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ORIGINAL ARTICLE

Results with a minimum of 10 years follow-up of the Coonrad/Morrey total elbow arthroplasty



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Accepted: 1st May 2013

KEYWORDS

Elbow;
Arthroplasty;
Linked;
Semi-constrained

Summary

Introduction: Few series have evaluated the long-term results of total elbow arthroplasty (TEA). *Materials and methods:* Fifteen patients with a Coonrad/Morrey total elbow implant were reviewed with a minimum follow-up of 10 years. There were nine women and six men with a mean age of 55 years at surgery. The aetiology was rheumatoid arthritis in eight cases, post-traumatic arthritis in five, psoriatic arthritis in one, and sequelae of neonatal septic arthritis in one. The TEA was performed as primary surgery in ten cases and during a revision surgery in four.

Results: At 136 months average follow-up (120–160), MEPS was 82 ± 14 points (range 60–100) with a Quick DASH score of 41 points (range 13–83). Fourteen patients had no or slight pain and six had a functional range of motion. Elbow function was normal in eight of 15 patients. Radiolucent lines were found around the humerus in six cases (all of them incomplete) and around the ulnar component in eight (five of them complete) with loosening and migration of the ulnar stem occurring in two cases. Wear of the bushings was moderate in five cases and severe in two. There were ten complications with a revision needed in three cases. Revision-free survival rate for the implant was 100% at 5 years and 90% at 10 and 13 years.

Discussion: The Coonrad/Morrey total elbow gives long-term satisfactory results. Increased incidence of radiolucent lines around the ulnar stem and bushing wear with longer follow-up is of concern and represents the failure mode for this total elbow arthroplasty implant.

Level of evidence: IV.

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Introduction

Over the past 30 years, semi-constrained linked total elbow arthroplasty (TEA) has been shown to be a reliable treatment for degenerative elbow arthritis [1]. However, few published series have described the long-term results of TEA [2–4]. Little et al. [5] compared three total elbow implants (two unlinked and one semi-constrained linked) as a treatment for rheumatoid arthritis of the elbow. All three implants gave the same clinical result after 65 months of follow-up. However, when looking at the survival of the three implants at 5 years, the Coonrad/Morrey semi-constrained linked implant had the best results over time. For the current study, we hypothesized that the published medium-term results with the Coonrad/Morrey total elbow would be maintained beyond 10 years.

Material and methods

Patient population

This was a retrospective study of a continuous cohort followed prospectively since 1997 in a single orthopaedics department. Inclusion criteria consisted of all patients having received a Coonrad/Morrey total elbow between 1997 and 2002, independent of diagnosis, and who were reviewed with at least 10 years of follow-up. Exclusion criteria consisted of patients with a Coonrad/Morrey total elbow with less than 10 years of follow-up and patients who required revision of their implant before 10 years.

Over this period, 44 Coonrad/Morrey total elbow arthroplasties were implanted in our department. At the time of the review, 13 patients had died, five had been revised before 10 years and 11 had less than 10 years of follow-up. All the deceased patients had their implant in place except for one where the implant had been removed to treat a deep infection. Of the five that had been revised, three were for aseptic loosening, one for ulnar component fracture and one to treat a deep infection. All of the 11 patients with less than 10 years of follow-up still had their implant in place and had not experienced any complications at the time of review.

Fifteen patients were reviewed that had more than 10 years of follow-up. There were nine women and six men; the average age at the time of the procedure was 55 years (range 22–74). The underlying pathology was rheumatoid arthritis in eight cases, post-traumatic osteoarthritis in five cases, psoriatic arthritis in one case and sequelae of juvenile arthritis in one case. The implant was used for primary TEA in 11 patients and revision of TEA in four cases.

Surgical technique

All patients were placed in dorsal decubitus. A Bryan-Morrey surgical approach was used. The ulnar nerve was identified in every patient and transposed in 14 of them (93%). A 10 cm long humeral stem was used in nine cases, a 15 cm stem in five cases and a 20 cm stem in one case. A normal length humeral flange was used in all cases except one where a longer flange was used to treat the sequelae of trauma. A standard length ulnar stem was used in

all cases. This implant had a plasma-sprayed polymethylmethacrylate (PMMA) surface coating; a new type of implant was introduced in 2002. Cement was used to fix the implant to bone in all cases; an antibiotic was added in seven cases (46%). A syringe was used to inject the cement in eight cases and an injection gun in seven cases. In 13 cases (86%), a bone graft was added behind the anterior flange of the humeral component. The central axis was locked with a pin in the first eight implants and a male–female connection in the next seven implants. Prophylactic antibiotics were used systematically. The average procedure time was 161 ± 34 minutes (range 120–240). Postoperative immobilization was performed in 15 cases for an average of 8 ± 11 days (range 2–45); the elbow was immobilized in extension in 13 cases and at 90° flexion in two cases. None of the patients were provided with rehabilitation. The average length of hospital stay was 8 ± 3 days (range 7–18) and all patients were able to return home afterwards.

Assessment methods

At the last follow-up, the clinical evaluation of patients consisted of the mayo elbow performance score (MEPS) [6] and Quick DASH [7]. A goniometer was used to measure the range of motion. Strength was assessed by testing resisted flexion and extension movements with the elbow in 90° flexion and comparing it to the opposite side. The radiographic analysis consisted of A/P and lateral X-rays to determine the fixation quality (correct or insufficient) and the presence of radiolucent lines. The fixation was deemed correct when cement was located around the entire implant and extended beyond the end of the stem; it was deemed insufficient if it did not extend beyond the end of the stem. Any radiolucent lines were classified using the Morrey classification system [8]. The quality of the bone graft integration behind the anterior flange was also analysed. Wear of the polyethylene bushings at the hinge was determined based on the angle of the ulnar stem relative to the humeral stem on an A/P X-ray of the elbow. If the angle was less than 3.5°, no wear was present; if the angle was between 3.5° and 5°, partial wear had occurred; complete wear was present if the angle was greater than 5°.

Statistical analysis

Univariate analysis was performed using the StatisticS® (version 5.6.6) software. A Mann-Whitney test was used to compare preoperative and postoperative data. The Chi² test was used to compare categorical data. The significance level was set at 5% when different variables were compared. The revision-free survival rate of the implant over time was evaluated using the Kaplan-Meier method with 95% confidence intervals.

Results

Overall results

At an average follow-up of 136 months (range 120–160), the MEPS was 82 ± 14 points (range 60–100) and the Quick DASH

Table 1 Characteristics of the 15 patients in the series before the surgery and at the last follow-up.

	Clinical evaluation (MEPS)		Statistics
	Preop	Postop	
Follow-up	—	136 ± 13	—
Pain	8 ± 9	37 ± 9	<i>P</i> < 0.001
Stability	5 ± 5	9 ± 1	<i>P</i> < 0.02
Function	9 ± 7	19 ± 4	<i>P</i> < 0.001
Mobility	10 ± 6	16 ± 4	<i>P</i> < 0.01
Extension	36 ± 43	39 ± 22	NS
Flexion	100 ± 31	130 ± 13	NS
Flexion–extension range	64 ± 49	91 ± 27	NS
Pronation	54 ± 26	70 ± 21	NS
Supination	57 ± 29	91 ± 27	<i>P</i> < 0.01
Pronation–supination range	112 ± 53	131 ± 28	<i>P</i> < 0.01
MEPS	31 ± 17	82 ± 14	<i>P</i> < 0.001
Quick DASH	—	43	—

The follow-up is given in months; Preop: preoperative; Postop: postoperative; extension, flexion, pronation and supination are given in degrees; the MEPS and Quick DASH are given in points; Statistics: significance level is (*P* < 0.05); NS: non significant; MEPS: mayo elbow performance score.

was 41 (range 13–83). The MEPS had significantly improved relative to preoperative values (*P* < 0.001) (Table 1). Based on the MEPS, the results were deemed excellent in seven cases, satisfactory in three and fair in five. There were no significant differences in terms of aetiology (rheumatoid arthritis or post-traumatic sequelae) or use of the implant for primary or revision arthroplasty.

Clinical results

The clinical results are summarized in Table 1. At the last follow-up, eight patients were pain-free and six had slight pain; only one patient was still experiencing pain. Six patients had a functional range of motion of at least 100°. All of the elbows were stable except two: one because of severe wear at the hinge mechanism and the other due to loosening of the ulnar stem. Eight of the 15 patients had normal function. Flexion strength was normal in 11 cases and slightly reduced in four cases. In contrast, extension strength was normal in only five cases, moderately decreased in five cases and significantly decreased in five cases. The patients with significantly lower strength had received their implant as part of a revision procedure in four cases and as a primary procedure in one case (*P* < 0.001).

Radiographic results

The radiographic results are summarized in Table 2. Neither the type of cement nor the type of injection system affected the quality of the fixation. At the last follow-up, incomplete radiolucent lines were found around the humeral implant in six cases. Radiolucent lines were found around the ulnar implant in eight cases, with five of them being complete; the implant had loosened and migrated in two of these cases. There were no correlations with aetiology, follow-up, preoperative data or surgical technique. Wear of the polyethylene

bushings at the hinge was directly correlated to the length of the follow-up (*P* < 0.05) (Fig. 1).

Complications and revisions

Complications were found in ten cases; surgical revision was required in three of these cases. Triceps insufficiency was observed in three cases where the implant had been used as part of a revision procedure. These were not revised because the deficit in active elbow extension was well-tolerated by these patients. Neurological complications occurred in three cases: two at the ulnar nerve and one at the radial nerve.

Table 2 Radiology results at the last follow-up for the 15 patients in the series.

	Humerus	Ulna
<i>Fixation</i>		
Correct	14	13
Incorrect	1	2
<i>Radiolucent lines</i>		
None	9	7
Type I	4	3
Type II	1	0
Type III	1	3
Type IV	0	2
<i>Bushing wear</i>		
None	7	
Partial	5	
Severe	3	
<i>Anterior graft</i>		
Incorporated	13	
Not incorporated	2	

Radiolucent lines: Type I: less than 1 mm thick and less than 50% of implant surface; Type II: more than 1 mm thick and more than 50% of the implant surface; Type III: 2 mm or more in thickness and over the entire implant surface; Type IV: loosened



Figure 1 A and B: X-rays of the Coonrad/Morrey total elbow used in a rheumatoid elbow at 11 years of follow-up. A. A/P view. B. Lateral view. Note the presence of moderate wear of the polyethylene bushings with a satisfactory implant-cement-bone interface.

The radial nerve injury occurred in a female patient with rheumatoid arthritis who presented with a distal humerus fracture that extended into the metaphysis and diaphysis. When preparing the humeral shaft, a false passage resulted in radial nerve laceration. The ulnar nerve involvement was limited to hyperaesthesia without sensory or motor deficits. One deep infection occurred 10 years after the initial surgery in a male patient with rheumatoid arthritis who had weakened skin due to long-term corticosteroid therapy. A wound in the pre-olecranon area resulted in a deep infection that required implant removal. The implant was not replaced and the elbow left as a resection arthroplasty. One patient presented with a failure of the male–female hinge mechanism 8 years after total elbow arthroplasty had been performed to treat a distal humerus non-union (Fig. 2). This mechanical failure was secondary to significant elbow valgus that had resulted in severe wear of the polyethylene bushings. A revision was required and consisted of changing the hinge mechanism and the polyethylene bushings without changing the stems, since these were well fixed. Six months after this surgery, the hinge mechanism failed again and a new revision procedure was performed with a custom central axis. Two fractures occurred: one was a proximal humeral shaft fracture that was proximal to the implant and the other was an ulnar shaft fracture around a completely loosened implant. One fracture was treated by immobilization only and the other patient refused further surgical procedures. Of the 15 patients at the last follow-up, 14 still had their implant in place.

Survival analysis

The Kaplan-Meier survival rate, using implant revision or removal as an end-point, was 100% at 5 years and 90% at 10 and 13 years.



Figure 2 Severe wear of the polyethylene bushings with failure of the central axis 8 years after the initial surgery for distal humerus non-union.

Discussion

The Coonrad/Morrey total elbow is a titanium alloy joint implant consisting of a chrome–cobalt central axis that goes around high-density polyethylene bushings to link the ulnar and humeral components. This hinge mechanism is semi-constrained because it allows for about 8° of varus–valgus motion and about 8° of internal–external rotation, which is similar to a normal elbow [9,10]. An anterior flange

Table 3 Comparison of published studies describing the long-term survival of total elbow arthroplasty.

Authors	Year	Type of implant	N	Follow-up (years)	Survival (%)
<i>Linked implant</i>					
Aldridge et al.	2006	Coonrad-Morrey	41	10–30	68 (20 years)
Gill and Morrey	1998	Coonrad-Morrey	78	12.5	92 (12 years)
Gschwend et al.	1999	GSBIII	36	13	78 (13 years)
Current series	2013	Coonrad-Morrey	15	11	92 (11 years)
<i>Unlinked implant</i>					
Ikävalko et al.	2010	Souter	522	10.6	89 (10 years)/77 (19 years)
Landor et al.	2006	Souter	58	9.5	70 (10 years)
Trail et al.	2002	Souter	207	9	79 (10 years)
Qureshi et al.	2010	Kudo-5	34	12	74 (12 years)
Tanaka et al.	2001	Kudo-3	50	13	90 (13 years)

at the distal part of the humeral stem helps to resist anterior–posterior and rotation forces. In 1998, a new central axis was introduced that made it possible to quickly and easily lock the ulnar and humeral stems together. In 2000, interchangeable components were designed that allowed humeral and ulnar stems of different sizes to be combined together. In 2001, a new ulnar stem with a roughened titanium coating replaced the previous, PMMA-covered, smooth ulnar stem.

There are few published studies describing the results with this implant beyond 10 years. Gill and Morrey [3] analysed 78 Coonrad/Morrey total elbows implanted in elbows affected by rheumatoid arthritis; 46 of these had an average follow-up of 136 months (range 120–184). The survival rate was 94% at 5 years and 92% at 10 years. At the last follow-up, 91% of elbows had a satisfactory result with MEPS of 90 points. Most of these elbows (98%) had no pain or minimal pain. Functional range of motion had been regained in all cases and the elbow was stable. A radiology analysis of the 46 elbows with the longest follow-up found loosening of the humeral and ulnar stems. Partial wear of the polyethylene bushings was found in six cases (13%) and severe wear in three cases (6.5%). Eleven of the 78 elbows (14%) had 14 complications that required surgical revision in ten cases (13%). The most common complications were triceps avulsion (3 cases), deep infection (2 cases), ulnar fracture (2 cases), and ulnar stem fracture (1 case). Loosening was present in four cases: both components once, humeral stem once, ulnar stem twice.

A more recent retrospective analysis of 41 elbows with a Coonrad implant or a Coonrad/Morrey total elbow arthroplasty was performed with a follow-up of more than 10 years [2]. Various aetiologies were included. With a follow-up of 10 to 15 years, there were 13 failures (32%), with six requiring revision and five requiring the polyethylene bushings to be changed. No revision was needed in the other 28 elbows (68%), with 14 of them still being functional after 10 to 14 years, seven after 15 to 19 years, six after 20 to 25 years and one after 31 years of follow-up. The average survival rate of the Coonrad implant or Coonrad/Morrey total elbow arthroplasty was 17.5 years. In the current study, the survival rate at 10 years was 90%. These two studies confirmed previously reported results [5] showing that the semi-constrained linked Coonrad/Morrey total elbow arthroplasty prevented

elbow instability without increasing the risk of loosening. A review of studies reporting results beyond 10 years with other linked and unlinked elbow implants showed a better long-term survival with the Coonrad/Morrey total elbow (Table 3) [1–4,11–15].

However, the limiting factor for this implant over time is worn in the polyethylene bushings at the hinge [16,17]. There seems to be a relationship between wear and any initial elbow deformity that was not corrected by soft tissue balancing during the procedure [8,16]. Younger patients and postoperative physical activity also seem to contribute to the wear [8,16,18], as does faulty implant positioning. In fact, rotational problems between the humeral and ulnar stems will lead to excessive loads being placed on the hinge mechanism, which are at the origin of its accelerated wear [19]. By carefully following the surgical technique outlined by the manufacturer and by restoring the elbow's rotational axis, the longevity of this implant can be ensured [20].

Annual monitoring of patients is required to detect wear and to propose bushing replacement when severe wear is found, preferably before signs of implant loosening or axis failure appear [16,17,21,22]. Frontal valgus–varus stress X-rays of the elbow can be useful in detecting this wear. The replacement procedure is straightforward and provides satisfactory results [16]. However, if the polyethylene bushing wear is excessive, metal on metal contact in the hinge will lead to failure of the axis and deformation of the hinge area in the humeral stem. This deformity may require that a custom-made central axis be used [22]. In the current study, the amount of bushing wear was correlated with the length of the follow-up. The impact of preoperative deformity was not studied. The hinge mechanism had to be revised in one patient in whom a distal humerus non-union had been treated by total elbow arthroplasty. Gradual valgus deviation of the elbow resulted in wear at the hinge; the revision was performed 8 years after the initial surgery. This hinge deformity led to failure of the new central axis and required a custom-made axis, as described by others [22]. Despite the semi-constrained nature of this implant, it seems important to preserve the pillars if possible, while trying to rebalance the periarticular soft tissues.

The other long-term failure mode of the Coonrad/Morrey total elbow arthroplasty is ulnar stem loosening. Loosening seems to occur more often in the ulnar than the humeral



Figure 3 Osteolysis around an ulnar stem at 157 months of follow-up.

stem [23,24]. In our series, radiolucent lines around the ulnar stem were found in eight of 15 cases, with four being complete; six cases of radiolucent lines were found around the humeral stem, but none were complete. Hildebrand et al. [23] noted increased osteolysis around ulnar stems relative to humeral stems, with a rate of 32% at a follow-up of 50 ± 11 months. This osteolysis was associated with the type of coating used on the ulnar stem, but was also found more often in elbows with trauma sequelae as opposed to elbows with rheumatoid arthritis. More recently, the results of three types of ulnar stems used in the Coonrad/Morrey total elbow arthroplasty were analysed [25]. The implant covered with PMMA (which was used in our study) had the highest failure rate in comparison to the new implant introduced in 2002. The survival rate at 7 years was 83% versus 100%. Failure of this implant manifests itself by the appearance of osteolysis around the implant and implant breakage in some cases (Fig. 3). It is recommended that the implant be revised before the ulna fractures around the implant or the implant itself breaks. Debris released by polyethylene bushing wear and any metal debris generated by wear in the hinge mechanism could trigger a foreign body reaction that could cause bone resorption around the implant. There is evidence that poor ulnar stem positioning or the presence of a flexion impingement between the coronoid process/cement and the anterior flange of the humeral stem brings about extraction forces that cause ulnar stem loosening.

The main limitations of this study are its retrospective nature and the small number of patients reviewed at more than 10 years, despite 44 patients having been operated on during the recruitment period. In addition, five patients were revised during the follow-up period affecting the interpretation of our results. However, this was continuous, single-centre study performed outside the designer's facility that provides insight into the reproducible results that can be achieved with the Coonrad/Morrey total elbow arthroplasty, no matter the initial indication.

Conclusion

The semi-constrained linked Coonrad/Morrey total elbow arthroplasty provides long-lasting, satisfactory results no matter if used for primary or revision indications. However, radiolucent lines around the ulnar stem and polyethylene bushing wear in the hinge mechanism seem to be weak points of this implant, with failure appearing with longer follow-up periods.

Disclosure of interest

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

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