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Tibial reconstruction using a non-vascularised fibular transfer

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Abstract A non-vascularised contralateral fibular transfer was performed on seven patients with non-union of the tibia and a sclerosed segmental bone defect following injury. The average follow-up was 2.7 years with a minimum of 2 years. The operation was successful in achieving fracture union in six patients, with an average time to union of 4.5 months (range: 3–6). Shortening of up to 2.4 cm was found in two patients and mild residual ankle stiffness in one. This procedure is successful and simple when compared to microvascular and Ilizarov techniques.

Résumé Une transposition fibulaire non – vascularisée a été exécuté sur sept malades avec une non-consolidation tibiale et un défaut osseux segmentaire après un traumatisme. Le suivi moyen était 2.7 années avec un minimum de 2 années. L'opération a permis la consolidation dans six cas, en un temps moyen de 4,5 mois (3 à 6 mois). Un raccourcissement jusqu'à 2.4 centimètres a été noté chez deux malades et une discrète raideur résiduelle de la cheville chez un autre. Cette méthode est efficace et simple comparée aux techniques microvasculaires ou d'Ilizarov.

Introduction

A non-union of the tibia with a segmental bone defect dramatically tests the limitations of conventional reconstruction techniques. Treatment usually takes several years with multiple surgical procedures, and the final result may be poor. The bone defect of the tibia can be either a gap defect or result from the large sclerosed segments at the ends of the un-united bone [8, 9]. Options for management include Papineau-type cancellous bone graft [15], vascularised tibio-fibular transport (centrali-

sed or synostosis) [13, 16, 19, 20], micro-vascular fibular transfer [5], double fibular graft [2], non-vascularised fibular graft [1] and Ilizarov external fixator [6, 11, 14]. Factors that influence the choice of treatment are the type of tibial bone defect (a gap or a sclerosed defect), presence of infection, local limb condition (especially of the skin and soft tissue cover), presence of an ipsilateral un-injured usable fibula, and general condition of the patient.

Some authors have tried to classify tibial non-union with a concomitant bone defect in order to define strategies for the management of this difficult problem. In their classifications, Gordo and Chiu [8] and Toh and Jupiter [18] considered the type of non-union (sclerosed or gap defect), length of the defect and condition of the ipsilateral fibula.

The idea of using the fibula as local bone-graft material is not new, as Hahn described this technique as early as 1884. Other authors have since written about its value. The desirability of using the fibula as a graft stems arises from its excellent structural strength, its osteogenic potential and the fact that it does not produce any distant donor site morbidity. As opposed to allografts, it has neither problems of immunogenicity nor risks of transmitting infection.

The purpose of our study was to determine the indications, technique and results of non-vascularised free fibular transfer for the treatment of tibial non-union associated with a sclerosed bone defect and where there was no usable ipsilateral fibula.

Material and methods

Seven patients with tibial non-union and a sclerosed bone defect were treated using contralateral non-vascularised free fibular transfer. There were six men and one woman. Average age was 39.3 years (range: 20–52); the right side was affected in five patients and the left side in two. Six of the original injuries were open fractures (Gustilo type III) due to road traffic accidents and one resulted from a high-velocity gunshot injury. Average number of operations prior to the index operation was 3.2 (range: 2–5). These procedures included internal fixation or external fixation

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Fig. 1 A X-ray of 42-year-old male patient showing an un-united tibial fracture with a sclerosed segmental bony defect and an unusable fibula. B X-ray 1 month after free fibular graft transfer. C X-ray 3 months post-operatively. D X-ray 3 years post-operatively showing union and incorporation of the graft

with or without a cancellous bone graft, and debridement and soft tissue cover operations. There was a delay of an average of 33 months (range: 22–38) prior to the fibular transfer operation. Pre-operatively, all patients had non-union of a tibia with sclerosed segments ranging in length from 3–8 cm (average 4.7 cm). The skin had been healed for at least 3 months, and no sign of infection was present. Two patients had pre-operative shortening (2 cm and 2.4 cm).

Operative technique included exposure of the non-union and bone defect. This allowed the creation of a longitudinal gutter in the sclerosed segment, and this was extended by 2 cm into each 'end' of the healthy tibia. The contralateral fibula was then harvested and was at least 4 cm longer than the sclerosed tibial segment. Average graft length was 11 cm (range: 7–15). The fibular graft was then firmly impacted into the gutter made in normal tibial bone for at least 2 cm above and below the sclerosed segment. The fibula was secured in place (in addition to impaction) by a double loop of 0.9 mm wires passed through the fibular graft and the tibia, both proximally and distally. No screws were used in order to avoid weakening the graft. Great care was taken not to

disturb any mechanical stability resulting from either the pseudarthrosis or the ipsilateral fibula, and no additional cancellous bone grafting was used. The limb was immobilised in plaster for 6–12 weeks after the operation. The patients were allowed non-weight-bearing walking with two crutches for 6 weeks, and then partial weight bearing for a further 6 weeks. This was followed by a lightweight plastic orthosis, either for a further 12 weeks or until radiographic and clinical union had occurred.

Union of the graft was assessed clinically and radiographically. In addition, all patients were assessed for donor site morbidity, checking specifically for pain, weakness of the extensor hallucis longus, range of motion at the ankle joint and any neurological deficit.

Results

Average period of follow-up was 2.7 years (range: 2–4.1); primary bone union occurred in six patients.

A pseudarthrosis at the distal graft-tibial junction developed in one patient only who required another procedure using a cancellous bone graft. This healed eventually without any change in fixation or loss of graft position. Six out of the seven grafts united within 6 months, with an average of 4.5 months (range: 3–6). However, solid union with fibular graft incorporation was present in all the patients at their final follow-up examination (Fig. 1). Functionally, all patients were walking when last seen. They all returned to their usual daily activities. Five were able to return to their previous jobs and two had to seek different employment. There were no major complications, although residual ankle stiffness occurred in two patients and two had shortening of 2 cm and 2.4 cm (which, in fact, had been present pre-operatively). No donor site morbidity was reported apart from mild weakness (grade 4/5) of the extensor hallucis longus in one patient. Patient satisfaction was excellent in all cases.

Discussion

Tibial non-union with a bone defect after open fractures and sepsis are among the most complex clinical problems facing orthopaedic surgeons. Open fractures are caused by high-energy injury, which usually affects both the tibia and the fibula to the extent that the ipsilateral fibula cannot be used for reconstruction of the tibia. Soft tissue is also severely injured and the likelihood of infection is very high. Previous multiple attempts at reconstruction may further complicate the situation.

Various methods have been used to treat this condition, including Papineau-type cancellous bone grafting, microvascular fibular transfer, vascularised fibular transport, Ilizarov external fixator, and free non-vascularised fibular transfer. Autogenous cancellous bone grafting is limited primarily by the quantity of bone that can be harvested from the donor site [15]. Although vascularised fibular transport (either centralisation or simple synostosis) is technically easy, it often results in a varus deformity [16, 17]. In addition, the fibula is not fully centralised, especially in synostosis procedures [13]. However, this method can be useful for non-union with a bone defect when the ipsilateral fibula is usable. The microvascular technique involves the use of the fibula with its own vascular supply and with or without the addition of a myocutaneous flap. This method has the advantage of stronger and more rapid hypertrophy than with the free fibular graft and also no vascular bed is needed. However, the major disadvantages to this procedure are the high incidence of re-fracture and pseudarthrosis [3, 10, 12]. It also requires special surgical skills and instruments and a long operating time. This method may be suitable for cases of non-union with a bone defect in the presence of infection or a soft tissue problem [7]. The Ilizarov technique enables simultaneous correction of deformity and of any limb-length discrepancy through the formation of new osseous tissue without the use of a bone graft. In addition, it allows weight bearing during

the period of treatment [14]. However, delayed union at the target site, re-fracture, axial deformity, joint stiffness, skin and pin tract problems and difficulties with acceptance of the frame for a long period are considered disadvantages [4, 6].

Our patients had the special problem of tibial non-union with a sclerosed bony defect together with the absence of a useable ipsilateral fibula. This situation can also be treated with various methods such as the Ilizarov and microvascular techniques. However, the procedure we used has several advantages. Firstly, the operation is technically simple; secondly, it avoids the time consuming process of microvascular anastomosis (which also requires special instruments and surgical skills that may not always be available); and thirdly, it allows early weight bearing through the preservation of the relative mechanical stability of the pseudarthrosis. It is also more readily accepted by patients than the Ilizarov apparatus. As with any surgical procedure it has some disadvantages, such as morbidity of the normal limb, and, although it can correct deformity, it cannot overcome any limb shortening.

The procedure is a simple, easy and successful solution of the difficult problem of tibial non-union with a sclerosed bone defect and in the absence of ipsilateral useable fibula. However, the small numbers in our study do not permit analysis of the factors affecting the success or otherwise of contralateral non-vascularised free fibular transfer.

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