Ilizarov fixation of tibial plafond fractures: does internal fixation of the fibula have a role?

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Objectives

This study was conducted to evaluate whether supplementary fibular fixation can affect reduction and maintain it and also to assess its effect in the healing process of distal metaphyseal tibial and fibular fractures treated by Ilizarov external fixation.

Patients and methods

A total of 28 patients met our inclusion criteria. All patients had a displaced distal third fibular fracture, associated with a distal tibial metaphyseal fracture, that needed to be fixed by Ilizarov external fixation between 2004 and 2008. The 28 patients with fractures were divided into the following three groups on the basis of the treatment method for the fractured fibula: group A comprised eight patients with fibular fractures treated by open reduction and plate fixation; group B comprised nine patients with fibular fractures treated by open reduction and intramedullary (IM) fixation; and group C comprised 11 patients with fibular fractures treated conservatively by closed reduction.

Results

There was a 100% union rate. The average functional and radiological outcome for all groups was satisfactory in 75% of patients. The radiographs were reviewed for adequacy of fracture reduction and for the presence of post-traumatic arthrosis if any. At the end of follow-up, the clinical outcomes were evaluated using the rating scale of Teeny and Wiss. The three groups were similar with respect to AO/OTA type, open fracture grade, and demographics. Patients in group A showed a decreasing trend of malunion and ankle arthrosis compared with those in group C ($P > 0.05$). They also had a better clinical outcome than those in group C ($P < 0.05$). In addition, patients in group A showed an increasing trend of satisfactory outcome compared with those in group B ($P > 0.05$).

Conclusion

We concluded that supplementary rigid fixation of the fibular fracture associated with pilon fractures provides strong ankle stability and might decrease postoperative ankle arthrosis. IM fixation of the fibula has been proven to be a stable method of fixation that can also help achieve a reasonable reduction in associated distal tibial fractures. We recommend using IM fixation of the fibula in patients with fibular fractures associated with either pilon or distal tibial fractures.

Keywords:

fibula fixation for tibial plafond fractures, Ilizarov fixation, tibial plafond fractures

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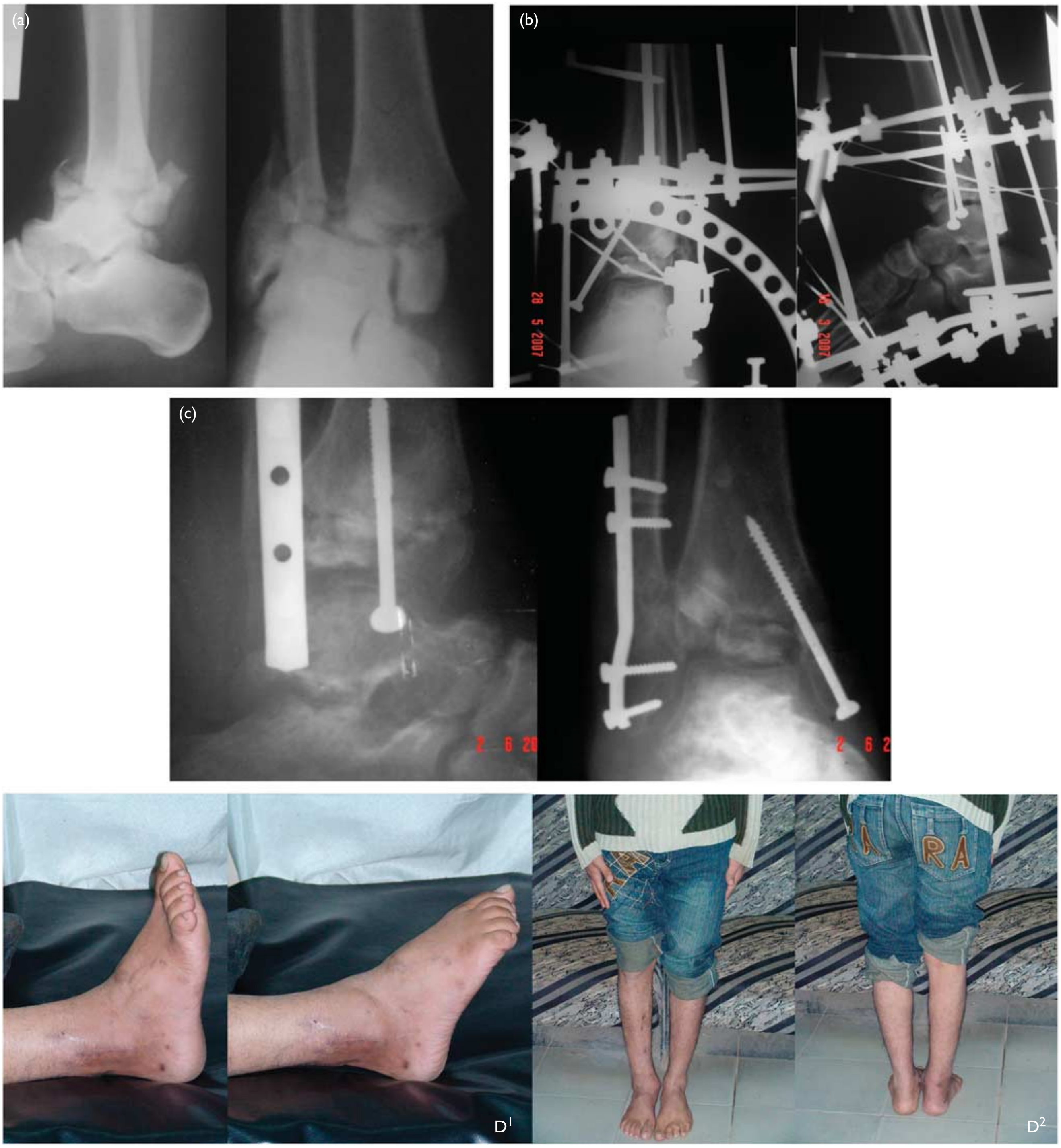
Introduction

The pilon fracture is usually caused by a high-energy force that commonly produces an ipsilateral distal fibular fracture [1,2]. For an optimal outcome of the displaced pilon fracture, most researchers agreed that there should be adequate management of soft tissue, anatomical reduction of the joint, restoration of the distal tibial alignment, and stabilization of the fracture to facilitate union [3–6]. Rüedi and Allgöwer [7] outlined four principles of open reduction and internal fixation for successful management of tibial plafond fractures, the first of which was fibular reduction and fixation with a plate to restore length. After treatment following these principles, high rates of complications have been reported in patients with high-energy fractures [8–10]. These complications have encouraged many surgeons to adopt a less invasive approach by predominantly using external fixation with percutaneous or limited open approaches to reconstruct the tibial articular surface [11–14]. Despite advising limited exposure of the tibia and the use of external fixation, many researchers have advocated open reduction and fixation of the fibula [13,15]. Restoration of length and reduction of the 'key' anterolateral fragment of the tibial articular surface are cited as reasons for anatomically restoring the fibula. Other potential advantages are increased mechanical stability and improved ankle joint function [16]. Stabilization of the fractured fibula in the pilon fractures may have an important role in clinical outcomes. However, for a combined distal tibia and fibula fracture, there exists a debate among surgeons as to whether fibular fixation is required as an adjuvant to tibial fixation, and only a few studies have mentioned the results of pilon fractures associated with fibular fractures. This situation inspired us to evaluate the outcome of pilon fractures associated with ipsilateral fibular fractures. The purpose of our study was to compare the results of fibular fractures that were treated either with plate or intramedullary (IM) fixation, or nonoperatively, in patients who had an associated pilon fracture.

Patients and methods

Between 2004 and 2008, 28 patients who had distal tibial fractures associated with fracture of the distal fibula were treated at the orthopedic department in Minia University Hospital. Inclusion criteria for this study were: (a) displaced pilon fracture associated with an ipsilateral distal fibular fracture and (b) the ability to walk without assistance before injury. Exclusion criteria for this study were as follows: (a) the presence of other fractures and

Figure 1



(a) Radiograph of a male patient aged 25 years, showing comminuted distal third tibial and fibular fractures following a fall from a height. (b) After application of Ilizarov for a pilon fracture, the fibula was treated using a plate. (c) Removal of Ilizarov after 22 weeks shows healing of the fractures. (d1) The fractured ankle in dorsi and plantar flexion; (d2) the patient in standing position.

operations performed on the same extremity, (b) pathological fractures, (c) associated neurological or vascular injuries, and (d) severe osteoporosis.

The 28 patients with fractures were divided into three groups on the basis of the treatment method used for the fractured fibula. Group A comprisd eight patients with fibular fractures treated by open reduction and plate fixation (Fig. 1). The average age of these patients was 27.2 years (ranging from 20 to 48 years). Group B comprised nine patients with fibular fractures treated by open reduction and IM fixation (Fig. 2). The average age of these patients was 29.3 years (ranging from 18 to 51 years). Group C comprised 11 patients with fibular fractures treated conservatively by closed reduction. The average age of these patients was 24.2 years (ranging from 19 to 42 years). The demographic data for all groups are summarized in Table 1.

Preoperatively, displacement measuring more than 4 mm in a fibular fracture was defined as a marked displacement. A fibular fracture with less than 2 mm displacement was defined as undisplaced [17]. Pilon fractures were classified on the basis of the Osteosynthesefragen/Association for the Study of Internal Fixation and Orthopaedic Trauma Association Classification (AO/OTA). There were 21 closed (75%) and seven open fractures (25%). Categorization of open fractures was based on the Gustillo and Anderson classification. There were three open fractures in group B and four in group C. An open fracture was treated by irrigation, thorough debridement, and appropriate intravenous antibiotics. The wound was approximated loosely, or if the bone was exposed it was covered with a flap according to the severity of the soft-tissue injury. Two of seven open fractures were classified as being of Gustilo grade IIIB; skin grafting was required in one patient and a local flap in another.

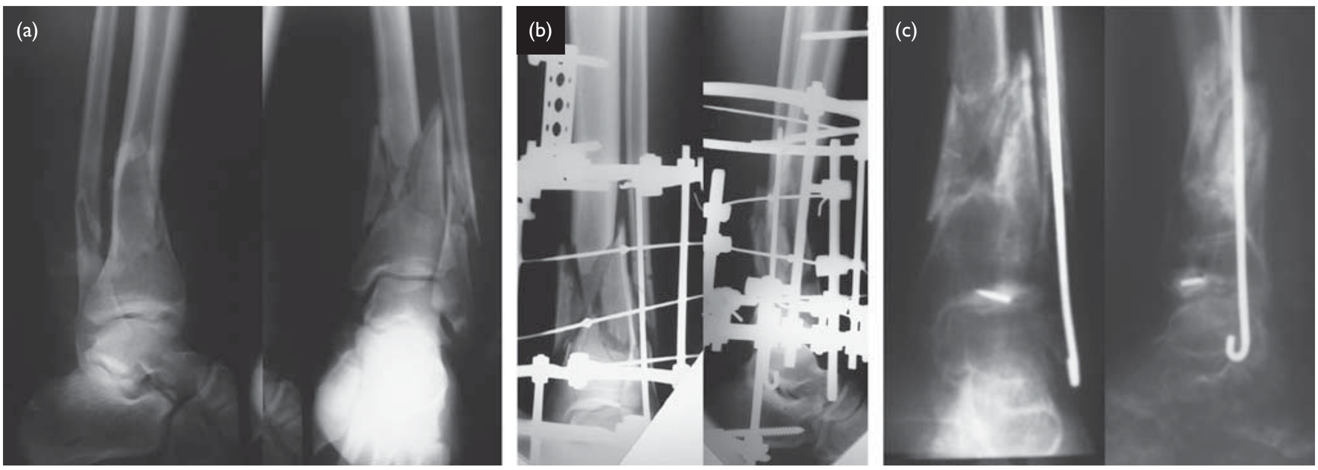
In all patients, we studied the following: (a) the quality of reduction of the articular surface according to the criteria of Conroy *et al*. [18]; (b) the incidence of complications over the fibular wound; (c) the time of external fixation; (d) the healing time (defined as the achievement of unprotected weight bearing combined with radiographic progress to union); and (e) the incidence of nonunion and malunion. The quality of reduction was based on a review of multiple postoperative films. Angular deviations were measured on films taken after healing and at a minimum of 6 months postoperatively. We used a McLennan and Ungersma scale [19] to grade the distal fibular reduction.

Table 1 The patients' demographic data, the mechanism of injury, AO/OTA type, and the grade of open fracture in the three groups

	Group A (N=8)	Group B (N=9)	Group C (N=11)
Sex (female/male)	5/3	7/2	10/1
Average age (years) >0.05	27.2	29.3	24.2
Mechanism of trauma (P=0.128)			
Vehicular trauma	4	6	8
Fall from a height	2	1	2
Other trauma	2	2	1
AO/OTA classification (P=0.97)			
Type A (N)	5	7	8
Type C (N)	3	2	3
Type of fibular fracture line			
Transverse	2	5	4
Oblique	4	3	5
Comminuted	2	1	2
Displacement of fibular fracture (P=0.437)			
Undisplaced	1	2	2
Marked displacement	7	7	9
Open fracture grade (N) (P=0.137)			
Gustilo type I	1	1	2
Gustilo type II	0	1	0
Gustilo type III	0	1	1
Type of plastic surgery if needed			
Skin grafting	0	1	0
Local flap	0	0	1
Free flap	0	0	0
Bone graft	1	1	2
Average follow-up (months)	27.2	28	26.9

AO/OTA, Osteosynthesefragen/Association for the Study of Internal Fixation and Orthopaedic Trauma Association Classification; group I, plate fixation of the fibula; group II, IM fixation of the fibula; group III, without fibular fixation; N, number of patients.

Figure 2



(a) Radiograph of a male patient aged 25 years, showing distal third tibia–fibula fractures following an animal bite. (b) After application of an Ilizarov the fibula was treated using an IM Ruch pin. (c) Removal of Ilizarov shows healing of the fractures.

Good reduction was defined as no fibular shortening, posterior displacement less than 2 mm, and less than 1 mm increase in medial clear space. A fair reduction represented a fibula shortening of 2 mm, posterior displacement of 2–4 mm, and an increase in the medial clear space of 1–3 mm. A poor reduction was defined as fibular shortening in excess of 2 mm, posterior displacement over 4 mm, and greater than 3 mm increase in medial clear space. We evaluated the adequacy of pilon fracture reduction using a scale described by Conroy *et al.* [18]. According to their criteria, an excellent reduction was defined as less than 2 mm of joint incongruity and less than 5° of varus/valgus metaphyseal–diaphyseal angulation. A good reduction was regarded as 2–5 mm of joint incongruity or fracture plane separation and 5–10° of varus/valgus metaphyseal–diaphyseal angulation. A poor reduction evaluation was given for more than 5 mm of joint incongruity and greater than 10° of varus/valgus metaphyseal–diaphyseal angulation. An adequate reduction included excellent and good reductions.

We defined the distal tibial malunion as an angulation of 10° or more in any plane, or internal rotation of 10° or more, external rotation of more than 15°, or tibial shortening of 2 cm or more.

Nonunion was defined as no evidence of healing after 6 months [17]. A radiographic assessment of arthrosis was determined for each ankle (grade 0, no changes; grade 1, small cysts or osteophytes; grade 2, mild joint space narrowing; grade 3, severe joint space narrowing or ankle arthrodesis) [20].

At the end of follow-up, we evaluated the results according to the rating scale of Teeny and Wiss [10]. In this system, the subjective and objective clinical data are evaluated, with the maximum score being 100 points, including pain, walking distance, requirement of support or orthosis requirement, running ability, toe raising ability, ability to climb or descend hills, ability to climb or descend stairs, whether limping or not, plantar range of motion of the ankles, dorsal range of motion, and swelling. An overall score of 93–100 points was ranked as excellent, 87–92 points as good, 65–86 points as fair, and 0–64 as poor. We defined excellent and good results as a satisfactory outcome. Fair and poor results were considered as unsatisfactory outcome.

All patients were followed up for a minimum of 2 years from the date of injury (group A – average 27.2 months, range 24–37 months; group B – average 28 months, range 24–39 months; and group C – average 26.9 months, range 24–34 months).

SPSS 10.0 statistical softwarewas used to analyze the data; *P* values below 0.05 were considered significant. All groups were analyzed for statistically significant differences in both injury and treatment variables and in the outcome measures using the χ^2-tests of independence for discrete outcomes and one-way analysis of variance for continuous outcomes.

Results

The demographics of the three groups were similar with respect to age, sex, mechanisms of injury, fracture classification, severity grading of open fractures, and average follow-up period, without any significant statistical difference.

Patients in group A averaged 23 weeks (range, 17–28 weeks) with respect to the duration of external fixation, and all fractures healed in an average of 20 weeks (range, 15–26 weeks). Patients in group B averaged 22 weeks (range, 13–0 weeks) with respect to the duration of external fixation and 18 weeks (range, 15–24 weeks) with respect to the time needed for fracture healing. These values were 26 weeks (ranging from 12 to 38 weeks) and 21 weeks (ranging from 18 to 29 weeks), respectively, for the patients in group C. We failed to prove significant differences among the three groups in these parameters (Table 1).

Evaluation of immediate postoperative roentgenograms revealed that 23 of the 28 (82.1%) patients had good reduction of the fibular fractures. Fracture reduction in group A was graded as good in seven patients and fair in one. Group B fracture reduction was graded as good in six patients and fair in three. However, in group C, the reduction was graded as good in five patients, fair in two, and poor in four. These differences did not achieve statistical significance ($P = 0.314$), although there was a trend for the fractures to show better reductions in group A, which was higher in quality than that of the other two groups ($P < 0.022$).

Adequate reduction of pilon fractures was seen in 24 of 28 (86%) patients. The adequate reduction rate of pilon fractures showed no significant difference among the three groups (88 vs. 89 vs. 82%, $P = 0.198$). However, in group A, seven patients (88%) had a satisfactory outcome, according to the rating scale of Teeny and Wiss [10], whereas seven patients (78%) in group B and seven (64%)

Table 2 Postoperative reduction rate and clinical results in the three groups

	Group A	Group B	Group C	*P* value
Union rate (%)	100	100	100	–
Radiographic healing time (weeks)	10–22	12–25	15–27	0.416
Good fibular reduction	8 (100%)	8 (89%)	7 (64%)	0.314
Adequate reduction of pilon fractures	7 (88%)	8 (89%)	9 (82%)	0.198
Satisfactory outcome	7 (88%)	7 (78%)	7 (64%)	0.213
Ankle score (points)	50–90	55–90	55–85	0.156

Table 3 Postoperative complications in the three groups

	Group A	Group B	Group C
Infection			
Superficial infection	2	2	4
Deep infection	2	1	1
Pin tract infection	4	5	8
Skin slough	1	0	1
Healing complications			
Delayed union	1	1	1
Malunion	0	1	3
Osteoarthrosis			
Grade I	1	1	4
Grade II	1	1	3
Grade III	0	1	1

in group C had a satisfactory outcome. Operative fixation of the fractured fibula with a tubular plate (group A) resulted in a better outcome compared with nonoperative treatment (group C) ($P = 0.009$). In addition, group A showed a trend of increased satisfactory outcome compared with group B, although this was not statistically significant (Table 2).

The total number of complications in each group was not statistically different (Table 3). We reported superficial infections in eight patients (21%), deep infections in four (14%) , pin tract infection in 17 (60%), skin sloughs in two (7%), and distal tibial malunions in four (14%). The types and prevalence of complications in different groups are matched in Table 3.

At the end of follow-up, the post-traumatic arthrosis rate was 25% in group A (two patients), 33.3% in group B (three patients), and 45% in group C (five patients). Patients in group A showed a trend for lower post-traumatic arthrosis compared with group C, although this was not significant.

Discussion

Fractures of the distal 1/3 of the tibia and fibula are relatively common fractures of the long bones. Owing to their types, etiology, limited coverage, and blood supply, these fractures often lead to nonunion and soft-tissue problems. Displacement, bone loss, soft-tissue injury, infection, and associated multiple injuries may negatively affect the prognosis of the treatment. These fractures have a wide range of treatment modalities ranging from closed reduction to external fixation. The objectives in the treatment of these fractures are ideal reduction and rapid healing, restoration of function, and prevention of residual deformity. The advantage of Ilizarov circular fixation using tensioned transfixion wires is that, in a small bone segment, multiple wires can be inserted and tightened, resulting in strong fixation of the bone [21–23]. In the current literature, many authors have recommended the use of external fixation for the treatment of these fractures, but there is little or no objective information on the indications for internal fixation of the associated fibular fractures [24]. Consequently, there is a debate among surgeons as to whether fibular fixation is required as an adjuvant to tibial fixation [25].

In the study by Bonnevialle *et al.* [26] 142 distal metaphyseal fractures of the tibia were surgically treated by either nailing, plating, or external fixation. The fibula was fractured in 126 patients and it was not treated in 79; nine patients were treated with IM pinning, and 38 were treated with plate and screw fixation. They found better correction of the tibial axes when the fibula was treated with fixation, and the absence of fibular fixation appeared as a probable factor of residual reduction defects, lack of stability of the tibiofibular complex, and tibial nonunion. In addition, Horn *et al.* [27] concluded that an intact or stabilized fibula provides additional support and better healing conditions to the tibial fracture despite impairment of fracture healing during the early phase after the incident.

Rüedi and Allgöwer [7] recognized that the fixed fibula could serve as a guide to appropriate length. Tornetta *et al.* [15] who advocated a hybrid external fixator that does not cross the ankle concurred with the need to restore length, usually with fibular plating, but used a femoral distractor across the ankle when the soft tissues do not permit an approach to the fibula. This approach highlights the fact that external fixation across the ankle can restore the length by serving as a distraction device without internally fixing the fibula. Todd *et al.* [20] found that when they used an external fixator that spans the ankle joint there was a better fracture reduction, but with less ankle score according to the criteria of Merchant and Dietz [28] (59 vs. 63); further, more complications were observed in group I patients in whom the fibula was plated. These differences were not statistically significant.

In our series, when we compared the results of fibular fixation in group A and B patients with the results of conservative treatment of the fibula in group C, we found that fibular reduction was better in groups A and B (94%) than in group C (64%). In addition, groups A and B showed greater satisfactory outcome compared with group C (82 vs. 64%). These differences were statistically significant ($P < 0.05$).

Previous studies have demonstrated significant differences in outcomes on the basis of whether the fibula was fixed. In this study, the different clinical outcomes were based on the treatment methods of the fractured fibula. The good reduction rate of the fibular fracture in group A was higher than that in groups B and C ($P < 0.05$). Nonoperative treatment resulted in a lower reduction rate owing to difficult restoration ofthe fibular alignment, although a closed reduction was achieved. In addition, we found that plate fixation could achieve stable fixation in contrast to an IM fixation, which runs the risk of poor control of fragment rotation. Furthermore, stable fixation of the fractured fibula in the pilon fracture might help maintain the distal tibial alignment. This might explain why patients in group A showed a trend for lower rate of distal tibial malunion compared with those in group C ($P = 0.091$). If we excluded pin tract infection from the complications, we found that complications in group B patients were fewer (78%) when compared with those in group A and C. This is because in group B we had the advantage of fibular fixation when compared with group C patients, and we avoided complications arising from the wound and from dissection of soft tissue as well as other complications arising from plating in group A patients. However, these differences were not statistically significant ($P > 0.05$).

We have compared our results with the results from published series on different methods of fibular fixation in association with pilon fractures. In our series, we found that 21 of 28 (75%) pilon fractures associated with ipsilateral fibular fractures achieved satisfactory clinical outcome. However, group A patients had a better outcome compared with group C patients (88 vs. 64%). Patients in group B showed a trend for decreasing satisfactory outcome compared with those in group A (78 vs. 88%). These results were comparable to the results achieved by Yih-Shiunn Lee *et al.* [17], who compared different methods of fibular fixation with pilon fracture treated with plates. They found that 65 of 98 (76.5%) patients achieved a satisfactory clinical outcome.

It was proved that the distal fibula plays a key role in the stability of the ankle joint, because a 1-mm lateral displacement of the talus decreases the tibiotalar contact surface by 42% [29,30]. It is known that ankle instability increases the risk of tibiotalar arthrosis. In our study, group A patients showed a lower rate of post-traumatic arthrosis (25%) compared with group B (33.3%) or group C patients (45.4%) ($P > 0.05$). These results were comparable to those of Yih-Shiunn Lee *et al.* [17], which were 16, 26.1, and 32%, respectively, for patients in group A, who were treated with plates and screws, patients in group B, who were treated by IM fixation, and patients in group C, who were treated conservatively.

It was hypothesized that fibular fixation might delay the healing of the tibial metaphyseal fracture by holding it at full length and not permitting the fixator to dynamize and increase contact at the often comminuted tibial metaphysis. In addition, it was thought that lateral fibular fixation might predispose to varus malunion by permitting the tibial fracture to settle more on the medial than on the lateral side [20]. Our data did not support either hypothesis because there was no significant difference in the healing rates among the groups and no tendency for malunion or a delayed healing process in ankles of patients in group A or B, in which the fibula was fixed. Indeed, the clinical series suggested fewer angular malunions and delayed union in group A and B patients (17.6%), compared with group C patients (54%). In some cases, fibular fixation may confer mechanical stability to the externally fixed fracture. However, the plafond fractures in all 11 patients who were treated without fibular fixation healed and 72% had no tibial malalignment. This trend for better alignment did not reach statistical significance with the numbers available in the present study.

With regard to fibular complications, four of the eight patients in group A showed complications at the fibular fracture after internal fixation with plates. There were three infections (37.5%) of fibular wounds and one delayed union (12.5%) of the fibula. These complications occurred despite the fact that all fractures in this group were closed. In our study, two patients, one in group B and one in group C, had deep infection at the fibular wound. These two patients originally had open Gustillo III fracture and were in need of debridement. These findings were not statistically different among the groups. These results agreed with those of Todd *et al.* [20], in whose study seven of 22 patients (31%) had complications at the fibula fracture after internal fixation. There were five infections (23%) and two nonunions (9%), four of which required additional surgery. These data suggested that reducing and internally fixing the fibula with a plate may be associated with significant complications.

There are several limitations in the present study that hamper the interpretation of these results. First, the decision to fix the fibula was not randomized but was based on surgeon preference and analysis of the individual case. Second, the different configurations of the distal tibial fractures and the severity of soft-tissue injury might bias the results. Finally, the small sample size, which diminishes the power to detect the possible real differences that might exist among the techniques, was also a limitation. In addition, the short-term follow-up could not allow effective judgment of each method of treatment with respect to the degenerative arthritic changes of the ankle joint.

Conclusion

We concluded that rigid fixation of the fractured fibula in pilon fractures provides strong ankle stability and may lead to a decrease in postoperative ankle arthrosis. The method of IM fixation of the fibula has been proven to be a stable method, leading to acceptable reduction. We recommend using IM fixation of the fibula in cases of fibular fractures associated with either pilon or distal tibial fractures.

Acknowledgements

Conflicts of interest

There are no conflicts of interest.

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