Split depressed lateral tibial plateau fracture fixation by locking compression plate with or without bone graft (comparative study)

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Abstract

Background
Evaluation of the outcome of fixation of split depressed lateral tibial plateau fracture using plate and screws in a comparative study by using a graft or without.
Objective
This study aimed to evaluate the effect of bone grafting on the functional and radiological outcome after split depressed lateral tibial plateau fractures treated with open reduction and buttress plates fixation.
Patient and Method
The current prospective randomized comparative study included 20 patients with tibial plateau fractures treated by the open reduction and internal fixation with buttress plate and screws. Tibial plateau fractures were categorized according to the Schatzker classification. Patients will be evaluated by history taking, physical examination, investigation, consent taking, and image.
Results
Union was achieved in all patients. The mean functional Rasmussen knee score at last follow-up in a group of patients was managed with bone graft was 14.53. While in the group of patients were managed without bone graft the mean was 13.93. The mean anatomical Rasmussen knee score at the last follow-up was in the group of patients were managed with bone graft was 8.07. While in the group of patients were managed without bone graft the mean was 7.53.
Conclusion
The current study showed that there is no statistically significant difference between the patients were managed with and without bone graft as regarding the collapse of the articular surface, condylar widening, union, functional and radiological outcomes. Meanwhile, there were complications associated with bone grafting as infection and graft site pain. There is a positive correlation between the radiological and the functional outcomes so anatomical reduction of the tibial plateau is mandatory.

Keywords
Split depressed tibial plateau fracture, bone graft, buttress plate.

Introduction

Tibial plateau fractures are one of the commonest intra-articular fractures resulting from indirect coronal or direct axial compressive forces. Fractures of tibial plateau constitute 1% of all fractures and 8% fractures in the elderly. These fractures include many and varied configurations that involve the medial plateau (10-23%), lateral plateau (55-70%), or both (11-30%) with various degrees of articular depression and displacement [1]. In case of improper restoration of the plateau surface these fractures could lead to the development of premature osteoarthritis, lifelong pain, and disability [2]. For assessment of the initial injury, planning for management, and prediction of prognosis, orthopedic surgeons widely use the Schatzker classification system, which divides tibial plateau fractures into six types. Each increasing numeric category specifies an increased level of energy directed to the bone thereby increasing the severity of the fracture. The first four are unicondylar and types V and VI are bicondylar [3]. Open or closed reduction and internal fixation of lateral tibial plateau fractures are accepted as the treatment of choice. [6] The objective of surgery is a restoration of the plateau surface through anatomical reduction, rigid fixation, and early joint mobility [6]. Various treatment modalities have been used over the years with mixed results. Surgical procedures including circular frames, [7,8] percutaneous screw fixation, [9] open reduction, and internal fixation (ORIF) [10]. More recent techniques such as the use of fixed angle devices, [11,12] arthroscopic assisted reduction, [13] calcium-based cement augmentation [14,15], and the use of novel grafting methods to address articular depression [16] constantly gain popularity among orthopaedic surgeons. The resultant metaphyseal defect is filled with either cancellous autografts, allografts, or calcium phosphates to maintain the reduction [17]. Autogenous bone-graft harvesting is associated with significant morbidity with a reported major complication rate of 8.6% and minor complication rate of 20.6% and there is limited availability for larger defects. [18,19] Allografts are associated with their problems such as the transmission of diseases like HIV and Hepatitis [20].

Aim of the Work:

This study aimed to evaluate the effect of bone grafting on the functional and radiological outcome after split depressed lateral tibial plateau fractures treated with open reduction and buttress plates fixation.

Patient and methods

The current prospective randomized comparative study included 20 patients with tibial plateau fractures treated by the open reduction and internal fixation with buttress plate and screws.

Tibial plateau fractures were categorized according to the Schatzker classification. Patients will be evaluated by history taking, physical examination, investigation, consent taking, and image.

Inclusion criteria:
Split depressed fracture lateral tibial plateau, age from 20 to 70 years, Closed tibial plateau fractures.

Exclusion criteria:
Tibial plateau fracture other than a split depressed lateral tibial plateau, Previous tibial plateau fracture, Concomitant injuries that could delay the weight-bearing of the patient e.g. ipsilateral fracture femur, Open fractures, Associated neurovascular injuries, Unfit for surgery.

Methods:

Each patient in this study is carefully assessed clinically in the form of detailed clinical history and thorough examination. We asked in detail about the mode of injury, first aids(If it was done) at the site of injury, the duration between injury and hospital admission, temporary maneuvers, and drugs were used from the time of injury till the operation time. Also, we asked about chronic medical diseases like(cardiac, hepatic, renal, DM, blood diseases…..etc.) Immunosuppressive drugs, previous surgeries and blood transfusion, and any patient factor claimed with the incidence of failure in proposed surgery[7].

General assessment:
This is done to assess the patient general fitness for such surgery. A detailed physical examination of the patient's overall medical status, age, and functional demands were necessary, also to detect any additional injuries. These may be other ipsilateral or contralateral skeletal injuries and injuries to other systems that may influence how the plateau fracture is managed.

Local assessment:
Complete and meticulous local examination of the involved knee and leg was our routine examination.

Radiological evaluation:
Routine plain X-ray (A-P & lateral views) of affected tibia(fig .1) . CT scan to determine the fracture pattern and the extension of the fracture to the articular surfaces. Besides the routine pre-operative investigations which were carried out for all patients, like (C.B.C, blood sugar tests, Liver & Kidney functions tests, coagulation profile, and E.C.G) further special investigations and medical or cardiac consultation were requested by anesthesia specialists to complement anesthetic judgment.

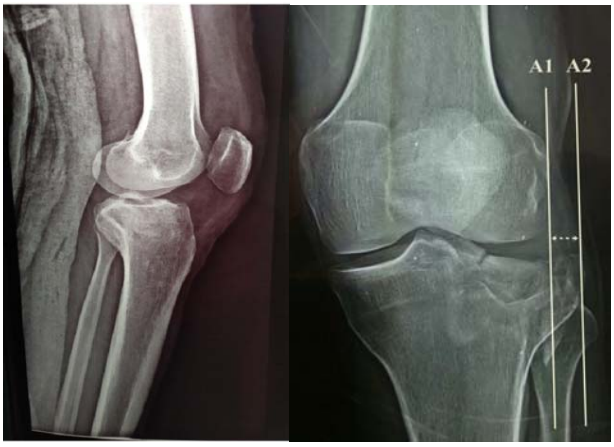

Figure. 1: Routine plain X-ray (A-P & lateral views)

Patient positioning:

The patient is placed supine with the knee flexed 90 degrees on a radiolucent table.

Approach:

The anterolateral approach was chosen in all cases as the depression was anterior or central in all cases. We made an anterolateral L shaped incision started approximately 3 to 5 cm proximal to the joint line, staying just lateral to the border of the patella tendon. Then we curved the incision anteriorly over Gerdy's tubercle and then we extended it laterally parallel to the joint line. The incision was extended proximally or distally when needed (fig .2).

Fig. 2: Clinical intra-operative photos for the approach of the operation.

Reduction of intraarticular fracture:
The major column fracture line was "gapped open" with a lamina spreader like a book to visualize and gain access to the impacted articular fragments. The depressed osteoarticular fracture fragments were elevated from below using a curved impactor, elevator, osteotome inserted from below under direct vision. Once the osteochondral fragments were repositioned and the joint was congruent, temporary Kirschner wires (K-wires) were used to provisionally stabilize the articular reduction. The defect created after elevating the joint surface was filled with bone graft in the group of patients managed with the use of bone graft (group B). Following graft placement, the split condyle was reduced and was held with a large reduction forceps and intra-operative fluoroscopy was used to assess the reduction.

The collection of bone grafts:
The iliac crest was used in all patients through an incision 2cm posterior to the anterior superior iliac spine (Fig.3). In all cases, we used a corticocancellous bone graft.

Fixation of the fracture:
In the two groups of patients, fixation was achieved with buttress T and L plates with subchondral 6.5 millimeters partially threaded cancellous screws supporting the joint surface (Fig.4). The level of the plate was determined under fluoroscopic guidance and then held in place with a reduction clamp and k-wires. The subchondral screws were taken through the proximal portion of the plate or outside the plate under fluoroscopic guidance and it acts as rafting screws. The screws extended across the subchondral region provided support for the reconstructed surface. Following column reconstruction, the elevated meniscus was then brought down and repaired using the holes at the proximal end of the plate or to the remaining cuff of the joint capsule and any peripheral meniscal tears that were present were managed in the same setting.

Fig.3: intra-operative photos for collection of iliac crest bone graft.

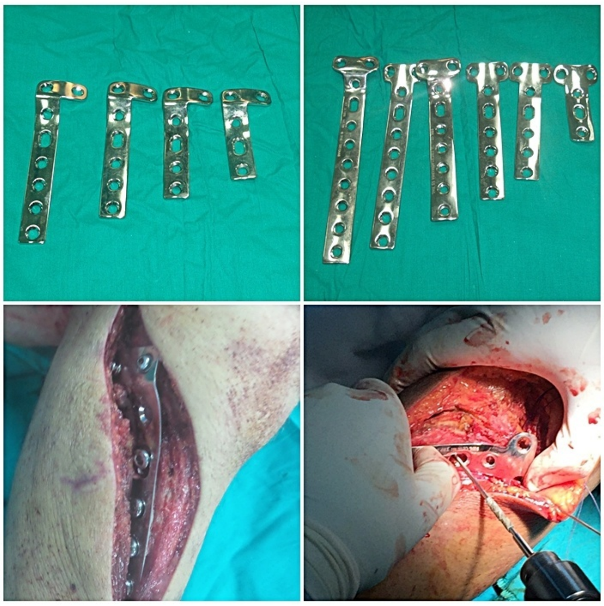

Figure. 4: Intraoperative fixation.

Postoperative instructions:
Medications an intravenous antibiotic as prophylaxis was given for all patients starting from the day of surgery and continued till drain removal after 48 hours. Anticoagulation therapy was given for three weeks and oral antibiotics for one week. Active Range of movement exercises up to 90 degrees between the third and fourth days post-operative. Isometric quadriceps strengthening exercises for six weeks. Mobilization of patient non-weight-bearing was started after removal of the drain using a walking frame for six weeks. Weight-bearing was allowed between 6 and 12 weeks after surgery, progressing from partial weight-bearing after 6 weeks till full weight-bearing after 12 weeks after achieving clinical union and radiological

union. Discharge and follow-up visits. The outcome following surgical intervention was determined using Rasmussen knee Score [84] at the last visit after 6 months post-operative. This scoring tool consists of anatomical (radiological) and functional grading. Anatomical grading of Rasmussen knee score consists of 3 parameters including assessment of joint depression, condylar widening, and angulation as shown in Table1. The total anatomical score was 18 points. The anatomical score was considered excellent if the score was 18. Good results if the range was between 12-18. While fair score if the range was between 6-12 and poor score if the range was less than 6 points.

Functional grading consisted of five parameters that were used to assess the function of the knee including pain, walking capacity, degree of extension, range of motion, and degree of stability as shown in Table 2. The functional score was considered excellent if the points were between 27 to 30 points. Good results were between 20-27 points while fair results were between 10-20 points and results were considered poor if the range was less than 10.

Table 1: Rasmussen Score Criteria for Radiological Assessment [84].

Parameter	Points
Depression	
None	6
< 5 mm	4
6-10 mm	2
>10 mm	0
Condylar widening	
None	6
<5 mm	4
6-10 mm	2
>10 mm	0
Angulation (valgus/varus)	
None	6
<10°	4
10°-20°	2
> 20°	0
Total	18

Table 2: Rasmussen Score Criteria for Clinical assessment [84].

Clinical Parameter	Points
Subjective	
Pain	
None	6
Occasional pain needs no medication	5
Stabbing pain	4
Intense, activity-related	2
Night pain, at rest	0
Walking capacity	
Normal	6
Outdoors walking >1 hour	5
Outdoors walking< 1 hour	4
Indoors only	1
Wheelchair/bedridden	0
Objective	
Extension	
Normal	6
>10° loss	4
< 10° loss	2
Total range of motion	
>140°	6
>120°	5
>90°	4
>60°	2
>30°	1
0°	0
Stability	
Normal	6
Abnormal in 20° flexion	5
Instability in extension<10°	4
Instability in extension >10°	2
Total	30

Statistical analysis:

Data were coded and entered using the statistical package SPSS (Statistical Package for the Social Science; SPSS Inc., Chicago, IL, USA) version 22. Data were summarized using mean, standard deviation, median minimum, and maximum in quantitative data, using frequency (count) and relative frequency (percentage) for categorical data. Comparisons between quantitative variables were done using the non-parametric Mann-Whitney test[85]. For comparing categorical data, Chi-square ($\chi 2$) test was performed. Exact test was used instead when the expected frequency is less than 5, P-values less than 0.05 were considered as statistically significant[86]. Correlations between quantitative variables were done using the Spearman correlation coefficient, which is a statistical measure of the strength of a monotonic relationship between paired data. In a sample, it is denoted by r and is by design constrained as follows $-1 \leq r \leq 1$ and its interpretation is similar to that of Pearson e.g. the closer to −1 or +1 the stronger the monotonic relationship [87]. Correlation is an effect size and so we described the strength of the correlation using the following guides for the absolute value of r as shown in Table 3. The confidence interval (CI) can be expressed in terms of samples (or repeated samples): "Were this procedure to be repeated on multiple samples, the calculated confidence interval (which would differ for each sample) would encompass the true population parameter. Note that this does not refer to the repeated measurement of the same sample, but repeated sampling [88].

Table 3: Interpretation of the correlation coefficient.

Correlation coefficient	.00-0.19،	.20-0.39،	0.40-0.59	.60-0.79،	0.80-1.0
Interpretation	very weak	weak	moderate	Strong	very strong

Results

According to Schatzker classification, all cases in our study were classified as type II (split and depression) and all of these cases were managed by open reduction and internal fixation using a locking compression plate and the cases were randomly divided into two groups one was managed without the usage of bone graft and was named group (A) and another one was managed with bone graft and was named group (B).

The difference between the degree of articular depression immediate and six months postoperative:

In the current study, the difference between the degree of articular depression immediate and six months postoperative is shown in Table 4 and Fig.5. In group (A) the mean is 0.33 millimeter ± 0.72 mm, 95% confidence interval (C.I) is 0.06 - 0.73 mm. In group (B) the mean is 0.60 millimeter ± 0.83 mm, 95% confidence interval (C.I) is 0.14 - 1.05 mm. The P-value is (0.28) which is statistically insignificant.

Table 4: The difference between the degree of articular depression immediate and six months postoperative.

	GROUP (A)					GROUP (B)					P value
	Mean	SD	Median	Minimum	Maximum	Mean	SD	Median	Minimum	Maximum	
The difference between the degree of articular depression immediate and six months post-operative	0.33	0.72	0.00	0.00	2.00	0.60	0.83	0.00	0.00	2.00	0.28

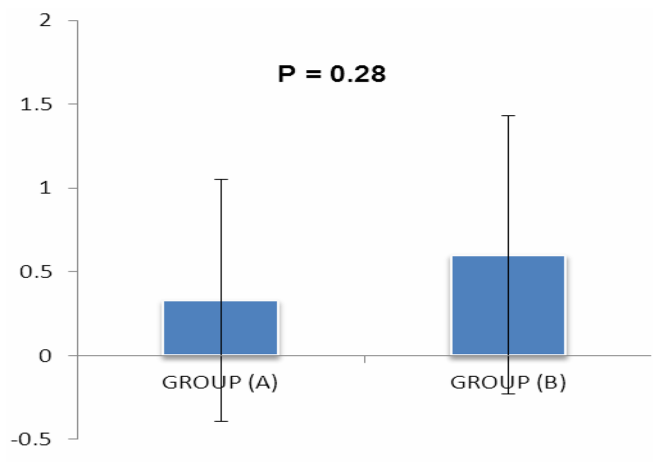

Fig.5: The difference between the degree of articular depression immediate and six months postoperative, mean= blue column and SD= black line.

The difference between the degree of condylar widening immediate and six months postoperative:
The difference between the degree of condylar widening immediate and six months postoperative in the current study is shown in Table 5 and Fig.6. In group (A) the mean is 0.27 millimeter ± 0.46 mm, 95% confidence interval (C.I) is (0.01-0.52). In group (B) the mean is 0.53 millimeter ± 0.64 mm, 95% confidence interval (C.I) is (0.17 -0.88). The P-value is (0.228) which is statistically insignificant.

Table 5: The difference between the degree of condylar widening immediate and six months postoperative.

	GROUP (A)					GROUP (B)					P value
	Mean	SD	Median	Minimum	Maximum	Mean	SD	Median	Minimum	Maximum	
Difference between the degree of condylar widening immediate and six months postoperative	.27	.46	.00	.00	1.00	.53	.64	.00	.00	2.00	0.228

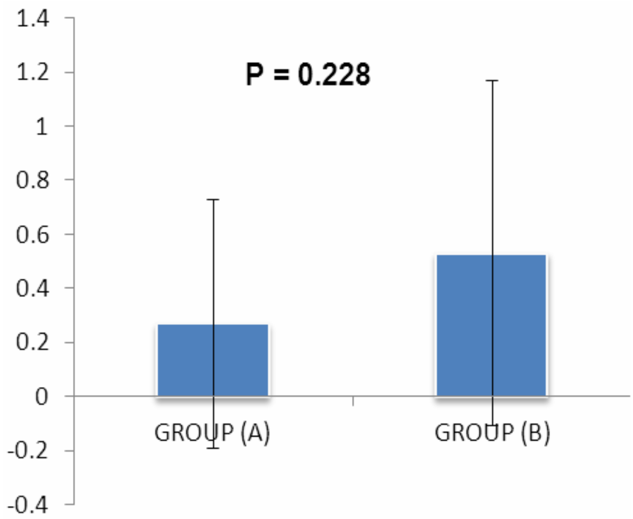

Fig. 6: The difference between the degree of condylar widening immediate and six months postoperative mean= blue column and SD= black line.

Relation between the clinical and radiological outcomes:
In the current study, there is a positive statistical correlation between the clinical and radiological outcome, the P-value is 0.024 which is statistically significant and the correlation coefficient is (0.439) which signify a moderate relation between the two variant as shown in Table 6 and Fig.7.

Table 6: Relation between the functional and radiological outcome.

RADIOLOGICAL OUTCOME		
FUNCTIONAL OUTCOME	Correlation Coefficient	.439
	P value	.024
	N	20

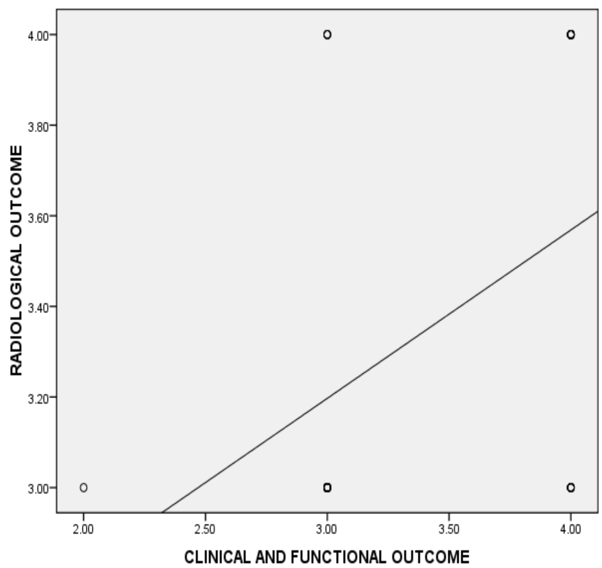

Fig.7: Relation between the functional and radiological outcome.

Complications:
In the current study the complications were as follows:

Infection:
In the current study, in group (A) infection occurred in the 2 patients (20%), in the group (B) infection occurred in 3 (30%) patients as shown in Table 7. Repeated dressing and antibiotics according to culture and sensitivity was given to all of them. Five of them debridement was done and only one removal of the implant was done. The P-value is (0.605) which is statistically insignificant.

Table 7: The frequency of infection in the two groups.

		GROUP (A)		GROUP (B)		P value
		Count	%	Count	%	
Infection	yes	2	20%	3	30%	0.605
	no	8	80%	7	70%	

Limitation of movement and deformity:
In the current study in a group (A) limitation of movement occurred in the 2 patients (20%) one patient had a limitation of flexion about 20 degrees and the other patient had a limitation of 15 degrees flexion, physiotherapy was done and the patient has recovered. In group (B) limitation of movement had occurred in 3 (30.0%) patients, one had a limitation of flexion about 25 degrees, and two patients had a limitation of flexion about 20 degrees. Physiotherapy was done and two patients have completely recovered and the other patient still has a residual limitation of flexion about 15 degrees. In group (A) 15 degrees flexion deformity has occurred in one patient, physiotherapy was done and the patient has recovered. In group (B) 20 degrees flexion deformity has occurred in one patient physiotherapy was done and still, there is a residual flexion deformity about 5 degrees. The P-value is 0.809 which is statistically insignificant as shown in Table 8.

Table 8: The frequency of limitation of movement and deformity in the two groups.

	GROUP (A)		GROUP (B)		P value
	Count	%	Count	%	
Limitation of movement	2	20%	3	30.0%	0.809
Deformity	1	10%	1	10%	

Painful hardware:
In the current study, there were 3 patients 30% suffered from painful hardware in a group (A). There were 2 patients 20% suffered from painful hardware in a group (B). The p-value was (0.605) which is statistically insignificant as shown in Table 9. In all cases, the pain can be tolerated by medication.

Table 9: The frequency of painful hardware in the two groups.

		GROUP (A)		GROUP (B)		P value
		Count	%	Count	%	
painful hardware	yes	3	30%	2	20%	0.605
	no	7	70%	8	80%	

Graft complications:
In the current study, in group (B) there are 6 patients (60%) who suffered from graft complications in 1 patient superficial infection occurred at the graft site and improved on antibiotics and repeated dressing and 3 patients complained of pain at the site of the graft. The pain continued in one patient for two months and in the other three patients, the pain continued for three months as shown in Table 10.

Table 10: The frequency of graft complications.

		Count	percentage
Graft complication	Non	6	60.0%
	Infection	1	10%
	pain	3	30%

Discussion

Tibial plateau fractures represent only 1% of all fractures.[1] If not appropriately treated, the consequences may be severe and have a great social impact. The management of the fracture depends on several factors such as fracture configuration, concomitant soft tissue injury, the patient's age, activity level, and bone quality.[2] Schatzcker type II tibial plateau fractures have been traditionally treated with open reduction, the elevation of the articular surface, cancellous autografting or allografting, and rigid internal fixation.[5]

Autogenous cancellous bone-graft harvesting is associated with significant morbidity. The reported minor complication rate is between 3 and 20% and includes cutaneous nerve damage, persistent discomfort, postoperative pain up to 2 years, local wound complications including superficial wound infection, iliac crest abscess, seroma, hematoma, and difficult ambulation.[18,19]Major complication rate has been reported up to 8.6% and includes pseudoaneurysm of pelvis vasculature, AV fistula, massive blood loss, avulsion of the anterior superior iliac spine, lumbar hernia, and neuropathies.[19]

Allografts may be associated with the transmission of diseases like HIV and Hepatitis, they showed an incidence of disease transmission as high as 3.6% was recorded. Screening of allograft is an expensive process and bone banks are not commonly available.[20] Frozen allogeneic bone grafts are associated with a risk of nonunion (10%), infection (10%), and evoking an immune response that can result in graft resorption or delay in graft incorporation.[22]

Another synthetic bone-graft substitute such as the injectable calcium phosphate cement was used as well with promising results. The bone defect can be filled with orthopaedic cement, which provides a useful degree of immediate mechanical strength. However, cement is an inert foreign body that can cause problems in the event of infection or revision surgery. Thus, cement should be reserved for very elderly patients. An appealing alternative consists in the use of hydroxyapatite, which provides the same immediate mechanical strength as cement but allows osteoinduction to occur, thus restoring bone stock. Disadvantages of hydroxyapatite are its high cost and risk of leakage into the joint cavity. The injection must be cautious, slow, and performed under arthroscopic guidance. [23]

In the current comparative study, there is no statistically significant difference between the patients who were managed with and without bone graft regarding the collapse of the articular surface, condylar widening, the union, the functional and radiological outcomes.

In the current study, there is no statistically significant difference regarding the frequency of complication in the two groups except the additional complications of bone grafting in patients were managed with the usage of bone graft. Patients with tibial plateau fractures are at high risk of thromboembolic complications. Only, one patient (6.7%) in the current study in a group (B) had deep venous thrombosis that was discovered after three weeks of operation. Other studies have reported rates ranging between 1.7% and 20% [21,29,30].

Conclusion

The current study showed that there is no statistically significant difference between the patients who were managed with and without bone graft regarding the collapse of the articular surface, condylar widening, union, functional and radiological outcomes. Meanwhile, there were complications associated with bone grafting as infection and graft site pain. There is a positive correlation between the radiological and the functional outcomes so anatomical reduction of the tibial plateau is mandatory.

Ethical considerations: The Dean of Al-Azhar faculty of medicine, Cairo Administrative approval and official permissions from the directorate of health affairs and managers of Al-Azhar University and Om El-Masreen hospitals were obtained before data collection **and** verbal consent was obtained from directors of orthopaedic departments following guarantee of data confidentiality to the patients in the study.

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Conflicts of interest: There are no conflicts of interest.

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