



## Treatment of delayed union or non-union of the tibial shaft with partial fibulectomy and an Ilizarov frame

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**We reviewed 28 patients treated with partial fibulectomy combined with an Ilizarov compression frame for a non-infected tibial delayed union or non-union. Patient data, time to referral, type of fracture (open or closed), type of non-union (atrophic or hypertrophic) and period of treatment were recorded. Neither time to referral, type of fracture or type of non-union did adversely affect the duration of treatment. Only smoking was found to have a negative influence on the healing time. There were no major complications associated with the treatment and all fractures united except one. We conclude that partial fibulectomy combined with an Ilizarov frame is a reliable method for the treatment of tibial delayed and non-union.**

**Keywords :** tibia non-union ; fibulectomy ; Ilizarov.

### INTRODUCTION

Healing problems in tibial fractures are not uncommon. The prevalence of non-union of closed tibial shaft fractures is 2.5% and increases 5-7 fold for open fractures with gross contamination and extensive soft-tissue damage (10). High-energy injuries are often open fractures, with greater displacement, bone loss, concomitant fibular fracture, comminution, and infection. Aggressive multiple debridements, administration of antibiotics and rigid immobilisation of the fracture fragments can substantially decrease the risk of non-union. Early weight-bearing mobilisation allows intermittent

compression to the fracture site contributing to healing and lowering the rate of non-union (10).

Associated fibular fractures usually heal quickly within 6 to 8 weeks. Compressive forces are then transmitted through the fibula, causing it to deform. Subsequently the compression at the tibial non-union site, essential for the healing, is reduced and healing is adversely affected (2,6,12).

Partial fibulectomy has been described and used for more than four decades to promote healing in tibial non-union because it allows better axial loading of the tibia (1,2,6,12).

Partial fibulectomy combined with the optimal axial compression provided by an Ilizarov frame represents a minimally invasive treatment which can avoid the need for bone grafting in non-unions without extensive bone loss or infection.

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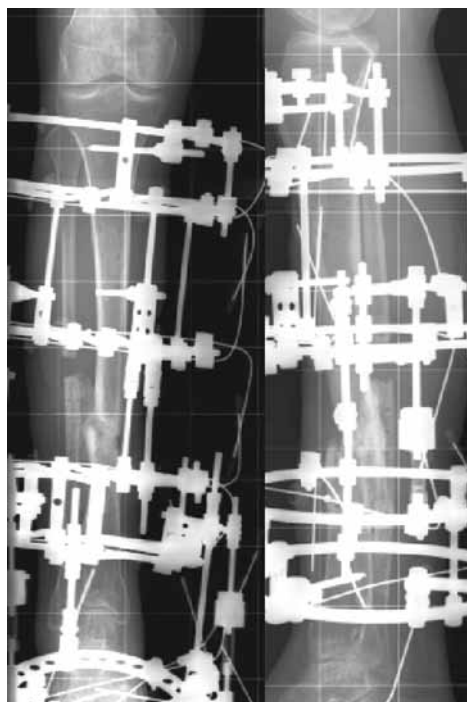
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a



*Fig. 1.* — Non-union with valgus and recurvatum position, despite previous bone grafting (a). Partial fibulectomy, acute alignment and compression with Ilizarov frame (b). Final result after frame removal at 6 months postoperatively (c).



b

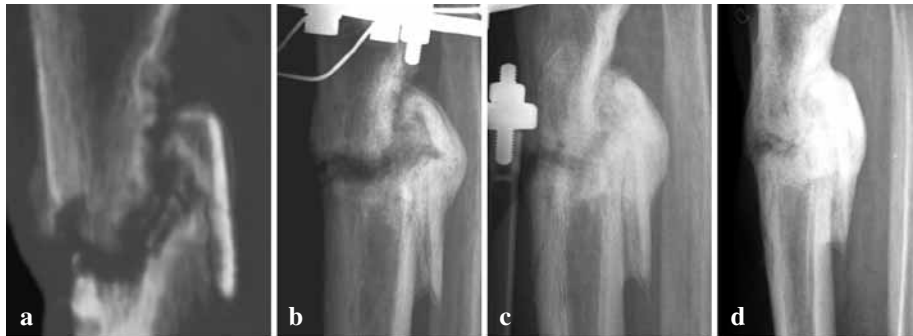
## METHOD

The records of 28 patients (21 male, 7 female) treated between 2001 and 2004 for a delayed union or non-union of the tibial shaft were retrospectively reviewed. Sixteen patients were smokers versus 12 non-smokers. Twenty-four cases were associated with high-energy injuries whereas four patients sustained a low-energy injury. Twelve had an open and 15 a closed tibial frac-

ture. The localisation was proximal in 4 patients, mid shaft in 15 and distal in 9. All patients sustained a concomitant fibular fracture at the initial injury; all but three fibula fractures were healed at the time of referral. The fracture ends appeared hypertrophic in 11 patients, atrophic in 7. Mean delay to referral was 16 months (range : 3 to 96). Four fractures were sustained no longer than 3 to 8 months previously and strictly spoken union was not delayed yet, but the radiographs indicated a natural evolution towards a definite non-union, as illustrated in figure 3. The number of previous treatments varied from 1 to 6 with a mean of 2. In 4 patients a fibulectomy had already been performed but was healed except in one case.

All patients were treated with combined partial fibulectomy (1 to 1.5 cm) and an Ilizarov frame without the use of any bone grafts (fig 1). The osteotomy was made at the distal one third level, unless access to this area was difficult due to a synostosis with the tibia or previous grafting, in which case the osteotomy was done at midshaft level.

Proximal tibial osteotomy was done simultaneously to correct shortening in four cases and a plate or nail had



**Fig. 2.** — Illustration of progressive callus formation with compression frame after fibulotomy : preoperatively (a), at 3 months (b) and 5 months (c) postoperatively, and immediately after removal of the hardware at 7 months since the start of treatment (d).

to be removed in 9 cases. Post-operative compression started at a pace of  $\frac{1}{4}$  mm twice daily in the first two weeks until good apposition was seen on plain radiographs. Compression was then reduced to  $\frac{1}{4}$  mm once daily until patients experienced pain or until good callus formation was visible (fig 2). All patients were allowed full weight bearing from post-operative day 1.

The Ilizarov frame was reduced to a unilateral frame when partial corticalisation was present. Complete removal of the unilateral frame was performed when complete healing was visible on four radiological views, and in 6 cases also in combination with CAT scan (fig 3). Frame treatment was not followed by cast or brace protection so that the total time of external fixation is considered as the total duration of the therapy.

## RESULTS

All delayed unions and non-unions except one healed uneventfully. There were no complications of hardware failure or infections, with the exception of common superficial pin tract infections that always healed with simple oral antibiotic therapy. The mean duration of treatment was 6 months (range : 3 to 11). Non-smokers had a significant shorter duration of treatment compared to smokers (5.7 months versus 7.5 months,  $p < 0.05$ ). No significant differences were noticed with respect to other parameters, i.e. time to referral and location of fracture, nor type of fracture or delayed or non-union (table I). There were 3 cases of re-fractures of the tibia following a new trauma. They were all within one year after the initial non-union was

healed and were successfully treated with a new Ilizarov application without further problems.

## DISCUSSION

In the sixties, fibulectomy was a well established procedure in the treatment of tibial fractures and non-unions. Sorensen (12) reported healing in 26 of 30 tibia fractures treated with partial fibulectomy and weight bearing in a cast in an average of seven months. A paper by Fernandez-Palazzi (4) mentioned 100% success in the treatment of 14 delayed unions following partial fibulectomy and cast within 7 to 18 weeks. In 1981 Delee *et al* (2) reported 37 healed tibial non-unions out of 48 after fibulectomy and weight bearing, with an average healing time of 25 weeks. Partial fibulectomy as a method for the treatment of tibial fractures and non-unions has thus been advocated for four decades, but its value now seems to be overlooked. In the 2006 Instructional Course Lecture on delayed unions of the tibia at the American Academy of Orthopaedic Surgeons, fibular osteotomy was deemed necessary only when the fibula prevents acceptable tibial alignment during the exchange of intramedullary nails (10).

Following the recommendations by Catagni (1), we consider partial fibulectomy as an essential part of the treatment for tibial non-union to allow sufficient compression when used in combination with the Ilizarov frame. The rationale is that a healed fibula distracts a greater percentage of the load as



**Fig. 3.** — Atrophic bone fragments at 3 months post trauma with limited partial bone loss (a), during compression at 3 months post-operatively (b), just before frame removal at 6 months with documentation of healing on CAT-scan (c) and final result (d).

Table I. — Relation between different parameters and healing time

	Treatment time (months)	
<i>Initial trauma</i>		
open fracture	6.1 +/- 2.4	°
closed fracture	6.9 +/- 2.5	
<i>Radiological aspect</i>		
hypertrophic	6.9 +/- 2.8	°
atrophic	6.4 +/- 2.0	
<i>Smoking habit</i>		
yes	7.5 +/- 2.6	*
no	5.7 +/- 2.0	

(°no significant difference, \*significant difference at  $p < 0.05$  level using Student's t-test).

well as resisting compression at the tibial non-union site. The fibula carries 6 to 15% of the load of the lower extremity (14). Teitz *et al* (13) studied the load on a fresh frozen adult human lower limb

after creating an oblique tibial fracture, while keeping both the fibula and interosseous membrane intact. With increasing load the interosseous membrane buckled and the distal tibia fragment developed varus angulation. This causes strain in the tibia and fibula which in the clinical condition may lead to non-union or malunion. In a series of 26 patients with tibial fractures but intact fibula, they reported 6 delayed unions and 6 varus malunions (13).

Thomas *et al* (15) used cadaver lower limbs to study the stresses on the tibia and fibula. They demonstrated that during loading on an intact tibia the anterior surface was continuously in relative tension. This tension diminished after partial fibulectomy. When a transverse fracture was made on the tibia with an intact fibula, a decreased compressive force was noted, leading to formation of an anterior gap. Partial fibulectomy increased the compressive strain of the tibia antero-medially and helped in closing the gap. The importance for



better tibial healing may not be fully elucidated, but previous clinical studies on the successes with partial fibulectomy and cast treatment seem to support this hypothesis. Moreover, as the Ilizarov frame resists translational shear, but with a low axial stiffness allowing optimal axial compression, the combination with partial fibulectomy offers an ideal tool for treating tibial non-unions.

Neither time elapsed since the injury nor the type of delayed union or non-union appeared to influence the healing process, which supports the hypothesis that most non-unions still have enough biological potential once an optimal mechanical environment is created, an observation also made by the authors for humeral non-unions (8). Although non-unions may be longstanding and appear atrophic and poorly vascularised, immunohistochemical localisation of BMP-signalling components can be documented, even in areas of dense fibrous tissue, as shown by Kloen *et al* (7). If cell signalling is preserved the bone repair process restarts under well aligned mechanical loading, as obtained by the Ilizarov fixator. The deleterious biological effect of smoking, on the other hand, easily explains the retarding effect on healing time (9,11). Here a good mechanical condition has to restore a disabled biological system leading to a prolonged treatment. Analogously, infected non-unions, having a completely disturbed biology with necrosis and ischaemia, do not respond or respond poorly, and in our opinion are better candidates for resection and bone transport (3,5).

### CONCLUSIONS

Partial fibulectomy combined with an Ilizarov compression frame appears as a reliable method for the treatment of delayed union or non-union of tibial fractures in the absence of infection or extensive bone loss. This treatment has a high success rate with only few complications and limited morbidity.

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