Epiphysis preserving resection of malignant proximal tibial tumours

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Abstract

Purpose The purpose of the study was to evaluate the treatment of five patients with proximal tibial epiphysis preserving resection for malignant tumours of the tibia.

Method Three patients suffered from Ewing sarcoma, two had osteosarcoma. The proximal level of the resection was in the line of the growth plate in four patients, and 2 cm below of the growth plate in one patient. The distal resection level was in the diaphysis, depending on the tumour border. The resected part of the tibia was substituted by both the ipsilateral and contralateral fibulas. The two fibulas were proximally built into the epiphysis, the contralateral, freely transplanted fibula was placed distally into the tibial diaphysis. The leg was fixed in an Ilizarov frame.

Results The follow-up period was 4.9 years on average (range, 3.5–8 years). Neither local recurrence nor metastasis was noticed in patients with tibia tumour resection during the observation time. Proper fixation of the transplanted fibula with all of the patients, both proximal to the tibia epiphysis and distal to diaphysis, was experienced. The range of motion of the knee was 122° on the average. Two patients can walk without support and three can walk with an orthosis fully weight bearing. The limb shortening of the affected side was 2.6 cm on average (range, 1.5–4.5 cm). In three patients the transplanted opposite side fibula has broken. In one patient, chronic osteomyelitis developed at the distal part of the transplanted fibula.

Conclusions The difficulties of intercalary segment supplementation were present to a greater extent because of the small size of proximal epiphysis, but the preserved knee joint can produce better function for the patient in this limb-saving surgery.

Introduction

A great portion of lower limb malignant tumours affect the proximal metaphysis of the tibia. Histologically, the majority of them are osteosarcoma and Ewing-sarcoma. Whenever possible, the treatment is limb-saving surgery. The most frequent therapy is radical resection and tumour prosthesis replacement in adolescents and adults. In childhood, however, the open physis can be a barrier that is able to prevent tumour spread into the epiphysis [14]. This observation allows radical resection of the tumour in the physal plate, and permits preservation of the tibial condyles. The primary and most suitable method for substitution of the resected tibial section is the transposition of the fibula, because the gap is generally ten to 15 cm long.

The benefit of this method is an easily loadable lower extremity in the long run, whereas the drawback is the long period of fixation and rehabilitation.

Patients and methods

Between the years 2002 and 2007, 143 patients were treated with malignant lower limb tumour; in 29 cases hip, in 63 knee, in 13 diaphyseal tumour prosthesis replacement, and in 38 cases bone graft supplementation was carried out during the limb saving operations.

In five patients, the tumour started from the proximal metaphysis of the tibia, but did not affect the proximal epiphysis. In these patients, the tumour resection was in the growth plate; thus, we could preserve the tibial epiphysis. The youngest patient was five years old, the eldest 14; their average age was 11.2 years. The histology proved osteosarcoma in two patients and Ewing-sarcoma in three. All of the patients received neoadjuvant chemotherapy. We determined the size of the tumours and proved the tumour

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free condition of the epiphysis by MR imaging. This operation was performed if the proximal tumour spread did not reach within 2 cm of the physis. In four patients, we excised the tumour proximally in the growth plate; in one patient, 2 cm below the physis. We had to remove the tuberosity together with the metaphysis in one patient. The distal resection level changed according to the size of the tumour—this was mainly in the middle of the diaphysis. To fill the bony gap, we used both the opposite and the same side fibula. The fibula from the contralateral side was transplanted free with the fibular head, and the head was rectangularly shaped by sawing off the cortical parts. We mobilised the fibular head of the ipsilateral side; then, by creating spongy surfaces, transplanted both into the epiphysis. The fibula was cut under the resection level of the tibia and was fixed to the tibia by wire cerclage. The limb was fixed in an Ilizarov frame, with one ring over the tibial epiphysis, one over the distal femoral metaphysis, and two placed over the distal tibia. We permitted full loading, which was gradually reached by the patients over two to 20 weeks (Fig. 1). The most proximal ring was removed after 16–18 months. All equipment was removed after 16–

25 (average 21.2) months. At this time, first we applied plaster cast fixation for six to eight weeks, then provided the patients with a free knee joint orthosis. The postoperative chemotherapy was conducted according to the usual procedure. We have been following up our cases for 4.9 years on average (3.5–8 years) (Table 1).

Results

Among the patients with tibia tumour resection, we did not notice any local recurrence during the observation time, and no metastasis developed. We experienced proper fixation of the transplanted fibula in all of the patients, both proximal to the tibia epiphysis and distal to diaphysis (Fig. 2). The range of motion of the knee was in one case 0–90°, with the others it ranged between 0 and 140° (0–122° on average) (Fig. 3). Two patients can walk without support and three can walk with orthoses, fully loading of the limb (Fig. 4). The limb shortening of the affected side was measured to be 1.5–4.5 cm (2.6 cm on average). In three patients, the transplanted (opposite side) fibula has broken. With all patients

Fig. 1 The 11-year-old boy (Patient No. 3) walked well in the Ilizarov device 12 months after the surgery (**a,b**)

Table 1 Clinical data of the patients

Case	Type of tumour	Age (years)	Duration of Ilizarov frame wearing (mo)	Follow up (years)	Knee orthosis
1	osteosarcoma	14	16	8	no
2	Ewing sarcoma	5	25	5	yes
3	Ewing sarcoma	11	20	4.5	no
4	osteosarcoma.	13	22	3.5	yes
5	Ewing sarcoma	13	23	3.5	yes
Mean		11.2	21.2	4.9	

wearing the Ilizarov-equipment, we noticed discharge periodically along the Kirschner-wires. In one case, the Kirschner-wires of the ring placed in the tibial epiphysis broke. In one patient, chronic osteomyelitis developed at the distal end of the transplanted fibula (Table 2).

Fig. 2 Serial pictures of Patient No.3. **a,b** The pre-op X-ray picture shows lytic-sclerotic changes of the bone structure in the region of proximal metaphysis and diaphysis with periosteal reaction. **c,d** Radiograph 4 months after surgery. The preserved tibial tubercle can be identified on the lateral view. **e,f** Radiograph 18 months after surgery. Both fibulas, incorporated well both proximally and distally. **g,h** Radiograph 34 months after surgery. Considerable strengthening of fibulas and the callus formation after fracture of the transplanted fibula was seen

Discussion

The proximal metaphysis of the tibia is the second most frequent site of development of malignant bone tumour. The open growth plate in childhood can serve as a barrier to tumour spreading, so the tumour does not affect the epiphysis and remains extra-articular. This resistance against the tumour spreading can be explained by a substance produced by the cartilage that inhibits angiogenesis and the collagenase of the tumour tissue [9]. In fact, the open physis can impede the tumour spread, but it does not resist entirely [14].

To determine the extent of the tumour, the most suitable method is magnetic resonance imaging (MRI), as this is indispensable for planning the operation. Hoffer et al. determined the accuracy of MRI for tumour spread to epiphysis, comparing with post-surgical histopathological studies, and found that T1 weighted and STIR imaging accurately

Fig. 3 Patient No. 1 has good range of motion 35 month after surgery

detected the epiphyseal extension of osteosarcoma when the observer distinguished tumour from non-tumoural abnormality [6].

There are several methods for the replacement of the resected segment of tibia. Canadell et al. used physal distraction before the resection, Brigman, Kumta and Musculo built in allograft, Capanna et al. used a combination of a free vascularised fibular graft and allograft [2, 4, 5, 10, 12]. In his case, Honoki transplanted a doubled free vascularised fibula graft with hydroxyapatite composites [7]. Tunn et al. used also a doubled free vascularised fibula graft for the replacement of the

defect [15]. Amitani's patient's bone defect was reconstructed using autoclaved autogeneous bone with a vascularised fibula [1]. Brunet et al. used a massive allograft in combination with a cortical-cancellous rectangular cuboidal tibia graft harvested from the contralateral side in treatment of the defect [3]. The fixation of the implant was by plate and screws in most of the cases where the author uses allograft [1, 3, 8, 11, 15]. Honoki used an Ilizarov system for the fixation of fibular graft and hydroxyapatite block [7].

In our cases, we transferred the contralateral subperiosteally removed fibula into the gap of the tibia. The

Fig. 4 Patient No. 1 walks well with a crutch 35 months after surgery (a,b)

Table 2 Results and complications of the procedure

Case	Knee flexion (°)	Shortening (cm)	Deviation of axis	Walking ability	Complication
1	130	1.5	22° varus	normal	Fracture of transplanted fibula, treated conservatively. Osteomyelitis.
2	90	4.5	no	good in orthosis	no
3	130	2.5	no	normal	Fracture of transplanted fibula, treated conservatively.
4	120	1.5	no	good in orthosis	no
5	140	3	no	good in orthosis	Fracture of transplanted fibula, pseudoarthrosis, cured operatively.
Mean	122	2.6

Fig. 5 One patient (No.1) has 22° varus axis deviation of the leg. There are multiple healed fractures of the transported fibula

head of the fibula was cut into rectangular form, and this cancellous surface was put into a matching hole of the proximal epiphysis of the tibia, slightly asymmetrical medially. The distal part of the fibula was simply placed into the marrow space of the tibial diaphysis. The ipsilateral fibula was proximally released and replanted into the lateral small hole of the epiphysis by the same method as the contralateral fibula, namely after resection of the cortical bone. In some cases, the ipsilateral fibula was cut under the level of the distal resection line of the tibia, and side-by-side synthesis was created with cerclage between the fibular and tibial diaphysis. The bony healing of these cases was better than the others where the fibular osteotomy was not done. Thus, the resected part of the tibia was replaced by a double fibula graft. The ipsilateral fibula is, of course, vascularised, while the contralateral is not. But we could see a good healing potential of the nonvascularised fibula during the recovery, though it was slower than with a vascularised fibula, as shown by data in the literature. Three of the five patients had fracture of the contralateral side, transplanted fibula. One was treated conservatively in long leg cast for six weeks, and the fracture healed. One patient had a delayed union and underwent autologous bone grafting, shortening osteotomy of the ipsilateral fibula, K-wire fixation and long leg cast. The third patient had malunion of the fracture. He was treated by methods similar to the previous patient, but the Ilizarov frame was re-applied, so that simultaneous lengthening of the distal tibia could be made. All these patients walk in orthosis.

The fixation of our cases was with the Ilizarov apparatus. It was suitable for fixing of every segment of the leg. We attached one ring to the epiphysis, one to the distal metaphysis of the femur, and two rings to the distal part of the tibia. The patients were able to walk in this system and could load the extremity. The most proximal ring was removed 16–18 months postoperatively. The fixateur was taken off 18–25 months postoperatively.

The flexion of the knee joint returned to the normal range (0–122° on average); only the youngest patient had

limited motion (0–90°). The leg became easily loadable first in the brace, but reached full loading without any support later on. The first patient has a 22° varus deformity of the leg, but his walking ability is good; it does not disturb the loading of the extremity (Fig. 5). Two patients have significant shortening. The youngest boy has 4.5 cm, and one of the 13-year-old patients has 3 cm shortening of the leg. Superficial infection around the K-wires was common in the patients, and usually local disinfection, or seldomly systemic antibiotics, was enough to eliminate it. There was no deep infection around the K-wires. However, the oldest patient suffered from chronic osteomyelitis in the middle part of the leg, where a wire cerclage fixed the ipsilateral fibula to the tibia. It was hard to treat because of relapse of osteomyelitis, but repeated curettage with local and systemic antibiotics and also adjuvant hyperbaric oxygen has finally given a good result.

Our results show that there are more difficulties in the limb saving treatment of patients under eight years of age [12, 13, 16]. It was hard to achieve the loading in the device with the youngest child; he had the most limited motion and the greatest shortening.

Conclusion

As an alternative limb saving procedure in the treatment of proximal tibial tumour, the excision can be performed in the growth plate to save the epiphysis on the basis of oncological principles. The saved knee joint may produce a better quality of life over a longer period compared to the tumour prosthesis replacement. The ipsilateral and contralateral fibulas together make a good support in the replacement. It is important to stress that the ipsilateral fibula is needed to osteotomise and fix to the residual part of the tibia for better integration of the transplanted fibula. The Ilizarov fixateur system gives an excellent fixation and the possibility of loading the leg. The function of the knee joint becomes normal soon after removing the fixateur. This method has limitations, including the long period of fixation of the leg and knee joint, and the long time needed to recover walking capability without any support.

Conflict of interest The authors state that they have no conflict of interest.

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