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Ilizarov Fixator Technique in Type V and VI Tibial Plateau Fractures: A Case Series

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Abstract

Background: Type V and VI tibial plateau fractures are severe fractures that can compromise knee structure and function.
Objectives: We discuss the therapeutic results of external fixator (Ilizarov) for these fractures.
Methods: In this study, 44 patients with high-energy type V and VI tibial plateau fractures treated with Ilizarov external fixator were enrolled. The considered variables were age, sex, fracture type, open or close fracture, soft tissue damage, subjective knee score, knee society score (KSS), and functional knee score (FKS). The obtained data were analyzed using SPSS, version 21.
Results: Thirty-four (77.28%) male and 10 (22.72) female patients with the total mean age of 36.38 years were included. Seventeen (38.63%) patients had open fractures, 38.63% of which were type V and 61.36% were type VI. Complete union was achieved in all the patients (mean union time of 16.95 weeks). Three patients had a flexion limit of up to 10 degrees, and in one patient, extension was limited to 5 degrees. Although pin-site infection was detected in 47.72% of the patients, no cases of osteomyelitis or septic arthritis were encountered. Based on the functional outcomes at the last follow-up, 86.36%, 9.09%, and 4.54% were excellent, good, and fair, respectively.
Conclusions: Based on our findings, Ilizarov technique can be used for the treatment of type V and VI tibial plateau fractures as an effective method with low complications.

Keywords: Ilizarov, External Fixation, Plateau Fracture

1. Background

High-energy fractures in the tibial plateau result in complicated damages, especially in soft tissues (1, 2). Tibial plateau fractures consist of 1% - 2% of fractures in adult patients and about 8% of those in elderlies (2, 3). The annual incidence of these fractures is reported as 10.3 per 100000 people (4). These fractures have different classifications, the most common of which is the Schatzker classification, based on which tibial plateau fractures are divided into six types as follows (5):

- type I: Lateral plateau fracture without depression
- type II: Lateral plateau fracture with depression
- type III: Compression fracture of the lateral (type IIIA) or central (type IIIB) plateau
- type IV: Medial plateau fracture
- type V: Bicondylar plateau fracture
- type VI: Plateau fracture with diaphyseal discontinuity

Types V and VI of the Schatzker classification are more severe and can threaten knee structure and function (2). Reaching a complete union, achieving perfect reconstruction of the damaged joint, and returning to the natural mobility of the joint are challenging issues in proximal tibial fractures (6). The amount of bone crushing, joint damage, and most importantly, the degree of soft tissue damage should be noted in the treatment of tibial plateau fractures (7).

Currently, some common therapeutic methods include dual column plating, assisted reduction, internal fixation with plating, and Ilizarov circular fixator (2). Each of these methods has certain disadvantages and advantages that should be considered by the surgeon. With severe crushing and soft tissue damage, external fixators provide excellent results (7). Ilizarov is an external fixator for the appropriate treatment of soft tissue damage, especially ligament damage (1). Peri-articular proximal tibia fractures (bumpering), bicondylar plateau fractures (type V), and tibial plateau fractures with diaphyseal discontinuity (type VI), which are associated with high levels of

soft tissue damage, are the most important uses of Ilizarov (7). Ilizarov technique has been successful even in patients with relatively severe osteoporosis (7).

2. Objectives

This study reports our experience about the management of type V and VI tibial plateau fractures by Ilizarov in a teaching hospital.

3. Methods

3.1. Study Protocol

In this longitudinal case-series study, patients with tibial plateau fractures treated by Ilizarov external fixator in our orthopedic clinic from 2012 to 2015 were enrolled. Their medical records were evaluated and different variables including age, sex, fracture type, open or close fracture, soft tissue damage, subjective knee score, knee society score (KSS), and functional knee score (FKS) were extracted. Fracture type based on the Schatzker classification, open or close fracture, and level of damage to soft and neurovascular tissues were also recorded. Then, patients who had complete records and completed follow-up (two weeks after surgery, then each month until the occurrence of full union and Ilizarov's removal) were called to attend the orthopedic clinic for the assessment of the final surgical results. The inclusion criteria comprised type V and VI Schatzker tibial plateau fractures with intraarticular extension occurring less than four weeks after injury, grade 1 and 2 open and close fractures, and age 18 - 60 years.

The exclusion criteria were pathological fractures, old neglected fractures, grade III open fractures, previously operated fractures, fractures associated with compartment syndrome or vascular injury, local or systemic neurological problems affecting the results of performance evaluation, fractures associated with ipsilateral neuromuscular defects, fractures associated with knee joint dislocation, any previous pathologic injury or fracture around the knee joint, and any surgical history around the knee joint.

Mean follow-up period was 45.68 months (range: 24 - 61 months). After the patients attended the clinic, SKS, KSS and FKS variables were evaluated in all the patients, and finally, 44 patients were included (24% of samples were excluded).

All the patients were operated by the first author (orthopedist). This study was approved by the Ethics Committee of the university, patients signed a consent form, and they were assured their personal information will remain confidential.

3.2. Surgical Techniques

The patient was placed in a supine position and underwent general anesthesia. In all the patients, minimal soft tissue manipulations, especially at the joint surface, were performed to reduce the fracture. These manipulations included fluoroscopy, arthroscopy, mini-open incision, and adding two or three screws for anatomical maintenance of the joint surface. Then, a suitable Ilizarove ring with an appropriate diameter based on the diameters of the knee and leg was used, and the distal rings were attached to the proximal ring with three special rods. Also, at least three olive pins in two levels were used in the tibial plateau. In the distal part of the fracture site, at least two Ilizarov rings, sometimes as hybrids connected to a 5-mm Schanz, were used.

3.3. Postoperative Advices and Rehabilitation Protocol

According to the treatment protocol, all the patients were trained on how to take care of the Ilizarov rings and wire and disinfect around the pin site (once a day) by disinfectant solutions such as betadine and alcohol. For knee mobilization, the patients were asked to stand with support 48 hours postoperatively, and physiotherapy was administered two weeks after surgery in the absence of pain under close supervision. Furthermore, all the patients were allowed partial weight-bearing immediately after surgery and full weight-bearing according to improvement in clinical and radiological outcomes. After union and removing Ilizarov, patellar tendon bearing orthosis brace was used for one month.

3.4. Statistical Analysis

After data collection, SPSS version 21 was used for statistical analysis. For describing data, frequency, percentage frequency and descriptive tables were used.

To analyze the data, Chi-square test was run to determine the relationship between the variables' ratio, Fisher's exact test was used for qualitative variables, and the Post Hoc test was used to compare the qualitative variables if the chi-square test was not valid. Independent *t*-test was run to determine the relationship between two variables, and one-way ANOVA test was performed to determine the relationship between the mean scores of more than two variables and plotting differences of means. P value less than 0.05 was considered significant.

4. Results

Of the 44 evaluated patients, 34 (77.27%) were male and 10 (22.72%) were female. The mean age of the patients was 36.38 $\pm$ 8.99 years and the mean follow-up time was 45 $\pm$ 9.58 months (range: 24 - 61 months). The most involved age group was 30 - 39 years old and the lowest involved age group was 50 - 59 years old. Seventeen (38.63%) patients

had open fracture and 27 (61.36%) patients had closed fractures. According to Schatzker classification, 17 (38.63%) patients had type V and 27 (61.36%) patients had type VI fractures. Also, based on Tscherne classification (8, 9), most patients (86.36%) had grade II soft tissue damage. Demographic characteristics and the results and complications of treatment with Ilizarov external fixator are shown in Tables 1 and 2 and Figures 1 and 2.

Table 1. Patients' General Characteristics

Variables	No. of Patients	% of Patients
Gender		
Male	34	77.27
Female	10	22.72
Diagnosis		
Open	17	38.63
Close	27	61.36
Type of fracture (Schatzker classification)		
V	17	38.63
VI	27	61.36
Soft tissue injury (Oestern and Tscherne)		
Grade 0	2	4.54
Grade 1	4	9.09
Grade 2	38	86.36

Table 2. Complications

Complications	Six Months After Surgery		Last Follow-Up	
	No.	%	No.	%
Superficial infection	21	47.72	-	-
Deep infection	-	-	-	-
Compartment syndrome	-	-	-	-
Deep vein thrombosis	-	-	-	-
Chronic regional pain syndrome	-	-	-	-
Secondary dislocation	-	-	-	-
Varus deformity	1 (10 <)	2.27	1 (10 <)	2.27
Limb length discrepancy	-	-	-	-

Complete union was achieved in all the patients. The duration of complete union was 16.95 $\pm$ 3.72 weeks (range 12 - 24 weeks). The superficial infection of the pin site occurred in 21 (47.72 %) patients, and in 10 (22.72%) cases, the infection occurred more than once, which was improved with the oral administration of antibiotics. No cases of osteomyelitis or septic arthritis and no cases of compartment syndrome were reported (Table 2).

In this study, limb length discrepancy of less than 10 mm was ignored; thus, we did not have any cases of limb shortening. In the final follow-up, there was only one case of varus deformity greater than 10 degrees Tables 1 and 2. Subjective knee score, KSS, and FKS were also evaluated six months after surgery and at the last follow-up. These results are fully shown in Table 3.

Range of motion was also evaluated in all the patients. In our study, the mean range of motion in the patients in the final fallopian was 134.31 $\pm$ 2.31 degrees (range: 0 - 125 to 135 - 1 degrees). In three patients, the flexion limit of 5 to 10 degrees was detected. Also, a patient had an extension limit of about 5 degrees that was due to the malunion of fracture site

5. Discussion

Tibial plateau fractures are often associated with serious complications. Damages of the articular surface and metaphysical region, soft tissue lesions, infection, and the risk of compartment syndrome are challenging factors in the management of fractures of the proximal tibial region (10). On the other hand, high-energy trauma with soft tissue damage increases the likelihood of infection. Accordingly, soft tissue management in these fractures is very important. Moreover, surgery at inappropriate times can increase injuries, complications, and failure of treatment (2). Open reduction and internal fixation techniques have been successful in the reconstruction of tibial plateau fractures. However, in most cases, surgical complications such as soft tissue infection and wound necrosis have been reported. For this reason, several researchers have proposed minimally invasive methods for fracture reconstruction by Ilizarov external fixator as an alternative method (6).

In this study, 44 patients with tibial plateau fractures treated by Ilizarov method were evaluated. The main studied variables were union, infection, range of motion, and knee function status.

Nonunion is a serious complication, especially in open and comminuted fractures, and has been studied as a major factor in the efficacy of the therapeutic approach in several studies. In our study, the mean time of complete union was 16.95 weeks. In a study performed by Ramos et al. on 30 patients with proximal tibial fractures treated by Ilizarov, 100% of patients achieved complete union (11). Keightley et al. (12), Lalic et al. (13), and Debnath et al. (1) also reported complete union in 100% of patients in their studies that used Ilizarov external fixator for the treatment of tibial plateau fractures. Tibial plateau fracture is located in

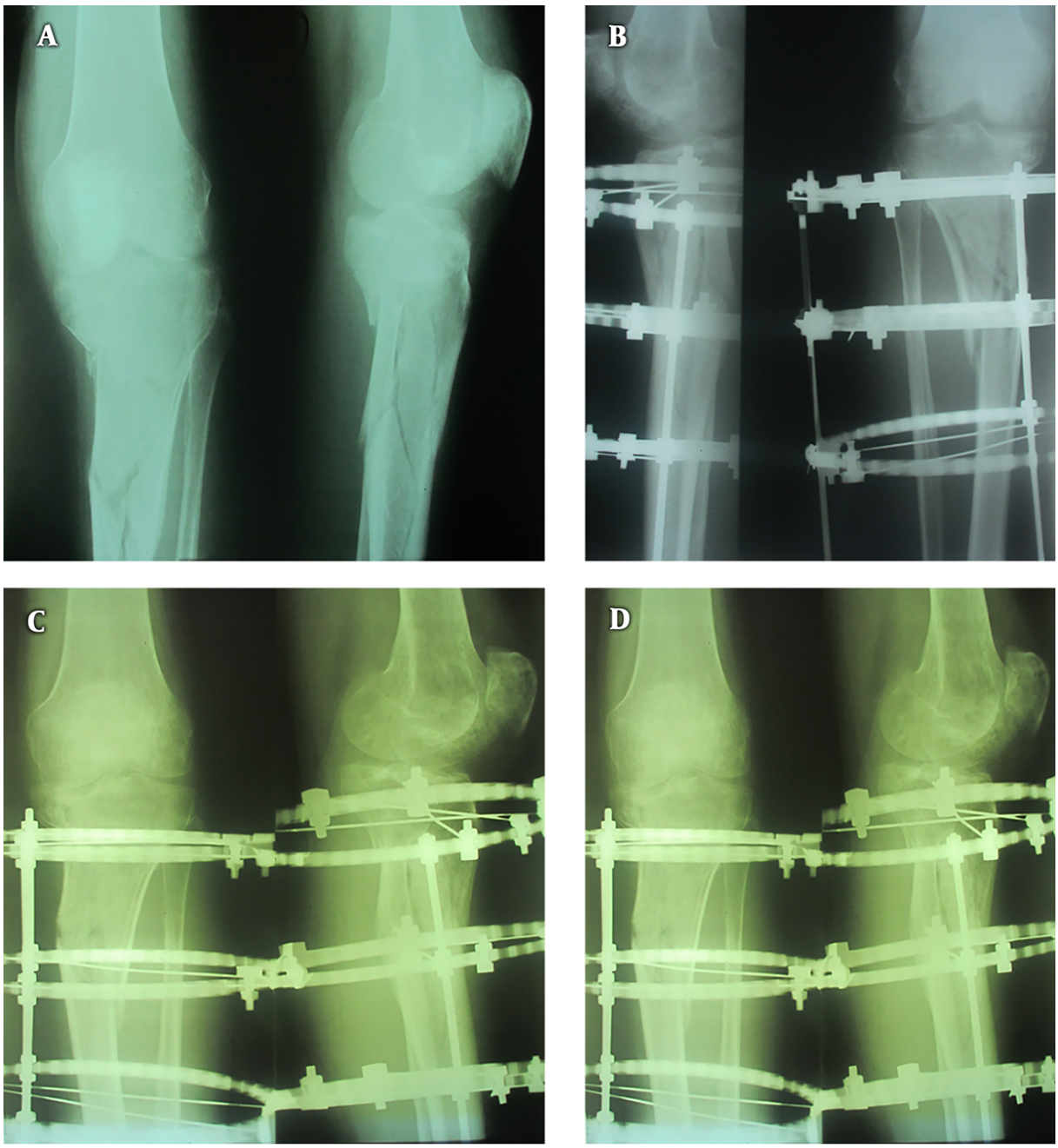

Figure 1. A 34-year-old man with type VI tibial plateau fracture with extension to the tibial shaft (Patient No. 4). A, before surgery; B, 1.5 months after surgery; C, 4 months after surgery; D, 5 months after surgery (complete union)

the high blood supply region of metaphyseal bone; thus, the high level of unions and the lack of non-union in these fractures are expected. However, in a study by Gross et al., who examined 40 patients with tibial plateau fractures treated by external hybrid fixator, 80% of patients achieved complete union (3).

Regarding complete union, our results were comparable to previous studies, and as expected, complete union was achieved in all the patients averagely after four months (1, 12, 13).

We full flexed and full extended the patients' knees after fixation and did not see any motions at the fracture

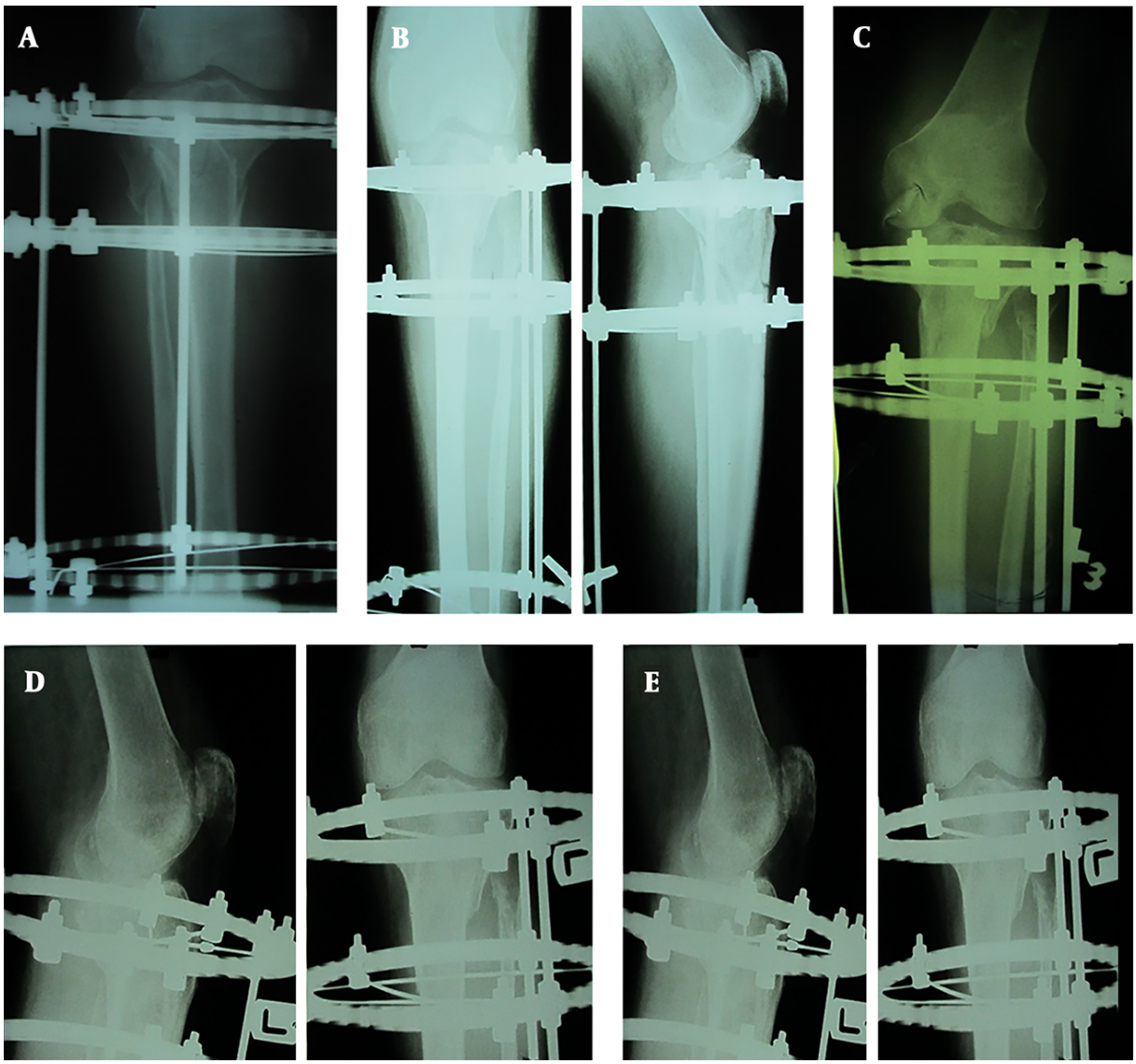

Figure 2. A 41-year-old man with type V tibial plateau fracture with extension to tibial shaft (Patient No. 12). A, one month after surgery; B, two months after surgery; C, three months after surgery; D, four months after surgery; E, six months after surgery (complete union)

site. Rigid fixation could be one of the reasons for obtaining a complete union in this study. Although instability is one of the major complications of proximal tibial fractures (10), Ilizarov external fixator is stable enough to allow early movement and early weight-bearing (1). In our study, despite rigid fixation, all the patients were allowed early weight bearing. Thus, early weight bearing may be considered as one of the other reasons for obtaining a complete union in our patients.

In this study, all fractures had occurred due to high-energy trauma. Unfortunately, regardless of the type of treatment, high-energy traumas with soft tissue damage have high rates of complications. Also, the incidence of infections and wound complications is more common when internal fixators are used because of the need for larger incisions and more soft tissue manipulations (14). These complications are created especially in open and complex fractures and in the lower extremities. In these conditions, the use of external fixator is reasonable. In most cases, the use of an external fixator is associated with minimum soft tissue manipulation and less damage to the blood vessels of the affected area (15), which increase the union chance.

Furthermore, in our study, there was no limb shortening of greater than 1 cm and there was only one case of

Table 3. Outcome Analysis

Grading	Subjective Outcome		Clinical Outcome		Functional Outcome		Radiological Outcome	
	N	%	N	%	N	%	N	%
Six months after surgery								
Excellent (80 - 100)	35	79.54	36	81.81	36	81.81	38	86.36
Good (70 - 79)	6	13.63	4	9.09	5	11.36	5	11.36
Fair (60 - 69)	3	6.81	4	9.09	3	6.81	1	2.27
Poor (< 60)	-	-	-	-	-	-	-	-
Last follow-up								
Excellent (80 - 100)	37	84.09	36	81.81	38	86.36	39	88.63
Good (70 - 79)	5	11.36	5	11.36	4	9.09	4	9.09
Fair (60 - 69)	2	4.54	3	6.81	2	4.54	1	2.27
Poor (< 60)	-	-	-	-	-	-	-	-

varus deformity of more than 10 degrees. One of the reasons for this deformity can be the severe crush and open type VI fractures, which have been malunioned. The use of C-arm in surgery can be helpful to prevent malunion.

In spite of suitable union, reduced range of motion is one of the most important complications of the Ilizarov fixator. In this study, flexion limit of 5 - 10 degrees in three patients and a 5-degree extension limit in one patient were detected, and the mean range of motion at final follow-up was 134.31 degrees (range: 125 to 135 degrees). All these four patients were those who did not pass the rehabilitation steps regularly, and the rate of complications might have been reduced if they followed the rehabilitation process. However, the results of range of motion in our study were higher than those reported in most previous studies (11, 12, 16).

Because of the risk of infection spreading and occurrence of deep infection, one of the most important issues when using an external fixator is pin care and control and treatment of pin infection. To prevent deep infection, it is recommended not to place the pins in the bulky muscle tissue behind the legs, unless when no other location is available for pin insertion (15). Although superficial pin-tract infections were observed in almost half of the patients of this study, no cases of deep infection were reported.

The incidence of infection in patients with proximal tibial fracture was also evaluated in other studies. In these studies, when using Ilizarov, the incidence of pin-site infection was 53.3% (11) and 73.3% (12) and the incidence of superficial pin-tract infection was 6.6% (11) and 0.95% (12). Using external hybrid fixators, superficial infection in 40% and deep infection in 2.5% of patients were observed (3), and when using dual plates, superficial infection in 16.67% (2) and 13.63% (17) and deep infection in 3.33% (2) and 4.54% (17) of patients were seen.

Despite superficial infection in approximately half of the patients, no deep infection, osteomyelitis, septic arthrosis, or other surgical complications such as compartment syndrome, secondary dislocation, deep vein thrombosis, and chronic regional pain syndrome were reported. However, in other studies, compartment syndrome, secondary dislocation, deep vein thrombosis, lateral popliteal nerve palsy, chronic regional pain syndrome, quadricepsplasty, compartment syndrome, deep vein thrombosis (12), transitory peroneal nerve lesions and deep vein thrombosis (13) were reported.

Care and hygiene of the pin site, appropriate antibiotic therapy, avoiding pin placement in soft tissues if possible, and avoiding high manipulation of fracture site, especially soft tissue manipulation, can be considered as the reasons that reduce the incidence of infection and other complications of surgery. We followed these conditions as much as possible in the treatment of patients.

Totally, outcome analysis was excellent in over 95% of our patients, which can be due to the absence of deep infection, complete union over a reasonable time, and an acceptable range of motion achieved in all the patients.

Our results showed that Ilizarov external fixator is very successful in treating tibial plateau fractures. The most important causes of this success are the use of rigid fixation, early weight-bearing, and the lack of manipulation and soft tissue damage when using this technique. Despite acceptable results, the biggest problems with the use of an external fixator are its prolonged duration of use and induced limitation in activity. Certainly, limitation of daily activities is one of the most important problems when using this technique, which can impose a psychological burden on the patient. Elsoe and Larsen expressed that the Eq5D-5L score in patients treated with a circular fixator was lower than the normal population. Eq5D-5L is a standard and valid tool for evaluating health outcomes and includes five dimensions including mobility, self-care, routine activ-

ities, pain/discomfort, and anxiety/depression (10).

Since we had no tests to assess the mental and psychological conditions of patients in our study, it was impossible to accurately measure the psychological and mental effects of treatment of tibial plateau fractures by Ilizarov. This is one of the limitations of the current study due to the retrospective nature of this study and the absence of psychological tests in our patient medical records. The retrospective nature and case-series design are the other limitations of the present study. Perhaps a prospective study with a control group that includes other methods, more patients, a longer follow-up time, and study of mental and psychological conditions of patients can yield efficient and more acceptable results.

5.1. Conclusion

Ilizarov fixator technique can be used as an effective and accessible method with low complications for the treatment of type V and VI tibial plateau fractures based on the Schatzker classification.

Footnotes

Conflict of Interests: None declared.

Ethical Considerations: This study was approved by the Ethics Committee of university, patients signed a consent form, and they were ensured their personal information will remain confidential.

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