

# Comparison of Functional and Radiologic Outcomes of Pilon Fractures Treated with Ilizarov External Fixator and Minimally Invasive Plate Osteosynthesis

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## ABSTRACT

Gold standard surgical treatment remains controversial for pilon fractures. This retrospective study aimed to analyze the mid-term results of tibial pilon fractures that were treated with the Ilizarov external fixator and Minimally Invasive Plate Osteosynthesis (MIPO).

The study population consists of 50 patients with a minimum of one-year follow-up. Patients were divided into two groups based on the treatment method (Group 1, Ilizarov, n=25; Group 2, MIPO, n=25). The American Orthopaedic Foot and Ankle Society (AOFAS) score, the Foot and Ankle Disability Index (FADI), and Visual Analogue Scale (VAS) score were used in the evaluation of functional outcomes. Ankle and subtalar joint range of motion (ROM) were evaluated at the last evaluation. The association between reduction quality and the development of ankle OA was analyzed as well.

There was no significant difference between the two groups regarding AOFAS, FADI, VAS scores, and ankle ROM at the last follow-up ( $P>0.05$ ). Also, union time and complication rates were similar between the two groups ( $P>0.05$ ).

Both MIPO and the Ilizarov techniques are effective and safe methods with low complication rates in the treatment of pilon fractures.

**Keywords** Ilizarov; Pilon; Plafond; External fixator; MIPO; Fracture

## Introduction

Intraarticular distal tibia fractures constitute 1-10% of lower extremity fractures (1). They generally result from major trauma with axial compression (2). Treatment of tibial pilon fractures is difficult due to intra-articular comminution, metaphyseal defect, and soft tissue problems. Anatomic reduction of the joint surface, maintenance of the alignment and the length of the extremity, and allowing an early motion are the primary goals of the treatment (3).

Historically, open reduction and internal fixation (ORIF) was the preferred method in the management of pilon fractures (4). After high rates of soft tissue problems of ORIF, Schatzker et al. introduced staged treatment for pilon fractures, and they reported a dramatic decrease in complications (5). Also, combined treatment was suggested with external and internal fixation to decrease soft tissue complications (6).

Various surgical approaches, such as anteromedial, anterolateral, extensile, and combined procedures, have been identified. After modern low-profile anatomic plate designs, minimally invasive plate osteosynthesis (MIPO) became more popular in the treatment of pilon fractures. MIPO treatment provides stable articular fixation with fewer soft tissue complications than classic ORIF (7). Definitive external fixation is also a useful method in pilon fractures (10). It has many advantages over ORIF. A circular external fixation device allows micromotion in the fracture site, which increases bony union, and it is possible to perform dynamization to promote union. It was shown that the Ilizarov external fixator has superior strength over hybrid fixators. Also, it is possible to allow weight-bearing earlier (8). Although there is a risk of superficial infection, septic nonunion is relatively rare after the external fixator application. Despite all these advantages, a high rate of malunion, pin tract infection, and cosmetic

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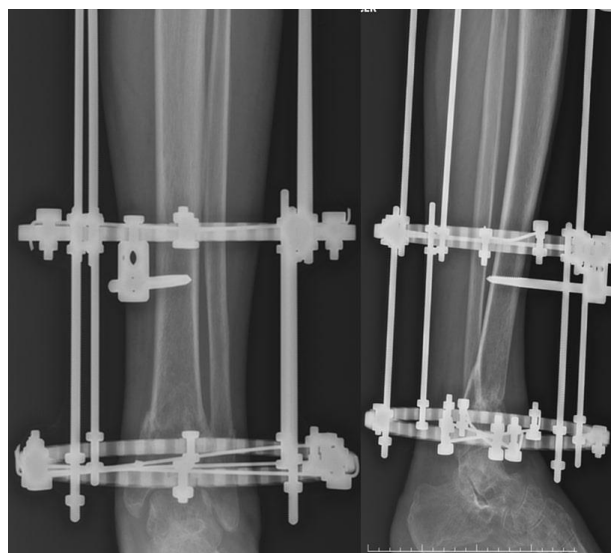
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**Fig.1a.** Preoperative X-Ray images of a patient in group 1



**Fig.1b.** Preoperative CT images of the patient



**Fig.1c.** Postoperative 3rd month images of the patient



**Fig. 1d.** Postoperative 12th month images of the patient

problems are the common disadvantages of external fixators (9, 10).

The optimal treatment of pilon fractures is not clear yet (3). The surgeon's preference, the soft tissue status of the patient, and the availability of implants are important factors in choosing treatment options for pilon fractures. Although clinical and radiologic outcomes after comminuted pilon fracture treatment with the Ilizarov external fixator and ORIF were evaluated (11), there are few studies comparing outcomes of Ilizarov external fixator and MIPO in pilon fractures (12).

The present study aimed to compare mid-term clinical, functional, and radiological outcomes and complication rates of surgically treated pilon fractures with the Ilizarov method to those treated with MIPO.

## Materials and Methods

**Study Design:** This single-center, retrospective study was started after institutional review board approval (approval date and number:15.9.2017-

2017/410). The medical records of patients who underwent external fixation with Ilizarov and MIPO between 2013 and 2018 were evaluated.

**Patient Selection:** Inclusion criteria were (1) surgically treated pilon fractures and (2) patients treated with the Ilizarov or MIPO within a minimum of the 12-month follow-up period. Patients with the ipsilateral neurovascular deficit, Gustillo Andersen type 3B and 3C open fractures (13), patients received other treatment than medial MIPO or Ilizarov external fixator; concomitant rheumatologic diseases may affect ankle joint, pathologic fractures, congenital or acquired deformity of the ipsilateral lower extremity and a previous ankle surgery were excluded from the study.

The study population consists of 50 patients. The groups were determined according to fixation preference. Group 1, patients received closed or limited open reduction and external fixation



**Fig. 2.** Temporary ankle spanning fixator for Type 1 open fracture with intact fibula

(n=25). In Group 2, patients were treated with MIPO as a definitive or staged surgery (n=25).

**Surgical Technique:** Patients were operated under general or regional anesthesia. In Group 1, the Ilizarov fixator group (Tasarim Medical, Istanbul, Turkey), the diameter of the rings was decided according to concerning patient's calf diameter, and the most proximal ring was placed parallel to the joint axis to the proximal tibia and second proximal ring placed just superior to the fracture line. These proximal two rings were fixed to the tibia with two 5 mm Schanz screws and a single wire. A 5/8 ring connected with the calcaneus and the distal ring was kept free to allow manipulation. After satisfactory reduction obtained with ligamentotaxis and manipulation, olive wires were inserted to reduce, compress, and fix the articular fragments. Once reduction was confirmed with fluoroscopy, additional Schanz screws were inserted in the distal ring. Foot ring application was performed routinely to avoid equinus deformity. The fibula was not fixed in any case. In the second group, MIPO was performed in two stages so as not to jeopardize the soft tissue in Tcherne grade 3 fractures and open fractures. In the case of Tcherne grade 1 or 2 soft



**Fig. 3.** MIPO application via anteromedial approach

tissue damage, single-stage surgery was performed. If concomitant fibula fracture existed, fixation performed with distal anatomic or 1/3 tubular plate in the first stage and simple ankle spanning external fixator (Tubular Circular Rod System, Tasarim medical, Istanbul, Turkey) was constructed with two Schanz screws to proximal tibia respected to future planned incisions and one Schanz screw to the calcaneus and medial cuneiform (Fig. 2). A three to four cm anteromedial or medial approach was used in this group. The articular reduction was obtained with traction and manipulation through the incision. Articular fragments were fixed temporarily with Kirschner wires. The appropriate plate length was determined according to fracture length, and then the plate was placed through the incision (Fig. 3). The alignment of metaphysis was corrected with closed manipulations and non-locking screws applied from proximal and distal fragments. Reduction and fixation of anterolateral and posterolateral fragments were performed through a limited stab wound with cannulated screws when needed. MIPO technique was the same between single-stage and double-stage surgeries. In the case of fibula fracture, in single stage group, a posterolateral approach was preferred to avoid soft-tissue complications.

#### **Postoperative Rehabilitation and follow-up:**

All patients received antibiotics for 24 hours and anti-thromboembolic prophylaxis for two weeks postoperatively.

For the first group, Pin-site care was made with antiseptic chlorhexidine solution daily. Partial weight-bearing was allowed postoperatively. The foot ring was removed at postoperative 6th week, and ankle ROM was initiated under the supervision of a physiotherapist. The system was removed entirely under sedation anesthesia when





**Fig. 4a.** Preoperative images of a patient in group 2



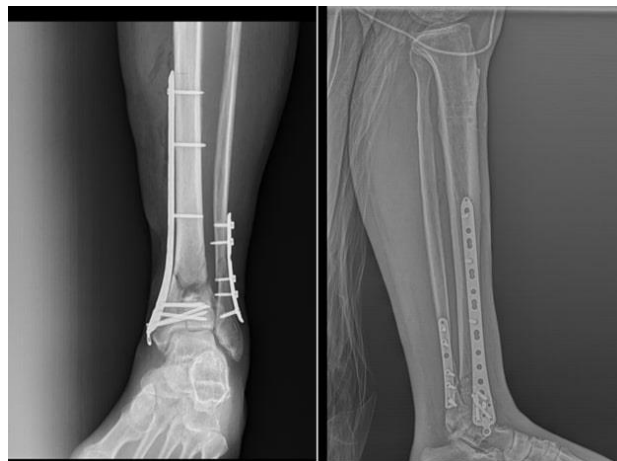
**Fig. 4b.** Preoperative CT images of the patient

the clinical and radiological union was completed (Fig. 1).

In the second group, the rehabilitation program was the same between single-stage and double-stage surgeries. For the first two weeks, the ankle was immobilized in a short leg cast to avoid soft-tissue complications. After two weeks, ankle ROM was initiated under supervision of a physiotherapist. Partial weight-bearing was allowed after 4<sup>th</sup> week and full weight-bearing was initiated after postoperative 8<sup>th</sup> week (Fig. 4).

A monthly follow-up protocol was performed for the first three months. Then, patients were seen in the outpatient clinic at three-month intervals until the postoperative 24<sup>th</sup> month.

**Outcome Measures:** Patient demographics, preoperative soft tissue conditions, mechanism of trauma, and concomitant injuries were evaluated. Soft tissue condition was classified based on the Tscherné classification (14). Postoperative reduction quality was evaluated according to the Ovadia criteria (15). Ovadia criteria consists of ankle and subtalar ROM, tibial alignment, tibial shortening, chronic swelling and deformity items. The result of each patient was



**Fig. 4c.** Postoperative images of the patient



**Fig. 4d.** Postoperative 12th-month images of the patient

classified as excellent, good, fair or bad based on those questions.

In the last visit, the American Orthopaedic Foot and Ankle Society (AOFAS)-Ankle and Hindfoot Score (16), Foot and Ankle Disability Index (FADI) (17), and the Visual Analogue Scale (VAS) score were obtained to evaluate the clinical and functional outcome. Ankle and subtalar joint ROM was measured using a universal goniometer to evaluate the clinical outcome. Postoperative radiographic osteoarthritis was evaluated according to Kelgren and Lawrence's OA staging system (18). The postoperative 15<sup>th</sup>-month radiologic outcomes were evaluated in Group 1 for standardization. Also, time to union and acute and chronic complications were recorded.

**Statistical Analysis:** The data were presented with mean, standard deviation (SD), median, lowest, and highest, frequency, and ratio. The Shapiro-Wilk test was used for the determination of the distribution of variables. The Chi-Square

test and Fischer exact tests were performed to analyze independent qualitative data. Mann Whitney-U test was used for the evaluation of independent quantitative data. The threshold for statistical significance was the P-value less than 0.05. SPSS v22 (IBM corp., Armonk, NY) was used for statistical analysis.

## Results

The mean age of the study population was  $45.5 \pm 14.7$  years (range, 18-77). Thirty-five patients were male (70%), and 15 female (30%) were female. Demographic findings of each group were presented and compared in Table 1. Eleven patients received single stage, 14 patients received two-staged treatment in group 2.

The comparison of AOFAS, VAS, and FADI scores hasis presented in Table 2. There was no difference between the ankle and subtalar ROMs between the two groups ( $P > 0.05$ ) (Table 3).

The postoperative reduction quality was similar in both groups ( $P = 0.25$ ). During the follow-up period, one patient from each group had nonunion. The patient from Group 1 was treated with fibula osteotomy and compression distraction, while the other patient who belonged to Group 2 was treated with revision surgery with a medial locking plate and autologous bone graft. The mean union time was similar in the two groups ( $3.87 \pm 0.9$  vs.  $3.75 \pm 0.8$  months, respectively) ( $P = 0.7$ ).

At the last follow-up, two patients from each group had Kellgren-Lawrence grade 1 osteoarthritis ( $p = 1$ ). Five patients from the first group (four-pin tract infection and one wound dehiscence) and two patients from the second group (one superficial infection and one wound dehiscence) had superficial wound complications. Those patients were treated with antibiotics and local wound care. The superficial wound complication rates were similar between the two groups (25 % vs. 10 %,  $p = 0.22$ ). Deep infection or osteomyelitis was not observed in any of the patients.

## Discussion

The main finding of the present study was that the treatment of Ruedi type 2 or 3 fractures with either Ilizarov external fixator and minimally invasive plate osteosynthesis have similar clinical, functional, and radiologic outcomes with high union rates as well as low complication rates.

For displaced intra-articular fractures, ORIF is a well-accepted method. Still, soft tissue problems after ORIF are common, and it can lead to catastrophic complications such as septic nonunion, arthrodesis, and even amputation. Therefore, treatment strategies focused on how to protect the soft tissue envelope as much as possible. The optimal treatment for displaced pilon fracture is still eristic. The main options are ORIF, MIPO, definitive external fixation with or without limited open reduction, and staged treatment (19). MIPO can provide rigid fixation of articular fragments with locking screws without disruption of soft tissue envelope. However, it is not always possible to fix all fragments with a single approach. Aneja et al. compared the capability of three different anterolateral plates to capture fracture fragments, and all of them failed to fix medial fragments (20). The Anteromedial approach is reliable for the reduction and fixation of the medial and anterior part of the joint, but the medial side is more vulnerable to soft-tissue complications. Kim et al. suggested using a combined anterolateral and medial approach in the second stage (21). They used small plates as a fixation tool. In the present study, we used the same approaches, but we preferred cannulated screws to fix the anterolateral fragment when needed.

The literature favors two-stage treatment to perform ORIF (22). Tang et al. investigated the outcomes of early and late ORIF, and they reported no difference in terms of functional, radiological outcomes, and complication rates (23). Temporary external fixation is an accepted method for two-stage treatment, but this method increases hospital stay and costs. In our study, the patients who had Tcherne grade 3 or open fractures received staged treatment in the MIPO group. Two patients experienced superficial wound complications in that group (one wound dehiscence and one superficial infection), and those patients were treated by local wound care and antibiotics.

Ring external fixators remain a safe choice for treatment of tibia plafond fractures (8). Ilizarov external fixator system allows distraction and ligamentotaxis with minimal soft tissue damage. Ring fixators provide adequate stability without excessive soft tissue damage (19). Internal fixation can be challenging in osteoporotic patients. Although Haller et al. reported similar failure rates in the elderly population who were treated with ORIF (24), dealing with soft tissue complications is more difficult in the elderly population.

**Table 1.** Demographic Details of The Study Population

		Group 1 (n=25)	Group 2 (n=25)	Total (n=50)	p
Mechanism of injury	High energy	19 (76%)	18 (72%)	37 (74%)	0.8
	Low energy	6 (24%)	7 (28%)	13 (26%)	
Fibula Fracture	+	23 (92%)	18 (72%)	41 (82%)	0.7
	-	2 (8%)	7 (28%)	9 (18%)	
Concomitant skeletal Injury	+	7 (28%)	5 (20%)	12 (24%)	0.8
	-	18 (72%)	20 (80%)	38 (76%)	
Tscherne Classification	2	9 (36%)	11 (44%)	20 (40%)	0.7
	3	7 (28%)	9 (36%)	16 (32%)	
Open fracture	Type 1	2	2	4	0.8
	Type 2	5	2	7	
	Type 3A	2	1	3	
Mean Follow-Up (mean ± SD)		25.3 ± 13.7	15.8 ± 5.5	20.4 ± 8.2	0.1

**Table 2.** Pain and Functional Outcome Scores

	Group 1 (n=25)	Group 2 (n=25)	p
AOFAS Score	76 ± 16.2	78 ± 18.6	0.21
VAS	76 ± 7.8	78 ± 8.2	0.50
FADI	78 ± 15.1	82 ± 9.3	0.11

AOFAS: American Orthopedic Foot and Ankle Society score, VAS: Visual Analog Scale, FADI: Foot and Ankle Disability Index

**Table 3.** Ankle and Subtalar Range of Motion (ROM) Values

		Group 1 (n=25)	Group 2 (n=25)	p
Ankle ROM (°)	Dorsiflexion	8.0 ± 2.4	10.0 ± 1.5	0.18
	Plantarflexion	32.6 ± 8.7	36.0 ± 7.5	
Subtalar ROM (°)	Inversion	12.0 ± 4.9	15.0 ± 1.6	0.72
	Eversion	8.0 ± 1.3	7.0 ± 0.9	

Iliopoulos et al. performed the Ilizarov external fixator to elderly pilon fractures, and they reported satisfactory results with low complication rates (25). The Ilizarov system allows early weight-bearing. Weight-bearing protects bone from osteopenia, and early mobilization reduces complication rates, especially in a population with high comorbidity (19). In our study, immediate partial weight-bearing was allowed to patients in the Ilizarov group. Most of the participants were male (70%), with a mean age of 45.5. Therefore, osteoporosis was of less concern in our population. One of the most significant advantages of the Ilizarov technique is that it is a single-stage operation. Especially in patients with high comorbidities, two operations increase

morbidity, and risks of two times anesthesia is another concern. We can speculate that Ilizarov can be suggested in elderly pilon fractures to avoid two operations and to allow earlier weight-bearing.

In their prospective study, Kapoor et al. treated 17 43-B and C fractures with the Ilizarov, and the mean AOFAS score was 79.8 at a mean follow-up of 29 months (8). Manegold et al. performed staged treatment on 27 patients, and the mean AOFAS score was 82.1, with a minimum of 2 years follow-up (26). In the present study, functional results were similar to the previous literature (27).

Treatment of co-existing fibula fractures when using a definitive external fixator remains a

debate, although some authors prefer fixing fibula before external fixator application (28). Williams et al. reported a significantly high rate of complications after fibula fixation with definitive external fixation, and they suggested left fibula unfixed for better results (29). In the present study, the fibula is left unfixed in the Ilizarov external fixation group. None of the patients showed fibular malunion or nonunion at the last follow-up.

In their study, Bicici and Bingol (12) compared the effectiveness of single stage, double stage and definitive external fixator options and they reported similar functional results in midterm period while soft tissue complications were higher in single stage group. In another study Rusldi et al. (31) analysed 91 distal tibia fractures and they tried to propose a algorithm for distal tibial fractures but they concluded that 'there is no single method of fixation that is ideal for all pilon fractures and suitable for all 'patients'. In the present study we did not find any differences between the two treatment options in terms of functional results, ROM and complication rates.

This study has some limitations to be acknowledged. The study has a retrospective design with a relatively small sample size and short follow-up. Prospectively designed studies including a larger sample size and longer follow-up period would give more precise data. Second, only medial plating was performed. Using different plating techniques or combined internal fixation constructs might give different results. Third, the outcomes in the fracture subgroups could not be evaluated due to small number of patients. Fourth, group 2 consists of single stage and double stage surgeries. This patients analysed as a single group which may cause bias as well.

Both MIPO and the Ilizarov techniques are effective and safe methods with low complication rates in the treatment of pilon fractures.

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