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Modular megaprosthesis reconstruction for oncological and non-oncological resection of the elbow joint

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ABSTRACT

Background: Reconstruction of large bone defects around the elbow joint is surgically demanding due to sparse soft tissue coverage, complex biomechanics and the close proximity to neurovascular structures. Modular megaprostheses are established reconstruction tools for the elbow, but only small case series have been reported in the literature.
Methods: Thirty-six patients who underwent reconstruction of the elbow joint with a modular megaprosthesis were reviewed retrospectively. In 31 patients (86.1%), elbow replacement was performed after resection of a bone tumour, whereas five non-oncological patients (13.9%) underwent surgery because of a previous failed elbow reconstruction. Functional outcome, rate of complications and oncological results were considered as primary endpoints.
Results: The mean follow-up was 25 months. The average achieved Mayo Elbow Performance Score (MEPS) was 77.08 (range 40–95) and the average Musculoskeletal Tumor Society (MSTS) score was 22.9 (range 8–30). Six complications (16.7%) were observed: two radial palsies, one temporary radial nerve dysfunction, one ulnar palsy, one disassembling of the articular prosthesis component and one deep infection necessitating the only implant removal. The overall 5-year survival rate of the patients was poor (25.1%) because of rapid systemic progression of the oncological disease in patients with metastatic lesion. However, the 5-year survival rate of the implant was very satisfactory (93%).
Conclusions: Modular megaprosthesis is a reliable and effective reconstruction tool in large bone defects around the elbow joint. The complication rates are lower than seen in osteoarticular allografts and allograft-prosthesis composites while the functional outcome is equal. In palliative situations with metastatic disease involving the elbow, modular megaprosthesis enables rapid recovery and pain relief and preserves elbow function

Introduction

The elbow joint and distal humerus are uncommon sites for primary bone tumours or metastatic disease. Only 91 (1.2%) of 7830 primary malignant bone lesions were found in the region of the elbow joint [1]. Although rare, tumours affecting the distal humerus or the elbow joint present a surgical challenge that requires careful preoperative planning and consideration of several possible resection and reconstruction techniques according to the size and location of the tumour. Similar considerations can be applied in the setting of complex intra-articular fractures with poor bone quality, rheumatoid arthritis or failed previous osteosynthesis. All these situations are associated with significant bone loss comparable to the resection of a bone tumour.

Restoration of limb function is a primary goal, regardless of the indication. Successful reconstruction of the elbow joint frequently results in a more satisfactory outcome than amputation of the

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upper extremity. Different surgical options have been reported in the past. An arthrodesis of the elbow is difficult to achieve in large bone defects and patient acceptance and functional outcome are often poor [2,3]. An osteoarticular allograft reconstruction enables most of the functionality of the elbow joint at the expense of a high complication rate [4–6]. Resulting instability, infection and non-union between allograft and host bone can require surgical revision [4–6].

Structural failure can be avoided by replacing the joint with a megaprosthesis. A conventional elbow prosthesis is often inconvenient because of the large bone defect [7]. Therefore, either modular systems or a custom-made prosthesis has to be implanted [8–19].

There are only a few published case series that discuss the difficulties and results of modular megaprosthesis for the elbow joint. All these studies were retrospective analyses with a small number of patients and included a broad spectrum of indications, including primary bone tumours, metastatic disease, salvage surgery after failed ostheosynthesis and prosthetic loosening.

The aim of this study was to present our experience of using a modular megaprosthesis for reconstruction of the elbow both after tumour resection and after failed previous osteosynthesis or conventional prosthesis. Functional outcome, rate of complications and oncological results were considered as primary endpoints.

Patients and methods

A consecutive case series of 36 patients who underwent reconstruction of the elbow joint with a modular megaprosthesis between 1999 and 2015 was reviewed retrospectively. All patients included had extensive bone loss of the distal humerus or proximal ulna in which the bone stock was insufficient for conventional elbow prosthesis. There were 14 males and 22 females with an average age of 60.1 years (range 11–84 years) in the study. In 31 patients (86.1%), elbow replacement was performed after resection of a bone tumour. The stage and extent of the tumours were assessed preoperatively using plain radiographs, CT scan, MRI and scintigraphy. PET scan was performed only in patients treated after the year 2010. The histological features of the tumour location and the extent of bone destruction dictated the indications for resection.

A total of 19 patients (52.8%) presented with metastatic disease and either an impending fracture (17 patients) or pathological fracture (two patients). The close localisation to the joint did not enable a more conservative approach as curettage or cement augmented osteosynthesis.

Five patients (13.9%) suffered a primary bone tumour (two osteosarcoma, one high-grade chondrosarcoma, one fibrosarcoma, one low-grade osteosarcoma). There were also two plasmacytomas (5.5%), two giant cell tumours (5.5%) and three soft tissue sarcomas (8.3%) involving the distal humerus in the oncological group.

Five non-oncological patients (13.9%) underwent surgery because of a previous failed elbow reconstruction: four patients (11.1%) because of insufficient osteosynthesis or aseptic loosening of a conventional elbow prosthesis; one patient with Ewing's sarcoma was initially treated with an intercalary resection and vascularised fibula graft, but development of pseudarthrosis and consecutive pathological fracture necessitated a total humerus replacement with latissimus dorsi flap coverage.

A more detailed overview of all patients included is shown in Table 1.

Surgical technique

A lateral surgical approach was used in all elbow resections. Except for in total humerus replacement, the incision was prolonged into a delto-pectoral approach proximally. The radial nerve was identified and preserved between the brachial and brachioradial muscles. After the osteotomy of the distal humerus or proximal ulna and the mobilisation of the surrounding tissues, the resection of the tumour was completed protecting the ulnar nerve. An HMRS megaprosthesis (Howmedica International, Limerick, Ireland) was used in 24 cases (66.7%) while a Discovery-SRS prosthesis (Biomet Orthopedics, Warsaw, Indiana, USA) was implanted in 12 cases (33.3%). Both implants are a constrained hinged implant. In three patients (8.3%), a total humerus replacement was necessary for reconstruction.

Passive mobilisation of the elbow was allowed immediately after surgery and active physiotherapeutic training was started after complete wound healing.

Follow up

All patients were followed clinically and radiologically and surgical complications were registered. Patient survival, metastasis, and local recurrence were also recorded in the oncological group. The Musculoskeletal Tumor Society (MSTS) score and Mayo Elbow Performance Score (MEPS) were used to evaluate functional outcome at the final follow-up [20,21]. An overview of both grading systems is shown in Tables 2 and 3.

Results

In the present study, the mean overall follow-up was 25 months (range: 2–204 months).

Oncological result

Out of 19 patients treated for a metastasis, 14 died due to systemic progression of disease. The remaining five patients showed no evidence of disease at the final follow-up.

Two of the five patients with primary malignant bone tumour (one osteosarcoma and one low-grade osteosarcoma) were alive at the final follow-up, the other three patients died after developing distant metastases (fibrosarcoma, osteosarcoma and high-grade chondrosarcoma). Both patients with a soft tissue sarcoma involving the distal humerus and with plasmacytoma died because of systemic progression of disease after a short follow-up of 10 months. The two patients diagnosed with giant cell tumour showed no local recurrence.

Although this is a very heterogeneous group of patients with a wide spectrum of histological diagnoses, the localisation around the elbow seems to be associated with poor outcome. Considering all patients together, the overall 5-year disease-associated survival was only 25.1% (95%CI: 8.8–45.4%) (see Fig. 1).

Functional result

The mean MEPS was 78.2 (range: 45–95). The achieved functional result was graded as excellent in six patients (16.7%), good in 18 (50%), fair in eight (22.2%), and poor in four (11.1%). There was no difference in MEPS between the oncological and non-oncological patients ($p = 0.366$).

The range of motion of the elbow joint was more than 100° in 24 patients (66.7%), between 50° and 100° in eight patients (22.2%) and less than 50° in four patients (11.1%). Shoulder abduction was poor in all three patients who underwent a total humerus replacement: two patients achieved an active abduction of 45° and one patient had no active abduction function at all.

The MSTS score was evaluated in all patients ($N = 31$) in whom the elbow had to be replaced following a tumour resection. The mean MSTS score was 23.4 (range: 8–30; 76.7% of maximal

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