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CASE REPORT

Using External Fixation in distal tibial fractures- good principle, debatable application- Case presentation

Olivera Lupescu* **, Mihail Nagea, Alina Grosu**, Alexandru Dimitriu* **, Gheorghe Ion Popescu* **, Răzvan Scurtu***, Nicolae-Marian Ciurea****
*"Carol Davila" University of Medicine and Pharmacy Bucharest, Romania
**Orthopaedics and Trauma Clinic, Clinical Emergency Hospital Bucharest, Romania
***Anatomo-Pathology Department, Clinical Emergency Hospital Bucharest, Romania

Correspondence to: Alexandru Lisias Dimitriu, MD, PhD,
"Carol Davila" University of Medicine and Pharmacy Bucharest, Romania,
8 Eroii Sanitari Bld., code 050474, District 5, Bucharest, Romania,
Mobile phone:+40723 687 092 E-mail: alex.dimitriu@yahoo.com

Abstract
Distal tibial fractures usually result from high-energy trauma, affecting young, active people, producing long-term disability and numerous complications. Their treatment is difficult, especially in type C fractures, which affect both the articular surface and the metaphysis, are quite frequent comminuted fractures, and are accompanied by soft tissue injuries. In these situations, External Fixation (EF) is used as a temporary bridging method, either for treating concomitant soft tissue injuries (in open fractures) or for achieving and maintaining reduction in order to prevent blisters or compartment syndrome, possibly resulting from severe displacement, bleeding or oedema. It must be however underlined that EF is rarely a definitive method for these fractures, especially when the ankle is splinted, and it must be followed by definitive Internal Fixation (IF) - the so-called "sequential method", otherwise restoration of a normal ankle anatomy and function is improbable, resulting in ankle stiffness or even osteoarthritis. This paper presents a case in which this principle was only partially applied, thus requiring corrective surgery followed by a long-term recovery period.
Keywords: distal tibial fractures, sequential method, algoneurodystrophy

Introduction

Distal tibial fractures represent 3%-10% of all tibial fractures and around 1% of the fractures of the lower limb but they are of considerable importance for modern traumatology, as they affect especially young people, are difficult to treat and have a high rate of complications. Although they are referred to as "distal tibial fractures", in 70%-85% of the cases, a fibular fracture is associated. These fractures usually result from high energy trauma, so, additional injuries, such as ipsilateral calcaneal or tibial fractures were described in almost 50% of the patients [1,2]. Etienne Destot originally introduced the term "pilon fracture", which indicates an axially directed force which involves the weight-bearing surface of the ankle joint acting as a mortar [3,4]. Treating these fractures is challenging and demanding, as they usually affect not only the ankle joint but also the tibial metaphysis, therefore complete treatment must address both these aspects. In certain situations, primary fixation by Open Reduction and Internal Fixation (ORIF) is impossible or with high risks, so Closed Reduction External Fixation (CREF) is used as a temporary stabilization method, based on traction and splinting [5,6]. However, it must be underlined that CREF does not allow complete surgical restoration, therefore it must be followed by internal fixation, thus applying the so-called "sequential method". If this is not completely applied, the results will be incomplete, due to limited possibilities of external fixation (EF). In order to underline the importance of properly understanding and appliance of this two-steps method, the current paper presents a case in which only the first part of the sequential method was applied, thus generating negative consequences for the patient and requiring supplementary surgical procedures and longer recovery period.

Case report

The patient, female, 29 yrs old, sustained a distal tibial fracture due to an accidental fall 3 months before coming to our hospital. She was operated in another Orthopaedic and Trauma Department using External Fixator (ExFix), which was kept for all this period. The patient addressed to the Orthopaedic and Trauma Clinic in our hospital, a Level 1 Trauma Centre, for further evaluation and treatment.

a b c

Fig. 1 Initial clinical aspect (a) and X-rays: AP (a) and lateral views (b)

The initial evaluation performed at the Clinical Emergency Hospital Bucharest revealed an ExFix spanning the ankle with a malposition of the ankle and foot compared to the axis of the tibia: varus and external rotation (Fig. 1a,b), combined with equine (Fig. 1c). After the removal of the ExFix, a complete evaluation of the ankle was possible (Fig. 2a-c), thus revealing several negative consequences of prolonged immobilization.

a b c

Fig. 2 Negative consequences of prolonged immobilization with malposition: equine (a) and algoneurodystrophy (back)

- ankle stiffness with equines position (Fig. 2a), with a very low possibility of correction
- shinny skin and oedema, consistent with the radiological findings of algoneurodystrophy shown in Fig. 2 b and c, with increased radio-lucency of the distal tibia
- multiple fragments within the fracture site, at least one of them possibly interposed between the two main fragments, potentially responsible for the space between these fragments, visible especially on the lateral view

In order to establish a proper pre-operative planning, more information were needed especially regarding the articular surface and the fracture site, therefore a CT scan was indicated. As shown in Fig. 3 (a,b and c), the following must be taken into consideration when establishing the treatment:

- Multiple cortical interposed fragments, which alter the bone contact

- Bone gap with no tendency of bone growth

a *b*

c *d*

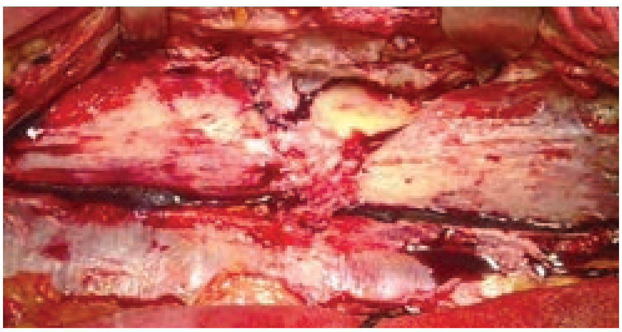
Fig. 3 CT scan with 3D reconstruction (a-c) and pre-operative implant length planning (d)

- Severe alterations of the quality of the bonesuggestiveforalgoneurodystrophy, affecting not only distal tibia, but also the talus, the calcaneus and the other bones of the foot
- The fractures at the level of the articular surface are not displaced
- The varus deformation is persistent, even without the ExFix, probably due to the position of the fibular fracture (Fig. 3a) fixed in a slight varus

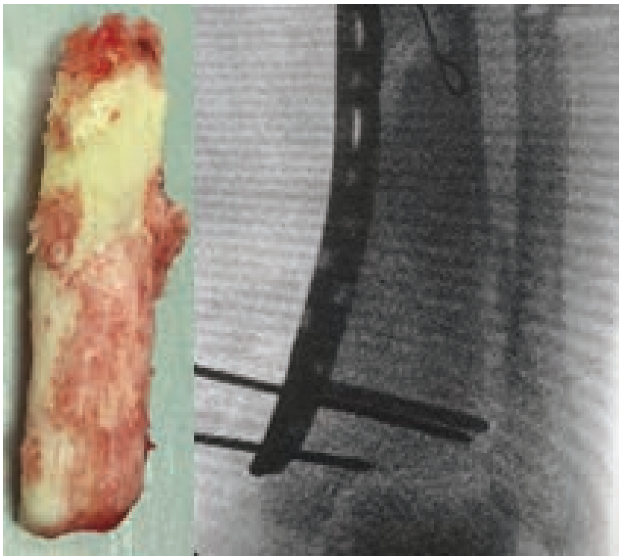
Under these circumstances, surgical treatment is indicated, with the following objectives:

- Restoration of the ankle joint: anatomical reduction of the articular surface and fixation achieving absolute stability, mortise stability achievement
- Restoration of the angle between the distal epiphyseal block and the diaphysis and stable fixation
- Good bone contact and optimal environment for healing

As one of the major steps of surgery is stabilization, choosing the type of implant is very important. Based on the previously described findings, nailing was excluded due to the aspect of the distal fragment, therefore plating was the only option. The impaired quality of the distal tibia due to prolonged immobilization considerably increased the risk of implant failure, thus requiring an angular stability plate. Because the fracture extends vertically to the diaphysis, the length of the plate must be calculated so that to allow a sufficient number of screws into the healthy bone in the proximal part and in the distal fragment as well (Fig. 3d).



a



b *c*

Fig. 4 Intra-operative aspect

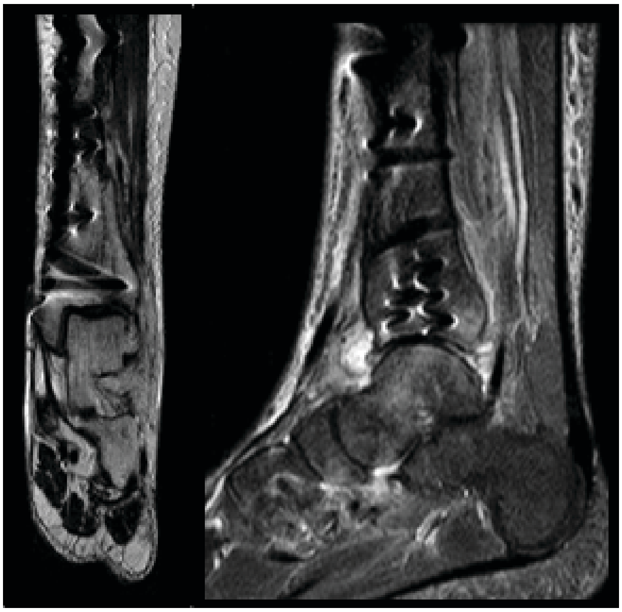
Surgical treatment started with the evaluation of the fracture site, which revealed (Fig. 4a) loss of bone contact due to interposed cortical fragments and fibrotic tissue within the fragments. The fibrosis was removed. The cortical fragment visible on the X-rays as well as on CT scan was obviously devascularised. Its color (Fig. 4a,b) was yellow and it was completely isolated, as a simple traction allowed its removal. Fixation was performed under fluoroscopic control (Fig. 4c), aiming:

- An optimal restoration of the distal fragment
- An optimal angle between the articular block and the rest of the bone
- Positioning the plate (titanium, angular stability) so as to have the maximal number of screws in the distal fragment, with optimal position - allowing the best fixation while avoiding the joint space
- Positioning the screws to assure a stable fixation; as the CT scan revealed a posterior fragment of the distal tibia in a closed relation with the peroneum, the latter was used as an indirect reduction tool in order to keep the fragment in place, and a trans-peroneo-tibial screw was introduced to protect the syndesmosis.

Considering the bone gap (due to multiple factors), the poor bone contact and the prerequisite of creating an optimal environment for healing, autologous bone grafting was performed using chancellors bone from the ipsilateral proximal tibial metaphysis.

The post-operative result is presented in Fig. 5a,b showing that all the goals were achieved. Moreover, the fact that an appropriate environment was created was demonstrated by the integration of the graft, as demonstrated by the follow-up MRI. Because the fixation provided a very good stability, early movements were started, including recovery therapy; this had a crucial positive impact, resulting in amending the signs of algo-neuro-dystrophy, as proven by the clinical outcome, as well as by the MRI (Fig. 5c,d).

b *b*



c d

Fig. 5 Post-operative X-rays (a,b) and follow up MRI (c,d)

Discussion

Distal tibial fractures refer to the area situated 8-10 cm proximal from the joint space, therefore affecting both the articular and the metaphyseal parts of the inferior tibia. Several classifications have been used to describe the fracture pattern. The most widely used nowadays is the AO system, which identifies 3 types of fractures:

- Type A - extra-articular, affecting only the metaphysis, with 3 subtypes: A1 (simple), A2 (wedge), and A3 (complex)
- Type B - partial articular fractures, with subtypes B1 (pure split), B2 (split-depression), and B3 (multifragmentary depression)
- Type C - complete articular fractures, with subtypes C1 (articular simple, metaphyseal simple), C2 (articular simple, metaphyseal multifragmentary), and C3 (articular multifragmentary) [7]

Treatment of these fractures must restore the ankle joint - which must be mobile, congruent, and stable, and the axial alignment, therefore certain landmarks need to be followed:

- the articular surface of the tibia needs anatomical restoration
- the length of the peroneum must be properly, so as to achieve a normal talo-crural angle (75-87 degrees, and symmetrical to the uninjured side)
- the joint must be stable and congruent, the width of the joint space must be the same on the internal, external and superior aspects and symmetrical to that from the uninjured site
- the vertical axis of the talus must be in line with the vertical axis of the distal tibial fragment and with the axis of the tibial diaphysis, both on AP and lateral views
- the middle point of the tibial articular surface and that of the talar articular surface must be on the in line with the vertical axis of the tibia [6,8-11].

The most difficult to treat are type C fractures and especially type C3, when comminution makes difficult the primary restoration. Moreover, due to bleeding in the metaphyseal area, the risk of circulatory complications is considerably higher than in simple fractures. Under these circumstances, the recommended attitude can be summarized in "span, scan, fix", meaning that: a spanning ExFix is used as a temporary reduction tool, allowing a complete evaluation of the fracture. The ExFix is kept only for a limited time (until definitive fixation is possible) as it may solve only some of the problems mentioned above (such as tibio-talar alignment), but it cannot restore the articular surface, nor the length of the peroneum, when this is fractured. If the peroneum is not fractured, it can be used as a landmark for the normal tibial length, and treatment must address the tibial fracture, without neglecting the tibio-fibular syndesmosis, which can be injured, even if there is no fibular fracture [12,13].

In this case, prolonged external fixation had serious negative consequences: not only ankle stiffness (especially that the position of the ankle was in equine, thus increasing the risk of retraction of the Achilles tendon), but also a severe alteration of the quality of the bones around it, due to algoneurodystrophy, usually accompanying prolonged immobilizations. At the same time, due to bone resorption, anatomical reduction of all the fractures (including the articular ones) is more difficult. In this particular case, fracture healing was improbable due to poor bone contact - the interposed cortical fragment not only made healing impossible, but became devascularised and needed to be excised, thus generating the problem of filling the bone gap.

The implant must be chosen according to the fracture pattern and to the bone stock. In comminuted fractures or when the bone quality is impaired, angular stability implants used on one side are usually stiff enough to ensure stability proven that the opposite cortex has an optimal bone contact and the peroneum is intact or restored [6,8,9]. In this case, a distal tibial plate was used; its position carefully checked fluoroscopically to neutralize the initial varus, allow joint movements, and allow enough locked screws to be inserted in the distal fragment. The optimal length and position of the plate restored the internal tibial cortex, while the external one was restored by reducing the fracture, thus getting optimal bone contact except for the gap resulted from excising the interposed devascularised fragment, which needed bone filling.

When deciding what to fill a bone gap with, we have to choose between osteogenic, osteoinductive or osteoconductive bone substitutes. In this case, due to the bone defect between two cortical tubes (the two diaphyseal parts), there were no stem cells to be stimulated, and therefore an osteogenic graft was mandatory. For these reasons, a cancellous autograft, still considered to be the gold standard in bone grafting, was preferred, thus achieving all the conditions stipulated by the Diamond Concept or the "biological chamber": cells, scaffold and growth factors (local + graft + blood stream), stability (optimal fixation) and vascularity (excisions up to vital tissues) [14,15].

As definitive fixation provided an optimal stability, sustained recovery therapy resulted in equine correction, with physiological movements of the ankle and complete remission of the algoneurodystrophy, thus demonstrating that mechanical stability and friendly biological environment are the prerequisites for a successful treatment and a favorable outcome.

Conclusions

Based on complete evaluation of the fracture pattern (usually by CT scan), surgical treatment of distal tibial fractures must address all the factors that affect local functional anatomy. In comminuted fractures, spanning external fixation can be used as a temporary reduction tool, but it cannot provide all the conditions necessary for an optimal healing, therefore, it must be followed, as soon as local and general conditions allow it, by definitive internal fixation. Prolonged ankle immobilization due to spanning, especially if done in an abnormal position, add supplementary negative elements to those induced by the initial trauma and require more complicated surgical treatment. An optimal bone contact must be obtained (with grafting, if necessary) and sustained by a stable fixation, thus creating the conditions for an early functional recovery.

Acknowledgments

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