We present two children with massive defects of the tibia and an associated active infection who were treated by medial transport of the fibula using the Ilizarov device. The first child had chronic discharging osteomyelitis which affected the whole tibial shaft. The second had sustained bilateral grade-IIIIB open tibial fractures in a motor-car accident. The first child was followed up for three years and the second for two years. Both achieved solid union between the proximal and distal stumps of the tibia and the fibula, with hypertrophy of the fibula. The first child had a normal range of movement at the knee, ankle and foot but there was shortening of 1.5 cm. The second had persistent anterior angulation at the proximal tibiofibular junction and the ankle was stiff in equinus.

The combination of a massive bony defect in the tibia with active infection is a difficult clinical problem since conventional management by bone grafting and internal fixation cannot be used.

A number of methods have been described such as the use of a free-vascularised graft to bridge the defect using the contralateral fibula or the ipsilateral fibula either through tibiofibular synostosis or medial transport of the fibula. Chacha, Ahmed and Daruwalla described a technique for medial transfer of the ipsilateral fibula for bridging large defects in the tibia in which the fibula was raised on a pedicle of peroneal and anterior tibial muscles and the peroneal vessels. This vascular graft was positioned along the posterior longitudinal axis of the tibia to provide mechanical support. The Ilizarov technique can be used for either bifocal or trifocal bone transport, medial transport of the ipsilateral fibula or transport of the hemifibula.

We describe two children with massive defects of the tibia in whom the Ilizarov technique was used to bridge the gap by medial transport of the ipsilateral fibula. The defects involved the whole diaphysis with no available proximal or distal tibial remnants suitable for bone transport.

**Patients and Methods**

The first child, a boy aged six, had chronic discharging osteomyelitis which had been present for three months. The proximal tibia was exposed and the whole diaphysis had been sequestrated.

The second patient, a boy aged seven, had been involved in a motor-car accident, and had sustained bilateral grade-IIIIB open tibial fractures. He presented two weeks later with both tibiae exposed and heavily infected. On the right side, there was a soft-tissue defect of approximately 12 cm × 5 cm. Nearly all the muscles of the anterior tibial compartment were infected and necrotic with damage to the anterior tibial neurovascular bundle. The peroneal compartment and the medial side of the posterior compartment were exposed with superficial infection, but were viable, with an intact blood supply. The situation was further complicated by the presence of multiple intramedullary Kirschner (K-)wires and cerclage wires in the tibia with two transfixing the proximal tibia and fibula and another intramedullary K-wire in the ipsilateral fibula (Fig. 1). The shaft of the right tibia was extensively comminuted. The left tibia and fibula were heavily infected, with soft-tissue loss of approximately 8 cm × 4 cm involving the anterior compartment, but the lateral and posterior compartments were intact with no neurovascular compromise. The midshaft of the left tibia was mildly comminuted over about 3 cm. Amputation had been suggested before referral to our institution, but the parents had refused.

Debridement of all necrotic, tissue and sequestrated bone resulted in a defect of 11 cm in the tibia in the first child and of 12 cm on the right side and 6 cm on the left in the second. We decided to use medial transport of the ipsilateral fibula with the Ilizarov frame for the
large defect which involved the whole diaphysis with no proximal or distal remnants suitable for bone transport in the first child and for the right leg of the second boy. The left leg of the second child was treated by a three-ring Ilizarov construct using bifocal bone transport from the proximal tibial stump to bridge the defect.

**Operative technique.** After debridement and thorough irrigation of the wound with saline solution, an Ilizarov ring of appropriate size was applied to the proximal fragment and fixed by two tensioned 1.8 mm K-wires. A second ring was applied to the distal fragment and also fixed by two tensioned 1.8 mm K-wires. The two rings were connected to each other by four threaded rods. Two olive wires were drilled through the shaft of the fibula and connected to the Ilizarov frame using a motor for medial transport of the fibula, which was approached through two separate posterolateral incisions 1.5 cm to 2 cm at length at its proximal and distal ends. Osteotomy of the fibula was performed through these two incisions using a 2.5 mm drill bit and a 6 mm osteotome almost at the level of the ends of the proximal and distal tibial fragments. The wound was left open in both children and daily dressings applied until signs of active infection were not present. In the first child delayed closure was achieved after seven days. In the second child the defect was filled by healthy granulation tissue after 20 days, but a second debridement was necessary for the proximal tibial fragment followed by split-skin grafting. Gradual medial transport of the fibula was started from the second post-operative day at a rate of 0.25 mm every six hours (1 mm/day) (Fig. 2). Active non-weight-bearing movement of the knee and ankle was encouraged post-operatively.

**Results**

Fibular transport was completed in 20 days in both children. The construct was then left in place for two months. In the first child there was evidence of union between the tibia and fibula distally but not proximally. Therefore, open refreshment for the proximal ends of the tibia and fibula was carried out and the construct left in place for a further 1.5 months to achieve sound union. The construct was then removed and a walking cast applied for a further month during which the child was allowed to bear weight fully. In the second child there was evidence of union proximally and distally between the fibula and tibia by the end of the second month after medial transport and the construct was therefore removed. A brace was then applied for another two months. For the left tibia, bifocal bone transport was started seven days post-operatively at a rate of 0.25 mm/6 hours (1 mm/day), and finished after eight weeks to bridge this 6 cm defect. The construct was then kept in place for another three months until consolidation of the
newly formed regenerate was evident on the plane radiographs (a continuous three cortices was present in the anteroposterior and lateral radiographs). The construct was then removed.

At the latest follow-up three years after the procedure, the first child was fully weight-bearing with no signs of infection. Radiographs showed hypertrophy of the fibula. The range of movement at the knee was full. At the ankle and foot, movements were also normal but there was a limb-length discrepancy of 1.5 cm.

Two years after operation the second child was fully weight-bearing on both legs (Fig. 3). On the right side, on which medial ipsilateral transport of the fibula had been performed, there was anterior angulation between the proximal fibula and the tibia of 30° and the ankle was stiff in 10° of equinus. On the left side the area of bone transport was completely consolidated but the ankle was stiff in mild valgus. The subtalar joint was also stiff in the neutral position, but adduction and abstraction of the forefoot were preserved. There was a full range of movement at the knee.

Discussion

Massive defects of the tibia involving the whole diaphysis are rare in children and the treatment is challenging. The presence of infection and extensive soft-tissue loss can be a serious threat to the viability of the limb. Amputation rather than reconstruction may be proposed as a cost-effective method. However, there has been much debate on the long-term disability after amputation, especially above the knee, as well as the cost of repeated prostheses.

Many techniques have been described for the reconstruction of limbs in which active infection is present. Tibiofibular synostosis causes eccentric loading through the fibula which may fail in the presence of a massive tibial defect. The use of a vascular pedicle graft of the ipsilateral fibula as described by Chacha et al. requires considerable dissection of the posterior and lateral compartments to free the fibula, with identification of the peroneal vessels which may not be easy in the presence of infection.

The use of a free-vascularised fibular transfer from the contralateral limb adds morbidity to the normal limb, is time-consuming and requires a specialised microsurgical team. A satisfactory vascular anastomosis may be difficult in infected tissue. In our second case, there was trauma to both lower limbs and infection with injury to the right anterior tibial neurovascular bundle which precluded the use of a free-vascularised fibular graft.

The use of the Ilizarov device provides a number of choices for the management of complicated tibial bone loss such as bifocal or trifocal bone transport, with or without acute or gradual shortening to close the tibial defect. However, these methods cannot be used when there is no suitable proximal or distal tibial remnant for transport. Catagni et al., Catagni, Ottaviani and Camagni and Atkins et al. have described the use of the Ilizarov technique to transport the fibula medially in 12 adults with massive defects of the tibia after trauma and chronic osteomyelitis. The advantages of this technique are that it is simple, requires minimal dissection of the fibula, and gradual transport ensures maintenance of the blood supply. The stability of the Ilizarov construct provides good fixation for the limb and the transported fibula which is difficult to achieve in children and with small tibial remnants, as described by Chacha et al. It also allows early movement of joints. However, in our second patient there was stiffness of the ankles bilaterally at the latest follow-up, as a result of spread of infection by the intramedullary K-wires. The mechanical stability of the limb avoids the need for transfixation of the distal tibiofibular joint with a screw to stabilise the ankle as advised by Chacha et al. We also found after the union of the transported fibula that a proximal and distal tibiofibular synostosis had developed increasing the stability of the limb and avoiding the need for transfixation of the distal tibiofibular joint with a screw to stabilise the ankle as advised by Chacha et al.

The parents of our two children were satisfied with the results, particularly those of the second patient despite the presence of anterior angulation at the proximal tibiofibular junction and stiffness of the ankle in equinus. In the first patient a full range of movement at the ankle, subtalar and midtarsal joints with no apparent deformities of the foot indicated that there was no evidence of damage to the peroneal muscles by gradual transport of the fibula medially.

No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.
References