USE OF THE IPSILATERAL VASCULARISED FIBULA FOR TIBIAL RECONSTRUCTION

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Between 1989 and 1994 we used a vascularised ipsilateral fibular graft in 24 patients with segmental tibial defects. We report 12 patients with a minimum follow-up of two years. The graft was either transposed medially or inverted on its vascular pedicle. Full weight-bearing was achieved at between four and seven months. We had few complications and consider that the use of this method is a valuable option in reconstruction of the tibia.

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Segmental defects of the tibia present a challenging problem, particularly in the presence of infection and instability. The various techniques which have been used include compression, decortication, bone grafting, segmental transportation and tibiofibular synostosis. The indications for a particular technique are poorly defined. Tibiofibular synostosis is regarded as a salvage procedure (Davis 1944; McMaster 1954; Bell 1961; McCabe 1961; Parisien 1963; McMaster and Hohl 1965; Doherty and Patterson 1967; Agiza 1981). Difficulty may be encountered in placing the fibula in close approximation to the tibia, and large amounts of cancellous bone graft may be needed to obtain fusion, with unpredictable results.

In 1981, Chacha, Ahmed and Daruwalla suggested the dissection and transposition of the fibula, preserving its vascular supply, and we began to use this procedure in 1988.

PATIENTS AND METHODS

We performed ipsilateral vascularised fibular transplantation in 13 patients. One died early due to metastatic disease, leaving 12 cases in the series. There were nine men and three women with a mean age of 34 years (19 to 58). The mean follow-up was 32 months (24 to 58). In nine patients the reason for the defect was injury: in eight infected nonunions were present. The other three patients had had a tumour. Debridement and various previous attempts at reconstruction had resulted in segmental tibial defects of varying length, with a mean of 12 cm (1 to 19). In two patients bifocal defects were due to failed segmental transport. The reconstructed segment was very weak in two patients after microvascular rib transplantation. In a further two patients transfer of the ipsilateral fibula had been performed as a planned procedure eight and nine weeks after microvascular transplantation of the contralateral fibula, providing a double strut.

Soft-tissue reconstruction had been necessary in 11 patients; in five flap coverage had been obtained at the time of fibular transfer and in six it had been undertaken before. Seven patients had been treated with a free microvascular flap, two with a medial and two with a medial and lateral gastrocnemius flap.

The mean number of previous operations was 5.5 for the post-traumatic patients. The mean time interval between the accident and the fibular transfer was 14 months (7 to 36). All patients with a tumour had immediate reconstruction after resection.

Operative technique. The lateral aspect of the leg was almost invariably well preserved, even after multiple operations and chronic infection, and a straight lateral approach was always possible. The peroneal fascia was incised. The peroneal nerve and its branches were identified and protected. The peroneal muscles were retracted anteriorly and sharply dissected off the fibula, leaving a cuff of muscle 1 to 2 mm thick on the periosteum and bone. The anterolateral intermuscular septum was incised.

Proximal and distal osteotomies were performed with an oscillating saw, allowing external rotation of the fibular segment. The medial aspect of the fibula was decorticated. Dissection proceeded along the interosseous membrane isolating the neurovascular bundle which was left anterior to the plane of dissection. The posterior aspect of the fibula was left intact when simple medial transposition was required. Dissection of the vascular pedicle was necessary when major proximal translation or an inversion of the graft was planned (Fig. 1). Decortication of the lateral
Dissection technique. For transposition of the fibula posterior dissection is not necessary (a,b). For inversion of the fibula circumferential dissection of the peroneal vessels is required (c).

The fibula was transposed without tension on the soft tissues and fixed with lag screws to the tibia. If necessary, additional plates were used for the stabilisation of nonunion of the fibula or an osteotomy. Additional fixation of the tibia was sometimes necessary and a uniplanar external fixator was usually adequate. The remaining gap between the tibia and the fibula was filled with cancellous bone harvested from the iliac crest. If an inverted or a double-strut configuration was planned, the fully dissected transplant was rotated at its base and the fibular segment was placed in the defect and stabilised by short compression plates and a long bridging plate (Fig. 2).

Mobilisation was started after 48 hours, with 10 kg of ground contact allowed immediately. Radiographs were
obtained at intervals of six weeks. Weight-bearing was increased according to the degree of healing.

RESULTS

Two patients with resections of tumours had a planned second cancellous bone graft 12 and 13 weeks after the fibular transfer. All other patients had union with a single operation.

Full, unprotected weight-bearing for normal walking was achieved at a mean of 5.5 months (4 to 7) after fibular transfer. The mean walking distance as subjectively stated by the patients was 12 km (1 km to unlimited) with impairment because of residual contractures of the ankle and knee or arthrodesis of the knee. Chronic oedema and pain were the cause of limitation in two patients. Two complained of painful pressure in the leg after long periods of standing or walking which was promptly relieved by elevation of the limb.

The soft tissues were stable in all patients and remained so during the entire follow-up period. Swelling and oedema of the latissimus dorsi flap and the foot were limiting factors in two patients. Compared with the uninjured side, the mean difference in thigh circumference was 3 cm (−1 to 7).

The range of knee movement was normal in eight patients. In three patients with a tumour a knee fusion was necessary. In one patient the range of movement was impaired due to an intra-articular fracture. Impairment of ankle movement was common. The mean range was 35° (15 to 60). Before fibular transfer six patients in the traumatic group had an equinus contracture. At the final review only one did not reach the plantigrade position. He maintained a fixed equinus of 10°.

In seven patients the axial alignment was normal. In three there was an asymptomatic valgus deformity of between 6° and 11°. One had a varus angulation of 6° and another a 9° flexion deformity. One patient had an external rotational deformity of 10° but in the remainder the rotation was normal. Shortening of between 1 and 2 cm was observed in eight patients.

Thickening, increasing radiodensity and surface irregularity of the fibula were seen as soon as four months after transposition. This periosteal reaction was interpreted as indicating satisfactory perfusion and viability. The extent of this reaction was variable and was probably related to the mechanical loading of the fibular segment. On standard radiographs we observed a mean increase in diameter of 3 mm (1 to 4).

The cancellous bone graft was incorporated as a radiodense bone mass in all instances. Partial graft resorption was seen in one patient, who lost about 50% of the transplanted cancellous bone. He had a sound fusion with strong bridging callus at the proximal and distal ends of the fibula which was mechanically sufficient, and no regrafting was necessary.

Refracture occurred in one patient 13 months after transfer. The degree of trauma was probably adequate to account for the fracture and the patient was under the influence of drugs at the time.

No other local or systemic complications have occurred and we have seen no cases of infection or nonunion.
Illustrative cases showing medial transfer for infected nonunion of the tibia (a), medial transfer for a bifocal defect after failed segmental transport (b), inversion of a single strut for radio-ostonecrosis and atrophic nonunion of the tibia (c) and inversion of a double strut after resection of a tumour at the knee (d).
Nine patients returned to full-time work, five to their previous level of work activity and four to a physically less-demanding job. One patient remained unemployed, one did not return to work because of alcohol addiction, and one died from a drug overdose.

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. The technique has evolved from a unifocal to a bifocal transfer with proximal and distal osteotomies, first in two stages but later in one stage only (Campanacci and Zanoli 1966). Wilson (1941) described bipolar osteotomy and medial transfer of the fibula for post-traumatic tibial pseudarthrosis. With his minimally invasive technique sufficient medial translocation could not be obtained and compression of the soft tissues jeopardised the perfusion of the transplant. Such problems led to the development of indirect methods such as fibriobular synostosis with interposed cancellous bone graft (Girdlestone and Foley 1933; Ramadier 1961; Salaman 1963), but the long time to consolidation and the need for a large amount of autologous cancellous bone graft were disadvantages.

The development of techniques for harvesting microvascular fibular transplants (Taylor, Miller and Ham 1975; O’Brien et al 1988) indicated the potential use of the ipsilateral fibula, retaining the periosteal and endosteal circulation (Chacha et al 1981). Shapiro et al (1993) described nine ipsilateral vascularised fibular transpositions for treatment of tibial defects and nonunions with encouraging results, similar to our findings. Coleman and Coleman (1994) reported five ipsilateral fibular transfers with a vascular pedicle for congenital pseudarthrosis of the tibia; all consolidated and no re-fracture had occurred during a follow-up period of 1.5 to 5 years.

Besides simple medial transposition, a vascularised segment of the fibula of up to 25 cm in length can be rotated 180° around the origin of its vascular axis, giving considerable versatility. The transplant can be used as a simple transposition with medial shift of the fibula or with inversion of a single fibular strut or of a folded, double strut (Figs 2 and 3). In simple transposition the peroneal vascular axis remains intact. In inversion the peroneal vascular axis must be interrupted either distally or proximally, depending on whether an antegrade or retrograde flow is desired. Figure 4 shows illustrative cases using these techniques.

The major advantage of a perfused transplant is to retain the biological potential of living bone. This gives a shorter time to consolidation, increased potential for remodelling, greater resistance to infection and better long-term mechanical properties.

Perfusion of the transplants is checked at the time of operation and later by radiological techniques. If the transplant is viable early union of the osteotomies occurs within eight to ten weeks and there will be a periosteal reaction around the transplant by four to six months, with increasing width of the graft.

Sacrifice of the fibula does not have any detectable functional disadvantage.

We have also successfully transposed pseudarthrotic fibulae, either directly, using osteosynthesis with a compression plate, or in a two-stage procedure with decortication and compression plating of the nonunion of the fibula, followed by transposition at a later stage. Interruption of the peroneal vascular axis in inversion procedures causes no problem when the anterior and posterior tibial vessels are patent. Residual stiffness of the ankle is not directly related to the fibular transfer. In all our cases it was present before the transfer and was related to the earlier management.

The ideal location of the transplant is debatable. An eccentric position, in a double-strut configuration, greatly increases the polar moment of inertia and thus the strength of the structure. It also gives the optimal mechanical and biological environment for consolidation of the osteotomies with a stable osteosynthesis and the bone surfaces in contact.

Errors in axial alignment can be avoided by careful technique and intraoperative radiographic control. Compared with other reconstructive options, such as massive cancellous bone grafting or segmental bone transport, the main advantages of vascularised fibular segments are the short healing time, the reduced number of secondary procedures, and the lower incidence of complications.

The use of the ipsilateral as compared with the contralateral vascularised fibula overcomes the need for operation on the sound limb, virtually guarantees perfusion and shortens the operating time.

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REFERENCES


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