Comparison Between the Modified External Fixation and Calcaneal Traction in Ruedi-Allgower Type II/III Pilon Fractures

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Data Collection B
Statistical Analysis C
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Background: To compare the effect of modified external fixation and calcaneal traction in a staged management of Ruedi-Allgower type II/III tibial pilon fractures.

Material/Methods: The data of 62 patients with Ruedi-Allgower type II/III tibial pilon fractures who were treated in Liuzhou People's hospital from January 2017 to December 2018 were extracted in this retrospective analysis. There were 32 patients in the temporary external fixation (TEF) group and 30 patients in calcaneal traction (CT) group. Outcomes, including the duration of the surgical procedure, pin track infection, degree of limb swelling, time to second-stage operation, postoperative comfort score, and visual analog scale (VAS) score, were compared.

Results: The effective rate of swelling reduction after treatment was 85% in the TEF group and 60% in the CT group; the average time to the second-stage operation was 8.34±1.29 days in the TEF group and 10.60±2.27 days in the CT group; the postoperative comfort scores were 70.1±3.2 and 61.3±3.5 in the TEF group and CT group, respectively; the postoperative VAS scores at 24 h, 48 h, and 7 days were 7.90±1.06, 4.88±0.83, 2.72±1.14 in TEF group, and 8.50±0.86, 6.27±1.36, 3.57±1.19 in CT group, respectively. There were 1 case of pin tract infection identified in the TEF group and 4 in the CT group. All differences were statistically significant ($P<0.05$).

Conclusions: The modified external fixation is more effective than calcaneal traction in treatment of Ruedi-Allgower type II/III tibial pilon fractures in the first-stage of combined management.

Keywords: Anesthesia, Conduction • External Fixators • Tibial Fractures • Traction

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Background

Fracture of the distal tibial plafond, also termed pilon fracture, is caused by high-energy axial compression force of the tibia, driving vertically into the talus [1-3], which accounts for about 5% of tibial fractures [4,5]. Described by the Ruedi and Allgower X-ray classification scheme, tibial pilon fractures can be specified into 3 categories according to the size and displacement of articular fragments [6]. Type I fractures are defined as nondisplaced "cleavage fractures" of the tibial plafond, whereas type II and type III fractures are defined as simple displacement to substantial comminution of the articular surface. Serious ankle injuries often result from high-energy trauma such as war wounds or fall from a height, and the surgical choices varies based on the severity of bone defect [7-9]. Management of tibial fractures is a great challenge for orthopedic surgeons, particularly for the Ruedi-Allgower type II and III pilon fractures, due to the severe impaction of the distal tibia and soft tissue damage [10,11].

Although various operations have been proposed to treat tibial pilon fractures, no consensus has been achieved. From the perspective of soft tissue preservation, staged surgical reconstruction remains the standard treatment for the management of high-energy pilon fractures owing to its good management of both the osseous and soft tissue elements of the injury [12-15]. This management includes applications of a temporary spanning external fixator or calcaneal traction at the early stage, followed by open reduction and internal fixation (ORIF) once the surrounding soft tissues are amendable.

The temporary external fixator is relatively stable to fix the fractured end, but it needs to be implemented under general anesthesia or spinal anesthesia. In such instances, this approach would result in an increased financial cost and would potentially increase the risk from anesthesia. Therefore, our institution managed to modified this approach by using a simplified external fixation combined with regional anesthesia in the early stage of management to reduce the damage from anesthesia. In regards to the calcaneal traction, axial traction at the fracture site aids in recovering the limb length and alignment while reducing pain and providing favorable conditions for the elimination of swelling [16]. However, although it is easy to conduct, patients tend to become less physically active due to the unstable fixation of the fractured end.

To the best of our knowledge, no previous study has directly compared the effect of temporizing external fixation under regional anesthesia with calcaneal traction in staged management. In view of this, we retrospectively compared the treatment of modified external fixation and calcaneal traction before ORIF for Chinese patients with Ruedi-Allgower type II and III pilon fractures.

Figure 1. Modified external fixation.

Material and Methods

Study Design and Participants

In the period between January 2017 to December 2018, patients with Ruedi-Allgower type II/III pilon factures who were diagnosed and treated in Liuzhou People's hospital were analyzed in this retrospective cohort study. Inclusion criteria were: 1) adults older than 18 years; and 2) unilateral Ruedi-Allgower type II/III pilon fractures with newly closed fractures (injured <48 h). Exclusion criteria were: 1) skin damage at the pin penetration site at admission; 2) severe soft tissue injury; and 3) complicated with diabetes and severe heart failure. The study was approved by the Ethics Committee of our hospital. Informed consents were waived due to the retrospective nature of this study.

Treatment Procedure

Patients were grouped according to the surgical procedures they received. In our institution, the routine steps of modified external fixation (MEF group) were as follow. The patient was in the supine position, the affected limb was routinely disinfected, covered with a sterile drape, and local anesthesia was performed on the tibial tubercle and the inner and outer sides of the calcaneus with 1% lidocaine. A 3.5-mm Schanz wire was drilled into the tibial tubercle and calcaneus. Then, the connecting rod was installed. A proximal buckle was tightened and pulled to the distal end to reposition the fixator, the device was placed as an angular deformity, and we tightened the distal buckle of the fixator (**Figure 1**). In the calcaneal traction (CT group), the following steps were performed. We selected the midpoint of the line between the tip of the medial malleolus and the posterior inferior edge of the calcaneus as the puncture site. After sterilizing the drape, we used 1% lidocaine for internal and external local anesthesia, and inserted a 4.0 bone round needle from the medial to the lateral penetrate the skin with a bone hammer to penetrate the calcaneus, and

Figure 2. Calcaneal traction.

then connected the bone traction bow device. The weight of the traction was 1/7~1/10 of the patient's weight (**Figure 2**). After the operation, both groups had the affected limb elevated, we changed the dressing frequently, and kept the local incision dry. X-rays were reviewed for the assessment of reduction of fracture 24 h after first-stage surgery. All patients were asked to stay in bed and remain in the hospital for the evaluation of outcomes. The determination to proceed with the later stage of ORIF was made by the treating surgeon whenever the soft tissue was deemed amendable.

Data Collection

The patients' demographics (eg, age, sex), the fracture classification according to Ruedi-Allgower, causes of injury, degree of limb swelling, time from injury to surgical procedure, and duration of operation were recorded. Preoperative limb swelling was defined as Degree I: the skin of the affected limb is tighter than normal skin, but dermatoglyphs present; Degree II: the skin of the affected limb is tighter than normal skin, and the streak disappears, the skin temperature is slightly higher than normal, but no tension blisters appear; and Degree III: the skin of the affected limb was tense and shiny, the streak disappeared, the skin temperature increased significantly, and tension blisters appeared.

Follow-up and Outcomes

Outcomes were evaluated by one senior surgeon at each postoperative visit. Clinical evaluation included the reduction of the swelling, pin site infection, and time from treatments to ORIF. The evaluation for the reduction of swelling was frequently used in the literature among Chinese patients, which was recorded as markedly effective [17]: swelling reduction time <3 days; effective: swelling reduction time 3~6 days; and invalid: swelling reduction time >6 days, the total effective rate was calculated by (markedly cases+effective cases)/total cases×100%.

The 28-item shortened General Comfort Questionnaire (GCQ) developed by Kolcaba in 2003 was used to measure the postoperative comfort score, which had been translated in a Chinese version to adapt to the target audience [18]. The questionnaire measures comfort in 4 contexts (physical, psychospiritual, social, and environmental) based on a 4-point Likert-type scale ranging from "Strongly Disagree" to "Strongly Agree". A higher score indicates a higher level of comfort. Patients were also asked to subjectively report their postoperative pain level at rest on a visual analog scale (VAS) in 1-digit increments from 0, "none" to 10, "disabling" at 24 h, 48 h, and 7 days after the operation.

Statistical Analysis

All analyses were performed in SPSS version 17.0 (Chicago, IL, USA). The normality of data distribution was tested by Kolmogorov-Smirnov test. Continuous variables are expressed as means±standard deviation or medians (IQR), as appropriate for the data distribution. Group differences were assessed by independent-samples t test or Mann-Whitney U test. Categorical variables are expressed as the number of cases or the percentages (%). Chi-squared or Fisher's exact tests were used for assessing the differences between groups. A P value less than 0.05 was considered to be significant.

Results

Study Population and Patient Characteristics

Of the 62 patients (34 males and 28 females) whose age ranged from 20 to 62 years, 32 patients were grouped into the MEF group and 30 patients into the CT group. The characteristics of the patients in the 2 groups are summarized in **Table 1**. No significant differences were observed between the 2 treatment groups (all P>0.05, **Table 1**).

Status of Postoperative Swelling

Twenty-one patients were grouped to Degree II according to the preoperative evaluation for the degree of swelling. Of the 10 patients in the MEF group, 3 were evaluated as markedly effective and 7 were evaluated as effective, in terms of the postoperative swelling reduction. For the 11 patients in the CT group, the reduction of swelling in 2 patients was evaluated as remarkably effective, 5 were effective, and 4 were ineffective. Of the 41 patients who were at Degree III of preoperative swelling, 22 patients were in the MEF group and 19 patients were in the CT group. In MEF group, there were 2, 15, and 5

Table 1. Characteristics of the patients.

	TEF group (N=32)	CT group (N=30)	P
Age, year	44.13±11.95	43.80±13.25	0.972
Male, %	17 (53.1)	17 (56.7)	0.806
Ruedi-Allgower type, %			0.511
Type II	11	8	
Type III	21	22	
Cause of injury, %			0.605
RTA	14	13	
FFH	15	16	
SAS	3	1	
Degree of swelling			0.653
Degree II	10	11	
Degree III	22	19	
Time from injury to surgical procedure, hours	7.12±2.28	6.80±2.51	0.595
Duration of operation, min	11.2±1.3	10.2±1.1	0.583

TEF – temporary external fixation; CT – calcaneal traction; RTA – road traffic accident; FFH – fall from a height; SAS – serious ankle sprain.

Table 2. Outcome assessments for swelling subsided by fracture type of patients.

	TEF group (N=32)	CT group (N=30)	P
Type II			0.900
Markedly effective	3	2	
Effective	7	5	
Invalid	0	4	
Type III			0.160
Markedly effective	2	1	
Effective	15	10	
Invalid	5	8	
Total effective rate	84%	60%	0.032

TEF – temporary external fixation; CT – calcaneal traction.

patients evaluated as remarkably effective, effective, and ineffective, respectively. In CT group, there were 1, 10, and 8 patients evaluated as remarkably effective, effective, and ineffective, respectively. The total effective rate was significantly better in the MEF group compared to the CT group (84% vs 60%, P=0.032, **Table 2**).

Pin Site Infection

Pin site infection occurred in 1 and 4 patients from the MEF group and CT group, respectively. The percentages of occurrence were statistically higher in the CT group compared to the MEF group (13.3% vs 3.1, P=0.189, **Table 3**).

Time to ORIF

The average times from treatment to ORIF were 8.34±1.29 days and 10.60±2.27 days in the MEF group and CT group, respectively, which differed significantly (P<0.001, **Table 3**).

Postoperative Comfort Score and VAS Score

The total comfort scores were 70.1±3.2 and 61.3±3.5 in MEF group and CT group, respectively (P<0.001). Compared to patients in the CT group, the comfort scores were significantly higher in the MEF group at each individual level (all P<0.05). Regarding the subjectively reported pain level, the VAS scores

Table 3. Postoperative outcomes.

	TEF group (N=32)	CT group (N=30)	P
Pin site infection, %	1 (3.1)	4 (13.3)	0.189
Time to ORIF, days	8.34±1.29	10.60±2.27	<0.001
Comfort score			
Physical	12.9±1.1	10.8±1.5	0.010
Psychospiritual	25.2±1.8	21.3±1.1	<0.001
Social	17.2±1.7	15.9±1.6	0.020
Environmental	15.6±1.2	13.2±1.7	0.010
Total	70.1±3.2	61.3±3.5	<0.001
Postoperative VAS score			
24 hours	7.90±1.06	8.50±0.86	0.022
48 hours	4.88±0.83	6.27±1.36	<0.001
7 days	2.72±1.14	3.57±1.19	0.010

TEF – temporary external fixation; CT – calcaneal traction; ORIF – open reduction and internal fixation; VAS – visual analog scale.

were significantly lower in the TEF group compared to the CT group at 24 h, 48 h, and 7 days after the treatment, respectively (all P<0.05, **Table 3**).

Discussion

This retrospective cohort study compared the effect of modified external fixation and calcaneal traction priori to ORIF for Chinese patients who were injured within 48 h and classified into Ruedi-Allgower type II and III tibial pilon fractures. The results suggested a significantly higher effective rate in terms of the swelling reduction in the MEF group compared to the CT group, irrespective of the Ruedi-Allgower type. The cases of pin site infection, time to proceed to ORIF, the total postoperative comfort score, and VAS score were also found to be significantly better in the MEF group.

In the context of lower-limb fractures, assessments of feasibility and quality of life, including the reduction of fracture, infection and union complication, soft tissue recovery, and functional outcomes, were commonly evaluated in the literature [19,20]. Various clinical studies have discussed the conventional strategies such as intramedullary nailing, locked plate, and external fixation in terms of the effectiveness in tibial or peroneal factures [21,22]. However, although all strategies were valid, the results indicated a comparable clinical outcome in the treatment of these fractures. A staged therapeutic strategy that considered the early application of temporary external fixation to avoid aggravating joint trauma and peripheral soft tissue injury was first introduced to treat high-energy fracture by Rotondo et al in 1993 [23]. Although multiple approaches are viable for pilon fractures, temporary external fixation in the

staged approach allows for excellent restoration of anatomical structure of articular and fracture-dislocation of the ankle, with less medial soft tissue damage and low complication rates [24]. Soft tissue injury is an important reference when determining the optimal timing of internal fixation surgery, and swelling is a direct indicator. In this study, both groups presented promising results in the total effective rate of swelling reduction (MEF group: 84%, CT group: 60%). The duration from treatment to ORIF also indicated the swelling was notably reduced in both groups (MEF group: 8.34±1.29 days, CT group: 10.60±2.27 days). In a study on the staged treatment of pilon fractures, Zelle et al [11] stated that severe soft tissue injuries usually require a transitional stage of 1-4 weeks. Canton et al [25] reported that internal fixation can be attempted for tibial fractures combined with soft tissue injuries 2-13 days after the injury. A retrospective review [26] that investigated the treatment results of 35 Chinese patients with Ruedi-Allgower type I to type III pilon fractures reported an average of 11.8 days (range: 8-16 days) from external fixation or traction of calcaneal tubercle to definite initial fixation, which is congruent with the results of our study.

Regarding pin site infection, it is difficult to compare our results with other published series since many articles did not break down their infection type, but usually reported the superficial infection, which showing minor infection rates to 80% [27-29]. Despite a lack of research in this field, we found a recent study [30] analyzing a series of 402 patient who underwent external traction fixation in the staged management of tibial fracture, which found a relatively lower incidence of pin site infection compared to our study (0.2% vs 3.1%); this might be explained by the milder impairment on the tibial fractures in patients in their study. In addition, the process of

regional anesthesia in the MEF group was not conducted in a sterilized operating room, which might also account for the higher incidence of pin site infection.

In 2017, Manoli et al [31] concluded that the use of regional anesthesia in treatment of tibial plateau fractures is associated with decreased pain levels in the early postoperative period (<3 months). For tibial pilon fractures, there was a significant difference between the MEF group and CT group in the VAS scores as well as the comfort scores. It should be noted that the VAS scores in each follow-up visit were lower in the MEF group compared to the CT group, indicating patients in the MEF group had less pain compared to patients in the CT group and therefore might require fewer pain-reducing medications during management. This assumption might be inconclusive since previous studies [32,33] have not demonstrated a significant improvement in pain reduction comparing with external fixation in a 2-stage approach vs other treatment procedures.

Limitations of this study include the retrospective design and small sample size, which might reduce the strength of the study. Second, although no significant differences were found between the groups in patient characteristics, we did not conduct a multivariate analysis to balance the potential effect from other covariates because we felt the relatively small sample size may affect the statistical power of regression analysis. Some bias may have existed in the selection of the technique due to the choice of surgical procedure depending on the surgeon's preference. Finally, outcomes after the second-stage of this staged management that reflect patient ability to function and their quality of life were not assessed in this study.

Conclusions

Our results suggest that the simplified temporizing external fixation under regional anesthesia is superior to calcaneal traction in the first stage of combined management for Chinese patients with Ruedi-Allgower type II/III tibial pilon fractures. However, due to the insufficient sample size in this retrospective study, the results might be biased and should be validated in a prospective study with a larger sample size.

Conflicts of Interest

None.

Declaration of Figures Authenticity

All figures submitted have been created by the authors, who confirm that the images are original with no duplication and have not been previously published in whole or in part.

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