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External Fixation combined with Limited Internal Fixation versus Open Reduction Internal Fixation for Treating Ruedi-Allgower Type III Pilon Fractures

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Background: The optimal treatment of type III pilon fractures remains controversial. Hence, we performed this study to investigate whether open reduction and internal fixation (ORIF) is superior to external fixations combined with limited internal fixations (EFLIF).

Material/Methods: From January 2012 to October 2013, a total of 78 patients were included. Twenty-six patients underwent EFLIF and 52 patients underwent ORIF. All subjects were followed up at 1, 3, 6, and 12 months postoperatively. All outcomes and complications were recorded.

Results: No statistical differences were observed in Mazur score or ROM between the 2 groups. There were significant differences between the 2 groups in hospital stay ($P<0.001$), reduction results ($P=0.019$), screw loosening ($P=0.025$), and traumatic arthritis ($P=0.037$).

Conclusions: Similar functional outcomes were achieved in EFLIF and ORIF groups. Due to several limitations of this study, a well-designed randomized controlled trial involving more patients and long-term follow-up is needed to find an optimal treatment protocol.

MeSH Keywords: Ankle Fractures • External Fixators • Internal Fixators • Orthopedics

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Background

Fractures of the horizontal surface of the distal tibia involving high-energy ankle joint injuries are commonly described as pilon fractures. They account for about 1% of lower limb fractures and 3–10% of tibial fractures [1]. They usually result from a fall from a great height, industrial mishaps, traffic accidents, or injuries from participating in contact sports [2–5]. This comminuted fracture pattern is often accompanied by a severe soft-tissue injury caused by axial load and shear forces [6]. All these injuries may result in poor prognosis, including arthritis, osteomyelitis, infections, and skin necrosis. Therefore, treatment options for pilon fractures are crucial.

In 1969 pilon fractures were first divided into types I, II, and III by Rüedi and Allgöwer [7,8]: type I is an intra-articular fracture admitted minimal displacement, type II is a displaced intra-articular fracture admitted comminution, and type III is a significantly comminuted intra-articular fracture with displacement. The goal of treatment of pilon fractures is to reconstruct the anatomic joint, restore tibial alignment, provide fast soft-tissue healing, and facilitate bone union, which usually can restore satisfactory ankle function [7,9,10]. However, due to complex fractures that frequently involve soft-tissue injuries, the optimal strategy in the treatment of type III pilon fractures remains controversial.

In general, the most common surgical procedures for the treatment of type III fractures are external fixations (EF) usually combined with limited internal fixations, and open reduction and internal fixation (ORIF). The external fixations combined with limited internal fixations (EFLIF) procedure reduce blood loss and protect soft tissue, but result in poor restoration of articular surface and high rates of traumatic arthritis [11–13]. The ORIF procedure can achieve anatomical reconstruction of the articular surface and satisfying functional outcomes postoperatively while sparing the soft tissue [14–16].

Although previous studies [17–19] have reported varied results comparing ORIF and EFLIF procedures, the optimal management remains unclear. Moreover, because most of these studies included several types of pilon fractures, the evaluation of the treatment for type III fractures was unclear. Therefore, we conducted this study to evaluate the clinical outcomes of type III fracture patients treated with ORIF or EFLIF combined with limited internal fixation.

Material and Methods

This retrospective study was approved by the Beijing Army General Hospital Institutional Review Board. We set the following criteria to identify suitable subjects: 1) diagnosed with type III pilon fractures according to trauma history, imaging database, and operating room records; 2) underwent EFLIF or ORIF procedure for the treatment of the fractures; 3) followed up for at least 1 year; and 4) age 18–70 years. Patients were excluded if they had the following: 1) pathological fracture or other fractures affecting the ankle function; 2) diabetes, cancer, or immunodeficiency; 3) follow-up of less than 24 months; or 4) lack of follow-up information. Informed written consent was obtained from each subject. We also excluded those who had bilateral pilon fractures. All fractures were categorized according to the Rüedi-Allgöwer system [7]. All patients with limb swelling were treated with mannitol.

From January 2012 to October 2013, 194 patients with fractures of the distal tibia were admitted to our center. A total of 108 patients met the inclusion criteria. Twenty-six out of 108 patients were treated with EFLIF procedure (EFLIF group). A 1:2 ratio matched-pair group was produced from the remaining 82 subjects based on age within 2 years, sex, and body mass index (BMI). All data including patient demographics and operative data were extracted from the patient records and hospital records. Clinical evaluations were performed soon after the operation and 1 year postoperatively. Radiographic data were evaluated separately by 2 senior professors.

All operations were performed by a single fellowship-trained and experienced surgeon. The EFLIF procedure is described by Marin et al. [20]. The ORIF procedure was performed on patients with type III fractures according to the published study by Egol et al. [21]. All patients underwent at least 5 days of limb-swelling treatment before the operation. After the operation, mannitol treatment was continued for at least 4 days. All patients received a similar rehabilitation protocol postoperatively. EFLIF patients could not move the ankle until postoperative week 4. Patients treated with ORIF were immobilized in a plaster slab and were encouraged to perform early passive exercises on postoperative day 10. Weight-bearing was allowed according to radiographic signs of union assessed by a radiographic specialist, usually at 12 weeks postoperatively. Patients were allowed to perform partial weight-bearing at 8–12 weeks postoperatively.

All patients were followed up at 1 month, 3 months, 6 months, and 1 year after surgery. Recovery status of patients was recorded. Anteroposterior and lateral views assessed by a radiographic specialist were categorized as “anatomic,” “acceptable”, or “poor”. Implant position changes, fixation failures, ankle range of motion (ROM), postoperative complications, Mazur score [22], incidence of traumatic arthritis, and the satisfaction of patients were recorded. Delayed union was defined in case of lack of formation of callus on plain film in postoperative month 4. Nonunion was identified when atrophic union or hypertrophic nonunion was found on films and patients complained of pain at

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Table 1. Patient demographic characteristics.

	Group A	Group B	*P* value
Sample size (n)	26	52	–
Age (years)	41.2±9.6	40.7±10.1	.834
Gender (f/m)	8/18	14/38	.722
Body mass index (kg/m^2)	23.9±4.2	23.6±3.9	.755
Side, No. left/right	10/16	17/35	.614
Smoking status	13 (50%)	24	.748
Detail of trauma, No			–
Fall	9 (35%)	15 (29%)	–
Traffic accident	17 (65%)	37 (71%)	–
Soft tissue			.818
Open	9 (35%)	15 (29%)	–
Closed	17 (65%)	37 (71%)	–
Time from injury to operation (d)	3.9	9.7	–
Follow-up (m)	14.2	15.7	–

the fracture site 6 months after the operation [23,24]. Patients could receive a maximum score of 100 points using the Mazur scoring system, including pain (50 points), walking distance (6 points), claudication symptom (6 points), applications of supports (6 points), the ability to climb a hill (6 points), the ability to walk up and down stairs (6 points), the ability to run (5 points), the ability to do toe raises (5 points), and the range of motion (dorsiflexion and plantarflexion) (10 points). Arthritis evaluation was classified into 4 grades according to the Kellgren-Lawrence grading scale [25]: 1) doubtful narrowing of joint space and osteophytes; 2) definite existence of osteophytes and narrowing of joint space; 3) moderate multiple osteophytes, sharp narrowing of joint space, subchondral sclerosis and possible bony deformity; and 4) large osteophytes, severe narrowing of joint space, marked sclerosis, and definite bony deformity.

All statistical analyses were conducted with SPSS version 17.0 software. The outcomes between the 2 groups were evaluated by the 2-tailed unpaired t test. The comparisons of continuous data, which were presented as mean ± standard deviation (SD), were conducted with the independent samples t test. Categorical variables were analyzed using the chi-square test. A P value of less than 0.05 was considered significant.

Results

Data collected on the subjects are presented in Table 1. A total of 78 patients (78 ankles) were included in this study. Twenty-six patients (EFLIF group) with EFLIF surgical treatment were followed up at an average of 14.2 months (range, 12 to 21 months), and the remaining 56 (The ORIF group) whose follow-up lasted an average of 15.7 months underwent ORIF surgery. With respect to age, sex, BMI, and smoking status, there were no significant difference between the 2 groups. Twenty-four injuries were open fractures (9 in the EFLIF group and 15 in The ORIF group).

The clinical and radiographic examination results of the subjects are displayed in Table 2. Regarding Mazur score (A, 79.2±10.6, and B, 81.5±11.4, respectively; P=0.392) and ROM, no statistical difference were observed between EFLIF and ORIF groups. Although there was no difference in the time for bone union between the 2 groups (P=0.100), the ORIF group had a relatively shorter time for bone union. We found no significant difference between the 2 groups in operative time and patient satisfaction. The EFLIF group had shorter mean hospital stay than the ORIF group (P<0.001). However, better reduction results were achieved in the ORIF group (P=0.019), compared the EFLIF group.

Table 3 lists all complications for the 2 treatment groups. Compared with the ORIF technique, the EFLIF procedure significantly decreased intraoperative blood loss (P<0.001). However, higher incidences of screw loosening (P=0.025) and traumatic arthritis (P=0.037) were observed in patients treated with EFLIF surgery. With respect to infection, no statistical difference was shown between the 2 groups. A total of 8 patients had malunion (5 in the EFLIF group and 3 in the ORIF group). There were 7 patients with delayed union (4 out of 7 in the EFLIF group and 3 in the ORIF group. All of the delayed union patients were encourage to perform weight-bearing and functional exercises and all finally healed by postoperative month 9.

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Table 2. Clinical outcomes intraoperatively and postoperatively.

	Group A (n=26)	Group B (n=52)	*P* value
Mazur score	79.2±10.6	81.5±11.4	.392
Time to bone union (m)	5.6±2.2	4.9±1.5	.100
Hospital stay (d)	7.7±3.1	16.1±4.5	<0.001*
Operative time (min)	75.67±12.16	78.6±9.7	.250
Reduction results (n)			.019*
Anatomical	12 (46%)	38 (73%)	–
Acceptable	11 (42%)	11 (21%)	–
Poor	3 (12%)	3 (6%)	–
ROM			
Dorsiflexion	13.6±5.8	14.1±5.9	.723
Plantarflexion	23.8±9.7	26.9±10.8	.218
Satisfaction			.667
Excellent/good	21 (81%)	44 (85%)	–
Fair/poor	5 (19%)	8 (15%)	–

ROM – range of motion; * *P* value was considered significant.

Table 3. List of all complications for the two treatment groups.

Complication	Group A (n=26)	Group B (n=52)	*P* value
Blood loss (mL)	105.3±11.76	159.4±14.27	<0.001*
Screw loosening	5	2	.025*
Overall infection			.067
Superficial infection	5	3	–
Deep infection	3	4	–
Skin necrosis/tensity wheal	2	5	.779
Traumatic arthritis			.037*
1	8 (31%)	19 (36%)	–
2	10 (38%)	27 (52%)	–
3	5 (19%)	5 (10%)	–
4	3 (12%)	1 (2%)	–
Bone union			–
Nonunion	0	0	–
Malunion	5 (19%)	3 (6%)	–
Delayed union	4 (15%)	3 (6%)	

* *P* value was considered significant.

Discussion

We found no differences in functional outcomes between the 2 groups, such as Mazur score and ROM. However, the EFLIF procedure showed its strength in shorter hospital stay and better control of blood loss, but the ORIF procedure significantly decreased the incidence of traumatic arthritis and screw-loosening and more closely restored normal ankle anatomy.

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Fractures of the horizontal surface of the distal tibia were first described as "pilon fracture" by the French radiologist Destot [26]. The outcomes of these fractures in the past were quite poor due to the lack of treatments. In 1969, Rüedi and Allgöwer introduced a new technique in the treatment of pilon fractures [8]. In their series of studies, the technique achieved anatomical restoration of the articular surface and significantly improved functional outcome. However, low-energy injuries accounted for the majority of fractures (73%). Type III pilon fractures are high-energy tibial intra-articular injuries frequently with displacement and soft-tissue injuries, and are so complex that treatment is a great challenge the trauma surgeon. A previous study by Teeny et al. [27] reported that patients treated with ORIF had a 70% complication rate and 26% fusion rate. Some researchers recommend ORIF because of its reliable anatomical restoration of the articular surface. Nevertheless, due to the potential for soft-tissue complications with ORIF, many surgeons choose EFLIF as the primary treatment [13,27–29]. Although many studies have compared EFLIF versus ORIF for the treatment of pilon fractures, the optimal management for type III fractures remains controversial.

Davidovitch et al. [11] reported comparable outcomes between the 2 procedures, except for a higher bother index as identified on the short musculoskeletal function assessment in the ORIF group. Pollak et al. [30] found poorer ankle ROM and greater ambulatory dysfunction in those patients treated with EFLIF compared to those treated with ORIF. However, our findings in this study were that there was no difference between the 2 groups in this regard. Barbieri et al. [12] and Bone et al. [13] reported better clinical outcome with EFLIF than with ORIF. The conflicting results among these studies may result from multiple factors, such as study design, inclusion criteria, and follow-up period.

As important outcome measures, postoperative complications need serious evaluation. In a surgeon-randomized study, Wyrsch et al. [31] demonstrated that EFLIF had an increased complication rate compared to ORIF. It is reported that the most common complication is infection. In this study, a total of 15 patients with infection accounted for 19% of 78 subjects. This higher infection rate might be due to the high-energy rotational type of pilon fracture. In a study by Helfet et al. [32], an impressive infection rate of 9% was observed in 32 high-energy fractures treated with ORIF (26 cases) or EFLIF (6 cases). In addition, prolonged use of EFLIF may result in pin-track infection [33]. Moreover, posttraumatic arthritis is an important evaluating indicator. Various factors, such as comminution of the articular surface, the sustained infection, soft-tissue injury, surgical method, and postoperative complications, may result in degenerative changes [34–36]. In this study, we found an increased incidence of posttraumatic arthritis among the patients treated with EFLIF, compared with those treated with ORIF. However, Wyrsch et al. [31] considered that the progression of arthritis might be associated with the type of fracture, not with the treatment received.

In the present study, there are several limitations that need to be considered. First, it should be noted that this was a retrospective analysis, which might reduce the strength of the study. Second, the follow-up period was too short to assess long-term effects of the 2 surgical treatments. Third, the relatively small sample size may affect the statistical power. Finally, some bias may have existed in the selection of the technique due to the choice of surgical procedure depending on the surgeon's preference.

Conclusions

We found no differences in functional outcomes between the 2 groups. Although EFLIF resulted in decreased hospital stay and intraoperative blood loss after the procedure, ORIF had better results for reduction, incidence of screw-loosening, and posttraumatic arthritis. A well-designed randomized controlled trial comparing these 2 treatment strategies is urgently needed to identify the optimal treatment protocol.

Competing interests

The authors declare that they have no competing interests.

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