Treatment of Tibial Plateau Fractures by Circular External Fixator

Adel H. Adawy, Mohammed A. Meselhy, Mahmoud I. Mostafa, Hossam M. Saad

Department of orthopedic surgery Faculty of Medicine Benha University, Egypt.

Correspondence to: Hossam M. Saad, Department of orthopedic surgery Faculty of Medicine Benha University, Egypt.

Email:

hossamme911@gmail.com

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Abstract

Background: Tibial plateau fracture is challenging for orthopedic surgeons because of the severity of trauma and associated soft tissue injuries. The treatment goals are to anatomically reconstruct the proximal tibial articular surface, restore limb axial alignment, and fix metadiaphyseal comminution to allow early knee mobilization and weight bearing. **Aim:** To evaluate the functional, clinical and radiological outcomes of treatment of high energy tibial plateau fractures by circular external fixator ± percutaneous screw fixation. **Patients and Methods:** Between June 2018 and July 2019, 20 tibial plateau fractures in 20 patients were treated with Ilizarov external fixator in Benha University hospital. The mean age was 39 years (range 22–55 years), and the mean follow-up period was 11±2 months (range 8–12 months). Closed reduction was performed by closed means in 70% of cases or through minimal incisions in 30% of cases. Clinical and functional evaluation of patients in the tibial plateau group was performed. **Results:** All patients started weight bearing the day after the surgery. Functionally, 70% had an excellent result, 20% had a good result. Radiologically 75% of had excellent results. Pin tract infection was controlled in all patients without need to implant removal. **Conclusion:** The degree of soft tissue injury associated with tibial plateau fracture is an important determinant for both the choice of the treatment modality and the prediction of treatment outcome. The use of Ilizarov external fixator is safe and effective option for the treatment of difficult Schatzker IV, V and VI tibial plateau fractures.

Keywords: Ilizarov circular fixation, ligamentotaxis, tibial plateau fracture.

Introduction

Tibial plateau fractures occur due to a combination of axial loading and varus/valgus applied forces leading to articular depression, mal-alignment and an increased risk of post traumatic osteoarthritis. ***[1]*** Like other intra-articular fractures, tibial plateau fracture is challenging for orthopedic surgeons because of the severity of trauma and associated soft tissue injuries. ***[2]*** Although dual plating is biomechanically proven to be the best stabilization option, it requires extensive soft tissue dissection with a potential high rate of postoperative complications particularly when single midline incision was used for dual plating. ***[3]*** The use of a minimal invasive technique, an external fixator in the treatment of S-V and S-VI fractures may provide fair reduction results without endangering the soft tissue elements. Moreover, it facilitates the access to any endangered soft tissue elements requiring interventions along the treatment period. The addition of minimal internal fixation with cannulated screws and k-wires prior to an external fixator application provides minimum soft tissue stripping and greater fixation stability, allowing for early mobilization and greater range of motion***.[4]*** The Ilizarov fixator is a small wire circular frame device invented by Gavril Ilizarov in Kurgan, Siberia in 1952. The method relies on the basic bio-mechanical principle of axial compressive loads and micro movement in the osteogenic zone stimulating biological bone bridging of the fracture gap. This is dependent on wire tension. ***[5]*** The Ilizarov external fixator enables patients to become full weight bearing, return to normal function, maintain range of motion, and increase strength of the involved extremity at a significantly greater rate. The percutaneous reduction techniques and rigid external fixator provide minimal soft tissue disruption and periosteal stripping, allowing fracture fragments to maintain their blood supply and promote an environment of new callus formation. ***[6]***

Patients and Methods

A prospective study on 20 tibial plateau fractures in 20 patients was treated with Ilizarov external fixator between June 2018 and July 2019 in Orthopedic surgery Department at Benha University hospital. Written consents were taken from all patients and procedures were approved ethical committee of Benha faculty of medicine. Patients were reviewed at an

average follow up period of 11±2 months. The level of function, clinical and radiological findings, and the patients' opinion were assessed. There were 18 men and 2 women with a mean age of 39 years (range, 22 to 55 years). Nine patients (45%) came in road traffic accidents "RTA", three (15%) were pedestrians struck by motor vehicles, while eight patients (40%) were injured due to falling from height. The type of fracture (according to Schatzker classification 1987) ***[7]*** was type IV in 3 (15 %) patients, type V in 11 (55%) patients and type VI in 6 (30 %) patients. Skin bullae were present in 14 cases and 6 cases were open fractures; 5 cases were Grade I and one patient was Grade II according to Gustillo and Anderson classification 1993 ***[8]*** . The rest of cases were closed fractures with surrounding soft tissue compromise. Twelve (60%) patients were operated within the first week, and 8 (40%) patients were delayed till subsidence of the edema in cases with severe skin bullae and who needed additional minimal open reduction and internal fixation for articular surface with screws. Closed reduction was performed by closed means in 70% of cases or through minimal incisions in 30% of cases. **Preoperative assessment:** All patients were assessed clinically and radiologically by different means.

Operative steps: The patients were placed on the fracture table supine under the control of the image intensifier (C-Arm). The objective is to reduce condyles in relation to one another and to reduce and stabilize the tibial shaft beneath the reduced condyle. In 6 cases (30%) open minimal incision assisted the reduction by means of reduction forceps, and to push the articular surface from below upwards to reduce the depressed surfaces and any defect found was filled by a cancellous bone graft placed in the defect to guard against redepression of the articular surface. After the reduction is achieved, the condyles were fixed by cancellous screws in 3 cases (15%) and cannulated screws "4.5 mm" guided under the C-Arm percutaneously in 6 cases (30%) to stabilize the condyles and restore the articular surface. In 11 cases (55%) compression using counter olive wire through the fragments was done to have good reduction. The middle ring was positioned just distal to any shaft fracture component, and the distal ring was placed at a lower level and secured to a transfixion reference wire positioned parallel to the ankle joint to insure restoration of the mechanical axis of the tibia. The knee was bridged in five cases

(25%) because these fractures were high energy unstable fractures with severe comminution. The first transverse wire was passed proximal to the fracture site and then ring was fastened after tensioning the wire either with wire transioner or manually with spanners and other two wires was passed at least 45 degree to first wire. 1.8 mm plain wires were used at diaphysis and olive tip at metaphysic, then 2nd constructed made distal to the fracture site. 4 and 5 mm Shans pins were used in 3 cases (15%) to augment the rings. The usual distance between construct proximal or distal to fracture was 2-3 cm, then another constructs were made proximal and distal to previous constructs respectively and fastened. The rings were larger than the diameter of the limb by 2 finger-breadths anterior and three finger-breadth posterior.

Postoperative Care: Broad spectrum antibiotics were given for one week according to the severity of the initial and extent of soft tissue damage. As a prophylaxis from DVT; low molecular weight heparin was given to all patients once admitted to the hospital. Assisted partial weight bearing was encouraged immediately after surgery in all cases after an average of 4 days (range 1-15 days). All patients started gentile exercises on the second post-operative day. In five cases (25%) whose knees were bridged, range of motion and weight bearing started once femoral ring was removed. Physiotherapy and rehabilitation programs were tailored according to the initial fracture type, co-morbidity and the severity of any associated injuries. Radiographic evaluation of the studied cases included standard A-P and lateral views immediately post-operative, X-rays on monthly basis till solid union was assured and every three months for a year afterwards till the final follow up visit. Before removal, fixators were dismantled first without anesthesia and fracture site examined for movements and tenderness. All the fixators were removed under general anesthesia, first the distal rings were removed and the wires were taken out with the help of chuck and then the more proximal constructs removed.

Statistical Methods:

Data management and statistical analysis were done using SPSS vs.25. (IBM, Armonk, New York, United states). Numerical data was summarized as means and standard deviations. Categorical data was summarized as numbers and percentages.

Time of union was compared as regard different study parameters using Mann Whitney U test. Range of motion was compared as regard different study parameters using Fisher's exact test. All P values were two sided. P values less than 0.05 were considered significant.

Results:

All the fractures united at a mean duration of 15±3.0 weeks. (range, 12 to 22 weeks). The tibial fixator was retained for a mean of 13±2.0 weeks (range, 12 to 16 weeks). Full weight bearing was allowed at a mean of 14±4.0weeks (range, 12 to 24 weeks). The patients were followed up for a mean duration of 11±2 months (range, 6 to 12 months). Patients were assessed for range of motion with mean average of knee flexion angle of 130±9 degrees. Extension deficit of >10 degrees was reported in 2 cases only (10%). According to Thoresen Scoring System 1985 ***[9]*** , range of motion was excellent in 13 patients (65%) , good in 6 patients (30%) and fair in only one patient (5%). To assess functional results of the study, All the patients had fulfilled the Lysholm knee scoring scale 1982 [13] in 14 patients (70%) ranged from 70-90 (excellent), 4 patients (20%) from 50-70 (good) and 2 patients (10%) <50(fair). After radiological assessment of all patients in last visit, fifteen patients (75%) had no plateau tilting at follow-up. Four patients (20%) had a tilt of less than 6°, and one (5%) a tilt of between 6° and 10°. Only 2 patients had a step-off in articular surface >3 mm. In 10 injured knees (50%) the alignment remained normal and only two (10%) deviated by more than 5°. Condylar widening was present in six cases (30%) and in only two of them was more than 6 mm. Assessment of post-traumatic arthritis was considered as preliminary because of the short follow-up. There were ten excellent results (50%), six (30%) good, two (10%) fair, and two (10%) poor. There were no intraoperative injuries to nerves or major vessels. One patient with a comminuted fracture required management in a functional brace for delayed union (22 weeks). All patients had received low molecular- weight heparin from admission. No cases in the study were reported with DVT or pulmonary embolism. There were no skin sloughs or severe wire-tract infections. No patient developed osteomyelitis or septic arthritis. None required removal of the Fixator before healing of the fracture. No significant stiffness of the ankle or hind foot encountered as particular attention was given to the maintenance of mobility of

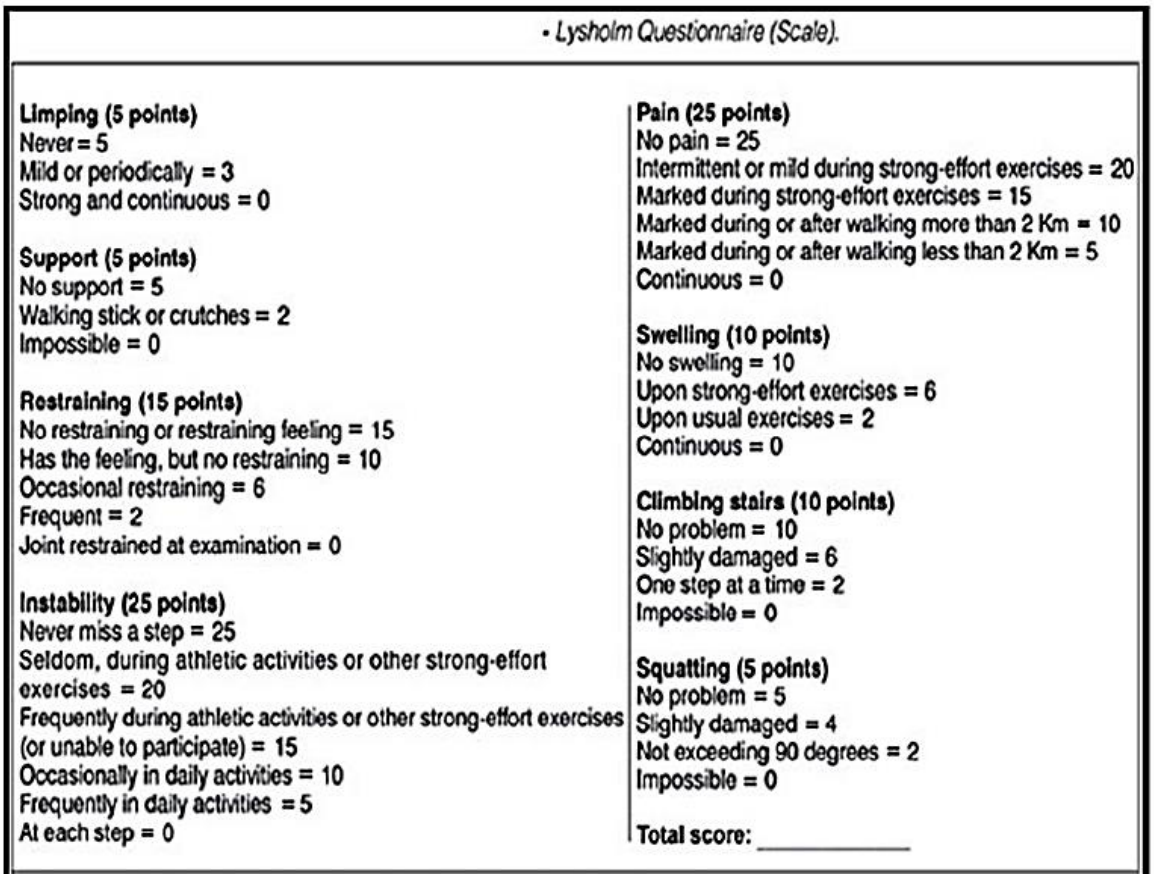
these joints. All patients were reported with one or more episodes of pin tract infection, and all were controlled with antibiotics and daily wash without complications.

Table (1): Details and results in patients of the study

Serial No.	***Age***	***Gender***	***Schatzker type 1987***	***Time of Fixation***	***Type of Reduction***	***Type of Fixation***	***Lysholm Scoring***	***Time of union (Weeks)***	***ROM (Degrees)***		***Complications***
									Flexion	***Extension***	
1	35	Male	V	1st week	Open	Min. internal	Excellent	17	130	Full	Healed PTI*
2	26	Male	VI	2nd week	Closed	External only	Excellent	16	150	Full	Healed PTI
3	40	Male	IV	2nd week	Closed	Minimal internal	Good	14	100	Deficit <10°	Condylar wide>6mm
4	32	Male	V	1st week	Closed	External only	Excellent	13	140	Full	Healed PTI
5	50	Male	VI	1st week	Closed	External only	Excellent	18	140	Full	Healed PTI
6	45	Male	VI	1st week	Closed	External only	Excellent	13	130	Full	Healed PTI
7	28	Male	VI	1st week	Open	Min. internal	Excellent	12	150	Full	Healed PTI
8	46	Female	V	2nd week	Closed	Min. internal	Fair	18	80	Deficit >10°	Valgus >5°
9	55	Male	VI	2nd week	Open	Minimal internal	Good	22	110	Full	Condylar wide>6mm
10	48	Male	V	1st week	Closed	Min. internal	Good	14	110	Full	Plateau tilt >6°
11	37	Male	V	1st week	Closed	External only	Excellent	15	140	Full	Healed PTI
12	50	Male	VI	1st week	Open	Min. internal	Fair	21	120	Deficit >10°	Step-off >3°
13	38	Male	V	1st week	Closed	External only	Excellent	14	150	Full	Healed PTI
14	22	Male	V	1st week	Closed	External only	Excellent	12	150	Full	Healed PTI
15	46	Female	V	2nd week	Open	Min. internal	Good	20	110	Deficit <10°	Varus >5°
16	43	Male	V	1st week	Closed	External only	Excellent	13	140	Full	Healed PTI
17	38	Male	V	2nd week	Open	Min. internal	Excellent	15	120	Full	Healed PTI
18	41	Male	IV	1st week	Closed	External only	Excellent	12	140	Full	Healed PTI
19	35	Male	VI	1st week	Closed	External only	Excellent	13	150	Full	Healed PTI
20	26	Male	IV	1st week	Closed	External only	Excellent	12	140	Full	Healed PTI

Table (2): Radiological grading used in the study

Score	Valgus/varus deformity (Degrees)	Plateau tilting (Degrees)	Articular step-off (MM)	Condylar widening (MM)	Degeneration (Narrowing of joint space)
Excellent	<5	<5	None	<5	None
Good (Notlowing)	6 to 10	6 to 10	1 to 3	6 to 10	<50%
Fair (Not more	>10	>10	>3	>10	>50%



• Lysholm Questionnaire (Scale).

Limping (5 points)
Never = 5
Mild or periodically = 3
Strong and continuous = 0

Support (5 points)
No support = 5
Walking stick or crutches = 2
Impossible = 0

Restraining (15 points)
No restraining or restraining feeling = 15
Has the feeling, but no restraining = 10
Occasional restraining = 6
Frequent = 2
Joint restrained at examination = 0

Instability (25 points)
Never miss a step = 25
Seldom, during athletic activities or other strong-effort exercises = 20
Frequently during athletic activities or other strong-effort exercises (or unable to participate) = 15
Occasionally in daily activities = 10
Frequently in daily activities = 5
At each step = 0

Pain (25 points)
No pain = 25
Intermittent or mild during strong-effort exercises = 20
Marked during strong-effort exercises = 15
Marked during or after walking more than 2 Km = 10
Marked during or after walking less than 2 Km = 5
Continuous = 0

Swelling (10 points)
No swelling = 10
Upon strong-effort exercises = 6
Upon usual exercises = 2
Continuous = 0

Climbing stairs (10 points)
No problem = 10
Slightly damaged = 6
One step at a time = 2
Impossible = 0

Squatting (5 points)
No problem = 5
Slightly damaged = 4
Not exceeding 90 degrees = 2
Impossible = 0

Total score: _____

Figure (1): Lysholm scoring scale ***(Lysholm 1982) [10]***

Table (3) : Lysholm scoring scale in patients of the study

Lysholm scoring scale	No.	Percent
70-90 (excellent)	14	70 %
50-70 (good)	4	20 %
<50 (fair)	2	10 %

Table(4) : Type of reduction & fixation and follow up features of the study:

		n (%)
Time of fixation	1st week	14 (70.0)
	2nd week	6 (30.0)
Type of reduction	Closed	14 (70.0)
	Open	6 (30.0)
Type of fixation	External only	11 (55.0)
	With minimal internal	9 (45.0)
Follow up characteristics		
Pin tract infection	Controlled n (%)	20 (100.0)
Lysholm scoring	Excellent n (%)	14 (70.0)
	Good n (%)	4 (20.0)
	Fair n (%)	2 (10.0)
Range of motion	Excellent n (%)	13 (65.0)
	Good n (%)	6 (30.0)
	Fair n (%)	1 (5.0)

Figure (2): A 26-year-old man had sustained comminuted fracture of his left tibial plateau (Schatzker type VI, AO/ASIF type C1). (a, b) Preoperative radiograph. (c, d) Postoperative radiograph. (e, f) Radiograph after healing. (g, h) Patient after healing.

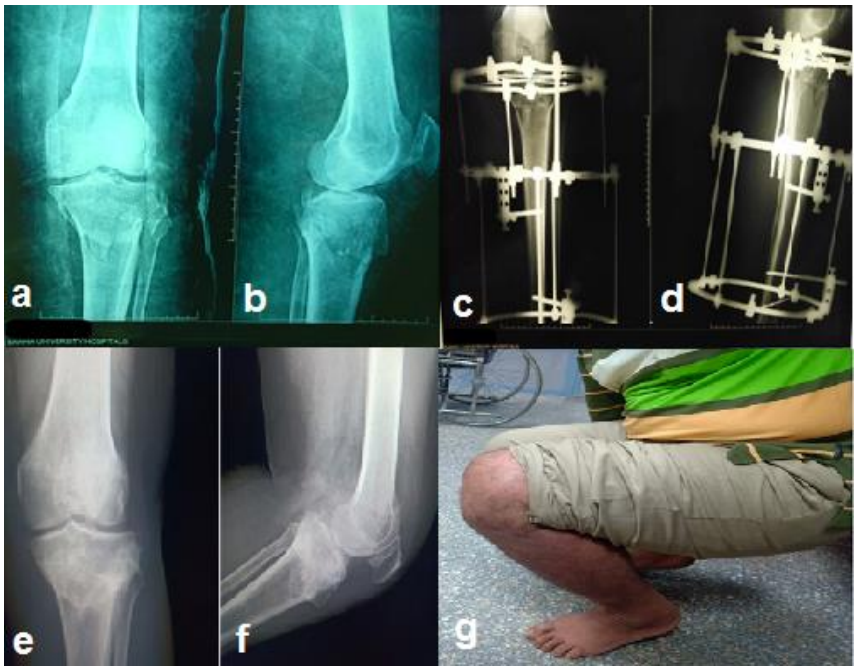


Figure (3): A male patient aged 50 years was admitted with an isolated closed left tibial plateau fracture (Schatzker type VI). (a, b) Preoperative radiograph. (c, d) Postoperative radiograph. (e, f) Radiograph. After healing. (g) Patient after healing.

Figure (4): A 55-year-old man had sustained comminuted fracture of his right tibial plateau (Schatzker type VI). (a, b) Preoperative radiograph. (c, d) Postoperative radiograph. (e, f) Radiograph after healing. (g, h) Patient after healing.

Discussion:

Fractures of the tibial plateau (Schatzker type V and VI) result of high energy trauma. Because of the nature of the trauma and the relative high frequency of soft tissue injuries, the rate of complications is high***.[11]*** The optimal treatment of Schatzker type V and VI tibial plateau fractures is a controversial and challenging. There is no specific and proven treatment protocol yet. Though open reduction and internal fixation of these fractures provides good fracture reduction and stability, several authors have reported high rates of complications-deep wound infection, unplanned secondary procedures, and even amputation. ***[12]*** Though superior to single lateral plate fixation, the dual plating technique is more damaging to the already compromised soft tissues in these high energy injuries and the wound infection rate with dual plating is as high as 20%. These problems prompted the development of Ilizarov ring fixation with or without minimal internal fixation as an alternative method for bicondylar fracture treatment. While the Ilizarov fixator seems a reasonable method of fixation of these fractures, there are few problems, including the inconvenience of an external fixator that requires careful maintenance, possibility of pin tract infections and subsequent collapse of the fracture fragments. However, it is useful in the treatment of open Schatzker type V and VI tibial plateau fractures, where the incidence of infection has been shown to be relatively high with plating. It may also allow early weight bearing with its attendant benefits. ***[12]*** The aim of this study was to evaluate the outcome of fixation of tibial plateau fractures Schatzker type IV, V and VI using Illizarov external fixator. This study was conducted on twenty patients with complex tibial plateau fracture (Schatzker type IV , V and VI), documented according to clinical or radiological examination.

Table (5): A comparison between our study results and similar studies.

Our study	Similar studies	
Age of patients doesn't influence time of union.	Lalić et al, 2014 **[13]** found that there was no affection of time of union by age or sex	El-Gazzar et al, 2014 **[14]** found no significant association between age of patient and time of union
Time of union was higher in patients with Schatzker type VI fractures compared to patients with fractures of Schatzker type IV & V	Mohamed and Youssef 2013**[15]** found that type of fracture affects time of union.	Lalić et al, 2014**[13]** found that there was no relation between type of fracture of the time of union
65% of our cases had excellent ROM, 30% had good ROM while 5% had fair ROMaccording to Thoresen score 1985 There was no statistical significant association between age and range of motion	Sheshgiri et al, 2016 **[11]** found that 55% had excellent outcome, 40% good, 5% fair and 5% poor outcome Lalić et al, 2014**[13]** found that there was no affection of (ROM) by age	Makhdoom et al, 2014 **[16]** found that 30% had excellent outcome, 40% good, 20% fair and 6.66% poor outcome El-Gazzar et al, 2014 **[14]** found no affection of ROM by age of patient.
There was a significant association between type of fixation and range of motion.	El-Gazzar et al, 2014 **[13]** found that, type of fixation can significantly affect the functional outcome(ROM)	Makhdoom et al, 2014**[16]** found no statistical significant association between type of fixation and ROM.
There was a significant association between time of fixation and range of motion.	El-Gazzar et al, 2014**[14]** proved fractures that fixed during the first 24 hours has good outcome (ROM) than that delayed after the first week	Sheshgiri et al, 2016**[11]** found that early fixation and ligamentotaxis improves outcome (ROM)
Pin tract infection as one episode at least was present in all of patients and all were treated with antibiotics.	Makhdoom et al, 2014 **[16]** found that pin tract infection was present in all patients.	Sheshgiri et al, 2016**[11]** found 25% of their patients complained of pin tract infection.

Conclusion:

The degree of soft tissue injury associated with tibial plateau fracture is an important determinant for both the choice of the treatment modality and the prediction of

treatment outcome. The use of Ilizarov external fixator with or without percutaneous cannulated screws is safe and effective option for the treatment of difficult Schatzker IV, V and VI tibial plateau fractures. It minimizes soft tissue complications and favor bony union with an acceptable return of function. The complications are mainly related to pin tract infection.

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