ONE-STAGE REVISION SURGERY FOR INFECTED MEGAPROSTHESES

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We have reviewed the results of one-stage revision surgery in 18 patients for infection of megaprotheses implanted after the resection of malignant bone and soft-tissue tumours.

At a mean follow-up of 52.0 ± 35.0 months (18 to 135) infection was eliminated in 14 of the 18 patients. The infection-free patients showed no abnormal tests for inflammation and had a mean Enneking score of 20.6 ± 5.0 points (maximum 30 points).

We suggest that one-stage revision without exchange of the anchorage parts is justified in patients with megaprotheses infected by antibiotic-sensitive micro-organisms.

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Since the introduction of neoadjuvant chemotherapy in 1975¹ for the treatment of primary and secondary tumours of bone and soft tissues, an increasing number of limb-salvage operations have been performed. In most cases preoperative shrinking of the tumour by neoadjuvant cytotoxic chemotherapy (NCC) enables tumour resection with wide margins. To bridge the bone defect, endoprotheses,²⁻⁶ biological reconstruction with osteoarticular allografts, allograft arthrodesis⁷⁻⁹ or rotationplasty¹⁰ may be used.

We have used megaprotheses for limb-salvage surgery since 1976. Although we started with custom-made endoprotheses we now principally use the Kotz Modular Femur Tibia Reconstruction (KMFTR) system³ and its successor, the Howmedica Modular Reconstruction system (HMRS) (Howmedica GMBH Schönkirchen/Kiel, Germany).¹¹

Despite highly-developed endoprosthetic technology and extremely careful surgical techniques there are complications such as wound dehiscence, neurapraxia, soft-tissue contractures, mechanical failure, dislocation and loosening. The two most serious complications are local tumour recurrence and infection.

Extensive soft-tissue resection as well as pre- and post-operative cytotoxic chemotherapy¹² increase the risk of deep infection; the reported rates for deep infection of megaprotheses are from 2.9% and 9.7%.^{5,12-17} In addition to the problems known to follow conventional hip and knee replacement surgery, the revision of infected megaprotheses has specific problems caused by the extent of the infection and tissue necrosis. In infected THRs and TKRs either one-¹⁸⁻²⁴ or two-stage revision²⁵⁻³¹ using antibiotic-loaded bone cement is recommended. If all the components are not exchanged the failure rate is extremely high²⁵.

We decided to perform one-stage revision in tumour patients with infected megaprotheses without exchange of the anchorage components, provided that they were well fixed to bone. The advantages are the avoidance of temporary gross instability, less suffering for the patient, a shorter period of hospitalisation and lower costs.

We made a retrospective study of the results of one-stage revision surgery for such infected megaprotheses.

PATIENTS AND METHODS

Between January 1979 and December 1993, we implanted 336 megaprotheses for limb salvage after the resection of benign and malignant bone and soft-tissue tumours. Deep infection occurred in 19 patients (5.7%) after a mean of 13.1 ± 15.7 (SD) months (1 to 60). Of these, 18 had one-stage and one had two-stage revision. There were nine women and nine men having one-stage revision with a mean age at the time of limb-salvage surgery of 26.5 ± 18.6 years (9 to 70). The mean follow-up was 52.1 ± 35.0 months (18 to 135).

The histological diagnosis had been osteosarcoma in nine patients, Ewing's sarcoma in three, and leiomyosarcoma, liposarcoma and malignant fibrous histiocytoma in one each. Three had been treated for metastases from hypernephroma, thyroid cancer and ameloblastic odontoblastoma respectively. The sites of tumour resection and endoprosthetic replacement and clinical details are given in Table I.

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Table I. Details of the 18 patients with infection of megaprotheses implanted for limb salvage

Case	Age		Infection delay (mth)	Chem*	Location	Micro-organisms†	Antibiotic course	F-U	WBC	CRP	ESR	
	(yr)	Sex					(mth)	(mth)	($\times 10^9$)	(mg/l)	1	2
1	10	M	6	CESS	Distal femur	<i>Staph epidermidis</i>	4	51	7.8	44.0	32	65
2	25	F	60	CWSS	Prox femur	<i>Staph aureus</i>	3	135	5.0	16.0	24	36
3	16	M	1	COSS	Prox tibia	<i>Staph aureus</i>	3	18	6.0	15.9	51	71
4	16	M	7	COSS	Distal femur	Coag-neg	3	45	5.6	1.0	5	12
5	19	M	30	COSS	Total femur	Strept	5	26	5.0	5.0	3	7
6	9	F	26	COSS	Distal femur	Coag-neg	7	33	4.0	17.0	18	35
7	14	F	11	COSS	Prox tibia	<i>Staph aureus</i>	30	45	5.8	19.4	35	78
8	10	M	10	COSS	Prox tibia	<i>Staph epidermidis</i>	3	62	6.8	5.0	1	1
9	41	M	14	COSS	Distal femur	Coag-neg	3	49	5.8	24.0	8	12
10	31	M	7	CESS	Total humerus	<i>Staph epidermidis</i>	8	23	6.7	15.0	70	115
11	63	F	1	-	Total humerus	Coag-neg	3	18	7.7	13.4	19	42
12	58	M	18	-	Prox femur	<i>Staph aureus</i>	3	111	6.9	8.0	15	45
13	31	M	6	COSS	Prox tibia	Gram-pos coccus	4	48	7.3	8.2	3	8
14	70	F	1	CWSS	Distal femur	<i>Staph epidermidis</i>	1	-	-	-	-	-
15	17	F	8	COSS	Distal femur	No growth	9	105	4.9	5.0	9	14
16	15	F	2	COSS	Distal femur	<i>Staph epidermidis</i>	3	32	-	-	-	-
17	16	F	1	COSS	Distal femur	<i>E coli</i>	3	32	-	-	-	-
18	16	F	39	T6T2	Prox femur	No growth	3	-	-	-	-	-

*Chemotherapy see text

† see text

All revisions were done by one of the senior authors (RW and RK).

In addition to surgical treatment, 15 patients received NCC; five had radiation therapy and four had NCC and radiation. Eleven of the 15 were treated according to the Cooperative Osteo-Sarkom Studie (COSS) protocol,³² two had the Cooperative Ewing-Sarkom Studie (CESS) protocol³³ and two the Cooperative Weichteil-Sarkom Studie (CWSS) protocol.³⁴ One other patient had the Rosen T6T2 protocol.³⁵

We performed aspiration of periprosthetic fluid for microbial culture at the time of admission although all the patients had already received some antibiotic therapy. The intravenous administration of antibiotics was continued after successful aspiration. In 16 patients the micro-organism was verified by culture of the infected periprosthetic fluid. *Staphylococcus epidermidis* was found in five patients, *Staphylococcus aureus* and coagulase-negative staphylococci in four patients each and streptococci, *Escherichia coli* and Gram-positive cocci in one each. In the remaining two patients no organisms could be cultured. Histological examination of the tissue showed chronic purulent infection in all patients.

All patients received pre-, peri- and postoperative antibiotic chemotherapy according to sensitivity tests for a mean of 5.9 ± 6.7 weeks (3 to 30). The antibiotics were given parenterally during hospitalisation and then orally for long-term treatment.

Operative technique. Initially, all exchangeable compo-

nents and all polyethylene parts, but not the anchorage components, were removed. Subsequently, excision of dead bone and thorough debridement of the soft tissues were performed. Povidone iodine (Betasisodona Lösung; Mundipharma GmbH, Limburg/Lahn, Germany) was used to rinse the wound thoroughly and to scrub the anchorage components carefully.

In recent one-stage revisions we have used the method of Göksan and Freeman,²⁶ packing povidone iodine sponges into the wound before a provisional closure. The area of surgery was again disinfected, the patient redraped and the entire operating team changed gowns and gloves. After reopening the wound and removing the sponges, thorough rinsing was again performed with saline and the anchorage components again cleaned with povidone iodine.

The removed metallic KMFTR or HMR System prostheses were resterilised and reimplanted, or new components were used. Polyethylene components were not reused. The wound was closed in layers after the insertion of at least two deep suction drains and the joint was immobilised in a cast for one to two weeks.

During April 1996, 14 patients were reviewed. Four of the 18 had died, three from their primary disease. Two of these had lung metastases at the time of surgery and one died from sepsis. For these the latest recorded follow-up data were used for evaluation.

The criteria of Enneking et al³⁶ were used for clinical evaluation. These include, for the *upper extremity*: pain, function, emotional acceptance, hand positioning, and man-

ual dexterity. For the *lower extremity*; pain, function, emotional acceptance, supports, walking ability, and gait. This provides a numerical rating system (maximum 30 points) for statistical analysis. Radiographs were assessed according to the ISOLS system for assessment of prostheses (bone remodelling, interface, anchorage)³⁷ and inflammation was assessed by measurement of the ESR and C-reactive protein (CRP) and leucocyte levels. Successful eradication of infection was defined as the absence of clinical signs of sepsis and inflammation for at least six months.

For statistical analysis we used Student's *t*-test (mean, SD, range).

RESULTS

Infection was eradicated in 14 of the 18 patients. One patient (case 14) died from sepsis during cytotoxic chemotherapy one month after a one-stage revision. Another (case 18) asked for hip disarticulation because of complete palsy of the sciatic nerve after three failed revisions. Two (cases 7 and 10) had draining fistulae at follow-up despite long-term antibiotic therapy.

Clinical findings (Table II). At follow-up the average total Enneking score was 19.8 ± 5.2 points (10 to 27). The 14 patients free from infection had a score of 21.3 ± 4.4 points (15 to 27) and the two infected patients (cases 7 and 10) scored 16 and 10 points, respectively. Individual criteria in the non-infected patients with replacements of the lower limbs were: pain 4.0 ± 0.8 points, function 2.8 ± 1.2 , emotional acceptance 4.8 ± 0.4 , support 3.6 ± 1.9 , walking ability 3.6 ± 0.9 and gait 2.5 ± 1.3 .

Radiological findings (Table II). Anteroposterior and lateral radiographs of the anchorage components of 16

patients were obtained at the most recent follow-up and compared with those taken immediately after the revision operation. Radiological assessment, according to the ISOLS criteria for bone remodelling, showed excellent and good results in eight patients (50%), fair in six (37.5%) and poor in two (12.5%). The bone-prosthesis interface was found to be excellent in 13 patients (81.25%) and fair in three (18.75%). The anchorage of the prosthesis was rated excellent in 15 patients (93.75%) and fair in one (6.25%). There were no failures of the stems of the prostheses or screw fractures. There were no radiological differences between the infected and non-infected patients.

Laboratory findings. At follow-up, the ESR was measured and CRP and leucocyte levels determined for 14 patients. In the infection-free patients the mean ESR was 15.7 ± 14.6 mm in the first hour (ESR 1) and 29.0 ± 23.5 mm in the second hour (ESR 2) with one patient in the elevated range (51 mm and 71 mm). In one of the two infected patients the ESR was 35 and 70 mm, and in the other 78 mm and 115 mm. The mean CRP in the infection-free patients was 14 ± 12 mg/l. It was elevated in the two infected patients (cases 7 and 10) to 19.4 and 15 mg/l, respectively. The mean leucocyte level was $6.0 \pm 1.2 \times 10^9$ cells, with all patients within the normal range.

DISCUSSION

Infection is a serious complication after limb-salvage surgery using endoprosthetic replacement. After total conventional joint arthroplasty, one-stage¹⁸⁻²⁴ or two-stage revision with complete exchange of all prosthetic components with the use of antibiotic-loaded bone cement²⁵⁻³¹ is usually recommended. In patients who have had revision

Table II. Enneking score and radiological assessment at follow-up in 16 patients. Cases 14 and 18 were not seen at follow-up

Case	Pain	Function	Emotional acceptance	Support	Walking	Gait	Hand position	Manual dexterity	Lifting	Bone remodelling*	Interface*	Anchorage*
1	5	2	5	5	4	4				P	F	E
2	4	2	5	1	3	1				G	E	E
3	2	3	5	5	5	4				F	G	E
4	5	3	5	5	4	3				F	G	E
5	5	2	4	5	4	4				G	E	E
6	4	4	4	5	3	3				F	F	F
7	3	0	3	3	3	1				F	F	E
8	4	4	5	5	5	3				P	E	E
9	3	4	5	1	3	1				E	E	E
10	3	0	3				0	2	2	G	E	E
11	5	1	4				1	4	2	E	G	E
12	4	1	5	1	3	1				F	E	E
13	4	2	5	5	4	2				F	G	E
15	4	5	5	5	4	4				G	G	E
16	4	2	5	2	3	1				G	E	E
17	4	2	4	2	2	2				E	E	E

* E = excellent; F = fair; G = good; P = poor

of infected megaprotheses, several additional problems are related to the use of chemotherapy or radiation or both and to the large bone defects and large infected areas associated with tissue necrosis. A more aggressive approach is required. Results after the revision of infected conventional replacements are reported to be influenced by the delay between the onset of infection and revision surgery, the type of chemotherapy and the cementless or cemented fixation of the prostheses.

Deep infections in patients with megaprotheses require treatment by surgical methods because the long-term administration of antibiotics alone is not sufficient. The methods which have been described include irrigation without revision of the prosthesis,⁷ wound debridement without revision of the prosthesis,^{13,16,23} revision of the prosthesis,¹³ two-stage revision with implantation of a cement spacer,^{23,38} arthrodesis with a vascularised fibular graft¹³ and ultimately in some cases amputation.^{5,13,14,16,17} There are few data on the outcome of these different procedures. We decided to perform one-stage revision without exchange of the anchorage components. The advantages are the avoidance of large bone defects, the need for only one operation putting a smaller burden on the patients, a shorter period of hospitalisation and the potential for lower costs.

Patients treated with NCC have more complications than those receiving no chemotherapy or only adjuvant chemotherapy.¹² All except two of our patients had been given NCC, but in two only did infection appear to start during

cytotoxic chemotherapy. One of these died from sepsis (case 14) and the other (case 10) still has draining fistulae.

Although the complete exchange of all replacement parts is recommended^{13,18} and it has been reported that patients who retain their prosthesis after treatment for infection have unsatisfactory results,¹³ we performed one-stage revision without exchange of the anchorage components (Fig. 1). In all our patients, infection was localised within the scar tube and did not invade the medullary canal. This may explain our success in most of our patients. Septic loosening of anchorage components is likely only in cases of chronic infection.

The emotional acceptance of limb-salvage procedures is confirmed by the fact that this gave the best result for a single criterion (4.8 ± 0.4 Enneking points), with lower scores for pain (4.0 ± 0.8), support (3.6 ± 1.8), walking ability (3.6 ± 0.9), function (2.8 ± 1.2) and gait (2.5 ± 1.3).

One-stage revision failed in four of our patients. Of the two with draining fistulae at follow-up, one with decayed teeth acquired the infection during cytotoxic chemotherapy, and the other had insufficient soft-tissue cover after wide excision due to the irradiation of a rhabdomyosarcoma which preceded a radiation-induced osteosarcoma. Both are still taking antibiotics and both refuse further surgery.

Our series of 18 had an overall success rate (absence of infection for more than six months) of 77.8% which is similar

Fig. 1a

Fig. 1b

Fig. 1c

Fig. 1d

Case 15. AP (a,c) and lateral (b,d) radiographs 105 months after revision for an infected megaprosthesis to show anchorage in the femur and tibia.

to the 82.4% reported for 18 patients by Grimer et al.³⁸

Our results suggest that the one-stage revision of infected megaprotheses without exchange of anchorage components is a sensible and useful choice for patients with antibiotic-sensitive micro-organisms. Two-stage revision should be used as a salvage procedure in case of failure, or for patients with micro-organisms resistant to antibiotics.

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