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A Retrospective Analysis of Long-Term Outcomes in Patients with Schatzker Type V–VI Tibial Plateau Fractures Treated with Ilizarov-type External Fixator Osteosynthesis

Mustafa Karahan¹, Damla Ünal Zilcioglu^{2,3}, Ahmet Kapukaya⁴

1 Department of Orthopedics and Traumatology, Private Dunyapark Hospital, Diyarbakır, Türkiye

2 Department of Physiotherapy, Sakarya University of Applied Sciences, Sakarya, Türkiye

3 PhD Candidate, Department of Physiotherapy and Rehabilitation, Gazi University, Ankara, Türkiye

4 Department of Orthopedics and Traumatology, Adana City Training and Research Hospital, Adana, Türkiye

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Abstract

Background: Tibial plateau fractures (TPF) are complex intra-articular injuries that account for 1–2% of all fractures. High-energy Schatzker type V–VI fractures are particularly difficult to manage because of comminution, soft-tissue compromise, and a high risk of postoperative complications. The Ilizarov-type circular external fixator has been proposed as a valuable alternative to open reduction and internal fixation (ORIF) in the management of such injuries, especially in patients with severe soft-tissue damage. This technique is preferred because it requires a smaller surgical incision, is associated with lower rates of deep infection, enables accurate restoration of the lower-limb mechanical axis, and allows early mobilization.

Aims: This study aimed to evaluate the long-term clinical and radiological outcomes of patients with high-energy Schatzker type V–VI TPF treated with Ilizarov-type external fixator osteosynthesis.

Methods: This single-center retrospective study included 42 patients (43 knees) with high-energy type V–VI fractures treated using Ilizarov-type external fixation. Demographic data, fracture patterns, complications, and functional and radiological outcomes were analyzed. The Knee Society Knee Score (KSKS) was used for functional evaluation, and post-traumatic osteoarthritis was graded radiographically.

Results: The mean follow-up was 36 months. Pin tract infection occurred in 57.1% of patients and was the most common complication. Anatomical reduction was achieved in 23.3% of cases. Functional results were excellent or good in 65%, and osteoarthritic changes were absent in 23.3%.

Conclusions: Circular external fixation with minimal internal fixation provides a stable construct and satisfactory long-term outcomes in high-energy Schatzker type V–VI TPF. Although reduction loss and suboptimal anatomical alignment remain the main limitations, this technique minimizes deep infection risk and preserves soft-tissue integrity, making it a reliable option for complex fractures.

Keywords: Ilizarov Technique; Tibial Plateau Fractures; Retrospective Studies; External Fixators; Fracture Fixation, External; Treatment Outcome

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Correspondence / Yazışma Adresi: Damla Unal Zilcioglu, Institutional Address: Department of Physiotherapy, Sakarya University of Applied Sciences, Sakarya, Türkiye e-mail: damlaunal@subu.edu.tr

Schatzker Tip V-VI Kırıklarında İlizarov Tipi Eksternal Fiksatorle Osteosentezi Gerçekleştirilen Olguların uzun dönem sonuçlarının Retrospektif İncelemesi

Öz

Giriş: Tibial plato kırıkları, tüm kırıkların yaklaşık %1-2'sini oluşturan karmaşık eklem içi yaralanmalardır. Yüksek enerjili Schatzker tip V-VI kırıkları, parçalanma ve eşlik eden yumuşak doku hasarı nedeniyle tedavisi en zor kırık tipleri arasındadır. Bu yaralanmalarda İlizarov tipi sirküler eksternal fiksator, yumuşak dokunun korunmasını sağladığı için açık redüksiyon ve internal fiksasyona (ARİF) alternatif bir yöntem olarak kullanılmaktadır. Bu yöntem, daha az cerrahi insizyon gerektirmesi, daha az derin enfeksiyon oranı, doğru alt ekstremitte mekanik eksenin restorasyonunu sağlaması ve erken mobilizasyon imkânı sağlaması nedeniyle tercih edilmektedir.

Amaç: Bu çalışmanın amacı, yüksek enerjili Schatzker tip V-VI tibia plato kırıklarında İlizarov tipi eksternal fiksator ile tedavi edilen vakaların uzun dönem klinik ve radyolojik sonuçlarını değerlendirmektir.

Yöntemler: Tek merkezli retrospektif bu çalışmaya, yüksek enerjili Schatzker tip V-VI tibia plato kırığı nedeniyle İlizarov tipi eksternal fiksator ve minimal internal fiksasyon ile tedavi edilmiş 42 hasta (43 diz) dâhil edildi.

Bulgular: Hastaların yaş ortalaması 39 (22-69) yıl ve ortalama takip süresi 36 aydı. En yaygın komplikasyon %57,1 oranla tel dibi enfeksiyonuydu. Anatomik redüksiyon %23,3 hastada sağlandı. Fonksiyonel sonuçlar %30,2 mükemmel, %34,9 iyi, %9,3 orta ve %25,6 kötü olarak değerlendirildi. Hastaların %23,3'ünde son kontrolde osteoartrit bulgusu saptanmadı.

Sonuç: Yüksek enerjili Schatzker tip V-VI tibia plato kırıklarında minimal internal fiksasyon ile sirküler eksternal fiksator uygulaması, stabil tespit ve tatmin edici uzun dönem sonuçlar sağlamaktadır. Redüksiyon kaybı ve anatomik hizalanma yetersizliği en önemli sınırlayıcı faktörler olmakla birlikte, bu yöntem derin enfeksiyon riskini azaltması ve yumuşak dokuları koruması açısından güvenilir bir seçenektir.

Anahtar kelimeler: İlizarov tekniği, Tibia kırıkları, Eksternal fiksatorler, Retrospektif çalışmalar.

INTRODUCTION

Tibial plateau fractures (TPF) are intra-articular fractures that account for 1-2% of all fractures and are challenging to treat¹. Because the tibial plateau is a weight-bearing surface, fractures in this region often require operative reduction to achieve optimal anatomical alignment of the fracture fragments². The Schatzker classification system is usually used to categorize displaced fractures. While treatment standards are well established for Schatzker type I, II, III, and IV fractures, the management of type V and VI fractures remains controversial³. In Schatzker type V-VI fractures, a therapeutic dilemma exists due to high-energy trauma that leads to compromised soft-tissue conditions, complicating surgical fixation³.

In the treatment of type V and VI fractures, the high rate of complications observed with the open reduction and internal fixation (ORIF)

technique has prompted consideration of alternative approaches. It has been reported that early definitive fixation may result in wound dehiscence, implant exposure, or skin necrosis, whereas delayed fixation may lead to knee joint stiffness³. Postoperative soft-tissue swelling following acute fracture surgery can also increase the risk of wound breakdown, delay the initiation of joint motion, and elevate infection rates, thereby complicating management⁴. The reported incidence of surgical site infection following ORIF of TPF ranges from 2% to 11%, which is higher than the overall rate for orthopedic procedures (1-3%)⁴⁻⁶. Therefore, alternative surgical techniques and their outcomes continue to be investigated⁷.

One of the surgical methods employed in the treatment of TPF is fixation using the Ilizarov

external fixator, which has yielded favorable results in open and periarticular fractures⁸. TPF can be managed with the Ilizarov fixator using the principle of ligamentotaxis for closed reduction or through minimally invasive open reduction. The advantages of this approach include a less invasive surgical procedure, a lower risk of deep infection, earlier progression to weight-bearing, temporary knee stabilization achieved via joint distraction, reliable restoration of the lower-limb mechanical axis, and a reduced length of hospital stay^{9,10}.

In this study, we aimed to present the outcomes of patients with high-energy TPF who underwent limited-incision reduction combined with autogenous bone grafting, percutaneous cannulated screw fixation, and Ilizarov-type external fixator osteosynthesis.

METHODS

This study was designed as a retrospective descriptive study. Prior to data collection, ethical approval was obtained (Decision number: 62/18, 17.10.2025). Data from 103 patients who presented to the Department of Orthopedics and Traumatology of a single tertiary care center after the year 2000 with TPF were retrospectively analyzed. Prior to the study institutional permission was obtained in accordance with the Helsinki Declaration.

Inclusion criteria were as follows: high-energy Schatzker type V or VI fractures, fixation with an Ilizarov external fixator during surgery, and completion of all follow-up sessions. Exclusion criteria included unclassifiable or Schatzker type I–IV fractures, patients with expulsive fractures, and those with incomplete follow-up data. Among the patients who presented to the clinic, 42 had high-energy Schatzker type V or VI fractures. Five patients were excluded because their fractures were expulsive and could not be classified within the Schatzker system. The remaining 61 patients were excluded as they had type I–IV fractures. Ultimately, 42 of 47

eligible patients with high-energy TPF were included in the study, as five patients were lost to follow-up. In total, 43 knees from 42 patients with high-energy type V, VI, or expulsive TPF treated with an Ilizarov external fixator were analyzed.

All patients who presented to the emergency department underwent general and local physical examinations, and appropriate interventions were performed. Diagnostic imaging was reviewed to determine fracture type. Demographic data, clinical characteristics, and treatment details were recorded. Anteroposterior (AP), lateral, and bilateral oblique radiographs were examined for each patient. The quality of joint surface reduction was assessed using postoperative AP and lateral radiographs. Bilateral tibial radiographs were used to evaluate limb shortening, and radiographs of the contralateral knee were used to assess condylar width. Computed tomography (CT) scans were reviewed to provide a more detailed evaluation of fracture patterns. Magnetic resonance imaging (MRI) was examined in selected patients to assess the soft tissue condition when deemed necessary.

Functional outcomes were evaluated using the Knee Society Knee Score (KSKS): scores between 100–85 were recorded as excellent, 84–70 as good, 69–60 as fair, and below 60 as poor¹¹. Post-traumatic osteoarthritis was evaluated on the most recent radiographs and classified into four grades: Grade 0 indicated no osteoarthritic changes; Grade 1 represented small osteophytes and cysts without joint space narrowing; Grade 2 denoted mild joint space narrowing accompanied by osteophyte formation and subchondral sclerosis; and Grade 3 corresponded to marked joint space narrowing¹².

RESULTS

Of the included patients, 30 (71.42%) were male and 12 (28.57%) were female. Fractures were

located in the left tibia in 31 (73.8%) patients and in the right tibia in 12 (28.57%) patients. One patient had bilateral plateau fractures. The mean age of the patients was 39 years (22–69). The mechanisms of injury included firearm injury in 12 patients (28.57%), traffic accident in 15 (35.71%), fall from height in 10 (23.8%), and occupational accident in 6 (14.28%). Additionally, 26 patients (61.9%) presented with open fractures. According to the Schatzker classification, 15 patients (32%) had type V and 22 (57%) had type VI fractures, while 5 patients (11%) could not be classified due to the presence of comminuted burst fracture patterns. Associated fractures were observed in 17 patients (40.47%) (Table 1).

Table I: Associated fractures

Associated Pathology	Number of Cases
Ipsilateral femur fracture	3
Ipsilateral patella fracture	2
Ipsilateral radius fracture	1
Humerus fracture	2
Vertebral fracture	2
Bilateral calcaneus fracture	2
Acetabular fracture	1
Ipsilateral pilon fracture	2
Multiple metatarsal fractures	1
Ipsilateral distal radius–ulna metaphyseal fracture	1

Soft tissue injuries were present in 22 patients (52.38%), the most common being anterior cruciate ligament (ACL) rupture and tibial eminence fracture (Table 2).

Table II: Associated soft tissue injuries

Associated Pathology	Number of Cases
Medial collateral ligament and medial meniscus tear	5
Incomplete patellar tendon rupture	3
Isolated lateral collateral ligament tear	6
Complete patellar tendon rupture	2
Lateral collateral ligament and lateral meniscus tear	5
ACL rupture and tibial eminence fracture	7

The mean follow-up period was 36 months (24–64). The mean time to union was 22.8 weeks (16–44) in open fractures and 19 weeks (16–32) in closed fractures. The mean duration before removal of the external fixator was 22.8 weeks in open and 19 weeks in closed fractures.

Pin tract infection occurred in 24 patients (57.14%). Twenty of these cases were successfully managed with local dressing and oral antibiotics, while four required wire removal due to persistent infection. One intraoperative popliteal vein injury and one peroneal nerve injury were reported; the latter presented as neuropraxia and fully resolved by the eighth postoperative month. The overall complication data are summarized in Table 3.

Table III: Complications and treatment

Complication	Patients n (%)	Treatment
Superficial infection	10 (23.8)	Dressing + antibiotics
Osteomyelitis	4 (9.52)	Multiple debridements + antibiotic therapy
Septic arthritis	2 (4.7)	Debridement + antibiotic therapy
Pin tract infection	24 (57.14)	Local care + antibiotics ± wire removal
Peroneal nerve injury	1 (2.38)	Exercise therapy and full recovery
Popliteal vein injury	1 (2.38)	End-to-end anastomosis
Loss of reduction	5 (3.36)	Patients declined further treatment
Malunion	2 (4.7)	Corrective osteotomy in one case
Ankylosis	1 (2.38)	—

Anatomical reduction of the articular surface could not be achieved in 19 patients (45.23%), and five of these experienced loss of reduction during follow-up. Abnormal reduction involving only the depression parameter was observed in eight patients (18.6%), with an average collapse of 11 mm (7–15) (Table 4).

Table IV: Reduction scores

Reduction Score	Patients n (%)
Excellent	10 (23.25)
Good	14 (32.56)
Fair	9 (20.93)
Poor	10 (23.25)

At the final follow-up, six patients (14.28%) exhibited varying degrees of fixed flexion

deformity, although all were able to ambulate without assistance. None of these patients agreed to secondary surgery. One patient who developed septic arthritis exhibited osseous ankylosis. Functional knee evaluations revealed excellent outcomes in 13 cases (30.23%), good in 15 (34.88%), fair in 4 (9.3%), and poor in 11 (25.58%) knees. Among patients without anatomical articular reduction, 8 (20%) achieved good outcomes, while the majority of fair and poor results were observed in this group.

Radiographic evaluation at final follow-up revealed post-traumatic osteoarthritis in varying degrees: 10 patients (23.25%) were grade 0, 18 (41.86%) grade I, 8 (18.6%) grade II, and 7 (16.28%) grade III.

DISCUSSION

An evaluation of patients with Schatzker type V–VI fractures treated with Ilizarov-type external fixator osteosynthesis and followed for at least two years revealed that the most common cause of fracture was traffic accidents, and most fractures were open and classified as type VI. The most frequent associated fracture was femoral fracture, while the most common concomitant soft-tissue injuries were anterior cruciate ligament (ACL) rupture and tibial eminence fracture. The union time and external fixator removal period were shorter in closed fractures. Pin tract infection occurred in 57.14% of patients and was the most frequent complication. Anatomical reduction was achieved in 23.25% of cases, and poor functional outcomes were observed in only 25.58% of patients. At the final follow-up, 23.25% of patients showed no radiographic evidence of osteoarthritis. In summary, circular external fixation combined with minimal internal fixation was found to be effective in preventing superficial and deep infections in both open and closed comminuted TPF. However, loss of reduction and low anatomical reduction rates were identified as the main

limitations of this technique. The treatment options for TPF remain a topic of debate¹³⁻¹⁵.

In a retrospective study published by Robinson et al. in 2023, which included 35 elderly patients with complex plateau injuries, a nonunion rate of 2.9% was reported⁷. In our study, no cases of nonunion were observed, and the malunion rate was 4.7%. The lower mean age of our patient cohort may have contributed to this difference.

Berven et al. compared plate fixation with Ilizarov external fixation and reported no significant difference in treatment outcomes after six months, emphasizing that the surgeon's experience plays a crucial role in technique selection¹⁶. Similarly, we believe that a detailed preoperative plan and well-defined surgical strategy are essential for successful management. In particular, in coronal plane fractures with posterior wall comminution, circular external fixation alone may be insufficient to provide adequate stabilization without minimal osteosynthesis. Therefore, radiographs should be obtained using appropriate projections, and detailed imaging with CT and MRI is essential for identifying concomitant injuries and planning the surgical approach.

The fundamental principle in the treatment of TPF is the anatomical reduction of the articular surface¹⁷. In some high-energy TPF, anatomical reduction of the articular surface cannot be achieved, as observed in our study. This is primarily due to the need to minimize additional soft-tissue trauma and avoid complications such as superficial or deep infections. Furthermore, articular surface realignment is often performed using a limited or indirect approach. The high incidence of non-anatomical reduction in external fixation treatments may also be explained by the frequent use of this method in severely comminuted fractures, cases with extensive soft-tissue damage, and polytraumatized patients¹⁸.

As in our study, favorable functional outcomes achieved with external fixation support its continued value as a treatment option. According to a meta-analysis published in 2021, external fixation provided better functional outcomes and range of motion compared with ORIF in TPF¹⁸. However, a meta-analysis published in 2024 reported insufficient evidence to determine the optimal fixation technique or the best method for addressing bone defects during surgery¹⁹. Thus, randomized controlled trials are still needed to identify the most effective treatment approach for Schatzker type V-VI fractures^{14,19,20}.

It should be noted that, in most patients, concomitant fractures and intra-articular soft-tissue injuries resulting from high-energy trauma affect long-term outcomes. Owing to nature of TPFs, the rate of osteoarthritis is high, as observed in our study^{21,22}. To reduce the risk of post-traumatic osteoarthritis, restoration of joint congruence, anatomical limb alignment, and minimization of complications are important²³.

The main limitation of this study is the lack of a comparison group of patients treated with ORIF. Nevertheless, the relatively large sample size, the inclusion of long-term follow-up data, and the ongoing debate regarding complication rates and treatment methods in TPF enhance the clinical relevance of these findings

CONCLUSION

In open comminuted TPF, the use of circular external fixators resulted in a low incidence of serious complications such as wound problems, septic arthritis, and osteomyelitis. Circular external fixation combined with minimal internal fixation proved to be an effective approach for preventing superficial and deep infections in both open and closed comminuted fractures of the tibial plateau. However, reduction loss and suboptimal anatomical

reduction remain the major challenges associated with this technique.

Ethical Approval: This study was designed as a retrospective descriptive study. Prior to data collection, ethical approval was obtained (Decision number: 62/18, 17.10.2025).

Conflict of Interest: The authors declared no conflicts of interest.

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