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Functional and radiological outcome of tibial plateau fractures treated with subchondral raft system- A prospective study

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Abstract

Background: Tibial Plateau Fracture (TPF) is a complex intra-articular fracture resulting from indirect coronal or direct axial compressive forces contributing to 1% of all fractures and 8% of fractures in elderly and is challenging when metaphyseal comminution is associated with osteoporosis and soft tissue injury. Different treatment approaches have been suggested for specific fracture patterns (Schatzker classification). In Schatzker type II and other unstable fractures, open reduction to elevate the depressed fragment through a cortical window in metaphysis, followed by rigid internal fixation with buttress plating along with bone grafts/substitutes is indicated. Present study is thus conducted to evaluate the stability of the internal fixation of proximal tibia fractures using a periarticular raft construct through a locking plate without use of a bone graft or bone substitute for split-depression tibia plateau fractures.

Materials and Methods: A prospective study was conducted for a period of 2 years on 30 patients with Tibial Plateau Fractures (Schatzker type II, III, V, VI and AO/OTA type 41B and type 41C) above age 18 years admitted to SS Institute of Medical Sciences and Research Centre, Davangere. Patients were assessed using Knee Society Score and Modified Rasmussen Radiological Score.

Results: Bony union was achieved at a mean of 8 weeks, with average range of movement 115.66° ± 7.73°. Rasmussen scores were excellent in 15 patients, good in 10 patients, and fair in 5 patients.

Conclusion: Use of a raft screw construct in the subchondral bone through a locking plate without use of a bone graft/substitute for split-depression tibial plateau fractures is aviable option.

Keywords: Tibial Plateau, Schatzker, Raft Construct, Raft Screw, Rasmussen

Introduction

Knee joint is the most complex and commonly injured joint. Being a superficial joint, knee joint is more exposed to external forces and is injured easily in vehicular trauma and sports related injuries [1].

In the fracture involving the articular surface, the Tibial Plateau Fracture (TPF) is one of the most common types 2

This constitutes for 1% of all fractures and 8% of fractures in elderly [3, 4] Most injuries affect lateral tibial condyle (55 to 70%) [3, 5] than medial tibial condyle (10 to 23%) whereas the involvement of bicondylar lesions is seen in 10-30% of the cases [6] Bicondylar tibial plateau fractures are seen in elderly in a bimodal age distribution whereas due to high energy trauma in young population, which is usually due to road traffic accidents (bumper fractures) resulting in comminuted fracture and severe soft tissue damage [4] Treatment for proximal tibial plateau fractures is difficult, especially when metaphyseal comminution is associated with osteoporosis [7] and soft tissue injury [8] The use of a raft screw construct in the subchondral bone through a locking plate can avoid these potential problems and provide adequate stability to the articular surface of the lateral and medial condyles of the proximal tibia, irrespective of bone quality and the type of fixation.

This approach prevents collapse, even in the absence of bone grafts or bone substitutes.

Main factors which determine the prognosis of tibial plateau fractures [9] are degree of articular depression, extent of separation of condylar fracture lines, diaphyseal-metaphyseal communition and disccociation and integrity of soft tissue envelope.

Even though there have been many papers over the past fifty years that discuss the issues of classification and the outcomes of different treatments, the best course of action is still debatable, especially for high energy tibial plateau fractures (Schatzker type IV, V and VI) 10 With appropriate patient selection and soft tissue dissection, we conclude that open reduction and internal fixation of tibial plateau fractures provide excellent to good functional outcomes with little soft tissue problems.

Materials and Methods

The present study was done in the Department of Orthopaedics, SS Institute of Medical Sciences Davangere, Karnataka, India, from February 2023 to February 2025. The present study is a prospective study conducted on the patients diagnosed with tibial plateau fractures. The ethical committee of the institute was informed about the objectives of the study and the ethical clearance certificate was obtained from them.

The following were the inclusion criteria

- Patients above 18 years of age (with closed growth plates).
- Patients who sustain proximal tibia intra-articular fracture with or without metaphyseal involvement (Schaztker type II, III, V, VI and AO/OTA type 41 B and type 41 C)

- Patients who have given informed written consent for surgical procedure.

The following were the exclusion criteria

- Patients less than 18 years of age
- Patients with floating knee (both distal femur and proximal tibia intraarticular fractures), open fracture, pathological fracture, previous knee joint surgery were excluded.
- Patients with history of any inflammatory joint and secondary arthritis.

30 patients satisfied the criteria and were enrolled in the study.

Once the inclusion criteria are satisfied, the principal investigator clinically examined the patient and routine investigations of patients were done. Thorough clinical, functional and radiological preoperative assessment of the patients was done. Informed written consent for surgery was obtained. Appropriate implants and instrumentation were arranged before the surgery. Patients underwent open reduction with internal fixation of tibial plateau fracture using raft-screw construct via anterolateral approach to proximal tibia.

Postoperatively radiographs were taken. Patients were followed up at 4 weeks, 8 weeks, 12 weeks and 6 months postoperatively with serial radiographs taken in Anteroposterior view and lateral view.

Functional assessment was done using Knee Society Score (KSS) [11] and radiological assessment made with modified Rasmussen criteria for radiological assessment

Implants and Instruments used for periarticular Raft Construct

A raft plate made up of four parallel 3.5 mm cortical screws is recommended for depressed tibial plateau fractures with good bone stock and adequate augmentation of the defect. These screws are placed through lateral locking plates Lateral plating is done with this approach. This is the most common approach used to reduce and fix tibial plateau fractures.

Following landmarks are noted: the joint line, gerdy's tubercle, the tip of the fibula and the lateral femoral epicondyle.

A slightly curved incision is made, starting in the epicondyle region and finishing between the fibula and Gerdy's tubercle, while the knee is in a 30-degree flexion position. If further exposure is needed, this incision can be extended both proximally and distally if required.

The deep dissection involves splitting the fibers of iliotibial tract. Care should be taken not to dissect the other structures that may be displaced, such as meniscus, etc.

The menisci are then palpated and the knee joint may be opened below the meniscus to visualize the articular fragments or arthroscopy can be used. The fracture fragments were mobilized with chisel and reduced directly under vision. Once reduction is achieved 1.5mm K-wire is passed through fracture fragments and confirmed under fluoroscopy.

In case of depressed fractures, through cortical window fragments were elevated and fixed with 1.5mm K-wires. In our study, we have not put bone graft or bone substitutes.

Plate templates are used to know the contour of tibia condyle and shaft for proper placement of Raft plate - variable angle locking compression plate. Once plate is placed 2mm K-wire passed through plate proximally and once plate positioning is confirmed, distal K-wire is fixed to plate and the shaft which confirmed under fluoroscopy.
Then a 3.5 mm raft screw is fixed to plate subchondrally about 2 mm beneath articular surface. Distally 3.5mm locking cortical screws locked to combi holes. Once the plate position is confirmed, rest of screws are locked to plate bone construct. After thorough wash, drain is fixed and wound was compacted to block the bleeders once tourniquet is loosened. The torn menisci and tibial ligaments were repaired and ilio-tibial band was closed. Subcutaneous tissue and skin were approximated. The drain was removed after 48-72 hours of surgery according to the protocol.

Post operative protocol

- Limb and foot end elevation is ensured immediate post-op.
- Static quadriceps exercise started as early as pain is tolerated.
- Range of motion exercises are taught to patients at 10-14 days postoperatively to ensure wound healing.
- Depressed fragments when elevated made non-weight bearing for 6 weeks.
- When signs of union is seen usually at 10-14 weeks complete weight bearing is allowed.
- At the time of discharge, patients were given instructions about ROM exercises and non-weight bearing till the union.

Follow Up

Patients were followed up every month to assess the range of movements, check X-rays are taken to know the collapse of fragments, signs of union and for angular deformity. Partial weight bearing allowed at 6 – 8 weeks.
Complete weight bearing at 10-14 weeks depending on rate of union and stability. Functional assessment was done using Knee Society Score (KSS) [11] and radiological assessment made with modified Rasmussen criteria for radiological assessment at an interval of 1, 3, 6 and 12 months. All data entered in proforma at every followup.

Statistical Analysis

Statistical analysis was carried out using SPSS version 25. Quantitative data was expressed as Mean ± SD. Qualitative data was expressed as numbers and percentages. Student's t-test, chi square test and other suitable tests of significance were applied at the time of statistical analysis. P values of <0.05 was considered statistically significant.

Results

Table 1: Age-Wise Distribution of Study Participants

Variable	N	Mean	SD	Minimum	Maximum
Age in years	30	47	13.70	32	79

Table 2: Gender Wise Distribution of Study Participants

Gender	N	Percentage	p-value
Male	25	83.3	0.000 (HS)
Female	5	16.7	

Table 3: Laterality Distribution Among Study Participants

Laterality	N	Percentage
Right	16	53.3
Left	14	46.7

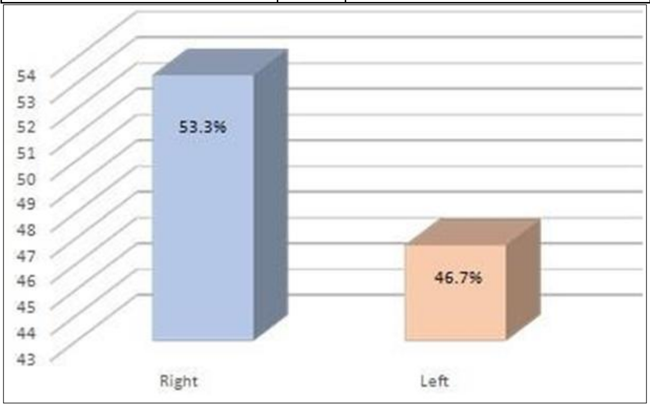


fig 1: Laterality Distribution Among Study Participants

Table 4: Distribution of Fracture Type Among Study Participants

Type of fracture	N	Percentage (%)	p-value
Type II	10	33.3	0.013 (S)
Type V	7	23.3	
Type VI	13	43.3	
Total	30	100	

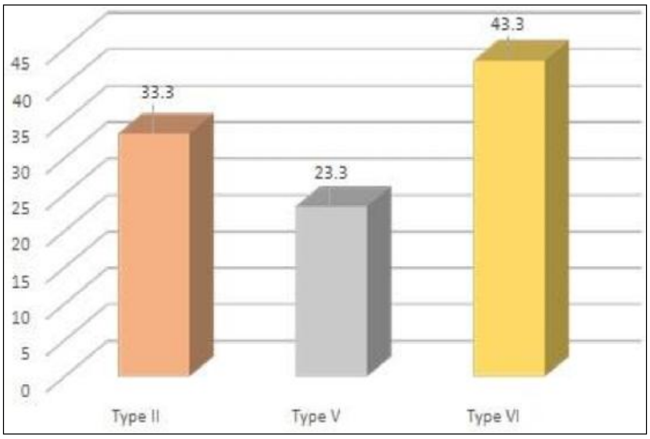


fig 2: Distribution of Fracture Type Among Study Participants

Table 5: Mean Time Before Surgery (In Days) Among Study Participants

Variable	N	Mean	SD	Minimum	Maximum
Time before surgery (in days)	30	3.9	1.44	1	7

Table 6: Mean Number of Hospital Stay (In Days) Among Study Participants

Variable	N	Mean	SD	Minimum	Maximum
Hospital stays (in days)	30	3.9	1.44	1	7

Table 7: Mean Union Time (In Weeks) Among Study Participants

Variable	N	Mean	SD	Minimum	Maximum
Union time (in weeks)	30	8.03	1.84	5	11

Table 8: Mean Follow Up (In Months) Among Study Participants

Variable	N	Mean	SD	Minimum	Maximum
Follow up days	30	13.10	1.06	12	16

Table 9: Total Number of Complications Among Study Participants

Complications	N	Percentage
Nil	25	83.3
INF+WD	1	3.3
Pain	2	6.7
SK	2	6.7
Total	30	100

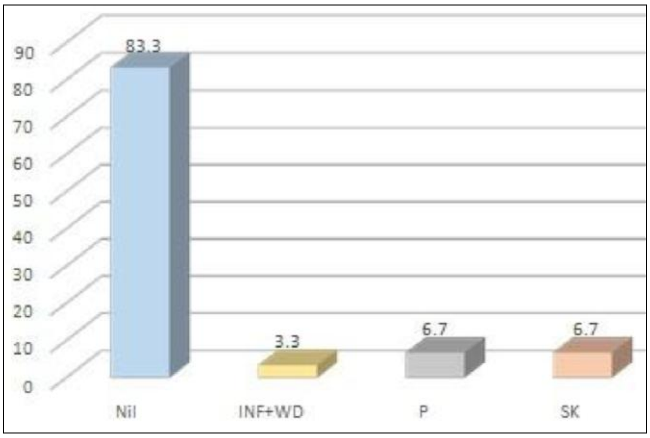
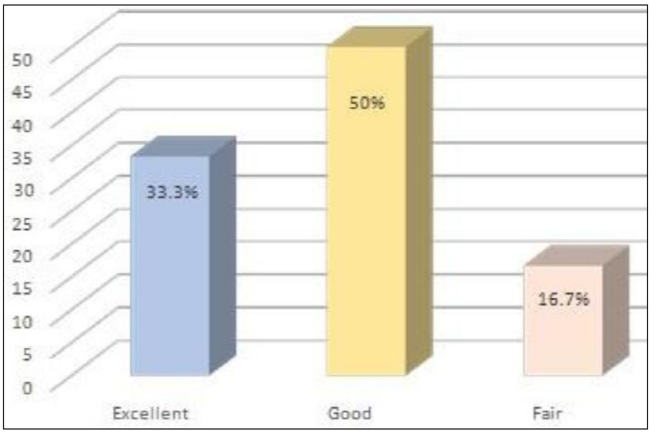


fig 3: Total number of complications among study participants

Table 10: Percentage Distribution of Knee Society Scores Among Study Participants

knee society scores	N	Percentage	p-value
Excellent	10	33.3	0.082 (NS)
Good	15	50	
Fair	5	16.7	
Total	30	100	



Graph 4: Grading of knee society scores among study participants

Table 11: Percentage Distribution of Modified Rasmussen's Scores Among Study Participants

Modified Rasmussen's scores	N	Percentage	p-value
Excellent	10	33.3	0.082 (NS)
Good	15	50	
Fair	5	16.7	
Total	30	100	

Table 12: Mean Distribution of Rom In Degrees

Variable	N	Mean	SD	Minimum	Maximum
ROM in degrees	30	115.66	7.73	100	130

- **Age Distribution**

Table 1 shows the age distribution of the participants. The average age was 47 ± 13.70 years, with the youngest patient being 32 years old and the oldest 79 years old.

- **Gender Distribution**

Table 2 details the gender distribution among participants. Of the 30 patients, 25 (83.3%) were male, and 5 (16.7%) were female. The gender difference was statistically significant (p =0.000).

- **Laterality of Injury**

Table 3 outlines the side of injury. Right-sided tibial plateau fractures were more frequent, affecting 16 patients (53.3%), while left-sided fractures were observed in 14 patients (46.7%).

- **Fracture Classification (Schatzker's System)**

Table 4 shows the distribution of fractures based on Schatzker's classification. Type VI fractures were the most common (13 patients, 43.3%), followed by type II fractures (10 patients, 33.3%). Type V fractures were least common, seen in 7 patients (23.3%). This difference was statistically significant (p = 0.013).

- **Time Before Surgery**

Table 5 presents the average time from injury to surgery, which was 3.9 ± 1.44 days, ranging from 1 to 7 days.

- **Hospital Stay**

Table 6 illustrates the duration of hospital stay, with an average of 3.9 ± 1.44 days, varying between 1 and 7 days.

- **Fracture Union Time**

Table 7 describes the time taken for fracture union, which averaged 8.03 ± 1.84 weeks, ranging from 5 to 11 weeks.

- **Follow-Up Duration**

Table 8 shows the average follow-up period of 13.10 ± 1.06 weeks, ranging from 12 to 16 weeks.

- **Post-Surgical Complications**

Table 9 outlines the complications following surgery. Most patients (25, 83.3%) had no complications. Pain and surgical site complications were reported in 6.7% of cases, while 3.3% of patients experienced infection and wound dehiscence.

- **Knee Society Scores**

Table 10 presents the Knee Society Score distribution. Half of the patients had a knee score of Excellent, 10 patients (33.3%) scored good, and 5 patients (16.7%) scored Fair. The difference was not statistically significant.

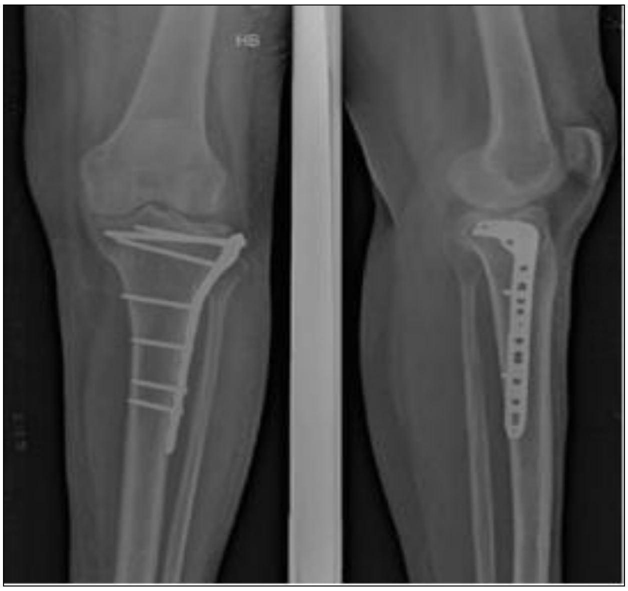
- **Modified Rasmussen's Scores**

Table 11 shows the Modified Rasmussen's Score distribution. Fifteen patients (50%) scored Excellent, 10 patients (33.3%) scored good, and 5 patients (16.7%) scored Fair. The difference was not statistically significant.

- **Range of Motion (ROM)**

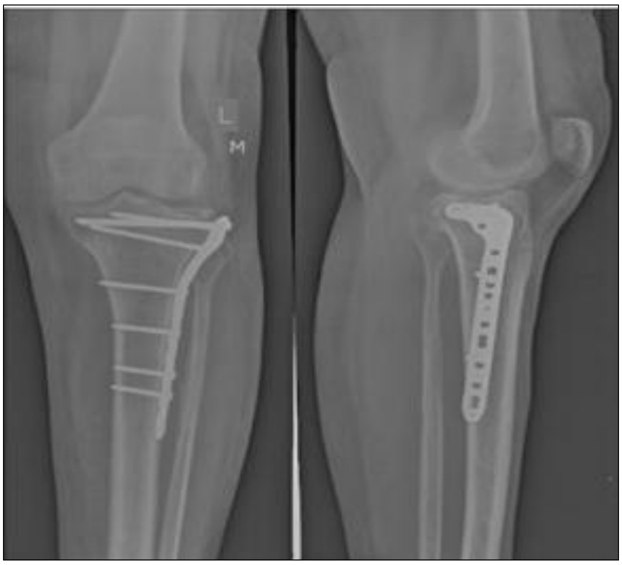
Table 12 outlines the range of motion among patients, with an average ROM of 115.66° ± 7.73°, ranging from 100° to 130°.

Pre-operative radio graphs, Radiographs and Clinical photographs of case No 1



Post-Operative radiographs at 3 months

Immediate post-operative radio graphs



Post-operative radiographs at 6 months

Post-Operative radiographs at 1 month

Post-Operative radiographs at 12 months

Clinical Pictures at 6 months

Clinical pictures at 2 months

Clinical pictures at 12 moths Squatting Sitting cross-legged

Radiographs and Clinical photographs of Case No 2

Post-Operative radiographs at 1 month

Pre-operative radiographs

Post-Operative radiographs at 2 months

Immediate Post Operative radiographs

Post-Operative radiographs at 6 moths

Post-Operative radiographs at 12 months

Post-Operative radiographs at 24 months

Clinical picture of wound dehiscence at 1 month

Clinical picture at 22 months

Discussion

Tibial plateau fractures present a significant challenge for orthopedic surgeons due to their complexity and the risk of long-term complications if not properly managed. Surgical intervention is crucial for restoring anatomical alignment, promoting fracture healing, and optimizing functional recovery This study aimed to comprehensively assess the outcomes of the subchondral raft system in the treatment of tibial plateau fractures, focusing on functional recovery, postoperative complications, and fracture healing rates.

Among the study participants, right-sided tibial plateau fractures were more common, affecting 16 patients (53.3%). According to Schatzker's classification, Type VI fractures were the most prevalent, observed in 13 patients (43.3%). Approximately 83% of patients did not experience postoperative complications, and half achieved a knee society score of G. At the one-year follow-up, the mean range of motion (ROM) was 115.66° ± 7.73°.

Demographic Details

The average age of patients in our study was 47 ± 13.70 years, which is comparable to the findings in studies by Eggli *et al*. (41 years) [12] and Lee *et al*. (49.1 years) [13]. However, Elsoe *et al*. [14] reported a mean age of 52.6 years, while Donovan [15] observed a significantly higher mean age of 74 years. This difference highlights the bimodal distribution of tibial plateau fractures. Younger patients (under 50) often sustain these injuries through high-energy trauma and are frequently associated with soft tissue damage [16]. In contrast, older adults, particularly those with osteoporosis, are at a higher risk due to low-energy mechanisms [17], often exacerbated by pre-existing conditions, degenerative joint disease, and functional limitations [18].

Our study found a higher prevalence of tibial plateau fractures among males, a finding consistent with studies by Vega *et al*. [19] in Bogotá, Colombia, and Albuquerque *et al*. [20] in Brazil. The higher incidence among men is likely due to their increased exposure to road traffic accidents, which not only impact productivity but also result in substantial costs associated with disability and rehabilitation.

Laterality of Injury

In this study, 16 patients (53.3%) sustained right-sided injuries, while 14 patients (46.7%) had left-sided fractures. Rasmussen *et al*. [21] reported an equal distribution of fractures between the right and left knees, whereas Carredano *et al*. [22] found a predominance of left-sided fractures (28 out of 43 patients), in contrast to our findings.

Fracture Classification (Schatzker's System)

A notable observation in this study was the high incidence of high-energy Schatzker type VI and V tibial plateau fractures, with a high-to-low-energy fracture ratio of 43/23. This contrasts with the ratios reported by Schatzker *et al*. (77/23), Zhu *et al*. (73/26) [23], and Albuquerque *et al*. (64/36). The increasing number of high-energy fractures in our setting underscores the severity of trauma mechanisms, which often result in compromised tibial plateaus and extensive soft tissue damage

Time Before Surgery

The mean duration between injury and surgical intervention was 3.9 ± 1.44 days, reflecting prompt healthcare-seeking behavior despite the common occurrence of delayed presentations. Studies indicate that outcomes tend to worsen when surgery is delayed beyond a week, as late presentation can complicate postoperative rehabilitation.

Hospital Stay

The average hospital stay in our study was 3.9 ± 1.44 days. This aligns with findings from previous studies, such as Thimmegowda *et al*. [24], Manidakis *et al*. [25] (5– 14 days, mean: 6 days), and Phisitkul *et al*. [26] (10–15 days).

Fracture Union Time

Fracture union in this study averaged 8.03 ± 1.84 weeks, ranging from 5 to 11 weeks. At each follow-up visit, patients were evaluated based on the Rasmussen clinical and radiological criteria.

Postoperative Complications

Postoperative complications were minimal, with only 6.7% of patients experiencing knee pain, likely due to post-traumatic osteoarthritis. Following trauma, proteoglycan loss occurs due to destruction or decreased synthesis, leading to chondrocyte damage and subsequent osteoarthritis. The use of a periarticular raft construct with a locking plate helps prevent further chondrocyte damage by maintaining anatomical reduction and facilitating bone healing without requiring bone grafts or substitutes, thereby reducing operative time and morbidity. One patient developed a superficial wound infection, which was effectively managed with intravenous antibiotics and debridement.

Range of Motion

The recorded ROM in this study ranged from 100° to 130°, with a mean of 115°. These results are comparable to those of Vadadoriya K *et al*. [27], who reported an average knee flexion of

105.7° at three months and 120.58° at six months, adequate for daily activities. Other studies have reported similar findings, including Lee *et al*. [28] (mean ROM: 105°), Stannard *et al*.

(90°–145°, mean: 127°), Schutz *et al*. [29] (0°–105°), and Egol *et al*. [30] (mean flexion: 109.3°, range: 60°–135°).

Functional outcome

Out of 30 patients, 33.3% achieved excellent Knee society and Rasmussen clinical scores, while 50% demonstrated good scores in both criteria. This suggests that the periarticular raft construct provides superior stability, even in osteoporotic bone.

Since most of our patients were elderly (>40 years), bone union was achieved within 11 weeks without the need for bone grafting. This approach helps prevent donor site morbidity (in the case of autografts), the risk of disease transmission (72– 75% with allografts), and potential immunogenic reactions associated with bone substitutes. However, metaphyseal fractures generally heal faster, even in the absence of bone grafts. The use of a periarticular raft plate in anatomically reduced split- depression tibial plateau fractures enhances rigidity and prevents collapse, regardless of bone quality. Among patients with good to fair functional scores, early weight-bearing led to the collapse of the reduced fragment.

Cross *et al*. emphasized the importance of internal fixation in preventing postoperative loss of reduction, as inadequate maintenance during rehabilitation increases the risk of post-traumatic arthritis. The subchondral raft technique is widely recognized for resisting depression and maintaining reduction, and it can be performed using Kirschner wires, lag screws, conventional screws, or locking screws, either through the plate or independently [31].

Raft Construction and Biomechanical Considerations

Several authors have explored the biomechanics of raft construction. Cole [32] suggested that comminuted, unstable fractures can be supported by placing a parallel raft of smaller-diameter screws just beneath the articular surface. After elevation and bone void filling, lateral cortex fixation is achieved using a buttress or periarticular "raft" plate. He recommended positioning the screws through the plate so that they are fixed laterally at the plate and medially in the intact medial column.

Karunakar *et al*. compared four fixation methods for type II fractures: the Lbuttress plate, four 3.5 mm subchondral raft screws with an antiglide plate, an L-buttress plate with cancellous allograft, and four 3.5 mm subchondral raft screws through a periarticular plate. They found no significant differences among these methods, though the subchondral raft screws provided better resistance to local depression forces [33].

In another biomechanical study, Cross *et al*. evaluated three raft configurations: screws outside the plate, non-locking raft screws through the plate, and locking raft screws through the plate. Their results indicated that placing the raft through the plate provided statistically significant stability compared to screws outside the plate. However, they found no superiority of locking screws over nonlocking screws and recommended considering raft construction through the plate as a more stable option. In our study, we used 5 mm raft screws through a locking plate to stabilize comminuted osteochondral fragments and prevent collapse.

The radiological and functional outcomes were encouraging. The functional results were all good or excellent according to KSS and Rasmussen criteria. There was no significant loss of knee ROM at the last followup.

Study Limitations

1. The sample size was relatively small.
2. No comparator group was there in our study.
3. The study was limited to a single geographic area and conducted within a restricted teaching institution.
4. The follow-up period was relatively short, extending only up to one year.
5. Pediatric patients were not included in the study.

Conclusion

Subchondral raft screws with a size of 3.5 mm offer sufficient construct stiffness and effectively prevent articular depression without the need for bone grafts or substitutes.

Anterolaterally placed small fragment plates provide adequate support for posterolateral and posteromedial fragments, minimizing the need for separate fixation and reducing wound healing complications.

Fracture union time is comparable to other treatment methods; however, the added benefit lies in avoiding the use of bone grafts or substitutes.

Locking plates enhance stability, preserve articular congruence, and reduce the likelihood of osteoarthritis. They also contribute to improved range of motion and reduced postoperative pain, leading to better overall outcomes.

Buttress plating is essential for Schatzker Type I, II, and III fractures to support raft screw fixation, particularly in cases with poor bone quality or unstable fragments.

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