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ORIGINAL STUDY

Custom-made endoprosthetic reconstruction of the distal humerus for non-tumorous pathology

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Eight patients underwent custom-made endoprosthetic elbow reconstruction between 1989 and 2006 either for failed primary total elbow replacements or following complex fracture complications. A functional assessment using the Toronto Extremity Salvage (TES) score was performed. Patients were followed for a mean of 46.1 months (range : 25 to 88). One patient who presented with an infected periprosthetic fracture around a total elbow replacement, failed two-stage reconstruction and underwent excision arthroplasty. The remaining seven patients were available for functional follow-up. Average flexion deformity was 15° (range : 7 to 35) and average flexion arc was 85° (range : 70 to 130). The mean TES score was 67.3 (range : 36.6 to 95.9). Custom made endoprosthetic reconstruction allowed for a satisfactory outcome in all but one of these eight patients with severe bony destruction around the elbow in the absence of tumour infiltration.

Keywords : elbow ; prosthetic reconstruction ; custom made ; non-tumorous.

INTRODUCTION

Custom-made endoprosthetic reconstruction around the elbow joint is rarely performed, reflecting the low incidence of tumours occurring in this region (*7*). Extensive bony destruction of the distal humerus is most commonly related to tumour infiltration, although severe fractures and failed total elbow replacements can also be responsible (*1,8*). Allograft reconstruction and endoprosthetic reconstruction remain the only viable treatment options when considering meaningful limb salvage. Dean *et al* reported a high complication rate with the use of allograft reconstruction in the treatment of predominantly non-oncological conditions and suggested that it should not be recommended for routine use (*1*). Whichever method is employed, pain control and restoration of upper limb function are the primary functional goals of treatment.

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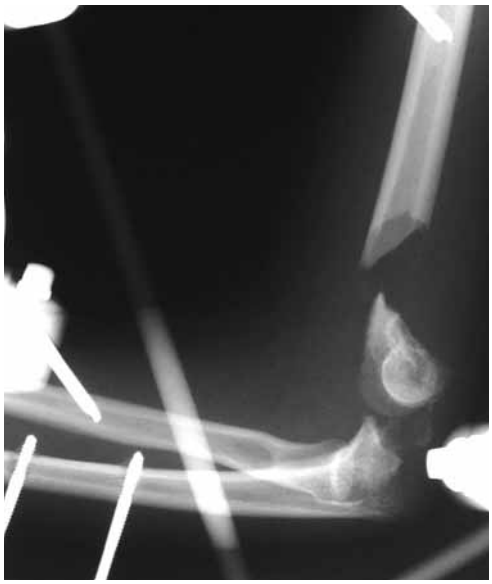

Fig. 1. — Complex distal humeral fracture with significant bone loss.

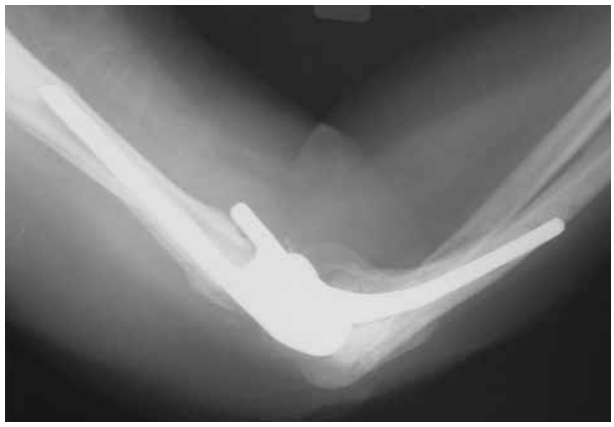

Fig. 2. — Failing total elbow replacement with loosening of both components. Significant bone loss was encountered on the humeral side during revision surgery.

The ability to reconstruct large bony defects following tumour resection (*2,4,8,10*) has resulted in the extended use of custom-made endoprostheses for a variety of non-oncological conditions in our unit. There are few reports in the literature describing this method of treatment, with only one report describing replacement for non-tumourous conditions (*8*). We herein review our experience with custom-made endoprosthetic replacement around the elbow joint for the treatment of complex fractures and failed total elbow replacements.

PATIENTS AND METHODS

All patients who had undergone custom-made endoprosthetic reconstruction around the elbow joint for non-tumorous conditions between 1989 and 2006 were identified using our unit's database. The study group consisted of 8 patients (4 males and 4 females), with a mean age of 48.9 years (range : 22 to 66). There were 5 fracture complications (fig 1) and 3 failed total elbow replacements (fig 2). Patient demographics and treatment are shown in table I.

A distal humeral prosthesis was used in 6 patients and a distal humeral and proximal ulna prosthesis in 2 patients. The distal humeral endoprosthesis was designed by Stanmore Implants (Worldwide Ltd, BME, Stanmore, UK). The construct was a constrained, hinged prosthesis with a proximal ulna component as required (fig 3).

In all cases a posterior approach to the elbow joint was made retaining a cuff of triceps tendon for prosthetic

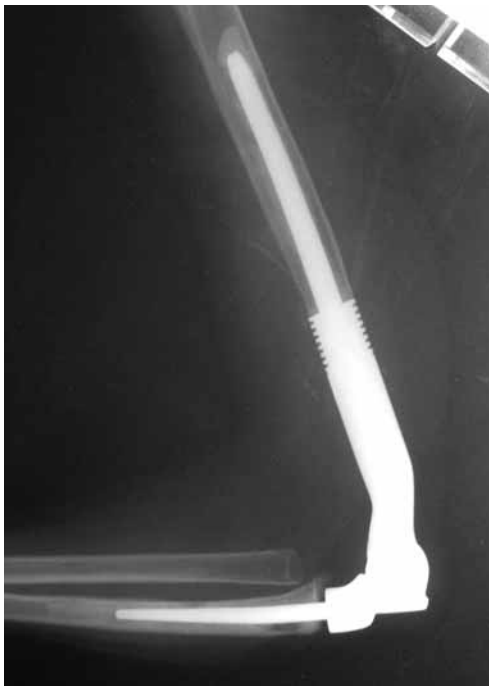

Fig. 3. — Custom-made distal humeral and proximal ulna prosthesis.

Table I. — Study demographics

Patients	Diagnosis (years)	Age	Gender	Prosthesis	Complications	Further surgery (Months)	Follow-up (%)	TES score
Fracture complications								
1	Acute fracture with bone loss	22	F	DH			59	62.5
2	Periprosthetic fracture	66	F	DHPU			48	36.6
3	Malunion	26	M	DH			32	80.3
4	Acute fracture with bone loss	42	M	DH			32	70.9
5	Infected non-union	58	M	DH			25	70.9
Failed Total Elbow Replacement								
1	Infection	57	M	DH			88	95.9
2	Infection and fracture	56	F	DHPU	Prosthetic infection	Excision arthroplasty		
3	Loosening	64	F	DH			39	54.3

DH – Distal Humeral
DHPU – Distal Humeral and proximal ulna.

coverage and to maintain the extensor mechanism. In most cases humeral resection preceded ulna resection and both components were cemented. In the previously infected group (one infected non-union and two infected total elbow replacements), a two-stage protocol was employed with initial removal of infected tissue and implants and second stage reconstruction following a minimum six-week period of intravenous antibiotics, and once the patient's inflammatory markers normalised. Active movements were withheld until there was satisfactory evidence of wound healing, with early institution of passive motion.

Clinical and radiographic review of all available patients, including a functional assessment with the Toronto Extremity Salvage (TES) score was undertaken. The TES score has been validated for use in upper extremity limb salvage and has been used by other authors reporting on this method of treatment (*2,4*).

RESULTS

Table I shows the various treatments and outcomes for all patients.

The average follow-up was 46.1 months (range : 25 to 88). Seven patients were available for functional follow-up. There were no cases of permanent nerve palsy. Average flexion deformity was 15° (range : 7 to 35) and average flexion arc was 85° (range : 70 to 130). The mean TES score was 67.3 (range : 36.6 to 95.9).

Fracture

Five patients required reconstruction for fracture related problems. There were 2 cases of a severely communited fracture with extensive bone loss, 1 case of infected non-union of a vascularised fibular graft performed for previous fracture non-union and 1 case of symptomatic malunion. The patient with the malunion was treated conservatively for a distal humeral fracture outside the UK and presented with a rotationally malaligned arm, with significant stiffness and pain arising form the elbow joint. We offered him a corrective osteotomy, but he preferred the concept of replacement. There was 1 case of periprosthetic fracture around a previous total elbow replacement. This patient had the worst outcome (TES : 36.6). The combination of poor bone stock and a poor soft-tissue envelope resulted in functional restriction and pain, although without evidence of component loosening at final follow-up.

Failed total elbow replacement

Three patients required custom implants for failed total elbow replacements. Two patients presented with infection and loosening. Both patients underwent revision (2-stage for infection) to a

custom-made prosthesis, with a good functional outcome (TES scores : 95.9 and 54.3). The third patient presented with a dual problem of infection and periprosthetic fracture. This patient had undergone two previous total elbow replacements for rheumatoid arthritis and loosening. She underwent two-stage revision which was complicated by further deep infection. Attempts at a further two-stage revision were halted after the first stage with unremitting sepsis. An excision arthroplasty was performed.

DISCUSSION

The indications for endoprosthetic reconstruction around the elbow should include not only malignant disease but also fracture-related complications and failed total elbow replacements, where excision arthroplasty or amputation remains the only surgical alternative. Few published articles address endoprosthetic replacement for non-oncological conditions (*8*). Dean *et al* (*1*) described allograft reconstruction of the elbow for 23 patients with post-traumatic disability and failed total elbow replacements, including one patient with a tumour. There were 16 complications with six cases of elbow instability and seven cases of non-union (*1*).

Endoprosthetic reconstruction for tumours has been reported successfully in carefully selected patients in a few small case series, reflecting the rarity of tumours around the elbow (*2,4,8*).

Ross *et al* (*8*) described 26 patients with destructive malignant and benign lesions of the distal humerus treated with resection, including total humeral resection and custom-made endoprosthetic reconstruction. The study group included 12 patients with fractures or failed total elbow replacements, 9 patients with high-grade malignancy (only one with metastases) and 5 patients with low-grade malignancy. Deep prosthetic infection was observed in three patients with previous compound fractures. No amputations were necessary although treatment outcome was not reported. Nerve injury was common in patients undergoing total humeral reconstruction. Nevertheless a useful range of motion, with a stable arm and good hand function was achieved in each case (*8*).

Outcome following distal humeral fracture in the elderly is historically poor, with bone quality precluding rigid osteosynthesis and a high rate of non-union and posttraumatic osteoarthrosis. Primary noncustom total elbow replacement in elderly patients has been reported with good success, but relies on smaller defects not requiring extensive distal humeral resections (*3,6*). In these circumstances allograft-prosthetic composites and custom endoprosthesis offer potential for reconstruction.

Complex acute fractures in young patients with extensive bone loss pose significant challenges to the orthopaedic surgeon. In this study, the patient with significant bone loss (fig 1), preferred the concept of replacement, as opposed to alternative options, such as Ilizarov external fixation and extensive grafting procedures.

When faced with non-union, further internal fixation and bone grafting or the use of circular external fixators have yielded good results although almost exclusively in younger patients. The treatment of infected non-unions can be challenging and often requires the use of prolonged external fixation (*9*). Treating these patients with two-stage reconstruction with a custom prosthesis offers an alternative to a difficult problem.

Total elbow replacement for arthritic conditions at the elbow is becoming increasingly common. Failure due to loosening and infection can lead to osteolysis and a reduced availability of sufficient bone stock for successful revision surgery. Very little has been documented in the literature, with Loebenberg *et al* (*5*) reporting reasonable results in a small series of 12 patients utilising an impaction grafting technique similar to that used in revision hip surgery. We treated three patients in this series with custom replacement, with two patients demonstrating good functional outcomes. Preservation of bone stock is clearly preferential, and studies involving larger numbers of patients will identify the role of impaction grafting as a salvage procedure for the failing total elbow replacement.

The weakness of this study relates to its retrospective analysis. The outcome measures, specifically the Toronto Extremity Salvage Score utilises parameters common to most elbow scoring systems, but has been validated in salvage reconstruc-

tion for the upper limb (*4*). We decided to use this measurement as all patients in this study were faced with either excision arthroplasty and a flail arm, or an amputation.

Whilst an accepted form of treatment following extensive resection around the elbow for tumourous conditions, the role of endoprosthetic reconstruction for non-tumourous conditions has not been evaluated in the literature. We have shown that good results can be achieved with this form of treatment. The one failure in this series related to unremitting infection. All patients embarking on this treatment should be warned of the possibility of excision arthroplasty and amputation in the presence of complications.

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