Rotationplasty after failure of a knee prosthesis for a malignant tumour of the distal femur

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Failure of massive knee endoprostheses implanted for malignant tumours of the distal femur in children presents a difficult problem.

We present the results of rotationplasty undertaken under these circumstances in four boys. They had been treated initially at a mean age of 9.5 years for a stage-IIB malignant tumour of the distal femur by resection and implantation of a massive knee endoprosthesis. After a mean period of eight years and a mean of four operative procedures, there was failure of the endoprosthesis because of aseptic loosening in two and infection in two. Function was poor with a mean Musculoskeletal Tumor Society score of 7.5/30, and considerable associated psychological problems.

At a mean follow-up of 4.5 years after rotationplasty there was excellent function with a mean score of 27.5/30 and resolution of the psychological problems.

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The treatment of stage-IIB osteosarcoma of the distal femur is chemotherapy, en-bloc resection and reconstruction either by replacement with a custom-made prosthesis in adolescents or adults or with an expandable prosthesis in children. With an increasing number of limb-salvage procedures being performed and longer periods of follow-up surgeons increasingly face the problems of failed reconstruction.

Rotationplasty was first described in 1930 by Borggreve for the treatment of a shortened limb with ankylosis of the knee after tuberculosis. In 1950, Van Nes described its use in the treatment of congenital defects of the femur. In the 1970s, Salzer and Knahr began to treat patients with malignant tumours around the knee by rotationplasty as an alternative to above-knee amputation. It is now one of the options in the surgical management of tumours of the distal femur, particularly in children. It may also be undertaken after failure of endoprosthetic replacement of the distal femur. To our knowledge, this indication has previously been reported in only three patients without details of the indications, technique or results.

We therefore report our experience in four patients.

Patients and Methods

A patient with a failed replacement of the distal femur presents with stiffness of the knee and a limb-length discrepancy. There may be bony resorption with or without infection, rendering a revision procedure impossible. Of the 120 patients treated with such a replacement in our department between 1983 and 1998, this occurred in four. There were two girls who refused further treatment and two boys who underwent rotationplasty. Our series includes these two patients and two other boys referred to us from elsewhere.

All had had a stage-IIB malignant tumour of the distal femur (Table I). The mean age at the time of initial treatment was 9.5 years (5.9 to 13.8). Treatment had involved neoadjuvant chemotherapy, en-bloc resection, replacement of the distal femur, and postoperative chemotherapy. One patient (case 2) had had a pulmonary metastasis which had been treated by chemotherapy and surgery. The prosthesis which had been used was either conventional or expandable. The mechanism of failure was aseptic loosening in two and infection in two. There had been a total of 16 revisions: four lengthenings of the prosthesis, two debridements for infection, one revision of a tibial component, one revision of a femoral component, seven complete revisions and one removal of the prosthesis and replacement with cement and an intramedullary nail as an arthrodesis (Fig. 1).

Table II summarises the data before rotationplasty which was undertaken at a mean age of 17.2 years (12.6 to 26). All the patients had been clinically free from disease for at least four years. There was shortening of the lower limb by 70 mm or more. The prosthetic knee was stiff, with a range...
of movement of 20° or less and there was a flexion contracture in two knees. The affected limbs were functionally useless. There were major psychological problems with social isolation, and one had a suicidal tendency. The mean preoperative Musculoskeletal Tumor Society (MSTS) score was 7.5 out of 30. The passive range of movement, sensation and active movement were normal in the ipsilateral foot and ankle. This is required for the technique.

A full psychological assessment should be undertaken before rotationplasty is performed and detailed explanations should be given to the patient and family including a videotape showing a patient after operation. Any chronic infection should be eradicated by surgical debridement and treatment with antibiotics. Preoperative assessment includes angiography to plan the dissection of major vessels. Skin incisions must take account of scars, providing ideally large anterior proximal and posterior distal musculofasciocutaneous flaps. The first step is dissection of the sciatic nerve and the femoropopliteal artery and vein. After removal of the prosthesis or cement and intramedullary nail, the distal segment is externally rotated by 180° to prevent stretching of the common peroneal nerve and to place the nerves and vessels on the medial aspect of the femur at a distance from the internal fixation. The femoral shaft is impacted into the proximal tibia, which is enlarged.

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Fig. 1
Anteroposterior preoperative radiograph after the infected prosthesis had been removed and replaced by an intramedullary femorotibial nail and cement. There is shortening and loss of bone from the proximal femur.

Fig. 2
Anteroposterior radiograph three years after rotationplasty.

Table I. The oncological and mechanical details for four boys with failure of a knee prosthesis implanted for a malignant tumour of the distal femur

<table>
<thead>
<tr>
<th>Case</th>
<th>Tumour</th>
<th>Age at initial treatment (yrs)</th>
<th>Implant</th>
<th>Mode of failure</th>
<th>Number of revisions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Osteosarcoma</td>
<td>11.2</td>
<td>Expandable</td>
<td>Aseptic loosening</td>
<td>3</td>
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<tr>
<td>2</td>
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<td>7.1</td>
<td>Expandable</td>
<td>Infection</td>
<td>3</td>
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<tr>
<td>3</td>
<td>Osteosarcoma</td>
<td>13.8</td>
<td>Standard</td>
<td>Infection</td>
<td>5</td>
</tr>
<tr>
<td>4</td>
<td>Ewing’s sarcoma</td>
<td>5.9</td>
<td>Expandable</td>
<td>Aseptic loosening</td>
<td>5</td>
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</tbody>
</table>
order to obtain equal length of both ‘thighs’. If growth is not complete, the level of the joint must be anticipated according to the method of Anderson, Green and Messner. Internal fixation must be stable using an intramedullary nail and/or a compression plate. Iliac cancellous bone grafts should be used if there is bone loss. Division of the popliteal and superficial femoral vein and artery is followed by venous and arterial anastomosis, undertaken by a vascular surgeon. This is mandatory in order to prevent stasis and thrombosis, induced by twisting of the vessels. The sciatic nerve is placed in loops between the muscles. The proximal hamstrings are sutured to the tibialis anterior, anterolateral muscles and tibial periosteum, and the triceps surae to the quadriceps and hip flexors. These muscles provide a good covering for the vessels, nerve, bone and implant. After 15 days the lower limb is immobilised in a unilateral plaster hip spica for two months. An intensive rehabilitation programme is required in order to regain active ankle movement, which is now equivalent to flexion and extension of the knee. A specially-designed orthosis allows the ankle movements to be transferred to the prosthetic leg and foot. It consists of a leather thigh socket proximally with a Velcro strap attached by side hinges to a below-knee prosthesis.

Table II. The status of the four patients, before and after rotationplasty after failure of knee prostheses implanted for malignant tumours of the distal femur.

<table>
<thead>
<tr>
<th>Case</th>
<th>Age (yrs)</th>
<th>Functional score</th>
<th>Limb-length discrepancy (mm)</th>
<th>Knee flexion (degrees)</th>
<th>Knee extension (degrees)</th>
<th>Follow-up (yrs)</th>
<th>Age (yrs)</th>
<th>Functional Score</th>
<th>Knee extension (degrees)</th>
<th>Knee extension (degrees)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>15.5</td>
<td>8</td>
<td>90</td>
<td>-20</td>
<td>20</td>
<td>3</td>
<td>18.75</td>
<td>27</td>
<td>100</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>12.6</td>
<td>6</td>
<td>80</td>
<td>0</td>
<td>0</td>
<td>3.5</td>
<td>16.1</td>
<td>28</td>
<td>90</td>
<td>0</td>
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<tr>
<td>3</td>
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<td>8</td>
<td>70</td>
<td>-10</td>
<td>30</td>
<td>5.25</td>
<td>31.25</td>
<td>28</td>
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<tr>
<td>4</td>
<td>14.75</td>
<td>8</td>
<td>70</td>
<td>0</td>
<td>0</td>
<td>6.5</td>
<td>21.25</td>
<td>27</td>
<td>110</td>
<td>0</td>
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</tbody>
</table>

Fig. 3a

Three years after rotationplasty with the affected limb fitted with a prosthesis showing active extension (a) and flexion (b) of the "knee".
made of a resin socket with a soft leather lining and a SACH (solid ankle cushioned heel) prosthetic foot.

**Evaluation of the results.** Clinical, radiological and psychological assessments were carried out. The data were combined as the MSTS score, which includes points for pain, emotional acceptance, function, the need for walking aids, walking ability and gait. Five points are given for each variable, with a maximum total score of 30 points.

**Results**

Table II gives the results. The mean follow-up was 4.6 years (3 to 6.5) and the mean age at follow-up was 22 years (16 to 31.5). There was one recurrent tibial infection which required further surgery, but this did not delay fusion or impair function (case 3). In the other patients, fusion was achieved without further surgery (Fig. 2). The mean MSTS score improved from 7.5 preoperatively to 27.5 at final follow-up.

The range of movement which was obtained included full active extension and flexion of 90° or more in the 'new knee'. The lengths of the lower limbs were equal (Fig. 3). The patients had no pain. Sporting activities such as swimming, jogging, martial arts or soccer, which had been impossible before rotationplasty, were achieved by all patients. The major improvement in function which was obtained with rotationplasty was associated with resolution of the psychological problems. The two youngest patients coped well with their schoolwork while the two oldest found suitable jobs and a marital partner or a steady relationship. The patients and their families confirmed that they would choose this treatment again if the need arose.

**Discussion**

Good functional results with rotationplasty have previously been reported. Hillmann et al. showed that the functional score obtained with rotationplasty is not significantly different from that after endoprosthetic replacement. Gait analysis allows assessment of these results and shows that after rotationplasty, patients can have a walking pattern which is nearly normal. Catani et al. described a co-ordinated pattern of gait, but showed kinematic changes attributable to rigidity of the ankle and foot of the prosthesis which is used as a pivot during the stance phase. McClenaghan et al. reported that, as judged by oxygen consumption, walking efficiency after rotationplasty was higher than that after arthrodesis. Van der Windt et al. showed that after rotationplasty patients can walk faster than after above-knee amputation or disarticulation of the hip with the same expenditure of energy. The foot tolerates better socket loads than does a stump and a shorter prosthesis is required than after an above-knee amputation. The incidence of degenerative changes of the ankle after this procedure is not known although Hanlon and Krajbich reported good mid-term results.

The major disadvantage of rotationplasty is the unusual appearance of the limb which requires a particular design of prosthesis. The psychological problems after rotationplasty are well recognised, and the improvements in our patients may be explained by the fact that they were aware that rotationplasty is a single definitive procedure with a relatively low incidence of complications and revision rate. Acceptance of this procedure is multifactorial. The gender of the patient is one factor. Our series included only boys. Rotationplasty was also offered to two girls who refused this treatment; one had an amputation and the other had an arthrodesis of the knee with a vascularised fibular graft, which remains ununited six years later.

Above-knee amputation or disarticulation of the hip may be performed after failure of a distal femoral prosthesis. When revision is required for infection, the reported rate of subsequent amputation varies from 33% to 100%. When revision is required for aseptic loosening, the reported rate of subsequent amputation, however, varies from 0% to 20%. Amputation required for mechanical failure of a distal femoral expandable prosthesis has also been reported in one knee. The function after an above-knee amputation or disarticulation of the hip depends on a bulky prosthesis and is inferior to that which is achieved after rotationplasty. Amputation is recommended only if the patient refuses rotationplasty or in the presence of unfavourable local conditions such as neuro-vascular damage or extensive chronic infection.

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**


