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## ORIGINAL ARTICLE

# Complex fractures of the distal humerus in the elderly: Is primary total elbow arthroplasty a valid treatment alternative? A series of 20 cases

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## KEYWORDS

Distal humeral fracture;  
Total elbow replacement;  
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## Summary

**Introduction:** Distal humerus fractures are fairly rare. But as our population ages, these fractures become more complex and the choice of treatment more delicate. Poor bone quality results in many technical problems and the fixation hardware stability remains at risk. The goal of this study was to evaluate the functional recovery and morbidity of complex distal humerus fractures in elderly patients when treated with elbow prosthesis.

**Hypothesis:** Good functional recovery can be achieved with a total joint replacement.

**Patients and methods:** This series consisted of 20 patients (18 women and two men) having an average age of 80 years (range 65–93, median 80). Based on the AO classification, there were two Type A2 fractures, two Type B fractures, 15 Type C fractures and one fracture that could not be classified because of previous rheumatoid disease history at this elbow. Two fractures were open. In two cases, the olecranon was also fractured. Treatment consisted of the implantation of a Coonrad-Morrey, hinge-type total elbow prosthesis (Zimmer®, Warsaw, IN, USA). The Mayo Clinic surgical approach was used 17 times and the transolecranon approach was used three times. Primary arthroplasty was performed in 19 cases and the surgery was performed after six weeks of conservative treatment (diagnostic delay) in one case. Unrestricted motion was allowed after surgery, but a maximum of 0.5 kg could be carried during the first 3 months; this was subsequently increased to 2.5 kg.

**Results:** Fifteen of the 20 patients were available for reevaluation with an average follow-up of 3.6 years (range 1.7–5.5, median 3.4). Four patients had died and one was lost to follow-up. The average range of motion was 97° (range 60–130°), comprising an average flexion of 130° (range 110–140°) and average loss of extension of 33° (range 0–80°). Pronation and supination

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were normal. The average Mayo Elbow Performance Score (MEPS) was 83 (range 60–100, median 80). X-rays revealed seven cases of radiolucent lines, with two being progressive. There was no visible wear of the polyethylene bushings at the hinge. Six patients had moderate periarticular heterotopic ossification. The two cases of olecranon osteotomy and one case of olecranon fracture had healed. There were no surgical site infections but two cases of ulnar compression, one of which required neurolysis. There was one case of humeral component loosening after 6 years, but the implant was not changed.

*Discussion:* The clinical range of motion results were comparable to published data. The functional scores were slightly lower, mainly because of the pain factor. The initial results were encouraging and consistent with published data as long as the indications were well-chosen. Based on this retrospective study, total elbow arthroplasty can be a valid alternative in the surgeon's treatment armamentarium for complex distal humerus fractures in elderly patients who have moderate functional demands. Our results support our hypothesis, since we found good functional recovery without associated morbidity.

*Level of evidence:* Level IV retrospective study without comparator.

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## Introduction

Distal humerus fractures occur in less than 2% of cases, thus are fairly rare [1,2]. They typically occur in older patients, most of them women [3,4]. When a trauma surgeon is faced with a complex fracture and poor bone quality [5], determining the surgical indication and treatment can be a challenge. Internal fixation can be tricky in these elderly patients because of the fragile hold of the hardware [2,5]. Given the technical problems and unstable fixation, some have proposed primary arthroplasty as a treatment [6–13], similarly to how complex proximal humerus fractures [14] and femoral neck fractures [15,16] are treated. More recently, hemiarthroplasty has been proposed as a treatment alternative [17,18]. These studies have had very encouraging results but only a small number of patients were included and the follow-up was only 1 year.

We chose to use total joint replacement as a treatment for complex distal humerus fractures in patients above 65 years of age when the complexity of the fracture, its distal location, poor bone quality and low probability of obtaining stable fixation did not favour conservative treatment.

The goal of this study was to evaluate the functional recovery and morbidity associated with this surgery. Our hypothesis was that functional recovery would be at least comparable to the recovery attained with internal fixation, with lower morbidity, but without having to systematically resort to restrictive rehabilitation.

## Patients and methods

### Patients

A retrospective, continuous study was performed (2003–2009) on patients greater than 65 years of age at the time of injury who were given a total elbow replacement as a treatment for a distal humerus fracture because its complexity, location or bone quality did not seem appropriate for internal fixation. For example, the distal fragment in an intra-articular supracondylar fracture does

not provide sufficient hold to allow for early mobilisation. Similarly, fractures with significant joint comminution (especially at the trochlea) or those with low bone density visible on X-rays can make the surgeon anxious about potential fixation failure. In these cases, CT scan could provide more precise information about the complexity of the fracture line and the bone mineral density. Bone densitometry is difficult to perform in an emergency situation in current practice.

Our series comprised 20 fractures in 20 patients (18 women, two men) having an average age of 80 years (range 65–93, median 80). Patients with less than three months of follow-up were excluded. Outside this series and during the same time period, internal fixation was performed in 80 cases of distal humerus fracture in patients from this age group.

All of our patients were retired and did not participate in sports. Five patients did some gardening. Three patients also suffered from rheumatoid arthritis, with radiological signs of the elbow being affected in one case. None of the patients had a history of trauma at the elbow. There were 13 right and seven left elbows. The dominant side was affected 16 times (80%). In most cases, the injury mechanism involved an accident at home such as a fall from a standing position.

Fractures were classified according to the AO system [19]: two were distal Type A2, two were comminuted Type B (one B2 and one B3) and 15 were Type C (one C1, five C2 and nine C3); one fracture could not be classified because of arthritis at the elbow.

Upon admission, two of the fractures were Gustilo Stage 1 open fractures [20]. In three cases, the olecranon was also fractured; in two cases, the proximal humerus was also fractured; in one case the ipsilateral distal radius was also fractured. The proximal humerus fracture was treated with a locking plate. The wrist was stabilized by intrafocal pinning. None of the patients had a neurological lesion or humeroulnar joint dislocation at the time of the injury.

The prosthesis was used for primary arthroplasty in 19 cases; in the other case, the prosthesis was implanted after failure of conservative treatment with secondary displacement (Fig. 1).



**Figure 1** Secondary displacement of a distal Type A2 fracture that was initially treated with cast immobilisation. Indication for arthroplasty. Pre- and postoperative X-rays. Non-union of the lateral column that had been attached by screw fixation because of the significance of this fragment, particularly its muscle attachments.

### Surgical technique

The Coonrad-Morrey, semi-constrained total elbow prosthesis was used in all the patients (Zimmer®, Warsaw, IN, USA). This is a cemented, titanium alloy implant that provides 8° of motion in the frontal plane and 8° of rotation. The humeral flange counters forces that could result in posterior and superior displacement and torsion. The stability of the humeral component is enhanced by inserting a bone graft under this anterior flange.

The procedure was performed under general anaesthesia with the patient in lateral decubitus and without a tourniquet cuff. A posterior approach was used, either by

reflecting the triceps ( $n = 16$ ) [21] or by transolecranon exposure, which was fixed at the end of the procedure by tension band wiring [22,23]. The olecranon osteotomy had been performed on two patients with the goal of performing internal fixation, but the operative findings led the surgeon to choose a different treatment. In the two other cases, the associated olecranon fracture was used for the approach. The ulnar nerve was identified and transposed forward if necessary ( $n = 4$ ). The columns were resected if the bone fragment was less than 15 mm long; if not, they were fixed with a compression screw. The head of the radius was always preserved, except in one case where it was resected because of degenerative changes secondary to

**Table 1** Mayo Elbow Performance Score (MEPS) system [24].

Pain (max. 45 points)
None (45 points)
Mild (30 points)
Moderate (15 points)
Severe (0 points)
Range of Motion (max. 20 points)
> 100 degrees (20 points)
50–100 degrees (15 points)
< 50 degrees (5 points)
Stability (max. 10 points)
Stable (10 points)
Moderate instability (5 points)
Gross instability (0 points)
Daily Function (max. 25 points)
Combing hair (5 points)
Feeding oneself (5 points)
Hygiene (5 points)
Putting on shirt (5 points)
Putting on shoes (5 points)
Total score (max. 100 points)

rheumatoid arthritis. The implants were cemented in one step using a syringe filled with normal viscosity gentamicin bone cement, without using an intramedullary plug. At the end of the procedure, the detached triceps ( $n=16$  cases) was reattached to the olecranon with transosseous sutures as described by Morrey [21]. The procedure was performed on the 8th day after the injury on average (range 1–45, median 5); the procedure time was 110 minutes on average (range 65–180).

Postoperative rehabilitation consisted of a home program with unrestricted motion. A sling and swath with the elbow at 90° was typically used in the first few days after surgery to provide pain relief. Carrying loads of more than 0.5 kg was contraindicated for the first three months; afterwards, the patients were told not to carry more than 2.5 kg.

## Evaluations

The follow-up consisted of clinical and radiological evaluations. A subjective opinion of satisfaction was collected from the patient and classified as either “satisfied patient” or “non-satisfied patient”. This information is important since it has been correlated to independence during everyday life. Active elbow flexion and extension, and forearm pronation and supination range of motion were measured with a goniometer. The Mayo Elbow Performance Score (MEPS) was used to evaluate the functional recovery [24]. Out of a potential score of 100, the result was deemed excellent when greater than 90, good when 75 to 89, fair when 60 to 74 and poor when below 60 (Table 1). The Quick DASH was useful in only a few cases because a large portion of the studied population was institutionalized.

The radiological assessment consisted of A/P and lateral X-rays to look for signs of loosening. The analysis was performed according to the criteria described by Morrey [6]:

- type 0: radiolucent line less than 1 mm less than 50% of the interface;
- type 1: radiolucent line of 1 mm less than 50% of the interface;
- type 2: radiolucent line greater than 1 mm more than 50% of the interface;
- type 3: radiolucent line greater than 2 mm the entire interface;
- type 4: significant loosening.

Any potential periarticular heterotopic ossification was identified. The healing of the osteotomy or olecranon fracture was also determined. Wear in the polyethylene bushings could not be systemically measured because the stress X-rays were inconsistent.

There was no significant effect of the quality of the cement application on the occurrence of periprosthetic radiolucent lines. But the follow-up may not have been long enough to see this effect.

During the review, we sought to evaluate functional recovery with the MEPS score and the DASH score. We realized that in this (very) elderly population, many could not answer at least three of the questions, thus the DASH score could not be interpreted. Given the small number of completed DASH tests, the results are not included in this report.

## Results

### The series

At the latest follow-up visit, one patient was lost to follow-up and four had died during the first year after the surgery for reasons unrelated to the fracture. Thus fifteen patients were reviewed with an average follow-up of 3.4 years (range 1.7–5.5, median 3.4).

### Clinical results

A large number of patients ( $n=14$ , 93%) were satisfied. Nine patients were pain-free. Among the six patients having residual pain, two had moderate pain and four had minimal pain, mostly related to the weather conditions.

Average elbow flexion was 130° (range 90–140°). The average extension deficit was 33° (range 0–80°). The average range of motion was 97° (range 60–130°). Seven patients (47%) had a “useful” range of motion, which is defined as 0/30/130° of motion or more than 100° of amplitude [25]. Pronation and supination was 152° on average (range 120–170). The average MEPS was 83/100 (range 60–100, median 80), thus 73% good and excellent results. The average pain score was 36 (median 45, range 15–45), the motion score was 17 (median 15, range 15–20), and the function score was 20 (median 25, range 0–25); all of the implants were stable. All the patients had restarted their activities, except for carrying heavy loads. The five patients who did gardening had restarted this activity within the recommended usage limits.

**Table 2** Results of the main published series using total elbow replacement.

	Number of patients	Implant	Age (years)	Follow-up (years)	Flexion deficit	Flexion	Extension deficit	Range of motion	Pain	MEPS [24]	Complications
Cobb and Morrey [7]	21	Coonrad-Morrey	72	3.3	—	130°	25°	105°	4 (20%)	93; 75% > 90, 25% > 75	1 implant failure (4,8%); 1 CRPS; 3 ulnar involvement (14%)
Hildebrand et al. [8]	17	Coonrad-Morrey	67 (27–87)	4	—	137°	30°	107°	—	78 ± 18	26% ulnar involvement; 8% SSI; 1 implant failure (3%)
Ray et al. [32]	7	Coonrad-Morrey	82 (74–88)	2–4	0°	—	20°	—	1 (14%)	71% > 90, 29% > 75	0 ulnar neuropathy; 0 SSI
Garcia et al. [10]	19	Coonrad-Morrey	73 (61–95)	3	5°	—	25°	—	6 (32%)	93 (80–100)	1 ulnar involvement (5%); 1 superficial SSI (5%)
Gambirasio et al. [9]	10	Coonrad-Morrey	85 (57–95)	1.5 (1–3)	5°	—	23.5°	—	—	80% > 90, 20% > 75	1 CRPS (10%); 1 PHO (10%)
Kamineneni and Morrey [33]	43	Coonrad-Morrey	69	7 (2–15)	—	131°	24°	—	—	93 (40 good and excellent results = 93%)	1 CRPS (2%); 3 SSI including 1 deep (7%); 5 revisions (11%); 2 ulnar involvement (4%)
Frankle et al. [11]	12	Coonrad-Morrey	73	3.75	—	113°	15°	—	—	Average = 95!!; 100% > 75	2 ulnar involvement; 1 prosthesis disassembly; 1 superficial infection, surgical lavage; 1 ulnar loosening
Prasad and Dent [12]	15	Coonrad-Morrey	78 (61–89)	4.37	—	119° (90–140)	26° (0–70)	93° (50–140)	7 (47%)	83 (60–100); 85% good and very good results	1 CRPS, 1 prosthesis loosening

Table 2 (Continued)

	Number of patients	Implant	Age (years)	Follow-up (years)	Flexion deficit	Flexion	Extension deficit	Range of motion	Pain	MEPS [24]	Complications
Charissoux et al. [34]	44	Coonrad-Morrey	81 (65–93)	2	–	124°	27°	–	–	84; 83% good and excellent	14%; 2 revisions (5%); 2 arthroplasty resections for deep SSI; 0 ulnar involvement
McKee et al. [35]	25	Coonrad-Morrey	78	2	–	133°	26°	107°	–	86; 21 good and excellent (85%)	1 deep SSI/1 revision (4%); 3 ulnar involvement (12%) (1 neurolysis); 3 PHO (12%)
Chalidis et al. [36]	11	Discovery	80 (75–85)	2.8	–	117°	10°	107°	–	90 (80–95)	0 SSI; 1 ulnar involvement (9%); 1 periprosthetic fracture secondary to loosening
Adolfsson and Hammer [17]	4	Kudo hemiarthroplasty	80 (79–89)	0.9	–	127°	20°	107°	0	3 excellent and 1 good result	?
Burkhart et al. [18]	10	Latitude hemiarthroplasty	75 (62–88)	1 (0.5–2)	–	125°	18°	–	20% (1 moderate + 1 mild)	91 (60–100)/9 good and excellent and 1 poor	1 ulnar involvement (10%); 1 superficial infection (10%); 2 PHO (20%)
Current series	15	Coonrad-Morrey	80 (65–93)	3.6 (1.7–5.4)	–	130°	33°	97°	6 (40%)	83 (60–100); 73% good and excellent results	2 ulnar involvement (13%); 6 PHO (40%); 0 SSI; 0 revision

The functional results are reported as the average value of the MEPS score and/or as the percentage of good and excellent results. Interpretation of MEPS results: excellent greater than 90, good 75 to 89, fair, 60 to 74, poor less than 60. SSI: surgical site infection; PHO: periarticular heterotopic ossification; CRPS: complex regional pain syndrome.

**Table 3** Results of the main published series using internal fixation.

	Number of patients	Implant	Age (years)	Follow-up (months)	Flexion	Extension deficit	Range of motion	MEPS [24]	Complications
Frankle et al. [11]	12	PRP	74 (65–86)	57	110° (80–120)	30° (10–50)	100° (90–120)	81	25% hardware failure; 8% infection
Charissoux et al. [34]	172	PRP TTP Screws	78	–	–	–	90°	77	25% complications; 6% ulnar neuropathy
McKee et al. [35]	15	PRP, AP, LCDCP	77	24	123° (90–150)	28° (5–60)	95° (30–140)	73	20% ulnar neuropathy
Greiner et al. [41]	14	LCP DHP	55 (21–83)	12	121° (90–140)	18° (0–35)	99° (70–140)	91 (70–100)	25% ulnar neuropathy
Kaiser et al. [42]	10	LCP DHP	75 (61–96)	32 (24–37)	129°	16°	–	–	86 (65–100) 1 delayed skin necrosis

The functional results are presented as the average MEPS score. PRP: Pelvis Reconstruction Plates; TTP: Third Tubular Plates; LCDCP: Low Contact Dynamic Compression Plates; LCP DHP: Locking Compression Plates – Distal Humerus Plates; AP: anatomical plate.

The female patient who also presented with an ipsilateral proximal humerus fracture upon admission was lost to follow-up. The female patient who also presented with an ipsilateral distal radius fracture at admission had 0/30/130° motion, 120° of pronation–supination and an MEPS score of 95 at the follow-up visit.

### Radiological results

All the olecranon fractures and osteotomies had healed. The anterior graft was integrated in 14 cases (93%). At the latest follow-up, periprosthetic radiolucent lines were apparent in seven cases (30%). Five were Type 1 located at the humeral component and one was bipolar Type 2. These did not change over time and were asymptomatic. One female patient showed Type 3 progressive radiolucent changes in the humerus (Fig. 2) but had very few symptoms. The patient chose not to have a revision arthroplasty performed. Five patients presented with partial wear of the polyethylene bushings; three of these patients also had periprosthetic radiolucent lines.

### Complications

The ulnar nerve was involved in two cases. The first case regressed spontaneously. Because of motor and sensory deficit, the second case required neurolysis; strength was partially restored but the paresthesia did not change. There were no infections or general complications. Six patients developed periprosthetic heterotopic ossifications without significant consequences to the joint range of motion ( $P < 0.05$ ). No implant failures were found at the latest follow-up.

### Discussion

The standard treatment for distal humerus fractures is open reduction and internal fixation [26,27]. In younger patients, the hardware will have good hold. However in elderly, osteoporotic patients, the fractures are often complex and comminuted, thus the hold of the fixation hardware can be precarious [5]. Additional bracing may be necessary, putting a strain on the functional prognosis while increasing

the risk of complications [11]. Indications for total elbow replacement in a trauma context have classically been for complications and sequelae of elbow fractures in elderly patients [28–30]. However, some surgeons have proposed primary arthroplasty as a treatment in hopes of offering a fast, satisfactory functional recovery to the patient [6–13,29,31] (Fig. 3). Conditions at the fracture site often require the use of a lax hinge-type implant, to overcome the bone loss and any potential ligament injuries [7]. Since then, many groups have published good and even excellent results with these implants [8–12,32–36] (Table 2). The largest and lengthiest series of fracture treatment using a prosthesis was published by Kamineni and Morrey [33]. From 1982 to 2001, 43 patients were operated and the average follow-up was 7 years (range 2–15). Nineteen patients had rheumatoid arthritis, which was a decisive factor when establishing the indication. In their series, the average MEPS was 93 (range 75–100) with 93% excellent or very good results. The average flexion deformity was 24° (range 0–75°) and the flexion amplitude was 131° (range 100–150°). X-rays showed radiolucent lines in nine patients, with six being stable over time. But they reported a complication rate of nearly 50% ( $n = 20$ ) with 11 infections, three fractures (implant or ulna) and three cases of loosening requiring the prosthesis to be changed five times. The functional results in our series were not as good as this reference study in terms of pain and extension amplitude. The pain result was in conflict with the high satisfaction rate reported by our patients. The X-rays provided no clues as to the reason for the extension deficit. The postoperative recovery was uneventful and the complication rate low. However, the length of the follow-up was not as long in our series; it is highly likely that loosening and implant fractures will show up later on. Series similar to ours had more consistent results but with better recovery of extension [9–11,32,34–36]. But these studies systemically used physiotherapy after the surgery, which is not an element of our current practice. Wearing an extension brace at night has also been proposed [37]. We will use this option in the future to improve the care of our patients. The rehabilitation protocols used in these studies were comparable: assisted active mobilisation; elbow sling and swathe for four to six weeks when not participating in rehabilitation sessions; passive mobilisation with stretching allowed six to eight weeks after the surgery.



**Figure 2** Type C3 fracture. Postoperative X-rays and after 6 years of follow-up: loosening with Stage 3 radiolucent lines around the humeral component, probably related to a problem with the initial cement application (heterogeneity).

Distal humerus hemiarthroplasty has also been proposed. But these studies included a small number of patients and had a short follow-up. However, the preliminary results were intriguing as the joint range of motion was well restored (Table 2).

But the high complication rate, especially later on, must make us weary of having this as an arthroplasty indication in a trauma context. We reported one case of humeral component loosening that was not revised. This mechanical failure may have been caused by the lack or resorption of the bone graft under the anterior flange of the humeral component. For the two reported cases of ulnar nerve involvement, we discovered that a fragment of the medial column had been left in place, which would explain the nerve compression. This was more likely a technical error as opposed to a faulty surgical indication.

Our two main goals for the series were attained: satisfactory functional recovery for the patients in the short and medium term, and a low immediate complication rate. Thus treatment of these complex elbow fractures in elderly patients with a prosthesis can reasonably be a therapeutic option. But the indications should be limited to complex fractures where internal fixation would be

precarious, elderly and osteoporotic patients are affected, and the functional demands are reasonable.

Thus joint replacement is an alternative to internal fixation. Based on our review of literature, three studies have compared these two treatments in patients above 65 years of age. Two were retrospective [11,34] and one was prospective [35] (Table 3). The latter compared elbow arthroplasty with fixation using two orthogonal plates with 3.5 mm non-locking screws. The same rehabilitation protocol was used in both groups: assisted active mobilisation right away with a splint worn at rest then unrestricted motion starting at week seven. The results were favourable with arthroplasty, since faster and better quality recovery was achieved. However, strength recovery was better after internal fixation. Newly introduced locking plates, which could be used in fragile bone [38,39], may be suitable for these indications but further study is required. Following the example of the lower limb, early rehabilitation could be allowed that would reduce the duration of immobilisation and the related complications [38–40], while making the fracture stable and allowing for good functional recovery. The evaluation of these fixation systems must continue [41,42]. However, internal fixation of these fractures in





**Figure 3** Type C3 fracture. Initial X-rays and after 3.4 years of follow-up. Full integration of the humeral bone graft, no loosening.

elderly patients remains the gold-standard treatment, especially if the fracture is not complex and significant functional demands exist. Arthroplasty is an alternative that should be not adopted systematically, but reserved for very complex fracture cases, in osteoporotic bone and in situations with reasonable functional demands.

## Conclusion

Complex distal humerus fractures in elderly patients are challenging to treat. One of the therapeutic options is a total elbow replacement implant. Such implants liberate the surgeon from problems caused by bone quality and fracture

complexity. Based on our results, the total elbow implant leads to satisfactory functional recovery in a population with low functional demands. Recovery of the joint range of motion in our series was not optimal, which has persuaded us to more systematically involve a physiotherapist in our rehabilitation protocol. In a trauma context, the indication must be made carefully. The preferred indications are a complex fracture in an elderly subject with low functional demands and/or significant co-morbidities, or in a patient who also already has signs of rheumatoid arthritis in the elbow. The new implants providing angular stability are also a treatment option in these specific indications and this population. The results with the plate versus arthroplasty should be compared in future studies.

## Disclosure of interest

The authors declare that they have no conflicts of interest concerning this article.

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