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## Distal femoral tumours treated by resection and custom mega-prosthetic replacement

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**Abstract** We have analysed the results of 246 cases of distal femoral tumours treated by resection and prosthetic replacement between 1988 and 2002. Patient ages ranged from 6–67 years averaging 24 years; 133 were males. The most common tumour was osteosarcoma (67% of patients). The follow-up ranged from 2 to 14 years. Stage II tumours were seen in 72% of patients. The technique of sleeve resection of the quadriceps musculature was followed to achieve local clearance of the tumour. The prosthesis used was a rotating hinge custom mega-prosthesis manufactured locally. The functional result achieved was excellent or good in 87%; 86% of the patients had no evidence of disease, and 13% had died. The 10-year patient survival was 76.9%. Periprosthetic fracture and infection were the most common complications.

**Résumé** Nous avons analysé les résultats de 246 cas de tumeurs fémorales distales traitées par résection et remplacement prothétique entre 1988 et 2002. L'âge des malades

s'étendait de 6 à 67 ans avec une moyenne de 24 ans. Cent trente trois étaient des hommes. La tumeur la plus fréquente était l'ostéosarcome (67% des malades). Le suivi était de 2 à 14 années. Des tumeurs de stade II étaient présentes chez 72% des malades. La technique de résection a été conduite pour faire une ablation complète de la tumeur. La prothèse qui a été utilisée était une méga prothèse à charnière rotatoire fabriqué localement. Le résultat fonctionnel obtenu était excellent ou bon dans 87%. Quatre-vingt-six pourcent des malades n'avait pas d'évidence de maladie et 13% étaient morts. La survie à dix ans était de 76,9%. Les fractures périprothétiques et l'infection étaient les complications les plus fréquentes.

### Introduction

The distal femur is the most common site for primary bone tumours occurring in young healthy adults [11, 14]. This places tremendous responsibility on tumour surgeons to provide durable and fully functional solutions for the patient. Progress in biomedical engineering along with better surgical and chemotherapeutic techniques has increased overall 5-year survival rate after endoprosthetic replacement from 20% to 85% in the past three decades [1, 4, 8, 12, 15].

These superior results along with minimal complications have established endoprosthetic replacement as the primary modality in the management of malignant bone tumours of the lower limb [14, 18]. Focus has now shifted from controversy over the various forms of limb salvage to methods of enhancing functional and oncological outcome after endoprosthetic replacement. We present here our experience over a decade with endoprosthetic replacement for distal femoral tumours.

### Materials and methods

Two hundred and forty-six patients with a minimum follow up of 24 months treated between 1988 and 2002 were analysed in this study. Patients who either died or were lost

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to follow-up before 24 months were not included. Patient ages ranged from 6 to 67 years averaging 24 years. There were 133 males and 113 females. Osteosarcoma was the most common tumour encountered (Table 1). Among the 57 patients with giant cell tumour (GCT), 19 were recurrent lesions after primary surgery elsewhere, 34 were primary aggressive (benign stage 3) and four were malignant. The majority of patients had stage II tumours according to the Enneking staging system [7], as depicted in Table 1.

### The prosthesis

The rotating hinge custom mega-prosthesis, manufactured in Chennai, India, was used in all patients. The design has been modified and upgraded over the years, and the present design is a distal femoral prosthesis with thrust-bearing pad and rotating axis mechanism. The basic components of the prosthesis are a femoral shaft, a condylar component, a median component, a thrust-bearing pad, a pivot pin and collar bushes (Fig. 1). Proximally, the prosthesis is angulated laterally by 6° to resemble the anatomical axis of the lower limb. The function of the thrust-bearing pad is to impart a flexion of 150° between the femoral and tibial components. The ultra-high-molecular-weight polyethylene-bearing pad serves to relocate the load transmitted during weight bearing. The rotating axis mechanism provides 3° of rotation between the femoral and tibial components. In 83% of patients, stainless steel was the material used to manufacture the prosthesis while titanium alloy was used in the remainder.

### Chemotherapy

Patients were given chemotherapy according to the drug regimen that was in use at the time. The current regimen used for osteosarcoma is six cycles of chemotherapy using cisplatin, adriamycin and ifosfamide, with 2–3 cycles pre-operatively (neoadjuvant). For Ewing's sarcoma, the drugs used are vincristine, adriamycin and cyclophosphamide. Chemotherapy was administered to 76% of patients with



Fig. 1 Distal femoral prosthesis with thrust-bearing pad and rotating axis mechanism

high-grade sarcomas. Eight patients received pre-operative radiotherapy, given before referral to us.

### Surgical technique

Various techniques of resection have been described for distal femoral tumours [2, 11]. Most of the cases in our series were late presentations, where the tumour had advanced to involve more than one muscle group. Therefore, the various techniques that involve resection of a group of muscles involved by the tumour were not applicable in our patients. We used the technique of sleeve resection of quadriceps musculature. The main objective of this technique is to excise a sleeve of quadriceps musculature all around the tumour but retain the functioning rectus femoris tendon. The excision removes a portion of the vastus lateralis, medialis and intermedius, as is deemed necessary in the particular

Table 1 Diagnosis and stage distribution

Histological diagnosis	Stage						No. of patients
	IA	IB	IIA	IIB	III	NA	
Osteosarcoma	7	9	64	81	4		165
Giant cell tumour							57
Malignant fibrous histiocytoma		2	2	5			9
Chondrosarcoma	1	3	1				5
Multiple myeloma		1				2	3
Ewing's sarcoma				1		1	2
Soft tissue sarcoma				1		1	2
Aneurysmal bone cyst		1					1
Fibrosarcoma		1					1
Metastasis						1	1
No. of patients	15	45	76	101	4	5	246

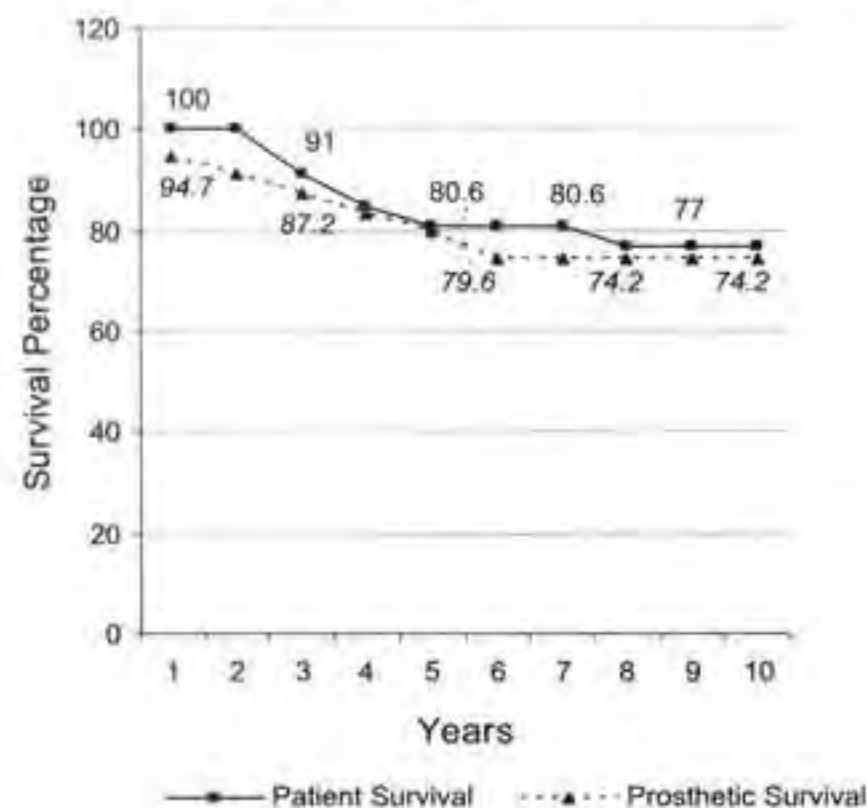
**Fig. 2** **a** Pre-operative X-ray of a patient with osteosarcoma of the distal femur. **b** Six-year follow up X-ray after wide resection and custom mega-prosthetic replacement



case, but preserves enough musculature to provide soft tissue cover for the prosthesis and retain adequate extension power. Using this technique, we were able to reach a balance between achieving an adequate surgical margin and retaining sufficient functioning musculature. The margin of resection was wide in 73% of our patients and marginal in 25%; in 2%, the margin was contaminated. The average length of the lesions was 110 mm. Most patients had between 100 mm to 150 mm of their femur excised.

## Results

The minimum follow up was 24 months and maximum was 175 months, averaging 60.7 months. Fourteen patients were lost to follow-up during various periods of the study. The modified rating system of the Musculoskeletal Tumour



**Fig. 3** Ten-year patient and prosthesis survival

Society [6] was used to determine the functional outcome. Excellent results were achieved in 104 patients, good in 99, fair in 22 and poor in 21. On analysing the oncological outcome, 209 patients had no evidence of disease, 31 had died due to disease, three were alive with the disease and three had died due to other causes. The Kaplan Meier estimator was used to calculate the 10-year survival. The 10-year patient survival was 76.9% (Fig. 3). Limb survival at 10 years was 81.2%, and prosthesis survival was 74.2% (Fig. 3). The pre-operative and six years follow up radiographs of a patient are given in Fig. 2.

Complications both minor and major in nature occurred in 41 patients. More than one complication occurred in 28 patients. Among the early complications, skin flap necrosis developed in three patients, all of whom were managed by additional plastic surgical procedures. One patient developed femoral artery thrombosis, which led to amputation. Aseptic loosening was the most common late complication and occurred in 24 patients, of whom 16 underwent revision and eight were satisfied with their function despite radiological evidence of loosening. Prosthesis-related failures observed were fracture of the prosthesis in 22 patients, 17 of whom underwent revision, three declined further treatment and two died. Bending of the prosthesis occurred in three patients and disassembly in one.

Infection occurred in 17 patients, of whom six responded to wound lavage and antibiotics while the prosthesis had to be removed in 11. Pulmonary metastasis occurred in 17 patients, of whom 15 died and two were alive with disease at the time of our study. Local recurrence occurred in 16 patients, of whom nine underwent amputation and seven underwent revision surgery. Thirteen patients who developed local recurrence died, proving that local recurrence is a poor prognostic factor [15].

## Discussion

The surgical technique for resection of distal femoral tumours involves a delicate balance between aggression and

restraint. Though the resection has to be wide enough to avoid local recurrence, the best functional results are obtained after limited or sub-total quadriceps excision. One of the major technical issues of distal femoral resection is the relationship between quadriceps excision and gait, which may influence implant failure [2]. Van Krieken et al. [19] have stated that complete excision of the quadriceps produces prosthetic instability resulting in gait pattern changes and excessive joint loads. According to Benedetti et al. [2], patients who had vastus intermedius and lateralis resected had a near-normal flexion-extension load absorption and gait pattern. Those who had excision of vastus intermedius had a stiff-knee gait. By following the sleeve resection technique of quadriceps musculature, we were able to achieve an excellent or good functional outcome in 82.5% of patients, which is comparable to the 84% reported by Mittermayer et al. [16].

The reconstructive procedure after resection of distal femoral tumours has to be based on several considerations, such as durability of the surgical procedure, the oncological prognosis, restoration of anatomy and function and the needs of the patient [15]. The surgical procedure chosen should be fully evaluated and compared with other alternatives while addressing the possible complications. Improved prosthetic designs have reduced implant-related complications and have achieved satisfactory results [14, 16]. The use of osteochondral allografts has been associated with several complications, such as infection, fracture and delayed healing due to concurrent chemotherapy [14, 21]. Wunder et al. [20] compared the functional results and complications of allograft implant composite and bone in-growth prosthesis for distal femoral tumours and concluded that limb salvage rate and functional outcome were superior for endoprosthesis compared with allograft reconstruction. Rotationplasty has advantages over endoprosthesis replacement, with less restriction of daily activities due to pain and a better quality of life, but the cosmetic outcome is a serious disadvantage of this procedure [8].

We observed that aseptic loosening is the most common late complication after distal femoral cemented endoprosthesis replacement, confirming other reports [4, 9, 16, 18]. The reasons for aseptic loosening are removal of greater than 60% of the bone, patients younger than 20 years and increased offset of the tip of the prosthesis from the anatomical axis [3, 4, 18]. Implant designs that reduce the incidence of loosening include the use of porous-coated collars [4, 5], anatomically curved stems [16] and polyethylene components, which allow a staged mechanical failure pattern to prevent additional prosthetic loosening [11, 16]. In our patients, we used the rotating hinge variety with a weight-bearing polymer pad mechanism; a design that has been proven to reduce the incidence of loosening by decreasing the stress at the implant cement interface [4, 11].

We observed, from this and earlier studies, that patients with distal femoral endoprosthesis replacement have a better limb survival although patient survival of proximal tibial replacements is superior [15]. This observation has also been made by other authors [11-13]. The better patient survival for proximal tibial tumours has been attributed to

the smaller size of the lesion at presentation and earlier detection of proximal tibial tumours [9]. The 5-year patient survival in our series was 80.6%, and the 10-year survival was 76.9%. Roberts et al. obtained a cumulative 5-year success rate of 72% in a series of 135 distal femoral replacements over a 16-year period [17]. The prosthetic survival in our series at 5 years was 79.6% and at 10 years 74.2%. These results compare well with those observed by Mittermayer et al., who observed a 5-year prosthetic survival of 79% and a 10-year survival of 71% [16]. Roberts et al. reported a 5-year prosthetic survival of 74.9% [17], and Ilyas et al. observed a 10-year prosthetic survival of 65% in a series of 48 patients [10].

The adequacy of resection of distal femoral tumours is the most important factor in local control of the disease. However, the prosthetic design and amount of bone resected have been shown to have an important role in long-term survival of the implant. A combination of effective chemotherapy, superior surgical techniques and improved prosthetic designs has extended the application of endoprosthesis replacement for tumours of the distal femur. By using the technique of sleeve resection of the quadriceps to excise the tumour and using the rotating hinge prosthesis with polymer pad for reconstruction, we have been able to achieve results comparable to several other authors. We advocate the method of sleeve resection of the quadriceps as a valuable technique in the armoury of a tumour surgeon, to achieve adequate tumour margins, particularly where presentation is late.

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