



## Management of comminuted closed tibial plafond fractures using circular external fixators

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Various types of external fixators have been used to treat Ruedi and Allgöwer Type III pilon fractures, as serious complications can occur using conventional treatment principles. However, insufficient reduction and loss of reduction are two of the main disadvantages of external fixator treatments.

We conducted a retrospective review of 14 patients with severe highly comminuted closed fractures of the distal tibia (Ruedi type III) treated using cross-ankle external fixators. Five patients underwent closed reduction, while the others required open reduction using minimal incision techniques. The reduction score, reduction loss, early and late complications, and ankle symptoms and functions were evaluated.

The patients were followed for an average of 48 months (range : 31 to 84) ; superficial wound infection developed in one case and minimal angular deformity in another. In ten cases, the reduction of the articular surface was anatomical ; in the other four cases, it was non-anatomical. Except for one case which developed an angular deformity, no loss of reduction was observed. On radiological control, only one case did not display osteoarthritis ; in the other 13 cases, osteoarthritis was diagnosed at different levels.

The most important disadvantage of this technique is retarded joint movement. Nevertheless, for such fractures, we consider cross-ankle circular external fixators as an alternative treatment method because it combines the advantage of a minimal risk of deep infections with better stabilisation of the limb, while providing early mobilisation.

**Keywords** : tibia plafond ; fracture ; external fixator.

### INTRODUCTION

Anatomic reduction of the articular surface, reconstruction of the ankle mortise as a stable functional unit, stabilisation of the articular surface to the tibial shaft with the appropriate alignment and length, and early return to functional activities are regarded as the main goals of the treatment of tibial plafond fractures. Successful results can be achieved when these principles are followed for treating low-energy tibial plafond fractures. By contrast, anatomic restoration of the articular surface and large exposure of the soft tissue for internal fixation may lead to an increased rate of complications in high-energy pilon fractures (16, 20, 24). Therefore, the standard treatment, especially for high-energy tibial plafond fractures, is still controversial. In recent years, various types of external fixators have been proposed with a minimally invasive operation (4, 14). Many different types of

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Table I. — Data on the 14 patients

Case	Sex/ Age	Injury mechanism	Reduction type of articular surface	Bone graft	Reduction Score of articular surface	Duration of fixation (Weeks)	Complication	Follow-up (Months)	Osteo- Arthrosis grade	Ankle Score
1	49/M	Fall (> 3 m)	Open	Yes	Good	11	–	39	1	Excellent
2	22/M	Fall (> 3 m)	Open	No	Anatomic	13	–	31	0	Excellent
3	28/F	Automobile accident	Closed	No	Good	12	Pin-track inf.	84	1	Good
4	61/F	Fall (> 3 m)	Closed	No	Good	18	–	59	1	Poor
5	17/M	Fall (> 3 m)	Open	No	Anatomic	11	Pin-track inf.	48	2	Good
6	22/M	Automobile accident	Open	Yes	Anatomic	14	Pin-track inf.	46	1	Good
7	31/F	Fall (> 3 m)	Open	Yes	Poor	16	Varus	45	3	Fair
8	33/M	Automobile accident	Closed	No	Good	13	–	41	1	Good
9	42/M	Automobile accident	Closed	No	Good	15	Pin-track inf.	58	3	Good
10	45/M	Automobile accident	Open	No	Poor	15	–	38	3	Fair
11	54/M	Automobile accident	Open	Yes	Fair	16	–	37	3	Good
12	52/F	Fall (> 3 m)	Open	No	Fair	18	–	45	3	Fair
13	64/M	Automobile accident	Closed	No	Good	18	–	48	3	Poor
14	71/M	Fall (> 3 m)	Open	Yes	Anatomic	21	Wound inf.	58	3	Poor

external fixators, including hybrid, articulated, unilateral, and circular external fixators, have been used for this purpose. Although these techniques have reduced the early complications related to soft tissues and bone to an acceptable level, it is still claimed that they cannot provide efficient fixation and anatomic reduction (6).

In our clinic, we treated 18 patients with high-energy type III closed tibial plafond fractures using external fixators. We report the reduction scores, arthrosis levels, and early and late complications in these patients.

#### PATIENTS AND METHODS

In our clinic, 18 patients with a high-energy closed tibial plafond fracture were treated using circular external fixators. All of the fractures were closed; open injuries were not included. This retrospective study includes only 14 patients who presented for a final follow-up. The average age of the four female and ten male patients was 42 years (range: 17 to 71). Seven of the injuries were the results of traffic accidents, and the other seven were falls from heights. Four patients had additional injuries: two had vertebral fractures, one a femur fracture, and one a contralateral tibial diaphysis fracture. All of the fractures were type III according to the Ruedi and Allgöwer classification.

Early complications, the reduction score of the articular surface, reduction loss, symptomatic and functional evaluation of the ankle, and osteoarthrosis findings were reported for the patients. The quality of the operative reduction was based on the initial postoperative roentgenograms and the criteria proposed by Ovdia and Beals (18) and modified by Teeny and Wiss (23). The quality of reduction, in a variety of aspects, was rated numerically: widening of the mortise, tilt or displacement of the talus, fibular shortening, and gaps in the articular surface (table II) (23). The symptomatic and functional evaluation of the ankle was based on a modification (17, 23) of the system proposed by Mazur (15). Clinical results were graded as excellent, good, fair, or poor (table IV). Osteoarthrosis was graded according to the criteria of Marsh and Bonar (12): Grade 0 indicated no evidence of arthrosis; grade 1, small spurs but no joint space narrowing; grade 2, osteophytes and some joint-space narrowing; and grade 3, complete loss of the joint space.

#### Surgical Technique

The patients were operated on at an average of 2 days (range: 1 to 3) post-injury. The first step involved pre-operatively preparing an external fixator appropriate for the fracture. During the operation, the fibula, if fractured, was first stabilised using a lag screw and a one-third tubular plate. Next, two rings were fixed to the tibia

Table II. — Scoring criteria for quality of reduction according to Teeny and Wiss

Anatomical site Quality of reduction	Score*		
	1	2	3
Lateral malleolus Displacement	0-1 mm	2-5 mm	5 mm
Medial malleolus Displacement	0-1 mm	2-5 mm	5 mm
Posterior malleolus Displacement	0-0.5 mm	0.5-2 mm	2 mm
Mortise widening	0-0.5 mm	0.5-2 mm	2 mm
Fibular widening	0-0.5 mm	0.5-2 mm	2 mm
Talar tilt	0-0.5 mm	0.5-2 mm	2 mm
Articular gap	0-2 mm	2-4 mm	4 mm

\* Values expressed are millimeters, corresponding to measurements made from final intra-operative or initial postoperative roentgenograms. For each measurement, the appropriate score is applied, based on the criteria listed. The sum of the seven scoring elements obtained represents the final score of the quality of reduction (23). Up to 8 points is accepted as anatomical.

diaphysis, and a half ring to the calcaneus, with 1.8- mm tensioned K-wires. The effect of ligamentotaxis on reduction was assessed using a C-arm. At this stage, no skin incision was made when the reduction of the articular surface was acceptable. Next, to stabilise the fragments in the metaphyseal region, percutaneous K-wires were used and fixed to the ring. The reduction was re-evaluated using a C-arm. We applied this technique in five patients, none of whom had a fibula fracture. In the other nine patients, for whom anatomic reduction of the articular surface was impossible using this technique, minimal incisions were made, and the articular surfaces were reduced. Minimal osteosynthesis with K-wires or screws was applied to the reduced fragments. In these patients, K-wires were used in different ways and to fix the small fragments (fig 1). In the patients with larger fragments, the fragments were fixed with lag screws. When minimal fixation was provided with screws, no rings were used in the metaphysis area (fig 2). In five patients, autogenous bone grafts were used when there was a deficiency in the metaphyseal region after reducing the articular surface. Prophylactic antibiotics were given postoperatively for 24 hours. In all cases, partial weight-bearing with crutches was started on the seventh postoperative day. After the third week, full weight-

Table III. — Radiological evaluation of our cases according to quality of reduction

Rating	Points	Number of patients
Anatomic	8	4
Good	9-11	6
Fair	12-15	2
Poor	> 15	2

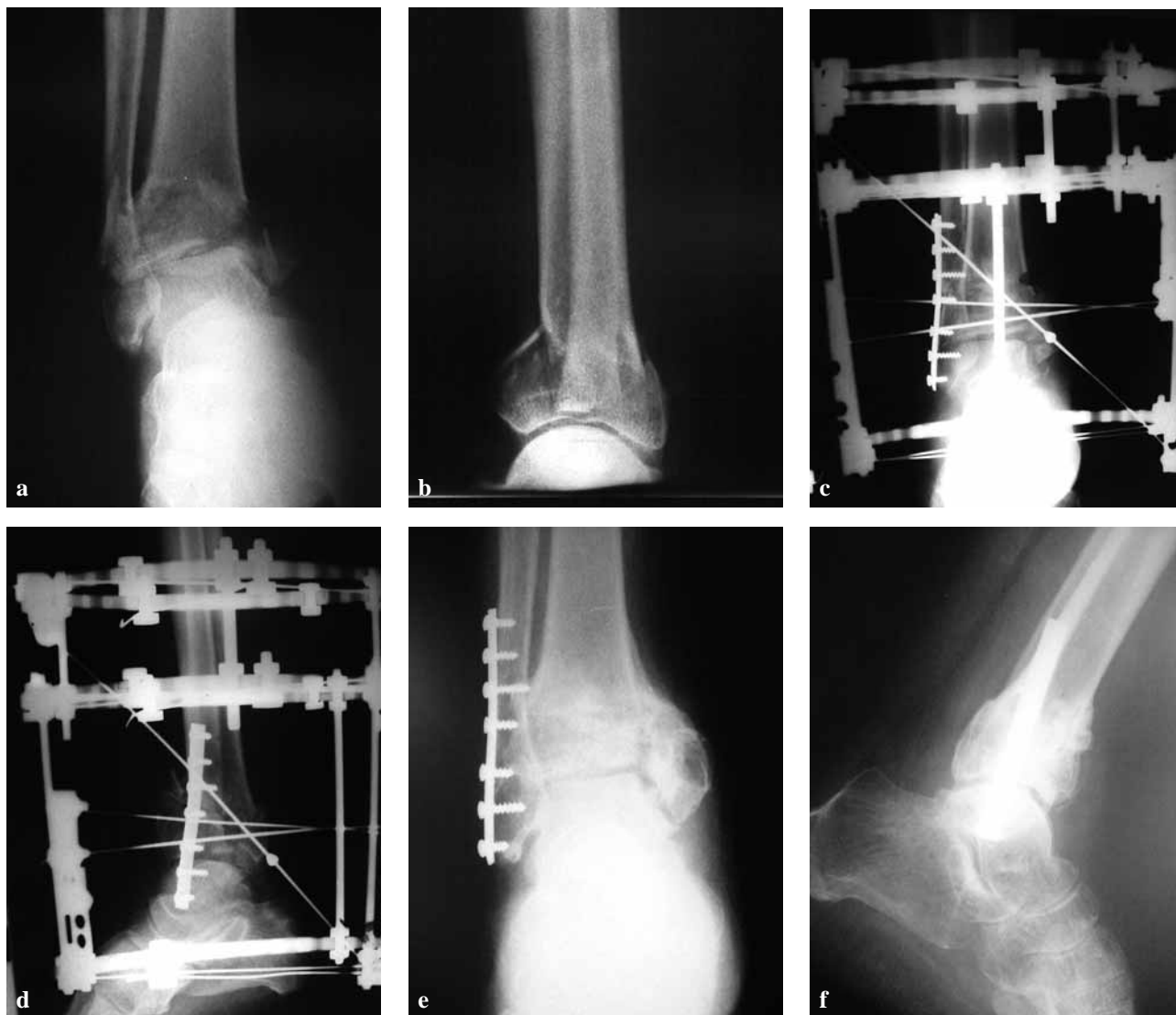
bearing was started. No immobilisation (plaster or brace) was used in these patients after the operation.

## RESULTS

The duration of the follow-up period averaged 48 months (range : 31 to 84). The calcaneal half ring was removed after 8~12 weeks, and ankle movements were started. In three cases, in which minimal osteosynthesis with a lag screw was used, calcaneal half-ring knitting was diagnosed, and the external fixators were removed entirely. The external fixators were removed after approximately 15 weeks (range : 11 to 21). In only one case superficial wound infection followed open reduction with minimal incision. The infection was controlled with parenteral antibiotics. In all of the patients, a total of 98 K-wires were used and pin-track infection was seen in 17 patients (17%). They were cured with oral antibiotics and dressings. In no case was a serious infection noted. In one case, a minimal angular deformity (5° varus deformity in the metaphysis area) developed (table I).

The articular reduction was considered excellent or good in ten ankles, fair in two and poor in two. The articular reduction did not change in any of the ankles during treatment (table III).

The functional evaluation of the ankle was excellent or good in eight cases, fair in three and poor in three. The range of motion was recorded for all patients. Dorsiflexion averaged 10.9° (range : 0° to 23°), compared with 24° on the contralateral side. Plantar flexion averaged 20.35° (range : 7° to 35°) compared to 37° on the contralateral side. Inversion averaged 4.50° (range : 0° to 10°), compared to 11° on the contralateral side. Eversion averaged 4.78° (range : 0° to 10°), compared to 14° on the contralateral side.



*Fig. 1 (Case II).*

1a and 1b : Preoperative AP and lateral radiographs of a fracture of the tibial plafond in a 54-year-old man.

1c and 1d : Postoperative radiographs showing circular external fixator as well as 3 K-wires used to fix the articular surface.

1e and 1f : Anteroposterior and lateral radiographs made 31 months after the injury, showing healing and grade-3 arthrosis.

Most ankles developed some degree of osteoarthrosis : one ankle was grade 0, five were grade 1, one was grade 2, and seven were grade 3. Not a single secondary ankle arthrodesis was needed by the time of the latest follow-up examination.

### DISCUSSION

Most authors would agree that the goals of the treatment of any displaced intra-articular fracture of

the ankle are : anatomic reduction, internal fixation of articular fragments, bone grafting of residual defects, open reduction/internal fixation (ORIF) of the fibula, and early mobilisation (1, 4, 10, 22). However, the application of these treatment principles in high-energy plafond fractures is controversial because very serious complications, including mal-union, nonunion, arthrodesis, osteomyelitis, and even amputation, have been reported in cases treated according to these principles (23, 24, 26).



**Fig. 2 (Case 2)**

2a and 2b : Preoperative AP and lateral radiographs of a fracture of tibial plafond in a 22-year-old man.

2c and 2d : Postoperative radiographs showing circular external fixator as well as limited internal fixation to restore the articular surface.

2e and 2f : Anteroposterior and lateral radiographs 37 months after the injury.

High-energy trauma can cause serious damage to both soft tissues and bone in this area with an insufficient vascular structure. Moreover, surgery involving much soft tissue exposure in this area has a high risk of soft tissue complications. Minor complications in the soft tissues increase the rate of

major complications. Therefore, delicate handling of the soft tissues has been advocated (4, 14). To prevent soft tissue complications, minimally invasive operations should be used for this type of fracture. In the present study, in which treatment was conducted in accordance with these suggestions, only

one superficial infection was observed. In addition, pin-track infections that were easily treated occurred in five cases. No deep infection occurred in any of our cases. This technique minimised the risk of deep infection, which is a serious complication often seen using conventional techniques. However, this technique also has some disadvantages. The potential pitfalls include less perfect reduction due to the more limited approach, loss of reduction due to a lack of stability of the external fixator and less motion of the ankle due to the fixator spanning the ankle joint (6).

One of the most important steps in treating tibial plafond fractures is anatomic reduction of the articular surface, to prevent the development of osteoarthritis (1, 7, 20). Ruedi *et al* (22) claim that reconstruction of the normal anatomy is only possible using open reduction and stable internal fixation. This view is acceptable for low-energy plafond fractures with relatively larger fragments. However, in some multi-fragmented tibial plafond fractures, it is very difficult to maintain stable anatomic reduction using internal fixation, even with open reduction. Teeny (23) successfully obtained anatomic reduction in only 30% of the patients with Ruedi type III fractures using open reduction and internal fixation, while the percentages were 77% for Ovaida and Beals (18) and 50% for Etter and Ganz (7). Conversely, the success at achieving anatomic reduction is greater in treatment protocols using external fixators, *e.g.*, Barbieri, 90% ; Marsh, 69% ; and Bone, 95% (2, 3, 13). In ten of our cases, we achieved excellent or good reduction (71.4%), in 5 of these with closed manipulation only. In 4 of the cases (28.6%), anatomic reduction could not be achieved. At the latest follow-up osteoarthritis was absent radiologically in only one case. The other 13 cases developed various degrees of osteoarthritis. Especially in high-energy plafond fractures, osteoarthritis not only results from the non-anatomic reduction of the articular surface, but from many other factors (1, 7, 22).

When reduction is attained in these fractures, it is difficult to achieve the ideal level of fixation because of the anatomic characteristics of the fracture. With poor fixation, reduction can be lost,

which causes complications such as non-union and mal-union at the metaphysis and articular surface. Reduction loss occurs in 30% of cases after open reduction and internal fixation (23), while the rate is 5~10% after treatment with an external fixator, depending on the type of external fixator and technique (13, 26). Fixation inefficiency is high with external fixators that do not cross the ankle (hybrid fixator). It is obvious that this type of fixator cannot provide efficient fixation of the fragments when the patho-anatomy of the fracture is considered, because the displacing effect of the talus on the fragments cannot be neutralised completely. Even efforts to minimise this effect by prolonging the period of non-weight-bearing are not fully successful. By contrast, when cross-ankle circular external fixators are used, the rate of fixation inefficiency is quite low (3, 13, 25, 26). We treated our patients with cross-ankle circular external fixators, and reduction loss was seen in only one case, which involved a 5° varus deformity in the metaphysis area. No mal-union or nonunion was observed in the other cases.

Another factor that determines the clinical result in tibial plafond fractures is early ankle movement. Early motion of the joint allowed after operative stabilisation improves articular cartilage nutrition and facilitates surgical wound and ligament healing (5). The effects of early motion on the clinical results with this type of fracture have not been investigated sufficiently. Many factors influence the final range of movement (ROM), and early movement is only one of the major factors determining the clinical results with intra-articular fractures. Another factor that affects the clinical results is early weight bearing on the extremity. Compression stiffness and dynamisation may be important for rapid fracture healing, callus maturation, and bone remodeling (9, 21). Biomechanical experiments have been conducted with many different types of external fixators. It has been reported that the compression stiffness with the Ilizarov fixator is low compared with that in other systems (8, 19). Another advantage of the Ilizarov fixator is its capability to fix even the smallest fragments from different planes with tensioned K-wires. Therefore, we treated all our patients with circular external fixators and started weight-

Table IV. — Modified Mazur classification : Clinical rating

Rating	Results
Excellent (> 92 points)	No pain, normal gait, normal ROM, no swelling.
Good (87-92 points)	Minimal pain, $\frac{3}{4}$ normal ROM, normal gait, trivial swelling.
Fair (65-86 points)	Aching with use, $\frac{1}{2}$ normal motion, normal gait, NSAID mild swelling.
Poor (< 65 points)	Pain with walking, or rest, $\frac{1}{2}$ normal motion, limp, swelling.

ROM : Range of motion.

NSAID : Nonsteroidal anti-inflammatory drugs.

bearing on the extremity only one week after the operation. However, the earliest ankle movement took two months. We achieved excellent or good clinical results in eight cases (58%), fair in three (21%), and poor in three (21%). No secondary arthrodesis was required in any of our patients.

High-energy plafond fractures should be investigated as a separate category. It is difficult to make a good comparison with other studies owing to the lack of a suitable classification for pilon fractures. Currently, all pilon fractures are categorised together, and different reduction scores have been used in each study.

In conclusion, circular external cross-ankle fixators have some disadvantages, such as inevitable wire-end infections, intra-operative neurovascular trauma, application difficulties, and unacceptable aesthetics. Conversely, the advantages are early weight bearing, minimal reduction loss, improved fracture stabilisation, little soft tissue exposure, and less deep infections. Therefore, we think that the appropriate treatment alternative for high-energy severely comminuted tibial plafond fractures is cross-ankle circular external fixators requiring a minimally invasive operation.

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