RESEARCH ARTICLE

Complex tibial plateau fractures: Clinical and radiological outcome following plate osteosynthesis

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Abstract

Objective: To assess the clinical and radiological outcome of complex tibial plateau fractures treated with single or dual plate osteosynthesis and augmentation of metaphyseal defects with bone graft substitute.

Methods: A retrospective review was conducted on patients presenting with tibial plateau fractures (TPF) between January 2018 and June 2019. Of the 62 patients who presented in this period, 33 met the inclusion criteria of complex type TPF. Simple split fracture types and open fractures were excluded. All patients were operated in the supine position and anatomical locking plate or low profile buttress plates for additional fragments were used. Synthetic bone graft substitute was used in filling of the metaphyseal defects. Patients were evaluated clinically using the Knee Society Score and with radiographic examination using the Heiney-Redfern Scale.

Results: All the patients were followed for an average of 13.39±4.63 months (range 6 - 24 months). All the included patients were males with the mean age of 41.3±12.84 years (range18-70 years). Objective knee society score graded excellent in 24 (72.8%) patients, good in 8 (24.2%) and fair in 1 (3%). Functional score, on the other hand, was excellent in 21 (63.6%), good in 9 (27.3%) and fair in 3 (9.1%) patients. Radiological outcome evaluated on x-rays and according to the H-R scale was good in 23 (69.8%) and fair in 10 (30.2%). Fracture union was achieved in all patients with no secondary loss of reduction.

Conclusion: The treatment of complex tibial plateau fractures with plate osteosynthesis and graft augmentation of metaphyseal defects has shown optimal results both clinically and radiologically. Excellent joint motion and knee society score is achieved by early rehabilitation following stable fixation. However, long-term risk of post-traumatic arthritis and its severity following complex TPF needs to be determined in different methods of fixation.

Keywords: Tibial Plateau Fractures, Complex, Plate Osteosynthesis, Bone Graft Substitute, Knee Society Score.

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Introduction

Tibial plateau fractures (TPF) account for 1-2% of all fractures and usually result from high energy trauma.[1] TPF with increasing complexity and vulnerable soft tissue envelope require optimal treatment which poses a surgical challenge.[2] The ultimate goal in these fractures is to restore the articular surface anatomically, stable fixation to allow early movements of the joint and minimal soft tissue invasion allowing ideal healing environment.[3] Several methods of fixation for complex TPF exist in the literature from column specific fixation to minimal invasive techniques and percutaneous hybrid or ring external fixators with good to excellent results.[4,5] The decision of definitive management depends on fracture configuration, local soft tissue status and patient's condition.

Recent advances in locked anatomical plates with raft screws and minimal invasive techniques have decreased the complication rates and secondary loss of reduction.[6] TPF often have metaphyseal defects in the subchondral zone that require filling either with autograft, allograft or synthetic bone graft substitutes for augmentation.[7] Bone graft substitutes (BGS) are synthetic biomaterials that have been reported to provide reduced fracture site pain, and better radiological and functional outcome compared to the use of cancellous autografts.[6,8] Furthermore, the risks of donor-site morbidity, allograft associated disease transmission and shortage of autograft or allograft is also eliminated with the use of BGS.[9]

The present study aimed at providing report on outcome of complex tibial plateau fractures (AO types 41.B3, 41.C1, 41.C2 and 41.C3), based on clinical and radiological evaluation, in which single or dual plate fixation were done along with filling of the bony voids with BGS.

Patients and Methods

After the local ethics committee approval, we retrospectively identified patients presenting with complex tibial plateau fractures (Schatzker Type II, IV, V & VI) or (AO 41 B3, C1, C2 & C3) to the Orthopaedic Surgery department of Combined Military Hospital (Rawalpindi, Pakistan) from January 2018 to June 2019. Unicondylar

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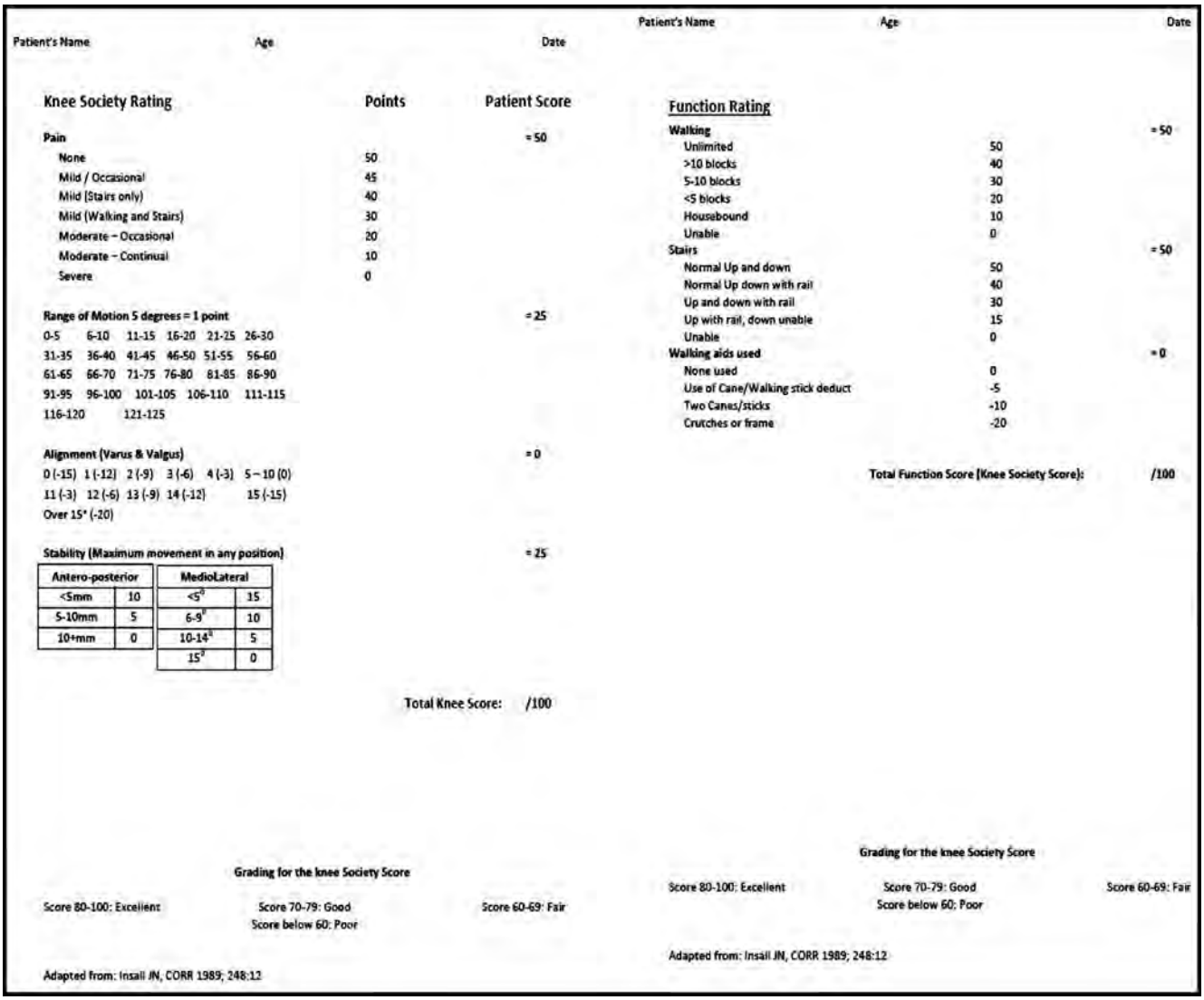
fractures (Schatzker II & IV) with articular comminution and depressed fragments that needed elevation and graft augmentation of the subchondral defect were also included. The exclusion criteria were open fractures, simple split or depressed fractures or neurological conditions that would affect post-operative rehabilitation.

Using a convenient sampling technique, a total of 62 patients presenting with proximal tibia fractures during the assigned time period were contacted on phone and requested for follow up in the out-patient department. Among the 45 patients who responded, 33 met the inclusion criteria of complex tibial plateau fracture. The included patients were operated by one of the authors.

All patients were operated in the supine position with pneumatic tourniquet placed high above over thigh. Thirty patients had their surgery within 48 hours of injury whereas 3 had to wait for about a week till resolution of soft tissue swelling. Fracture blisters were initially managed with limb elevation, non-adherent dressings and long leg cast, as is also described by Tolpinrud et al.[10]

Preoperatively, all the patients had standard radiologic protocol of X-rays and CT scan with three dimensional reconstructions. Fracture morphology and type were identified according to AO and Schatzker classifications.[11,12] Schatzker types V and VI were most frequent (23 cases), followed by type II (9 cases) and type IV (1 case). All the bicondylar fractures (Schatzker type V & VI) were fixed with dual medial or posteromedial and lateral plates. Silicon containing coralline hydroxyapatite bone graft substitute was used in the filling of



Patient's Name Age Date

Knee Society Rating **Points** **Patient Score**

Pain = 50

None	50
Mild / Occasional	45
Mild (Stairs only)	40
Mild (Walking and Stairs)	30
Moderate – Occasional	20
Moderate – Continual	10
Severe	0

Range of Motion 5 degrees = 1 point = 25

0-5 6-10 11-15 16-20 21-25 26-30
31-35 36-40 41-45 46-50 51-55 56-60
61-65 66-70 71-75 76-80 81-85 86-90
91-95 96-100 101-105 106-110 111-115
116-120 121-125

Alignment (Varus & Valgus) = 0

0 (-15) 1 (-12) 2 (-9) 3 (-6) 4 (-3) 5 – 10 (0)
11 (-3) 12 (-6) 13 (-9) 14 (-12) 15 (-15)
Over 15° (-20)

Stability (Maximum movement in any position) = 25

Antero-posterior		MedioLateral	
<5mm	10	<5°	15
5-10mm	5	6-9°	10
10+mm	0	10-14°	5
		15°	0

Total Knee Score: /100

Grading for the knee Society Score

Score 80-100: Excellent Score 70-79: Good Score 60-69: Fair
Score below 60: Poor

Adapted from: Insall JN, CORR 1989; 248:12

Patient's Name Age Date

Function Rating

Walking = 50

Unlimited	50
>10 blocks	40
5-10 blocks	30
<5 blocks	20
Housebound	10
Unable	0

Stairs = 50

Normal Up and down	50
Normal Up down with rail	40
Up and down with rail	30
Up with rail, down unable	15
Unable	0

Walking aids used = 0

None used	0
Use of Cane/Walking stick deduct	-5
Two Canes/sticks	-10
Crutches or frame	-20

Total Function Score (Knee Society Score): /100

Grading for the knee Society Score

Score 80-100: Excellent Score 70-79: Good Score 60-69: Fair
Score below 60: Poor

Adapted from: Insall JN, CORR 1989; 248:12

Figure-1: The knee society clinical rating system.[14]

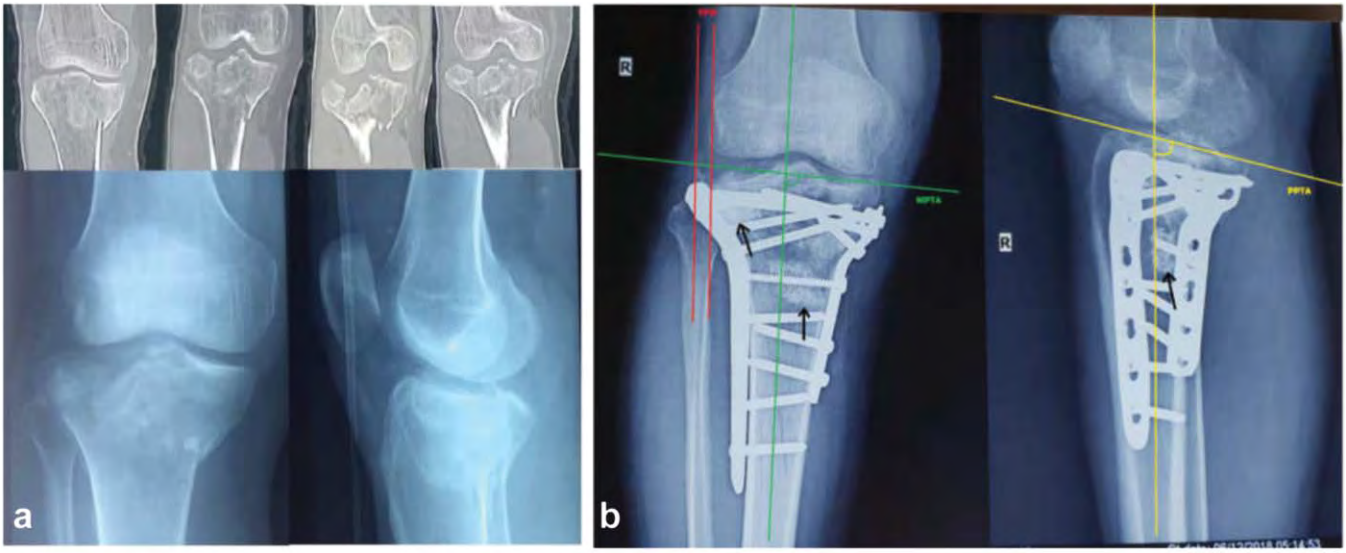


Figure-2: (Case 1): A 40 year old patient with complex tibial plateau fracture. (a) Pre-operative radiograph showing severe comminution of the lateral articular surface. (b) Six months post-operative AP and lateral X-ray with coloured markings for medial proximal tibial angle (green), tibial plateau widening (red) and posterior proximal tibial angle (yellow). Black arrows indicating the structural void filler support with synthetic bone graft substitute.

metaphyseal defects to augment the articular reduction.[13]

The minimum follow-up in the present study was 6 months with the maximum follow up being 24 months. Patients were clinically evaluated for knee function using the knee society score (KSS).[14] The main parameters of knee score include pain, range of motion, alignment (varus & valgus), and stability in mediolateral and anteroposterior planes. Patient's functional score was assessed in part two of the form which considers walking distance and stair climbing, and also deductions for walking aids used (Figure-1).

Seven radiographic parameters were evaluated; medial proximal tibial angle (MPTA) or coronal alignment, posterior proximal tibial angle (PPTA) or sagittal alignment, tibial plateau widening (TPW), articular reduction, fracture union, post-traumatic arthritis and structural void filler support (Figure-2). The results were then summarised according to the Heiney-Redfern scale (H-R scale) Table-1.[15]

Table-1: The Heiney-Redfern Scale.[15]

H-R Scale	0	1	2
MPTA*	<80° or >94°	80°-84° or 91°-94°	85° - 90°
PPTA*	<3° or >15°	3°-5° or 13°-15°	6°-12°
TPW*	>5mm	>2-5mm	0-2mm
Articular Step-off	>5mm	>2-5mm	≤ 2mm
Fracture Union	No evidence	Partial	Complete
Post-traumatic Arthritis	Severe	Moderate	None
Structural Void Filler Support	Incorrect position and insufficient concentration	Partial void filling and concentration	Correct position and sufficient concentration

Sum Scale: 11-14 good result, 7-10 fair result and 0-6 poor result.
*MPTA: Medial Proximal Tibial Angle, *PPTA: Posterior Proximal Tibial Angle, *TPW: Tibial Plateau Widening.

SPSS software (version 23) was used in the statistical analysis of the data. Mean and standard deviation were calculated for descriptive analysis. Pearson's rank correlation coefficient was applied to the functional scores and the radiological outcome (H-R Scale) with p-value of ≤ 0.01 considered as significant.

Results

In our study, complex tibial plateau fractures occurred due to high energy trauma between the age group 18-70 years with the mean age of 41.3±12.84 years. All the 33(100%) patients included were males. Females were either in the exclusion criteria or lost to follow-up. The mean follow-up was 13.39±4.63 months (range 6-24 months).

Functional and radiological outcome was assessed on the last follow-up. Objective knee society score graded excellent in 24(72.8%) patients, good in 8 (24.2%) and fair in 1 (3%). Functional score, on the other hand, was excellent in 21 (63.6%), good in 9 (27.3%) and fair in 3 (9.1%) patients (Table-2).

Radiological outcome on the H-R scale was good in 23 (69.8%) and fair in 10 (30.2%) of the x-rays evaluated. The mean H-R score was 11.6 ± 3.24 points.

Table-2: Patient and postoperative data.

Fracture Type (Frequency) Age/Sex	Knee Score		Functional Outcome		Radiological Outcome (H-R Scale)	
Schatzker Type II (27.3%)						
27/M	95	Excellent	90	Excellent	12	Good
35/M	100	Excellent	100	Excellent	14	Good
50/M	85	Excellent	90	Excellent	10	Fair
30/M	100	Excellent	100	Excellent	14	Good
55/M	100	Excellent	90	Excellent	14	Good
28/M	100	Excellent	100	Excellent	14	Good
60/M	88	Excellent	70	Good	12	Good
28/M	100	Excellent	100	Excellent	13	Good
38/M	95	Excellent	90	Excellent	14	Good
Schatzker Type IV (3%)						
42y/M	88	Excellent	80	Excellent	13	Good
Schatzker Type V (24.2%)						
34/M	89	Excellent	80	Excellent	10	Fair
41/M	99	Excellent	90	Excellent	11	Good
50/M	100	Excellent	100	Excellent	14	Good
60/M	73	Good	70	Good	10	Fair
34/M	90	Excellent	90	Excellent	11	Good
53/M	95	Excellent	100	Excellent	11	Good
32/M	92	Excellent	90	Excellent	13	Good
34/M	68	Fair	70	Good	10	Fair
Schatzker Type VI (45.5%)						
34/M	78	Good	70	Good	10	Fair
18/M	90	Excellent	100	Excellent	13	Good
47/M	89	Excellent	90	Excellent	11	Good
56/M	87	Excellent	80	Excellent	13	Good
33/M	94	Excellent	90	Excellent	11	Good
42/M	72	Good	70	Good	8	Fair
53/M	78	Good	65	Fair	12	Good
47/M	82	Excellent	80	Excellent	12	Good
40/M	100	Excellent	90	Excellent	13	Good
28/M	77	Good	70	Good	10	Fair
70/M	94	Excellent	70	Good	10	Fair
44/M	71	Good	60	Fair	7	Poor
21/M	79	Good	65	Fair	10	Good
65/M	75	Good	70	Good	12	Good
34/M	80	Excellent	70	Good	11	Good

There was a significant positive relationship between the knee score and the radiological score (Heiney-Redfern scale), $r = .71$, $n = 33$, $p < 0.001$. This indicated the direct correlation of quality of reduction on X-rays with the clinical outcome.

Skin complication occurred in 1(3%) patient which was managed successfully with local wound care. Mild to moderate post-traumatic secondary arthritis was seen in 4(12%) patients. Another 2(6%) had their implants removed at one year due to discharging sinus (late onset) on the medial side. None of the patients developed non-union or secondary loss of reduction in this series.

Discussion

Treatment of complex tibial plateau fractures (TPF) with plate osteosynthesis and bone graft substitute augmentation successfully achieves normal or near normal knee joint biomechanics with optimal functional outcome Figure-3 & 4. Rigid constructs used for fixation in this study allowed early movements in the knee joint leading to excellent functional outcome in most of the patients Table-2.

In a CT scan based study, McGonagle et al reported 72% and 91% effectiveness of modern locking plates for lateral and medial tibial plateau fractures, respectively.[16] Lateral proximal tibia anatomical plate with rafting screws and low profile buttress plates for medial or posteromedial fixation were mostly sufficient as is confirmed by our results with no secondary loss of reduction. Minimal soft

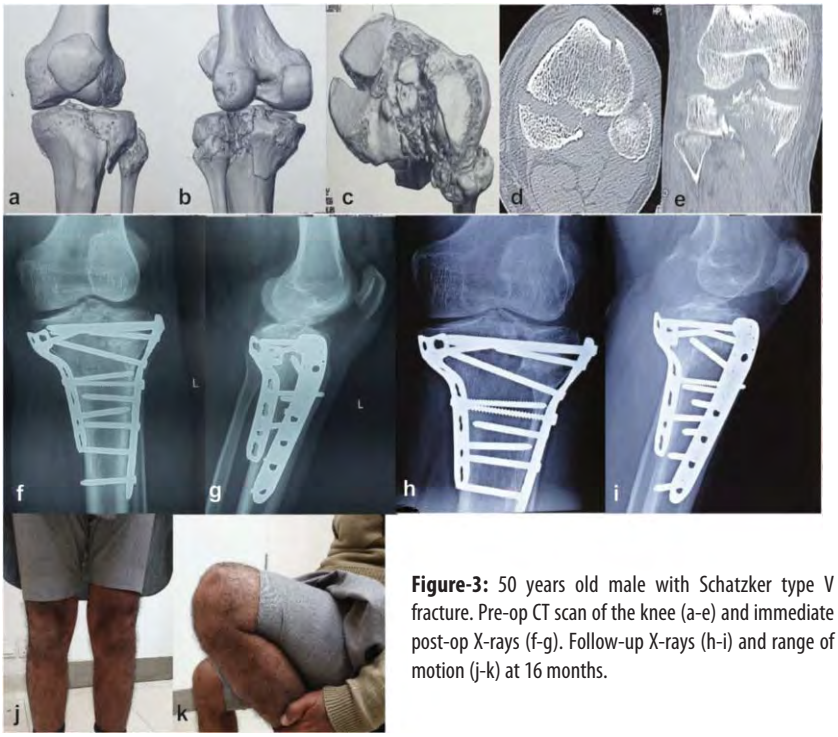


Figure-3: 50 years old male with Schatzker type V fracture. Pre-op CT scan of the knee (a-e) and immediate post-op X-rays (f-g). Follow-up X-rays (h-i) and range of motion (j-k) at 16 months.

Figure-5: Complex injury of the lateral tibial plateau (a-b) in a 38 years old male. Post-op X-rays (c-d) showing plate osteosynthesis and augmentation with bone graft substitute (Bone Medik - S).

Figure-4: 34 years old male with complex Schatzker type VI fracture (a-g). Immediate post-op X-rays (h-i). Follow-up X-rays (j-k) at 18 months. Knee range of motion (l-m) at 18 months.

tissue invasion was our preference due to which difficulties were faced in few dealing with the posterolateral fractures (Figure 3 & 4). Newer trends in patient-specific designed implants and pre-operative templating on 3D printed models may further improve surgical precision.[17]

Silicon containing coralline hydroxyapatite bone graft substitute used in filling of subchondral defects worked excellent as a scaffold with minimal resorption observed at last follow-up Figures-3, 4 & 5. Studies have also confirmed its non-inferiority to cancellous autograft.[18]

In a study by Ollivier et al, the mean H-R score was 12.3 ± 3.8 points in the bone substitute group compared to the bone graft group.[6] Similarly, the mean H-R score in our study was 11.6±3.24 points also ranging in the good outcome criteria.

Excellent objective and subjective knee society score was achieved in 72.8% and 63.6%, respectively in the present study. Several authors including Citak et al, Rohra et al and A.D. et al have all reported similar results in their series with plate osteosynthesis of the TPF.[19-21]

Conclusion

The treatment of complex tibial plateau fractures with plate osteosynthesis and graft augmentation of metaphyseal defects has shown optimal results both clinically and radiologically. Excellent joint motion and knee society score is achieved by early rehabilitation following stable fixation. However, long-term risk of post-traumatic arthritis and its severity following complex TPF needs to be determined in different methods of fixation.

Disclaimer: None.

Conflict of Interest: None.

Funding Disclosure: None.

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