Treatment of high-energy pilon fractures with external fixation as a method of minimal invasive approach - long term results

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INTRODUCTION

High energy pilon fractures present a unique challenge to the patient and orthopaedic surgeon. Care for the soft tissue envelope is as important as management of this articular fracture. This article presents long term results of patients suffered type C pilon fractures treated with the method of external fixation with minimal invasive approach. We observe a total of fifty five patients, between August 2008 and January 2015, underwent external fixation of type C pilon fractures with minimal invasive approach at Clinic of Orthopaedic and Traumatology, Clinical center Niš, Serbia. Infectious complications secondary to wound healing problems are a major concern after open surgery for pilon fracture. Therefore, soft-tissue management is critical for successful operative treatment of these fractures. According to our long term results in the present study, it seems that external fixation represent a rational approach to obtain and maintain alignment of the distal tibia through ligamentotaxis, thereby avoiding formal open reduction for treatment of the patient with severe pilon fracture.

Key words: pilon fracture, high energy fractures, external fixation

MATERIAL AND METHODS

55 patients with 55 tibia pilon fractures were treated at our clinic. The indications for an operation included unacceptable alignment of the fracture with incongruity of the articular surface of more than 2 mm or an open fracture. The mechanism of injury was vehicle accidents in 33 patients (60%), high-energy falls in 13 patients (23.6%) and sports injuries in nine patients (16.4%). The mean age was 45.4 years (22–76) SD 12.6 and the mean follow-up 76 months (36–132) SD 86.4. Thirty-two patients (58.1%) were rural workers. Three operative procedures were performed: external fixation with ankle spanning, external fixation with ankle sparring or two staged internal fixation. All the patients were managed by one of three surgeons who were on call. Each surgeon performed one treatment protocol only. Each surgeon had the same number of calls every month. All the surgeons were trained in trauma. All the patients were prospectively contacted and asked to return to the hospital for assessment of long-term outcome. During this last evaluation, they were examined clinically and radiographically. All the patients underwent a range of motion measurements and radiographic evaluation. Fractures classified according the AO-ASIF system. Sixty-five percent (n = 36) were Type C injuries (14 Type C1, 16 Type C2 and 6 Type C3), and 35% (n = 19) were Type B (15 Type B2 and 4 Type B3). In all patients, there was a concomitant fracture of the fibula that was classified according to
Weber classification (45 Type B and 10 Type C). There were 24 open and 31 closed fractures. Closed soft tissue was classified in the manner described by Tscherne and open soft tissue damage was graded according to Gustilo and Anderson references. All the patients were initially evaluated in the emergency room. Plain radiographs were taken and CT scan was used in all Type C fractures. Forty patients underwent primary surgery within 24 h of injury. The remaining had surgery after soft tissue recovery within 10–12 days from injury.

Open fractures were treated with immediate debridement and stabilization, either temporary or definite. All the patients received preoperatively antibiotics. All the patients were seen after the exit of the hospital at 1 week, at 1 month, monthly for 12 months and then annually. Each patient underwent a range of motion measurement, stair-stepping ability and radiographic evaluation.

Fracture union was defined as having three cortices bridging on the plain radiographs for a patient who was able to bear full weight. Nonunion was defined as a fracture that did not heal within a year. Malunion was defined as the incongruity of the articular surface of more than 2 mm or malalignment greater than 10° in any plane. Three surgical protocols were used.

In 20 patients, Group A (7 Type B, 13 Type C, 2 II-a-two I) with mean age 42.0 years (22.0–74.0) SD 14.1 and mean follow-up 77.7 months (38.0–132.0) SD 25.4, a half pin external fixator with ankle spanning was performed (Fig. 1). The external fixation was applied on the calcaneus. After radiographic appearance of union, the hardware was replaced with partial weight-bearing cast for 10 days. The fibula fracture was always internally fixed with a plate.

In 22 patients, Group B (4 type B, 18 Type C, 5 I-two II) with mean age 48.4 years (28.0–76.0), SD 12.4 and mean follow-up 67.9 months (36.0–132.0), SD 27.8, a single ankle sparring ring hybrid external fixator with tensioned wires was performed (Fig. 2). After primary reduction and plating of the fibula, reconstruction of the articular surface of the tibia was performed through a small anterior arthrotomy. After the surgery the patients used a splint for 2 weeks. In both Groups A and B, the patients were not allowed to bear weight until the fracture had adequately consolidated.
In 13 patients, Group C (eight Type B, five Type C, five I-three IIIa) with mean age 45.69 years (30–66), SD 9.76 and mean follow-up 78.62 months (55–132), SD 25.47 a two-staged internal fixation was performed with an periarticular plating system according to the AOASIF principles (Fig. 3).

All the patients underwent immediate fibular fixation and placement of a medial spanning external fixator. After, on an average, 12 days (11–16), the patients underwent removal of the external fixator and internal fixation of the fractures. Via a short distal skin incision, the plate is introduced subcutaneously, pushed proximally and fixed by screws inserted via stab incisions. The hardware was removed 2 years after the primary surgery. The demographic data are shown in Tables 1, 2, 3.

**RESULTS**

**MECHANISM OF INJURY**

There were 16 patients in group A who were involved in traffic accidents, three who had fallen and one who was involved in a sports injury. In group B, ten patients were involved in traffic accidents, nine had fallen and three were involved in sports injury. In group C, seven patients were involved in traffic accident, one had fallen and five were involved in sports injury.

**FRAC TURE PATTERN**

There was significant relationship between the type of fractures - 77.8% type C from traffic accidents and the mechanism of injury ($\chi^2 = 15.07; P = 0.001$). When the mechanism of injury was traffic accidents, the most com-
mon fracture was type C, while type B fractures were more common in sports injuries.

There was a statistically significant difference ($P < 0.003$) in the treatment of type C fractures because external fixation was used in 50% of them.

**OPEN FRACTURES**

There was significant relationship between the type of fractures -91.7% of open fractures were from traffic accident — and the mechanism of injury ($\chi^2 = 17.816, P < 0.001$).

**FRACTURE UNION**

Fracture union was achieved in 5.9 months (4.0–11.0), SD 1.7. Group A had union in 6.9 months (4.0–11.0) SD 2.4 months, group B in 5.6 months (4.0–9.0) SD 1.1 and group C in 5.1 months (4.0–6.0) SD 0.5. In group A, there were four delayed unions in 11 months. There was significant relationship between the type of fixation—external fixation 6.9 months—and the time of union ($P = 0.009$). According to the post-hoc comparisons, Group A had longer time until union as compared to both Group B and C ($P = 0.046$ and $P = 0.013$, respectively), while there was no significant difference regarding time to union between Groups B and C ($P = 0.688$). In stratified statistical analysis by type of fracture, the mean union time in type B was as follows: Group A mean 6.7, SD 1.7; Group B mean 6.0, SD 0.8; and Group C mean 5.2, SD 0.4; $F = 3.065, P = 0.07$. Similarly, within fracture type C we had the following union time: Group A mean 7.0, SD 2; Group B mean 5.5, SD 1.1; Group C mean 5.0, SD 0.7; $F = 2.905, P = 0.06$. Therefore, the associations noted for both fracture groups combined were also noted separately within each fracture group.

Twelve fractures in group A, nineteen in group B and ten in group C were bone grafted (corticocancelous allografts) at the time of the initial procedure. There was a significant relationship between the type of fracture—61.1% of type C—and the use of grafts ($P = 0.006$). There was no significant relationship between the use of grafts and the type of fixation ($P = 0.14$).

There were four patients in group A, two in group B with pin infection that resolved with a change in pin care, a short course of oral antibiotics, or removal of the pin (three patients). One patient from group C—with a type C fracture—developed infection with Staphylococcus aureus in 2 months past surgery and the plate was removed. A second stabilization was performed with a hybrid ring fixator 3 weeks later. The final result was fair. There was no significant relationship between the type fixation and the infection ($P = 0.307$). In stratified by fracture type statistical analyses, results were similar. However the infection in Group C was devastating as the

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**TABLE 2**

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<th>Method of fixation</th>
<th>Type</th>
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</tr>
<tr>
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<tr>
<td>Total</td>
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**TABLE 3**

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<tr>
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The patient had two more surgeries. There was significant relationship between the type of fracture, 19.4% of type C had infection, and the infection ($\chi^2 = 4.233, p = 0.04$).

Six patients (10.9%) have developed arthrosis and are candidates for arthrodesis. Four patients from group A, one from group B and one from group C—the one with the infection—have developed arthritis and loss of joint space. These have pain during walking. These patients are smokers and had type C injuries. There was no significant relationship between the mechanism of injury and the development of arthritis ($P = 0.069$). There was significant relationship between the type of fracture—all were type C—and the development of arthritis ($P = 0.017$). There was no significant relationship between the type of fixation and the development of arthritis ($P = 0.25$). In stratified by fracture type statistical analyses results were similar.

The range of ankle motion was measured in comparison with the contralateral side. Limitation was defined as range of ankle motion < 25%. Nine patients (16.3%) had limitation of ankle motion. In group A, in 30% ($n = 6$) there was limitation more than 25%. In group B, 10% ($n = 2$) had limitations less than 25%. The patient with the infection from group C has limitation more than 25%.

There was no significant relationship between the type of fixation with the limitation of motion ($P = 0.47$). Fracture type stratified statistical analyses did not produce different results. There was no significant relationship between the mechanism of injury and the limitation of motion ($P = 0.069$). There was a significant relationship between the type of fractures (77.7% type C—and the limitation of motion ($P = 0.017$). There was significant relationship between the type of fractures (six open fractures) and the limitation of motion ($P = 0.012$).
Six patients from group A and one from group B had a healing of with 5–10 of malalignment. The patient with the infection from group C had ten of varus malalignment. In groups A and B, there was tendency to lose the reduction. These patients had to be followed-up more often.

**DISCUSSION**

Pilon fractures are the result of high-energy injuries that create a large amount of bony comminution. This fracture remains an unsolved problem with various methods and philosophies of treatment. The best results have been achieved with reconstruction of the articular surface of the tibia, stable fixation, and only a short period of joint immobilization. In 1959, Jergersen stated that open reduction and stabilization of tibial pilon fractures would be impossible. In 1969, Ruedi and Allgöwer presented their good results using internal fixation in eight-four fractures. In 1988, Ayeni confirmed the poor results of nonoperative treatment of displaced pilon fractures.

Numerous surgeons have turned to external fixation with spanning ankle joint for several years. External fixation with ankle spanning is advantageous because of ease of the application and the ability to dynamize the fixator to promote union. Alternatively, many other authors have reported the use of hybrid ring fixators for treating these injuries. These frames have smaller pins and do not cross the ankle joint and it is possible to stabilize the fracture soon after injury when soft tissues swelling would otherwise prevent formal ORIF. This method is beneficial in the treatment of open fractures where plates would not have adequate soft tissue coverage and for severely comminuted fractures.

There are few series that have directly compared internal and external fixation. Blauth et al. assessed the long term results of one the three methods of management for severe pilon fractures. They reported that the group with the two staged protocol—external fixation and then plating—had the lowest rate of complications. Wyrsch et al. prospectively randomized thirty-nine patients with pilon fractures to internal fixation or external fixation. With a minimum 2-year follow-up, they found more complications in the internal fixation group, without significant difference between groups in clinical score. However, in group one, patients underwent internal fixation of the tibia on an average of 5 days which could account for the high complications in this group. Pugh et al. reported no significant differences in complications rates between patients who were treated with the three different methods, ankle—spanning external fixator, single-ring hybrid external fixator and ORIF. However the group with internal fixation had severe complications—two amputations—and the group with the external fixator had more malunions.

Our patients were treated with three different techniques. The group with the hybrid fixation had the more type C fractures—eighteen—than the others groups. There were no malunions and nouncions. There were six (10.9%) patients who have developed arthritis and are candidates for arthrodesis. All the patients had type C fractures. There was no significant relationship with the type of fixation and the development of arthritis. Previous authors have reported rates of arthrodesis from 5–30%.

There were nine patients with limitations of range of motion of the ankle. Although, there was no significant relationship with the type of fixation, six patients were from group A, one from group B and one from group C. There was significant relationship between the limitations of range of motion and the type of fractures (six open and seven type C fractures). There were four and two patients with pin infections from group A and B, respectively, and one deep infection in group C which was resolved with removal of the plate and stabilization with external fixator 3 weeks later. Other studies using the same method with the delayed internal fixation have reported a rate of deep infection of 0–6%. In three patients from group A, the pins had to be removed. The results of this study are comparable with the literature that type C fractures have the worst prognosis. However, there is no evidence in the literature to indicate which method of treatment is better for type C fractures. In contrast to other studies, our findings showed a better clinical outcome with unilateral external or hybrid ring fixation combined with mini arthroscopy though in this group there were the more type C fractures.

**CONCLUSION**

Our conclusion is that type C pilon fractures are very demanding injuries and meticulous preoperative planning is necessary. Patients with type C fractures had higher rate with infection (P < 0.001), higher rate of limitation of motion (P < 0.001) and higher rate of activities reduction (P = 0.026). Preoperatively, CT scanning and 3D reconstruction for these fractures seems necessary. Two staged plating is a method with good results regarding the union and the range of motion. In addition, for type C fractures, the external fixator with ankle sparring using a mini arthroscopy to have direct visualization to the fragments would be a useful method.

**SUMMARY**

Prelomi pilona, izazvani silom visokog stepena inteziteta, predstavljaju jedinstven izazov u leçenju kako za ortopedskog hirurga tako i za samog pacijenta. Oèuvanje meko tkivnog omotaèa distalne tibije za ortopedskog hirurga tako i za samog pacijenta.
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