



## Linked total elbow arthroplasty as treatment of distal humerus fractures

Samuel A. ANTUÑA, Raúl BARCO LAAKSO, Juan L. BARRERA, Xavier ESPIGA, Angel FERRERES

*From Hospital Universitario La Paz, Madrid, Spain*

**Treatment of distal humerus fractures may be challenging, especially in the elderly patient. Total elbow replacement has been proposed as an option in selected patients. We present the results of a linked elbow replacement in 16 patients with a comminuted fracture of the distal humerus which was not considered amenable to reliable open reduction and internal fixation. At a mean follow-up of 57 months, average range of motion was from 28° to 117° of flexion-extension. Five patients with moderate to severe pain (31%) were not satisfied with the results of the operation. Three patients had an infection which resulted in implant removal in one patient. Eight patients had symptoms of sensory ulnar nerve neuropathy. Our results show that elbow replacement may be an optimal solution for highly comminuted osteoporotic fractures, if there are no associated complications. However, the rate of significant and minor complications such as infection or postoperative ulnar nerve symptoms is probably higher than reported. Appropriate selection of ideal candidates for this procedure and meticulous surgical technique are of paramount importance in reducing the risk of complications.**

**Keywords :** elbow arthroplasty ; fracture ; humerus.

### INTRODUCTION

Fractures of the distal humerus may be a challenging problem if there is severe joint comminution, especially in the elderly patient or when there is previous damage to the joint as in rheumatoid

patients (10,12). Under these circumstances, open reduction and internal fixation may not be feasible and elbow replacement has been proposed as a viable option (5-8).

Both linked and unlinked elbow replacements have been used to treat distal humerus fractures (13). However, the majority of published series have focused on linked implants (1,5,7-9,14,16,24,25). Although the reported results seem to support the use of elbow replacement for comminuted distal humerus fractures in a very selected group of patients, a relatively high rate of complications has been documented after replacement for posttraumatic conditions of the elbow (3,4,14).

The purpose of this study is to present the results and complication rate of a linked elbow replacement in a selected group of patients with a distal

- 
- Samuel A. Antuña, Orthopaedic Surgeon.
  - Raúl Barco Laakso, Orthopaedic Surgeon.  
*Hospital Universitario La Paz, Madrid, Spain.*
  - Juan L. Barrera, Orthopaedic Surgeon.  
*Hospital Valle del Nalón, Asturias, Spain.*
  - Xavier Espiga, Orthopaedic Surgeon.  
*Hospital Del Mar, Barcelona, Spain.*
  - Angel Ferreres, Orthopaedic Surgeon.  
*Instituto Kaplan, Barcelona, Spain.*

Correspondence : Dr Samuel A. Antuña, Shoulder and Elbow Unit, Department of Orthopedic Surgery, Hospital Universitario La Paz, Paseo de la Castellana 261, Madrid 28046, Spain. E-mail : santuna@asturias.com

© 2012, Acta Orthopædica Belgica.

---

Table I. — Clinical data on the 16 patients

Case	Age (yrs.)	Initial Treatment of acute Fx.	Follow up (months)	Flexion-Extension Postop (degrees)	Elbow Pain	Ulnar nerve symptoms	Patient Satisfaction	DASH.	MEPS.	Complications
1	63	TEA	76	120/90	Mild	Mild	Satisfied	59	55	
2	73	ORIF	91	150/10	None	None	Very Satisfied	9.75	100	
3	76	TEA	72	140/20	None	None	Satisfied	7.5	100	
4	57	ORIF	68	130/50	None	None	Satisfied	15	90	
5	75	TEA	78	120/60	None	None	Very Satisfied	20	95	
6	77	TEA	38	140/60	None	Mild	Satisfied	33.9	90	Acute infection. Healed after debridement
7	85	TEA	82	130/10	None	None	Satisfied	81	85	Subsequent proximal humerus fracture
8	81	TEA	71	100/30	None	Mild	Satisfied	15	95	Subsequent proximal humerus fracture
9	75	TEA	36	120/15	None	Mild	Very Satisfied	32.5	100	
10	78	TEA	68	140/0	Severe	Mild	UnSatisfied	79	45	Symptomatic humerus loosening
11	84	TEA	48	30/0	Moderate	None	Very UnSatisfied	100	35	Acute infection. Ab. suppression. Loose components
12	89	TEA	24	110/10	Mild	Mild	UnSatisfied	78.3	60	
13	88	TEA	36	110/30	Moderate	None	UnSatisfied	75	55	
14	69	TEA	60	100/40	Moderate	Moderate	Very UnSatisfied	90	30	Late infection- Resection arthroplasty
15	75	TEA	48	130/0	Mild	None	Satisfied	55	75	
16	72	TEA	24	110/20	Moderate	Mild	Satisfied	65.8	55	

humerus fracture which was not considered suitable for open reduction and internal fixation.

## PATIENTS AND METHODS

### Patient Data

We studied 16 patients with a fracture of the distal humerus treated by joint replacement. All patients had a complete preoperative clinical evaluation, operative records, and a minimum 2 years follow-up period (average 57 months ; range, 24-91 months) (Table I).

There were fifteen women and one man, whose ages ranged from 57 to 89 years (mean 76 years). The dominant extremity was involved in ten of the sixteen cases. The mechanism of the initial injury was a fall from standing height in all but one patient who fell from a ladder. Fourteen patients underwent an elbow replacement

as a primary procedure and two patients had a previous failed attempt to fix the fracture which was converted to an elbow arthroplasty three and six weeks after the initial injury. The fractures were classified according to the AO system and there were 2 B3, 2 C2 and 12 C3 fractures. The average time from the initial injury to the elbow replacement was 8 days (range, 2 to 45 days).

### Operative Technique

With the patient supine on the operating table, a tourniquet was applied and the arm was brought across the chest. A posterior skin incision was preferred but if an incision was previously used to fix the fracture, this scar was reopened. The ulnar nerve was identified, dissected, and protected throughout the operation in every case.

According to the technique previously described by Morrey and Adams (19) the triceps tendon was left intact

in fourteen cases. The fractured fragments were removed from the medial and lateral aspect of the distal humerus through the paratricipital approach described by Alonso Llamas (2). Once the distal humerus was removed, excellent exposure of the humeral canal can be obtained through either side of the triceps. The ulnar notch was exposed by forearm rotation, usually from a lateral to medial direction. In the two patients who had undergone open fixation of the fracture initially, the elbow was approached through the previous unhealed olecranon osteotomy.

In all patients a cemented linked elbow implant was used (Coonrad-Morrey total elbow prosthesis, Zimmer, Warsaw, Indiana) (Fig. 1). Fourteen patients underwent subcutaneous transposition of the ulnar nerve. In the two patients with a previous transposition at the time of initial fracture fixation, the nerve was identified at the triceps and its path followed, but no further dissection was carried out distally because there were no preoperative symptoms of nerve irritation. Once the implant was linked in place, the triceps was intact in fourteen cases and the olecranon was repaired with two parallel K-wires and a wire cerclage technique in two patients.

Postoperatively, the arms were placed in a plaster cast with the elbow extended and elevated for 24-48 hours. Once the immobilization was removed, the patients were allowed to use their arms freely, with the only limitation of avoiding heavy weight lifting with the operated arm.

### Clinical Review

Our Institutional Review Boards approved a review of the medical records and an invitation to patients to return for evaluation. All patients were contacted and returned to our hospitals for an interview, physical examination, and radiographic evaluation.

The outcome assessment included the Disabilities of the Arm, Shoulder, and Hand questionnaire (DASH), which is a validated thirty items self-reported outcome instrument which assesses symptoms and physical function in patients with upper extremity musculoskeletal disorders (10,27). The score is scaled between 0 and 100, with higher scores indicating worse upper-extremity disability.

Elbow pain was graded as none, mild (only with activity, no need for medication), moderate (with and after any activity), or severe (pain at rest, need of constant medication). Additional information was collected regarding the presence of ulnar nerve symptoms. A visual analogue scale (VAS) was used for the assessment of patient satisfaction. Patients were also asked to give a

verbal categorical rating of their degree of satisfaction as very satisfied, satisfied, unsatisfied, or very unsatisfied.

Physical examination included measurement of the range of motion of the elbow and forearm. Flexion and extension were measured with the forearm in neutral rotation, and pronation and supination with the elbow at 90°.

With the information collected from the interview and the physical examination, a physician-based scoring system was used to define the results. The elbows were evaluated with the Mayo Elbow Performance Score for pain (maximum score, 45 points), motion (maximum score, 20 points), stability (maximum score, 10 points), and daily functional activities (maximum score, 25 points) (20). A score of 90 to 100 points was defined as an excellent result ; 75 to 89 points, as a good result ; 60 to 74 points, as a fair result ; and less than 60 points, as a poor result. A result was considered satisfactory if an excellent or good rating was attained.

### Radiographic Review

At the time of the most recent follow-up examination, plain anteroposterior and lateral radiographs of the elbow were performed in all patients. The radiographs were examined for evidence of radiolucent lines, migration of components, and incorporation of the anterior bone graft.

Implant loosening was assessed on radiographs and was graded on a scale of 0 to 4, as previously described (21). Type 0 describes a radiolucent line that is less than 1 mm thick and involves less than 50% of the interface ; type 1 is a radiolucent line that is 1 mm thick and involves less than 50% of the interface ; type 2 is a radiolucent line that is greater than 1 mm thick and involves more than 50% of the interface ; type 3 is a radiolucent line that is greater than 2 mm thick and involves the whole interface ; and type 4 describes gross loosening with migration of components.

## RESULTS

### Subjective outcome

At the most recent follow up, 8 patients had no pain, 3 had mild pain only after unusual activities, 4 had moderate pain, and 1 patient, with symptomatic loosening of the humeral component, had severe pain. Eight patients complained of ulnar nerve irritation, which was only mild and sensory in seven and moderate with some intrinsic weakness in one.



**Fig. 1.** — A-B : Anteroposterior and lateral radiographs of an 85-year-old lady with a very distal comminuted fracture of the humeral metaphysis. C-D : Anteroposterior and lateral radiographs of the elbow 82 months after a total elbow replacement. E-F. The patient had no pain, achieved a functional arc of motion and she was satisfied with the outcome of the operation.

However, none of the sixteen patients sought further treatment for neurological problems.

The mean satisfaction score on the VAS was 6.5 (range : 10 to 1). According to patients' own assessments, 11 patients (69%) were satisfied with the result of the operation and 5 (31%) were not

satisfied. The mean DASH score at the time of the latest examination was 52 points (range : 7.5 to 100).

### Objective outcome

Three patients (18%) had an infection postoperatively. One patient had a superficial infection with *Staphylococcus epidermidis* in the cultures. She was treated with prompt debridement three weeks after the operation, polyethylene exchange and 6 weeks of intravenous antibiotics. The infection was cleared with no signs of recurrence after 38 months follow-up. One patient had wound-healing problems two months after the operation, when a necrotic infected ulcer over the olecranon process developed. *Staphylococcus epidermidis* was also isolated in the cultures and the patient underwent debridement, coverage with a fasciocutaneous flap, and intravenous antibiotics. The flap healed uneventfully but the haematologic parameters of infection remained high with elbow pain. She refused further treatment and has been maintained under antibiotic suppression therapy with satisfactory control of the infection. One patient had a late infection three years after the total elbow arthroplasty was performed. She was treated with joint resection and refused further treatment.

At the latest follow-up examination, the mean range of motion was from 28 degrees of extension (range : 0 to 90°) to 117° of flexion (range : 30 to 150°), with a mean total arc of 90° (range : 30 to 140°). Five elbows had a functional arc of flexion-extension (30 to 130°) at the time of the latest follow-up (11). At the latest follow-up evaluation, they had a mean of 78° of pronation (range : 60 to 90) and 75° of supination (range : 0 to 90).

The mean MEPS was 73 points (range : 30-100). The result was excellent for seven elbows, good for two, fair for one and poor for six. Thus, based on the objective score, nine elbows (56%) had a satisfactory result and seven (44%) had an unsatisfactory result.

### Radiographic Analysis

Three of the sixteen elbows had radiographic evidence of loosening : one patient had a sympto-

matic septic loosening that required resection arthroplasty, One patient with an infection treated with antibiotic suppression, had symptomatic loosening of both the humeral and ulnar components, and another patient presented with humeral component loosening which caused pain, but the patient refused further treatment due to severe co-morbidities (Fig. 2). Three additional patients showed Type-1 radiolucent lines in the humeral component. Incorporation of the bone graft between the anterior prosthetic flange and the distal humeral cortex was seen radiographically in all elbows.

### DISCUSSION

Distal humerus fractures may represent one of the most difficult problems in elbow surgery. When they present in young patients, rigid internal fixation is the procedure of choice and good results have been reported when the joint surface is not severely damaged (28). However, bone healing is more difficult to achieve in the elderly patient with poor bone quality and small fragments. The results of internal fixation of complex distal humerus fractures in patients with osteopenic bone have been disappointing in the past.

There are, however, reports of optimistic results with open reduction and internal fixation of distal humerus fracture (11,17,23,29). John *et al* examined 39 patients treated with open reduction and internal fixation for distal intrarticular humeral fractures, with an average age of 80 years (range : 75-90 years). There were 8 type A, 13 type B, and 28 type C fractures (11). At an average follow-up of 18 months, 80% of the patients reported a good result, 15% a fair result, and 5% a poor outcome. Flexion and extension range of motion was reported to be functional in 85% of cases. Pereles *et al* examined 12 patients with an average age of 71 years (range, 63-85 years) (23). They reported 25% excellent and 75% good results. None of the fractures experienced loss of fixation. The conclusion was that open reduction and internal fixation of distal humerus fractures in patients older than 60 years of age can yield good results. The use of new anatomic and locking plates may improve the



**Fig. 2.** — A-B : Immediate postoperative anteroposterior and lateral radiographs of a distal humerus fracture treated with a total elbow replacement. C : Radiographs taken 68 months after the operation show evidence of humeral loosening. Despite a good range of motion, the patient had significant pain, and was not satisfied with the outcome of the operation. She refused further treatment and was treated with pain medication.

rate of healing and the clinical outcome of these patients (17,28,29).

Cobb *et al* first reported on the use of a linked elbow replacement as a primary procedure for complex distal humerus fractures (5). All patients included in the original study were elderly, with a complex fracture, and many of them with previous damage to the joint from inflammatory arthritis. The experience from the Mayo Clinic was updated a few years later by Kamineni and Morrey (14). In this series, the clinical outcome was satisfactory for the majority of patients, but 14 out of 49 elbows included in the study had a complication and 10 patients required another operation. In expert

hands this is a difficult procedure and it remains to be seen if these results can be replicated by less experienced surgeons. Several other series have also reported good clinical outcomes, but the majority of them have a short follow-up or very low numbers of cases. Most of these reports have shown a high rate of asymptomatic radiolucent lines, which raises doubts as to the durability of these arthroplasties (8,9,16,24,25).

Several studies have tried to compare the outcome of ORIF versus TEA in distal humerus fractures in the elderly (6,7,18,22). Although one of these reports shows consistent evidence in favor of elbow arthroplasty, others have not found such a significant difference in outcome. One of the limitations of these comparative studies is that it is very difficult to match patients for a randomized trial because not only the type of fracture but also the comorbidities of these elderly patients should be taken into consideration : age, ability to regain function

postoperatively, level of implication in the rehabilitation, expectations, etc. Moreover, recent clinical studies have shown that newer fixation devices may clearly improve the outcome of ORIF in osteoporotic bone (17,29).

Our experience shows that if there are no complications, elbow replacement is an extremely gratifying operation for complex distal humerus fractures both for the surgeon and for the patient. Patients usually achieve a functional range of motion and are able to use the arm soon after the surgical procedure. Several factors may be involved in the success of this procedure. Preservation of the extensor mechanism is one key factor in regaining early range of motion and avoiding postoperative weakness of the triceps. Elderly patients require limited use of the arm and do not place the elbow at high risk for mechanical loosening or bushing wear, except those using walking aids. Finally, implantation of an elbow prosthesis in the setting of a fracture is technically easier and faster than any reconstructive procedure aimed at achieving bone healing with joint preservation. However, the rate of complications in our group is high, and deserves detailed consideration.

Half of our patients, when asked, reported variable degrees of diminished sensation in the ulnar nerve territory, one of them with demonstrable weakness. It is important to understand that none of these patients sought further treatment for the neurologic symptoms, and many of them only recognized their problem when they were asked directly or clinically examined. It is our impression that ulnar nerve symptoms after any approach that involves nerve dissection may be higher than previously reported. It might be wise to develop approaches in which the ulnar nerve can be left in place or with minimal dissection without transposition. In cases where the nerve must be moved, every attempt should be made to preserve its vascularity.

Infection after elbow replacement may be a disastrous complication. Three patients in our group had an infection. One was clinically cleared after debridement and appropriate intravenous antibiotics; another patient was treated with antibiotic suppression without implant removal and declined further surgery; the third patient had a late infec-

tion and required implant removal with a poor functional outcome. Therefore, two of the sixteen patients (12.5%) had an infection that significantly influenced the clinical outcome. With traumatic elbows, replacement surgery is a high-risk procedure for infection. Meticulous skin protection and a delicate surgical technique are of paramount importance. Antibiotic impregnated cement should be used routinely and the wound should probably be protected postoperatively by elevating the arm and avoiding an aggressive early mobilization protocol.

In conclusion, our experience shows that elbow replacement may be an optimal solution for highly comminuted osteoporotic fractures, which are not amenable for fixation, if there are no associated complications. However, the rate of significant and minor complications may be higher than previously reported. Ulnar nerve symptoms, although very mild, are fairly prevalent when the nerve is moved, and we should probably explore approaches without ulnar nerve transposition. Infection after elbow arthroplasty is a devastating complication and every effort should be directed to reduce it, including meticulous surgical technique, protection of wound healing and the use of cement with antibiotics.

## REFERENCES

1. **Ali A, Shahane S, Stanley D.** Total elbow arthroplasty for distal humeral fractures: Indications, surgical approach, technical tips, and outcome. *J Shoulder Elbow Surg* 2010; 19: 53-58.
2. **Alonso Llames M.** Bilateral tricipital approach to the elbow. Its application in the osteosynthesis of supracondylar fractures of the humerus in children. *Acta Orthop Scand* 1972; 43: 479-490.
3. **Chaldis B, Dimitriou C, Papadopoulos P, Petsadotis G, Giannoudis PV.** Total elbow arthroplasty for the treatment of insufficient distal humeral fractures. A retrospective clinical study and review of the literature. *Injury* 2009; 40: 582-590.
4. **Charissoux JL, Mabit C, Fourastier J et al.** [Comminuted intra-articular fractures of the distal humerus in elderly patients.] (in French). *Rev Chir Orthop Reparatrice Appar Mot* 2008; 94: S36-62.
5. **Cobb TK, Morrey BF.** Total elbow arthroplasty as primary treatment for distal humeral fractures in elderly patients. *J Bone Joint Surg* 1997; 79-A: 826-832.
6. **Egol KA, Tsai P, Vazques O, Tejwani NC.** Comparison of functional outcomes of total elbow arthroplasty vs plate

- fixation for distal humerus fractures in osteoporotic elbows. *Am J Orthop* 2011 ; 40 : 67-71
7. **Frankle MA, Herscovici D Jr, DiPasquale TG, Vasey MB, Sanders RW.** A comparison of open reduction and internal fixation and primary total elbow arthroplasty in the treatment of intraarticular distal humerus fractures in women older than age 65. *J Orthop Trauma* 2003 ; 17 : 473-480.
  8. **Gambirasio R, Riand N, Stern R, Hoffmeyer P.** Total elbow replacement for complex fractures of the distal humerus. An option for the elderly patient. *J Bone Joint Surg* 2001 ; 83-B : 974-978.
  9. **Garcia JA, Mykula R, Stanley D.** Complex fractures of the distal humerus in the elderly. The role of total elbow replacement as primary treatment. *J Bone Joint Surg* 2002 ; 84-B : 812-816.
  10. **Hudak PL, Amadio PC, Bombardier C.** Development of an upper extremity outcome measure : the DASH (disabilities of the arm, shoulder and hand) [corrected]. The Upper Extremity Collaborative Group. *Am J Ind Med* 1996 ; 29 : 602-608.
  11. **John H, Rosso R, Neff U et al.** Operative treatment of distal humeral fractures in the elderly. *J Bone Joint Surg* 1994 ; 76-B : 793-796.
  12. **Jost B, Adams RA, Morrey BF.** Management of acute distal humeral fractures in patients with rheumatoid arthritis. A case series. *J Bone Joint Surg* 2008 ; 90-A : 2197-205.
  13. **Kalogrianitis S, Sinopidis C, El Meligy M, Rawal A, Frostick SP.** Unlinked elbow arthroplasty as primary treatment for fractures of the distal humerus. *J Shoulder Elbow Surg* 2008 ; 17 : 287-292.
  14. **Kaminen S, Morrey BF.** Distal humeral fractures treated with noncustom total elbow replacement. *J Bone Joint Surg* 2004 ; 86-A : 940-947.
  15. **Korner J, Lill H, Müller LP et al.** Distal humerus fractures in elderly patients : results after open reduction and internal fixation. *Osteoporosis Int* 2005 ; 16 : S73-S79.
  16. **Lee KT, Lai CH, Singh S.** Results of total elbow arthroplasty in the treatment of distal humerus fractures in elderly asian patients. *J Trauma* 2006 ; 61 : 889-892.
  17. **Liu JJ, Ruan HJ, Wang JG, Fan CY, Zeng BF.** Double-column fixation for type C fractures of the distal humerus in the elderly. *J Shoulder Elbow Surg* 2009 ; 18 : 646-651.
  18. **McKee MD, Veillette CJH, Hall JA et al.** A multicenter, prospective, randomized, controlled trial of open reduction-internal fixation versus total elbow arthroplasty for displaced intra-articular distal humeral fractures in elderly patients. *J Shoulder Elbow Surg* 2009 ; 18 : 3-12.
  19. **Morrey BF, Adams RA.** Semi-constrained arthroplasty for the treatment of rheumatoid arthritis of the elbow. *J Bone Joint Surg* 1992 ; 74-A : 479-490.
  20. **Morrey BF, An KN, Chao EYS.** Functional evaluation of the elbow. In: Morrey BF. (ed). *The Elbow and its Disorders*. 2<sup>nd</sup> Edition. W.B. Saunders, Philadelphia, 1993.
  21. **Morrey BF, Bryan RS, Dobyns JH, Linscheid RL.** Total elbow arthroplasty. A five-year experience at the Mayo Clinic. *J Bone Joint Surg* 1981 ; 63-A : 1050-1063.
  22. **Obrebsky WT, Bhandari M, Dirschl DR, Shemitsch E.** Internal fixation versus arthroplasty of comminuted fractures of the distal humerus. *J Orthop Trauma* 2003 ; 17 : 463-465.
  23. **Pereles TR, Koval KJ, Gallagher M, Rosen H.** Open reduction and internal fixation of the distal humerus : functional outcome in the elderly. *J Trauma* 1997 ; 43 : 578-584.
  24. **Prasad N, Dent C.** Outcome of total elbow replacement for distal humeral fractures in the elderly : a comparison of primary surgery and surgery after failed internal fixation or conservative treatment. *J Bone Joint Surg* 2008 ; 90-B : 343-348.
  25. **Ray PS, Kakarlapudi K, Rajsekhar C, Bhamra MS.** Total elbow arthroplasty as primary treatment for distal humeral fractures in elderly patients. *Injury* 2000 ; 31 : 687-692.
  26. **Robinson CM, Hill RM, Jacobs N, Dall G, Court-Brown CM.** Adult distal humeral metaphyseal fractures : epidemiology and results of treatment. *J Orthop Trauma* 2003 ; 17 : 38-47.
  27. **Rosales RS, Delgado EB, Diez de la Lastra-Bosch I.** Evaluation of the Spanish version of the DASH and carpal tunnel syndrome health-related quality-of-life instruments : cross-cultural adaptation process and reliability. *J Hand Surg Am* 2002 ; 27 : 334-343.
  28. **Sanchez-Sotelo J, Torchia ME, O'Driscoll SW.** Complex distal humeral fractures : internal fixation with a principle-based parallel plate technique. *J Bone Joint Surg* 2007 ; 89-A : 961-969.
  29. **Srinivasan K, Agarwal M, Matthews SJ, Giannoudis PV.** Fractures of the distal humerus in the elderly : is internal fixation the treatment of choice ? *Clin Orthop Relat Res* 2005 ; 434 : 222-230.