Comparative evaluation of internal versus external fixation of fractures of the tibial plafond

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Background

We carried out a randomized, retrospective study to compare the results of two methods for the operative fixation of fractures of the tibial plafond. In the first group, which included 18 patients, open reduction and internal fixation of both the tibia and the fibula was performed through two separate incisions. An additional patient, who had an intact fibula, underwent fixation of the tibia only through an anteromedial incision. The second group included 20 patients who were managed with external fixation with or without limited internal fixation (a fibular plate or tibial interfragmentary screws).

Patients and methods

Ten (26%) of the 39 fractures were open and 17 (44%) were type III according to the classification of Rüedi and Allgower. There were 15 operative complications in seven patients who had been managed with open reduction and internal fixation and four complications in four patients who had been managed with external fixation. All except four of the complications were infection or dehiscence of the wound that had developed within 4 months after the initial operation.

Results

At a minimum of 2 years postoperatively (average 39 months; range 25–51 months), the average clinical score was lower for the patients who had a type II or type III fracture, irrespective of the type of treatment. With the numbers available, no significant difference was found between the average clinical scores for the two groups. All of the patients, in both groups, who had had a type II or a type III fracture had some degree of osteoarthrosis on plain radiographs at the time of the latest follow-up.

Conclusion

External fixation is a satisfactory method of treatment for fractures of the tibial plafond and is associated with fewer complications than internal fixation, especially in open fractures.

Keywords:
Internal fixation, external fixation, tibial plafond

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Introduction

Intra-articular fractures of the tibial plafond (pilon fractures) are among the most challenging of orthopedic problems [1]. Open reduction and rigid internal fixation [2–4] replaced the traditional nonoperative treatment [5–7] of these injuries.

The optimum treatment of this fracture remains controversial as retrospective reviews of the results of open reduction and internal fixation have reported high rates of complications. External fixation with limited internal fixation [8] has gained some popularity since the late 1980s.

Most previous studies had focused on retrospective analyses of either mode of operative treatment for these fractures. The aim of this randomized, prospective study was to compare the rate of complications, the radiographic results, and the functional results after treatment of displaced fractures of the tibial plafond with open reduction and internal fixation with those after treatment of such fractures with external fixation and limited internal fixation.

Patients and methods

All adult patients who received operative treatment for a displaced fracture of the tibial plafond at the Royal Commission Hospital, KSA, from January 2006 till November 2011 were included in this study. The patients were subjected to either one of two operative procedures: open reduction and internal fixation or external fixation and limited internal fixation.

All of the patients included in the study had sustained an intra-articular fracture of the tibial plafond, which was classified using the system of Rüedi and Allgower [1]. The indications for an operation included an open fracture and unacceptable alignment of the fracture or incongruity of the articular surface of more than 2 mm or malreduction in the form of angulation greater than 10° in any plane [9].

Among the patients, 27 were males and 12 were females. Their ages ranged from 16 to 67 years. The average age was 39 years in group I and 38 years in group II. Of the 39 fractures, 29 (74%) were closed and 10 (26%) were open. There were three open fractures (one grade I and two grade II) [9,10] in group I and seven (one grade I, two grade II, and four grade III) in group II. According to the system of Rüedi and Allgower [17,22], eight fractures (21%) were type I, 14 (36%) were type II, and 17 (44%) were type III. There were four type I, 10 type II, and five type III fractures in group I and four type I, four type II, and 12 type III fractures in group II. Twenty-one patients (54%) had other associated injuries. Fifteen fractures (38%) had been sustained in a motor-vehicle accident and 24 (62%) had resulted from a fall or a jump from a height (Table 1).

Plain anteroposterior and lateral radiographs were prepared preoperatively and postoperatively. All patients who had an open fracture underwent debridement, followed by immediate stabilization of the fracture, at an average of 10 h (range 6–14 h) after the injury. The closed fractures were treated with reduction and application of a splint, followed by operative treatment within 48 h unless severe swelling or fracture blisters were present or there were medical contraindications. The average time from the injury to the operative fixation of the closed fractures overall was 3 days (range 36 h–9 days).

Eighteen of the 19 patients in group I underwent an operation that involved two separate incisions to stabilize both the tibia and the fibula. The fracture of the fibula was reduced through a lateral incision and was stabilized with a plate in 17 patients and with an intramedullary rod in one patient. The tibial fracture was exposed through an anteromedial incision, with at least a 7 cm skin bridge from the posterolateral incision. The 19th patient had an intact fibula and only one incision was made, for fixation of the tibia. After open reduction of the distal articular surface of the tibia and inspection of the talar dome, a buttress plate was applied to stabilize the fracture (Fig. 1).

Bone grafting was performed at the time of fixation in 10 patients in this group. Seven patients in whom the wound could not be closed primarily were returned to the operating room within 72 h for repeat irrigation and debridement or a soft-tissue coverage procedure, or both. This was not recorded as a complication. Postoperatively, the lower extremity was immobilized in a plaster splint or cast for 2–3 weeks until the swelling had resolved and the soft tissues had healed. Active and passive range-of-motion exercises were then initiated and the patient walked with toe-touch weight bearing for an additional 8 weeks.

The 20 patients in group II had limited internal fixation combined with external fixation; an orthofix fixator was used for 11 patients and a synthes AO fixator was used for nine patients. In 18 patients, an unstable fracture of the fibula was fixed with a plate; however, no tibia was fixed with a plate. Two patients had an intact fibula.

Reduction of the articular surface was performed through a small anteromedial incision in each patient. Any joint-surface fragments were disimpacted and reduced using a 3.5-mm interfragmentary screw or a percutaneous cannulated screw in all except three patients. For external fixation, two proximal and two distal 5.0-mm pins were used. Distal fixation was performed using one talar pin and one calcaneal pin in 18 patients and with two calcaneal pins in two patients (Fig. 2).

The patients were also advised to maintain toe-touch weight bearing for 10–12 weeks. The external fixator was kept in place for an average of 10 weeks (range 6–14 weeks) and was removed after there was radiographic evidence of healing callus. Bone grafting was not performed at the time of the initial fixation in any patient in this group; at an average of 6 weeks (range 4–8 weeks) after the initial treatment, bone from the iliac crest was grafted to fill a metaphyseal defect and promote fracture healing in 10 patients.

A major complication was defined as an infection that necessitated operative treatment, breakdown of the wound [10,11] that necessitated a soft-tissue coverage procedure, a neurovascular injury, failure of fixation, malunion (>10° angulation in any plane), or

Figure 1

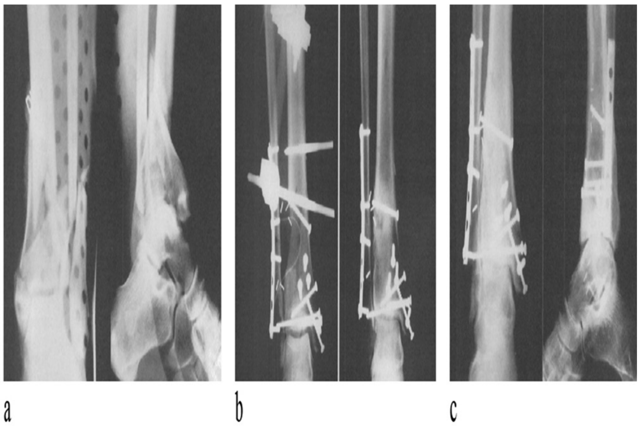
(a) Anteroposterior and lateral radiographs prepared preoperatively; (b) anteroposterior radiograph prepared after open reduction and internal fixation; (c) lateral postoperative radiograph.

Table 1 Data on the patients

Case	Sex, age (years)	Type of fracture	Wound classification	Bone grafting	Complications (months after initial operation)	Number of additional operations	Incongruency of joint reduction	Clinical score (points)
Open reduction and internal fixation								
1	M, 21	II	Closed	No	None	–	Anatomical	60
2	F, 28	I	II	Yes	Infection around hardware	1	1 mm	33
3	M, 41	II	II	Yes	Wound breakdown; recurrent infection	3	2 mm	71
4	F, 16	I	Closed	No	None	1	Anatomical	95
5	F, 31	III	Closed	Yes	None	–	2 mm	33
6	M, 46	II	Closed	Yes	None	–	Anatomical	84
7	M, 33	III	Closed	No	None	–	2 mm	39
8	F, 52	III	Closed	Yes	None	1	1 mm	56
9	M, 29	II	Closed	Yes	None	–	Anatomical	54
10	M, 35	I	Closed	Yes (delayed)	Wound breakdown; recurrent infection and osteomyelitis	6	Anatomical	44
11	F, 29	II	Closed	Yes	None	–	Anatomical	42
12	M, 47	II	Closed	No	None	–	2 mm	75
13	M, 45	III	Closed	No	Wound breakdown; recurrent infection	5	1 mm	17
14	M, 38	II	Closed	Yes	Wound breakdown; recurrent infection and osteomyelitis, debridements, resection of sequestrum	6	Anatomical	29
15	F, 38	III	Closed	No	Wound breakdown recurrent infection and osteomyelitis	3	2 mm	52
16	M, 30	II	Closed	Yes	None	–	1 mm	77
17	M, 66	II	I	No	Wound breakdown	2	2 mm	39
18	M, 46	II	Closed	Yes	None	–	1 mm	71
19	M, 67	I	Closed	No	None	–	Anatomical	100
External fixation								
20	F, 24	III	II	Yes	None	–	3 mm/5° valgus	97
21	M, 30	II	III	Yes	None	–	1 mm/10° recurvatum	72
22	M, 50	III	I	Yes	None	–	2 mm/3° varus	74
23	M, 45	I	Closed	No	Posterior tibial nerve injury	1	Anatomical/ anatomical	80
24	M, 45	I	Closed	Yes	None	–	Anatomical/ anatomical	73
25	F, 47	III	III	No	None	–	2 mm/anatomical	37
26	M, 34	III	III	Yes	Failure of skin graft	1	2 mm/anatomical	84
27	M, 48	III	Closed	Yes	None	–	2 mm/anatomical	78
28	F, 31	III	II	Yes	None	–	1 mm/anatomical	62
29	F, 24	I	Closed	No	Loss of reduction	1	Anatomical/ anatomical	82
30	M, 30	III	Closed	No	Pin-track infection	2	NA/anatomical	Spontaneous fusion
31	M, 48	III	Closed	No	None	–	1 mm/anatomical	80
32	M, 44	II	Closed	No	None	–	2 mm/anatomical	85
33	M, 47	III	Closed	No	None	–	2 mm/anatomical	95
34	M, 38	II	Closed	No	None	–	1 mm/anatomical	62
35	M, 29	III	Closed	No	None	–	2 mm/3° procurvatum	60
36	M, 43	II	III	Yes	None	–	2 mm/anatomical	47
37	F, 27	I	Closed	No	None	–	Anatomical/ anatomical	97
38	M, 47	III	Closed	Yes	None	–	3 mm/5° valgus	58
39	F, 22	III	Closed	Yes	None	–	1 mm/8° recurvatum	62

F, female; M, male.

Figure 2



(a) Anteroposterior and lateral radiographs prepared preoperatively. (b) Anteroposterior radiograph prepared after immediate debridement, followed by limited internal fixation and placement of an external fixator. (c) Anteroposterior and lateral radiograph prepared 11 months postoperatively, indicating union with moderate narrowing of the joint space.

nonunion. Nonunion was defined as failure of clinical and radiographic union more than 6 months after the injury.

Patients returned for follow-up visits at least every 3 months for the first year and every 6 months thereafter. The average duration of follow-up was 39 months (range 25–51 months). A clinical score [12] was calculated using a questionnaire with which the patient evaluated pain and the functional outcome and the surgeon evaluated gait and the range of motion (Table 2). Serial radiographs were prepared during follow-up visits at the clinic and were evaluated for the development and progression of post-traumatic osteoarthrosis. Degenerative changes, if present, were rated as mild (1–2 mm of narrowing of the joint space), moderate (>2 mm of narrowing with or without periarticular cysts or osteophytes), or severe (complete loss of the joint space with osteophytes or cysts). At the time of the latest follow-up, the grade of osteoarthrotic changes and the clinical score were determined and documented [13].

Table 2 Clinical scoring system (maximum 100 points) [12]

Subjective (80 points)	Score points
Pain (54 points)	
Always after any activity	0
Prolonged after mild activity	10
Transient after mild activity	20
Prolonged after heavy activity	35
Transient after heavy activity	40
None	50
Requires medication regularly	0
Requires medication occasionally	2
Requires no medication	4
Function (26 points)	
Unable to climb stairs	0
Uses normal foot first	1
Requires aid of banister	2
Climbs normally	3
Unable to descend stairs	0
Uses normal foot first	1
Requires aid of banister	2
Descends normally	3
Walks <1 block	0
Walks <5 blocks	2
Walks <10 blocks	3
Walks=10 blocks	5
Walks unlimited distances	6
Recreational activities limited	0
No activities limited	3
Requires walker	0
Requires crutches	1
Requires one crutch	2
Requires cane	4
Requires no walking aids	8
Dissatisfied	0
Moderately satisfied	2
Very satisfied	3
Objective (20 points)	
Gait (6 points)	
Antalgic limp	0
External rotation gait	3
Normal gait	6
Range of motion (difference from contralateral side) (14 points)	
Dorsiflexion	
Difference>20°	0
Difference 10–20°	2
Difference <10°	4
No difference	7
Plantar flexion	
Difference>20°	0
Difference=20°	2
No difference	3
Supination	
Difference>0°	0
No difference	2
Pronation	
Difference>0°	0
No difference	2

Results

Group I (open reduction and internal fixation)

In seven patients, 15 major complications necessitated 28 additional operations. The complications included breakdown of the wound necessitating coverage with a free flap (six patients); recurrent infection or osteomyelitis, or both, which developed after a soft-tissue coverage procedure and the parenteral administration of antibiotics (five patients); infection around the hardware (one patient); and removal of internal fixation and conversion to an external fixator (three patients). Of the six patients who had breakdown of the wound, four had a closed fracture and two had had an open fracture (one grade I and one grade II). Breakdown of the wound occurred at an average of 6 weeks (range 4–13 weeks) postoperatively. The patient who had infection around the hardware (with no breakdown of the wound) had a grade II open fracture [10]. Three of the four recurrent infections were because of *Staphylococcus aureus* that was resistant to methicillin. The fourth infection was caused by *Enterococcus* spp. and was associated with a nonunion. Despite an initial good result after treatment with an external fixation device, recurrent osteomyelitis developed with a draining sinus that persisted for 20 months after the initial treatment for the closed fracture. Two other patients had a wound slough after a closed, comminuted fracture; treatment had included debridement, prolonged antibiotic therapy, and soft-tissue coverage with a free flap. In both patients, osteomyelitis caused by methicillin-resistant *Staphylococcus aureus* developed, and they were operatively converted from internal to external fixation in an attempt to save the limb.

Group II (external fixation)

There were four major complications in four patients, necessitating five additional operations. Diminished plantar sensation and mild reflex sympathetic dystrophy developed in the foot of one patient postoperatively. At the time of the latest follow-up, the dystrophy was gradually resolving, with full return of the function of the posterior tibial nerve. In another patient, who had a grade III open fracture, the wound became infected and the skin graft failed 2 weeks postoperatively. The patient was managed successfully with a free flap. One patient had loss of the reduction 4 weeks postoperatively; the fracture healed in satisfactory alignment after revision with a biplanar fixator. The fourth complication occurred in a patient who had a closed fracture; a pin track became infected with methicillin-resistant *Staphylococcus aureus* and infection subsequently developed in the ankle joint. The patient was managed successfully with two irrigations and debridements. A spontaneous fusion of the tibiotalar joint occurred as two-thirds of the articular surface of the tibial plafond had been lost at the time of the injury.

Of the 19 complications in the two groups, thirteen had occurred within 4 months after the injury and all involved a soft-tissue infection or a wound breakdown. In one patient in group I, the hardware was removed because of infection 11 months after the injury and an additional three patients in this group had a conversion to an external fixator at 14, 20, and 24 months after the injury because of recurrent breakdown of the wound, purulent drainage, and osteomyelitis.

For both groups, postoperative radiographs were evaluated for the adequacy of the reduction of the joint. In group I, eight (three type I and five type II) fractures showed an anatomical reduction. A 1 mm incongruency was observed after the reduction of five (one type I, two type II, and two type Ill) fractures and a 2 mm step-off or gap in the articular surface was observed after the reduction of six (three type II and three type Ill) fractures. All of the patients in group I showed an anatomical reduction or healing with less than 5° of angular malalignment.

In group II, four type I fractures showed an anatomical reduction. A 1 mm incongruency was observed after the reduction of five (two type II and three type Ill) fractures and a 2 or 3 mm incongruency was observed after the reduction of 10 (two type II and eight type Ill) fractures. Four (one type II and three type Ill) fractures healed in malalignment, with 5–10° of recurvatum (two fractures) or valgus (two fractures). Substantial metaphyseal comminution or bone loss, or both, was associated with all of these fractures. The remaining fractures healed in anatomical alignment or less than 5° of angulation. The fractures in group I healed at an average of 14 weeks (range 10–42 weeks) after the operation.

Ten patients underwent bone grafting at the time of the initial operation or after delayed closure of an open wound. One patient underwent bone grafting at 12 weeks because of delayed union.

The fractures in group II healed at an average of 15 weeks (range 8–40 weeks) after the operation. None of these patients had undergone bone grafting at the time of the initial treatment of the fracture; however, eight patients had undergone bone grafting, at an average of 6 weeks (range 4–8 weeks) after the initial treatment, to fill a metaphyseal defect and promote fracture healing. Bone grafting was performed 16 weeks postoperatively in an additional two patients because of delayed union of a metaphyseal fracture.

A clinical score could be determined at the end of follow-up for fifteen patients in group I and for 19 patients in group II; the average scores were 61 and 73 points, respectively (Table 2). A general trend, however, was found when the average scores associated with each type of fracture were compared. The patients who had a type I fracture had a greater average score (80 points) than the patients who had a more comminuted fracture (average score, 65 points for the patients who had a type II fracture and 64 points for those who had a type Ill fracture).

Only one patient (in group I) had a late, elective arthrodesis for intolerable pain from complete loss of the tibiotalar articulation. All of the patients who had a type II or a type III fracture, irrespective of the treatment, had some degree of narrowing of the joint space on the latest follow-up radiographs. In group I, the osteoarthrotic changes were mild in six patients, moderate in four patients, and severe in four patients. Similar results were found in group II: six patients showed mild changes, eight patients showed moderate changes, and four patients showed severe changes. With the numbers available, the difference between the two groups was not significant. One patient in group II had a spontaneous fusion of the ankle joint, which was solid at the time of the most recent follow-up. All of the patients who had severe osteoarthrotic changes showed progressive narrowing of the joint space on radiographs, beginning within 1 year after the injury.

Discussion

In 1969, Rüedi and Allgower [1] reported a 74% rate of good or excellent functional results after the treatment of 84 consecutive pilon fractures with open reduction and internal fixation. They advocated that surgeons follow four ASIF principles in the treatment of these fractures:

(a) Restoration of the length of the fibula,
(b) Reconstruction of the articular surface of the tibia,
(c) Grafting with cancellous bone to fill metaphyseal defects, and
(d) Stabilization of the medial portion of the tibia with a buttress plate [1,9].

Many authors have reported good results, with anatomical reduction and stable fixation of these fractures, after treatment according to these basic principles [2–4,14].

Many of the fractures in the series of Rüedi and Allgower [1] had occurred during skiing accidents and involved a rotational mechanism of injury. A rotational injury usually results in large metaphyseal fragments with minimum impaction or comminution of the joint. In contrast, in large urban trauma centers, the most common cause of fractures of the tibial plafond is axial compression (dorsiflexion), which results in severe comminution of the joint with impacted fragments and injury of the articular cartilage. In addition, soft-tissue trauma usually is much less severe with a rotational fracture than with an axial-compression injury [3]. As a result, the axial-compression injury is more challenging to treat [15], with a greater likelihood of soft-tissue complications postoperatively and a poorer clinical result secondary to post-traumatic osteoarthrosis.

In various clinical series [2–4,7,16], the reported frequencies of osteomyelitis, amputation, post-traumatic osteoarthrosis of the ankle, and nonunion have been as high as 54%. In addition, the rates of wound breakdown and deep infection have been reported to be as high as 10% after open reduction and internal fixation of severely comminuted fractures of the tibial plafond [17,18].

Excellent results with few complications after treatment with external fixation have been reported recently [19–22]. Delicate handling of soft-tissues and meticulous debridement of wounds in open fractures have been advocated to minimize soft-tissue complications [14,15,23]. The timing of the operation is also an important factor [23]; an operation that is performed in the presence of severe intradermal edema or fracture blisters may increase the risk of wound tension, leading to sloughing of the skin and tissue necrosis, with subsequent infection. Even with at least a 7 cm skin bridge between the medial and lateral incisions, skin slough and wound breakdown may be inevitable because of the initial soft tissue injury. Excessive skin tension at the time of closure of the wound may also be problematic when tissue edema is present. Even after swelling of the soft tissues has subsided, there may be increased wound tension as a result of the medial skin flap being stretched over a buttress plate on the tibia.

Some soft-tissue problems and complications may be avoided with the use of a lower profile, less bulky buttress plate. In addition, open reduction and internal fixation may be an excellent option for this fracture when the fibula is intact; because a lateral incision is unnecessary, the need to create a vulnerable skin bridge between two incisions is avoided. Furthermore, open reduction and internal fixation can usually be performed safely when there is little soft-tissue injury or compromise, as is often observed after a rotational injury. In two reports by Bone *et al.* [20], the result was good or excellent for 11 of 16 patients who had been managed with external fixation combined with limited internal fixation; there were no infections or clinically important complications related to the wound.

Recently, Bonar and Marsh [19] reported on 21 patients in whom a severe fracture of the tibial plafond had been treated with unilateral external fixation. There were no soft-tissue complications and osteomyelitis did not develop in any patient. The early functional results were promising. Those authors also reported good functional results with few complications after the use of an articulated fixator [14]. The results of our study are similar to these findings; we found a markedly lower rate of soft-tissue complications after the use of external fixation, even for severely comminuted and open fractures.

In their long-term follow-up study, Rüedi and Allgower noted that 48% of their patients had some loss of motion compared with that of the contralateral extremity [15,24]. Bourne *et al.* [2] reported that 81% (25) of their 31 patients had loss of motion after open reduction and internal fixation of a type II or a type III fracture. Bone *et al.* [20] reported that of 20 patients who had external fixation of an open fracture of the tibial plafond, 14 had loss of motion at the time of the most recent follow-up. The findings in the current study seem to be similar to the results of these latter two studies: almost 80% of our patients had some loss of tibiotalar motion. A loss of motion, however, does not always correspond with a poor outcome.

There was some loss of the joint space and radiographic changes consistent with post-traumatic osteoarthrosis at the time of the latest follow-up. Mild, moderate, or severe osteoarthrotic changes developed in all of the patients who had a type II or a type III fracture in both groups. This suggests that the development of post-traumatic osteoarthrosis after a fracture of the tibial plafond may be a result of severe damage to the articular cartilage at the time of the original injury and is independent of the type of treatment or the accuracy of the articular reconstruction. Lower rates of osteoarthrosis have been found in previous studies [2–4,7,15,16,25].

Etter and Ganz [26] noted that severe osteoarthrosis did not correspond with a poor subjective or objective result. This is relevant because the decision on an arthrodesis should be made on the basis of consideration of pain, disability, functional limitation, and overall dissatisfaction, rather than the radiographic appearance of the joint after trauma.

Because of the markedly greater number of complications after open reduction and internal fixation in our series, with no difference in the long-term clinical outcome, we concluded that limited internal fixation combined with the use of an external fixator is an equally effective and safer method of treatment for most fractures of the tibial plafond.

Acknowledgements

Conflicts of interest

There are no conflicts of interest.

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