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Lower limb salvage surgery: modular endoprosthesis in bone tumour treatment

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Abstract We retrospectively analysed 90 patients who underwent "en bloc" resection and modular endoprosthesis reconstruction in the lower limbs between 1987–2003. After proximal femur resection, reconstruction was performed with a modular endoprosthesis by Howmedica (KFTR, designed by Kotz) and modular revision endoprosthesis by W. Link or Lima-Lto (Revision system, designed by Wagner). The knee joint was reconstructed with a modular endoprosthesis (Howmedica, KFTR designed by Kotz) after distal femur or proximal tibia resection. Malignant bone tumours were present in 58 patients (64.5%), benign tumours in 16 (17.8%), metastases in 8 (8.9%), tumour-like lesions in 4 (4.4 %) and non-tumour-related destruction of the femur in 4 patients (4.4%). High-grade tumours were found in the majority of malignant bone tumours (70.7%). Treatment complications, which occurred in 26 patients, were: local recurrence of the tumour, deep infection, acetabular destruction following hemiarthroplasty, recurrent dislocations of endoprosthesis, periprosthetic fracture and hardware problems. In total, 23 patients (25.6%) died due to tumours. Endoprostheses should be considered as a treatment of choice for bone tumours in the hip and knee joint region. Advances in limb salvage surgery are, and will long continue to be, a great challenge for orthopaedic oncologists of the 21st century.

Résumé Nous avons analysé de façon rétrospective 90 patients sur une période s'étendant de 1987 à 2003 et ayant bénéficié d'une résection au bloc avec reconstruction du membre inférieur par une endoprothèse modulaire. Cette reconstruction a été réalisée avec une endoprothèse de type Howmedica KFTR (Kotz), une endoprothèse médulaire de Link Lima-Lto (Wagner). La reconstruction articulaire du genou étant réalisée avec l'endoprothèse modulaire Howmedica KFTR (Kotz) après une résection du fémur distal ou du tibia proximal. Cinquante-huit patients (64.5%) présentaient une tumeur maligne, 16 (17.8%) une tumeur bénigne, 8 (8.9%) une métastase et 4 (4.4%) une tumeur tissue-like. Enfin, quatre patients ont été traités après une destruction fémorale non tumourale (4.4%). Une tumeur de haut grade a été trouvée dans la majorité des patients présentant une tumeur maligne (70.7%). Des complications sont survenues chez 26 patients avec récidive de la tumeur, infection profonde, destruction acétabulaire après hémiarthroplastie, luxation récidivante, fracture périprothétique. Au total, 23 patients (25.6%) sont morts de leur tumeur. L'endoprothèse a été considérée comme un traitement de choix pour les tumeurs osseuses de la hanche et du genou. Néanmoins, des progrès doivent être encore réalisés par les chirurgiens au cours du 21ème siècle.

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Introduction

Limb salvage surgery, currently an accepted bone tumour treatment method, has traditionally been a difficult problem in orthopaedic oncology. With the development of modern chemotherapy, the outlook for malignant tumours has greatly improved, and this has encouraged surgeons to consider limb salvage surgery in most cases. The success of limb salvage is the result of advances in the understanding of the biology and staging of tumours, improvement in the reconstructive techniques and the development of effective

adjuvant chemotherapy for primary tumours, and progress is still continuing [7, 18].

The appropriate treatment to achieve local control after the resection of bone tumours is still a subject of debate, and the long-term durability of various reconstructive methods is not known. Currently, the three most popular options are using an endoprosthesis, allograft-prosthetic composite and biological reconstructions [6, 10, 17, 21]. Each of these methods has its short- and long-term advantages and disadvantages, and a surgeon should consider each patient individually.

Endoprosthetic replacement offers several advantages, such as early stability, mobilisation and weight bearing, a shorter operating time and hospital stay in comparison to biological reconstructions, and it allows the early introduction of postoperative adjuvant therapy. Reconstruction with a modular endoprosthesis after resection of a bone tumour gives good functional results in most of the cases [14, 22].

Patients and methods

We retrospectively analysed 90 patients treated by resection and reconstruction with a modular endoprosthesis in the lower extremity over a 17-year period (1987–2003) (Fig. 1). There were 39 males and 51 females with a median age at diagnosis of 30 (7–66) years.

The tumour was localised in the proximal femur in 44 patients, distal femur in 30 patients and proximal tibia in 16 patients. For reconstruction of the hip joint after proximal femur resection, we used the modular endoprostheses by Howmedica (KFTR, designed by Kotz) in 26 and modular revision endoprosthesis by W. Link or Lima-Lto (Revision system, designed by Wagner) in 18 patients. For knee joint reconstruction, we used only modular endoprostheses (Howmedica, KFTR designed by Kotz) in both distal femur and proximal tibia reconstruction.

All patients were given chemotherapy and radiotherapy according to the regimen in use at the time. The surgical approach was performed according to the general principles of limb salvage surgery, and the resection length was determined preoperatively by radiographic and other imaging methods. In total, the median resection length was 15 cm (range, 6–25): the longest resections were performed in the distal femur (median, 16 cm; range, 12–25), followed by the proximal femur (median, 15 cm; range, 6–25) and proximal tibia (median, 12 cm; range, 7–15). All patients received perioperative prophylactic antibiotics and thromboprophylaxis according to the guidelines in our hospital at the time.

We analysed the clinical findings before the primary operation: radiographic and other imaging methods, radioisotope bone scans, open biopsy findings, intraoperative findings and finally the clinical results during postoperative ambulatory control examinations. All tumours were graded according to the Enneking system [8].

The mean follow-up was 9 years (range, 3–19); 72 of 90 patients had follow-up for more than 5 years.

Results

Malignant bone tumours were present in 58 patients (64.5%), benign tumours in 16 (17.8%), metastases in 8 (8.9%) and tumour-like lesions in 4 (4.4 %) patients. The

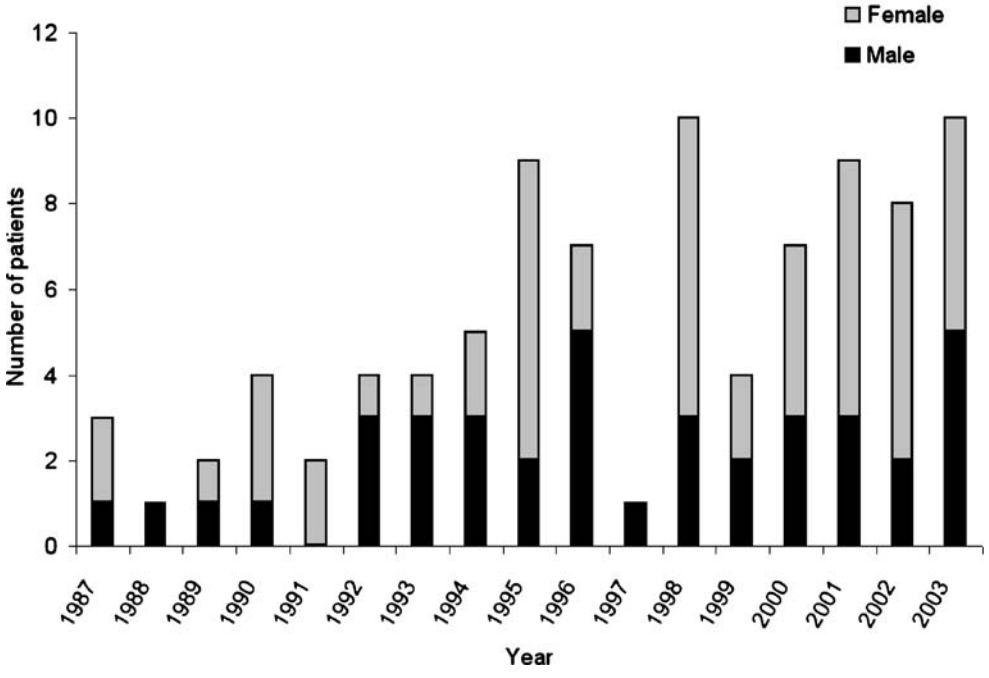

Fig. 1 Distribution of patients according to year of resection and endoprosthesis implantation

most common diagnosis was osteosarcoma in 27 patients (30%), Ewing's sarcoma in 15 patients (16.7%) and giant cell tumour of the bone in 13 patients (14.4%).

High grade tumours (grades 2a and 2b) were found in the majority of malignant bone tumours: in 21 of 27 (77.8%) patients with osteosarcoma, in 10 of 15 (66.7%) patients with Ewing's sarcoma and in 41 of 58 (70.7%) of all malignant bone tumours. Active tumour grade 3 was found in the majority of patients with giant cell tumours of the bone [in 7 of 13 (53.8%) patients]. Detailed histological findings and tumour grades are shown in Table 1. Destruction of the femur due to war wounds or primary endoprosthesis instability, present in four patients, was also included in this analysis.

We found six patients with pathological fracture prior to the primary operation: in two patients with osteosarcoma, two patients with secondary bone tumour, one patient with Ewing's sarcoma and one with giant cell tumour of the bone. Five of them had pathological fracture of the proximal femur, and one of the distal femur.

During treatment, 26 patients had one of the following complications: local recurrences of tumours, deep infection, acetabular destruction following hemiarthroplasty, recurrent dislocations of the endoprosthesis, periprosthetic fractures and hardware problems. Details of the complications, the treatment methods and final results are shown in Table 2.

In ten patients, we found local recurrences of the tumour, and five of them died. Of the patients who died due to tumours 9 of 27 patients had osteosarcoma (33.3%), 4 of 15 patients had Ewing's sarcoma (26.7%), 4 of 8 patients had secondary bone tumour (50%), 3 of 8 patients had chondrosarcoma (37.5%), 1 patient had fibrosarcoma, 1 patient had malignant fibrous histiocytoma, and 1 patient had a war wound. In total, during the follow-up period, 23 patients died due to tumours.

At the last follow up examination, 65 patients showed no evidence of primary disease. Two patients were lost to follow-up after moving because of the situation in the region.

Discussion

Chemotherapy has dramatically changed the cure rate of malignant bone tumours. Since the introduction of effective

Table 1 Number of patients according to histological type and tumour grade

Tumour type					Total no.
Benign bone tumours					
	Grade 1	Grade 2	Grade 3		
Giant cell tumour of bone	1	5	7		13
Chondroma		1	1		2
Fibroma		1			1
Total	**1**	**7**	**8**		**16**
Primary bone tumours					
	Grade 1a	Grade 1b	Grade 2a	Grade 2b	
Osteosarcoma	3	3	10	11	27
Ewing's sarcoma	3	2	2	8	15
Chondrosarcoma		3	1	4	8
Periosteal osteosarcoma		1			1
Fibrosarcoma				2	2
Plasmocytoma	1				1
Synoviosarcoma			1		1
Malignant fibrous histiocytoma				1	1
Leiomyosarcoma				1	1
Angiosarcoma		1			1
Total	**7**	**10**	**14**	**27**	**58**
Tumour-like lesions					
	Grade 1	Grade 2	Grade 3		
Aneurysmal bone cyst	1		2		3
Fibrous dysplasia		1			1
Total	**1**	**1**	**2**		**4**
Metastatic bone tumour					
Total					**8**
Other					
War wound					2
Instability of endoprosthesis					2
Total					**4**

Table 2 Complications of treatment. Number in parentheses represents the number of patients

Complication	Diagnosis	Treatment	Final result
Local recurrence (10)	Osteosarcoma (7)	Re-resection (2)	DOD (4)
		Amputation (4)	NED (3)
		No therapy (1)	
	Chondrosarcoma (2)	No therapy (1)	DOD (1)
		Re-resection (1)	NED (1)
	Periosteal osteosarcoma (1)	Re-resection (1)	NED (1)
Infections (5)	Osteosarcoma (3)	Curettage (2)	Local recurrence, amputation, DOD (1) Knee ankylosis, NED (1)
		Extraction of EP, rearthroplasty (1)	NED (1)
	GCT (1)	Curretage (1)	NED (1)
	War injury (1)	Refusing treatment (1)	NED (1)
Acetabular destruction (4)	Ewing's sarcoma (3) Aneurismal bone cyst (1)	Transformation partial to total EP (4)	DOD (1) NED (3)
Dislocation of hip EP (4)	Osteosarcoma (1) Chondrosarcoma (1) Malignant fibrous histiocytoma (1) Metastasis (1)	Closed reposition (4)	DOD (1) NED (3)
Periprosthetic fractures (2)	Osteosarcoma (1)	Elongation of EP (1)	NED (1)
	GCT (1)	Osteosynthesis (1)	NED (1)
Technical problems with EP (1)	GCT (1)	4 re-operations (1)	NED (1)

DOD, died of disease; NED, no evidence of disease; EP, endoprosthesis

neoadjuvant chemotherapy in the 1980s, more than 80% of patients with osteosarcoma of an extremity have been considered candidates for limb-salvage surgery [2, 15]. An increasing trend in limb-salvage surgery using an endoprosthesis was also evident in this study (Fig. 1).

More than a third of our patients (37.8%) were younger than 20, and almost half of them (47.8%) were under the age of 25. For medical, surgical and rehabilitative advances, limb-salvage surgery has surpassed amputation as the primary treatment for malignant bone tumours in young children [4, 14]. Preservation of limb function in the paediatric oncology patient is uniquely challenging. In skeletally immature patients, the functional impairment due to the subsequent growth inhibition must be considered in conjunction with limb-salvage surgery [1, 9].

Prosthetic reconstruction in the skeletally immature patient is demanding because of the necessity to cope with the expected disruption of limb growth after resection of one or more major growth plates and the high demands placed on implants by young patients. Expandable endoprostheses have an important place in treating still-growing children, but we did not use them, mainly for financial reasons. Although endoprosthetic reconstruction in children is fraught with many problems, it is usually possible to obtain a good functional limb at skeletal maturity. Treatment must be strictly prioritised in terms of the patient's life, the limb, its function, length equalisation and cosmetic appearance. Orthopaedic intervention in the care of children and young adults with oncological conditions must be individualised [1, 24].

An individual approach to every patient is essential in order to choose the most suitable surgical treatment for pathological fractures due to primary bone tumours, metastases or tumour-like lesions. The aim of surgical treatment is primarily to treat/remove tumourous tissue, and then to heal the fracture, maintain or restore function and minimise pain, thus improving the patient's quality of life [23].

The relatively small number of patients with secondary bone tumour in this report does not represent the real incidence of these tumours. Our department has no emergency units, and only exceptionally do we treat such patients.

We used the Wagner modular endoprosthesis model in treating bone tumours in the proximal femur region mostly for technical and financial reasons in our health system. Our department always has all sizes of Wagner stems in stock for treating aseptic loosening; therefore, in the case of emergency, endoprostheses are available immediately.

Two patients with low-grade tumour-like lesions were treated by resection and endoprosthesis reconstruction: in one patient with grade 1 aneurysmal bone cyst, the reason was articular surface destruction, and in a patient with fibrous dysplasia, the lesion size was more than 2/3 of the total length of the femur, and the proximal femur resection size was 22 cm.

More than two-thirds of the patients began the orthopaedic treatment of a malignant bone tumour at the point when histological activity of the tumour shifted to a more aggressive histological grade. Malignant bone tumours are of major concern in orthopaedic surgery, and treatment should be started as soon as possible. Losing precious time,

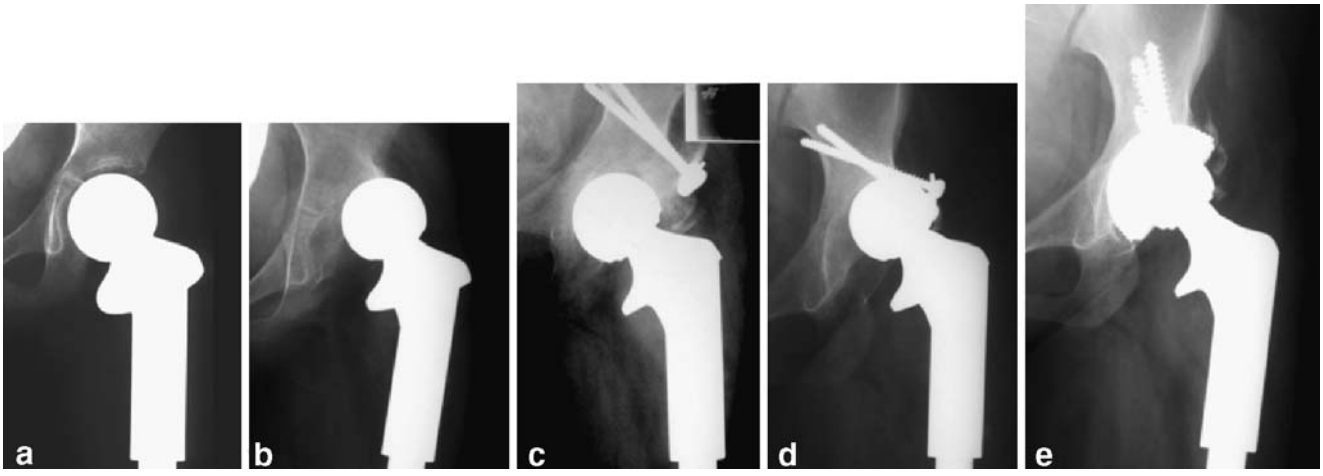

Fig. 2 **a** Hemiarthroplasty after the "en bloc" resection of Ewing's sarcoma localised in the proximal femoral part. Patient at the age of 7. **b** Subluxation of the endoprosthetic head (39 months after primary operation). **c** Acetabuloplasty of the lateral roof with bone homotransplant, implantation of greater diameter endoprosthetic head (41 months after primary operation). **d** Again subluxation of the endoprosthetic head (72 months after primary operation). **e** Implantation of metal-backed uncemented acetabular part of endoprosthesis (73 months after primary operation)

these patients come late to a specialist of orthopaedic oncology, which is a sign of the inefficiency of our health system. Education of general physicians, physicians of other specialties and the general population should also be in the domain of the orthopaedic oncologist.

The most common complication in treating our patients was local recurrence of the tumour. The data should be analysed together with information about the tumour grade. The majority of the patients with malignant bone tumours had high grade tumours, which made the treatment more complicated. After local recurrence of the tumour (in ten patients), radical surgical treatment resulted in saving half of those patients, who are now disease-free.

Deep infection was the second most common complication, occurring in five patients in our study. In the literature, the rate of deep infection has ranges from 4 to more than 30% [5, 11]. Curettage, debridement and irrigation were performed in three patients, and in two patients we had

Fig. 3 **a** A patient with osteosarcoma localised in distal femur. **b** Implantation of knee modular endoprosthesis (Howmedica, KFTR designed by Kotz) after the "en bloc" resection of tumour. **c** Periprosthetic fracture of the femur, which occurred during a car accident 10 years after the primary operation, treated with (**d**) endoprosthesis elongation

unsatisfactory final results: amputation following local recurrence in one patient and knee ankylosis in the other patient. Staged reimplantation was performed in one patient, and one patient with endoprosthesis implantation for a war wound (because of post traumatic stress disorder) refused treatment.

Dislocation is the most common complication after primary or secondary femur endoprosthetic reconstruction, regardless of the indication. There is still no widely accepted method that helps to avoid this complication. In the orthopaedic literature, the rate of hip dislocation following reconstruction of proximal femoral tumours with megaprosthesis varies from 2 to 28% [3]. In general, the main reason for dislocated hips is extensive soft tissue resection due to the large size of the tumour. Our study showed that 4 of 44 (9.1%) patients had hip dislocation. We managed to perform closed repositioning and applied the hip brace in all four of our patients for 4–6 weeks.

Reconstruction of the femur after tumour resection was performed by hemiarthroplasty in four children. Growing acetabular bone and the selection of the proper size of the endoprosthetic head for achieving congruence gives satisfactory limb function during the early postoperative period. The main problem occurs after a few years because of the enlargement of the acetabular diameter: incongruency between the endoprosthetic head and the acetabular results in an alteration of the pressure on the acetabulum and lateral migration of endoprosthesis head, which finally leads to destruction of the acetabular roof and subluxation of the endoprosthetic head.

Acetabuloplasty with a total hip endoprosthesis in growing children will cause epiphysiodesis and restrain acetabular growth; this procedure is reserved mostly for older children and adults. In younger children with proximal migration of the prosthesis in hemiarthroplasty, an acetabuloplasty with bone graft and implantation of a greater diameter femoral endoprosthetic head can be performed. The goal is to allow the acetabulum to grow as normally as possible for as long as possible. The acetabuloplasty with an endoprosthesis was the final step of the acetabular reconstruction in all of our four young patients (Fig. 2) [20].

Periprosthetic fracture occurred in two patients: after a car accident in one, and during a sports activity in the other patient. Good functional status after surgery encourages the patient to go “beyond the limits” of the operated limb. If there is no primary disease, treatment of such patients should not be a difficult problem (Fig. 3).

Poor design of the “bearing polyethylene shift” part of knee modular endoprosthesis (Howmedica, KFTR designed by Kotz) resulted in early wear of that component. That model of endoprosthesis was implanted in one patient with GCT, and we performed four reoperations in order to change the bearing polyethylene shift and solve related technical problems. In later models of the endoprosthesis, that hardware problem had been solved [19].

Many studies have been performed to investigate endoprosthetic survival rates after tumour resection, but the results cannot be summarised and systematic review cannot be performed, mostly because of the small number of patients, as well as the different models and principles of endoprosthesis. Tumour endoprosthetic survival rates are mostly about 60–80% at 5 years and 40–70% at 10 years [12, 13, 16]. Specific long-term consequences of endoprosthetic reconstructions after tumour resection for the patient’s affected limb are still unknown [12]. In our opinion, endoprostheses should be considered as the treatment of choice for bone tumours in the hip and knee joint region. Advances in limb salvage surgery are, and will long continue to be, a great challenge for orthopaedic oncologists of the 21st century.

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