

ORIGINAL ARTICLE / ОРИГИНАЛНИ РАД

High-energy tibial plateau fractures treated with Ilizarov fixator

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**SUMMARY**

Introduction/Objective Tibial plateau fractures constitute a significant group of injuries to a major weight-bearing joint. High-energy fractures are difficult to treat, as they entail articular depression, condylar displacement, dissociation of comminuted metaphysis, and closed degloving injuries. The principles of the treatment are anatomical reconstruction of the articular surface, restoration of the anatomical axis, fixation spanning the metaphyseal comminution, and further minimization of soft tissue injury. The aim of this study is to evaluate the clinical outcome of using Ilizarov external fixator in the treatment of high-energy Schatzker IV, V, and VI tibial plateau fractures.

Methods This retrospective study was conducted from 2013–2016 on 35 patients (36 fractures) with high-energy tibial plateau fractures classified as Schatzker type IV, V, and VI. The mechanisms of injury were road traffic accident, fall from a height and direct trauma. The fractures were closed in 26 cases and open in 10 cases. All patients were treated with ligamentotaxis and percutaneous fixation using Ilizarov fixator. Functional outcome was determined using the Knee Society Score.

Results The mean follow-up period was 20 months. All fractures healed in an average time of 14 weeks. The range of knee flexion after one-year follow-up averaged at 100°. Average Knee Society Score in our study was 77.

Conclusion Ilizarov external fixation is a safe and efficient treatment modality for high-energy tibial plateau fractures. It allows reconstruction of the articular surface, stable fixation, early rehabilitation, and care of soft tissue injuries.

Keywords: Ilizarov method; tibial plateau; fracture

INTRODUCTION

Tibial plateau fractures constitute a significant group of major weight-bearing joint injuries and are often associated with functional impairment [1]. High-energy plateau fractures are difficult to treat, as they are followed by articular depression, condylar displacement, comminuted of metaphysis, and extensive soft tissue injuries. The outcome is usually poor with a high rate of complications that directly affect surgical treatment and long-term outcomes [2]. Complications include severe soft tissue coverage problems, lower extremity compartment syndrome, peroneal nerve and vascular injury, and eventual osteoarthritis of the knee. These accompanying complications directly influence surgical decision-making and prognosis [3].

The treatment principles are an anatomical reconstruction of the joint surface, spanning the metaphyseal comminution, restoration of the anatomical axis and further minimization of secondary insult to an already traumatized soft tissue envelope [4]. These goals can be achieved through various methods such as: internal fixation, bridge plating, and percutaneous screws with casting, external fixator with or without limited open and bone grafting or a combination of these methods [3].

Over the years, many treatment modalities have been proposed for these complex fractures

[2]. The most popular treatment option has been open reduction and internal fixation with double plating but research data showed that this method is associated with many complications that include joint stiffness, non-union, mal-union, skin defects, osteomyelitis, which could lead to amputation and even death [5]. The complication rate appeared to be as high as 50% in some studies and the rate of postoperative skin infection and osteomyelitis has been reported to be up to 33% [6]. In order to reduce the occurrence of these problems, closed reduction and percutaneous external fixation was proposed by Ilizarov [6, 7].

With an extensive contusion or soft-tissue injury, a joint-bridging external fixator is useful to provide a sufficient stability needed for soft tissue recovery. The concept of “spanning” the knee joint was introduced in the 1990s. This concept evolved as proponents of indirect fracture reduction and external fixation reported increased full recovery rates [6].

The aim of this study is to evaluate the clinical outcome of using Ilizarov external fixator in the treatment of high-energy Schatzker IV, V, and VI tibial plateau fractures.

METHODS

This retrospective study was conducted at the Banjica Institute for Orthopaedic Surgery on

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35 patients (36 fractures) with high-energy tibial plateau injuries classified as Schatzker type IV, V, and VI [8]. Patients were treated from 2013–2016 using Ilizarov external fixation method. Age ranged from 43 to 72 years with an average of 56 years, 16 patients were females and 19 were males. The mechanism of injury was a road traffic accident in 21 patients, a fall from a height in ten patients, and direct trauma in four patients. The right limb was affected in 19 and the left limb in 17 cases with one patient had bilateral Schatzker type IV fracture. The fractures were closed in 26 cases and open in 10 cases. The open fractures were Gustilo–Anderson type I in six cases and type II in four cases [9]. Eight out of 26 closed fractures had closed soft tissue injuries grade II according to the classification of Tscherne and Gotzen [10]. Eight fractures were Schatzker type IV, 13 cases Schatzker type V and 15 cases type VI (Table 1). Fracture classification was performed by the co-authors retrospectively based on preoperative radiographs.

Soft tissue condition had a crucial role in planning the time of the operation. All patients with open fractures ($n = 10$) were operated within two days after injury with Ilizarov technique after wound debridement, irrigation, and intravenous antibiotics (first generation cephalosporin and aminoglycoside); others were treated within an average period of five days after injury (range: three to nine days) in order to allow soft tissue oedema to subside.

The operation was performed under spinal or general anesthesia. Prophylactic first generation cephalosporin antibiotics were administered intravenously in all cases until third postoperative day. All operations were performed by the lead author. The fragments were reduced by ligamentotaxis, applying distraction force on a traction table. After satisfactory radiographic confirmation of reduction, axial and rotational alignment, counter opposed olive wires through the fragments were used to achieve interfragmentary compression. The number and direction of wires used on the fracture site was defined by fracture pattern and reduction stability. The wires were placed below joint surface to prevent synovial contact and to avoid septic arthritis. After the first ring was fixed to the proximal wires, it was then connected to two rings distally with four interconnecting rods. The middle ring was positioned just distal to any shaft fracture component. The distal ring was placed proximally and parallel to the ankle joint surface. Special care was taken to restore the mechanical axis in relationship to the condyles. Based on intraoperative assessment and surgeons experience in cases of extremely complex and unstable fractures ($n = 9$), frame was extended onto the distal femur with two levels of fixation. Thromboprophylaxis with low-molecular-weight heparin were carried out for three weeks or until femoral part of the frame was removed.

Postoperative care consisted of daily-performed thorough pin care, from the first postoperative day. Ankle equinus deformity was prevented by active joint mobilization. From the second postoperative day passive range of knee motion, isometric quadriceps exercises and hip raising exercises were began. All patients were allowed to bear weight as tolerated from the second postoperative day. The external fixator was removed once radiographic and clinical

Table 1. Preoperative parameters and surgery outcome.

Case	Age/ Sex	Injury	Type	Schatzker class.	Fixator time (weeks)		Knee ROM Flex./Ext.	Knee Society Score
					Tibia	Femur		
1	63♀	Fall	Closed	V	15		120/-15	78
2	71♂	Fall	Closed	VI	17	4	105/-5	84
3	63♀	TA	Closed	V	14		110/-15	76
4	55♀	TA	Open	IV	15		80/0	87
5	49♂	TA	Open	VI	14		85/-5	74
6	62♂	TA	Closed	VI	14	4	120/-15	83
7	54♀	Fall	Open	V	12		130/-10	91
8	43♀	TA	Closed	IV	15		80/-15	68
9	53♂	TA	Closed	V	13		115/-15	87
10	43♂	TA	Open	VI	18	5	95/-15	61
11	60♀	Fall	Open	VI	16	4	85/-10	65
12	63♂	TA	Closed	V	14		85/-15	64
13	62♀	TA	Closed	VI	13		85/-10	69
14	44♂	DT	Open	V	16		130/-15	82
15	60♂	Fall	Closed	IV	12		100/-10	86
16	44♀	TA	Closed	VI	12		105/-5	81
17	53♂	TA	Closed	VI	16	4	100/-10	77
18	57♀	DT	Closed	V	14		80/-15	69
19	61♀	TA	Open	VI	18		125/0	88
20	61♂	TA	Closed	IV	12		115/-5	83
21	55♂	TA	Open	V	16	4	80/-10	57
22	46♂	TA	Closed	V	13		120/-10	85
23	54♀	TA	Closed	VI	13		115/-5	84
24	50♀	DT	Open	V	17		115/-15	78
25	51♂	Fall	Closed	IV	13		120/0	90
26	65♂	TA	Closed	VI	12		85/-10	67
27	57♂	TA	Closed	VI	14		105/-5	79
28	49♂	TA	Closed	V	15		80/-10	72
29	63♀	Fall	Closed	V	16		80/-15	70
30	56♂	DT	Open	VI	17	5	80/-15	66
31	59♀	Fall	Closed	VI	13		80/0	71
32	43♀	TA	Closed	V	13		125/0	89
33	47♂	TA	Closed	IV	14		130/-15	85
34	63♂	Fall	Closed	VI	15		100/-5	76
35	72♀	Fall	Closed	IV	16	6	120/0	84
			Closed	IV	16	6	120/0	

DT – direct trauma; TA – traffic accident; ROM – range of motion

evidence of union were established. Clinically, healing was defined as the ability to bear full weight without pain. Physiotherapy was continued after removal of the fixator to improve range of knee motion. Functional outcome was determined using the knee society score (KSS) [11]. For data description, we use measure of central tendency (arithmetic mean) and measures of variability (minimum and maximum value). This study was done in accord with standards of the institutional Committee on Ethics.

RESULTS

The mean follow-up period was 20 months (ranging from 16 to 28). All patients were monitored by the lead author. The mean interval between injury and surgery was four

(range: 1–9) days. All fractures united in an average time of 14 (range: 12–18 weeks). Patients did not require blood transfusion, nor had any nonunion, septic arthritis, myositis ossificans, pulmonary embolism, deep venous thrombosis, soft tissue necrosis, or peroneal nerve palsy.

After removal of the frame, an extension lag was a common finding. It was observed in 19 cases, most of them improved with physiotherapy with mean lack of extension of 10° (range: 0–15°) after 1 year (Table 1). In nine cases, there were extremely complex and unstable fractures with extensive soft tissue injury. Therefore, knee was spanned using additional femoral ring as frame extension. The femoral frame was removed in average 5 weeks postoperatively (range: 4–6 weeks), and then patients were encouraged to fully bear weight (Table 1).

The range of knee flexion after one-year follow-up averaged at 100° (range: 80–130°) (Table 1). Four patients had a positive anterior drawer test, but they did not show functional instability. There were no cases of mediolateral instability. Complications included pin tract infection in five cases; all were improved with local treatment and a short course of systemic antibiotics. Malunion was established on standing radiographs in the form of varus deformity 10° in two cases and valgus deformity 10° in two cases. All the patients were allowed to go back to work and their daily activities within five months of their injury and were able to carry out their job requirements and daily activities as before. According to the KSS, the results were evaluated as excellent in 16 patients, good in ten patients, fair in eight patient, and poor in one. Average KSS in our study was 77 (Table 1).

DISCUSSION

Tibial plateau fractures, caused by high-energy trauma, inflict extensive damage to the bone and additional injury to the soft tissue. Early problems in treatment include fracture instability and inability to adequately reduce and fixate the bone fragments [12].

An open wound is present in one third of the Schatzker type-IV, V, and VI fractures that correspond to our sample in which open fractures occurred in 29% of patients. Careful management of the soft-tissue injury is crucial and the use of the Ilizarov method allows its undisturbed healing [13]. Patients with closed and open fractures were analyzed in a same sample group. The reason for this is that the objective was not to compare these two types in terms of treatment methods and outcomes, which is one of the drawbacks of the study.

The presence of fracture blisters or extensive subcutaneous hemorrhage and bruising does not limit the placement of the percutaneous wires that avoids additional devitalization of the bone since the periosteal and endosteal blood supply are not damaged any further. Small tensioned wires allow capture of small bone fragments with olives that compress the condylar fractures in the same way lag screws would. Maintenance of the desired mechanical axis can be continually monitored by frame adjustment [6].

In our study, the fractures were most common for patients in their fifties, with an average of 56 years. The other series show a higher incidence of fractures in younger age groups [14]. The most common cause of proximal tibia fractures in our study was traffic accident (TA). This corresponds to the study of Ngim et al. [15] who described 60% of patients with fractures of the tibia following road traffic accidents. In our case, fracture union time was 14 weeks in average (range: 12–18 weeks). Other studies also show similar healing time [16].

Ilizarov circular fixation allows both early movement and early weight bearing. The value of early movement has been well established but early loading of fractures of the tibial plateau has generally been avoided because of the concern that the reduction may be lost, resulting in depression of the articular surface [6]. Studies show that early weight bearing, however, stimulates bone healing, increases the formation of new woven bone, and allows retention of muscular strength [17]. In our study, partial weight bearing was allowed from second postoperative day, while full weight bearing was allowed at four weeks.

The mean range of motion (ROM) reported by Guadinez et al. [18] was 85° and by Morandi and Pearse [13] was 113°. All patients reported by Zecher et al. [19] achieved at least 90°. The average knee ROM in our study was 100° of flexion and lack of extension was 10°, which is in the spectrum of other studies.

Opponents of this technique may argue that congruous reduction can only be confirmed by open reduction, but even with open reduction, one requires imaging to confirm congruous reduction. Internal fixation of these highly complex injuries has led to some disastrous results. Moore [20] reported that 23% of cases treated with open reduction with internal fixation (ORIF) became infected. The rate of infection with ORIF in other studies ranged from 30% to 40% [12]. Pearse and Morandi [13] reported an advantage of external fixation of complex tibial plateau fractures with decreasing rates of complications.

In our case, we saw that the average optimal femoral fixation time for the intra-articular fractures to form soft callus and soft tissues to complete healing was five weeks. Spanning the knee with the external fixator also allows adequate initial weight bearing (Figure 1, 2).

When applying the KSS, the average knee score in our study was 77. The observed results were 16 (46%) excellent, 10 (28%) good, eight (23%) fair, and one (3%) poor. Our findings were similar to the results of Mikulak et al. [21], who reported a mean score of 78.5, and Kumar and Whittle [22], who described a mean KSS of 83.

Complications included pin tract infection in five cases; all were successfully cured with local treatment and a short period of systemic antibiotics. Four patients had axial deformities established on standing radiographs in the form of varus deviation of 10° in two cases, valgus deviation of 10° in two cases. However all the patients were allowed to go back to work within five months of their injury and were able to perform their job requirements and daily activities as before the injuries. Limitation of this study is the relatively short follow up period to make assessment about

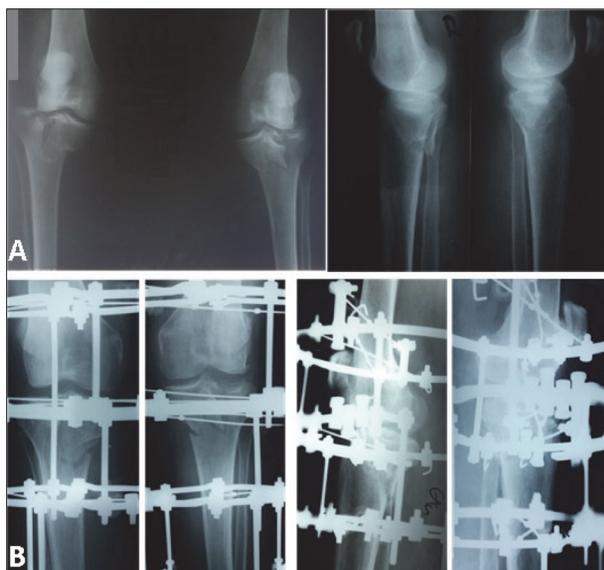


Figure 1. A – Radiographs of closed bilateral Schatzker IV type fracture in a 72 year old female patient; B – postoperative radiographs after fracture reduction and fixation using Ilizarov external fixator with femoral frame extension

degenerative arthritis as one of the late complications after tibial plateau injury. The other limitation is reliance on radiographs alone in lack of much superior computerized tomography imaging.

CONCLUSION

Ilizarov external fixation is a safe and efficient treatment modality for high-energy tibial plateau fractures. It provides reconstruction of the articular surface, stable fixation

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Figure 2. Same patient two years after surgery; postoperative radiological and functional outcome

of fracture fragments, early rehabilitation of the joint, and care of associated soft tissue injuries.

The functional outcomes of this treatment method are more predictable with the high rate of union. Decreased incidence of soft tissue complications, early range of motion, early weight bearing, and good functional recovery all compare favorably with other reported results and serve as recommendation that Ilizarov external fixator should be the treatment of choice for such injuries.

Conflict of interest: None declared.

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Високоенергетски преломи тибјалног платоа лечени фиксатором по Илизарову

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САЖЕТАК

Увод/Циљ Преломи платоа тибјје представљају значајну групу повреда једног од главних носећих зглобова. Високоенергетски преломи су захтевни и тешки за лечење услед артикуларне депресије, размицања кондила, коминуције метафизног региона, као и оштећења мекоткивног покривача. Циљеви лечења су анатомска реконструкција зглобне површине, успостављање анатомске осовине ноге, стабилна фиксација фрагмената и што мање додатно оштећење меких ткива.

Циљ овог рада је процена успешности лечења применом фиксатора по Илизарову код високоенергетских прелома тибјалног платоа који обухватају тип IV, V и VI класификације по Шацкеру.

Методe Ретроспективно су у периоду 2013–2016. године анализирани подаци о 35 болесника (36 прелома) са високоенергетским преломима платоа тибјје класификованим као Шацкеров тип IV, V и IV. Механизам повређивања обухватао

је саобраћајне несреће, пад са висине и директну трауму. Затворени преломи констатовани су у 26 случајева, док је отворене имало 10 болесника. Сви преломи су репонирани принципима лигаментотаксе и фиксирани перкутано апаратом по Илизарову. Функционални опоравак болесника праћен је коришћењем резултата Удружења за колено.

Резултати Просечан период праћења износио је 20 месеци. Сви преломи су зарасли у просеку за 14 недеља после ношења апарата по Илизарову. Средња вредност флексије у колелу после годину дана праћења износила је 100°. Просечан резултат Удружења за колено био је 77.

Закључак Апарат по Илизарову представља безбедан и ефикасан начин лечења високоенергетских прелома платоа тибјје. Њиме се постижу реконструкција зглоба, стабилна фиксација уз минимално оштећење меких ткива и спровођење ране рехабилитације.

Кључне речи: Илизаровљева метода; плато тибјје; прелом