	11.5%	27%	7.5%	3.33%
II	30.5%	30.76%	30%	33.33%
III	9.9%	9.4%	2.5%	10%
IV	9.2%	5.12%	20%	26.67%
V	21.3%	18.8%	27.5%	10%
VI	17.5%	12.8%	12.5%	16.67%

All patients in our study underwent operative treatment. Surgical indications were based on standard criteria including condylar widening >5 mm, lateral condylar step-off >3 mm, and all medial condyle fractures, as suggested by Honkonen [19]. Additionally, an articular depression ≥3 mm was considered a surgical indication in our protocol. The average time from injury to surgery was 6.63 days (range: 3–12 days), with delays mainly due to soft tissue swelling.

No specific fixation protocol was employed for each fracture type; treatment was individualized. Types I and selected Type II fractures were managed using percutaneous cancellous screws, whereas displaced fractures with split depression morphology underwent open reduction and internal fixation (ORIF) [18]. Bone grafting, along with buttress plating or locking compression plating (LCP), was employed in Types II–VI as required for structural support and maintenance of joint congruity.

The most common complications observed were postoperative joint stiffness and superficial infection. Stiffness likely resulted from extended immobilization, while infection may have been due to suboptimal wound care after discharge, as well as the soft tissue complexity associated with higher-grade fractures (Types IV–VI) [17].

Despite these challenges, functional outcomes were encouraging: 50% of patients achieved excellent results, 36.67% had good outcomes, and 13.3% showed fair results. No poor outcomes were reported. These results are comparable to those published by Ebraheim *et al*., who reported excellent outcomes in 68%, good in 13%, fair in 11%, and poor in 8% of cases [20].

Radiological outcomes, based on Modified Rasmussen scores, were similarly favorable. The mean radiological score was 7.47 (range: 5–9), with 23.33% of patients achieving excellent

scores, 70% good, and 6.67% fair. These results align closely with previous findings. For instance, Keriban *et al*. reported excellent results in 27.3%, good in 48.5%, fair in 6%, and poor in 18.2% of their cases [10], while Paleti *et al*. observed 12.5% excellent, 67.5% good, 12.5% fair, and 7.5% poor outcomes [21, 22].

When analyzing outcomes in relation to Schatzker types, our data demonstrated that Types I and II had the best functional and radiological outcomes. In contrast, Types V and VI yielded good to fair results. The poorer outcomes in higher Schatzker grades may be attributed to the increased complexity of fracture morphology, more invasive surgical requirements, and extended healing times. Nevertheless, favorable results in these complex fractures were still achievable with careful reconstruction of the articular surface and prevention of post-reduction collapse [23].

Conclusion

Tibial plateau fractures remain a significant cause of morbidity. Optimal outcomes depend on anatomical reduction, stable fixation, and early mobilization to prevent stiffness and minimize complications. Functional recovery correlates with fracture severity and the precision of articular surface restoration. In our series, tailored surgical management achieved excellent or good functional outcomes in the majority of patients.

Conflict of Interest

Not available

Financial Support

Not available

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