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Is Coonrad-Morrey total elbow arthroplasty a viable option for treatment of distal humeral nonunions in the elderly?

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Objective: The purpose of this study was to evaluate the functional and radiological results of semiconstrained Coonrad-Morrey total elbow arthroplasty for distal humeral nonunions in the mid-term period.

Methods: Seven patients were treated with Coonrad-Morrey total elbow arthroplasty for distal humeral nonunion. All patients were female, and the mean age was 65.6 years (range: 64–68 years). Patients were followed for at least 5 years, and the mean follow-up time was 73 months (range: 63–84 months). Anteroposterior and lateral radiographs at preoperative and early postoperative period of the joint replacement and latest follow-up were used to detect postoperative radiological changes in terms of loosening. The Mayo Elbow Performance Index (MEPI) and Q-DASH Score were used for functional evaluation.

Results: At the latest follow-up, joint stability had been achieved in all 7 patients. Six patients (85.7%) were pain free. The mean range of motion was 30° (range: 0–60°) preoperatively, and this improved to 90.7° (range: 60–110°) at the latest follow-up ($p<0.05$). Five patients (71.4%) had excellent or good outcomes on the MEPI. The mean Q-DASH Score was improved from 93.2 to 34.5 ($p<0.01$). Two humeral components had aseptic loosening, and 1 of them was revised.

Conclusion: Semiconstrained total elbow arthroplasty can be a reliable choice of treatment if other internal fixation methods fail. Significant pain relief and improvements in elbow function and stability can be achieved with semiconstrained elbow arthroplasty in patients with distal humeral nonunion.

Keywords: Distal humerus nonunion; total elbow prosthesis.

Rigid osteosynthesis and early motion is the gold standard treatment for distal humerus fractures; however, nonunion is not an uncommon complication of surgically treated distal humerus fractures, occurring in 2–10% of cases.[1] The recommended treatment for distal humeral nonunion is revision, open reduction, and internal fixation with bone grafting.[2] Even if the procedure is performed properly with internal fixation and grafting,

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union may not be achieved due to large bone defects, destruction of the articular cartilage, diminished range of motion (ROM), and/or uncertain bone viability, making it impossible to obtain satisfactory clinical results.[1] In the case that all fixation attempts fail, total elbow arthroplasty remains a noteworthy salvage procedure for patients with distal humeral nonunion. Stability of the elbow can be restored, and functional ROM can be achieved with total elbow arthroplasty.[3]

Linked and unlinked designs of total elbow arthroplasty are available. Linked semiconstrained total elbow prostheses have the advantage of stability, whereas instability is the major complication of unlinked total elbow prostheses.[4,5] The most commonly used linked semiconstrained implant is the Coonrad-Morrey prosthesis,[6] which offers promising results. However, linked semiconstrained prostheses have some disadvantages, including restriction of some activities and the potential for the implants to eventually fail. In a recent study evaluating long-term outcomes of the Coonrad-Morrey prosthesis for distal humeral nonunions with an average of 6.5 years of follow-up, 85% of patients were rated as satisfied or very satisfied compared to their preoperative conditions. However, the rate of prosthetic survival without additional intervention for any reason was 96% at 2 years, 82% at 5 years, and 65% at both 10 and 15 years.[7]

This retrospective study aimed to evaluate mid-term clinical and radiographic results of linked semiconstrained Coonrad-Morrey total elbow arthroplasty for patients with distal humeral nonunion. The hypothesis of the study was that for distal humerus nonunions in the elderly, good functional and radiological results can be obtained and preserved with a semiconstrained elbow prosthesis in the mid-term period.

Patients and methods

The results of 7 patients with distal humeral nonunions who were treated with Coonrad-Morrey elbow arthroplasty from 2005–2008 by a single surgeon were retrospectively reviewed. Informed consent was obtained from each patient.

All patients were women, and mean age was 65.6 years (range: 64–68 years) at time of elbow replacement. Minimum follow-up time was 5 years, and mean follow-up time was 73 months (range: 63–84 months) (Table 1).

Mitsunaga classification was used to categorize the nonunions.[8] Mitsunaga classified the humeral nonunions according to the anatomic location. Four nonunions were supracondylar, 2 transcondylar, and 1 intercondylar (Table 1). All patients had a history of interventions for distal humerus fractures with open reduction (Figure 1a–c).

Table 1. Patient demographics and functional results.

	Patient 1	Patient 2	Patient 3	Patient 4	Patient 5	Patient 6	Patient 7
Age	65	65	64	66	64	64	68
Prior surgery	2	1	1	3	1	1	2
Interval (month)	30	32	40	120	5	45	51
Follow-up (month)	63	84	75	72	70	75	74
Complication					**Humeral loosening**	**Humeral HO loosening**	
Revision					**Yes**	**Planned**	
Preop ROM	45	55	35	0	10	0	60
Postop ROM	105	110	100	80	80	60	100
Preop Q-DASH	94.8	95.8	92.4	91.7	93.3	94.2	90.8
Postop Q-DASH	39.2	13.6	30.4	28.6	38.4	59.1	32.5
Preop MEPI	15	30	35	15	20	10	45
Postop MEPI	95	90	80	85	70	50	90
	Excellent	**Excellent**	**Good**	**Good**	**Fair**	**Poor**	**Exellent**
Humeral cementing (Type)	1	2	2	1	2	3	1
Ulnar cementing (Type)	1	1	2	1	1	1	2
Humeral loosening (Grade)	1	1	2	2	4	4	2
Ulnar loosening (Grade)	1	1	1	1	1	2	2

MEPI: Mayo Elbow Performance Index; ROM: Range of motion.

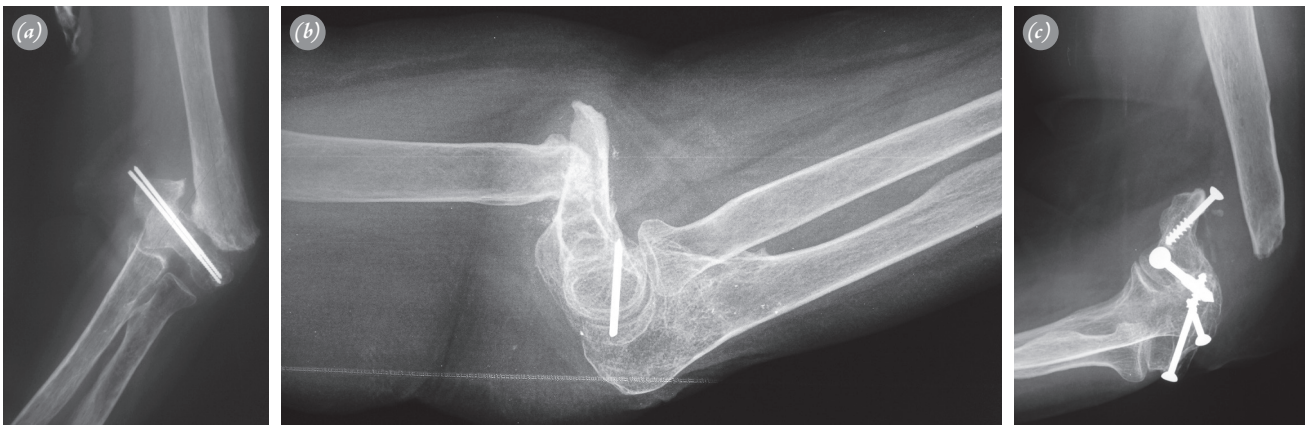

Fig. 1. **(a–c)** Preoperative X-rays of Cases 1, 5, and 7 showing distal humerus malunions.

No suspicion or evidence of infection was noted according to previous surgeries. Five fractures were fixed with multiple K-wires, 1 with cannulated screws, and 1 with locking plate and screws. Average time from initial surgical procedure to elbow arthroplasty was 46 months (range: 5–120 months). The patient (Case 5) with a time interval of 5 months from the initial procedure had sclerotic bone ends with gross instability at the fracture site; therefore, it was also considered nonunion. Average number of previous surgical procedures was 1.7.

Indications for total elbow arthroplasty were poor bone stock, pain, gross instability, and loss of function in daily activities, especially in the flexion-extension arc. A secondary osteosynthesis with rigid fixation was not considered suitable, as it is a complex procedure which frequently needs additional procedures, especially if the bone quality is poor and the viability of the bone is unpredictable.

Surgical technique

The patient was placed supine on the operating table, and a tourniquet was applied. A posterior midline incision was performed, and the ulnar nerve was exposed and transposed subcutaneously. In 2 cases (Cases 2 and 5), the nerve was already transposed anteriorly during previous open reduction. In these cases, a groove was made anteriorly in the subcutaneous tissue to provide adequate coverage of the nerve. The triceps were left intact. The condylar fragments were detached from their soft tissue attachments and removed with all previously implanted K-wires and screws to expose the distal humerus. Soft tissue and bony samples were taken for microbiological cultures, the results of which were all negative. In 6 cases, a piece of removed bone was placed behind the flange of the humeral component to improve stability. In 1 case (Case 4), fibular strut allograft was used to augment the component fixation due to a significant loss of the distal humerus. First the ulnar then the humeral components were cemented, and the joint was articulated.

A splint was applied to the arm at 45° elbow flexion, and the arm was elevated to decrease soft tissue swelling. After 48 hours, the drain was removed, and active and passive ROM exercises were allowed.

Patients were assessed using the Mayo Elbow Performance Index (MEPI) and Q-DASH score.[9] Clinical examination included goniometric assessment of ROM (extension, flexion, supination, and pronation). Patient-related outcome measures were evaluated using Q-DASH score.

Standard anteroposterior and lateral radiographs made preoperatively, early postoperatively, and at latest follow-up were reviewed for signs of fracture in the bone, implant, cement, bushing wear, and signs of loosening (Figure 2a, b). The cementing technique was evaluated on the early postoperative radiographs for both components and was classified into 3 types according to Morrey.[6] Bushing wear was assessed at latest follow-up on anteroposterior radiographs and was graded by Lee et al.[10] Loosening was graded on a scale from 0–4 as described by Morrey et al.[6] (Table 2).

Primary outcome variables were the MEPI and Q-DASH scores. Preoperative and final follow-up scores were compared using Student's t-test. The level of significance was set at 0.05. All analyses were performed with the MedCalc® statistical software package version 10.1.6 (MedCalc Software, Mariakerke, Belgium).

Results

At early postoperative period, pain-free joint stability was restored in all 7 patients with flail elbow. The ability to perform daily activities was restored. However, at final

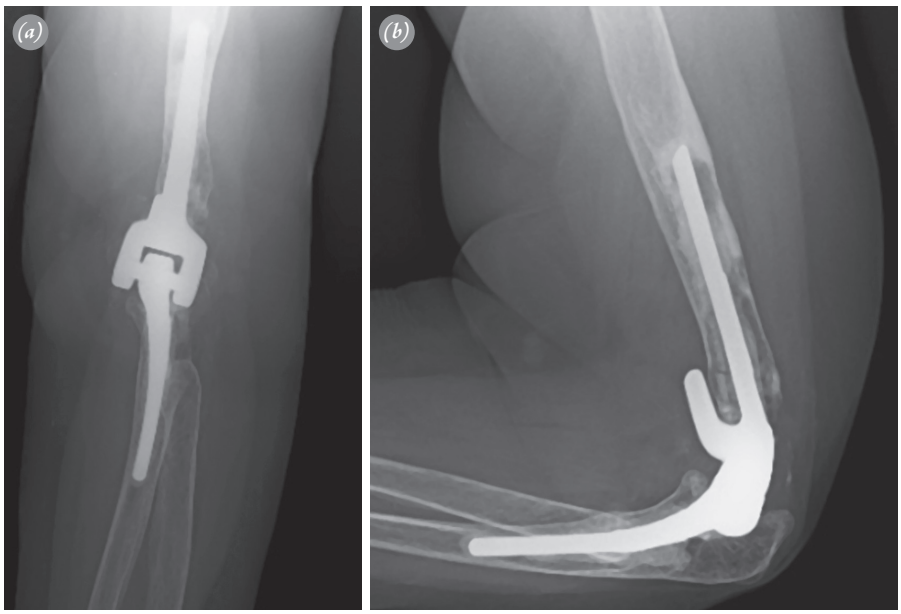

Fig. 2. **(a, b)** Radiographs 7 years after total elbow arthroplasty (Case 2).

follow-up, the results deteriorated due to implant related problems in 2 patients.

Clinical outcomes are summarized in Table 1. Mean preoperative MEPI score was 24.2 (range: 15–45). Mean MEPI score improved to 80 at time of the last follow-up (range: 50–95). Of the 7 patients, 3 had an excellent result, 2 had a good result, 1 had a fair result, and 1 had a poor result. A statistically significant difference was found at the latest follow-up compared with preoperative values (p=0.008).

Table 2. Grading systems used for radiological assessments.

Loosening grading according to Morrey
Grade 0: Radiolucent line <1 mm and <50% of the interface
Grade 1: Radiolucent line 1 mm and <50% of the interface
Grade 2: Radiolucent line >1 mm and >50% of the interface
Grade 3: Radiolucent line >2 mm and 100% of the interface
Grade 4: Gross loosening
Grading of the cementing technique according to Morrey
Type 1 Adequate cementing: <1 mm radiolucent zone, cement past tip of the prosthesis
Type 2 Marginal cementing: 2 mm wide radiolucency, cement past tip of the prosthesis
Type 3 Inadequate cementing: >2 mm radiolucency, cement not past tip of prosthesis
Grading of the bushing wear according to Lee
Grade 1 Normal bushing: <3.5° ulnohumeral angulation
Grade 2 Partial bushing wear: 3.5–5° ulnohemural angulation
Grade 3 Complete bushing wear: >5° ulnohumeral angulation

Mean ROM increased significantly from 30° preoperatively (range: 0–60°) to 91° at the latest follow-up (range: 60–110°) in flexion-extension (p=0.003). Only 1 patient (Case 6) had a flexion contracture of more than 20° due to heterotopic ossification, and this patient had a fair result according to the MEPI score (Figure 3). Three patients had flexion contracture of 10°, which does not impair daily activities. Three patients had no flexion contracture.

Mean Q-DASH score improved significantly from 93.2 preoperatively (range: 90.8–95.8) to 34.5 at latest follow-up (range: 13.6–59.1) (p=0.004).

Fig. 3. Heterotopic ossification after total elbow arthroplasty (Case 6).

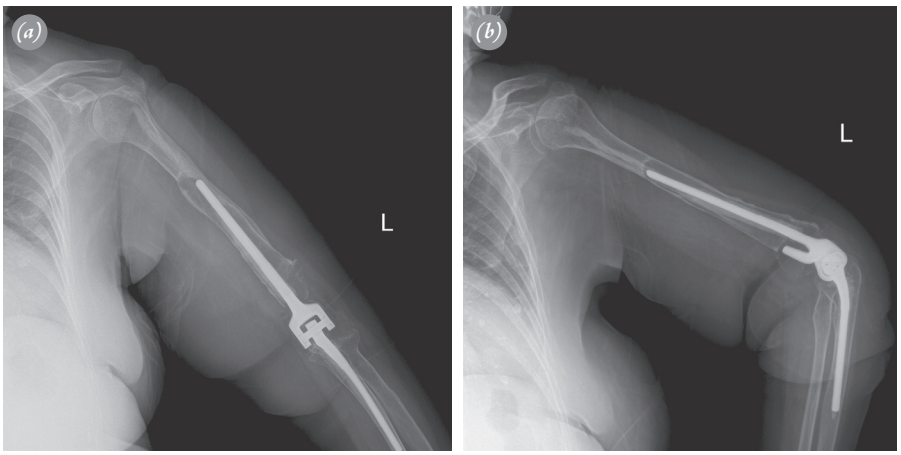

Fig. 4. **(a, b)** Radiographs of Type 4 humeral loosening (Case 5).

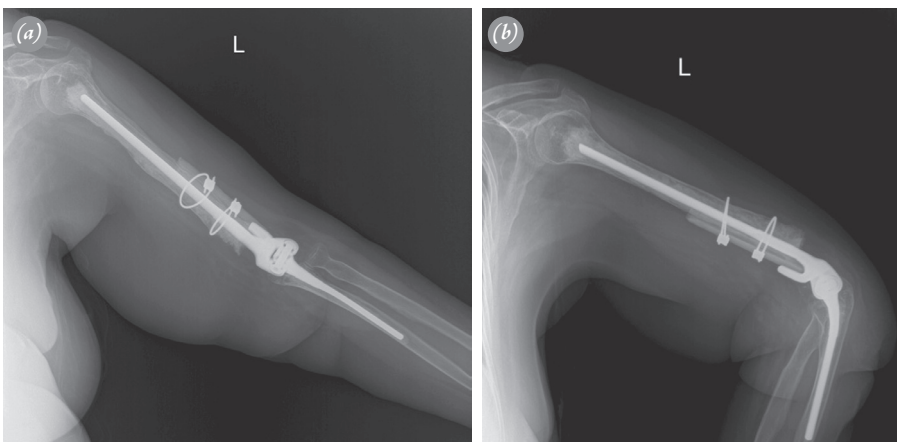

Fig. 5. **(a, b)** One year after revision of the loose humeral component with longer cemented humeral component and strut allograft.

The cement technique was evaluated on early postoperative radiographs. Type 1 humeral components were found in 3 patients, Type 2 in 3 patients, and Type 3 in 1 patient. Five ulnar components were Type 1, and 2 ulnar components were Type 2 cementing.

Two elbows (28%) showed evidence of bushing wear, and both had Type 2 wear at the latest follow-up.

Non-progressive radiolucent lines were noted around 3 humeral and 2 ulnar components at the latest follow-up. Progressive radiolucency and Type 4 loosening developed in 2 humeral components (Figure 4a, b).

At early postoperative period, neither wound or soft tissue complications nor deep or superficial infections occurred. Only 1 late complication, heterotopic ossification, occurred in 1 patient (Case 6). A revision is planned for this patient due to aseptic loosening. During revision the heterotopic bone is scheduled to be removed.

There were 2 aseptic loosenings of the humeral components. One of them was revised, with only the cemented humeral component being replaced with another cemented humeral component using the same prosthesis with a longer stem. One year following the revision, the patient had no pain, and there was no loosening of the component (Figure 5).

Discussion

Nonunion is not uncommon and is one of the most difficult complications of distal humeral fractures, occurring in approximately 2–10% of fractures treated with open reduction and internal fixation.[1] Few studies have been published to guide management decisions. Fundamentally, the 2 options for treatment of distal humeral nonunion are, firstly, open reduction and internal fixation and, secondly, total elbow arthroplasty. Although open reduction and internal fixation with bone grafting is the most commonly recommended treatment, it is a complex procedure and frequently needs additional proce-

dures.[1] Union can be achieved with these complex and multiple surgical procedures, but residual elbow stiffness and pain were commonly reported as major reasons for long-term disability.[1] While comparative studies have demonstrated the superiority of elbow arthroplasty in acute proximal humerus fractures when compared with internal fixation in selected patients over the age of 65 with a short term follow-up,[11] there are few reports in the literature for distal humerus nonunions treated with semiconstrained total elbow arthroplasty.[7,9,12] Morrey and Adams reviewed 39 patients with an average age of 68 years who had Coonrad-Morrey prostheses for distal humeral nonunions at an average follow-up of 4 years. At the latest follow-up, 86% of patients had satisfactory results, and 91% had only mild or no discomfort after the procedure.[9] Cil et al.[7] reported 91 patients with Coonrad-Morrey prostheses for distal humeral nonunions; after a mean postoperative follow-up of 6.5 years, 74% of the patients had mild or no pain at time of the latest follow-up, and 78% of the patients had excellent or good results according to the MEPI score. In the present study, 7 distal humerus nonunion cases in elderly patients with poor bone stock and loss of elbow function were evaluated on an average of 6 years postoperatively. Patient satisfaction was very high, and 5 of 7 patients had good or excellent results and mean ROM of 90.7° (range: 60–110°) at latest follow-up.

Aseptic loosening is a primary cause of implant failure in long-term follow-up. This problem may be related to several factors, including patient age, implants, and surgical techniques used. However, due to the small number of patients in the present study, none of these factors were identified as significant. Although higher rates of loosening are reported on the ulnar component with semiconstrained devices, in our study, ulnar component loosening was nonexistent. It is difficult to determine whether absence of ulnar component loosening was attributable to surgical technique or characteristics of patients. Failure at the bone-cement interface in the humerus is common, and it was the leading cause of humeral component failure in the present study; prevalence of loosening of the humeral component was 28.5% at 5 years after arthroplasty. In a study of 92 Coonrad-Morrey total elbow arthroplasties with a mean follow-up of 6.5 years, the rate of mechanical implant failure was 25%; 12 of these cases (50%) included aseptic loosening, and 1 case had isolated bushing wear. The authors reported higher rates of loosening or bushing wear associated with post-traumatic deformity or loss of a humeral condyle.[7] In this study, both condylar fragments were removed due to unreconstructable comminution, and this could be the reason for early humeral loosening in 2 patients. In LaPorte's review with a mean age of 61 years (range: 36–81 years), radiographic lucency was noted around the humeral implants in 3 patients (25%) at a 36-month follow-up.[13] However, in an older population with a mean age of 80 years (range: 71–84 years), Espiga et al. reported that none of the 6 elbows showed radiographic evidence of loosening, with a mean follow-up of 40 months.[12] Additionally, they noted Type 1 radiolucent lines in only 2 humeral components.

Patients' age and activity level play an important role in the selection of treatment method. The recommended age for total elbow arthroplasty varies between 65–70 years in the literature.[7,14] Cil et al. noted that elbow implants in patients under 65 years of age were 3 times more likely to require revision as a result of mechanical failure than in those older than 65 years.[7] In our case series with a mean age of 65 years, there were 2 aseptic loosenings of the humeral component after the 5th year, and 2 elbows (28%) showed evidence of bushing wear at the time of follow-up, both with Type 2 wear. Periprosthetic fractures or component fractures did not occur in the follow-up period.

A weakness of our study is that it is a retrospective study of a small subset of patients. Another weakness of the study is a lack of a control group of patients with distal humeral nonunions treated with rigid fixation and grafting. Therefore, it is difficult to compare elbow arthroplasty and rigid osteosynthesis for distal humeral nonunions.

However, specific diagnosis, mid-term to long-term follow-up, and use of the same prosthesis, surgical technique, and surgeon are strengths of the study.

Although the gold standard treatment of distal humerus non-unions remains internal fixation and bone grafting, semiconstrained total elbow arthroplasty can be a reliable choice of treatment if other internal fixation methods fail, and this procedure provides pain relief and restores elbow function and stability in patients with distal humeral nonunion. Although early- and mid-term functional and radiographic evaluations show better results, aseptic loosening emerges as the primary reason for long-term functional impairment after 5 years. In the future, multicenter studies comparing different implants would be beneficial.

Conflics of Interest: No conflicts declared.

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