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ORIGINAL STUDY

Free non-vascularised fibular graft for treatment of post-traumatic bone defects

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Post-traumatic bone defects usually occur from severe high-velocity injuries due to road traffic accidents ; they may be difficult to fill.
We have managed defects of long bones by the use of free non-vascularised fibular grafts harvested subperiosteally and held by screw fixation of the fibular strut ends to the ends of the bone defect, combined with an external fixator in 8 tibial defects and with a plate and screws in 2 ulnae and 2 humeri. Twelve patients, eleven male and one female, with a mean average age of 25 years (range 12-40), underwent this procedure. Eleven grafts (92%) united at both ends within an average of 4 months (range, 3 to 5 months). The defect lengths averaged 7 cm (range from 6 to 10 cm). The long-term follow-up showed complete 'tibialisation' of the fibula.
Non-vascularised fibular graft, compared to microvascular reconstruction and Ilizarov techniques, is a simple procedure that is still valid to bridge bone defects successfully in selected cases.

Keywords : bone defects; fibular grafts ; non-vascularised.

INTRODUCTION

A large diaphyseal, segmental bone defect is a challenging problem in orthopaedic practice. Several surgical methods are available for bridging such defects (*4*) : bone grafting, free vascularised fibular grafts, or bone transport with an external ring fixator.

Many studies have demonstrated the clinical usefulness of autogenous cortical bone and allograft reconstruction, but resorption of bone and fractures of the graft are possible complications (*5, 12*). Operative procedures involving non-vascularised autogenous or allogenic bone grafts may be unsuitable because their success depends on the ability of the surrounding soft tissues to withstand the operative manipulation and to revascularise the transplanted bone graft.

Although free vascularised bone grafts have been advocated recently (*23*), the older methods of bridging these gaps with autogenous non-vascularised bone grafts are still successful (*5*). The free vascularized osteocutaneous fibular graft has been recommended as a useful treatment modality for the reconstruction of extensive tibial defects combined with soft tissue injury (*9, 10, 21*).

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Ilizarov bone transport procedures have provided alternatives for the reconstruction of composite skeletal and soft-tissue defects ; however, such procedures are complex and lengthy and have been associated with many complications.

Procedures used in the reconstruction of segmental defects of both bones of the forearm should, whenever possible, preserve forearm pronation and supination. Traumatic diaphyseal bone defects of the forearm larger than 6 cm can best be managed with a free fibular graft with excellent functional and cosmetic results (*21*).

The purpose of our study is to describe our experience with 12 non-vascularised fibular autogenous grafts that were used for the reconstruction of post-traumatic tibial, ulnar, and humeral bone defects.

PATIENTS AND METHOD

There were eleven male and one female patients with a mean age of 25 years (range 12-40). The mean follow-up was 24 months (range, 12 to 48). The mean time interval between the accident and the fibular graft was 3 weeks, the initial management was debridement and external fixation or temporary immobilisation. The patients were followed throughout the course of treatment by the surgeon who had performed the operation. The follow-up evaluation consisted of subjective and objective assessment of functional capacity as well as the documentation of any problems associated with either the reconstructed part or the donor limb. Radiographs were made at the time of the most recent follow-up examination.

Tibial bone defects were encountered in 8 cases, forearm defects in 2 cases, while the humerus was affected in another 2 cases. The length of the bone defect ranged from 6 to 10 cm (mean 7 cm).The bone loss was the result of the initial injury in all cases.

Before the injury, three patients were employees ; one each was a student, a teacher, a farmer or a house wife ; and five were unemployed. The injuries were caused by motor vehicle accidents (8 cases), machinery-related accidents (3 cases), and fall from a height (one case).

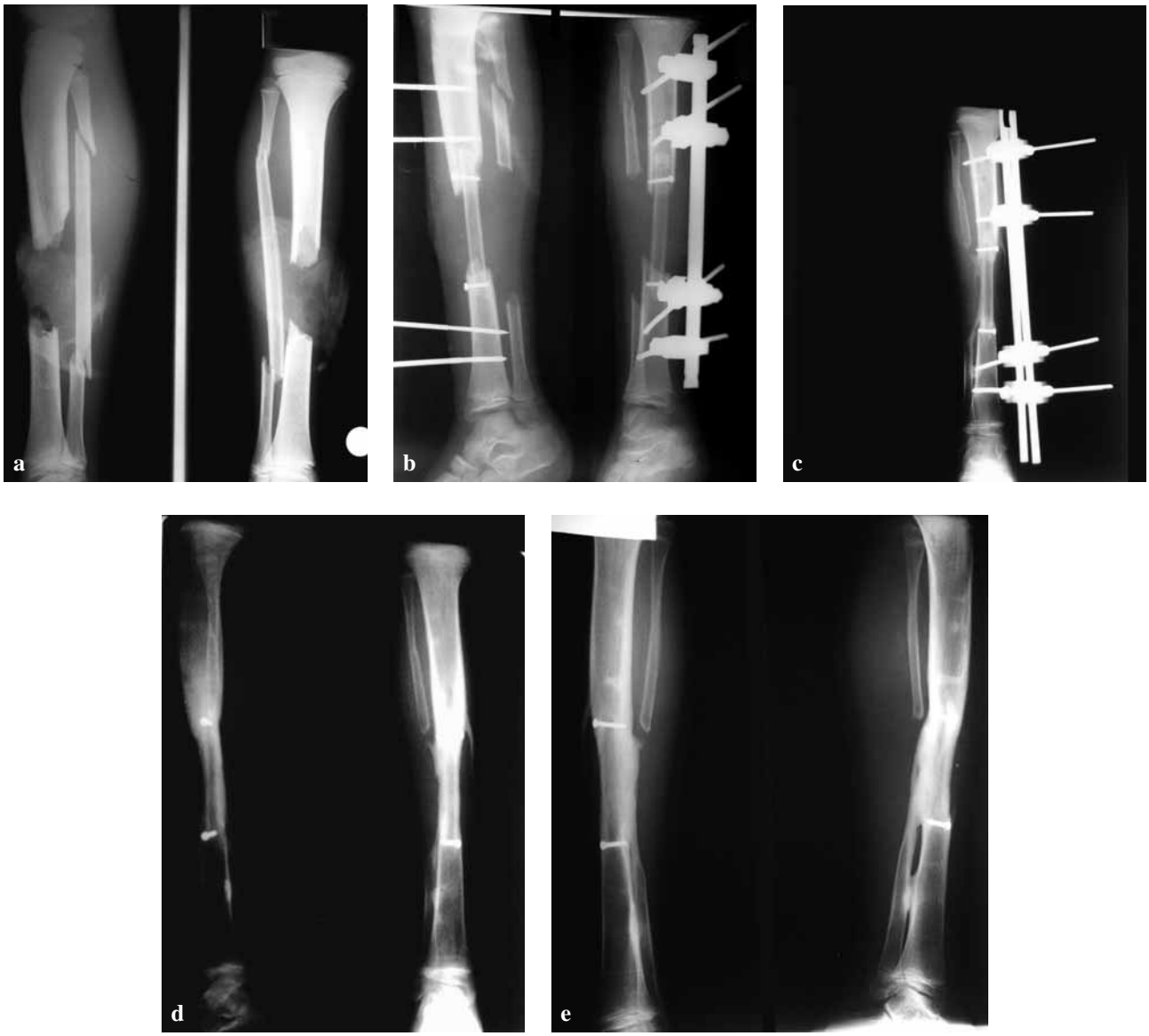
Operative technique

In all tibial cases except two, we used the contralateral fibula as a free non-vascularised graft to bridge the tibial defect. Under tourniquet the proposed portion of the fibula, leaving 6 cm at least from the distal end, was exposed and the fibula was dissected subperiosteally then it was osteotomised proximally and distally with a by pneumatic or Gigli saw. The fibular graft length was measured about 5 cm longer than the bone defect. After preparation of the bone ends of the gap and soft tissue bed, the medullary cavity of both ends was opened and the fibular strut graft was inserted into the medullary cavity proximally and distally, then fixed by one screw at each end holding the fibular graft to the recipient bone. Mechanical protection was achieved using an external fixator in tibial defects and a reconstruction plate and screws in upper limb defects. The fibular grafts were augmented, along their whole length, by cortico-cancellous bone graft in tibial defects of adult patients. The forearm was protected with an above-elbow splint. Immobilization was discontinued when there was radiographic evidence of union. The donor limb was supported in a posterior splint until the wound had healed.

RESULTS

The patients were followed for an average of 24 months (range, 12 to 48) after the reconstructive procedure. Nine patients (75%) returned to their pre-injury occupation. No patient presented any symptoms suggestive of infection. Within an average of 4 months, all but one of the patients had radiographic evidence of bony union (92%), at both the proximal and the distal graft-host bone junction. The remaining patient had a non-union of the distal junction of a humeral gap. The bone healing results were rated as excellent in 11 cases. The functional results were rated as excellent in all eight tibial cases (table I). None of the fibular autogenous grafts fractured, and no patient had radiographic evidence of osseous resorption.

No patient had pain or functional disability involving the donor leg at the time of the most recent follow-up examination, although all patients noted discomfort with exertion for some time after the operative procedure. The two forearm cases graded as excellent results. The average pronation of the reconstructed forearm was 60° and the average supination was 40°. The average extension and flexion arc was 100°. The grip strength on the



Figures 1 through 3 show three illustrative cases.

Fig. 1. — (a) This 12-year-old boy was admitted with a Grade IIIa open fracture of the tibia with 7 cm of bone missing. Debridement was done and the patient was prepared one week later for a free non-vascularised fibular graft taken from the ipsilateral side ; (b) : The defect was bridged with a free fibular graft, fixed in the medullary cavity with proximal and distal screws, augmented by an external fixator ; (c) : The proximal pin of the fixator was readjusted after 8 weeks ; (d) : Radiographs after 6 months showing complete healing at both ends of the fibular graft ; (e) : Hypertrophy and tibialisation of the fibular graft was evident on radiographs taken after 4 years.

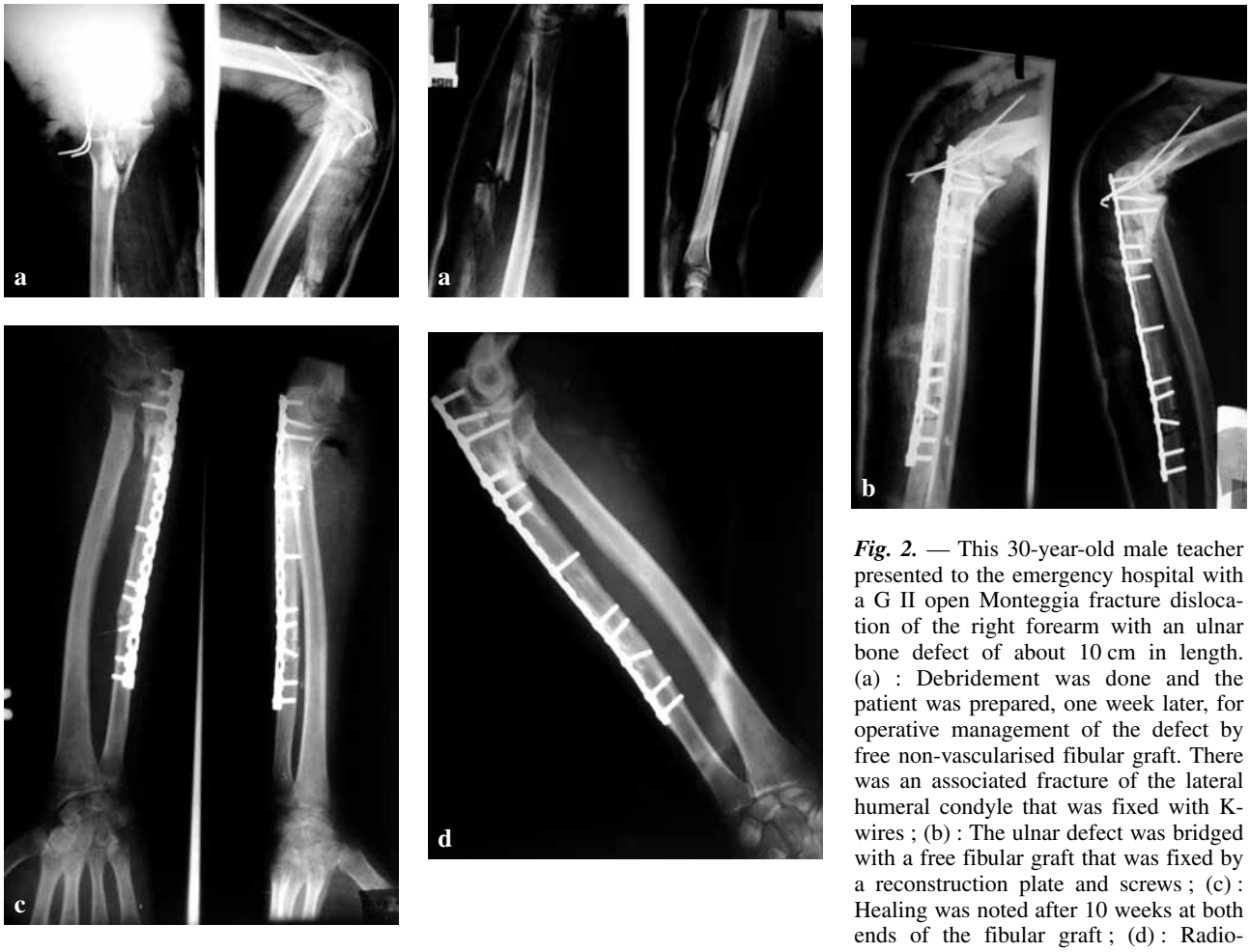


Fig. 2. — This 30-year-old male teacher presented to the emergency hospital with a G II open Monteggia fracture dislocation of the right forearm with an ulnar bone defect of about 10 cm in length. (a) : Debridement was done and the patient was prepared, one week later, for operative management of the defect by free non-vascularised fibular graft. There was an associated fracture of the lateral humeral condyle that was fixed with K-wires ; (b) : The ulnar defect was bridged with a free fibular graft that was fixed by a reconstruction plate and screws ; (c) : Healing was noted after 10 weeks at both ends of the fibular graft ; (d) : Radiographs taken after 3.5 years showing hypertrophy of the fibula.

involved side, measured for four patients, averaged 80% of the contralateral side.

In the lower limb, there was no leg length discrepancy, with good range of knee and ankle motion.

Final follow-up radiographs showed hypertrophy of the fibula with definite tibialisation in bridging the tibial defect.

DISCUSSION

In 1877 Albert first proposed the use of the fibula as a substitute for the tibia. He obtained fusion between the fibula and the femur in a patient with congenital absence of the proximal tibia. Since then, the fibula has been used as a substitute for a missing segment of tibia or to reinforce a weakened section (*8*). Sacrifice of the fibula does not appear to have any detectable functional disadvantage.

Several studies have shown that vascularized grafts are significantly stronger than conventional non-vascularized grafts (*14*). While a high incidence of stress fractures has been reported with non-vascularized grafts (*5*), they have also been shown to occur with free vascularized grafts (*18*). In our study, there was no instance of fracture of the graft.

In many studies comparing non-vascularised with vascularised grafts, union of the fractures with

Table I. —

Site of defect	Length of defect	Final union	Functional results	Definite hypertrophy	No. of cases
Tibia	7 cm	All cases	Excellent (8)	All cases	8 cases
Forearm	9 cm	All cases	Excellent (2)	All cases	2 cases
Humerus	5 cm	1 case	Good (1) Poor (1)	1 case	2 cases

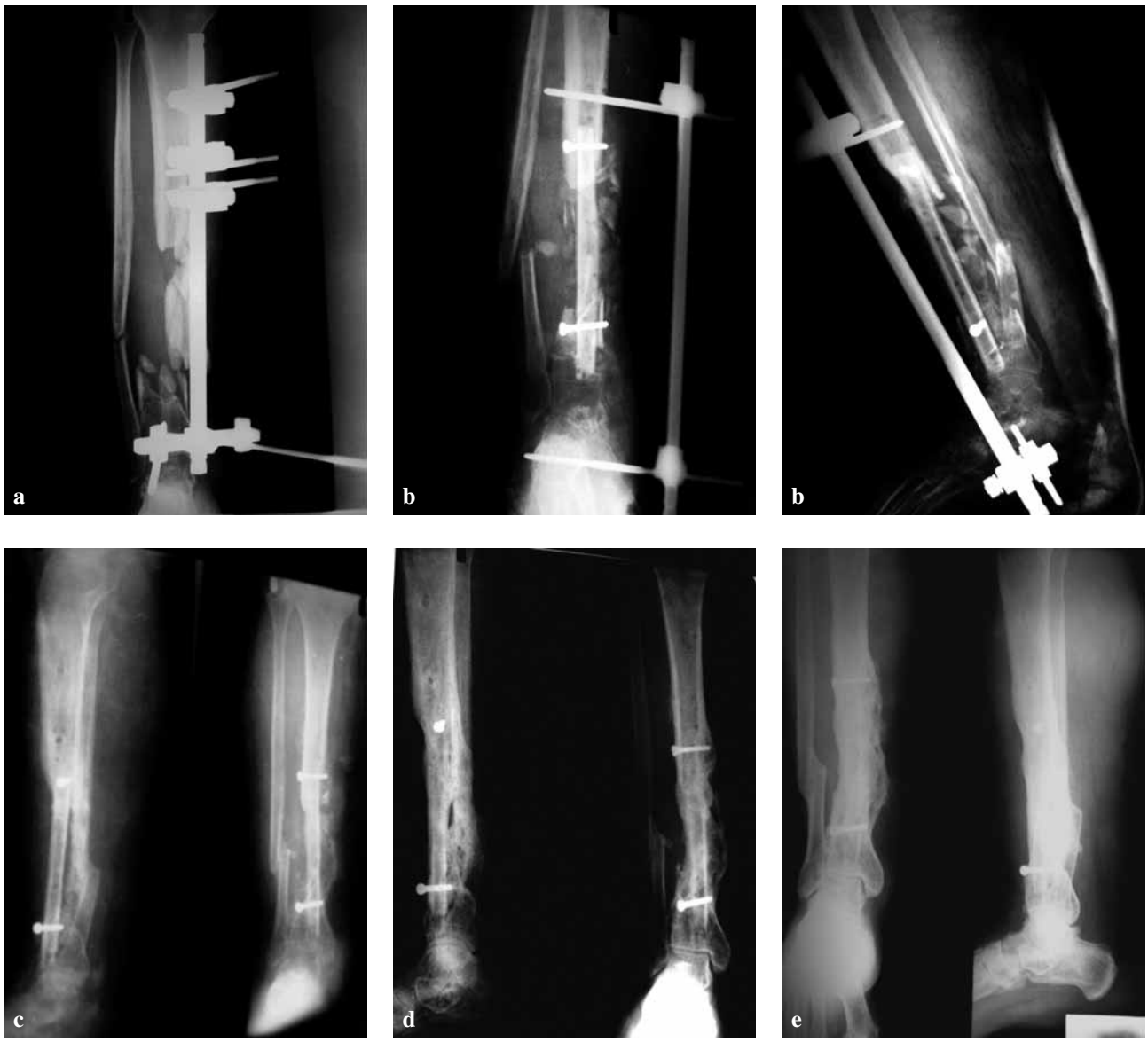


Fig. 3. — (a) : This 40-year-old male presented with an open comminuted fracture of both bones of his left leg with a tibial bone defect of about 6 cm. (b) : Debridement was done and the patient was prepared after two weeks for operative management of the tibial defect by a free non-vascularised fibular graft that was augmented by an external fixator ; (c) : The fixator was removed 20 weeks postoperatively ; (d) Twelve months postoperatively, radiographs showed union at both ends of the fibular graft ; (e) : Radiographs 4.5 years after treatment showed hypertrophy and tbialisation of the fibula.

non-vascularised grafts was found to be a major problem (*7*). However, in our study, bony union of a large non-vascularised segment occurred by twelve weeks. Even when the periosteum of the segment was absent or the medullary canal was blocked, bony union still occurred, although it was slightly delayed.

In our study, we had a success rate of 92% among 12 cases treated in a simple and effective way to bridge an average bone gap of 7 cm. Similar results were achieved by al-Zahrani *et al* (*2*) who had primary union in 92% of 27 patients treated by a non-vascularised single fibular strut graft augmented with corticocancellous bone graft along its whole length ; the indications were varied and included infection, fracture with bone loss, non-union, bone tumour, bone cyst and congenital pseudoarthrosis. Also Omolou (*15*) succeeded in bridging a tibial gap in two patients treated by a non-vascularised fibular graft, and Morsi (*13*) achieved fracture union in six patients out of seven treated by a non-vascularised contralateral fibular transfer. Onuba (*16*) also had successful results in two cases of bone defects post sequestrectomy managed in the same way with a non-vascularised free ribular graft. Also Steinlechner *et al* (*20*) have found this to be a straightforward technique with reliable results and were able to salvage the limb in all the seven patients who were reviewed.

In our cases, we noted no donor site ankle instability, presumably because we made a point of preserving at least 6-8 cm of the residual fibular length distally, as recommended by Pacelli *et al* (*17*) after their biomechanical analysis study.

At the forearm, fibular grafts allow the use of a segment of diaphyseal bone which is structurally similar to the radius and ulna and of sufficient length to reconstruct most skeletal defects affecting these bones. Using a free non-vascularised fibular graft,we achieved excellent results in two cases (100%) of segmental ulnar defect with an average length of 9 cm.

Our results confirm what had been found by Falder (*6*), who noted that long term behaviour of the non-vascularised fibular graft, which responds physiologically to biomechanical loading, resulted in complete 'tibialisation' of the fibula.

In our opinion, non-vascularised fibular graft is a simple procedure that is still a valid option to successfully bridge bone defects in selected cases with good vascular bed and soft tissue coverage.

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