



Functional outcome following treatment of segmental skeletal defects of the forearm bones by Ilizarov application

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Managing a segmental skeletal defect is a challenge, even more so if the combination of local infection with bone defect exacerbates the problem and provides an even more negative prognosis. Several techniques have been tried, among which skeletal allografts, autologous cortical or cancellous bone graft and vascularised bone graft, each with its limitation and success. In this study, we report our results with the Ilizarov method of bone transport to overcome bone defects of forearm bones due to infection.

This series included 16 patients with bone defects of forearm bones, following either debridement of osteomyelitis or infected nonunion. The mean time from injury to the Ilizarov procedure was 11.7 months. The mean number of operative procedures before application of the Ilizarov device was 3.4. The mean length of the defects after debridement was 6.4 cm. Monofocal osteotomy was performed.

The mean external fixation index, distraction index and maturation index were 41.5 days/cm, 19.8 days/cm, and 21.7 days/cm respectively. The mean time in the frame was 8.9 months. The mean total duration of treatment was 11.4 months. There were 14 complications in 11 patients including pin-track infection, premature consolidation, delayed union at the docking site and refracture. Ilizarov's technique of bone transport is an ideal solution for a large skeletal defect in spite of the high incidence of associated complications.

INTRODUCTION

Segmental defects of forearm bones are difficult to treat with conventional methods. The combination of local infection with bone defect exacerbates the problem and provides an even more negative prognosis (1).

Many authors believe that diaphyseal bone defects of the forearm smaller than 6 cm in length can be managed with corticocancellous bone grafting (20) or non vascularised fibular graft (18), provided the patient has an adequate soft tissue envelope. In case of soft tissue compromise, primary bone grafting is still the treatment of choice, combined with simultaneous soft tissue coverage (20). Long bone defects greater than 6 cm can be managed with vascularised bone graft or bone transport using the Ilizarov external fixator (4, 11, 14, 20).

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Ilizarov's technique of bone transport was viewed as an ideal solution for a large skeletal defect because a) a defect of virtually any size could be eliminated, b) rapid corticalisation of regenerate bone might shorten treatment time and eliminate the need for prolonged post treatment casting or bracing and c) no donor site morbidity would occur as the need for bone grafting had been eliminated (9).

We report our results with the Ilizarov method of bone transport to overcome bone defects of forearm bones due to infection.

MATERIAL AND METHODS

This series included 16 patients with an infected bone defect of forearm bones. The radius was involved in eight cases, the ulna in five and both bones in three. The aetiology of the bone defect was infected nonunion following debridement in 12 patients ; four others followed debridement of osteomyelitis. There were 12 men and 4 women with a mean age of 32 years (range : 18 to 55). The mean time from injury to the Ilizarov procedure was 11.7 months (range : 6 to 18). The mean number of operative procedures before application of the Ilizarov device was 3.4 (range : 2 to 6). After debridement and culture sensitivity test for the infected tissue, the mean length of the defects was 6.4 cm (range, 4 to 9 cm). Monofocal osteotomy was performed to allow a bone segment to be transported to fill the defect produced. Distraction was begun approximately 7 days (range : 5 to 10) after the operation at a rate of 0.25 mm four times daily. The patients received antibiotics treatment based on the culture and sensitivity test.

Radiological assessment : Radiographs were taken in two planes before and after surgery, then on a weekly basis during the distraction and consolidation period. The external fixator was removed when the distraction gap was consolidated enough and corticalised on at least three of the four sides as seen on anteroposterior and lateral radiographs. The cortices had to be 2 mm thick and uninterrupted across the distraction gap. The regenerate bone should demonstrate uniform radiographic density appearing to the surgeon's eye halfway between the density of the adjacent normal bone cortex and that of its medullary canal (9).

Three indices were used to evaluate the results : an external fixation index obtained by dividing the entire duration of external fixation by the length of bone regeneration ; a distraction index obtained by dividing the

duration of distraction by the length of bone regeneration ; and a maturation index calculated by dividing the duration of external fixation, measured from the completion of distraction to the removal of external fixation, by the length of bone regeneration (3).

RESULTS

The mean period of follow-up for the 16 patients after removal of the frame was 27 months (range : 13 to 38). Union was achieved in all patients, and infection was cleared in all infected cases (fig 1 and 2). The mean external fixation index was 41.5 days/cm (range : 27.9 to 57.9), the mean distraction index was 19.8 days/cm (range : 13.4 to 24.4) and the mean maturation index was 21.7 days/cm (range : 16.5 to 33.5). The mean time in the frame was 8.9 months (range : 3 to 13). The average duration of distraction was 10.1 weeks (range : 6 to 14). The mean total duration of treatment was 11.4 months (range : 5 to 16) (table I). The roentgenographic appearance of the regenerated bone in each patient was similar to the host bone adjacent to the site of the corticotomy. There were 14 complications in 11 patients. These included pin-track infection in 4 cases, premature consolidation in one case, delayed union at the docking site in 8 cases and fracture after removal of the fixator at the docking site in one case. The case of premature consolidation of regenerated bone was managed by a further percutaneous osteotomy, resulting in excellent bone regeneration. For delayed union at the docking site, bone graft was taken from the iliac crest and placed at the docking site to facilitate union. Fracture after fixator removal healed by immobilisation in plaster. After the Ilizarov reconstructions, there was a varying degree

Table I. — Results

External fixation index	41.5 days/cm (range : 27.9 to 57.9)
Distraction index	19.8 days/cm (range : 13.4 to 24.4)
Maturation index	21.7 days/cm (range : 16.5 to 33.5)
Time in the frame	8.9 months (range : 3 to 13)
Duration of distraction	10.1 weeks (range : 6 to 14)
Total duration of treatment	11.4 months (range : 5 to 16)

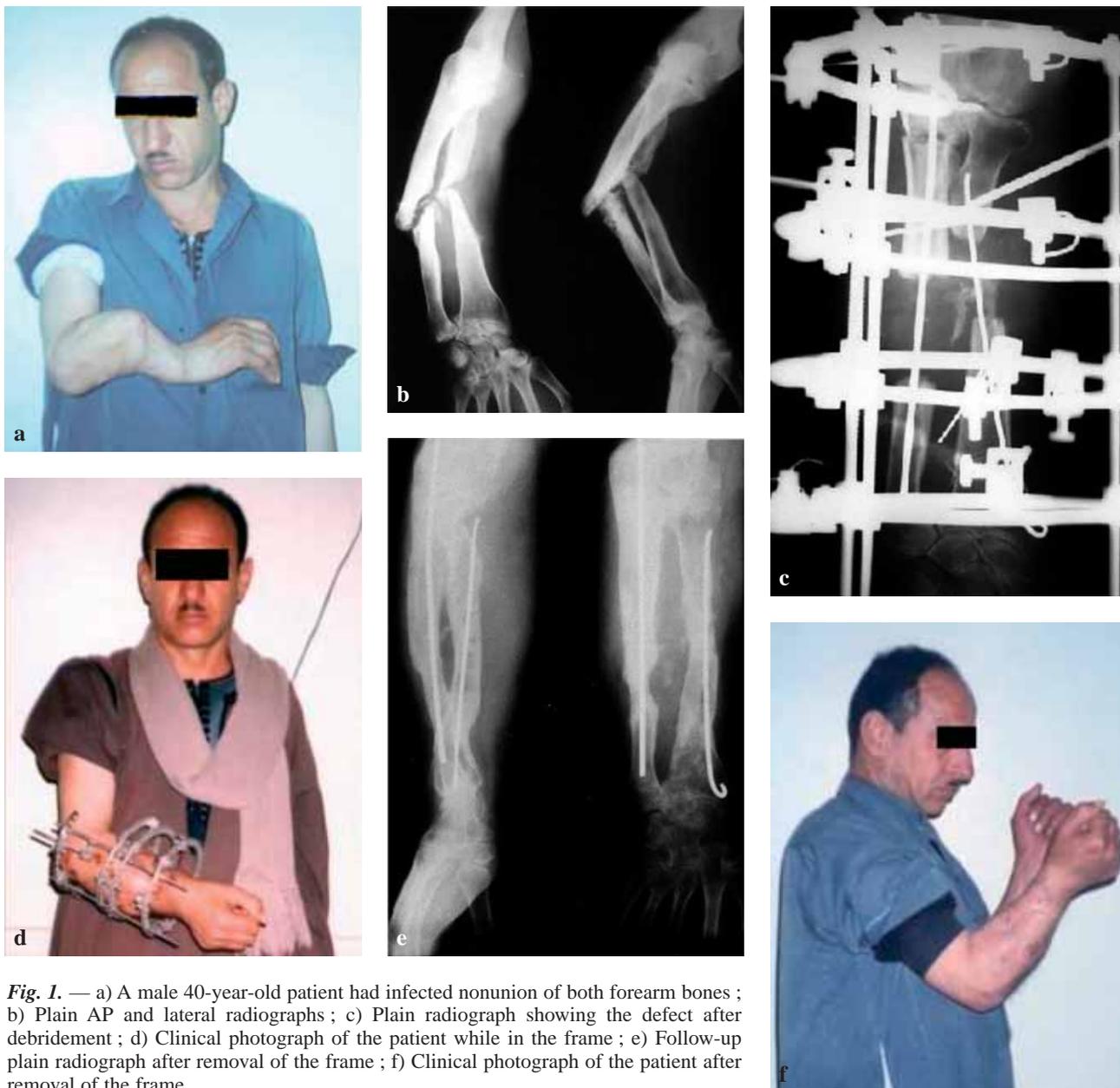


Fig. 1. — a) A male 40-year-old patient had infected nonunion of both forearm bones ; b) Plain AP and lateral radiographs ; c) Plain radiograph showing the defect after debridement ; d) Clinical photograph of the patient while in the frame ; e) Follow-up plain radiograph after removal of the frame ; f) Clinical photograph of the patient after removal of the frame.

of limitation of pronation and supination in all patients with an average loss of 50% (range : 20% to 70%) of the range compared to the unaffected forearm. However, all patients had improvement in their ability to perform activities of daily living without pain or deformity.

DISCUSSION

The treatment goals include elimination of deformity, infection, and defect at the same time as obtaining union. This can be achieved using a number of methods.



Fig. 2. — A male 45-year-old patient had infected non union of the radius : a) Plain AP and lateral radiographs ; b) Plain radiograph showing the defect after debridement ; c) The patient with the frame ; d) Follow-up radiograph one year after removal of the frame ; e) The patient clinically one year after removal of the frame.

The surgical technique combining autogenous bone graft (non vascularised fibular graft or non vascularised coticocancellous bone graft) and internal fixation is successful in treatment of segmental bone defects of the forearm (2, 16, 18, 20).

Barbieri *et al* (2) reported their experience with the use of autogenous bone graft and internal fixation ; the most frequent complication was infection (40%). Moroni *et al* (17) reported that out of 24 patients with segmental bone loss of the forearm treated with autogenous bone graft and internal fixation, 10 cases had excellent results. Arai *et al* (1) claimed that massive long bone defects of greater than 6 cm are difficult to treat with autogenous bone graft, and other method are sometimes recommended.

Vascularised bone graft was introduced in the treatment of large soft tissue and bone defects using microvascular techniques. Both fibular and

iliac crest transfer have been reported with rates of success in achieving union from 80% to 90%. This procedure is technically difficult, time consuming and with a relatively high complication rate both to the donor and the treated sides (15, 21). As well, it is found by many authors to be labor intensive and demanding for both the hospital personnel and the patient (7, 15). The results of treatment by this technique seem to be less favourable in infected cases (21) and with larger bone defects where a significantly higher incidence of refracture was reported (12). Moreover, the use of this technique requires a prolonged period of protection and non-to partial weight bearing in cases where the involved bone is a weight bearing one. A prolonged rehabilitation program is also required. In addition, the technique is essentially an open one with extensive exposures and prolonged operative time, which may add to the morbidity of the procedure. Green *et al* (10) claim that the large volume of bone needed to fill a defect greater than 6 cm required multiple donor sites, a source of discomfort and morbidity for the patients.

The Ilizarov system provides rigid fixation even in osteoporotic bone and allows early active and passive motion starting from the first postoperative day. The Ilizarov system is superior to other methods of treatment, especially where there is infection and bone loss, as the mechanical stimulations increase local tissue nourishment, and transosseous osteosynthesis restores the function of the injured limb, increases local blood flow and stimulates osteogenesis (13).

In 1994, Green (9) evaluated two different methods of managing segmental skeletal defects. A total of 15 patients treated with the open bone graft (Papineau) technique were compared with 17 patients treated with the Ilizarov procedure. There were many complications in the bone grafted group such as limited graft availability, donor site morbidity and graft fractures. In the bone transport group, the main problem was failure of the docking site to unite without supplementary graft.

Harrington *et al* (11) reported that five open fractures of the ulna with bone loss of more than 8 cm were treated by bone transport and external fixator. A satisfactory functional result was achieved,

demonstrating the efficacy of this technique for difficult forearm reconstruction. Esser (6) reported a case treated with bone transport; treatment was completed at 10 months and the only complication was transient superficial pin site infection.

In this study, the rate of complications was relatively high, which may relate to the fact that patients had undergone on average 3.4 operations (range: 2 to 6) before application of the Ilizarov device. These procedures caused atrophy of articular cartilage, intra-articular adhesions, contracture of the surrounding tissue and osteoporosis of the forearm bones. However the main complication was delayed union at the docking site. Many authors (9, 13) advise to use autogenous cancellous bone graft at the docking site.

Many authors claim that the Ilizarov procedure is well established in the treatment of many complex musculoskeletal disorders including non-union, osteomyelitis, angular deformities and limb-length discrepancies (5, 8, 19).

The Ilizarov method offers advantages over other methods of reconstruction. It allows for early functional rehabilitation, controls the infection, restores the bone length with a high rate of healing, and has no major complication.

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