ENDOPROSTHETIC REPLACEMENT OF THE HUMERUS AND ELBOW JOINT

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Between 1969 and 1985 26 patients with destructive lesions of the distal humerus were treated by endoprosthetic replacement; each implant was custom-made and incorporated part of the distal humerus or the entire bone as well as a hinged total elbow replacement.

Recurrence occurred in three of the patients with tumours, and three prostheses were removed because of deep infection in patients with previously compound injuries of the elbow. Another three loosened without infection, but none needed revision or removal and no amputations resulted. Other complications included nerve palsies, but the only deaths were from metastases. A useful range of elbow movement, with a stable arm and good hand function, was achieved in every patient.

Destruction of a large part of the distal humerus may be caused by injury, rheumatoid arthritis, tuberculosis, tumour or failed total elbow replacement and can result in a flail elbow and a disabled hand. If there is minimal bone loss, the elbow may be treated by arthrodesis (Koch and Lipscomb 1967), by excisional or interpositional arthroplasty (MacAusland 1947; Hurri, Pulkki and Vainio 1964) or by total joint replacement (Lenggenhager 1958). If, however, a large portion of the humerus has been destroyed, these methods are seldom applicable. The choice is then between a difficult arthrodesis, which produces a "serviceable elbow" (Enneking 1983); hemiarthroplasty replacing either the distal humerus (Mellen and Phalen 1947; Venable 1952; Barr and Eaton 1965; Kestler 1970; Dunn 1971) or the proximal ulna (Johnson and Schlein 1970); allografting (Mankin, Doppelt and Tomford 1983; Urbaniak and Black 1985); or endoprosthetic replacement incorporating a total elbow joint (Scales, Lettin and Bayley 1977; Yoshimoto, Kaneko and Tatematsu 1977). Alternatively the flail elbow may be supported by an external orthosis.

In response to this problem a custom-made prosthesis incorporating a hinged total elbow joint was

Fig. 1

Fig. 2

Fig. 3

Figure 1 - Pre-operative radiograph of a comminuted fracture which failed to unite. Figure 2 - The prosthesis used to replace the distal humerus and elbow joint. Figure 3 - The postoperative radiograph showing the prosthesis in situ.

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developed at the Royal National Orthopaedic Hospital in 1969 (Scales et al. 1977). Since then another 25 patients have been treated, and we report the results.

PATIENTS AND METHODS

The clinical records and radiographs of 26 patients with an endoprosthetic humeral replacement incorporating a hinged elbow joint were reviewed. Information taken at

regular clinic attendances was also retrieved and studied, and patients living abroad were reviewed by their local doctor; in this way, no patient was lost to follow-up. The duration of follow-up was defined as the length of time the prosthesis had survived in a living patient, and ranged from four months to 16 years (mean 4.5 years).

Three patterns of replacement had been undertaken. Eleven patients had between 35 and 217 mm of the distal humerus resected and replaced by a titanium or titanium-alloy prosthesis with a hinged total elbow replacement (Figs 1 to 3). Six patients had

later; the other had a local recurrence which resolved with chemotherapy and irradiation but he also died eight months after replacement. The third had a spindle-cell sarcoma and died of metastases four months after operation. The remaining six patients showed no sign of recurrence. The mean follow-up for this group was 15 months (range 4 to 31 months).

Patients treated for low-grade malignancy. There were five patients in this group, four with low-grade chondrosarcomas and one osteoclastoma. The aim of surgery was complete curative resection of the tumour without resorting to amputation. Two patients died, one with Ollier's disease who developed two further metastatic chondrosarcomas but no local recurrence at the site of the original tumour; the second patient died after local and systemic recurrence of a chondrosarcoma requiring disarticulation of the shoulder joint. The three remaining patients showed no sign of recurrence at an average of 6.7 years after replacement (range four months to 15 years).

Patients treated for benign conditions. Twelve replacements had been carried out for conditions which rendered the arm flail. Nine had been for fractures around the elbow (six of them compound) resulting in substantial bone loss or non-union while the remaining three were for failed elbow replacements. No deaths occurred in this group. In the six patients with compound fractures, three prostheses were removed after deep infection, but no amputations were necessary. In the remaining patients there were two cases of aseptic loosening, but neither required revision, removal or

Figure 4 - Pre-operative radiograph of atrophic non-union. Figure 5 - Type of prosthesis used to replace the distal humerus, elbow joint and proximal ulna. Figure 6 - Postoperative radiograph.

between 23 and 163 mm of the distal humerus replaced as well as 60 to 90 mm of the proximal ulna (Figs 4 to 6). Nine patients had the whole of the humerus and elbow joint replaced (Figs 7 to 9).

RESULTS

Patients treated for high-grade malignancy. Nine patients had undergone endoprosthetic replacement for high-grade tumours: there were five osteosarcomas, one spindle-cell sarcoma, two liposarcomas and one isolated secondary deposit from an adenocarcinoma of the kidney. The aim of surgery was to control local disease without amputating a normal forearm and hand. Three patients died from metastases. Two of these three had had extensive osteosarcomas at the time of replacement: one patient had required a forequarter amputation for local recurrence after four months but died 20 months

Figure 7 - Radiograph of a chondrosarcoma. Figure 8 - Type of prosthesis used to replace the entire humerus and elbow joint. Figure 9 - Postoperative radiograph.

amputation. The mean follow-up for the entire group was six years (range 14 months to 13 years).

Type of replacement. *The entire humerus and elbow joint* were replaced in nine patients. Four had osteosarcomas, three had low-grade chondrosarcomas, one a myxoid liposarcoma and one a secondary deposit from an adenocarcinoma of the kidney. None of the prostheses loosened and there were no cases of deep infection. Postoperatively there was one superficial wound infection. Three patients developed a transient ulnar nerve palsy lasting less than two weeks but two of these (and two other patients also) had a severe radial nerve palsy. One of these patients died after four months from metastatic spread of an osteosarcoma. The other palsies had completely resolved within six months.

Postoperatively, active flexion, extension and abduction of the shoulder joint each ranged from 20° to 45° (mean 32°). Passive movements, with the exception of medial and lateral rotation (which were increased), were normal. Active elbow extension ranged from 0° to 45° (mean 17°), active flexion was from 70° to 135° (mean 107°), and the arc of movement ranged from 55° to 125° (mean 90°). The mean follow-up for this group was 21 months (range 4 to 70 months).

The distal humerus and elbow joint were replaced in 11 patients; there were seven old ununited fractures and four tumours (one osteosarcoma, one spindle-cell sarcoma, one liposarcoma and one osteoclastoma). Two deep infections occurred, both in previously compound fractures; the implants were removed at 14 and 48 months (one of these patients had also developed a sensitivity to cobalt and nickel). There was one superficial wound infection.

Aseptic loosening of the humeral stem occurred after 14 months in a third patient: one month after operation, the humeral and ulnar components dislocated and had to be reassembled at a further operation. The prosthesis was not removed and the patient continues to do heavy work using a flail arm in a splint. One patient developed radiological signs of slow osteolysis around the humeral stem without clinical evidence of loosening 11 years after operation.

Two nerve palsies occurred. One patient had a transient ulnar nerve palsy which lasted for two weeks. In the second patient, a densely adherent median nerve was damaged at operation and was repaired primarily; however, this patient died after four months with metastases from a spindle-cell sarcoma.

Postoperative elbow flexion ranged from 80° to 145° (mean 119°), fixed flexion ranged from 5° to 65° (mean 37°), and the arc of movement ranged from 55° to 140° (mean 82°). The mean follow-up for this group was 5.8 years (range four months to 15 years), and for the eight surviving prostheses 6.8 years (range 15 months to 15 years).

The distal humerus and proximal ulna were replaced in six patients, three with failed total elbow replacements, two

with massive elbow fractures, and one after excision of a chondrosarcoma. One prosthesis inserted late after a compound injury became infected and was removed after two-and-a-half years. Although painful aseptic loosening of the humeral component occurred in two patients after three and eight years respectively, neither was removed. Another patient had a transient ulnar nerve palsy which resolved completely.

Postoperative elbow flexion was from 100° to 140° (mean 115°), fixed flexion ranged from 5° to 60° (mean 35°), and the arc of movement was from 40° to 135° (mean 80°). The mean follow-up in this group was six years (range 2.5 to 10 years).

DISCUSSION

Certain criteria should be fulfilled if endoprosthetic replacement of the humerus and elbow joint is to be an acceptable method of treating destructive lesions of the distal humerus. The prosthesis itself must be strong enough to withstand normal use, it should allow a normal range of movement at the elbow (both in flexion-extension and in pronation-supination), it should accurately replace the length of the bones, and it should provide stable movement of the forearm and hand in all positions. The surgical technique for implantation should be as simple as possible, and fixation must be secure and long-lasting. The operation need not cater for possible salvage, since massive replacement is only indicated in patients for whom major reconstruction or amputation are the only alternatives.

When replacement is undertaken after the excision of a malignant tumour, the prognosis is related to the degree of malignancy provided that operation is uncomplicated. If the prognosis is poor, local disease may be controlled by wide excision and massive replacement followed by radiotherapy or chemotherapy. Amputation and major reconstruction are avoided and the quality of remaining life is improved. If a curative tumour resection is possible, replacement may be undertaken if sufficient soft tissue remains to cover the prosthesis adequately and sufficient muscle to move the elbow joint against gravity. If the tumour recurs locally, the resection may have been insufficient and consideration should be given as to whether amputation might have been preferable. Under no circumstances should massive replacement be undertaken where amputation offers a better prognosis. With benign lesions, the only entirely satisfactory outcome is an uncomplicated recovery resulting in a fully functional limb.

Few reports exist of alternative approaches to this problem, and, although isolated case reports have been published, we were unable to find a comparable series of prosthetic replacements. Urbaniak and Black (1985) have described their six-year experience with 10 cadaveric elbow allografts, all but one of which were performed for trauma. Significant complications oc-

curred in four patients; non-union of the humerus and elbow instability each occurred in two patients, and the radial nerve was damaged in a patient who had undergone five previous operations. A satisfactory result was eventually achieved in seven of their 10 patients.

There was local recurrence in 11.5% of our cases. We regard these as resulting from a failure to excise the primary tumour adequately. Although Enneking, Spanier and Goodman (1980) have classified primary chondrosarcomas as high-grade tumours, our patients were considered to have tumours of low histological grade, and it was thought that wide local excision would give an adequate margin of resection.

Infection and aseptic loosening each occurred in 11.5% of patients. Deep infection required removal of the prosthesis which, in each case, had been implanted in an attempt to treat severe compound fractures. Aseptic loosening only occurred on the humeral side of the prosthesis. We attribute the absence of loosening on the ulnar side to the lack of rotatory constraint at the shoulder; this allows passive movement in response to the torque applied across the elbow when lifting (Souter 1977).

Nerve palsies occurred in 31% of cases, usually when the whole humerus was resected. These all recovered eventually. Because the ulnar nerve is particularly susceptible to traction injury, we would caution against inadvertent traction on the arm. The presence of extensive scarring also increases the risk of direct nerve injury.

After operation, a full range of passive movement was retained and was of functional use to the patient. The overall average flexion arc at the elbow was 85°, which is much better than an amputation, a flail limb or an arthrodesis. Pronation and supination were full unless restricted pre-operatively, and pain occurred only when the prosthesis was loose. However, shoulder movement was poor when the proximal humerus had been replaced due to the loss of the rotator cuff and the insertion of the deltoid muscle.

It seems that endoprosthetic replacement is an effective way of replacing the humerus and elbow joint when a large osteoarticular segment has been destroyed. The operation is not without technical difficulties; postoperative nerve palsies have occurred frequently in the past and loosening may occur eventually. Considerable caution should also be exercised in patients with a history of previous infection. Despite these problems, in

selected patients endoprosthetic replacement remains the only practical alternative to amputation.

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