Treatment of Noninfected Nonunions: Parafoveal Osteotomy

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Introduction

Osteotomies performed in the management of nonunions can be classified into three types [1]:

- Intrafoveal osteotomy (performed at the nonunion site: it consists essentially of the resection of the entire area around the nonunion);
- Transfoveal osteotomy (performed through the nonunion site to reshape the bone ends: it is indicated for nonunions with a longitudinal or oblique fracture line);
- Parafoveal osteotomy (Paltrinieri's osteotomy, performed some centimeters from the nonunion site).

In this chapter the original idea by Paltrinieri (parafoveal osteotomy) and the indications for this technique are described and discussed.

Parafoveal Osteotomy

In the 1960s Paltrinieri described a personal operative technique that had not previously been described in the literature [2, 3]. According to this technique, it was possible to stimulate the osteogenic potential of the bone in cases of delayed union or nonunion and obtain healing of the nonunion through a single or double osteotomy performed some centimeters away from the nonunion level, proximal or distal to the lesion.

In such cases osteotomy has a dual role: (1) to remove all mechanical stimulation from the nonunion site, transferring it to the osteotomy, and (2) to reestablish the axis to normal by correcting single or complex deformities. In this manner well-vascularized bone tissue can be deposited, substituting the formerly nonvascularized connective tissue interposed between the bone ends.

Paltrinieri developed this technique when attempting to treat a tibial nonunion in a 48-year-old man. This patient was affected by a left tibial nonunion, as a consequence of an open fracture sustained 2 years previously during a road accident, and had previously been treated with osteosynthesis, without healing. That nonunion caused a severe varus and recurvation leg deformity.

Paltrinieri performed a tibial osteotomy to correct the deformity and immobilized the limb in a cast. Three months later, he surprisingly noticed that the nonunion had healed, refuting the dominant idea that nonunions are irreversible. In Paltrinieri's opinion the mechanical moment is the main event in determining the lack of fracture consolidation, and therefore healing could be achieved by resting the nonunion site. The operation indeed produces a perfect immobilization of the nonunion site, protecting it from any mechanical stress; moreover, it facilitates the contact between the bone ends and the renewal of the physiologic pressure stimulus, and eliminates flexion and torsion tibial movement (improved by fibular integrity, which works as a lever), which have a detrimental effect on bone healing. To this mechanical or passive effect, a biological or active effect was added, consisting in stimulation of osteogenic mesenchyma.

In brief, the bone healing process ends at the nonunion site, but the creation of a new fracture site stimulates the regenerative capability of the former site.

Surgical Technique

The operative technique for parafoveal osteotomy is simple: for tibial nonunion a short skin incision is performed, taking care not to tear soft tissues; then the periosteum is cut and carefully separated from the cortical bone. For nonunion of other long bones, the technique is similar, but the soft tissues must be carefully dissected to reach the bone.

The osteotomy is performed 3–6 cm away from the nonunion site and preferably with an osteotome rather than a motorized saw, to avoid the risk of bone tissue necrosis. The osteotomy level is chosen according to certain considerations: areas of dystrophic skin and areas with phlogosis or infection are to be avoided. Moreover, the osteotomy must be performed at a healthy bone level, and radiograms may help exclude areas involved in nonunion or those with osteoporosis, sclerosis, with a closed medullary canal, or previously affected by inflammation.

The osteotomy requires immobilization so that the anatomical axis of the bone segment is maintained during healing. For this, Paltrinieri used a cast. Umiarov [4] suggested the use of a parafoveal osteotomy associated with

immobilization by means of a compression-distraction device, to combine the advantages of these techniques.

Indications

Parafoveal osteotomy is indicated in delayed unions and nonunions where the mechanical moment is predominant (hypertrophic or normotrophic nonunions). It is also indicated for treating nonunions with simple or complex deformities and is useful in nonunions with skin lesions at the affected site.

Parafoveal osteotomy is contraindicated for infected nonunions with extensive tissue loss.

This treatment is particularly indicated for lower limb nonunions. In upper limb nonunions, whose origin is more biological than mechanical, and where traction or compression forces depending on weight bearing are lacking, this technique is less useful.

Patients and Methods

Between 1984 and 2002, 10 patients affected by tibial nonunion were treated with Paltrinieri parafoveal osteotomy. Among the patients there were eight men and two women with a mean age of 32 years (range 25–50 years). We began employing this technique at the Department of Orthopaedics and Traumatology of the University of Pavia in 1996, so the real period the cases refer to is 1996–2002.

Eight patients had been previously treated with osteosynthesis for the former fracture (intramedullary nailing in four cases, plating in two, and external axial fixation in two). Two patients were treated conservatively with a cast.

Nonunions were normotrophic in six patients and hypertrophic in four. Each case was associated with a simple or complex bone deformity: four patients had a varus deformity, three a valgus deformity, two had a recurvation deformity, and one a proximal varus and a distal valgus-recurvation deformity. All patients were treated 8–17 months after the fracture had occurred (mean: 10 months).

The operation consisted of osteotomy, performed as a corticotomy close to the nonunion site, 3–6 cm away from the nonunion. The osteotomy was usually performed distal to the nonunion site. The double complex tibial deformity was treated with a double (proximal and distal) parafoveal osteotomy. In all cases both nonunion and osteotomy were stabilized with an Ilizarov apparatus.

The postoperative plan required an immediate rehabilitation program and early weight bearing. From the second postoperative day, gradual corrective maneuvers were performed at the corticotomy site until the deformity was corrected and a good axis restored. At the end of the correction phase, moderate compression was given at the nonunion level. Nonunion and corticotomy healing processes were radiographically, sonographically, and extensimetrically monitored.

Results

Patients were followed up for 3–9 years. No vascular or nervous lesions were observed in this period. During treatment, wires broke in two cases (treated with wire substitution). Four patients developed superficial infection at some wire tracts, which healed with local dressing and antibiotic therapy.

Nonunion healing, with simultaneous consolidation of the corticotomy and correction of the deformity, was obtained in all patients in an average of 110 days (range 90–155 days) (Figs. 1–3).

Fig. 1a, b. X-rays of a proximal metaphyseal nonunion with axial and translational deformity of the left tibia in a 45-year-old man

Fig. 2a-d. Same case as in Fig. 1. **a, b** Treatment with Paltrinieri's technique. A corticotomy was performed 5 cm distal to the nonunion level and axial and translational deformities were corrected. Stabilization was obtained by means of an Ilizarov device. **c, d** X-rays after 45 days

Fig. 3a-d. Same case as in Fig. 1. **a, b** X-rays after 90 days. **c, d** X-rays at the removal of the compression-distraction device (after 4 months), showing healing of the corticotomy, consolidation of the nonunion, and complete correction of the deformity

At the end of treatment no worsening of the knee or ankle range of motion was observed. Hypotrophy of the femoral quadriceps muscle was initially observed, but rapidly improved with physiotherapy. All patients were able to walk without canes.

Discussion

Paltrinieri thought that trophic and reactive alterations of bone tissue occur at the nonunion site. This would explain the not infrequent failure of local treatments, such as bone grafting. Failure risk increases in the management of open or infected fractures, even after the phlogosis ended, because of the latent microbial colonization.

The osteotomy performed at the fracture site has the ideal effect of perfectly interfacing the opposite fragments, anatomically reconstructing the morphology and completely resolving the mechanical aspect of the problem. However, this method fully ignores the biological aspect: it acts on bone tissue that generally is sclerotic and not entirely suitable for undergoing a new regenerative process.

To solve the biological problem, the osteotomy is indicated at a site away from the original fracture. Biologically, the metaphysis offers the best result; here the cortical bone is sharp, with a lot of spongy tissue and the possibility of obtaining wide contact surfaces. The metaphyseal osteotomy, however, has limited indications both in femur and tibia, because it is not suitable from the mechanical point of view.

If the indications for osteotomies at the fracture site and at a distance conflict, the former with the biological factor and the latter with the mechanical factor, it is logical to assume that an osteotomy performed as close as possible to the fracture site would successfully solve the problem. The parafoveal osteotomy acts on a normal bone tissue with normal osteogenic capacities and achieves a good correction both aesthetically and mechanically.

As for the convenience of performing the osteotomy proximal or distal to the nonunion site, some biological and mechanical aspects should be considered. Biologically, vascularization by the feeding artery must be considered. The osteotomy must be performed in respect of vascularization proximal or distal to arterial penetration into the diaphysis. From the mechanical point of view, parafoveal osteotomy aims to correct angular displacements. The irregular weight distribution on abnormally oriented articular surfaces causes degenerative alterations over time: it is then necessary to ensure that the articular lines are parallel. The closer the osteotomy is to the fracture line, the less difference there will be between the nonunion angle and the osteotomy angle.

Paltrinieri evaluated the possibility of performing a double osteotomy, proximal and distal to the lesion, on the basis of the hypothesis that complete rest at the site of delayed union or nonunion can only be achieved with this solution. The results obtained in his series do not confirm this hypothesis; on the contrary, they failed to show any advantage over the single osteotomy.

Paltrinieri's technique was successfully employed later by other authors [1, 4, 5-15]. In particular, the stabilization with circular external fixation systems, suggested by Umiarov [4], shows many favorable aspects: stability, assembly modularity, multiplanar control, and the possibility of gradually correcting deformities.

Therefore compression-distraction techniques seem to represent a natural complement to Paltrinieri's technique: the elasticity of these systems allows easy control of mechanical stress, taking away the cut and torsion forces and maintaining and improving the compression and distraction forces at the corticotomy site. This represents a further stimulus to healing and helps improve weight transfer from the fixator to the bone as the consolidation proceeds.

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