Total elbow arthroplasty for non-rheumatoid patients with a fracture of the distal humerus

A MINIMUM TEN-YEAR FOLLOW-UP

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Aims
We review our experience of Coonrad-Morrey total elbow arthroplasty (TEA) for fractures of the distal humerus in non-rheumatoid patients with a minimum of ten years follow-up.

Patients and Methods
TEA through a triceps splitting approach was performed in 37 non-rheumatoid patients for a fracture of the distal humerus between 1996 and 2004. One patient could not be traced and 17 had died before the tenth anniversary of their surgery. This left 19 patients with a minimum follow-up of ten years to form the study group. Of these, 13 patients were alive at the time of final review. The other six had died, but after the tenth anniversary of their elbow arthroplasty. Their clinical and radiological data were included in the study.

Results
The mean follow-up of the 19 patients was 156 months (120 to 210). Two patients in the study group had undergone revision. One further patient had undergone a two-stage revision for infection but died before ten-year follow-up. Six other patients in the study group had evidence of loosening or wear of their bushings. Two were clinically symptomatic and were offered revision surgery. Male patients showed higher incidence of loosening and wear.

Survivorship, with revision and definite loosening as end-points, was 89.5% at ten years in those patients followed for a minimum of ten years and 86% in the whole group of 36 patients.

Conclusion
This study shows that only 53% of non-rheumatoid patients who undergo TEA for a fracture of the distal humerus survive to the tenth anniversary of their index procedure. For those that survive, TEA provides acceptable outcomes in terms of function and implant survival.

Take home message: The surgeons undertaking these procedures should be aware of the long-term revision rates and also the gender difference in the rates of loosening.

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Osteoporotic fractures of the distal humerus are likely to become more common as the population ages.1 Although rigid internal fixation with early mobilisation is the preferred technique for managing these fractures, this is often difficult to achieve in the elderly owing to a combination of osteoporosis and comminution of the fracture. Cobb and Morrey2 were the first to advocate the use of total elbow arthroplasty (TEA) in this situation and since then, a number of publications have reported the early and mid-term results of this procedure.3-8 However, data relating to longer term outcomes are limited.9 To date, there has been no published study with a minimum ten-year follow-up of TEA for fractures of the distal humerus in non-rheumatoid patients.

We report our experience of TEA using the Coonrad-Morrey prosthesis for fractures of the distal humerus in non-rheumatoid patients. The minimum follow-up was ten years.

Patients and Methods
Between 1996 and 2004, 37 non-rheumatoid patients with a mean age of 72 years (40 to 85) underwent Coonrad-Morrey TEA (Zimmer, Warsaw, Indiana) for a fracture of the distal humerus. Of these, 17 had died before the tenth anniversary of their surgery and one was lost to follow-up: these were excluded leaving 19 patients in the study group. Their mean age was 68 years (40 to 85) and all but one was over the age of 60 at the time of surgery. The
one remaining patient was 40 years of age and underwent TEA for a complex fracture with pre-existing osteoarthritis of the elbow. In most cases, fractures were complex and intra-articular (type C according to the AO classification) full demographic information and details of fracture types are given in Table I.

Of those who survived to ten years, 13 had clinical and radiological data at final follow-up. The other six patients had died, but with at least ten years’ follow-up. While these patients are included in the survival analysis, their clinical and radiological data are not presented.

Operative technique. All patients underwent surgery in the lateral decubitus position under high-arm tourniquet. A posterior skin incision was used and thick subcutaneous flaps were raised to the mid-lateral line medially and laterally. The ulnar nerve was decompressed superficially and left in its bed rather than transposed. A triceps-splitting approach was used to gain access to the joint in all cases. We use this approach as we have found that it makes accurate preparation of the humeral and ulnar canals easier and enables precise placement of the implants, while allowing excision of the fracture fragments. We do not excise the radial head unless it is fractured so as to preserve the proximal radio-ulnar joint.

Following exposure and preparation of the canal, trial implants were inserted to confirm correct alignment of the prosthesis and to ensure that there was no pistoning of the components during flexion and extension of the elbow. If pistoning was present, the axis of rotation was deemed incorrect and the position of the implants adjusted. With the trial components in place, a careful examination was undertaken to exclude impingement during flexion and extension, as this results in rapid aseptic loosening and early failure.

After trial reduction, a bone fragment from the excised distal humerus was inserted into the humeral canal to act as a cement restrictor. The appropriately sized humeral and ulnar components were then cemented in place.

The implant has remained similar throughout the series apart from the surface finish, which had a polymethylmethacrylate (PMMA) pre-coating between 1995 and 2000, and was plasma-sprayed from 2000 onwards.

Having inserted the prosthesis, the triceps mechanism was carefully reconstructed to the olecranon using intra-osseous Ethibond sutures before closing the skin and soft tissues.

Post-operatively, with the elbow in extension, a plaster backslab was applied for 48 hours to allow the soft-tissue swelling to settle. A lighter dressing was then applied, and the patient encouraged to carry out gentle active flexion and extension exercises.

Clinical and radiological review. Clinical review of the surviving patients was undertaken using the Mayo Elbow Performance Score (MEPS), Oxford elbow score and a visual analogue score (VAS) for pain. Pre-operative radiographs were evaluated to classify the presenting fracture pattern. A review of the immediate post-operative anteroposterior (AP) and lateral radiographs at follow-up were inspected for evidence of loosening, implant failure and wear of the bushings. The degree of peri-prosthetic radiolucency was graded from zero to four as described by Morrey et al, with types 0 and 1 indicating a radiolucent line < 1 mm thick involving < 50% and > 50% of the interface respectively; type 3 indicating a radiolucency > 2 mm thick involving the whole interface, and type 4 indicating gross loosening. Wear of the bushings was measured on an AP radiograph with the elbow in maximal extension using the previously described Mayo clinic criteria. Statistical analysis. Kaplan–Meier survival analysis was performed for the entire group and for patients who had survived for at least ten post-operative years. The primary end point was revision for all causes; secondary end-points included the presence of definite loosening (Morrey types 3 and 4) and bushing wear, and the presence of possible loosening with bushing wear.

Gender differences in loosening/bushing wear were compared using the chi square test. A p-value < 0.05 was considered to be significant.

Results

Complications, revisions and re-operations. Early complications occurred in five patients, three of whom survived to ten years. Two patients suffered a radial neurapraxia. In one patient (who was in the study group) this recovered fully within six months of surgery. In the other (a patient who died within ten years of surgery) there was only partial recovery. Symptomatic heterotopic ossification occurred in three

<table>
<thead>
<tr>
<th>Table I. Patient demographics</th>
<th>Minimum ten-year follow-up group (study group)</th>
<th>Whole series</th>
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<tr>
<td>N</td>
<td>19</td>
<td>36</td>
</tr>
<tr>
<td>Male:female</td>
<td>7:12</td>
<td>10:26</td>
</tr>
<tr>
<td>Mean age (range) (yrs)</td>
<td>68 (40 to 80)</td>
<td>72 (40 to 85)</td>
</tr>
<tr>
<td>Mean follow-up (range) (mths)</td>
<td>156 (120 to 210)</td>
<td>112 (24 to 210)</td>
</tr>
<tr>
<td>Fracture type (AO)</td>
<td>A3</td>
<td>B1 and B3</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>2 and 3</td>
</tr>
<tr>
<td></td>
<td>C1 and C3</td>
<td>4 and 6</td>
</tr>
<tr>
<td>Ulna component type</td>
<td>PMMA pre coat</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>Plasma spray</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td></td>
<td>18</td>
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In the study group, two patients had undergone revision surgery by the time of final assessment. One patient (case one) was revised for type 3 aseptic loosening of the humeral component at 104 months (Fig. 1) and another patient (case five) underwent an exchange of bushings at 116 months (Fig. 2). One other patient, who had died from unrelated causes before the ten-year review, had previously undergone a revision for infection.

With revision as the end-point, implant survival was 89.5% at ten years in those patients followed for a minimum of ten years, and 86% of those who had died or been lost to follow-up within ten years were included (Figs 3 and 4).

**Clinical outcome.** The median MEPS was 90 (50 to 95); excellent in six patients, good in six and fair in one. The fair outcome (50 points) was reported by a patient with a loose humeral component who is awaiting revision surgery. On a visual analogue scale of zero to ten the median pain score was one (0 to 5; interquartile range (IQR) 3). The median Oxford elbow score was 40 (16 to 48; IQR 11). The mean range of flexion was from $34^\circ$ ($0^\circ$ to $90^\circ$) to $118^\circ$ ($110^\circ$ to $140^\circ$).

At final review none of the 13 surviving patients had any clinical evidence of ulnar nerve dysfunction. All 13 patients had MRC grade four to five triceps muscle power. On reviewing the records of the six patients who had died with a minimum ten-year follow-up, we could not identify any evidence of ulnar nerve dysfunction or triceps muscle weakness.
Radiological outcome. Six patients (31.5%) in the study group had radiological evidence of loosening of the prosthesis or wear of the bushings. One patient had an isolated type 2 humeral component radiolucency and one had an isolated type 3 ulnar radiolucency. As described above, one patient (Case 16) had a type 4 humeral loosening and a type 0 ulnar radiolucency, and is awaiting revision surgery. The radiographs of the remaining three patients were suspicious of bushing wear; one patient also had a type 0 ulnar radiolucency.

Of the patients with evidence of loosening or bushing wear, five had a PMMA pre-coat ulnar component and three had a plasma-sprayed component. Both the patients who were revised had a plasma-sprayed ulnar component: the patient awaiting revision has a PMMA pre-coat ulnar component.

Although there were six patients with some radiological evidence of loosening or wear of the bushings, only two were symptomatic (case 16 and 17). Both patients had radiological evidence of definite loosening (types three and four) and both were offered revision surgery, although one declined. Inclusion of these patients in the survival analysis did not alter the implant survival at ten years as these patients had a follow-up of 182 and 192 months, respectively (case 16 and 17). Beyond ten years, inclusion of these patients alters the subsequent survivorship as shown by the Kaplan-Meier curve in Figure 5. Including all patients with any radiological signs of loosening or bushing wear further modifies the survivorship curve (Fig. 6).

No evidence of radiological loosening was seen in the other 11 patients (Fig. 7, case 11). Loosening and wear of bushings were more common in men (p = 0.04): five out of seven men (71%) and three out of 12 women (25%) showed some radiological signs of loosening and or possible wear of the bushings.

Review of the radiographs of the 17 patients who had died before ten-year follow-up revealed type 1 loosening of
the ulnar component in one patient at 74 months. Another patient had type 0 humeral and type 1 ulnar loosening at 96 months. Review of these patients’ case notes suggested that they were clinically asymptomatic.

Discussion
This study is the first reported series of TEA for fracture of the distal humerus in non-rheumatoid patients with a minimum ten-year follow-up, and is a single surgeon series from a non-designer centre.

The pain relief and function achieved by the patients in our series is acceptable and is comparable with the results of other published studies at shorter follow-up intervals. The overall revision rate of 8.3% (three out of 36) in our series and the revision rate in the minimum ten-year study group of 10.5% (two out of 19) were also similar to that reported in previous studies. The rate of symptomatic heterotopic ossification was low compared with that expected after this type of fracture. However, radiolucency and/or wear of the bushings occurred in an additional 31.5% (six out of 19) of our patients in the minimum ten-year study group, with men more commonly affected than women. It is likely that these patients will also need revision surgery in due course. This finding of adverse radiological findings in asymptomatic patients indicates the need for long-term follow-up of these patients and should be borne in mind when advising such patients pre-operatively. The finding that only around half the patients who underwent this surgery survived beyond the tenth anniversary of their operation underlines that this is a frail, elderly patient population.

Comminuted fractures of the distal humerus in elderly osteoporotic patients are difficult to manage. The options include treating the fracture as a “bag of bones”, open reduction and internal fixation or arthroplasty. Over the last two decades, the use of semi-constrained arthroplasties for such fractures has gained popularity. In 1997, Cobb and Morrey were the first to report the early results of this technique and later Kamineni and Morrey published their experience with a mean follow-up of seven years. Kamineni and Morrey reported encouraging results, with a mean ROM of 24° to 131°. They also reported a complication rate of 35% with a revision rate of 10%, and 93% good to excellent results based on the Mayo elbow performance score. However, in their series of 49 total elbow arthroplasties, 17 procedures were performed in patients with rheumatoid arthritis. The inclusion of patients with rheumatoid arthritis may introduce bias as it is known that patients who undergo TEA for rheumatoid arthritis in the absence of a fracture have good long-term outcomes. Rheumatoid patients generally have lower functional expectations than the non-rheumatoid patient with an isolated fracture about the elbow.

There are a few short to medium term follow-up studies in the literature which evaluate the outcome of TEA for fractures of the distal humerus in non-rheumatoid patients using linked prostheses. At a mean follow-up of three years, Garcia et al reported a mean flexion arc of 24 to 125° in non-rheumatoid patients undergoing TEA for a fracture of the distal humerus with no revisions. A second study of 32 patients with a mean follow-up of 56 months compared the outcome of primary TEA with delayed treatment after failed internal fixation or conservative management. This study reported a survival of 93% at 88 months after acute TEA compared with 76% at 84 months in the delayed group. Finally, a multi-centre study from France and Switzerland reviewed a cohort of 87 elderly patients who had undergone a TEA for a fracture of the distal humerus, with a mean follow-up of only 37.5 months (6 to 106). The mean MEPS was 86 ± 14 with 56% excellent, 30% satisfactory, 8% fair and 6% poor, with a complication rate of 23% and a revision rate of 9%.

Unlinked prostheses have also been used to treat fractures of the distal humerus, although additional column fixation may be needed to achieve satisfactory stability of the humeral implant. A study from Liverpool in 2008 reported good functional results in nine distal humeral fractures treated with the unlinked iBP (Biomet, United Kingdom) implant at a mean of 3.5 years. The authors concluded that this implant could be used successfully after a fracture of the distal humerus provided that one column of the distal humerus was preserved.

The management of fractures of the distal humerus in elderly patients remains a controversial topic. Advances in plate design and the availability of locking screws undoubtedly allow many more fractures of the distal humeral to be fixed than was possible at the time this study began. However, rigid internal fixation is not always achievable.

The results of this study indicate that TEA is an appropriate treatment option with an acceptable ten-year survival. They also suggest that, in addition to the revision and loosening rates, a surgeon undertaking this procedure should be aware of the gender difference in rates of loosening, and the fact that only 53% of patients will live to celebrate the tenth anniversary of their TEA.

Supplementary material
A table showing a summary of results in patients who survived a minimum of ten years after total elbow arthroplasty is available alongside the online version of this article at www.bjj.boneandjoint.org.uk

Author contributions:
N. Prasad: Reviewed patients and radiographs, Data analysis, Writing the paper.
A. Ali: Data analysis, Performing surgeries, Reviewing the paper.
D. Stanley: Performing surgeries, Writing and reviewing the paper.

No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

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References