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Original Article

# Tibial pilon fractures: Single center experience

## *Tibia pilon kırıkları: Tek merkez deneyimi*

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## ABSTRACT

**Aim:** This study aims to investigate the mid-term clinical outcomes of surgically treated Pilon Fractures (PF).

**Material and Methods:** Twenty patients, surgically treated for PF between 2002 and 2012 were included in the study. Patients were evaluated functionally based on the Weber and American Orthopaedic Foot & Ankle Society (AOFAS) protocols.

**Results:** Mean follow-up period was 31.55 (20–48) months. Nine (45%) of the 20 patients had open fractures. According to the Rüedi–Allgöwer Classification: type 1 in nine, type 2 in nine (45%) and type 3 fractures were observed in two patients. A comparison of the duration of union between closed and open fractures revealed that the union of open fractures took a significantly longer time (p= 0.004). Moreover, soft tissue complications developed to a proportionally lesser extent in patients who were applied staged fixation compared with those were applied direct fixation, although the difference was not statistically significant (p= 0.999).

**Conclusion:** The surgical treatment phase of PF should comply with maximum care provided and attention paid to soft tissue. It should be remembered that the fate/outcome of certain fractures is determined at the time of the incident and that certain negative outcomes are inevitable in some patients despite the best efforts.

**Keywords:** pilon fractures; tibial fractures; fractures; Weber and AOFAS; trauma

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## ÖZ

**Amaç:** Bu çalışmanın amacı cerrahi tedavi uygulanan tibia pilon kırıklarının orta dönem klinik sonuçlarını incelemektir.

**Gereç ve Yöntemler:** 2002-2012 yılları arasında, tibia pilon kırığı nedeni ile cerrahi olarak tedavi edilmiş 20 hasta çalışmaya dahil edilmiştir. Çalışmaya dahil edilen hastalar fonksiyonel açıdan Weber ve Amerikan Ortopedik Ayak ve Ayak Bileği Derneği (AOFAS) protokolüne göre değerlendirildi.

**Bulgular:** Hastaların ortalama izlem süresi 31.55 (20-48 ay) aydı. Hastaların 9'u (%45) açık kırıktı. Ruedi Allgöwer Sınıflamasına gore 9 hastada tip 1, 9 hastada tip 2 (%45) ve 2 hastada tip 3 kırık mevcuttu. Kapalı kırıklar ile açık kırıkların kaynama süreleri karşılaştırıldığında, açık kırıklarda kaynama süreleri anlamlı bir şekilde uzun bulundu (p=0,004). Aşamalı tespit yaptığımız hasta grubunda yumuşak doku komplikasyonlarının direk tespit uygulanan hastalara göre oransal olarak daha az geliştiği görüldü ancak istatistiksel olarak anlamlı bir farka rastlanmadı (p=0,999).

**Sonuç:** Pilon kırıklarının cerrahi tedavi aşamasında, yumuşak dokuya maksimum saygı ve özen gösterilmelidir. Bazı kırıkların kaderinin olay anında çizildiği ve tüm çabalara rağmen bazı hastalarda kötü sonuçların kaçınılmaz olduğu unutulmamalıdır.


**Anahtar kelimeler:** pilon kırıkları, tibia kırıkları, kırıklar, Weber ve AOFAS, travma

## Introduction

Pilon fractures (PF) are generally complex fractures caused by high-energy trauma, which are accompanied by major soft tissue injuries and involve the distal articular surface of the tibia and metaphysis. These account for 5%–7% of tibial fractures [1] and are gradually becoming more common due to widespread sports activities, increased lifespan and traffic accidents [2].

As PF are high-energy fractures, they are frequently accompanied by soft tissue injuries. In 10%–30% of the cases, it has been reported that even the tibia was exposed externally [3]. High-energy PF represent a great dilemma for the treating orthopaedist, and an appropriate soft tissue treatment constitutes the most important phase of the therapy [4].

The principles of Rüedi and Allgöwer, which classify the treatment into four main phases to deal with the soft tissue and joint damages, have become a milestone in the treatment of PF [5].

In this study, we aimed to present the mid-term outcomes of 20 patients with PF treated by following the principles of Rüedi and Allgöwer.

## Material and Methods

Among 36 patients who were surgically treated for PF at a single centre by single surgeon (third author) between 2002 and 2012, we retrospectively evaluated the 20 PF of 20 patients who regularly visited for follow-up. Cases <18 years of age and with osteoporotic fractures were excluded. The study was approved by the local ethics committee (2015/124) and conducted in accordance with the principles of the Declaration of Helsinki.

Anteroposterior (AP) and lateral ankle radiography were performed as preoperative assessments. Fractures were classified according to Gustilo–Anderson Classification [6,7], Rüedi–Allgöwer classification [8], and AO classification [9].

The subluxated or dislocated ankles were reduced at emergency department. Afterwards, a short leg splint was applied to all patients. Patients who had open fractures underwent wound irrigation and debridement, and the fibula was identified through lateral incision. For the tibia, fixation with plates and screws were applied to those who received staged fixation after external fixator (EF) and to those who did not receive any in the same session, following the repair of the distal tibial articular surface. Following surgery, the limb was placed in a short leg splint and elevated. Cold compress was applied. Following the relief of the pain and oedema in patients whose drainages were pulled 48 hours after surgery, active and assisted ankle movements were initiated. Mobilisation was ensured using by crutches to prevent any load until bone consolidation was observed on radiographs.

The surgical treatment plan of the patients was developed based on soft tissue damage. We used the classification defined by Tscherne and Goetzen [10] to evaluate soft tissue damage.

Type of surgical incision was determined and modified according to the major fracture line revealed via radiography and the condition of the soft tissue. A distance of at least 7 cm was maintained between two incisions.

## Statistical Analysis

Fisher's exact test was used for the analysis of categorical variable. Measured values of both groups were compared using the Mann–Whitney U Test. The analyses were performed using SPSS 22.0. A $P < 0.05$ was considered statistically significant.

## Patient Evaluation:

Weber and AOFAS (hindfoot) protocols were performed in all patients who were admitted to outpatient clinic for follow-ups or examinations. In the Weber protocol, a healthy ankle was compared with a damaged ankle. A score of 0 is considered as a perfect outcome, scores of 1 and 2 as good and satisfying outcomes and scores of 3 and 4 as poor outcomes. In the AOFAS protocol, a score of ≥70 is considered as a good outcome, while a score <70 is considered a poor outcome.

## Results

Eleven (55%) of the patients were males, while 9 (45%) were females; mean patient age was 48.60 (range 24–85) years. Eleven of the fractures were right and nine were left tibial fractures. Five patients had other organ and bone injuries. The accompanying injuries included lumbar vertebrae and contralateral lower extremity fractures in one patient; contralateral lower extremity fractures (tibia, talus and calcaneus) in two patients; ipsilateral neurovascular damage in one patient; and femur and tibial plateau fractures in the ipsilateral segment in one patient. The fractures of the lumbar vertebrae were treated conservatively, while other extremity fractures were treated surgically. Distribution of open and closed fractures according to aetiological factors and Gustilo–Anderson Classification [6,7] was reported in Table 1.

**Table 1:** Distribution of open and closed fractures according to aetiological factors

| Aetiological Factors | Closed Fractures | Open Fractures (Gustillo-Anderson) | | | | TOTAL |
|---|---|---|---|---|---|---|
| | | Type1 | Type 2 | Type 3A | Type 3C | |
| Falling from a height | 5(%25) | - | 2(%10) | 1(%5) | - | 8(%40) |
| Falling down while walking | 5(%25) | 1(%5) | - | 1(%5) | - | 7(%35) |
| Motor-cycle accident | 1(%5) | - | - | - | - | 1(%5) |
| Fall of a heavy object | - | 1(%5) | 2(%10) | - | - | 3(%15) |
| Gunshot Injury | - | - | - | - | 1(%5) | 1(%5) |
| TOTAL | 11(%55) | 2(%10 | 4(%20) | 2(%10) | 1(%5) | 20(%100) |

According to the Rüedi–Allgöwer classification [8], nine patients had type 1 fractures, nine patients had type 2 fractures and two patients had type 3 fractures. According to the AO classification [9], one patient had a 43B1 fracture, 13 patients had 43C1 fractures, five patients had 43C2 fractures and one patient had a 43B3 fracture. Six patients had grade 0, eight had grade 1, five had grade 2 and one had grade 3 soft tissue damage according to Tscherne and Goetzen classification [10].

The surgical intervention was delayed by an average of 13 (range 5–25) days in three patients to allow for the regression of oedema and the healing of soft tissue damage. In one of these patients, the calcaneal skeletal traction step was skipped and there was a 3-week waiting period before continuing the procedures. The remaining 17 patients received the first surgical intervention on the same or next day. Nine of the patients who received surgical intervention on the same day had open fractures.

EF was applied on the tibia of nine patients who received staged fixation. For fibula fractures, seven patients received semi-tubular plate fixation and two patients received intramedullary fixation. In these nine patients, the tibial distal medial anatomic plate was placed during the second session after an average of 41.8 (17–90) days. In three patients whose bones could be united via EF and who did not need any staged fixation as well as in one patient who had a Tscherne grade 3 soft tissue damage and tissue defect, the uniplanar EF was removed and the Ilizarov EF was applied once the soft tissue problems were solved with the EF (3 months later). In one patient, the Ilizarov EF was applied directly and the treatment was completed with this. In one patient, the treatment was completed with a short leg circular cast following the union achieved with the uniplanar EF.

Surgical incision was applied from the anteromedial in 15 patients, in two patients from the anterior and in one patient from the medial. In nine patients, the fixator was removed after soft tissue problems were solved, and the distal medial anatomic plate was used afterwards. Distal tibial medial anatomic plate was applied to 13 (65%) patients; T-L plate was applied to two of these for Tillaux fracture. Interfragmentary screw was applied in three (15%) patients, the DCP plate was applied in one (5%) patient and EF were applied in three (15%) patients (two Ilizarov types and one uniplanar).

Surgical fixation was applied to 14 of the 18 patients who had fibula fractures and conservative treatment was applied to four. The fibula of two patients was intact. Semi-tubular plate was applied in 11 (79%), intramedullary K wire in two (14%) patients and interfragmentary screw in one (7%) of the patients who had fibula fixation.

The mean preoperative period for the patients was 2.8 (0–25) days. In patients who waited for 25 days, the process was prolonged due to the delay in the regression of soft tissue lesions and oedema. The mean duration of surgery was 104.65 (range: 45–200) minutes.

The mean duration of postoperative parenteral antibiotic treatment was 6.4 (3–14) days. Cases in which the use of antibiotics lasted longer were those with open fracture and wound problems. Postoperative splinting was applied for an average of 7.4 (4–14) weeks.

Twelve (60%) of the patients received staged fixation (Figure 1), while eight (40%) of them directly received open reduction + internal fixation (Figure 2) (Table 2). In three of the patients in whom staged internal fixation was planned, the treatment was continued with an EF applied in the first session.

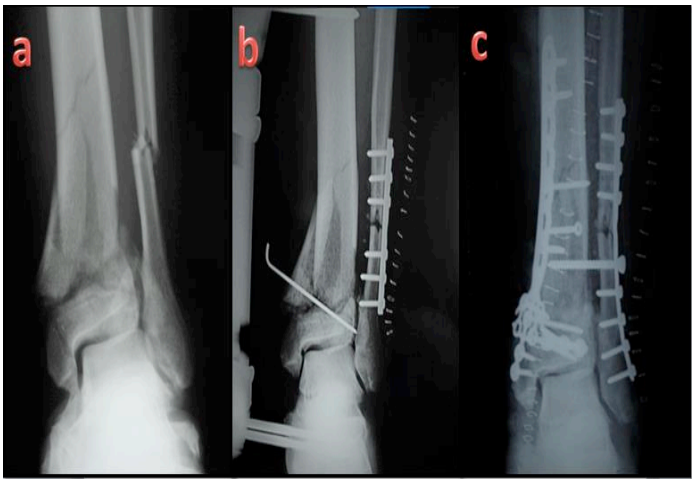


**Figure 1:** Staged fixation. a, Preoperative radiograph; b, First operation: EF+ Fibular plate; c, Early postoperative radiograph.

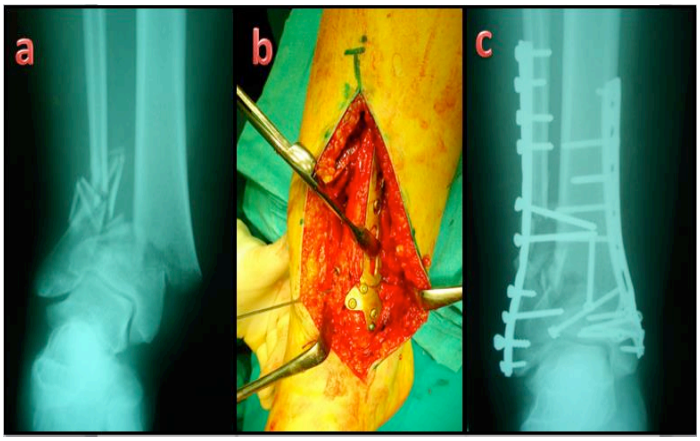


**Figure 2:** Patients who received direct fixation; a, preoperative radiograph; b, intraoperative imaging; c, postoperative radiograph

**Table 2:** Distribution of soft tissue complications after staged and direct fixations

| Surgical Treatment | Soft Tissue Complication (+) | Soft tissue Complication (-) | TOTAL |
|---|---|---|---|
| Staged Fixation | 5(%41,6) | 7(58,4) | 12(%60) |
| Directly Fixation | 3(%37,5) | 5(%62,5) | 8(%40) |
| TOTAL | 8(%40) | 12(%60) | 20(%100) |

Nine (45%) of the patients had open fractures. The preoperative and postoperative follow-ups of the fractures varied depending on whether they were open or closed. The duration of union varied depending on the type of fracture (Table 3).

**Table 3.** Distribution of duration of union for the open and closed fractures

| Fracture Type | Case | Union Time (week) | | |
|---|---|---|---|---|
| | | Average | Minimum | Maximum |
| Closed | 11 | 10,18 | 7 | 14 |
| Open | 9 | 22,22 | 9 | 58 |
| TOTAL | 20 | 15,6 | 7 | 58 |

In the present study, mean patient follow-up period was 31.55 (20–48) months. The mean duration of union for the fractures was 15.6 (7–58) weeks. In statistical analysis using the Mann–Whitney U test for the duration of union of closed and open fractures, the duration of union for open fractures was significantly longer ($p = 0.004$).

When we compared the outcomes according to the AOFAS scale as good and poor outcomes, no significant difference was found across age groups ($p = 0.530$). There were no statistically significant difference across age groups ($p = 0.530$ and $p = 0.114$; respectively) of the AOFAS and Weber scores (Table 4). The distribution of the outcomes depending on the fracture classification according to the AOFAS and Weber score is summarised in Table 5.

**Table 4.** Distribution of the outcomes according to the Weber protocol by age groups

| Result of Weber Protocol | Age Group (years) | | | TOTAL |
|---|---|---|---|---|
| | 15-40 | 41-60 | >60 | |
| Perfect | 2(%10) | 1(%5) | - | 3(%15) |
| Good/satisfying | 3(%15) | 5(%25) | 2(%10) | 10(%50) |
| Poor | - | 5(%25) | 2(%10) | 7(%35) |
| TOTAL | 5(%25) | 11(%55) | 4(%20) | 20(%100) |

When we examine the distribution of outcomes according to whether the fractures were open or closed, there were no statistically significant difference between each types for each groups according to the Weber and AOFAS protocol ($p = 0.362$ and $p = 0.285$; respectively). Moreover, RSD developed in three patients and deformity in two patients (Figure 3), (Table 6).


**Figure 3.** Final period radiographs of patient number 6 who had open fracture. a, varus deformity; b, tibia distal diaphyseal metaphyseal flexion

Four of the nine patients with open fractures had the history of smoking more than 10 packets per year. These four patients had delayed union but the statistical evaluation was not possible to declare the effect of smoking.

## Discussion

The present study supported the proposal of the staged fixation principles if soft tissue conditions are not appropriate for direct fixation. The union time of the open fractures take longer than the closed ones.

There are many studies reporting the outcomes of different therapies in the literature. Kelam and Waddell [11] reported 94% good and perfect outcomes in PF developed due to rotational forces and stated that this rate decreased to 53% in fractures occurred due to high-energy trauma. In our study,

**Table 5.** Distribution of outcomes depending on the fracture classification according to the AOFAS and Weber score

| Classification | | RESULTS | | | | | TOTAL |
|---|---|---|---|---|---|---|---|
| | | Weber | | | AOFAS | | |
| | | Perfect | Good/satisfy-ing | Poor | Good | Poor | |
| Ruedi-Allgöwer | Type 1 | 2(%10) | 4(%20) | 3(%15) | 8(%40) | 1(%5) | 9(%45) |
| | Type 2 | 1(%5) | 6(%30) | 2(%10) | 7(%35) | 2(%10) | 9(%45) |
| | Type 3 | - | - | 2(%10) | 1(%5) | 1(%5) | 2(%10) |
| AO-Müller | 43B1 | 1(%5) | - | - | 1(%5) | - | 1(%5) |
| | 43B3 | - | - | 1(%5) | - | 1(%5) | 1(%5) |
| | 43C1 | 2(%10) | 8(%40) | 3(%15) | 12(%60) | 1(%5) | 13(%65) |
| | 43C2 | - | 2(%10) | 3(%15) | 3(%15) | 2(%10) | (%25) |
| TOTAL | | 3(%15) | 10(%50) | 7(%35) | 16(%80) | 4(%20) | 20(%100) |

the majority of our cases had PF that had resulted from high-energy trauma and that were accompanied by compression and disintegration of the limbs, and 45% of the patients in this study had open fractures. Based on the results of our study, the relatively low success rate compared to the one reported in the literature may be related to the fact that 40% of the patients had fallen from heights (vertical compression) and 15% of them had experienced trauma due to the falling of heavy objects, with majority of these fractures being open ones. However, these results may also have been due to the patient age of ≥40 years in 75% of the cohort.

Ganz evaluated the success rate of therapy with respect to the fracture type during the long-term follow-up of cases who received open reduction and internal fixation. He pointed out that the type 3 fractures that occur following high-energy traumas, soft tissue injuries and bone disintegration tend to be more severe. Therefore, outcomes of type 3 fracture tend to be worse [12]. Watson et al. applied different fixation methods depending on the severity of soft tissue injury and fracture types [13]. According to the AO classification, they reported that non-union and wound complications in type C fractures treated with open reduction were much frequent than in those treated with external fixation. Ovadia and Beals [14] have demonstrated that functional outcomes are related to fracture types and have drawn attention to the fact that outcomes become worse as the fractures become more complex. In agreement with the literature, the functional outcomes of complicated fractures in our study were proportionally poorer.

Bone and Stegemann [15] emphasised in their study on open PF that complication rates increased and the time required for union became longer. In our study, wound problems were observed in six (30%) cases. The duration of union of closed and open fractures, the time required for the union of open fractures was significantly longer ($p = 0.004$).

**Table 6.** Demographics and clinical outcomes of the cases

| Patient | Gender | Age (years) | R-A | AO | G-A Type | Complication | Weber | AOFAS |
|---|---|---|---|---|---|---|---|---|
| 1 | M | 52 | Type 1 | 43C1 | Type 1 | No | Poor | Good |
| 2 | F | 47 | Type 2 | 43C2 | Type 2 | Delayed union, serous leakage, wound dehiscence arthritis, | Poor | Poor |
| 3 | F | 51 | Type 2 | 43C2 | Closed | No | Poor | Poor |
| 4 | M | 26 | Type 1 | 43C1 | Type 2 | serous leakage | Perfect | Good |
| 5 | F | 46 | Type 1 | 43C1 | Closed | serous leakage, | Good/satisfying | Good |
| 6 | M | 67 | Type 1 | 43C1 | Type 3a | Varus deformity, non-union, deep infection, wound dehiscence, seropurulent leakage, arthritis | Poor | Poor |
| 7 | F | 47 | Type 1 | 43C1 | Closed | No | Good/satisfying | Good |
| 8 | F | 24 | Type 1 | 43C1 | Closed | No | Good/satisfying | Good |
| 9 | M | 49 | Type 1 | 43C1 | Type 2 | No | Poor | Good |
| 10 | M | 54 | Type 3 | 43C2 | Closed | RSD, arthritis | Poor | Good |
| 11 | F | 41 | Type 2 | 43C1 | Closed | No | Good/satisfying | Good |
| 12 | F | 45 | Type 2 | 43C2 | Closed | RSD | Good/satisfying | Good |
| 13 | M | 43 | Type 2 | 43B1 | Type 3a | No | Perfect | Good |
| 14 | F | 45 | Type 2 | 43C1 | Type 1 | No | Good/satisfying | Good |
| 15 | F | 85 | Type 1 | 43C1 | Closed | Superficial infection | Good/satisfying | Good |
| 16 | M | 80 | Type 2 | 43C2 | Closed | Peroneal nerve lesion, RSD | Good/satisfying | Good |
| 17 | M | 65 | Type 3 | 43B3 | Type 3c | deep infection, , seropurulent leakage, arthritis, valgus deformity, shortening | Poor | Poor |
| 18 | M | 36 | Type 1 | 43C1 | Closed | No | Perfect | Good |
| 19 | M | 36 | Type 2 | 43C1 | Type 2 | serous leakage | Good/satisfying | Good |
| 20 | M | 33 | Type 2 | 43C1 | Closed | No | Good/satisfying | Good |

M: Male, F: Female, R-A: Ruedi-Allgöwer Classification, AO: AO-Müller Classification, G-A: Gustillo-Anderson Type, RSD: Reflex Sympathetic Dystrophy

Among the methods used for treating PF, the "two-stage protocol" is the method that is presently drawing the most attention [16]. It gives time for the regression of soft tissue oedema before any open reduction and internal fixation is performed. Helfet et al. [17] previously evaluated 17 patients with PF in whom they applied the two-stage therapy. They obtained union in an average of 14.1 weeks in all cases, and they encountered superficial wound infections in only two cases, which recovered with local wound care. In a study conducted in 2001, Blauth et al. [18] evaluated, both functionally and radiographically, 51 of the 77 patients operated for PF over the last decade. They reported that compared with the other groups, range of motion was higher in the group in which the staged therapy was applied and that this group also had less pain, earlier return to work and faster improvement in activity levels. Moreover, there were no soft tissue complications and post-traumatic arthritis in this patient group. In our study, according to statistical analysis, there were no significant difference in terms of soft tissue complications between patients who had staged fixation and those who had direct fixation. This outcome was related to the insufficiency of the number of patients and the fact that 80% of the patients who developed complications had open fractures.

The incidence of various complications in PF treated with open reduction and internal fixation varies between 10% and 55% [14-18]. In a series prepared and studied by Teeny and Wiss [19], the ratio of wound problems was reported as 20.7% among those who received limited open reduction using only screws and then an EF and as 33.7% among those who underwent fixation with plate screws. The rate of deep tissue infection was 0% for Rüedi–Allgöwer types 1 and 2 fractures and 37% for type 3 fractures [5]. In our study, we observed wound problems in six cases (30%); these had open fractures, and wound problems were related to post-traumatic wounds in five of these six patients. Antibiotherapy and recurrent operations (debridement) were applied in two patients with seropurulent leakage.

Different success rates according to Rüedi–Allgöwer types have been reported in the literature [19,20]. In fractures accompanied by fibula fractures, the requirement of applying

plates to fibula remains debatable. Williams et al. argue that in the presence of segmented tibia fracture, the fibula plating may prevent broken pieces of the tibia from contacting each other, thereby delaying the progress of the union [21]. And also, there are some studies reporting delayed union of tibial diaphyseal fractures in the presence of associated fibular fractures [22]. In our case series, delayed union was observed in one patient, while deep infection and non-union were observed in one patient. Healing was achieved with recurrent surgical procedures in the patient with delayed union. In the other patient, healing of the deep infection was achieved through antibiotherapy and recurrent debridement.

Rüedi and Allgöwer reported that arthritis develops in the first two years in general after the injury [5]. Likewise, in their study reporting minimum 51 months follow-up outcomes of PF treated by ilizarov external fixator, Fırat et al. reported an arthritis ratio of minimum 31% [23]. In our series, four (20%) of the patients showed post-traumatic arthritis. It was observed that all patients who developed complications had complicated fractures or Gustilo type 3 fractures in which the reconstruction of the articular surface was anatomically difficult and which could result in the avascular necrosis of the subchondral bone.

We considered that the low success rate of our treatment compared to the one reported in the literature was due to the fact that majority of our cases had vertical compression due to falling from heights and most cases within the series had complicated fractures. The fact that 45% of the patients had open fractures effected the success rate of our study. It was observed that treatment become more difficult in patients with multipart articular surfaces, with cartilages that had collapsed towards the metaphysis, with bone loss and with prior exposure to high-energy traumas that increased the extent of soft tissue injury.

Limitations: Our study is retrospective and has no control group with a number of low patient number. Randomized controlled trials with large samples needed to determine the standard care.

## Conclusion

The pilon fractures which requires highly orthopaedic fracture treatment experience was treated successfully by the leadership of a single surgeon with respect to the principles of Rüedi and Allgöwer.

## Declaration of conflict of interest

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