Original Article

Functional Outcome Study of Mega-Endoprosthetic Reconstruction in Limbs With Bone Tumour Surgery

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Abstract

Introduction: Amputation is no longer the sole contribution of the orthopaedic surgeon to the management of primary bone tumours. Improvements in the design of endoprostheses and surgical reconstructive techniques have combined with advances in chemotherapeutic regimens to result in surgical procedures for salvaging limbs with aggressive sarcomas and in limb reconstruction. This has made limb salvage a viable alternative to amputation in many cases. The aim of this study was to evaluate functional outcome and complications of patients with primary bone tumours who were treated with re-section and mega-endoprosthetic replacement. Materials and Methods: Nineteen patients with bone tumours were retrospectively reviewed. These patients had wide local re-section and mega-endoprosthetic reconstruction performed between 1999 and 2006 in a tertiary hospital. Functional evaluation was performed based on the Musculoskeletal Tumour Society (MSTS) scoring system, with numerical values from 0 to 5 points assigned for each of the following 6 categories: pain, function, emotional acceptance, use of supports, walking ability and gait. These values were added, and the functional score was presented as a percentage of the maximum possible score. Complications were also analysed. Results: The final mean functional score was 78.3% ± 16.6%. Eight patients had complications related to surgery, including infection and subluxation of hip implant. Six patients had infection, while 2 had subluxation of hip implants. Infection was a common complication in our study. None had implant breakage, loosening or fracture. We found no statistical difference in the functional outcome between upper limb and lower limb procedures, and between hip and knee procedures. T-test also showed no evidence of gender differences in functional outcome. Kaplan-Meier survival analysis revealed the mean survival duration of megaprosthesis to be 75.6 months. Conclusion: Mega-endoprosthetic reconstruction in limb salvage provides good functional outcome in patients with bone tumours. The early results from patients treated with mega-endoprosthesis have been encouraging.

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Key words: Limb salvage, Megaprosthesis

Introduction

Limb salvage surgery is a widely accepted alternative to amputation in patients with primary bone tumours. The success of limb salvage is the result of the combined understanding of the biology and staging of tumours, improvements in reconstructive techniques, and the development of effective adjuvant chemotherapy for the primary tumours and bone sarcomas. Metallic implants fixed with methylmethacrylate cement are now well established in the management of pathological fractures secondary to metastatic carcinoma.[1,2] In such patients with metastatic disease, the treatment aims at improving the quality of short life expectancy that remains, and the demands placed on the prosthetic implant and the length of time it is expected to function satisfactorily are also limited. On the other hand, patients requiring resection of primary bone tumours are often young and are expected to live with the prosthesis for many years. A substantial amount of healthy bone may need to be resected to ensure a safe margin, leaving the remnant bone segment a little short for the secure fixation of a mega-endoprosthesis.

This study aims to evaluate the functional outcome of 19 patients with primary malignant or aggressive benign bone tumours that necessitated large bone segment resection and mega-endoprosthetic replacement in the Musculoskeletal

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Tumour Service of a Singapore hospital between 1999 and 2006.

Materials and Methods

Nineteen patients diagnosed with primary malignant or aggressive benign bone tumours underwent definitive wide local resection and mega-endoprosthetic reconstruction and were evaluated with regards to their functional outcome using the Musculoskeletal Tumour Society (MSTS) scoring system (Table 1). Numerical values from 0 to 5 points were assigned for each of the following 6 categories: pain, function, emotional acceptance, use of supports, walking ability and gait. These values were added, and the functional score was presented as a percentage of the maximum possible score. The results were graded according to the following scale: Excellent – 75% to 100%; good – 70% to 74%; moderate – 60% to 69%; fair – 50% to 59% and poor – <50%. Stryker Modular Resection System and Howedine Modular Resection Systems were used in some of the surgical operations.

Complications related to surgery such as infection, implant breakdown, aseptic loosening, dislocation, skin necrosis and fractures were evaluated. Local recurrences and metastases were also recorded. A complication was defined as "early" when it occurred within 6 months after the primary surgery and as "late" when it occurred more than 6 months after the primary surgery. The management of complications, such as revision surgery (removal of endoprosthesis, arthrodesis, amputation) was also recorded. Furthermore, complications related to the disease itself, such as metastases, and any treatment of such complications, were recorded.

Results

Of these 19 patients, 10 were diagnosed with osteosarcoma (OS), 3 had giant cell tumour (GCT), 2 had aneurysmal bone cysts (ABC), 3 had chondrosarcoma (CS) and 1 had Ewing's sarcoma (ES). All underwent wide local resection with mega-endoprosthetic reconstruction. The surgery was performed between 1999 and 2006. The MSTS functional scores were calculated for these 19 patients. The mean final functional score was 78.3% ± 16.6%. In our study, we achieved good to excellent results with our mean functional score of 78.3%.

Statistical analysis was performed on the MSTS functional scores using the SPSS software *t*-test. Upper limb procedures have a higher mean functional score compared with lower limb procedures (27.0 vs 23.1). Using the independent

Table 1. Musculoskeletal Tumour Society Functional Outcome Score

Patient no.	Musculoskeletal Tumour Society Functional score (%)
1	93.3
2	83.3
3	80
4	95
5	90
6	60
7	70
8	90
9	60
10	90
11	70
12	85
13	74
14	90
15	70
16	70
17	74
18	75
19	68
Mean Final Functional Score	78.3 ± 16.6

Table 2. Breakdown of Procedures into Upper and Lower Limb Procedures

Upper Limb	**2 (1 low-grade chondrosarcoma of proximal humerus, 1 osteosarcoma of proximal humerus)**
Lower Limb	17 patients: (Knee procedures: 13, Hip procedures: 4)
	7 distal femur osteosarcoma
	3 proximal tibia osteosarcoma
	2 proximal tibia chondrosarcoma
	2 proximal femur aneurismal bone cyst
	1 proximal tibia GCT
	1 proximal femur clear cell chondrosarcoma
	1 proximal femur Ewing's sarcoma

GCT: giant cell tumour

Table 3. Complication Rate of the Patients in Our Study

Complication	No.	%
Early infection	3	15.8
Late infection	3	15.8
Infection requiring revision	1	5.3
Subluxation of implant	2	10.5
Aseptic loosening	0	0
Implant breakage	0	0
Common peroneal nerve palsy	1	5.3
Periprosthetic fracture	0	0

Table 4. Comparison of Results of Our Study and That of Other Studies

	No of patients	Results (%)
Hiroyuki et al[12]	40	74
Schindler et al[6]	12	77
Wilkins et al[7]	26	73
Miller et al[7]	10	79
Our Study	19	78

Table 5. Comparison of Infection Rate of Our Study With That of Other Studies

Study	No. of patients	Infection (%)
Hiroyuki[12]	40	24
Cool et al[8]	24	4
Schiller et al[9]	5	40
Our Study	19	31

t-test, we found no statistically significant difference between the 2 groups (t=7.38, P=0.118). This finding may be influenced by the small sample size and the uneven sub-group sizes (Upper limb procedure no = 2, lower limb procedure no = 17). Retrospective examination revealed that the statistical power of the test was low (power = 0.343). In addition, comparing hip and knee procedures using the *t*-test found no significant statistical difference between the 2 groups (t = 6.97, P = 0.125), even though hip procedures were found to have a higher mean functional score (25.3 vs 23.4). In addition, we found no evidence of gender difference in terms of functional score (t = 0.227, P >0.05, n = 19).

Kaplan-Meier survival analysis was performed to examine the duration (months) of disease-free survival of the megaprosthesis. The megaprosthesis was considered a failure when revision surgery had to be performed for any reason. We found the mean survival time to be 75.6 months with standard errors (SE) of 6.5 months, and a 95% confidence interval between 62.8 and 88.3 months (refer to Figure 4 which shows the Kaplan-Meier Curve). Two patients had metastastatic disease on follow-up: 1 had metastasis to the lung, while the other had metastasis to the cervical spine. The patient with pulmonary metastasis had osteosarcoma of the proximal humerus, while the patient with spinal metastasis had distal femur osteosarcoma. Two other patients had recurrence of the primary bone disease. One of them had recurrence of GCT, while the other had recurrence of osteosarcoma. Both required further surgery for the recurrence. The age of the patients ranged from 13 to 63 years (mean, 33.26). Seventeen patients underwent lower limb surgical procedures while 2 underwent upper limb procedures (Table 2).

Among the 19 patients, 8 had complications related to surgery (Table 3). Three had early infection such as cellulitis which required intravenous antibiotics treatment. Three had late infections that required intravenous antibiotics treatment. Of the 3 who had late infections, 1 required surgical debridement. This patient had a left proximal femur aneurysmal bone cyst and underwent wide resection with proximal femoral reconstruction with bipolar implant using the Howedine Modular Resection System. Nine months post-operation, he was walking with walking aids with minimal pain. However 3 years post-operation, he presented with infected ulcers over the left gluteal region with subluxation of hip implant, requiring wound debridement and revision of hip mega-prosthesis with pedicled gluteal flap coverage.

Two patients had subluxation of the hip endoprosthesis. One required revision surgery as it was infected as well as subluxed as described above. The other patient was able to ambulate with crutches. None had implant loosening, breakage or periprosthetic fractures. One had foot drop secondary to common peroneal palsy. This patient had proximal tibia osteosarcoma. Six months post-surgery, he was able to walk with a single crutch and coped well with his foot drop. Understandably, a tendency toward higher functional scores was noted in patients who did not have complications compared with those who did. For example, the patients with infection, hip implant subluxation and common peroneal nerve palsy were found to have a lower functional outcome score. The common peroneal nerve palsy rate was 5.3%.

Discussion

The first reported case of a prosthetic implant for tumour was for a recurrent GCT of the proximal femur. This was replaced with a 25-cm long Vitallium mould of the upper end of the femur. After the operation, the active range of motion at the hip joint was approximately three quarters of the normal, although unfortunately, this patient died 20 months later from cardiac failure.[3] Custom built protheses have been used to replace the femur, the hip joint, part of the pelvis, the knee joint, the humerus and shoulder joint, and parts of the ulna and radius. These are the most common predilection sites of primary bone tumours. The use of limb-preserving mega-endoprostheses should be considered in patients with malignant bone tumours such as CSs or osteosarcomas. Those with benign and aggressive but destructive bone lesions unsuitable for simple bone grafting such as in Enneking stage 3 GCTs are suitable for mega-endoprosthetic reconstruction in replacing resected bone segments.

Megaprosthetic reconstruction has many advantages. It provides immediate stability which allows earlier

Fig. 1. Showing resected bone ends of distal femur and proximal tibia.

Fig. 2. Showing trial components of megaprosthetic implants.

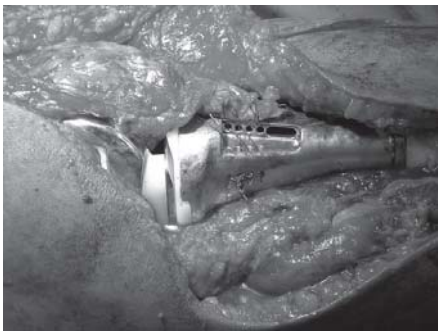

Fig. 3. Showing megaprosthetic reconstruction of the knee after wide resection of distal femur osteosarcoma.

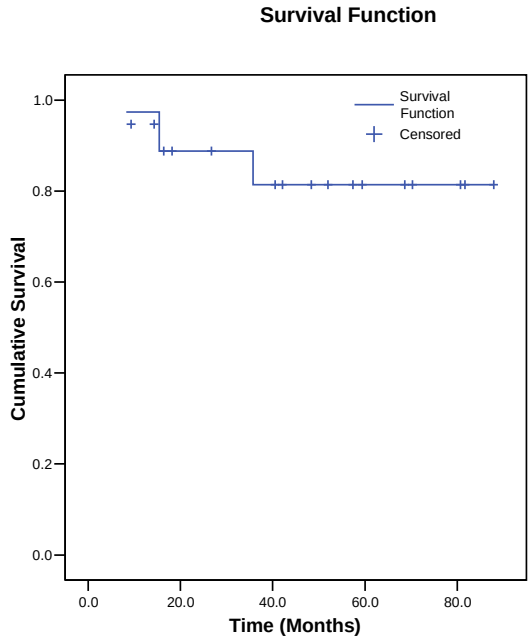

Fig. 4. Cumulative survival graph for megaprothesis.

rehabilitation with immediate full weight-bearing. Most endoprostheses are modular, thus allowing incremental prosthetic replacement in response to the length of resected bone. In addition, improvement in implant materials have greatly increased the durability of modern endoprostheses. They are able to achieve their primary aim of providing long-term function for some patients with relatively low physical demands.

Mega-endoprostheses have known complications. Polyethylene wear is a limiting factor for articulating surfaces, but polyethylene bearing spacers and lugs are replaceable in most prostheses. Fatigue fracture is common at the yoke of a rotating hinge. However, fatigue fracture at the base of the intramedullary stem where it attaches to the body of the prosthesis is more problematic as extraction of the remaining stem can be very difficult.

Oncological reconstruction may appear to have higher complication rates compared with standard total joint arthroplasty due to the extensive nature of the operation, extensive tissue loss, and the compromising effects of associated radiotherapy and chemotherapy (Figs. 1 to 3). In addition, reconstructions are often done in younger patients who are relatively more active, thus incurring a higher rate of wear.

Our study of the 19 patients who had primary bone tumours with mega-endoprosthetic reconstruction revealed a mean MSTS functional score of 78.3%. This result is comparable with those in other studies, such as in the study by Schindler et al, in which the mean MSTS functional score was 77% in 12 patients with Stanmore custom-made extendable distal femoral prostheses.[6] We note that this study involved extendable implants (Table 4). Wilkins and Miller[7] found the mean functional scores of 73% in 26 patients with primary limb-preservation surgery with re-operations and 79% in 10 patients without re-operations. In this study, the outcome was better for those patients without re-operations. We had achieved a grading of "good to excellent" results in terms of mean functional score.

Infection was the most common complication, with 3 patients (15.8%) having early infection and 3 patients (15.8%) having late infections, out of the 19 patients (Table 5). The rate of infection in the literature has ranged from 4% (1 out of 24 patients) in the study by Cool et al[8] to 2 out of 5 patients in the study by Schiller et al.[9] We note that these 2 studies were for extendable prostheses which have a known higher rate of infection. Comparable results have been reported by other investigators.[10,11] In our study, 1 patient required surgical debridement and revision of implant. The rest had their infection treated successfully with intravenous antibiotics and dressings.

Of significance, none of the patients in our study had implant breakage, loosening or periprosthetic fracture. All the patients in our study were able to walk with or without amubulatory aids after surgical reconstruction. The limitations of this study are the small number of patients,

and its retrospective nature. Thus, tumour-related factors, adjuvant therapeutic treatments or other unexplored factors might have biased the decision with regard to the type of surgery performed. In our study, we included both benign and malignant bone diseases. We acknowledge that their outcomes will be very different, for example, in a patient with osteosarcoma who would have a very different prognosis compared with one with a benign disease such as aneurysmal bone cyst.

Conclusion

Mega-endoprosthetic reconstruction provides good functional outcome in patients after bone tumour re-section. They provide yet another treatment option in limb salvage. These patients have been evaluated and seem to have acceptable functional outcomes in our institution. Infection, though, remains a common complication in our study.

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