



Ilizarov trifocal lengthening followed by intramedullary nailing for massive posttraumatic tibial bone defects

Naser M. SELIM

From Mansoura University Hospital, Mansoura, Egypt

The treatment of massive tibial bone defects takes a very long time. An Ilizarov trifocal approach decreases the lengthening time. Subsequent intramedullary fixation decreases the complications of the conventional Ilizarov method.

This technique was applied between June 2010 and June 2011 in 10 male patients with a mean age of 30 years. All had grade III open tibial fractures. The patients were treated at Mansoura University Hospital and a private hospital. The sequence of treatment included trifocal lengthening using the Ilizarov method, followed by removal of the fixator, temporary plaster cast immobilisation and subsequent intramedullary fixation until complete union was achieved. The length of the tibial bone defect ranged between 6-12 cm; the lengthening time ranged between 45-75 days and the consolidation time ranged between 90-160 days. The results were evaluated according to Paley's bone and functional assessment scores.

The bone results were excellent in 7 patients and good in 3. Two patients had non union and one patient had pin tract infection. The functional results were excellent in 7 patients and good in 3. Two patients had equinus deformity and one patient had limited range of knee motion. There were no deep infections, DVTs or leg length discrepancies greater than 2.5 cm.

Ilizarov trifocal lengthening followed by delayed intramedullary fixation appeared in this study as a good method of treatment for massive posttraumatic tibial bone defects. It reduced fixator time and minimized the complications associated with the Ilizarov fixation.

Keywords : tibia ; bone defect ; Ilizarov ; intramedullary nailing.

INTRODUCTION

Distraction osteogenesis using the Ilizarov method has been widely used in the treatment of patients with a massive bone defect (10). However, this requires a very long time of treatment (17).

Pin-tract infection, joint stiffness, muscle wasting, osteopenia, long duration of discomfort, poor tolerance, close monitoring, psychosocial complications and even premature termination of the procedure (1,17) may complicate the very long duration of the Ilizarov method of treatment.

The combination with intramedullary locked nailing (ILN) allows conventional lengthening by the Ilizarov method and subsequent fixation by ILN protecting the regenerate until consolidation. Nailing can be done in the presence or after removal of the Ilizarov fixator (26).

In this study, conventional trifocal Ilizarov lengthening was followed by delayed intramedullary nailing, in order to decrease the very long time of Ilizarov fixation in the treatment of posttraumatic

■ Naser M. Selim, MD, Orthopaedic Consultant.
Department of Orthopaedic Surgery, Mansoura University Hospital, Egypt.

Correspondence : Naser M. Selim, Consultant of Orthopaedics, Department of Orthopaedic Surgery, Mansoura University Hospital, Mansoura, Egypt.

E-mail : dr.nasereleem@yahoo.com

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massive tibial bone defect and hence decrease the rate of complications.

PATIENTS AND METHODS

Patients were included in the study if they had acute, traumatic, 6-12 cm tibial bone defect due to bone loss or after debridement. Patients were excluded if they had non traumatic, neglected or small defects, or open physes.

Between June 2010 and June 2011, 10 male patients with a mean age of 30 years (22-40) were included in the study.

All patients underwent a treatment including an initial, intermediate and final treatment. Initial management included: radical bone and soft tissue debridement, Ilizarov fixation, two cortical osteotomies at the upper and/or lower tibial metaphysis i.e. trifocal approach and distraction osteogenesis after a latent period of one week.

After lengthening with evidence of consolidation, the management included: removal of Ilizarov fixator, application of an above-knee plaster cast for one and a half month, coverage of this intermediate period with broad spectrum antibiotics and laboratory investigations to exclude infection. The final stage in the management included ILN fixation after exclusion of infection, bone grafting at the docking site if needed and physiotherapy.

Radical bone and soft tissue debridement left healthy bone edges, an opened intramedullary canal and a viable soft tissue coverage. Early aggressive debridement of all non-viable bone is important. It is better to deal with the reconstruction of a large bone defect than to allow infection and osteomyelitis. After debridement, the mean bone defect was 9 cm (range: 6-12 cm), soft tissue coverage was adequate in 8 patients and a muscle flap was used (5) in 2 patients.

In all patients, 4 concentric (5) rings were used, 2 proximal and 2 distal to the bone defect. Each ring block had 3 smooth 1.8 mm wires; the central one was in the coronal plane and the peripheral 2 wires were in the transverse ring plane within the safe zone of neurovascular structures. The central wire in the upper and lowermost rings was parallel to the knee and ankle joint lines respectively, with proximal and distal tibiofibular fixation. The ends of the wires were fixed on the ring under a tension of 110 kg (5). The crossed wires of the intermediate rings were placed near the corticotomy sites and far from the ends of the bone defect.

Two cortical osteotomies were done under fluoroscopy using a sharp osteotome at the upper and/or lower tibial metaphysis (proximal and/or distal to the defect) i.e. a trifocal approach (Fig. 1). In the trifocal approach

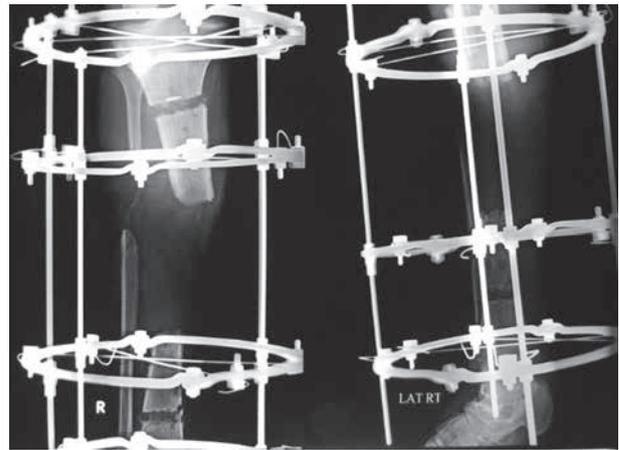


Fig. 1. — Upper and lower corticotomy

(tandem procedure) (5), there are three segments: one segment is undergoing compression – shortening and two segments of bony regenerate are undergoing distraction – lengthening (24).

Distraction osteogenesis was started one week after Ilizarov fixation at a rate of 1 mm/day both at the proximal and distal distraction sites, i.e. 2 mm/day. The consolidation occurred at a rate of 1/4-1/2 mm per day both at the proximal and distal distraction sites, i.e. 1/2-1 mm per day. The time for Ilizarov fixation is usually between 10-20 days per centimeter gain in length; e.g. a defect of 6 cm needs 60-120 days until the proper length is achieved; these values decrease to nearly half with the trifocal approach. The mean lengthening time was 56.7 days (45-75 days). The mean consolidation time was 127 days (90-160 days)

When the distraction was completed and consolidation started (Fig. 2), removal of the Ilizarov fixator and application of an above-knee plaster cast for one and a half month was done, with coverage of this intermediate period with broad spectrum antibiotics. This allows healing of pin sites, decreases the risk of infection, protects the regenerate and prevents fracture of the callus (17). When laboratory investigations excluded infection and consolidation of the regenerate started (5), an interlocking nail was applied (Fig. 3). Autogenous iliac bone grafting was done in 2 patients. Touch weight bearing with crutches started, range of motion of the knee and ankle joint were encouraged until complete union.

The results were assessed as bony or functional. For bony results, 5 criteria were evaluated as recommended by Paley *et al* (18,20): union, infection, deformity, leg-length discrepancy and cross-sectional area of union

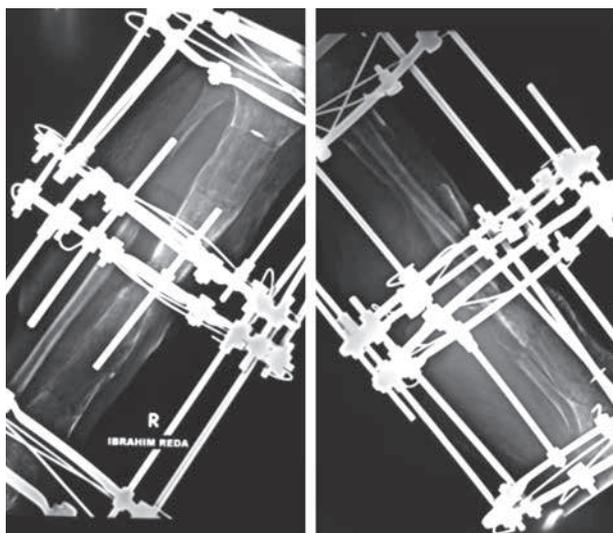


Fig. 2. — At the end of distraction osteogenesis

of the regenerate bone and docking site. Functional assessment was also based on 5 criteria according to the evaluation system previously reported by Paley *et al* (18,20): pain; need for walking aids or braces; foot, ankle, or knee deformity or contracture; ankle and/or subtalar loss of range of motion as compared with the preoperative range; and ability to return to normal activities of daily living and/or work.

RESULTS

The mean lengthening time was 56.7 days (range: 45-75). The mean duration of Ilizarov fixation was 78 days (range: 60-90). The mean external fixation index was 0.28 month/cm (range: 0.25-0.3). The mean consolidation index was 14.8 days/cm (range: 12-18.3). The mean follow-up duration was 28.8 months (range: 24-36).

Bony union was achieved after treatment in 8 patients. Persistent nonunion was noted in 2 patients (due to soft tissue interposition) and was treated by autogenous iliac cancellous bone grafting into the nonunion site. Refracture occurred in one tibia after removal of the Ilizarov; plaster cast immobilisation was applied for nearly 2 months until interlocked nailing. One patient had pin tract infection which was treated by frequent dressing and antibiotics. No patient had residual deformity $> 5^\circ$. No patient had

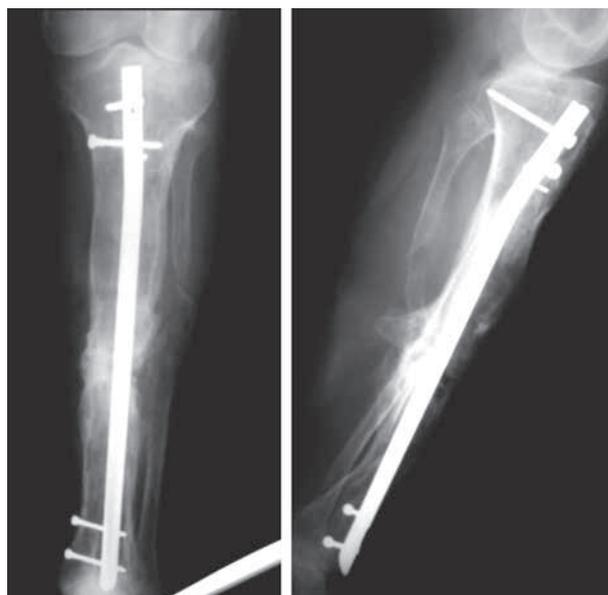


Fig. 3. — Consolidation of regenerate and complete union at the docking site.

a leg-length inequality > 2.5 cm. Based on the criteria recommended by Paley *et al* (18,20), 7 bone results were excellent and 3 were good.

Functionally, all patients could walk well without support. Two patients felt pain when walking for long distances (> 2 km) and were treated by oral analgesics. One patient had limited range of knee motion ($0-100^\circ$) at 6 months follow-up and was improved by physiotherapy ($0-120^\circ$) at final follow-up. Another 2 patients had equinus deformity at 6 months follow-up, which was corrected by physiotherapy in one patient and Achilles tendon lengthening plus physiotherapy in the other. According to Paley's functional score (18,20), 7 functional results were excellent and 3 were good.

DISCUSSION

The treatment of posttraumatic defects of the tibia with severe associated soft-tissue injuries in open fractures includes bone and soft tissue reconstruction. Soft tissue reconstruction can be achieved by skin grafts, muscle flaps or myocutaneous flaps. Bone reconstruction can be achieved by autogenous bone graft, vascularized bone graft, allograft,

synthetic bone substitute, tibiofibular synostosis or distraction osteogenesis (9,22). Simultaneous treatment of tibial bone and soft tissue defects can be done by the Ilizarov method (24).

The method of distraction osteogenesis was first introduced by Ilizarov (10) and later popularized by many surgeons and used widely in the management of tibial fractures with bone defects (25,27).

The Ilizarov technique can control the lengthening rate, limb alignment, and soft-tissue tension (8). The external fixator can remain in place until consolidation of the bone and soft tissues (4), or be removed earlier in cases of lengthening over nails (11) or lengthening followed by nailing (23). Early removal of the external fixator provides more comfort to the patient and reduces the pin-site complications (6).

Massive bone defects require a very long time for treatment by the Ilizarov method (17): adding the distraction phase (1 mm per day) and the consolidation (1/4-1/2 mm per day), the overall time in the external fixator is between 30 and 50 days per centimeter gain in length (1,17). The mean overall duration for traditional lengthening was 285 days for a mean lengthening of 7 cm (4), whereas with lengthening and subsequent nailing, it was 96 days for a mean lengthening of 7.6 cm.

A trifocal approach decreases the duration of lengthening down to half the time. Lengthening over a nail and lengthening followed by nailing allow early removal of the Ilizarov fixation. In the trifocal approach, rings are placed on either side of the defect. Additional rings are placed around what will be the two lengthening sites. If the defect is in the middle of the tibia, 2 osteotomies are performed: one in the proximal and one in the distal tibia. Two intercalary bone segments are transported towards each other. If the defect is in the proximal or the distal tibia, another trifocal option exists where two intercalary segments are transported in the same direction (2).

Staged fixation in compound fractures of the tibia carries a rate of infection from 0% up to 43.8%. Debridement of the pin track, administration of local and systemic antibiotics (13,14,26) and shortening the period of external fixation decrease this incidence of infection (16). The highest rate of infection

has been seen in patients who required prolonged external fixation (15). The role of the external fixator in compound fractures of the tibia is fixation only, whereas the role of the Ilizarov fixator in compound fractures of the tibia is fixation and lengthening. The increased blood flow associated with distraction osteogenesis (3) may play a role in reducing the risk of infection.

Although nailing may decrease the endosteal blood supply (3) of the regenerate and may increase the incidence of deep infection (3%-15%) (26), it allows rotatory stability, maintains the length of the bone, helps healing at the docking site, obtains good consolidation of the regenerate (12) and prevents distraction callus collapse, callus fracture and angular deformity (7). Lengthening over a nail carries an incidence of deep infection up to 15% (19) even with the use of precautions such as no contact between the pins of Ilizarov fixator and the nail, and the distal locking screws placed 2 to 3 cm away from the pins.

The technique of lengthening followed by nailing has advantages over the technique of lengthening over a nail (21). Lengthening followed by delayed nailing allows insertion of a nail of proper length and diameter and avoids having a short or small nail. The nail is inserted after exclusion of pin-site infection, thus minimizing the risk of infection as compared to lengthening over a nail (23).

Bone graft either allogenic or autogenous can be applied to distraction sites or to distraction and docking sites before removal of the Ilizarov fixation or through open nailing technique (28) or after nailing in cases of non union. Reaming was done in all patients. Although the blood flow may be altered by reaming (3), the osseous debris which is created may serve as bone graft.

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