M. Natarajan · J. C. Bose · G. Rajkumar

Proximal femoral reconstruction with custom mega prosthesis

Accepted: 13 February 2003 / Published online: 26 March 2003
© Springer-Verlag 2003

Abstract Seventy-seven patients with proximal femoral tumours underwent limb salvage surgery with custom mega prostheses between July 1989 and January 2002. We describe 44 cases with a mean follow-up of 57.8 months. Forty-one patients presented with malignant neoplasms of which 11 were malignant giant cell tumours, eight were chondrosarcoma and five were metastases. Wide margins were achieved for all malignant tumours, and marginal resection was done for all benign and metastatic lesions. Six patients died of disease and two were lost to follow-up. Mechanical complications were observed in six cases, fracture being the most common. Oncological complications occurred in five patients. Functional activity was satisfactory in 79% of patients.

Résumé 77 patients avec des tumeurs fémorales proximales ont eu une chirurgie de résection avec reconstruction par des méga-prothèses faites sur mesure entre juillet 1989 et janvier 2002. Nous présentons 44 cas avec un suivi moyen de 57,8 mois. 41 patients avaient une tumeur maligne, dont 11 tumeurs à cellules géantes, 8 chondrosarcomes et 5 métastases. Une résection large a été faite pour toutes les tumeurs malignes. Les tumeurs bénignes ainsi que les lésions métastatiques ont été traitées par une résection marginale. Six patients sont morts de la maladie et 2 ont été perdus de vue. Des complications mécaniques, principalement des fractures, ont été

observées chez 6 patients. Des complications oncologiques ont été observées chez 5 patients. Le résultat fonctionnel était satisfaisant chez 79% des patients.

Introduction

Limb-salvage surgery for benign and malignant tumours has reached unforeseen strides in recent times. With advances in cancer chemotherapy and better investigational backup, salvaging limbs that otherwise would have been amputated has evolved into a continuing and accepted concept of the new millennium. This requires a multidisciplinary approach involving various surgical fields like vascular and plastic specialities.

Resection of tumours and reconstruction of the proximal femur with various methodologies like arthrodesis with autograft or allograft; rotation plasty; bone transport techniques such as that of Ilizarov; and arthroplasty using allografts, allograft-prosthesis composites and endoprosthesis, have been in vogue [8].

Compared with various reconstructive methods available, prosthetic replacement offers several advantages, such as early stability, mobilisation and weightbearing [11, 12, 13]. Adjuvant treatment with chemotherapy and radiotherapy for providing pre-operative downstaging and control of micro-metastasis improve the oncological outcome [2, 10].

Materials and methods

During the period July 1989 to January 2002, 77 patients with tumours of the proximal femur underwent limb salvage surgery with custom mega-prosthesis in various institutions. Patients treated after August 2000 were excluded from the series.

We describe 44 patients of whom six have died of disease and two were lost to follow-up. We present the oncological results and functional outcome of prosthetic replacement in those 44 patients followed-up for a minimum of 24 months. We also evaluated the rate of prosthetic and limb survival and overall survival, and early and late complications. Mean follow-up period was 57 months. Male/female ratio was 1:1 with an age range of 14–66 (mean 34.5) years.

M. Natarajan
Department of Orthopaedics and Traumatology,
Madras Medical College and Research Institute,
Government General Hospital, 600 003 Chennai, India

J. C. Bose
Government Royapettah Hospital, 600 014 Chennai, India

G. Rajkumar
Madras Medical College and Research Institute,
Government General Hospital, 600 003 Chennai, India

M. Natarajan (✉)
14 Bank Street, Kilpauk, 600 010 Chennai, India
e-mail: drmayil@bonetumour.org
Tel.: +91-44-6442279, Fax: +91-44-6442499

Table 1 Patient details. *E* excellent, *G* good, *F* fair, *P* poor, *NED* no evidence of disease, *AWD* alive with disease, *DOD* died of disease, *NA* not applicable, *PR* prosthesis removed

Patient	Age (years)	Gender	Histopathological diagnosis	Stage	Pre-op chemo. no. of cycles	Pre-op radio-therapy	Post-op chemo-therapy	Follow-up (months)	Functional result	Oncological outcome	Complications	Remarks
1	30	F	Chondromyxoid fibroma	NA	0	No	No	24	E	NED		
2	26	F	Chondrosarcoma	IB	0	No	No	120	P	NED	Recurrence	PR; amputation
3	15	F	Chondrosarcoma	IB	0	No	No	144	E	NED		
4	66	M	Chondrosarcoma	IA	0	No	No	66	E	NED		
5	27	M	Chondrosarcoma	IB	0	No	No	60	E	NED		
6	20	F	Chondrosarcoma	IA	0	No	No	54	E	NED		
7	45	F	Chondrosarcoma	IB	0	No	No	46	P	NED	Recurrence	Amputation
8	29	F	Chondrosarcoma	IB	0	No	No	44	E	NED		
9	28	M	Chondrosarcoma	IA	0	No	No	25	E	NED		
10	20	M	Ewing's sarcoma	NA	4	Yes	Yes	24	E	DOD	Lung mets	
11	24	M	Ewing's sarcoma	NA	3	No	Yes	46	E	NED		
12	22	M	Ewing's sarcoma	IIB	3	Yes	No	26	G	DOD	Lung mets	
13	22	F	Fibrous dysplasia	NA	0	No	No	36	E	NED		
14	21	F	Giant cell tumour	IA	0	No	No	120	E	NED		
15	50	M	Giant cell tumour	IA	0	No	No	84	E	NED		
16	32	M	Giant cell tumour	IB	0	No	No	87	E	NED	Dislocation	Reduction
17	40	M	Giant cell tumour	IA	0	Yes	No	74	E	NED		
18	27	F	Giant cell tumour	IB	0	No	No	64	E	NED	Fracture	Revision
19	23	M	Giant cell tumour	IB	0	No	No	42	E	NED		
20	35	M	Giant cell tumour	IIA	0	No	No	40	E	NED		
21	27	M	Giant cell tumour	IIA	0	No	No	35	E	NED		
22	24	M	Giant cell tumour	IIB	0	No	No	32	G	NED		
23	21	M	Giant cell tumour	IIB	0	No	No	26	E	NED		
24	50	F	Giant cell tumour	IIA	0	No	No	25	G	NED		
25	42	F	Metastasis	NA	0	Yes	No	62	G	DOD	Dislocation	Reduction
26	31	F	Metastasis	NA	0	No	No	68	E	AWD		
27	33	F	Metastasis	NA	0	No	Yes	52	E	NED		
28	62	M	Metastasis	NA	0	Yes	No	120	NA	NA	Dislocation	Lost
29	45	F	Metastasis	NA	1	Yes	Yes	62	NA	NA		Lost
30	60	M	Multiple myeloma	NA	1	No	Yes	60	E	DOD		
31	58	F	Multiple myeloma	NA	0	No	Yes	27	P	NED	Infection	
32	50	F	Multiple myeloma	NA	0	No	Yes	108	F	NED	Infection	
33	44	F	Non-Hodgkin's lymphoma	NA	0	No	Yes	64	F	DOD	Fracture	
34	23	M	Non-Hodgkin's lymphoma	NA	0	No	Yes	70	E	NED		
35	16	M	Non-Hodgkin's lymphoma	NA	0	No	No	40	F	AWD		
36	34	F	Non-Hodgkin's lymphoma	NA	0	No	No	35	G	NED		
37	19	M	Osteosarcoma	IIB	1	No	No	102	E	NED		
38	27	M	Osteosarcoma	IIB	2	No	No	40	G	DOD	Lung mets	
39	16	M	Osteosarcoma	IIB	3	No	Yes	84	E	NED	Loosening	
40	14	F	Osteosarcoma	IIB	0	No	Yes	56	E	NED		
41	23	M	Osteosarcoma	IIIB	1	No	No	46	G	NED		
42	51	M	Osteosarcoma	IIB	3	No	No	25	E	NED		
43	58	F	Paget's sarcoma	IIB	1	No	No	56	P	NED	Infection	Amputation
44	46	F	Plasmacytoma	IB	0	No	No	25	G	NED		

Diagnosis and tumour grade

We encountered 41 malignant tumours. Giant cell tumours formed 11 cases; eight were cases of chondrosarcoma followed in number by metastases and osteosarcoma. Surgical staging was done according to Enneking's staging system [3] for benign and malignant tumours based on radiological and histopathological evaluation. The majority of the patients with malignant tumour presented as stages IB and IIB. Computerised tomography helped evaluate the tumour extent in 17 patients. Technetium-99m bone scan was done

in 13 patients to assess bone metastasis. Open biopsy was done in 23 patients. Lesion length ranged from 20 mm to 270 mm with an average of 108 mm. Soft-tissue encroachment was observed in 11 cases, and 22 patients presented with a pathological fracture.

Table 1 summarises histopathological diagnoses, surgical stages encountered, pre-operative and post-operative chemotherapy, pre-operative radiotherapy, follow-up period, and functional and oncological outcomes with complications.

Fig. 1 a Pre-operative radiograph of a case of chondrosarcoma of the proximal femur. **b** Post-operative radiograph after resection and custom mega-prosthetic replacement – 1-year follow-up

Adjuvant treatment

Pre-operative chemotherapy was given to 12 patients with malignant tumours. Pre-operative irradiation was given to six patients. Fifteen patients presented with a history of previous surgery in the form of excision, curettage and bone grafting done especially for benign tumours. Twelve patients received post-operative chemotherapy.

Resection

Surgical margins were wide in 17 patients and marginal in 25. In a case of non-Hodgkin's lymphoma the margin was contaminated. One patient presented with chondromyxoid fibroma after excision. The most frequent length of resection was between 100 and 150 mm.

Reconstruction

Prostheses used were indigenously manufactured, customised to each patient with either stainless steel (37 patients) or titanium alloy. Vitallium alloy was used in a total hip prosthesis after resection of an osteosarcoma. Required prosthesis dimensions were estimated using X-rays in all patients. Total hip replacement prosthesis was used in 27 patients and proximal femoral prosthesis in the remaining patients (Fig. 1).

Results

Patients were evaluated every 3 months during the first year and 6 monthly thereafter with physical examination and plain radiography.

Complications

Three patients had intra-operative complications, which were manageable. Three patients had post-operative deep-wound infection, which was managed conservatively with antibiotics in one patient, the prosthesis was removed in one and the limb removed in the other. Six patients had mechanical complications, two in the form of reducible dislocations with satisfactory functional results.

Fractures were observed in three patients among whom one patient had a revision giving an excellent result, one was lost to follow-up and the other died of disease. One patient had a satisfactory functional result despite aseptic loosening at the bone/cement interface. Five patients showed evidence of oncological complications that took the form of lung metastases in two cases of Ewing's sarcoma and in one case of osteosarcoma; all three succumbed to the disease. Local recurrence occurred in two cases of chondrosarcoma.

Functional outcome

Functional outcome was estimated using Enneking's evaluation criteria [4], an assessment that evaluates pain, functional limitation, walking distance, use of support, gait and emotional acceptance as parameters. At their latest follow-up, 27 patients had excellent functional outcome, eight good, three fair and four poor. Two patients with metastatic lesions were lost to follow-up at 120 and 62 months respectively.

Table 2 Diagnoses and oncological outcome in patients followed up for a minimum of 2 years

Diagnosis	Number	Alive		Died follow-up	Lost to
		No disease	With disease		
Giant Cell tumour	11	11			
Chondrosarcoma	8	8			
Metastasis	5	1	1	1	2
Osteosarcoma	6	5		1	
Ewing's sarcoma	3	1		2	
Non-Hodgkin's lymphoma	4	2	1	1	
Multiple myeloma	3	2		1	
Paget's sarcoma	1	1			
Chondromyxoid fibroma	1	1			
Plasmacytoma	1	1			
Chondromyxoid fibroma	1	1			
Subtotal		34	2	6	2
Total	44	42			2

Fig. 2 Kaplan-Meier survivorship analysis of the 44 cases of custom mega-prosthesis in proximal femoral tumours. X axis time in years; Y axis survival percentage

Oncological outcome

There was no evidence of disease in 34 patients, two were alive with disease and six had died of disease (Table 2).

Survivorship analysis

The survival analysis was done using the Kaplan-Meier survivorship method, using the following parameters:

1. Patient survivorship with death as the end point
2. Limb survivorship with amputation as the end point
3. Prostheses survivorship with mechanical failure and revision as the end point.

Prosthesis 5-year survival percentage was 97.2%; limb survival rate was 94.5% and patient survival rate was 87.2% (Fig. 2).

Discussion

This series represents custom mega prosthesis as a reliable method of reconstruction following resections of malignant tumours of the proximal femur. Major advantages of this method are early functional recovery, a relatively low complication rate and a high level of emotional acceptance. In contrast with most series [6, 7], fractures outnumbered dislocations after proximal and total femoral resection and reconstruction.

Local recurrence, as a marker of local tumour control, was observed only in two cases, denoting the oncological adequacy of the resections. Both of these patients had extra-compartmental chondrosarcoma; no case of osteosarcoma had a local recurrence. This overall recurrence rate fares superior to that reported by a similar series by Kabukcuoglu et al [9] who report a rate as high as 28%. This rate reiterates the fact that generous excision margins are needed in such tumours.

In our series, infections were met with in three cases only, which is lower when compared to reconstruction procedures like osteoarticular allografts, allograft prosthesis composites and allograft–arthrodesis after tumour resections, infection, the rate in those instances being 11% [1, 5]. Also, these methods have problems of non-union (3.7–15%), problems that did not arise with our endoprostheses. In the same series, allograft fractures were 19%. In our series, only three cases (6.8%) of peri-prosthetic fractures were encountered, indicating that, with an equivalent successful outcome of 80%, the morbidity associated with endoprosthetic replacement is remarkably low.

Patients with osteosarcoma performed considerably worse than those with chondrosarcoma as regards oncological outcome (Table 2). The number of survivors was the least (1/3) with Ewing's sarcoma, understandably as these patients presented to us with higher surgical stages.

Breakage of prosthesis occurred in none of our patients, results that fared better than the reports that quote as high as 1–4% [14, 15]. This was probably due to improving implant design and metallurgy.

Treating malignant tumours of the proximal femur with its unique problems has remained one of the complex areas of management in orthopaedic oncology. As patients present to us in different surgical stages, contemplating limb salvage with the support of chemotherapy and endoprosthetic reconstruction needs a meticulous patient selection, an individualised approach to the tumour type and consideration of the likely functional recovery, making it almost impossible to decide which modality of reconstruction could offer the best overall results. Our indigenously manufactured custom mega prostheses have proved to serve as a better limb-salvage procedure as regards local recurrence rate and morbidity, besides satisfactory oncological and functional outcomes when compared with the various modalities of reconstruction.

References

1. Donati D, Zavatta M (2001) Modular prosthetic replacement of the proximal femur after resection of a bone tumour – a long-term follow-up. *J Bone J Surg [Br]* 83:1156–1160
2. Eilber F, Giuliano A, Eckhardt J, Paffersou K, Moseley S, Goodnight J (1987) Adjuvant chemotherapy for osteosarcoma: a randomized prospective trial. *J Clin Oncol* 5:21–26
3. Enneking WF (1986) A system of staging musculoskeletal neoplasms. *Clin Orthop* 204:9–24
4. Enneking WF, Dunham W, Gebhardt MC, Malawar N, Pritchard DJ (1993) A system for the functional evaluation of reconstructive procedures after surgical treatment of tumours of the musculoskeletal system *Clin Orthop* 286:241–246
5. Fox EJ, Hau MA, Gebhardt MC, Hornicek FJ, Tomford WW, Mankin HJ (2002) Long-term follow-up of proximal femoral allografts. *Clin Orthop* 397:106–113
6. Ilyas I, Pant R, Kurar A, Moreau PG, Young DA (2002) Modular prosthesis for proximal femoral tumours. *Int Orthop* 26:170–173
7. Jacob Bickels, Isaac Meller, Robert M.Henshaw, Martin M Malawar (2000) Reconstruction of hip stability after proximal and total femur resections. *Clin Orthop* 375:218–230
8. Johnson ME, Mankin HJ (1991) Reconstructions after resections of tumours involving the proximal femur. *Orthop Clin North Am* 22:87–103
9. Kabukcuoglu Y, Grimer R, Tillman RM, Carter SR (1999) Endoprosthetic replacement for primary malignant tumours of the proximal femur. *Clin Orthop* 358:8–14
10. Link MP, Goorin AM, Miser AW, et al (1986) The effect of adjuvant chemotherapy on relapse-free survival in patients with osteosarcoma of extremity. *New Engl J Med* 134:1600–1606
11. Malawar MM, Chou LB (1995) Prosthetic survival and clinical results with use of large-segment replacements in the treatment of high-grade bone sarcomas. *J Bone J Surg [Am]* 77: 1154–1165
12. Mankin HJ, Doppelt SH, Sullivan TR and Tourford WW (1982) Osteoarticular and intercalary allograft transplantation in the management of malignant tumor of bone. *Cancer* 50:613–630
13. Mankin HJ, Gebhardt MC, Jennings LC, Springfield DS, Tomford WW (1996) Long-term results of allograft replacement in the management of bone tumours. *Clin Orthop* 324:86–97
14. Unwin PS, Cannon SR, Grimer RJ et al (1996) Aseptic loosening in cemented custom-made replacements for bone tumours of the lower limb. *J Bone J Surg [Br]* 78:5–13
15. Veth RPH et al (1989) Megaprotheses in the treatment of primary malignant and metastatic tumours in the hip region. *J Surg Oncol* 40:214–218