CASE REPORT

Distal femoral physeal growth arrest secondary to a cemented proximal femoral endoprosthetic replacement

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We report a case of spontaneous physeal growth arrest of the distal femur in a nine-year-old child with Ewing’s sarcoma of the proximal femur treated with chemotherapy and endoprosthetic replacement. Owing to the extent of disuse osteoporosis at the time of surgery, the entire intramedullary canal up to the distal femoral physis was filled with cement. Three years later, the femur remained at its pre-operative length of 19 cm. Pre-operative calculations of further growth failed to account for the growth arrest, and the initial expandable growing prosthesis inserted has been revised to a longer one in order to address the leg-length discrepancy.

To our knowledge, this is the only reported case of distal femoral physeal growth arrest following cemented endoprosthetic replacement of the proximal femur.

Reconstruction after resection of tumours in the proximal femur in children currently usually involves the use of a growing prosthesis and assumes continuing growth to maturity in the distal femoral physis. We report an unusual cause of growth arrest under these circumstances and describe the subsequent treatment that was required.

Case report

A nine-year-old girl was referred to our unit with a Ewing’s sarcoma of the left proximal femur. Staging studies revealed pulmonary metastases. After two cycles of chemotherapy, the tumour had decreased in size clinically and radiologically, and limb-salvage surgery was subsequently carried out after six cycles of chemotherapy. After wide local resection of the proximal femur and reaming of the distal femur, a Mark 5 custom-made extendable proximal femoral endoprosthesis from Stanmore Implants (Watford, United Kingdom) was cemented into the remaining femur using a third-generation cementing technique (vacuum mixed, pressurised cement nozzle). At closure, her legs were equal in length. Post-operative radiographs showed that the whole intramedullary canal of her distal femur was filled with bone cement up to the distal femoral physis (Fig. 1). Her immediate post-operative course was uneventful, and on completion of chemotherapy, CT scans of her chest revealed no residual disease.

Six months after the initial surgery, she was noted to have a difference in leg length of 3 cm and she subsequently underwent lengthening of the extendable prosthesis. After eight months she developed a subluxation of the prosthesis, which we have previously reported in skeletally immature patients who had undergone endoprosthetic replacement of the proximal femur. More pressing note was the fact that the remaining portion of her left distal femur had not grown since the original operation (Fig. 2).

Over the next two and a half years, she underwent three more lengthenings and a revision of the unipolar cup to an uncemented acetabular component in order to correct the subluxation. Three years after this operation, despite lengthening to the maximum of 3 cm of the growing prosthesis, her leg was still 2 cm short. Radiographs of her knee showed that the level of cement at the distal femoral epiphysis was unchanged (Fig. 3). In order to correct the leg-length discrepancy and accommodate further growth, she recently underwent a revision to a longer growing prosthesis. Leg-length radiographs confirm that the growth plate of the opposite distal femur has added 2.8 cm in the time since operation, as can be clearly demonstrated by the presence of the growth arrest line, which almost always appears in children who have had chemotherapy. The tibia on the operated side has grown 2 cm, compared with 2.5 cm on the normal side.
Six weeks after the revision procedure, she started to walk unaided without crutches and is now able to walk reasonable distances, but has a persistent limp due to weakness of her abductor muscles. Recent functional evaluation showed a Musculoskeletal Tumor Society score of 22.

**Discussion**

Historically, the reconstruction options after resection of malignant bone tumours in the lower limb of skeletally immature patients were limited to amputation and biological reconstruction, although rotationplasty has also been described.\(^5\)\(^7\) With the advent of expandable growing prostheses, the ability to achieve a functioning limb with equal leg lengths at maturity has become more attainable.\(^1\)\(^2\)\(^5\)\(^6\)\(^8\) The key to a successful growing prosthesis is accurate estimation of the remaining potential growth of the reconstructed limb. In a nine-year-old girl, we would expect 1.5 cm of growth in the proximal femoral physis and 7 cm in the distal physis.\(^9\)\(^10\) In this case, the original prosthesis was designed to allow 30 mm of lengthening, which would be more than enough to compensate for the loss of proximal femoral growth.

Although uncemented prostheses are popular in some countries,\(^11\)\(^13\) the results of cemented prostheses with a hydroxyapatite collar to prevent loosening are very satisfactory.\(^14\)\(^15\) In some cases it is appropriate to use a cement restrictor to prevent the cement extending distally, but in this case the plane of transection of the femur was virtually at its midpoint, so a cement restrictor would have been of little value as the tip of the stem of the prosthesis was expected to end at the distal metaphysis of the femur. At surgery the bone was found to be very osteopenic, but there was no suggestion that the cement would fill the cavity as it did. This is the first time that we have had this complication in 46 proximal femoral replacements in children under the age of 14, 20 of which had an extendable proximal femoral replacement.\(^15\)

In an animal study, growth plates treated with radiofrequency ablation at 60°C were seen to fuse.\(^16\) As the heat of polymerisation of bone cement ranges from 60°C to 80°C,\(^17\) this could potentially damage an epiphysis, and appears to have done so in this case. We can find no other case document-
ing physeal arrest adjacent to bone cement. Other rare causes of iatrogenic physeal arrest reported are CO2 laser,\(^1\) intravenous extravasation\(^1\) and arterial cannulation.\(^2\) Chemo- and radiotherapy have previously been shown to cause temporary physeal arrest of long bones in children being treated for sarcomas.\(^1\) Our patient, the contralateral limb as well as the ipsilateral tibia have shown continued growth, indicating that chemotherapy alone cannot explain the loss of growth of the affected physis.

Our patient is now aged 13 and has an estimated further growth of 0.25 cm in the contralateral proximal femur and 1.5 cm in the distal femur. Her current prostheses will allow a further 3 cm of lengthening to accommodate this growth. One unexpected sequela of this has been that the ipsilateral tibial growth plate has continued to grow whereas the femoral one has not. Despite this, her knee remains stable and without symptoms, and radiographs show no significant discrepancy between the two sides of the joint (Fig. 4).

Potential future problems include the possibility of a stress fracture through the femoral epiphysis. If this happened we would attempt to fix it, but if this failed we would have to consider converting the existing prosthesis to a total femoral replacement. Her current poor function is mostly due to persistent weakness of her hip abductors. We anticipate that as she gets older this will improve, as is our experience with most of the children we have treated with proximal femoral replacements.\(^2\)

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References