THE ILIZAROV METHOD IN THE MANAGEMENT OF GIANT-CELL TUMOURS OF THE PROXIMAL TIBIA

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We have used the Ilizarov technique for the management of subarticular defects after the excision of giant-cell tumours in the proximal tibia in five patients. The defect was reconstructed with a segment of 5 to 6 cm obtained from the diaphysis of the affected tibia and by autogenous bone graft from the iliac crest. The newly developed defect in the diaphysis was reconstructed by distraction using the Ilizarov apparatus. Bone grafting at the docking site was performed soon after positioning the bone segments.

The mean length of the bone defect was 5.7 cm and the mean duration of external fixation was 233 days. The relative blood flow in the leg measured by $^{99m}$Tc angiography increased by 1.7 to 2.3 times that of the control level during distraction and consolidation. When seen at a mean of 43 months all patients showed a normal range of motion in the knee and ankle with no collapse of the articular surfaces.

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Giant-cell tumour of the bone is usually benign but may recur locally. Almost half of the lesions involve the distal end of the femur or the proximal end of the tibia (Dahlin, Cupps and Johnson 1970; Goldenberg, Campbell and Cribbigo 1970; Larsson, Lorentzon and Boquist 1975; Mjöberg et al 1984; Persson et al 1984; Jacobs and Clemency 1985; Kreicbergs, Lonnqvist and Nilsson 1985; Capanna, Fabbri and Bettelli 1990; Pals and Wilkins 1992), but with fewer complications and better functional results (Gitelis et al 1993; Aboulafia et al 1994).

For local control, an extensive cortical window is necessary to allow thorough curettage. This causes loss of bone stock in the subarticular area which is sometimes difficult to reconstruct; methylmethacrylate, autogenous bone graft, allograft, or hydroxyapatite have all been used (Campanacci, Cervellati and Donati 1985; Mankin, Gebhardt and Tomford 1985; Mjöberg, Nilsson and Pettersson 1985; Uchida et al 1990; Gitelis et al 1993; Aboulafia et al 1994).

We have used the Ilizarov method to reconstruct extensive subarticular defects of the proximal tibia. Our aims were to achieve biological healing, give sufficient biomechanical strength, avoid subarticular collapse and preserve the extensor mechanism of the knee.

PATIENTS AND METHODS

We treated five patients (two males and three females) with giant-cell tumour of the proximal tibia. Their mean age at operation was 30 years (15 to 54). There were three stage-III lesions and two stage-II lesions (Campanacci et al 1987; Table I). Hemicortical distraction was used in one stage-II tumour because the lesion was localised to the lateral side of the proximal tibia. Function of the knee was assessed by the evaluation system of Enneking (1987).

Increase in the relative blood flow during treatment was measured by $^{99m}$Tc angiography after operation. Rectangular regions of interest (ROI) were established in the bone-lengthening area and on the opposite leg at the same level, and over the whole bone and soft tissue on both sides. A time-activity curve for each ROI was generated and the index of blood flow determined by dividing the peak count of the arterial phase of the lesion by that on the control side.
Operative technique. A 5-6 cm segment of bone is removed from the diaphysis of the affected tibia below and clear of the lesion and the patellar ligament is cut with or without the tibial tuberosity (Fig. 1a). Resection of the tumour en-bloc and thorough curettage around the subarticular area are performed. The surface of the defect is cauterised with 80% phenol (Campanacci 1990) using a cotton-tipped applicator. The phenol is removed by lavage with 99% ethanol and irrigated with physiological saline; this procedure is repeated three times.

The subarticular defect is then reconstructed with the segment removed from the diaphysis and the remaining gap under the articular surface is filled with autogenous cortico-cancellous bone graft from the iliac crest (Fig. 1a). This supports the articular cartilage after the subchondral bone has been thoroughly curetted. An Ilizarov external fixator is

Table I. Details of the five patients

<table>
<thead>
<tr>
<th>Case</th>
<th>Sex</th>
<th>Age (yr)</th>
<th>Stage*</th>
<th>Length of defect (cm)</th>
<th>Duration of distraction (days)</th>
<th>Duration of external fixation (days)</th>
<th>TI (days/cm)†</th>
<th>Complications</th>
<th>Functional evaluation (Enneking 1987)</th>
<th>Duration of follow-up (mth)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>M</td>
<td>20</td>
<td>III</td>
<td>6.5</td>
<td>130</td>
<td>278</td>
<td>42.8</td>
<td>None</td>
<td>Excellent</td>
<td>48</td>
</tr>
<tr>
<td>2</td>
<td>F</td>
<td>54</td>
<td>II</td>
<td>5.0</td>
<td>102</td>
<td>208</td>
<td>41.6</td>
<td>Fracture at the docking site, pes equinus</td>
<td>Excellent</td>
<td>47</td>
</tr>
<tr>
<td>3</td>
<td>M</td>
<td>15</td>
<td>III</td>
<td>6.5</td>
<td>133</td>
<td>285</td>
<td>43.8</td>
<td>Early consolidation</td>
<td>Excellent</td>
<td>46</td>
</tr>
<tr>
<td>4</td>
<td>F</td>
<td>21</td>
<td>II</td>
<td>4.5</td>
<td>159</td>
<td>162</td>
<td>36.0</td>
<td>Subluxation of the fibular head</td>
<td>Excellent</td>
<td>42</td>
</tr>
<tr>
<td>5</td>
<td>F</td>
<td>40</td>
<td>III</td>
<td>6.0</td>
<td>65</td>
<td>230</td>
<td>38.3</td>
<td>None</td>
<td>Excellent</td>
<td>32</td>
</tr>
</tbody>
</table>

* according to Campanacci et al (1987)
† treatment index (duration of external fixation divided by the length of the defect)

Diagrams of the method of reconstruction.
then applied and the proximal tibia stabilised (Fig. 1b). Usually, two wires are introduced at the most proximal ring. The first wire is passed through the fibular head, the preserved medial or lateral cortical wall and the grafted segment, and the second through the remaining medial or lateral cortical wall and the grafted segment, crossing the first wire at an angle of more than 45°. A five-eighths ring is usually used proximally to allow knee flexion. At the second proximal ring two additional wires are used to fix the grafted segment. Iliac-crest struts are used to reconstruct the medial or lateral wall if required. The patellar ligament, with or without the tibial tuberosity, is reattached using one or two screws with spike washers. The medial collateral ligament is reattached to the medial wall or to the grafted segment if necessary.

Two distal rings are used to fix the distal tibia with two wires for each ring. A third proximal (middle) ring is used for the segment with three wires allowing bone transport to reconstruct the newly-created defect in the diaphysis. Osteotomy is usually performed with an oscillating saw or a Gigli saw (Fig. 1b).

Distraction is started at 0.5 mm twice daily or 0.25 mm four times daily approximately seven to ten days after operation, being modified according to the degree of bone formation, from 0 to 1.0 mm a day. Three weeks after the operation the patients begin to move the knee and perform straight-leg raising. At six weeks they progress to full weight-bearing. To facilitate union at the docking site fibrous tissue is removed and cancellous bone grafts applied soon after the defect has been bridged. A further biopsy is then taken at this stage.

RESULTS

The mean length of the diaphyseal defect was 5.7 cm (4.5 to 6.5). The mean duration of distraction was 117.8 days.
(65 to 159) and of external fixation 232.6 days (162 to 285). The mean treatment index, obtained by dividing the duration of external fixation by the length of bone regeneration, was 40.5 days/cm (36.0 to 43.8). All patients obtained union at the docking site and corticalisation of the regenerated bone. The final function of the affected leg was excellent in all cases. There were no local recurrences and no collapse of the joint surface of the proximal tibia at a mean follow-up of 43 months (32 to 48) (Figs 2 and 3).

There were complications in three patients. One (case 2) had a fracture at the docking site and a pes equinus at the ankle. The other two had early consolidation of the regenerated bone (case 3) and subluxation of the fibular head (case 4). In case 2, the Ilizarov apparatus was reapplied at the docking site and in case 4 the subluxation of the fibular head was reduced and fixed by screws at the time of removal of the Ilizarov apparatus. Early consolidation of the regenerated bone in case 3 was managed by a further subcutaneous osteotomy. The pes equinus in case 2 was treated successfully by physiotherapy after removal of the Ilizarov apparatus (Table I).

Histological examination at the time of docking showed varying degrees of callus formation continuous with the bone trabeculae of the transported segment (Fig. 4a); this segment was shown to be viable in all cases at 65 to 133 days after the initial operation (Fig. 4b).

During the lengthening period, from one to three months after surgery, the mean blood flow increased to 2.2 times more than control level at the distraction site and 1.7 times the control level for the whole leg. During consolidation,
from three to nine months after operation, the increased flow persisted at levels of 2.2 to 2.3 times greater than the control levels at both the distraction site and in the whole leg (Table II).

**DISCUSSION**

After the excision of a giant-cell tumour from the subarticular area of the upper tibia reconstruction should supply sufficient biomechanical strength, resistance to infection, and biological healing with maintenance of the extensor mechanism of the knee and avoidance of collapse of the articular surface. The Ilizarov method is widely used for reconstruction of the proximal tibia in the treatment of fractures, nonunion, traumatic bone defects, osteomyelitis and deformity (Ilizarov 1991; Maiocchi and Aronson 1991), but there are few reports of the use of distraction osteogenesis in the management of bone tumours (Stoffelen, Lammens and Fabry 1993; Tsuchiya et al 1993; Cañadell, Forriol and Cara 1994; Said and El-Sherif 1995).

Methylmethacrylate has been utilised, but low-grade radiological osteoarthritis was found in two of 14 patients with a giant-cell tumour treated by curettage and cement (Persson et al 1984). Cryosurgery and composite reconstruction using cement and internal fixation can achieve local control of the tumour and preserve joint function in patients with large, aggressive, subchondral, periarticular tumours of the knee (Aboulafia et al 1994). Cement, however, cannot always be used because of the danger of heat necrosis of unsupported cartilage where the subchondral bone has been lost. When the tumour is less than 1 cm from the articular cartilage, the incidence of degenerative changes after the use of polymethylmethacrylate alone is more than 2.5 times greater than that when the tumour is more than 1 cm away (Campanacci et al 1990).

Allografts are an alternative to endoprosthetic reconstruction but the high incidence of complications such as fracture, deformity, and infection makes the outcome unpredictable (Brien et al 1994; Clohisy and Mankin 1994). The results of vascularised bone transfer are more favourable but there are limitations in biomechanical strength and availability (Han et al 1992).

Distraction osteogenesis provides complete biological healing at the subarticular defect. Reconstruction requires a long period of external fixation, has a high incidence of complications and needs a second operation for bone grafting. Once achieved, however, it provides good function at the knee and avoids the sequelae associated with prosthetic replacement and allografts such as fracture, loosening and infection. Once the bone has regenerated, the patient is unlikely to require a revision operation, and CT and MRI are available for the detection of local recurrence of the tumour after the removal of external fixation and internal screws.

The Ilizarov apparatus allows effective fixation of complicated structures and simultaneous bone transport and is also useful in resolving complications such as joint contracture, translation of moving segments, or deformity during external fixation. We were able to reduce the subluxated fibula in case 4 at the time of the removal of the Ilizarov fixator using an arched wire technique.

**Conclusions.** The advantages of this method include the lack of graft rejection, the reattachment of ligaments and tendons to bone, the prevention of articular collapse, early movement of the knee and ankle, and early weight-bearing. Disadvantages include the long duration of external fixation and related problems such as wire-track infections, wire breakage and the frustration of patients due to the long period of treatment. Biological healing can be achieved and the method may be useful for reconstructing similar defects of the proximal tibia after trauma, resection of bone tumours other than a giant-cell tumour, and for failure of primary limb-salvage surgery.

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**


**Table II.** Details of the relative blood flow compared with control levels in the five patients during the lengthening and consolidation periods

<table>
<thead>
<tr>
<th>Case</th>
<th>Lengthening period</th>
<th>Consolidation period</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Callus</td>
<td>Whole leg</td>
</tr>
<tr>
<td>1</td>
<td>1.88</td>
<td>-</td>
</tr>
<tr>
<td>2</td>
<td>2.72</td>
<td>2.09</td>
</tr>
<tr>
<td>3</td>
<td>2.02</td>
<td>1.26</td>
</tr>
<tr>
<td>4</td>
<td>2.26</td>
<td>2.39</td>
</tr>
<tr>
<td>5</td>
<td>1.86</td>
<td>1.16</td>
</tr>
<tr>
<td>Mean</td>
<td>2.15±0.36</td>
<td>1.73±0.61</td>
</tr>
</tbody>
</table>


