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Temporary bridging external fixation in distal tibial fracture

F. Lavini, C. Dall'Oca, S. Mezzari, T. Maluta *, E. Luminari, F. Perusi, E. Vecchini, B. Magnan

Department of Orthopaedics and Traumatology, Azienda Ospedaliera Universitaria Integrata Verona, Piazzale Stefani, 1, 37136 Verona, Italy[1]

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ABSTRACT

Fractures that involve the distal area of the tibia are associated with a high percentage of complications. Soft tissue oedema, swelling, blisters, skin abrasions and open wounds could compromise the outcome of these lesions. The waiting time before surgery with ORIF is mostly due to soft tissue conditions. Early application of a simple joint-spanning external fixator would achieve the initial goal of stability and the respect of soft tissue, thereby decreasing the time necessary for definitive treatment.

A total of 40 consecutive patients (22 male and 18 female) with a mean age of 52 years (range 17–82 years) with distal tibial fracture treated between January 2010 and January 2013 were evaluated. Early temporary external fixation was the first treatment step. Twenty patients had pilon fractures, characterised by the intra-articular involvement of the distal tibia with metaphyseal extension, and 20 patients had malleolar fracture-dislocation.

Patients were divided into two groups, A and B. Group A comprised 10 patients with ankle fracture-dislocation and bone fragmentation, who were treated with a temporary bridging external fixation that was maintained after ORIF to exploit ligamentotaxis during the first phases of bone healing.

In Group B (30 patients), the external fixation was removed after ORIF.

The results of the study are in line with the recent literature: temporary external fixation in high-energy trauma and fracture-dislocation of the ankle enables soft tissue to be restored, which facilitates postoperative assessment of bone fragments by CT scan. The complication rate in this study was 5% in patients with malleolar fractures and 20% in patients with pilon fractures.

The maintenance of temporary external fixation after ORIF synthesis during the entire first stage of bone healing seems to be a good method of treatment that has a low rate of soft tissue complications.

Introduction

Fractures that involve the articular distal area of the tibia (tibial pilon) are associated with a high percentage of complications, and the outcome is often poor because of posttraumatic ankle arthritis or metaphyseal non-union and malunion [1,2]. The complications related to soft tissue injury are oedema, severe swelling, blisters, skin abrasions and open wounds, which predispose the patient to the development of wound dehiscence, skin necrosis and infections [3]. The objective of treatment is to restore articular congruency, epiphyseal-metaphyseal alignment and functional recovery. The choice of treatment must take into account correct and stable fracture treatment, and also, ideally, soft tissue management because this is a common source of frightening complications.

Severe ankle fractures caused by high-energy trauma or polytrauma that result in epiphyseal disruption and articular damage are associated with open wound and soft tissue injury, and massive swelling of the foot and ankle in more than 30% of cases. The correct treatment of these fractures therefore involves the use of temporary external fixation, particularly in the case of comminuted fractures with soft-tissue damage, unstable fracture pattern, fracture associated with articular dislocation or fracture associated with vascular damage. The timing of definitive surgery is crucial to reduce complication rates. There are two safe surgical windows for open surgery and definitive treatment: an early period, within 6 h after injury, and a late period between 6 and 12 days after injury [4]. The choice of timing will depend on the soft tissue condition, the general condition of the patient, and the expertise of the surgeon. The immediate treatment should be performed by a trained surgeon with extensive experience in this field after consideration of the possible risks and CT evaluation.

* Corresponding author. Tel.: +39 0458123542; fax: +39 0458123578.
E-mail address: tommasomaluta@yahoo.it (T. Maluta).
[1] clinica.ortopedica@ospedaleuniverona.it.

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Table 1
Group A: external fixation group.

	Age (years)	Male/female	Type of fracture		Side	AOFAS at 12 months
			Pilon fracture	Ankle fracture dislocation		
1	66	M	43.B		R	72
2	45	F	43.C		R	79
3	62	F	43.C		L	89
4	54	M	43.C		L	79
5	55	M		44.C	L	92
6	44	M		44.C	L	90
7	38	F		44.C	L	88
8	46	F		44.C	R	73
9	54	F		44.C	R	91
10	65	M		44.C	R	78
Mean	52.9					83.1

After a waiting period, the optimal time for definitive treatment is shown by skin wrinkling and skin recovery from blisters, thereby avoiding delayed skin healing and complications, such as wounds dehiscence, skin necrosis and infections [5].

Early application of a simple joint-spanning external fixator would achieve the initial goal of stability and the respect of soft tissue, thereby decreasing the time necessary for definitive treatment [6]. Several techniques can be used for definitive treatment of these fractures, including traditional ORIF, external fixation with or without limited internal fixation, intramedullary nailing (mainly for extraarticular fractures or as retrograde technique when an early arthrodesis is indicated) or minimally invasive plate osteosynthesis (MIPO) [1,7]. All of these techniques have advantages and disadvantages and the management of soft tissue injuries is of paramount importance as it often determines the final outcome.

The aim of this study was to evaluate the clinical and radiological results of the treatment of distal tibial fractures using an early temporary external fixation followed by definitive reconstruction and stabilisation. Also considered was a new stage possibility in treatment: the maintenance of the temporary bridging external fixation after ORIF to exploit ligamentotaxis during the first phases of bone healing.

Materials and methods

A total of 40 consecutive patients (22 male and 18 female) with a mean age of 52 years (range 17–82 years) with distal tibial fracture treated between January 2010 and January 2013 were evaluated. Early temporary external fixation was the first treatment step. Twenty patients had pilon fractures, which were characterised by the intra-articular involvement of the distal tibia with metaphyseal extension, and 20 patients had malleolar fracture-dislocation.

ORIF was performed in 12 of the 20 patients who had pilon fractures; hybrid external fixation was performed in the remaining eight patients. Eight of the 12 patients who underwent ORIF were treated with cannulated screws (Hit Medica 4.0 mm) for the tibial pilon and plates and screws (LCP Synthes) for fibular fractures; the remaining four patients were treated with plates and screws (LCP anterolateral Synthes) for tibial pilon and plates and screws (LCP Synthes) for fibular fractures.

All 20 patients with malleolar fractures were treated definitively by ORIF with cannulated screws (Hit Medica 4.0 mm) for tibial malleolus and plates and screws (LCP Synthes) for fibular fractures.

Patients were divided into two groups, A and B.

Group A comprised 10 patients with ankle fracture-dislocation and bone fragmentation; these patients were treated with a temporary bridging external fixation that was maintained after ORIF to exploit ligamentotaxis during the first phases of bone healing. This method was used in three patients with pilon fractures to enable a better check of the condition of soft tissue, three patients with malleolar fracture-dislocations to avoid a cast as they had damage to the skin of the heel and four patients affected by peripheral neuropathy because of diabetes (Table 1). In Group B (30 patients), the external fixation was removed after ORIF synthesis and a postoperative cast was applied (Table 2).

The AO/OTA (Arbeitsgemeinschaft fur Osteosynthesefragen) classification of pilon fractures that divides fractures of district 43 into type A (extra-articular), type B (partial articular), or type C (complete articular) was used in the study. Malleolar fractures were classified according to the AO/OTA classification of district 44 and with Danis–Weber classification: type A (infra-syndesmotic), type

Table 2
Group B: temporary external fixation group.

	Age	Male/female	Type of fracture		Side	AOFAS at 12 months
			Pilon fracture	Ankle fracture dislocation		
1	60	M	43.B		L	95
2	17	M	43.C		R	80
3	78	M	43.C		R	92
4	54	F	43.B		R	91
5	66	F	43.B		L	90
6	35	M	43.C		R	91
7	59	M	43.B		L	86
8	82	M	43.C		R	95
9	45	F	43.C		L	85
10	66	F	43.B		L	52
11	78	M	43.C		R	95
12	55	M	43.B		L	90
13	34	M	43.C		R	95
14	55	M	43.C		L	74
15	55	F	43.C		L	95
16	44	F	43.C		R	80
17	36	M		44.C	R	95
18	35	M		44.C	R	88
19	49	F		44.C	L	100
20	65	M		44.C	R	91
21	57	F		44.C	L	90
22	51	M		44.C	L	91
23	42	F		44.C	R	86
24	56	F		44.C	L	96
25	43	M		44.C	R	85
26	69	M		44.C	L	74
27	39	F		44.C	L	98
28	37	M		44.C	R	90
29	56	F		44.C	L	99
30	56	M		44.C	R	74
Mean	52.4					88

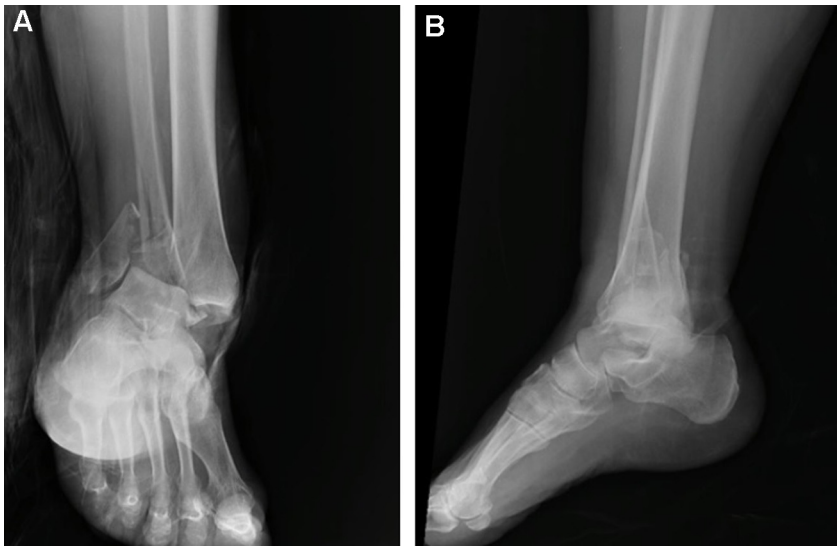

Fig. 1. (A) Pilon fracture with ankle dislocation, AP. (B) Pilon fracture with ankle dislocation, LL.

B (trans-syndesmotic) and type C (supra-syndesmotic). Eight of the 20 pilon fractures were type 43 B and 12 were type 43 C; all of the 20 malleolar dislocation-fractures were type 44 C. The fracture was open in 12 patients (six type A, four type B and two type C) according to the Gustilo-Anderson classification [3]. The standard radiographic examinations included antero-posterior, Mortise and lateral projections. CT was performed in all cases for fracture analysis and for planning the second step of the treatment (Figs. 1–6).

Primary fracture stabilisation was performed by the OrthoFix PreFix or Galaxy external fixation devices within 12 h after trauma. The time window between temporary bridging external fixation and definitive treatment (ORIF or hybrid external fixation) was never more than 2 weeks after trauma, and took into account healing of the skin and surrounding tissues to reduce the risk of infection and problems with the wound [8]. The average waiting time between the first step (temporary bridging external fixation) and the second step (definitive synthesis) was 12 days (range 6–14 days).

A clinical examination with American Orthopaedic Foot and Ankle Score (AOFAS) and X-ray control evaluation was made for all patients at three, six and 12 months after the definitive treatment. The AOFAS classifies the evaluated items into three major categories: pain (40 points assigned), function (50 points) and alignment (10 points) [9].

Results

At final follow-up (12 months), the average AOFAS score was 86 points in patients with malleolar fracture-dislocation and 72 points in patients with pilon fracture. The score was excellent (90–100) in 12 patients, good (75–89) in six patients and fair (50–74) in two patients affected by malleolar fracture-dislocation, and good in six patients, fair in 12 patients and poor (<50) in two patients with pilon fracture (Tables 1 and 2).

Complications occurred in 10 patients (25%), eight of whom had pilon fractures and two of whom had malleolar fractures. Two patients had early posttraumatic arthrosis in pilon fractures detected at one-year follow-up; two patients (one with malleolar fracture-dislocation and one with pilon fracture) had superficial infections; three patients with pilon fractures had delayed wound healing related to exposed fracture; and three patients (two with pilon fractures and one with malleolar fracture-dislocation) had

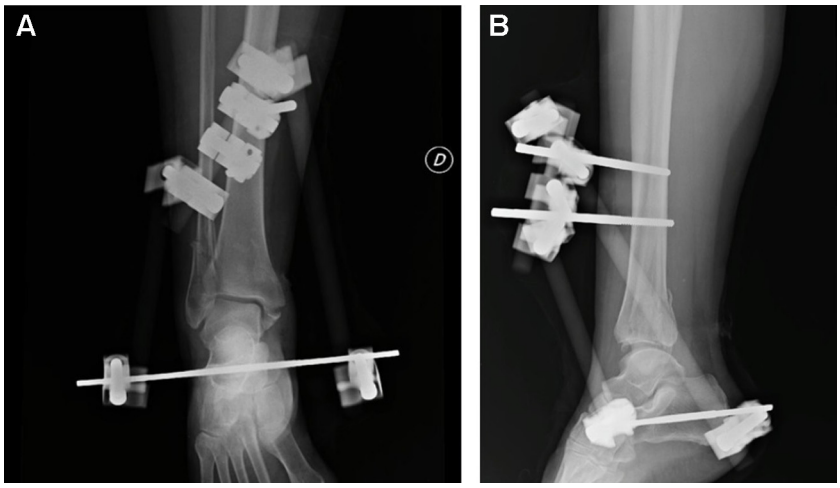

Fig. 2. (A) Urgency synthesis, AP. (B) Urgency synthesis, LL.

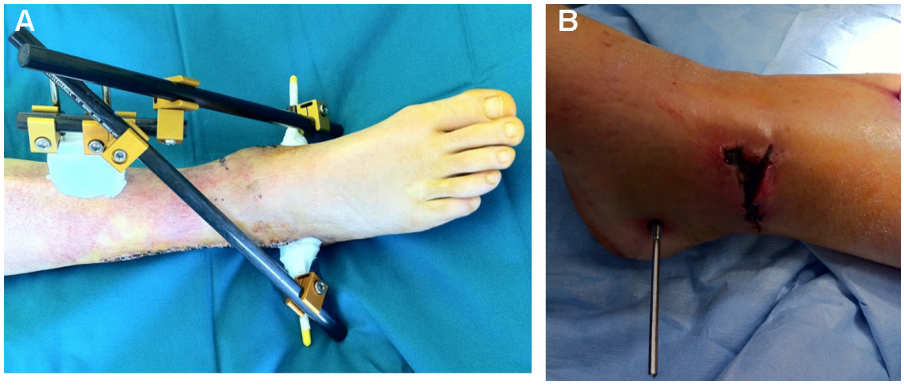

Fig. 3. (A) Temporary bridging ex-fix implant. (B) Soft tissues swelling and skin wound.

reflex sympathetic dystrophy. No neurovascular injuries were detected. No further surgical procedures were necessary for the treatment of complications (Table 3).

Discussion

Pilon fracture and malleolar fracture-dislocation of the ankle are two of the most severe injuries due to comminution and displacement of fragments, and are often associated with severe soft tissue damage. In these cases, high rates of complications are reported when conventional methods are used to treat these conditions; therefore, some authors recommend a two-stage protocol [8,10].

In the presence of comminution, the condition of the soft tissue guides the therapeutic choice. Tscherne et al. [11] proposed a classification of soft tissue damage in open and closed fractures as a guide for decision making.

Smoking and diabetes are other negative factors that influence the final outcome. Patients with complicated diabetes have over three times increased risk for overall complications, while there is an overall decreased incidence of complications with prolonged smoking cessation.

A two-stage protocol was proposed by Sirkin in 1999 [5]. This was followed by other authors who reported decisional algorithms for treatment of distal tibial fracture and showed reduced infection rates and complications with this regimen [12–14].

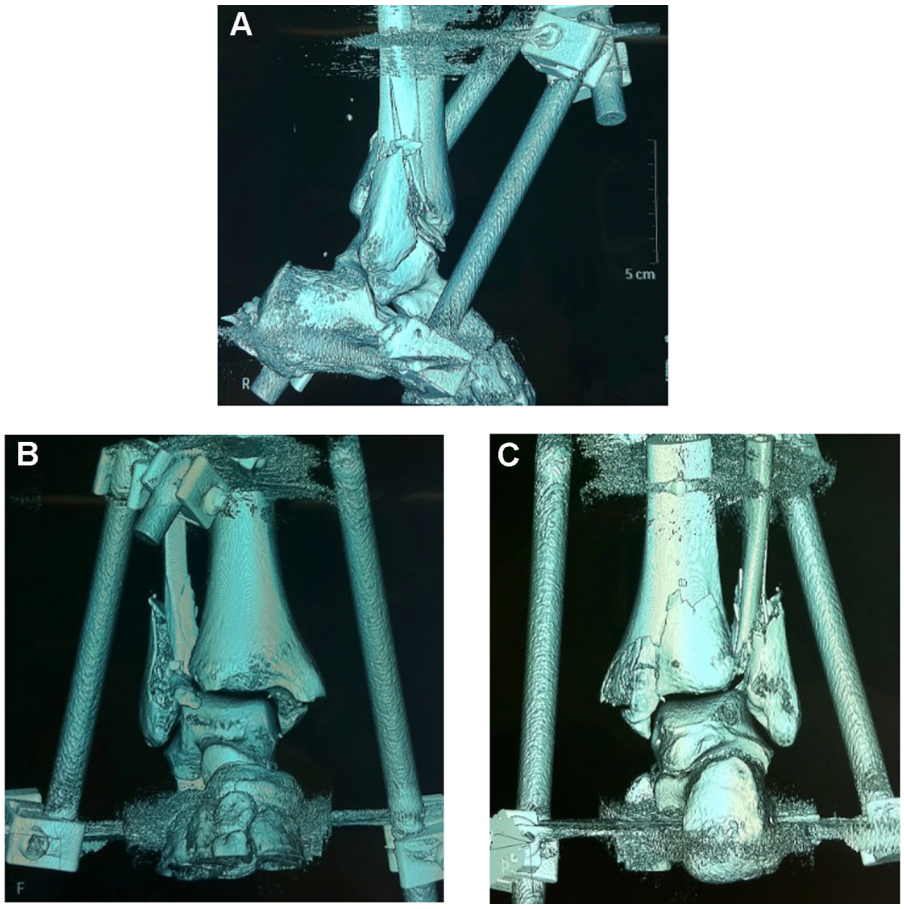

Fig. 4. (A) TC reconstruction lateral view. (B) TC reconstruction anterior view. (C) TC reconstruction posterior view.

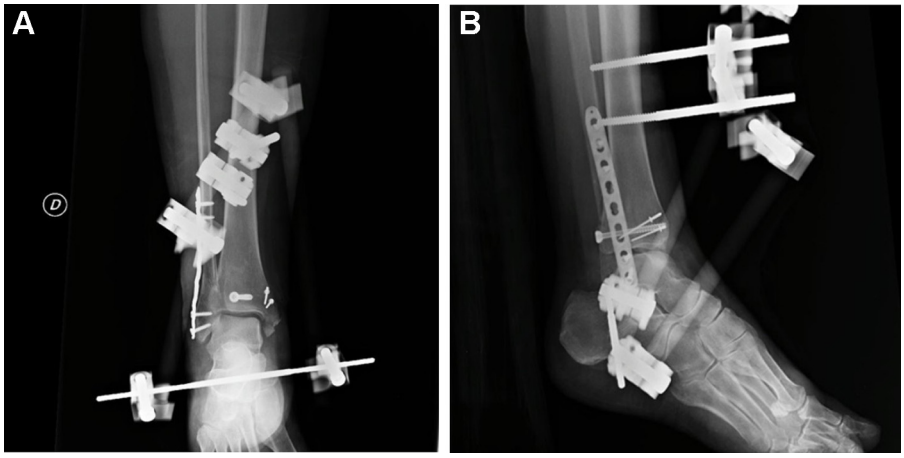

Fig. 5. (A) ORIF AP 7 days after trauma. (B) ORIF LL 7 days after trauma.

The first stage consists of an approximate reduction and application of an external fixator spanning the ankle joint to restore length and alignment of the limb. The external fixator comprises a delta frame construction with two pins in the tibial shaft and a calcaneal transfixation pin in the posterior tuberosity of the calcaneus. A posterior splint supplementation can also be associated to maintain a plantigrade foot before definitive treatment [5].

The second stage is carried out if the soft tissue allows. Three types of surgery with different indications and techniques are used mostly for definitive surgery, according to the literature: ORIF, external fixation and MIPO [10,15].

In our experience, provided the condition of the soft tissues allows, ORIF can be considered the best method to restore anatomical bone status; however, soft tissue conditions are often compromised in high-energy tibio-tarsal fractures. A new step was therefore introduced as a possibility of treatment: the maintenance of temporary bridging external fixation for 4 weeks after definitive ORIF synthesis to include the entire first stage of bone healing. This method maintains ligamentotaxis during the first 4 weeks after surgery to enable deflation and restoration of soft tissues.

During the waiting period, CT scanning is common practice for obtaining reconstruction images in sagittal and coronal planes, and for planning definitive surgery. CT scanning should be conducted only after external fixation, when extremity length and mechanical axis are restored.

Mauffrey et al. [10] reported a decision-making flowchart for tibial pilon fractures that takes into account the level of associated soft tissue injuries. They suggested that temporary external fixation is indicated for all cases of open fractures and closed type C, and for type A or B fractures with signs of skin lesions.

The two-stage protocol is a simple and convenient procedure that has several advantages. This method is safe, provided safe corridors are used for pin insertion, and neurovascular damage can be avoided by the use of non-trespassing screws on the diaphyseal area.

Oh et al. [16] reported three types of complication directly related to temporary bridging external fixator: problems related to the achievement of original length; half pin-related infections and medial calcaneal nerve injury. Also, the location and size of soft tissue wounds are often in the zone of pin placement. In such cases, other means of temporary stabilisation may be indicated. Other complications have been reported, including nerve or vessel injury, inappropriate positioning of the pins or inadequate stability or reduction of the fracture [17]. Sirkin [5] reported a rate of infection of 3% in both closed and open fractures, whereas postoperative complications vary from 20–50% in other series with a two-stage

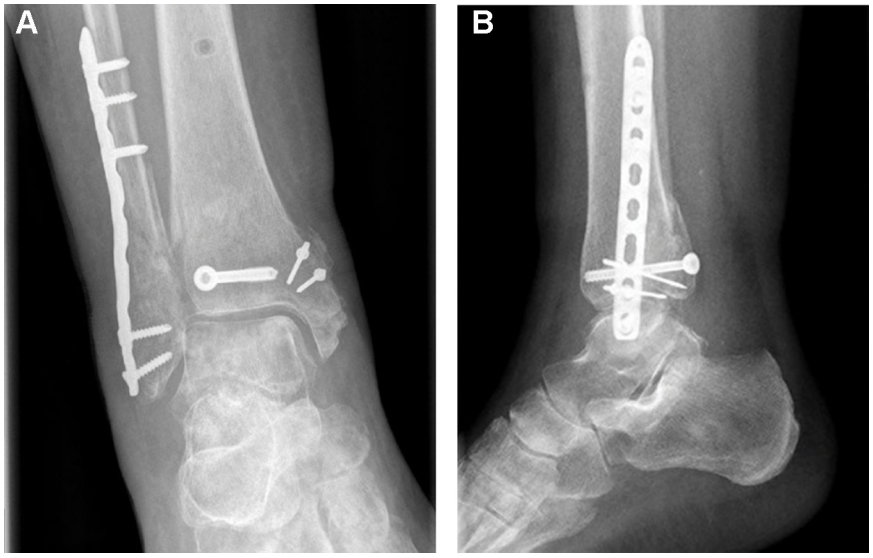

Fig. 6. (A) AP Rx control after removal of temporary external fixation after 4 weeks. (B) LL Rx control after removal of temporary external fixation after 4 weeks.

Table 3
Complications.

Complications	Group A		Group B	
	4 pilon fractures	6 ankle fracture – dislocations	16 pilon fractures	14 ankle fracture – dislocations
Delayed wound healing	1	–	2	–
Reflex sympathetic dystrophy	1	–	2	–
Early arthritis	1	–	1	–
Deep infections	–	–	–	–
Superficial infections	1	–	–	1

protocol [18]. There is a correlation between complication rate and initial fracture severity, likewise high fracture severity is associated with poor clinical results [19–21]. The pin placement should be out of the zone of injury, but also out of the planned incisions of definitive surgery. Pollak [22] showed that clinical outcome varied depending on bone and soft tissue injury, presence of open fracture, compliance of the patients, other injury and the surgeon's experience.

Conclusion

Distal tibial fractures are complex and require appropriate treatment to limit the incidence of complications. This type of fracture is often associated with a high complication rate, particularly related to skin and soft tissue trauma and suffering [16,22]. The two-stage protocol can be reserved for trauma with severe skin injury, such as complex pilon fracture and malleolar fracture-dislocation of the ankle. In the current study, this technique was associated with a complication rate of 5% in patients with malleolar fracture-dislocation and 20% in patients with pilon fracture. This effective protocol, which is widely accepted in the literature, optimises soft tissue management thereby decreasing infection rate associated with ORIF of pilon fracture [5,6,8,10,12–14,16,17,22,23]. The maintenance of temporary external fixation after ORIF synthesis during the entire first stage of bone healing seems to be a good method of treatment that has a low rate of soft tissue complications.

There were no significant differences in AOFAS score between Group A and Group B, but the number of cases was too small to enable a definitive conclusion.

The heterogeneity of the cases in terms of type of fracture, mechanism of injury, age of patients and type of treatment and, moreover, pre-operative skin and neurological conditions, does not enable the superiority of one method to be highlighted. The results of the study confirm the efficacy of the immediate external fixation in high-energy trauma of the ankle joint and the necessity of maintaining the external fixation in the post-ORIF period in selected cases.

Conflict of interest

The authors of this manuscript certify that there are no contributors and no conflicts of interest.

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