

# TREATMENT OF COMPLEX TIBIAL PLATEAU FRACTURES USING ILIZAROV TECHNIQUE

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**SUMMARY** – Complex tibial plateau fractures are most commonly caused by high-energy trauma and they are often associated with severe soft tissue injuries that can frequently result in severe complications. Ilizarov external circular fixation is an ideal method of treatment for high-energy fractures of the tibial plateau when extensive soft tissue dissection and internal fixation are contraindicated. Our research included 50 consecutive patients and clinical features of the patients were evaluated during the follow up period using the following instruments: Gustillo-Anderson, Schatzker and Arbeitsgemeinschaft für Osteosynthesefragen/Orthopaedic Trauma Association (AO/OTA) classification methods. Bony results were evaluated using the Association of the Study and Application of the Method of Ilizarov (ASAMI) protocol. The mean functional recovery scores were obtained by the modified functional evaluation system of Karlstrom-Olerud. All fractures healed successfully. Circular fixators could be removed without anesthesia for type IV fractures at 16 weeks (range 12-21) and for type V-VI at 18 weeks (range 15-26) after the operation. According to ASAMI bone results, there were 39 (78%) excellent, 7 (14%) good, 3 (6%) fair results and 1 (2%) poor result. Analysis of data obtained by the Karlstrom-Olerud functional evaluation system in this study yielded a mean value of 24.7 after six months, which implies recovery. Functional recovery at 12 months after surgery revealed satisfactory recovery with a mean value of 27.7, whereas the mean score of 29.8 recorded at the last evaluation suggested good functional status. The treatment of patients with open and closed multiple intra-articular fractures of proximal tibia applying Ilizarov apparatus showed good functional outcome, which had positive impact on our patients' quality of life.

*Key words: Tibial fractures – surgery; Ilizarov technique; Treatment outcome*

## Introduction

Multiple intra-articular fractures of proximal tibia, which result from traumatic events and experiences in modern times, represent a serious problem for both the patient and the orthopedic surgeon. These injuries are severe because many of them lead to major defects of the soft and bone tissues and ligamentous apparatus

of the knee joint. Typical clinical presentation includes swelling, pain, reduced motion of the knee joint, as well as deformities of the proximal tibia. Establishing appropriate indication for adequate treatment modality is the crucial moment in managing these patients. Surgeon's responsibility involves precise classification of the injury and selection of an adequate method for management of the trauma<sup>1-5</sup>. Literature data specify a number of diverse classifications<sup>6-8</sup>. The majority of them take into account the status, that is, comminution of the articular surface; however, none of these classifications implies and fully describes all types of fractures.

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The methods of external fixation are a potential therapeutic option in orthopedic treatment of open and closed intra-articular fractures of proximal tibia. The goals of surgical treatment of such fractures are prevention of infection, improvement of healing process and recovery of function of the injured limb<sup>9,10</sup>. In dislocated multiple intra-articular fractures in which normal anatomical positioning of fragment cannot be accomplished by other treatment modalities, the application of transosseous osteosynthesis with Ilizarov apparatus is the method of choice due to its numerous advantages over other methods<sup>11-13</sup>. According to literature data, the application of Ilizarov apparatus-method in surgical treatment of intra-articular fractures of proximal tibia provides optimal conditions for the formation of bony tissue along with re-establishment of the anatomical structure and function of the limbs. This is accomplished by placing pins through the bone, their fixation to the ring-frame and subsequent connecting using adequate threaded rods<sup>13</sup>. Current initiatives and developments in orthopedic surgery and traumatology strongly advocate techniques associated with minimal trauma and maximal functional recovery of patients. The aim of this study was to assess functional abilities of patients with open and closed intra-articular fractures of proximal tibia (Gustillo Anderson I-III; Schatzker IV, V, VI) treated by Ilizarov technique, as well as to identify factors contributing to better functional recovery during 18-month follow up period.

## Patients and Methods

This research aimed at evaluating functional outcome of the treatment of multiple intra-articular fractures of proximal tibia applying Ilizarov apparatus, as well as at identifying factors contributing to better functional recovery. The study was conducted at the University Department of Orthopedic Surgery and Traumatology, Clinical Center of Vojvodina in Novi Sad, Serbia. The research was designed as a prospective study carried out in the period from January 2007 to December 2013. The study encompassed patients with multiple intra-articular fractures of proximal tibia, who underwent surgical treatment with the Ilizarov apparatus. Inclusion criteria were age over 18 years and diagnosis of open or closed fracture of

proximal tibia, Schatzker classification IV, V and VI. Exclusion criteria were age under 18 years; diagnosis of open or closed fracture of the tibia plateau, Schatzker classification I-III; fracture of tibia treated: ORIF, intramedullary nails, screws, rigid external fixator, external fixator with limited internal fixation and plaster immobilization; diagnosis of rheumatoid arthritis, diabetes mellitus and peripheral vascular disease. The anonymity and confidentiality of the patients were ensured by signing a written informed consent by the patients. Each patient had a protocol number to be used for follow up during the study period and for entering into the electronic database. Data sheets for all patients involved in the study contained the following data: gender, age, diagnosis at admission, etiology of the injury, category and type of the injury (classification according to Gustillo-Anderson, Oestern and Tscherné, Schatzker and Arbeitsgemeinschaft für Osteosynthesefragen/Orthopaedic Trauma Association (AO/OTA)) diagnosed by radiological methods (anterior-posterior, lateral-lateral and oblique radiographs) preoperatively, postoperatively and at follow up. Computed tomography (CT) scans were performed preoperatively. We used magnetic resonance imaging (MRI) in suspected vascular and ligamentous injuries associated with proximal tibial fractures. The classification according to Gustillo-Anderson classifies open fractures into five different categories: I, II, IIIA, IIIB and IIIC. Schatzker classification of complex proximal tibial fractures encompasses grades IV, V and VI. In the 2007-2013 period, we treated 50 patients (38 male and 12 female) aged 28 to 77 (mean 57.6) years. According to the category of injury, high-energy injuries prevailed in our patient population. Fifty fractures of proximal tibia were classified as Schatzker IV, V and VI. Among 28 open fractures there were 12 type I, 10 type II, 4 type IIIA and 2 type IIIB according to Gustillo-Anderson classification. For soft tissue injuries in closed fractures, we used Oestern and Tscherné classification; there were two patients with grade 0, three patients with grade 1 and 17 patients with grade 2. According to the AO/OTA classification, there were two patients with type B2, three patients with type C1, three patients with type C2 and 42 patients with type C3 fracture (Table 1).

All operations were preceded by adequate preoperative preparation, with cephalosporin antibiotics administered for prophylaxis, and in open fractures also aminoglycosides and metronidazole, along with checking the tetanus immunization status. Anticoagulant therapy with low-molecular heparin or fraxiparine was administered from the day of admission to the hospital for up to 10 days after leaving the hospital. Primary surgical treatment of wounds in open fractures, and passive or active drainage were also done. Conventional radiography was used in all

*Table 1. Review of population details according to patient data*

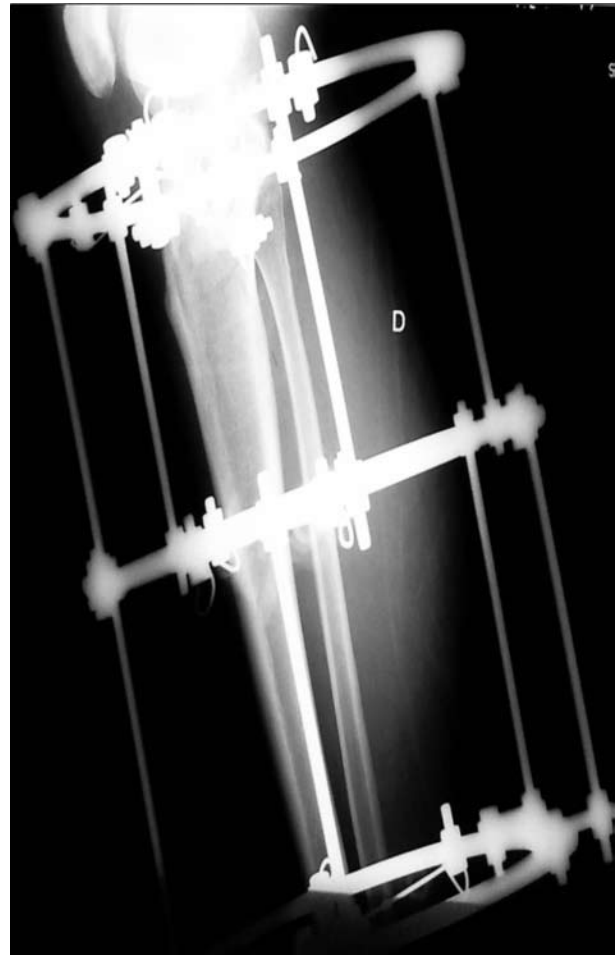
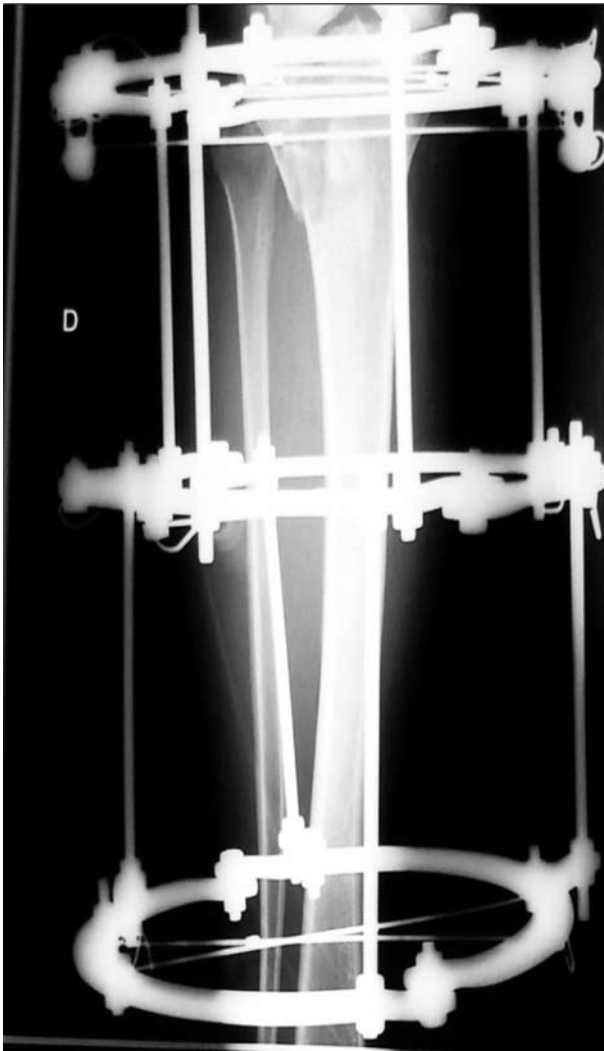
		n	%
Sex	Male	38	76.0
	Female	12	24.0
Side	Right	22	44.0
	Left	28	56.0
Mechanism of injury	Fall	23	46.0
	Traffic	16	32.0
	Riding	6	12.0
	Work	2	4.0
	Assault	3	6.0
Energy type	Low-energy	9	18.0
	High-energy	41	82.0
Type of fracture (Gustillo-Anderson classification)	I	12	43.0
	II	10	36.0
	III A	4	14.0
	III B	2	7.0
Diagnosis	Open	28	56.0
	Closed	22	44.0
Soft tissue injury (Oestern and Tschernke)	Grade 0	2	9.0
	Grade 1	3	14.0
	Grade 2	17	77.0
Type of fracture (Schatzker classification)	IV	9	18.0
	V	22	44.0
	VI	19	38.0
Type of fracture (AO/OTA classification)	B3	2	4.0
	C1	3	6.0
	C2	3	6.0
	C3	42	84.0

AO/OTA = Arbeitsgemeinschaft für Osteosynthesefragen/Orthopaedic Trauma Association



*Fig. 1. Preoperative x-ray of proximal tibial fracture.*

types of fractures (Fig. 1); coronal and sagittal three-dimensional reconstructive CT images revealed the exact location and degree of articular depression and found intact regions of the plateau above which stable construction could be incorporated and olive wires placed. MRI was used in Schatzker type VI fractures. Arteriography was used in two cases of Schatzker type VI fractures. Preoperative arthroscopy and arthrography were not used. Preoperatively, skeletal transcaneal traction was performed in patients with open fractures and those in whom surgery was delayed, and a plaster splint was placed over the knee in closed or grade I fractures by Gustillo if surgery was planned in 12-24 hours from the injury. Spinal anesthesia was given to all patients. Reduction on the traction table with the help of image amplifiers was preoperatively performed in all study patients. Intra-articular pressure was decreased by arthrocentesis. Biplane fluoroscopy was used during the reduction, insertion of olive wires and frame adjustment. Axial reduction was achieved by traction. The goal was adequate reduction of the condyles in relation to one another, and reduction as well as stabilization of tibial axis beneath the



*Fig. 2. Postoperative x-ray of proximal tibial fracture.*

reduced condyles. Anatomic reduction of the articular surface was a secondary goal, which is often achieved percutaneously or through limited approaches. At this stage, associated soft tissue injuries such as meniscal injury, injuries of cruciate or collateral ligaments were not treated. Condylar reduction was supported by longitudinal traction using valgus and varus forces. A large reduction forceps placed percutaneously helped us achieve adequate condylar compression and reduction. In some cases, bone fragments were moved with high caliber K-wire in order to maintain reduction. After reduction of the condyles, the olive wires were placed through the fragments in order to achieve the inter-fragmentary compression. Three, and sometimes four olive wires, minimum 15 mm from the joint line with a total divergence of minimum 60 degrees, were com-

monly required for stabilization of the condylar and metaphyseal fragments. The previously prepared frame, made of three duly sized rings attached to each other by threaded rods, was placed on the already inserted olive wires. The intermediate ring was situated distally to the fracture, and distal ring was placed in the lower part and secured with olive wires that were inserted in parallel with the joint to enable renovation of the mechanical axis of the tibia (Fig. 2). Femoral frame was set in fifteen patients when distraction over the knee was necessary. In Schatzker V-VI fractures, two rings were added to the structure on the distal part of the femur. Nine of fifteen patients with femoral frames had hinged rods over the knee joint to allow active movement. Femoral frame was removed at an average of 5 weeks. We had a total of 13 bone grafting procedures.

Table 2. Modified functional evaluation system by Karlstrom-Olerud

Measure	3 points	2 points	1 point
Pain	No	Little	Severe
Difficulty in walking	No	Moderate	Severe/limp
Difficulty in stairs	No	Supported	Unable
Difficulty in previous sports	No	Some sports	Unable
Limitation at work	No	Moderate	Unable
Status of skin	Normal	Various colors	Ulcer/fistula
Deformity	No	Little, <7°	Remarkable, >7°
Muscle atrophy	<1cm	1-2 cm	>2cm
Leg length discrepancy	<1cm	1-2 cm	>2cm
Loss of motion at knee joint	<10°	10-20°	>20°
Loss of motion at subtalar joint	<10°	10-20°	>20°

Autologous bone graft harvested from the iliac crest was used in five patients, whereas in eight patients frozen cancellous allograft harvested from the head of the femur was used to fill the metaphyseal tibial bone defect. All patients were treated using Ilizarov external fixation method and metaphyseal bone defects filling with open method through the bone window on the medial or lateral side of proximal tibia.

For postoperative care of the site of pin insertion we used Kurgan protocol<sup>14</sup>, while for description of pin infection we used Checketts-Otterburns classification<sup>15</sup>. All our patients underwent rehabilitation program starting from the second postoperative day (48 hours after the operation).

In our study, functional status, i.e. assessment of actual status in all three time - periods, was evaluated by use of a modified scale for functional assessment according to Karlstrom-Olerud<sup>16</sup>. A standardized procedure for measuring the amplitude of active and passive motion and knee joint was performed with a goniometer<sup>17</sup>.

Postoperative weight-bearing in patients without grafting and those who had femoral frames was allowed as tolerated in the first three weeks, and till the end of the sixth week all these patients reached full weight-bearing. In patients who underwent grafting, in the first three weeks weight-bearing was minimal, and till the end of the sixth week all these patients reached successively an increase up to 50% of weight-bearing. All patients reached full weight-bearing after 3 months of carrying the frame. Patients with marked articular comminution were kept non-weight.

Fractures were considered healed if anteroposterior and lateral radiography showed bridging callus and/or fracture was stable on forced varus/valgus stress. The mean postoperative follow up was 23 (18-35) months. Patients were followed up clinically at 2, 4, 6, 8 and 12 weeks and finally at one year. Radiography was performed at these same time intervals.

Assessment of bony status in this study was performed using the Association for the Study and Application of the Method of Ilizarov (ASAMI) scoring system. Quantification of functional outcome was performed using modified functional evaluation according to Karlstrom-Olerud scoring system (Table 2). The evaluation was performed at three time intervals during follow up, at 6, 12 and 18 months after surgery. The number of points within the scale ranged from 21 to 33, where 21-23 indicates poor, 24-26 moderate, 27-29 satisfactory and 30-32 good functional status, whereas 33 points indicate excellent functional status<sup>16</sup>. Following data control, the analysis encompassed the methods of descriptive and inferential statistics. In all analysis procedures, the obtained differences were considered statistically significant if p values were less than 0.05 (p<0.05).

A research proposal for this study was reviewed and approved by the Ethics Committee of the School of Medicine, University of Novi Sad, Ethics Committee of the Clinical Center of Vojvodina and Professional Board of the University Department of Orthopedic Surgery and Traumatology, Clinical Center of Vojvodina in Novi Sad.



Fig. 3. Healed plafond fracture after 6 months (with bone grafting).

## Results

All fractures healed successfully. Circular fixators could be removed without anesthesia for type IV fractures after 16 (range 12-21) weeks and for types V-VI after 18 (range 15-26) weeks of the operation (Fig. 3).

According to ASAMI bone results, there were 39 (78%) excellent, 7 (14%) good, 3 (6%) fair results and 1 (2%) poor result (Table 3). Considering complications, we had transitory peroneal nerve lesions in four cases and deep vein thrombosis in three cases. Twenty patients had 35 pin site infections, Checketts-Otterburns grades 1-3, all of which were successfully treated with oral antibiotics, and five had pin tract infection grade 4 that healed after pin removal. There were no cases of bone allograft or autograft reabsorption. Broken pins were recorded in five patients, all of which were replaced in short-term intravenous anesthesia. We had three cases of deep tissue infection, which were successfully treated with soft tissue debridement and parenteral antibiotic therapy. None of our patients developed osteomyelitis or septic arthritis. Compartment syndrome was not recorded in our series of pa-

Table 3. Assessment of bone status by the Association for the Study and Application of the Method of Ilizarov (ASAMI) scoring system

Bone results		n	%
Excellent	Union, no infection, deformity $<7^\circ$ , limb length discrepancy $<2.5$ cm	39	78.0
Good	Union + any two of the following: no infection, deformity $<7^\circ$ , limb length discrepancy $<2.5$ cm	7	14.0
Fair	Union + only one of the following: no infection, deformity $<7^\circ$ , limb length discrepancy $<2.5$ cm	3	6.0
Poor	Nonunion/refracture/union + infection + deformity $>7^\circ$ + limb length discrepancy $>2.5$ cm	1	2.0

tients either. If femoral frame was not assembled and cancellous allografts and autografts were not used, the average operative time was 95 (range 80-130) minutes. In cases where femoral frame was added and cancellous allografts and autografts were used, the average operative time was longer, 135 (range 105-155) minutes.

The reliability of the modified functional evaluation according to Karlstrom-Olerud scoring system was analyzed using Cronbach's alpha coefficient. Values were expressed as Cronbach's alpha coefficient at three time intervals. Cronbach's alpha coefficient was 0.837 at 6-month follow up, 0.862 at 12-month follow up and 0.887 at 18-month follow up. The obtained Cronbach's alpha coefficient values exceeded 0.80, thus our modified scale for functional evaluation according to Karlstrom-Olerud proved to be reliable in this study.

At 6-month follow up (applying modified Karlstrom-Olerud score), no limb-length differences were found in the study population and no deformities in the majority ( $n=40$ ) of study participants. In most patients, the limitation of the range of motion of the knee joint declined by 10-20 degrees from the full range of

Table 4. Clinical features at follow up examination 6 months after surgical procedure according to modified Karlstrom-Olerud score

		n	%
Pain	Severe pain	0	0.0
	Moderate pain	45	90.0
	None	5	10.0
Walking difficulties	Significant/limping	2	4.0
	Moderate	48	96.0
	None	0	0.0
Climbing difficulties	Impossible	4	8.0
	With support	40	80.0
	None	6	12.0
Difficulties during sport activities	Impossible	50	100.0
	Some sports	0	0.0
	None	0	0.0
Working restrictions	Impossible	21	42.0
	Moderate	29	58.0
	None	0	0.0
Skin status	Ulcer/fistula	0	0.0
	Skin discoloration	46	92.0
	Normal	4	8.0
Deformities	Significant over 7 degrees	3	6.0
	Low up to 7 degrees	9	18.0
	None	38	76.0
Muscle atrophy/tibial circumference	>2 cm	4	8.0
	1-2 cm	34	68.0
	<1 cm	12	24.0
Lower-limb-length difference	>2 cm	0	0.0
	1-2 cm	0	0.0
	<1 cm	50	100.0
Knee-joint motion range limitation	>20	7	14.0
	10-20	33	66.0
	<10	10	20.0
Subtalar-joint motion range limitation	>20	2	4.0
	10-20	3	6.0
	<10	45	90.0
Capacity of full weight-bearing	Yes	50	100.0
	No	0	0.0

motion. Clinical findings revealed the capacity of full weight-bearing in all study participants (Table 4).

In order to identify the factors contributing to improved functional outcomes in patients treated by Ilizarov method, we performed analysis applying the Spearman correlation coefficient. The results indicated high correlation of the functional patient status with deformity grade both in valgus/varus and recurvatum/anteurcurvatum directions, as well as accomplishment of full weight-bearing at 12-month follow up after treatment (Tables 5 and 6).

Mann-Whitney U test revealed no statistically significant differences in study patients according to sex and functional status at all three time intervals. In our sample population, there were no statistically significant age differences in functional status.

Correlation of functional recovery and bone status was expressed by Spearman correlation coefficient ( $r_o$ ), indicating a significant correlation rate at all three time intervals (Table 7).

Analysis of data from the modified functional evaluation system by Karlstrom-Olerud yielded the mean functional recovery score of 24.7 at 6 months, which is considered moderate recovery by other researchers. Follow up of functional recovery at 12 months postoperatively revealed a satisfactory recovery rate with the mean score of 27.7, whereas the mean score of 29.8 recorded at the last evaluation strongly suggested good functional status according to most authors. At the last testing of functional status performed 18 months after treatment, maximum score values, 33 points, were recorded (Table 8).

## Discussion

During the past three decades, the development of new techniques and equipment has changed approach in the treatment of these injuries toward minimally invasive surgery. The biological and mechanical advantages of the circular external fixator in the treatment of high velocity tibial plafond fractures have been described<sup>9-13, 18-22</sup>. Current literature data strongly indicate the advantages of Ilizarov method, such as adequate fixation of tibial bone fragments, low rate of trauma of the surgical procedure, preservation of fragment vascularity, adequate compression (during and after surgery), as well as stable limb fixation and minimizing the risk of posttraumatic osteoarthritis<sup>9-13, 18-22</sup>.

Table 5. Correlation of functional status and deformity level after 12 months determined by Spearman correlation coefficient

		Valgus-varus admission	Ante/re -curvatum admission	Valgus-varus dismissal	Ante/re -curvatum dismissal
Functional status	ro	0.409**	0.240	0.282*	0.320*
	p	0.003	0.093	0.047	0.023
	N	50	50	50	50

Table 6. Correlation of functional results and capacity of full weight-bearing after 12 months determined by Spearman correlation coefficient

		Full weight-bearing (dismissal)	Month of weight-bearing accomplishment
Functional status	ro	0.235	-0.321*
	p	0.100	0.023
	N	50	50

Table 7. Correlation of functional and bone status by Spearman correlation coefficient (months)

		6 months	12 months	18 months
Functional status at 6 months	ro	0.528**	0.485**	0.420*
	p	0.002	0.0006	0.019
	N	50	50	50
Functional status at 12 months	ro	0.002	0.364*	0.355*
	p	0.028	0.044	0.005
	N	50	50	50
Functional status at 18 months	ro	0.215	0.354*	0.608**
	p	0.246	0.051	0
	N	50	50	50

\*Correlation significant at the confidence level of less than 0.05; \*\*correlation significant at the confidence level of less than 0.01

Table 8. Descriptive indicators of scoring points according to modified functional evaluation system by Karlstrom-Olerud

		Mean	Median	SD	Min	Max
Functional status (6-month follow up)	Ilizarov	24.695	25.000	1.598	22	28
Functional status (12-month follow up)	Ilizarov	27.737	28.000	1.668	24	30
Functional status (18-month follow up)	Ilizarov	29.781	29.000	1.869	26	33



Some studies support two-staged protocol for the treatment of proximal tibia fractures, especially in the presence of high-energy fracture<sup>23,24</sup>. Irrespective of the fracture pattern, all patients can be operated without delay, wherein Ilizarov method has advantages. In this study, two-staged protocol was not used, so we were able to avoid disturbance of the healing process with other procedures that can delay rehabilitation process.

Dual plating appeared to be the best way for stabilization of these fractures, since it included lateral and medial condyles in order to achieve mechanical stability<sup>6</sup>. However, this method is often followed by complications because it requires extensive dissection of soft tissue due to plate placing. Past studies indicated that the rate of infection after treatment of tibial plateau fractures with open reduction and internal fixation (ORIF) varied from 6% to 85%<sup>25-27</sup>. Decrease of implant size and use of bilateral incisions reduced the rate of infections by 3% to 8.4%<sup>28,29</sup>. Egol *et al.*<sup>24</sup> recorded a 5% rate of deep wound infection despite using two-staged protocol. The rate of deep wound infection of 4.7% in double plating and 7.3% in using a less invasive stabilization system (LISS) was recorded by Jiang *et al.*<sup>30</sup>. In order to overcome complications, a less invasive technique with external fixators was presented as a strategy to decrease iatrogenic injuries of soft tissue. Monolateral fixators have been used and, although they have proved highly successful in decreasing complications related to soft tissues<sup>31,32</sup>, mechanical stability in this technique is not adequate and loss of reduction has been recorded<sup>32</sup>. Parameswaran *et al.* report that the ring external fixator has the lowest frequency of infection, while Catagni *et al.* using Ilizarov technique recorded no deep infections in a series of 59 patients with Schatzker type V and VI fractures<sup>33,34</sup>. In our study, pin site, pin tract and deep wound infections were successfully treated and did not affect final outcome, similar to the results of other authors<sup>9-15,18-21,33,34</sup>. Restitution of articular surface by ligamentotaxis is not always possible to achieve. In some cases, it is necessary to perform limited open reduction, elevation of the plateau and bone grafting. In our study, we had 13 (26%) open reductions and bone grafting. Watson and Coufal<sup>35</sup> had 79% of open reduction and 57% of bone grafting. Dendrinios *et al.*<sup>20</sup> had 50% of open reduction, El

Barbary *et al.*<sup>18</sup> had 17% of bone grafting and Weiner *et al.*<sup>36</sup> had 60% of open reduction. The frequency of compartment syndrome in severe fractures (types V and VI) was not recorded in this series, although the reviewed compartment syndromes were interpreted as a result of fracture and injury of soft tissue and not as a result of operation. In their retrospective study, Park *et al.*<sup>37</sup> found a low rate (1.6%) of compartment syndrome which needed fasciotomy. The risk of compartment syndrome is significantly higher for Schatzker type VI fractures. Stark *et al.*<sup>38</sup> found a total risk of 27%, as well as a difference depending on whether the medial plateau was dislocated (53%) or not (18%). Although Ilizarov technique is useful concerning decrease in the risk of compartment syndrome, setting of the frame does not exclude fasciotomy when it is necessary. In our study, the average duration of operation was 95 minutes in patients where we did not use femoral frame and bone grafting and 135 minutes in those that required femoral frames and bone grafting. Ramos *et al.*<sup>11</sup> report on the average duration of operation of 130 minutes for Schatzker type I-IV and 223 minutes for Schatzker type V and VI. Lee *et al.*<sup>22</sup> had an average duration of operation of 150 minutes in a series of 36 fractures of tibial plateau using LISS. An important advantage of Ilizarov technique is that it is essentially closed method, and if the time of operation extends, the risk of wound contamination is low when compared with open insertion of the plate in the tibial plateau<sup>39</sup>. Arthroscopic procedure was not used in this series of patients. Lobenhoffer *et al.*<sup>40</sup> were not able to show any significant benefit using arthroscopy in comparison to fluoroscopy reduction in 168 patients with tibial plateau fracture. Ohdera *et al.*<sup>41</sup> found no significant difference between arthroscopic treatment of tibial plateau fractures and the method of open reduction in terms of duration of operation, postoperative flexion and clinical results in 28 patients. Arthroscopy is widely suggested as a treatment option in meniscal lesions, which may occur in tibial plateau fractures, whether performing resection or repair<sup>42</sup>. The mean time of carrying fixator in our study was 16 weeks for Schatzker type IV fractures and 18 weeks for Schatzker type V and VI fractures, which is comparable with the mean time in other studies<sup>11-13,18-21</sup>.

The results of our study indicated high correlation between the functional status of patients and defor-

mity grade both in valgus/varus and recurvatum/ante-curvatum directions, as well as accomplishment of full weight-bearing at 12-month follow up examination. The authors believe that satisfactory joint reconstruction and good functional results achieved in the majority of patients associated with only mild complications strongly indicate the application of Ilizarov apparatus in the treatment of complex bone fractures of proximal tibia. By monitoring bone and functional outcomes of the treatment of open fractures of the tibia (Gustillo-Anderson IIIA, IIIB and IIIC) by Ilizarov method in 32 patients, Hasankhani *et al.*<sup>12</sup> suggest that this approach is an excellent method of choice associated with minimum complications and fast functional recovery. The results of our study, when speaking of correlation between bone and functional results, strongly indicated a significant correlation at all three time intervals throughout the follow up period. Mohamed and Youssef<sup>13</sup>, the authors of a study published in 2013, confirmed the low rate of morbidity and good functional outcomes associated with the application of Ilizarov apparatus in complex tibial fractures, which corresponds with the results of our research. Our results, obtained during 18-month follow up period, demonstrated that the application of transosseous osteosynthesis by Ilizarov apparatus along with early rehabilitation therapy resulted in improved functional outcome (good according to Karlstrom-Olerud) in the treatment of open and closed multiple intra-articular fractures of proximal tibia in the majority of patients, which compares favorably with similar published studies<sup>11-13,18-21</sup>. Highly personalized approach to the patient and commencement of early rehabilitation are prerequisites to accomplish better quality of life of the patients.

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## Sažetak

## LIJEČENJE KOMPLEKSNIH PRIJELOMA PLATOA TIBIJE ILIZAROVljeVOM TEHNIKOM

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Kompleksni prijelomi platoa tibije su često uzrokovani visoko energetsom traumom i udruženi su s teškim povredama mekog tkiva koje često rezultiraju teškim komplikacijama. Cirkularna vanjska fiksacija po Ilizarovu je idealna metoda liječenja visoko energetskih trauma tibijalnog platoa kada su ekstenzivna mekotkivna disekcija i unutarnja fiksacija kontraindicirane. Naše istraživanje je uključilo 50 bolesnika, a njihove kliničke značajke su procjenjivane tijekom razdoblja evaluacije koristeći sljedeće instrumente: klasifikacije Gustillo-Anderson, Schatzker i AO/OTA. Koštani rezultati su procjenjivani koristeći protokol *Association of the Study and Application of the Method of Ilizarov* (ASAMI). Prosječni funkcionalni oporavak je određen pomoću modificiranog evaluacijskog sustava po Karlstrom-Olerudu. Svi prijelomi su uspješno srasli. Cirkularni fiksatori su se mogli ukloniti bez anestezije 16 tjedana (raspon 12-21 tjedan) za prijelome tipa IV., a za tipove V.-VI. 18 (raspon 15-26) tjedana nakon operacije. Prema koštanim rezultatima ASAMI bilo je 39 (78%) odličnih, 7 (14%) dobrih, 3 (6%) solidna rezultata i 1 (2%) loš rezultat. Analiza podataka na temelju funkcionalnog evaluacijskog sustava po Karlstrom-Olerudu u ovom istraživanju pokazala je srednju vrijednost od 24,7 nakon šest mjeseci, što predstavlja oporavak. Funkcionalni oporavak 12 mjeseci nakon operacije pokazao je zadovoljavajući oporavak sa srednjom vrijednosti do 27,7, gde je srednja vrijednost zbira do 29,8 zabilježena na posljednjoj kontroli ukazivala na dobar funkcionalni status. Liječenje bolesnika s otvorenim i zatvorenim intraartikularnim prijelomima proksimalne tibije koristeći Ilizarov aparat rezultiralo je dobrim funkcionalnim ishodom koji je pozitivno utjecao na kvalitetu života naših bolesnika.

Cljučne riječi: *Tibijalne frakture – kirurgija; Ilizarovljeva tehnika; Ishod liječenja, procjena*