Coonrad-Morrey total elbow arthroplasty for tumours of the distal humerus and elbow

We reviewed 20 patients who had undergone a Coonrad-Morrey total elbow arthroplasty after resection of a primary or metastatic tumour from the elbow or distal humerus between 1980 and 2002. Eighteen patients underwent reconstruction for palliative treatment with restoration of function after intralesional surgery and two after excision of a primary bone tumour. The mean follow-up was 30 months (1 to 192).

Five patients (25%) were alive at the final follow-up; 14 (70%) had died of their disease and one of unrelated causes. Local control was achieved in 15 patients (75%). The mean Mayo Elbow Performance Score improved from 22 (5 to 45) to 75 points (55 to 95). Four reconstructions (20%) failed and required revision. Seven patients (35%) had early complications, the most frequent being nerve injury (25%). There were no infections or wound complications although 18 patients (90%) had radiotherapy, chemotherapy or both.

The Coonrad-Morrey total elbow arthroplasty provides good relief from pain and a good functional outcome after resection of tumours of the elbow. The rates of complications involving local recurrence of tumour (25%) and nerve injury (25%) are of concern.

The elbow and distal humerus are uncommon sites for primary bone tumours or metastatic disease. Before the advent of limb-salvage surgery in the late 1970s, amputation was the primary treatment for malignant tumours of the upper limb. The outcome after reconstructive surgery improved with advances in imaging, staging and oncological treatments such that preservation of the upper limb with functional reconstruction has become the standard treatment for patients with bone tumours.

The options for reconstruction after excision of a bone tumour around the elbow are limited. Arthrodesis is often poorly tolerated and technically difficult because of the bone deficit after resection of a tumour. Excision arthroplasty is also rarely feasible because of the amount of bone which is required to be resected. Osteoarticular allografts have been used to address bone loss, but there is a high rate of complications.

Total elbow arthroplasty (TEA) has been used extensively for rheumatoid arthritis, osteoarthritis and trauma. It has also become the treatment of choice for most patients with tumours around the elbow or distal humerus. In primary bone and soft-tissue tumours, TEA may be used to restore function after limb-salvage surgery for cure. In metastatic disease after intralesional surgery, TEA may be used for palliation and to restore function. TEA provides good function and relief from pain with minimal post-operative immobilisation. Our aim was to determine the oncological and functional outcome and the complications of the Coonrad-Morrey TEA when used for the management of bone tumours involving the elbow and distal humerus.

Patients and Methods

Between 1980 and 2002, 21 patients underwent TEA after resection of tumours of the elbow and distal humerus. There were 12 men and nine women with a mean age of 66 years (38 to 83) at the time of surgery. One patient was lost to follow-up. All the remaining patients were followed for a minimum of 24 months or until death. The mean follow-up from TEA to the latest examination was 34 months (1 to 192) for all patients, 87 months (25 to 192) for the five who were alive at the time of this review and 16 months (1 to 60) for the 14 who had died from their disease. The early results in 11 of these patients have been previously reported. The present study, which had ethical approval, provides long-term follow-up on those patients and describes nine additional patients.

At our institution, patients undergoing TEA have regular clinical and radiological review at
two or three months after operation and at one, two and five years and each subsequent five-year interval until revision or death. Patients who are unable to return for evaluation are sent standardised letters or undergo telephone questionnaires. The accuracy and completeness of the database have been shown previously to be greater than 95%.11,12

The arthroplasty database allowed retrieval of details of the patients, the date of surgery, the type of implant and complications. A retrospective review of the medical

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<th>Patient</th>
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<th>Age (yrs)</th>
<th>Gender</th>
<th>Status</th>
<th>Presentation</th>
<th>Reconstruction*</th>
<th>Operating time (mins)</th>
<th>Complications</th>
<th>Mayo elbow performance score†</th>
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* CM, Coonrad-Morrey total elbow arthroplasty; APC, allograft-prosthetic-composite
† E, excellent; F, fair; G, good; P, poor
‡ failed internal fixation
records determined the mode of presentation, the site and nature of the tumour, the surgery which was undertaken, all subsequent procedures, the presence of metastases or local recurrence, adjuvant treatment and functional scores. The pre-operative, post-operative and most recent follow-up radiographs were reviewed for loosening, bearing wear, recurrence of the tumour and osteolysis. The Mayo Elbow Performance Score, which has subjective, objective and functional characteristics, was calculated pre-operatively and at the most recent follow-up in all patients.

The most common primary diagnoses were lymphoma (six patients) and metastatic renal-cell carcinoma (four patients); these and the remaining diagnoses are listed in Table I. Seventeen lesions were in the distal humerus and two in the olecranon. One patient had neoplastic involvement of both the distal humerus and proximal radius. The indications for surgery included pathological fracture with bone loss not amenable to intralesional curettage and open reduction and internal fixation in ten patients, failed previous open reduction and internal fixation for pathological fracture after intralesional curettage in seven, limb-salvage surgery for cure in one, wide resection of a recurrent benign aggressive tumour for cure in one and a painful distal humeral metastasis with extensive bone loss and impending fracture in one. In all, 18 patients underwent surgery with the primary goal of intralesional excision for palliation and restoration of function. Ten patients had radiotherapy before surgery and 11 had radiotherapy post-operatively. Twelve had chemotherapy before surgery and 11 chemotherapy post-operatively.

A standard linked semi-constrained Coonrad-Morrey TEA (Zimmer, Warsaw, Indiana) was used in 19 patients and a custom humeral component with an extended flange and a standard ulnar component in one. The Bryan-Morrey posteromedial approach was used in 11 patients, the triceps sparing approach in seven and the osteo-anconeus flap and triceps splitting approaches in one each. The ulnar nerve was identified in all patients and transposed anteriorly in 15. In one patient, it had already been transposed anteriorly in an earlier surgical procedure and in four the final location of the nerve had not been recorded.

Allograft-prosthetic composites were used in two patients and allograft struts in one. Sixteen patients (80%) had operations on the affected elbow before TEA. These included eight open biopsies, five attempted open reduction and internal fixations, one curettage with bone grafting, one Ender’s nailing and one failed internal fixation treated by debridement and a cement spacer.

Statistical analysis. This was performed using paired and unpaired t-tests and a p value of less than 0.05 was considered to be significant.

Results

Oncological. Five patients (25%), three with lymphoma, one with chondrosarcoma and one with recurrent giant-cell tumour, were alive at the time of review. All five were without evidence of recurrent disease at a mean follow-up of 87 months (25 to 192). All ten patients with metastatic disease around the elbow died at a mean of 19 months (4 to 65). In total, 14 patients (70%) died from their disease or because of treatment-related complications, such as adriamycin-induced cardiomyopathy or chemotherapy-induced febrile neutropenia. One patient died of unrelated causes. Twelve patients (60%) had generalised metastases at the time of presentation.

Five patients (25%) had local recurrence. Two with locally-recurrent metastatic renal-cell carcinoma had palliative treatment only. One with multiple subcutaneous metastases from renal-cell carcinoma presented with intermittent lesional haemorrhage and was treated by local excision. This patient subsequently sustained a pathological fracture of the proximal humerus which was treated by a proximal humeral allograft. One patient sustained a pathological periprosthetic fracture at the tip of the ulnar component because of a metastatic lesion (Fig. 1), which was probably due to intra-operative seeding of tumour cells down the ulnar canal. This was treated palliatively by radiotherapy and splinting. One patient with locally recurrent metastatic adenocarcinoma from the colon underwent an above-elbow amputation at another institution three months after TEA and died two months later. This represents a rate of amputation of 5%.

Functional. The pain scores improved in all patients from a mean of 2 (0 to 15) to 32 (15 to 45; p < 0.05). No patient had pain which was as severe as before surgery. At the final
follow-up, 15 patients (75%) had mild or no pain. The mean arc of movement of the elbow increased from 48° (0° to 95°) to 92° (35° to 135°; p < 0.05). The mean score for activities of daily living also improved from 3 to 17 (p < 0.05). The Mayo Elbow Performance Score improved in all patients from a mean of 22 (5 to 45) to 75 (55 to 95; p < 0.05; Table I). Of the six patients with lymphoma, two had excellent results (Fig. 2), two good and two fair. Of the ten patients with metastases, one had an excellent result, one good, seven fair and one poor. All patients with local recurrence had fair to poor results. At the final follow-up, three patients were bedridden and five required a wheelchair because of progression of metastatic disease and involvement of the lower limbs and spine.

Non-oncological complications. These occurred in ten (50%) patients (Table I). Seven (35%) had early and five (25%) had late complications either related to the prosthesis or to the allograft. Five patients (25%) had nerve injuries. One patient who sustained a 60% laceration of the ulnar nerve which was primarily repaired had persistent symptoms despite undergoing a subsequent neurolysis. Three patients had nerve palsy (one ulnar, one radial and one radial and ulnar) which resolved at a mean of four months (2.5 to 5). One patient with pre-operative intermittent symptoms in the ulnar nerve had constant paraesthesiae post-operatively. Other early complications included a case of an intra-operative split fracture of the ulna which healed uneventfully after cerclage wiring and one patient who developed a complex regional pain syndrome. Despite the chemotherapy and radiotherapy, there were no wound complications or infections.

Survival of the implant. Of the five patients who remained alive, two had stable implants with no signs of loosening, osteolysis or bearing wear at follow-up of 25 and 26 months, respectively. One who had wear of the polyethylene bushing but declined revision surgery at 16 years follow-up (Fig. 3). One patient, who had undergone allograft-prosthetic-composite reconstruction, required revision surgery because of nonunion at the allograft-host humeral junction with further bone grafting and revision internal fixation. The final patient had pain after a fall. The initial radiographs were reported as normal. She presented three months later with persistent pain and a periprosthetic fracture with a loose humeral component. She did well after revision of the humeral component with allograft strut augmentation.

Of the 15 patients who had died, 12 had stable components with no signs of loosening, osteolysis or bearing wear at a mean follow-up of 14.7 months (1 to 49). One who had undergone allograft-prosthetic-composite reconstruction required revision surgery for nonunion at the allograft-host humeral junction. Another sustained a fracture of the ulnar component which was revised 20 months after TEA and subsequently developed a triceps avulsion which was surgically repaired 22 months after TEA. He had a local recur-
rence in the olecranon at 36 months after TEA which was treated palliatively by radiotherapy until he died. One patient underwent an above-elbow amputation at another institution and radiographs were unavailable.

Discussion
Neoplastic disease around the elbow and distal humerus is exceeding rare.\(^7\)\(^-\)\(^{10}\) The efficacy of endoprosthetic replacement for tumours of the elbow and distal humerus has given surgeons a viable alternative to amputation, resection arthroplasty or arthrodesis.\(^7\)\(^-\)\(^{10}\) Patients are typically offered adjuvant therapy and various reconstruction options, such as TEA with standard components, allograft-prosthetic-composites, custom-made megaprostheses and modular segmental tumour implants.

In 1987, Ross et al\(^7\) described 14 patients with elbow and humeral endoprosthetic replacements after resection of a tumour, as part of a series of 26 patients with both benign and malignant causes of bone loss. In all cases a custom implant was used with varying lengths of humeral and ulnar components. In nine patients the primary procedure was total humeral replacement and in only five was elbow replacement undertaken for tumours of the distal humerus or elbow. Complications included nerve palsy and infection, occurring in 31% and 11.5% of patients, respectively.

Kulkarni et al\(^9\) described ten patients who underwent TEA for tumours of the distal humerus. Five had sarcoma, two plasmacytoma, two metastasis and one a giant-cell tumour. All the implants were custom modifications of the Stanmore elbow replacement (Stanmore Implants, Stanmore, UK) which is a constrained, linked implant. Of the six patients available for follow-up, all had satisfactory function and relief from pain. Three underwent revision for aseptic loosening of the humeral component and three subsequently required replacement of the polyethylene bushings. Impressively, there were no complications of infection, and no cases of nerve palsy or local recurrence of the tumour.

Weber et al\(^10\) described 11 patients who had undergone segmental TEA as part of a series of 23 distal or total humeral replacements. This series has the greatest number of patients treated by resection of a tumour and TEA with the intention of cure. There were several different designs of TEA with both standard and custom-made components. The site of the tumour was described as the diaphyseal humerus in 12, soft tissue in four and distal humeral or olecranon in seven. Local control was achieved in 74% of patients and 96% had marked improvement in their pain. Of the 11 patients with segmental arthroplasties, five were available for follow-up at a mean of 36 months and had a mean arc of movement of 107°. They reported an early complication rate of 35% with the most frequent complication being nerve injury (17%). They also reported an infection rate of 9%.

Our series is the largest reported of distal humeral and elbow tumours treated by TEA. The most common presentation was a pathological fracture (90%) and pain (100%); 12 patients (60%) also had generalised metastases. Post-operatively, all patients had marked relief from pain and improvement in function. Seven (35%) had early complications, the most common being nerve injury (25%). The ulnar nerve was most frequently injured (four patients) followed by the radial nerve (two patients). Both radial nerve and two of the ulnar nerve injuries resolved. The intra-operative partial laceration of the ulnar nerve occurred as the nerve was being dissected from dense scar tissue by an experienced microsurgeon. This rate of nerve injury is similar to that previously reported\(^7\)\(^-\)\(^{10}\) and we suggest that the high rate is because of the altered anatomy secondary to pathological fracture, pre-operative irradiation and previous surgery.

Three of four patients with metastatic renal-cell carcinoma and both patients with metastatic adenocarcinoma had local recurrence of tumour. This is a recurrence rate of 25%, which is similar to that previously reported.\(^10\) Renal-cell carcinoma has a particularly aggressive biology which predisposes to local recurrence, and to a poor outcome.\(^10\) In our series, it is difficult to determine whether the aggressive nature of the metastatic tumours or the quality of the resection resulted in the recurrence. However, in the patient with recurrence of tumour associated with a pathological ulnar fracture (Fig. 1), it is most likely that a breach in technique, with seeding of tumour cells down the intramedullary canal, led to the recurrence.

Subjectively, patients with metastatic disease initially had better function and relief from pain. However, as their disease progressed they became more incapacitated and their performance scores declined. Calculation of interim scores was hampered by the limited life span of the patients with metastatic disease. At the final follow-up, 60% of patients with metastases could not walk independently. We have previously reported that patients with primary bone tumours around the elbow had better scores than those with metastatic lesions.\(^8\) The present, more comprehensive data do not support this statement, and we conclude that both groups have similar scores and complications.

Most reports describe the use of modular tumour or custom-made segmental implants.\(^7\)\(^-\)\(^{10}\) Our series shows that a standard system, with variable sizes and interchange of components, addresses most resections of tumours of the distal humerus and elbow with comparable outcomes. It is beyond the scope of our study to determine whether one technique of reconstruction is better than another. However, in a patient with a limited life span it would seem appropriate to use a simpler, quicker and more cost-effective implant.

In our series, there were no infections or wound complications, although 18 patients (90%) had radiotherapy, chemotherapy or both. This finding was unexpected, and indicates that peri-operative radiotherapy and/or chemotherapy is not necessarily detrimental to wound healing.
around the elbow. Conversely, the small number of patients in our series may not be indicative of the true rate of infection, although Kulkarni et al\textsuperscript{9} had no infections in their series, nor did Ross et al\textsuperscript{7} in their reconstructions for tumour.

Standard TEA provides significant relief from pain and improved function after resection of tumours of the elbow and distal humerus. The oncological and non-oncological outcome using the Coonrad-Morrey system is comparable to that of previous series\textsuperscript{7,9,10} using modular tumour prostheses and custom-made segmental implants.

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References