DYNAMIC EXTERNAL FIXATION OF COMMINUTED INTRA-ARTICULAR FRACTURES OF THE DISTAL TIBIA (TYPE C PILON FRACTURES)

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We report 26 patients with 28 type C3, distal intraarticular tibial (pilon) fractures treated by dynamic external fixation. Follow-up was at least two years, and the results (subjective and objective) were classified according to the Ovadia system. The mean to fracture union was 14 weeks (range : 12 to 20 weeks). There were three cases with angulation deformity (from 7° to 20°). There were no cases with nonunion or deep infection. Based on these results, this treatment with closed reduction and dynamic external fixation allowing early motion appears as a suitable method for treatment of comminuted intraarticular tibial pilon fractures.

Keywords : tibial pilon ; fracture ; external fixation.
Mots-clés : pilon tibial ; fracture ; fixation externe.

INTRODUCTION

Fractures of the distal part of tibia are the most severe ankle fractures, resulting in epiphyseal disruption and articular damage. This type of fracture has become fairly frequent. The usual term, pilon fractures, was introduced by Destaut in 1911.

The treatment of these fractures is very difficult, particularly in type C in the AO system classification. The goals of treatment are to achieve accurate articular reconstruction, physiological epiphyseal alignment, osseous and soft tissue healing, restoration of function, and to avoid complications.

The goals are difficult to achieve using classic internal fixation ; external fixation is therefore a widespread method. Most frequently, external fixation deals with comminuted fractures in which the necessary stability cannot be achieved by internal fixation. For this reason, orthopedic surgeons often resort to temporary external fixation. The fractures are often open (most frequently, penetration of the sharp end of a bone fragment from inwards to outwards), so external fixation is desirable in any case. External fixation is most commonly performed by bridging the joint, leading to rigid fixation of the ankle. Such a fixation causes stiffness, which is subsequently difficult to rehabilitate. Also, it is well known that the cartilage of the small fragments in intraarticular fractures is nourished only by means of joint movements. Suppression of the physiological movements will lead to rapid destruction of the cartilage, irrespective of fracture union. The available literature offers several works related to dynamic joint fixation using external fixation and a specific articulation which otherwise is not a constituent of external fixation (11). The objective of our study was to demonstrate an option to dynamic fixation of the ankle using the standard "Mitkovic" bone external fixator. This fixator consists of only three components, with no additional articulating component. The same principle, yet with a somewhat different arrangement of components, may provide dynamic articulating fixation of different joints (ankle, wrist, knee, elbow).

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The aim of this study was to evaluate the results of the treatment of complex type C pilon fractures by closed reduction (ligamentotaxis) or open reduction and minimal internal fixation, all treated by dynamic external fixation.

PATIENTS AND METHODS

A series of 26 patients (28 fractures) with type C (C1, C2, C3) pilon fractures was analyzed in this study. There were 18 closed and 10 open fractures.

The patients were treated over a 6-year period (1995-2000) with follow-up of 2 to 7 years (mean 3.6 years). After admission anteroposterior and lateral radiographs were taken, and the fractures were classified according to the AO system. For the purpose of the study we included only type C pilon fractures.

The mean age of the patients was 44 years (range : 23 to 74 years). The mechanism of injury in all patients but one was a fall from a height.

The patients were treated using a dynamic external fixation frame with or without minimal internal fixation (fibular fractures were treated by plating). In cases with open fractures, the wound was irrigated, rigorously debrided, and prophylactic antibiotics were administered. Early coverage with a free microvascular flap was performed in one case.

The fractures were graded according to the AO classification. Open reduction and minimal internal fixation (K-wires and screws) were used in 24 patients, while ligamentotaxis alone, without opening the fracture site, was applied in four patients having numerous, very small fragments (mostly at the anterior aspect of the joint).

To present the results of the study as well as possible complications of the treatment, we used the Ovadia and Beats systems for subjective and objective evaluation of the results (16).

Objective results were based on the evaluation of ankle/subtalar motion, tibiotalar alignment, tibial shortening, chronic swelling, range of pronation/supination, and presence or absence of an equinus deformity. All the findings were described in terms of excellent-good-fair-poor.

Subjective results were based on the evaluation of the following parameters : pain, return to work, recreational activity, walking capability, pain medication requirement, and limp. All findings were also ranked from excellent to poor.

As a fixation device, we used the external fixator designed by Mitkovic (14, 15). This system, which has already been applied in 12,000 patients, consists of only three components : a pin, a clamp carrier, and a clamp (fig. 1). With this design, this unilateral external fixator frame permits rotatory and axial mobility of the clamp carrier in relation to the bar, and rotatory and axial mobility of the clamp in relation to the clamp carrier and in relation to the pin (fig. 2). It allows each pin to be placed independently, using no guide, and the frame may be placed easily each time, regardless of the position of the pins. Besides, such a design permits all three components to be mutually connected in different ways, making it possible to construct a variety of frames with respect to the fixed segment type, current need, etc. Moreover, the high flexibility of the frame allows for one type of the frame to be transformed into another during the intervention, e.g. from a rigid to a dynamic one, without changing the position of the pins, all of which may be performed in the outpatient clinic. In our series, for the treatment of unstable intra-articular fractures, dynamic fixation with two convergent pins through the proximal fragment of the tibia, 1 or 2 pins through the calcaneus, and one through the base of the first metatarsal bone, respectively, was placed in all

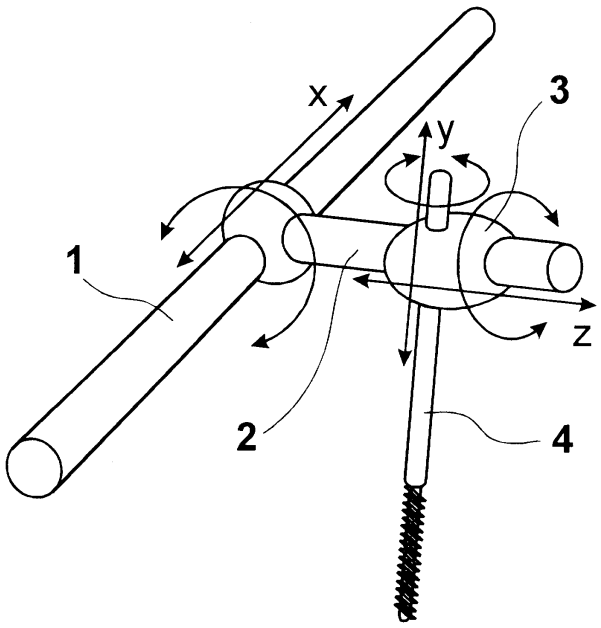

Fig. 1. — "Mitkovic" concept of the unilateral external fixator frame : Rotatory and axial mobility of the clamp carrier (**2**) in relation to the bar (**1**), and rotatory and axial mobility of the clamp (**3**) in relation to the clamp carrier (**2**) and in relation to the pin (**4**).

Fig. 2. — The frame of the 3D-unilateral external fixator, set to the model of the tibia.

26 patients intraoperatively. Then, a rigid frame was applied so that the distal end of the tibia could be fully visible on the xray in both AP and lateral projection (fig. 3b). Three weeks later, the rigid frame was converted into an articulated one in the outpatient clinic. The conversion comprised the removal of all the clamp carriers as well as the clamps from the distal half of the frame. Afterwards, the clamps from the proximal half of the frame (from two pins in the tibia) were unlocked and the bar of the frame was adjusted to be parallel and medial to the long axis of tibia. By using a special axis rotation finder device designed by Mitkovic (not described here), one clamp carrier was then positioned onto the distal part of the bar to be in the axis of the ankle joint. This clamp carrier was locked on the bar, and another one was completely pulled over to the former and locked while mounting the remaining components of the frame. On completing the frame, this clamp carrier, pulled over on the ankle axis clamp carrier, was unlocked to allow for dorsal and plantar flexion and to prevent undesirable movements (varus-valgus angulation and translation). The patient was encouraged to practice active movements of the ankle, not only passive ones. Depending on the degree of comminution and fracture instability, weight-bearing was gradually introduced after three weeks. After two months, full weight-bearing on the leg was allowed in all cases, but the apparatus was removed 3-5 months following the operation.

RESULTS

Good and excellent objective results were found in 20 patients (71%). Good and excellent subjective results were found in 19 patients (67%). In only one case was the outcome poor, and ankle arthrodesis had to be performed.

The time to bone union was 3 to 5 months (mean 14 weeks). Figure 3 shows a representative case of a patient who sustained a C3 grade I open distal tibial fracture, as well as the end result. Superficial wound infection was noted in three cases, but no deep infection or osteomyelitis was registered.

Other complications included secondary collapse laterally after fixator removal in two cases, and one collapse medially. In one lateral collapse, the angulation was 20° ; therefore nine months after the injury and the first operation, a second corrective intervention was performed, including hemicorticotomy of the distal metaphysis of the tibia and hemicallotasis using the varus-valgus frame built from three components of the same, above mentioned, external fixator (15). In one lateral collapse, the angulation was within tolerable limits (7°), while in the case with medial collapse, the angulation was on the borderline of tolerance (10°). Therefore, no intervention was undertaken in these cases. Arthrosis developed in four patients. Arthrodesis was required in one case, while the remaining three did not complain about any significant pain. No infection was noted in any of them.

DISCUSSION

The type C group of pilon fractures, caused by high-energy trauma, includes the most severe

injuries, with the greatest comminution and displacement of fragments. Severe damage of soft tissue is also present, although an open wound may be lacking.

Most authors (16, 18) report poor results when type C pilon fractures were treated by open reduction and internal fixation. Ovadia and Beals (16) found only 22% good - to - excellent results in this group of patients treated with conventional internal fixation, with a high rate of complications (infection, wound dehiscence). Pugh *et al*. (18) report two cases with below-knee amputation after open reduction and internal fixation.

In contrast, French and Tornetta (8) reported excellent results in 75% of patients after only limited internal fixation combined with external fixation bridging the ankle joint. Some authors stressed the importance of hybrid external fixation for comminuted pilon fractures (2, 8, 9), while others suggested articulated (dynamic) external fixation (3, 6, 12) in which the position of the external fixator at the ankle joint level was of the greatest importance, as demonstrated by Bottlang *et al*. (3) in their cadaver study. A third group of authors suggested circular external fixation (13, 19) with or without limited internal fixation. Compared to others, this method is faster and easier to perform (7, 10, 17). Thordarsen's (21) treatment consists of temporary external fixation followed by delayed internal fixation and bone grafting of the metaphyseal defect. We have demonstrated that the angulation deformities can be corrected by modifying the external fixator or later by hemicorticotomy. Some authors have gone so far in treatment of these fractures as to suggest primary tibiotalar arthrodesis as a salvage procedure for the most complicated cases. However, we have not found that this method has a place as a primary procedure.

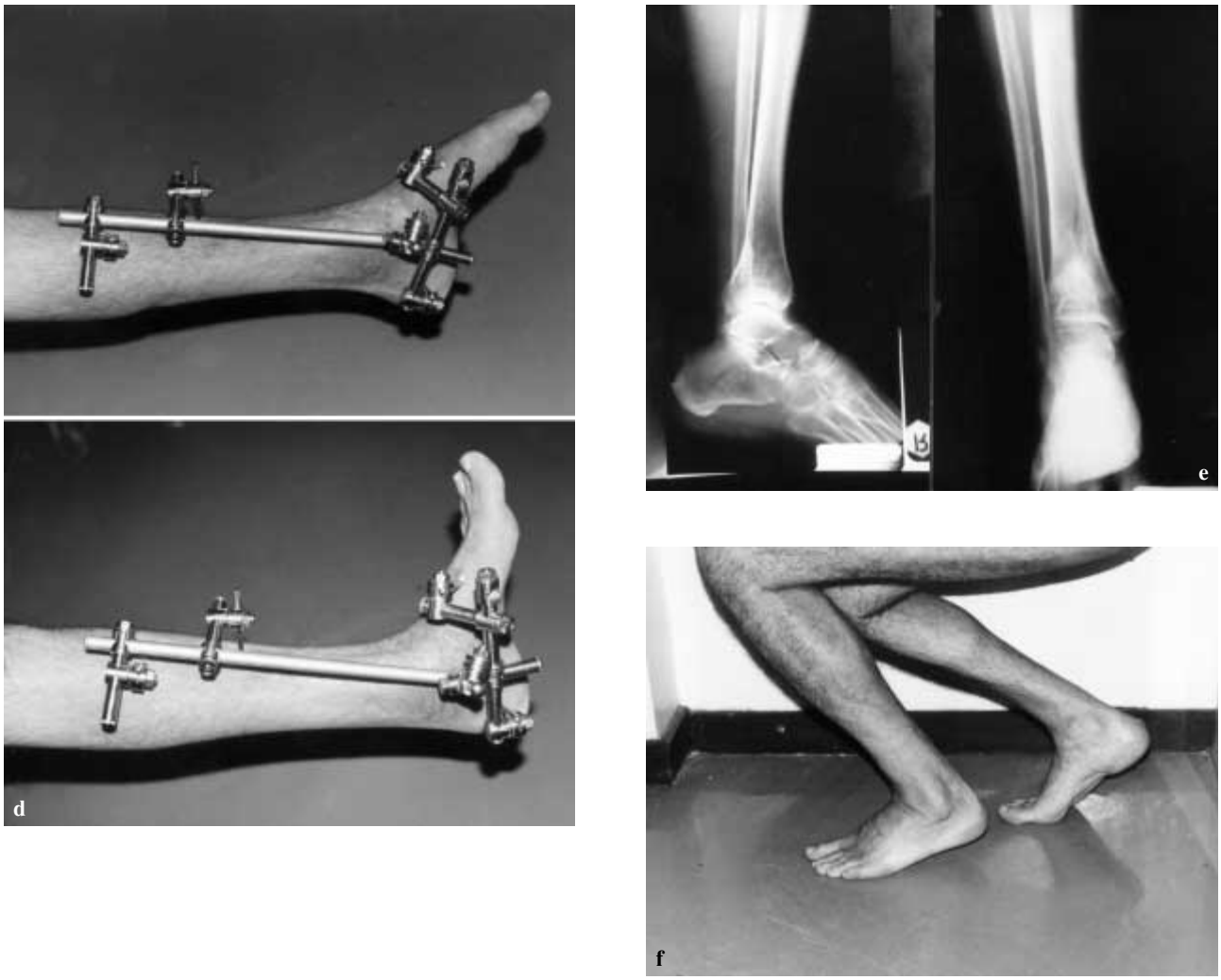

Fig. 3. — A 42-year-old man who sustained a type C3 grade I open distal tibial fracture when he fell from a tree : **a**. Xray before surgery. **b**. Radiograph after minimal internal fixation and rigid external fixation, 5 hours after injury. **c**. Clinical appearance after conversion of the rigid into an articulated frame (three weeks after injury). **d**. Dorsal and plantar flexion 6 weeks after operation. **e**. Radiographs three years after operation. **f**. Clinical appearance three years after operation.

Thus, when one is faced with such unsalvageable pilon fractures (with severe bone comminution and articular damage), the concept of closed reduction by ligamentotaxis and articulated external fixation (with only limited internal fixation) is reasonable and advisable. The method is particularly superior in the presence of stable articulated external fixation with no ankle bridging, thus allowing for early ankle motion and restitution of ankle function. Recently, Carr (4) has reported a balanced approach in which the approach depends on severity and the surgeon's skills. Kodros (11) also proposed articulated hybrid external fixation. External fixation helps in solving the soft tissue problem, which prevails in this group of fractures (20). The opinion that the fibula must be stabilized is not supported by Williams *et al*. (22). De Coster *et al*. (5) state that factors other than injury pattern and quality of articular reduction are important in determining the outcome in this type of injury. However, there are also data that are not supportive of the concept of hybrid external fixation (1). This question needs to be further investigated.

CONCLUSION

Dynamic external fixation, with or without open reduction and minimal internal fixation, provides maintenance of vascularization at the fracture site, early mobilization, good fracture union, and preservation of ankle function. The Mitkovic external fixator is applicable for dynamic and rigid fixation of the joints, because a transformation from rigid to dynamic fixation is a simple procedure that does not require additional components. This procedure is thus suitable in type C pilon fractures. Using this procedure, as opposed to open reduction and internal fixation, we can minimize the rate of complication which frequently follow major surgical reconstructions in this region.

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SAMENVATTING

M. B. MITKOVIC, M. Z. BUMBASIREVIC, A LESIC, Z. GOLUBOVIC. Dynamische externe fixatie voor comminutieve intraarticulaire breuken van de distale tibia (type pilon).

Het artikel bespreekt 28 gevallen van type C3 pilon tibial fracturen bij 26 patiënten verzorgd met reductie van de breuk, gevolgd van dynamische uitwendige fixatie en vroegtijdige mobilisatie. Bij follow-up na minstens twee jaar werden de subjectieve en objectieve resultaten geëvalueerd volgens Ovadia. De gemiddelde helingstijd bedroeg 14 weken (gaande van 12 tot 20).
Driemaal ontstond een hoekafwijking gaande van 7° tot 20°. Er waren geen gevallen van pseudarthrosis of infectie.
Derhalve menen de auteurs dat deze behandeling een geschikte aanpak is voor comminutieve pilon fracturen.

RÉSUMÉ

M. B. MITKOVIC, M. Z. BUMBASIREVIC, A LESIC, Z. GOLUBOVIC. La fixation externe dynamique dans le traitement des fractures intra-articulaires comminutives de l'extrémité distale du tibia (fractures du pilon de type C).

Les auteurs présentent les résultats obtenus chez 26 patients qui présentaient 28 fractures du pilon tibial traitées par fixation externe dynamique. Les résultats, avec un suivi minimum de deux ans, ont été évalués dans le système d'Ovadia. Le délai moyen de consolidation a été de 14 semaines (12 à 20 semaines). Trois fractures ont consolidé avec une déformation angulaire (de 7 à 20°). Il n'y a eu aucune pseudarthrose ni aucune infection. Au vu de ces résultats, la réduction à foyer fermé suivie d'une fixation externe dynamique apparaît comme une méthode de traitement recommandable pour les fractures intra-articulaires comminutives du pilon tibial.