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Evaluation of Subchondral Raft Construction without Bone Graft for Management of Split-Depression Tibial Plateau Fractures

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ABSTRACT

Background: Split-depression tibial plateau fractures constitute the most prevalent type of tibial injury, accounting for twenty-five to thirty-three percent of all tibial plateau fractures. Utilizing a Kirschner wire, the subchondral raft technique is a well-known method for resisting depression and loss of reduction.

Objectives: To assess the radiological and functional finding of split-depression tibial plateau fractures treated via subchondral raft screws combined with locking plates without bone graft and to describe the advantages and disadvantages of this technique.

Patients and methods: This study was a prospective interventional that was performed on twenty-five cases aged between 18-60 years old of both sexes who had split-depression fractures of tibial plateau, admitted, and operated upon in Orthopedic Department of Suez Canal University Hospital (SCUH), Ismailia, Egypt.

Results: There wasn't statistically significant variance among the study population regarding age, gender, residency, comorbidities, flexion contracture, extension leg and range of flexion and Rasmussen radiological score at 2, 6 and 12 weeks follow up after the surgery, and complications. There was statistically significant improvement in the pain score among the study population with the follow up. There was statistically significant change in the depression score at 2, 6 and 12 weeks follow up after the surgery.

Conclusion: One of the best ways to fix split-depression and isolated depression tibial plateau fractures is with a periarticular rafting screw, which doesn't need bone grafts or bone replacements. This can be done during open reduction and internal fixation.

Keywords: Subchondral Raft Construction, Bone Graft, Split-Depression Tibial Plateau Fractures

INTRODUCTION

Twenty-five to thirty-three percent of all tibial plateau fractures are split-depression tibial plateau fractures, which are the most prevalent tibial injuries [(1,2)]. Fractures of the proximal tibial plateau are challenging to treat, particularly when soft tissue injury is present in conjunction with metaphyseal comminution. Weight bearing occurs on the tibial plateau; therefore, restoring joint congruity is essential for maintaining the knee's normal function [(3)].

Split-depression tibial plateau fractures with severe depression of the articular surface require reduction to elevate the depressed fragment with a bone plug through a cortical window in the metaphysis, followed by rigid internal fixation. To maintain the reduction, the subchondral defect is usually filled with cancellous autografts, allografts, or bone substitutes [(4,5)].

Allografting correlates with donor site morbidity, blood loss, infection risk, and prolonged surgical duration, while autografting leads to transmission of diseases, inadequate graft incorporation into host bone, and low initial stability in metaphyseal defects [(4)].

By employing a raft screw construct in the subchondral bone via a locking plate, these potential complications can be avoided and the articular surface of the lateral and medial condyles of the proximal tibia can be supported, irrespective of fixation type and bone quality. This methodology effectively restricts the risk of collapse, even in the absence of bone substitutes or grafts [(6)].

The aim of the research was to assess the radiological and functional results of split-depression tibial plateau fractures cured via subchondral raft screws combined with locking plates without bone graft and to describe the advantages and disadvantages of this technique.

PATIENTS AND METHODS

THIS was prospective interventional research that was performed on twenty-five cases who had split-depression fractures of tibial plateau, admitted and operated upon in Orthopedic Department of Suez Canal University Hospital (SCUH), Ismailia, Egypt.

Inclusion criteria: Split-depression fractures of tibial plateau, both sexes and age range: from eighteen to sixty years old.

Exclusion criteria: cases with other comorbidities like (uncontrolled diabetes mellitus, end stage liver diseases, cancer and decompensated heart failure), bed ridden non-active patients, open fracture, and fracture in place.

Ethics consideration: This study was conducted after approval of Orthopedic Surgery Department, Faculty of Medicine, Suez Canal University by Ethics Committee.

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All cases felt free to withdraw from the research at any period point, in accordance with their demands. The study was conducted in accordance with Helsinki Standards. An informed written consent has been signed by all patients following a full explanation of the advantages, benefits, and potential complications of each intervention.

Sample size:
The sample size was found with this equation [7]:

$$\mathbf{n = \frac{(Z_{1-\frac{\alpha^2}{2}})^2 * p(1-p)}{d^2}}$$

Where:

- n = the sample size.
- $Z_{1-\alpha/2}$ = the confidence interval which equals to 1.96 when type 1 error is 5%.
- P= prevalence of Rasmussen score of <14 (excellent and good outcome) equals to 6.67 % based on previous literature. [7]
- d=Absolute error or precision, usually equals 10 %.
- Accordingly, the calculated sample size was 25 participants.

Patients were subjected to the following: preoperative evaluation: (History taking, Examination (General and Local examination), Investigations, Radiological findings, Diagnosis and classification (Schatzker classification) and First aid.

Surgical procedure

following the exposure of the lateral tibial plateau, a submeniscal arthrotomy was conducted. To enable direct visualization of the comminuted region, an articular osteotomy of the lateral plateau rim was executed utilizing an oscillating saw in instances of pure joint depression fractures. Through the opening of the lateral wall, the articular depression was exposed. Using the wide Cobb elevator, the depressed fragments were elevated as a block to the level of the original articular surface.

Under both direct visualization and fluoroscopy, the articular reduction was regulated, and minor mosaic-like fragments were rectified to their ultimate anatomical location. Depending on the size of the fragments, temporary fixation was achieved using multiple double-ended trocar tip K-wires measuring 1.2 millimeters or 1.6 millimeters in length. K-wires were inserted into the intact tibial plateau portion, which was typically the medial area. Instead of a bone graft, the metaphyseal defect was filled. The periarticular reduction device was utilized to temporarily secure the lateral condyle in position after it was reduced. Following the insertion of K-wires through the lateral condyle, the reduction device was eliminated.

The reduction was optically observed using fluoroscopy. The positioning of a plate was observed using fluoroscopy. Definitive fracture fixation was initiated subsequent to the certification of anatomic reduction. Using lag-screwing, lengthy cortical screws were inserted through the plate, just below the subchondral extension. The final fixation was examined through the utilization of fluoroscopy. The wounds were irrigated prior to closure. Following the reattachment of the lateral meniscal, the incision was closed in layers.

A bulky dressing was utilized to treat the knee joint [8].
Follow up was undertaken at 2 weeks, 6, and 12 weeks.

CASE
History
A 49-year-old male smoker has been brought to Emergency Department with history of falling from height.

Examination
The man had swelling and deformity in the left knee. On palpation he felt pain and tenderness over knee joint. The overlying skin was intact with no evidence of neurological or vascular deficit.

Investigations including: X-ray left knee (Figure 1), CBC, kidney and liver function, bleeding profile, and virology tests.

Management: Anterolateral approach of tibial plateau was performed (Figure 2) and postoperative X-rays were done (Figure 3).

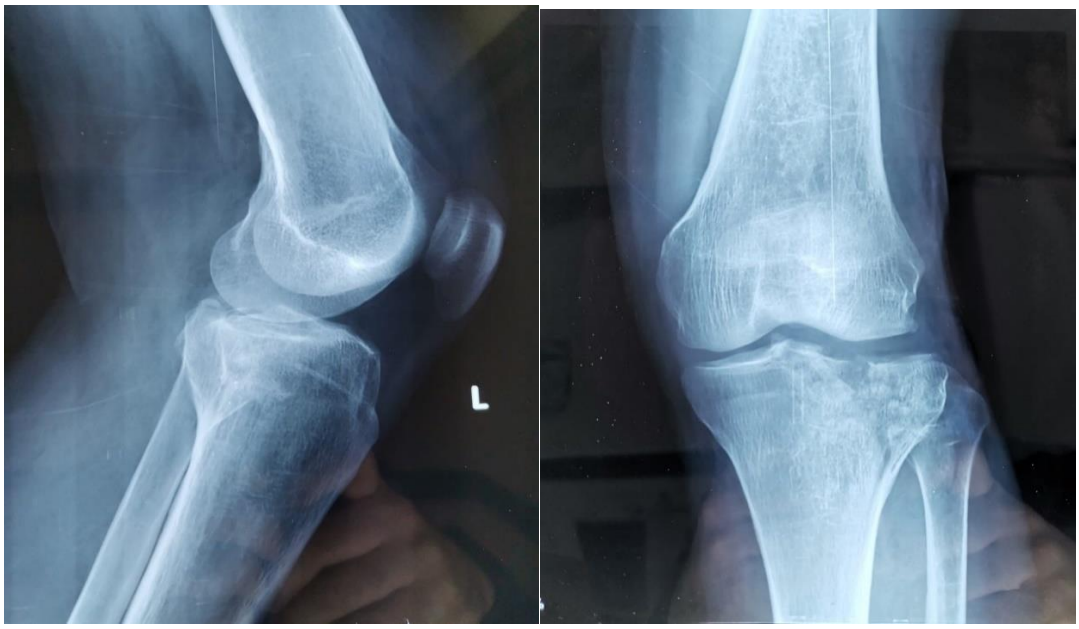

Figure (1): The preoperative X-rays show a split-depression tibial plateau fracture with visible depression and potential displacement of the lateral plateau.

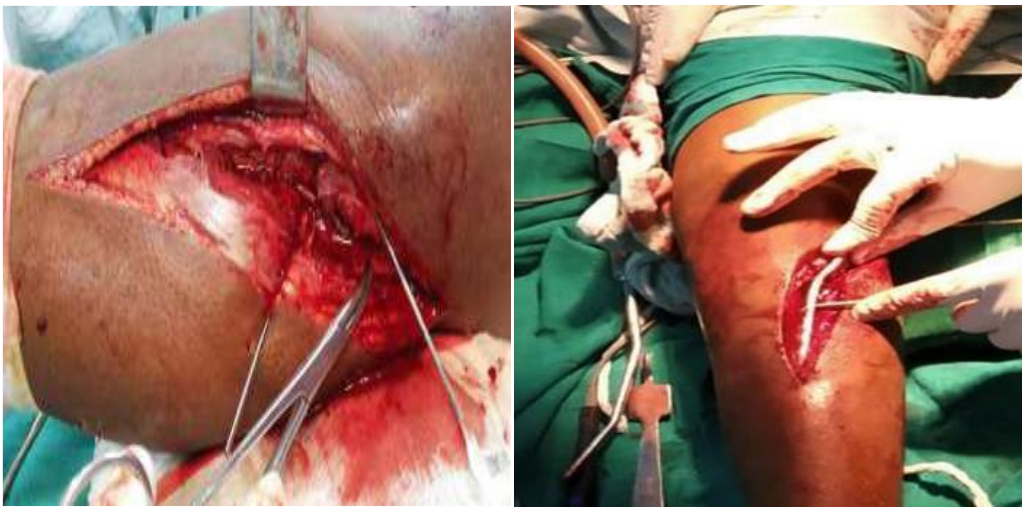

Figure (2): This figure depicts the anterolateral surgical approach, providing clear exposure of the fractured lateral plateau.

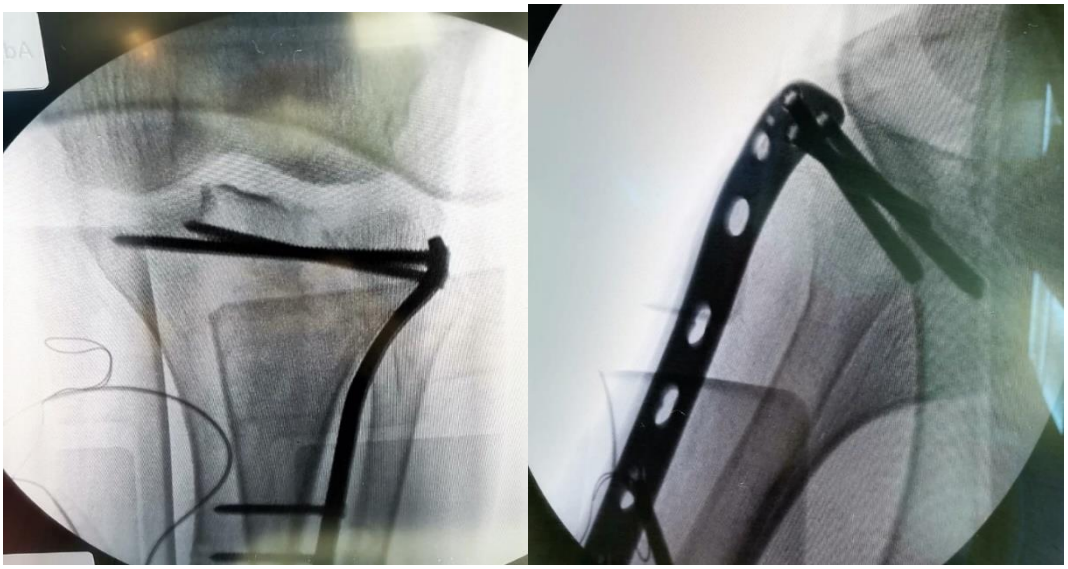

Figure (3): The postoperative X-rays confirm successful fracture reduction and fixation. The images show proper elevation of the depressed fragments and correct placement of rafting screws and locking plates, ensuring restored joint congruity.

Data management: Data were managed utilizing the "Statistical Package for the Social Sciences (SPSS) for windows" program, version 22.0. Quantitative data were presented as mean and standard deviation (SD) and were compared by independent t-test. Qualitative data were presented as frequency and percentage and were compared by Chi-Square test. A one-way analysis of variance (ANOVA): when comparing between more than two groups (for normally distributed data). P value < 0.05 was considered significant.

RESULTS

There wasn't statistically significant variance among the study population according to age, sex, and residency **(Table 1)**.

Table (1): demographic data of the study population

Variables		study population N=25	P value
Age(year) Mean ± SD		35.71 ± 4.14	NA
Gender	Male	17 (68%)	0.07
	Female	8 (32%)	
Residency	Rural	11 (44%)	0.55
	Urban	14 (56%)	
Smokers		11 (44%)	

NA: Not applicable

There was no statistically significant difference among the study population according to the comorbidities **(Table 2)**.

Table (2): Distribution of comorbidities among the study population

Variables	Study population N=25	P value
DM	7 (28%)	0.06
HTN	5 (20%)	
CHD	2 (8%)	
CLD	1 (4%)	
CKD	1 (4%)	

DM: Diabetes mellitus, HTN: Hypertension, CHD: Coronary heart disease, CLD: Chronic liver disease, CKD: Chronic kidney disease.

This table showed the distribution of pain score among the study population at 2, 6 and 12 weeks follow up after the surgery. There wasn't statistically significant improvement in the pain score among the study population with the follow up according to the pain score **(Table 3)**.

Table (3): Pain score follow up among the study population

Pain score	2 weeks	6 weeks	12 weeks	P Value
None (50)	13 (52%)	20 (80%)	23 (92%)	0.14
Mild occasional	4 (16%)	2 (8%)	1 (4%)	
Mild (Stairs only)	4 (16%)	2 (8%)	1 (4%)	
Mild (walking and stairs)	3 (12%)	1 (4%)	0 (0%)	
Moderate – occasional	1 (4%)	0 (0%)	0 (0%)	
Moderate – continual	0 (0%)	0 (0%)	0 (0%)	
Severe	0 (0%)	0 (0%)	0 (0%)	

There was statistically significant alteration in the knee movement assessment among the study population according to flexion contracture, however there wasn't statistically significant alteration in the knee movement assessment among the study population according to extension leg and range of flexion at 2, 6 and 12 weeks follow up after the surgery **(Table 4)**.

Table (4): Movement assessment follow up among the study population

Movement		2 weeks	6 weeks	12 weeks	P Value
Flexion Contracture	None	22 (88%)	25 (100%)	25 (100%)	0.04
	5-10º	3 (12%)	0 (0%)	0 (0%)	
	10-15º	0 (0%)	0 (0%)	0 (0%)	
	16-20º	0 (0%)	0 (0%)	0 (0%)	
	≥ 20º	0 (0%)	0 (0%)	0 (0%)	
Extension lag	None	23 (92%)	25 (100%)	25 (100%)	0.13
	< 10º	2 (8%)	0 (0%)	0 (0%)	
	10-20º	0 (0%)	0 (0%)	0 (0%)	
	> 20º	0 (0%)	0 (0%)	0 (0%)	
Range of flexion Mean ± SD		94.2 ± 13.7	95.8 ± 11.7	96.1 ± 10.8	0.83

According to this table there was no statistically significant difference regarding depression categories, condylar widening categories, and angulation, while there was statistically significant difference regarding depression Mean, and condylar widening Mean Through Follow up. **(Table 5).**

Table (5): Movement assessment follow up among the study population using Rasmussen radiological score

		2 weeks	6 weeks	12 weeks	P Value
Depression	**None**	**20 (80%)**	**23 (92%)**	**24 (96%)**	**0.44**
	< 6	**3 (12%)**	**1 (4%)**	**1 (4%)**	
	6-10	**2 (8%)**	**1 (4%)**	**0 (0%)**	
	> 10	**0 (0%)**	**0 (0%)**	**0 (0%)**	
	Mean ± SD (Score)	**5.44 ± 0.8**	**5.76 ± 0.3**	**5.92 ± 0.04**	**0.003 P1=0.06 P2=0.002 P3=0.4**
Condylar widening	**None**	**24 (96%)**	**25 (100%)**	**25 (100%)**	**0.36**
	< 6	**1 (4%)**	**0 (0%)**	**0 (0%)**	
	6-10	**0 (0%)**	**0 (0%)**	**0 (0%)**	
	> 10	**0 (0%)**	**0 (0%)**	**0 (0%)**	
	Mean ± SD (Score)	**5.92 ± 0.04**	**6± 0.04**	**6 ± 0.07**	**<0.001 P1<0.001 P2<0.001 P3=Na**
Angulation	**None**	**24 (96%)**	**24 (96%)**	**25 (100%)**	**0.60**
	< 6	**1 (4%)**	**1 (4%)**	**0 (0%)**	
	6-10	**0 (0%)**	**0 (0%)**	**0 (0%)**	
	> 10	**0 (0%)**	**0 (0%)**	**0 (0%)**	
	Mean ± SD (Score)	**5.92 ± 0.04**	**5.92 ± 0.04**	**6 ± 0.03**	**0.99**
Total	**Mean ± SD (Score)**	**5.76 ± 1.1**	**5.89 ± 0.5**	**5.97±0.02**	**0.56**
Excellent =6, Good =4, Fair =2, Poor =0					

SD: Standard deviations, NA: Not applicable

There wasn't statistically significant variance among the study population according to the complications. The infection was superficial and was treated with antibiotics and a daily dressing, common peroneal nerve injured in one case but only neuropraxia and followed up for 6 months and neurotronic supplements **(Table 6)**.

Table (6): Distribution of complications among the study population

Complications	Study population	P value
No	19 (76%)	0.88
Infection	2 (8%)	
Nerve injury	1 (4%)	
Articular surface depression	1 (4%)	
Delayed union	2 (8%)	

DISCUSSION

In our study, the sociodemographic data of the study population showed that average age was 35.71 compared to **Reddy *et al.*** study where the mean age was 40.4 years [9].

Gender showed that males represented 68% but females were 32%, Urban residency represented 56% while rural was 44% and there was 44% of the study population who were smokers but these data were not statistically significant.

The distribution of comorbidities among the study population showed that 28% had diabetes mellitus, 20% hypertension, 8% coronary heart disease, 4% chronic liver disease, 4% chronic kidney disease.

There wasn't statistically significant variation among the study population according to the comorbidities.

Road traffic accidents (RTAs) are also responsible for 1.8 percent of all deaths and 2.4 percent of all disability-adjusted life years (DALYs) lost in Egypt [10].

In our study, RTA was the most frequent mode of trauma 68%, 20% fall from height and 12% twisting trauma. This incidence was similar to **Hegazy *et al.*** study, which showed that RTA revealed in 60% of the patients who presented with tibial fracture [11].

Our study showed that there wasn't statistically significant improvement in the pain score among the study population with the follow up according to the pain score.

In the first 2 weeks 52% of the patients had no pain while 16% had mild pain, 16 % had mild pain on stairs, 12% had mild pain on walking and stairs, and 4% had moderate occasional pain. In 6 weeks 80% of the patients had no pain while 8% had mild occasional pain, 8% had mild pain on stairs, and 4% had mild pain on walking and stairs. In 12 weeks 92% of the patient had no pain, while 4% had mild occasional pain, and 4% had mild pain on stairs.

Our results disagreed to **AbdEl-Samad *et al.*** study, which showed significant improvement (P value <0.05) in the VAS score in the patient follow up after rafting screw surgery of the tibial plateau fracture [12].

Regarding movement assessment after rafting screw surgery of the tibial plateau fracture, our study showed insignificant improvement in the range of flexion in the study population.

Regarding flexion contracture in the first 2 weeks, 88% of patients showed 0º degree, while 12% showed 5-10º degrees after 6 weeks, and after 12 weeks 100% of patients showed no flexion contracture. There was statistically significant alteration in the knee movement assessment among the study population according to flexion contracture, however there wasn't statistically significant alteration in the knee movement assessment among the study population according to range of flexion at 2, 6 and 12 weeks follow up after the surgery.

Liu *et al.* study showed that the flexion angle was less than 110°. But, the flexion function between the groups of the study wasn't significantly various [13].

Also, our study showed insignificant improvement in extension function through the follow up period of our study population.

Regarding extension lag, 92% of patients showed no lag, while 8% had less than 10 degrees of lag in the first 2 weeks and in 6 weeks and at 12 weeks 100% of patients showed no extension lag.

This was concerning to **Liu *et al.*** study, which revealed that the extension function of the cases in all included patients improved evidently, with no significant variations [13].

In our study the radiological outcomes were assessed by Rasmussen score. Total Rasmussen radiological score showed no statistically significant alteration in the follow up after the surgery. There was no statistically significant difference regarding depression categories, condylar widening categories, and angulation, while there was statistically significant difference regarding depression Mean, and condylar widening Mean Through Follow up. In the first 2 weeks 80% of patients showed no depression, 12% showed depression less than 6 degrees, while 8% showed 6 to 10 degrees of depression. At 6 weeks 92% showed no depression, 4% less than 6 degrees, and 4% of patients showed from 6 to 10 degrees of depression. At 12 weeks 96% showed no depression, while 4% showed less than 6 degrees of depression.

The research of **Singleton *et al.*** demonstrated that at 3.9 years, cases who had smaller residual articular depression experienced considerably less knee range of motion loss. The mean knee range of motion for the normal knee was found to be 0–131 degrees, while for the injured knee it ranged from 4–119 degrees, across all groups. Patients who exhibited reduced levels of residual articular depression demonstrated diminished disability, accompanied by markedly improved functional and pain scores [14].

As regard to radiological outcome, **AbdEl-Samad *et al.*** study demonstrated that there wasn't significant variance among raft construction with or

without bone graft. Both the functional outcome and the overall results were nearly equivalent [12].

In our study, there was no complications in 76% among the study population but 8% had infection, 4% nerve injury, 4% articular surface depression and 8% delayed union.

The prognosis following open reduction and internal fixation of split-depression (more than five millimeters) tibial plateau fractures was evaluated by **Molenaars *et al*.** Without utilizing bone grafting, a securing plate was employed to construct a periarticular raft. All patients didn't suffer any serious complications during the operation, including osteoarthritis, osteomyelitis, implant failure, breakage, or screw backout. For split-depression proximal tibial plateau fractures, they suggested that fixation with a periarticular raft construct via a locking plate in lieu of a bone graft or bone substitute may be a viable option [15].

A buttress plate, with or without a bone graft, is less resistant to local depression stresses than raft fixation utilizing 3.5-millimeters subchondral screws. More stability against plateau displacements is provided by screwing through (rather than outside) the plate [16].

CONCLUSION

During open reduction and internal fixation, fixation of split-depression and isolated depression tibial plateau fractures with periarticular rafting screws without the use of bone grafts or bone substitutes is viable and one of the best options. It preserves the anatomical joint line and normal mechanical axis more effectively, resulting in superior short-term functional outcomes. Consequently, it was possible to prevent the morbidity correlated with bone grafting while maintaining the stability of the fracture.

DECLARATIONS

- **Funding:** No fund
- **Availability of data and material:** Available
- **Conflicts of interest:** No conflicts of interest.
- **Competing interests:** None

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