Semiconstrained Primary and Revision Total Elbow Arthroplasty with Use of the Coonrad-Morrey Prosthesis

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Background: Semiconstrained total elbow prostheses are used routinely by many surgeons to treat a variety of severe elbow disorders. Our objective was to review the results of primary and revision total elbow arthroplasty with use of the Coonrad-Morrey prosthesis. The selected use of this semiconstrained implant in patients with instability and poor bone stock was hypothesized to provide inferior results compared with those in the published reports.

Methods: The results of sixty-seven semiconstrained total elbow arthroplasties that were performed in fifty-six patients between 1990 and 2003 were evaluated. Thirty-seven elbows had a primary arthroplasty and were followed for a mean of eighty-six months, and thirty elbows had a revision arthroplasty and were followed for a mean of sixty-eight months. Mayo elbow performance scores and radiographic analyses were used to assess the clinical results.

Results: In the primary arthroplasty group, the average flexion improved from 116° to 135°; average extension, from –40° to –33°; average pronation, from 60° to 81°; and average supination, from 60° to 69°. The improvements in flexion and pronation were significant ($p < 0.001$ for both). Preoperatively, twenty-five (74%) of thirty-four elbows with data available had moderate or severe pain, whereas only four (11%) had pain postoperatively. The average postoperative Mayo score (and standard deviation) was 84 ± 16. Eleven of the thirty-seven primary replacements failed, and the five-year survival rate was 72%. In the revision arthroplasty group, average flexion improved from 124° to 131°; average extension, from –32° to –22°; average pronation, from 66° to 75°; and average supination, from 64° to 76°; the improvement in supination was significant ($p < 0.05$). Preoperatively, eighteen (64%) of the twenty-eight elbows with data available had moderate or severe pain, while only five (17%) had pain postoperatively. The average postoperative Mayo score was 85 ± 16. Eleven of the thirty revision replacements failed, and the five-year survival rate was 64%.

Conclusions: A Coonrad-Morrey semiconstrained total elbow arthroplasty provides excellent pain relief and good functional return in patients with severe destructive arthropathy. The higher prevalence of failure in this cohort compared with series reported elsewhere is likely due to adverse patient selection as this implant was reserved for more complex arthroplasties with severe bone loss and ligamentous laxity.

Level of Evidence: Therapeutic Level IV. See Instructions to Authors for a complete description of levels of evidence.

Total elbow arthroplasty has been reported to be successful with use of both linked, or semiconstrained, and unlinked, or resurfacing, prostheses[1]. In the last thirty years, advancements in the design of total elbow prostheses have reduced the rate of complications, but patients with complex elbow disorders continue to pose surgical challenges. The initial use of single-axis, metal-hinged total elbow prostheses was associated with high failure rates because of aseptic loosening[2-5]. As a

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result, the use of unlinked, or resurfacing, prostheses has become popular. Several groups of investigators have reported lower rates of aseptic loosening with unlinked implants, but they also noted early postoperative complications such as dislocation, subluxation, and transient nerve palsy[6-9]. As a result, semiconstrained prostheses are used in many centers and are used routinely by some surgeons. The Coonrad-Morrey total elbow prosthesis (Zimmer, Warsaw, Indiana) is a semiconstrained implant that was used first at our institution in 1990. Investigators at the Mayo Clinic and elsewhere have described long-term outcomes of the Coonrad-Morrey prosthesis when they were used routinely[10-14]. All reported that >80% of the patients had excellent or good results at the time of the latest follow-up. Most patients had good elbow function and good pain relief. The studies had failure rates, defined as the need for revision surgery, ranging from 5% to 22%.

At our institution, the Coonrad-Morrey prosthesis has not been used routinely but rather has been the elbow implant of choice for patients with extensive capsuloligamentous injury, atrophic musculature, and loss of considerable bone stock. Moreover, it was the most common revision total elbow arthroplasty used during the period of this study. Typical patients include those with end-stage rheumatoid arthritis with extensive bone loss, severe posttraumatic arthritis, or failed resurfacing and semiconstrained replacements. The objective of the present study was to review the results of the primary and revision Coonrad-Morrey total elbow arthroplasties in these selected patients. Primary and revision total elbow replacements were analyzed separately with regard to functional outcome, survival rate, and complications.

Materials and Methods

One hundred and two Coonrad-Morrey total elbow arthroplasties were performed for eighty-six patients at our institution between July 1990 and November 2003, as identified by hospital records. Sixty patients were alive at the time of this review, according to the Social Security Death Index (www.ancestry.com). Every patient was contacted by telephone to urge them to return for a follow-up evaluation. A previously described protocol was used to ascertain the contact information of the patients who were lost to follow-up[15]. All but one of the sixty patients were reached on the telephone. Thirty-nine patients (forty-six elbows) returned to the clinic, eleven (fifteen elbows) were evaluated in their homes or offices, and, for one patient (one elbow), the outside hospital records were reviewed. At the time of writing, nine patients had not yet returned for follow-up. Twenty-six patients died prior to the review, and only five of those patients (five elbows) are included in this report as they had greater than twenty-four months of follow-up, defined as the elapsed time from the index procedure to the most recent clinic visit that included a history, a physical examination, and radiographs. All subjects gave informed consent to participate in the study, and the study was approved by our institutional review board.

Sixty-seven Coonrad-Morrey total elbow arthroplasties are included in the data analyses (Table I). The average age of the thirty patients (thirty-seven elbows) who had primary total elbow arthroplasty was sixty-one years (range, thirty-five to eighty-seven years) at the time of surgery, and they had a mean length of follow-up of eighty-six months (range, twenty-seven to 168 months). The diagnoses were rheumatoid arthritis (six-

TABLE I Characteristics of the Study Cohorts

	Primary Total Elbow Arthroplasty (N = 37)	Revision Total Elbow Arthroplasty (N = 30)
Age at time of surgery* *(yr)*	61 ± 14 (35-87)	65 ± 9 (43-77)
Gender†		
No. (%) of elbows in female patients	28 (76)	26 (87)
No. (%) of elbows in male patients	9 (24)	4 (13)
Side†		
Left	11 (30)	10 (33)
Right	26 (70)	20 (67)
Diagnosis†		
Rheumatoid arthritis	16 (43)	24 (80)
Posttraumatic osteoarthritis	10 (27)	0 (0)
Trauma	9 (24)	4 (13)
Osteoarthritis	1 (3)	2 (7)
Hemophiliac arthropathy	1 (3)	0 (0)
Dominant arm†	19 (51)	19 (63)
Failures†	11 (30)	11 (37)

*The values are given as the mean and the standard deviation, with the range in parentheses. †The values are given as the number of elbows, with the percentage in parentheses.

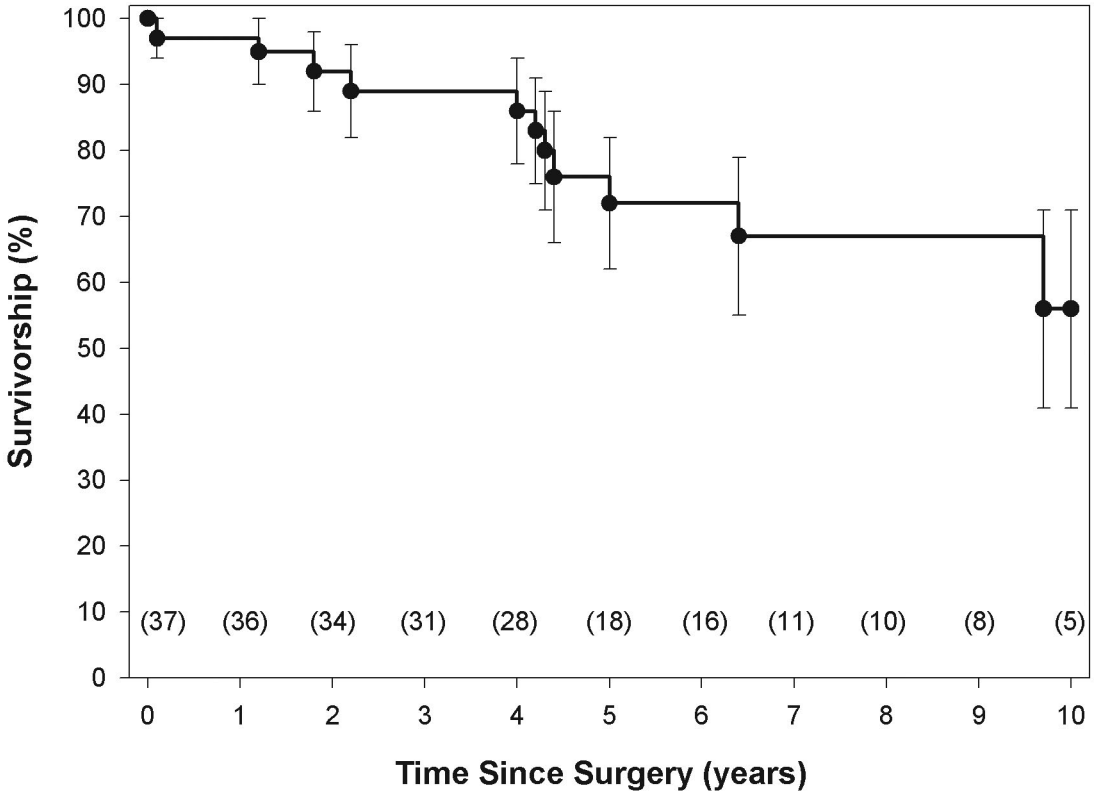

Fig. 1

Kaplan-Meier survivorship curve for primary total elbow replacements. Each stepwise decline between the beginning point and the end point on the curve represents a failure that happened at a specific time after the index procedure. With each of the eleven failures, there is a lowering of the survivorship percentage. The bars bracketing each point indicate the 95% confidence interval for the survivorship at that time. The numbers in parentheses on the x-axis represent the number of total elbow replacements that survived at a given time after surgery; the decreasing trend in these numbers is due to a combination of failures and those that were no longer being followed. The five-year survival rate is 72% (95% confidence interval, 62% to 82%).

teen elbows), posttraumatic arthritis (ten), trauma (nine), osteoarthritis (one), and hemophiliac arthritis (one). There were thirty revision total elbow arthroplasties. The average age of the twenty-six patients (thirty elbows) who had revision arthroplasty was sixty-five years (range, forty-three to seventy-seven years) at the time of surgery, and they had a mean length of follow-up of sixty-eight months (range, twenty-four to 167 months); the diagnoses were rheumatoid arthritis (twenty-four elbows), trauma (four), and osteoarthritis (two). Only one patient who had a total elbow arthroplasty with less than twenty-four months of follow-up is included in the data analyses because the elbow was found to be infected at ten months after the surgery. Fifty-eight of the sixty-seven total elbow arthroplasties were performed by the two senior authors (M.J.K. and T.S.T.); the remaining nine were performed by five surgeons who also had hand and/or upper extremity or arthroplasty fellowship training.

The Coonrad-Morrey Total Prosthesis

The semiconstrained Coonrad-Morrey prosthesis with fixation of both stems with cement was used in all patients. The implant allows for 7° to 10° of varus-valgus movement and 7° to 10° of axial rotation[16]. There were minor changes in the component design during the study period: the central locking pin was redesigned in 1996, and the ulnar component changed from a beaded surface to a precoat of polymethylmethacrylate in 1992 and then back to a beaded surface in 2001. The modified Kocher or triceps-splitting surgical approach was used in all patients. The ulnar nerve was isolated but was not routinely transposed. On occasion, the medial epicondyle was excised. When possible, the medial head of the triceps was preserved. If it was removed, it was reattached through holes in the ulna and, if possible, was fortified with the anconeus. The radial head was excised in all patients. Of note, humeral allografts were required in seven revision arthroplasties, one of which also needed an ulnar allograft.

Data Collection

For each patient, hand dominance, range of motion (flexion, extension, supination, and pronation), stability, pain level, and functionality of the affected elbow(s) were recorded. Preoperative data were gathered from the written and electronic

TABLE II Range of Motion and Evaluation Scores for Thirty-seven Elbows That Had Primary Total Elbow Arthroplasty

Variable	Preop.	Postop.	P Value
Range of motion* *(deg)*			
Flexion	116 ± 21	135 ± 13	<0.001†
Extension	–40 ± 29	–33 ± 23	0.30
Pronation	60 ± 24	81 ± 17	<0.001†
Supination	60 ± 24	69 ± 24	0.16
Pain score*	12 ± 12	36 ± 12	<0.001†
Mayo score*	44 ± 21	84 ± 16	<0.001†
Level of pain‡			<0.001†
None	3 (9)	23 (62)	
Mild	6 (18)	10 (27)	
Moderate	10 (29)	4 (11)	
Severe	15 (44)	0 (0)	

*The values are given as the mean and standard deviation. †The difference was significant. ‡The values are given as the number of elbows with the percentage in parentheses. Preoperative pain scores were not obtained for three patients.

medical record. Postoperative data were gathered from the medical record, clinic evaluations, or home visit evaluations. Mayo elbow performance scores were used in the analyses[17]; the 100-point system contains four components: pain, motion (flexion arc), stability, and function and/or activity. Some patients with elbow injuries had incomplete preoperative data, as a thorough evaluation (i.e., range of motion) was not appropriate in some of those situations. Also of note, the function and/or activity component of the preoperative Mayo scores for approximately one-quarter of the patients was estimated from the history if specific activities were not noted. Postoperative anteroposterior and lateral radiographs of the elbows were analyzed to evaluate component position, cementing technique, and radiolucent lines. Radiolucencies were examined for progression over time. Failures were defined as arthroplasties that required revision or resection, or those that had radiographic signs of failure (i.e., progressive radiolucencies over time or a radiolucency of >2 mm between the implant and cement on any one radiograph). Dates of the onset of failure were noted.

Statistical Analysis

All continuous variables were tested for normality with use of the Kolmogorov-Smirnov test, and no significant skewness was detected. Therefore, age, range of motion, pain scores, and Mayo scores are presented as means and standard deviations. Primary and revision groups were compared with respect to age, gender, side, dominant arm, and diagnosis by univariate analysis with the two-sample Student t test for continuous variables and the Fisher exact test for categorical variables. Preoperative and postoperative range of motion as well as pain scores and Mayo scores were tested for each of the two cohorts (primary and revision groups) with use of paired t tests. Changes in the level of pain (none, mild, moderate, or severe) were evaluated with use of the nonparametric Wilcoxon signed-rank test[18]. For each group, time to failure was analyzed with use of the Kaplan-Meier product-limit method with 95% confidence intervals around the curves as calculated by the Greenwood formula[19]. This survivorship method accounts for so-called censoring (i.e., elbows that had not had failure but continued to be at risk for failure). For multivariate analysis, both multiple logistic regression (stepwise backward selection) and the Cox proportional-hazards model were applied to control for confounding and to evaluate possible predictors of failure, including age, gender, side, dominant arm, diagnosis, and preoperative Mayo score[20]. Statistical analysis was performed with the SPSS software package (version 14.0; SPSS, Chicago, Illinois). All two-tailed p values of <0.05 were considered significant. Power analysis indicated that the patient sample sizes of the primary (thirty-seven elbows) and revision groups (thirty elbows) provided 90% power to detect significant changes of at least one standard deviation in each of the range-of-motion variables, pain scores, and Mayo scores on the basis of paired t tests (two-tailed $\alpha = 0.05$, $\beta = 0.10$). In addition, precision of the Kaplan-Meier survivorship curves as determined by error bars representing 95% confidence intervals would be to within 10% to 15% of the estimated steps along the curves (version 6.0, nQuery Advisor; Statistical Solutions, Saugus, Massachusetts).

Results

Primary Arthroplasties

In the thirty-seven elbows that had primary total arthroplasty, all range-of-motion measurements improved after the elbow replacement (Table II). Average flexion improved from 116° ± 21° to 135° ± 13° ($p < 0.001$). Average extension improved from –40° ± 29° to –33° ± 23° ($p = 0.30$). Average pronation improved from 60° ± 24° to 81° ± 17° ($p < 0.001$).

TABLE III List of Failed Primary Total Elbow Replacements

Case	Gender	Diagnosis	Length of Survival of Total Elbow Replacement *(mo)*	Reasons for Failure	Treatment
1	F	Rheumatoid arthritis	48.8	Loose humeral component and broken bushing	Revision
2	F	Posttraumatic arthritis	117.8	Loose ulnar and humeral components, broken bushing, bone loss, and triceps avulsion	Revision
3	F	Rheumatoid arthritis	61.1	Loose humeral component and osteolysis	Revision
4	F	Osteoarthritis	26.3	Periprosthetic fracture of distal end of humerus	Revision
5	F	Trauma	51.5	Loose humeral component	Revision
6	M	Rheumatoid arthritis	14.4	Loose ulnar component and periprosthetic fracture	Revision
7	F	Posttraumatic arthritis	25.9	Loose ulnar and humeral components and severe osteolysis	Revision
8	M	Posttraumatic arthritis	1.6	Infection	Resection
9	F	Traumatic	0.5	Infection	Resection
10	M	Traumatic	22.1	Infection	Resection
11	M	Posttraumatic arthritis	52.2	Loose ulnar component	None

Supination improved from 60° ± 24° to 69° ± 24° ($p = 0.16$). Twenty-five (74%) of the thirty-four elbows with data available had moderate or severe pain preoperatively, and only four (11%) had moderate or severe pain postoperatively. This difference was significant ($p < 0.001$). When converted to a numerical measure as a component of the Mayo score (with 0

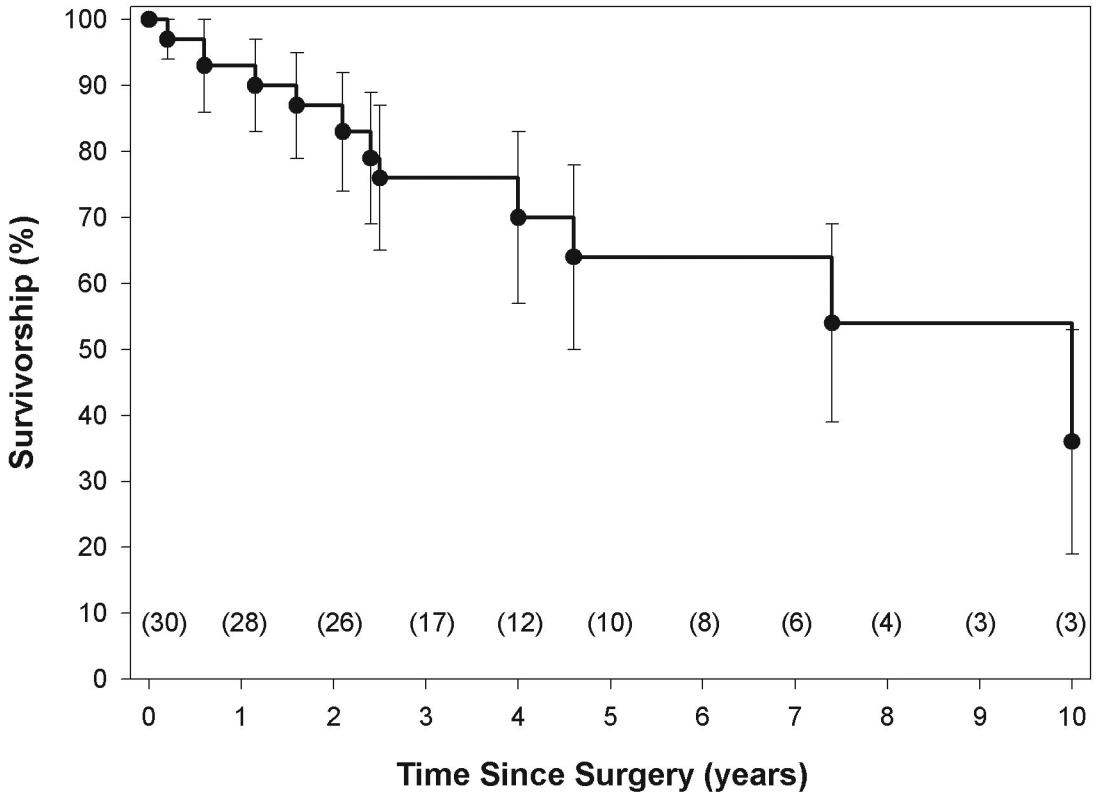

Fig. 2

Kaplan-Meier survivorship curve for revision total elbow replacements. With each of the eleven failures, there is a lowering of the survivorship percentage. The five-year survival rate is 64% (95% confidence interval, 50% to 78%).

TABLE IV Comparison of Primary Total Elbow Replacements That Failed and Those That Survived

Variable	Replacements That Survived (n = 26)	Replacements That Failed (n = 11)	P Value
Age* *(yr)*	59 ± 15	66 ± 7	0.14
Preop. Mayo score*	50 ± 19	27 ± 16	<0.01†
Gender			0.40
No. (%) of elbows in female patients	21 (81)	7	
No. (%) of elbows in male patients	5 (19)	4	
Diagnosis†			0.47
Rheumatoid arthritis	12 (46)	3	
Other	14 (54)	8	
Dominant arm†	11 (42)	8	0.15

*The values are given as the mean and the standard deviation. †According to multivariate analysis, the preoperative Mayo score was the only significant predictor of radiographic failure. ‡The values are given as the number of elbows, with the percentage in parentheses.

indicating severe pain; 15, moderate pain; 30, mild pain; and 45, no pain), the average pain score improved significantly from 12 ± 12 preoperatively to 36 ± 12 postoperatively ($p < 0.001$). In the primary total elbow arthroplasty group, the Mayo score increased from an average of 44 ± 21 preoperatively to an average of 84 ± 16 postoperatively ($p < 0.001$).

Eleven of the thirty-seven primary total elbow replacements failed. Seven of the failed elbows were revised, three were resected, and one was treated nonoperatively (Table III). The primary reason for the seven revisions was periprosthetic fracture in two, humeral component loosening in three, and loosening of both components in two. All three total elbow replacements that were resected had an infection around the prosthesis. In one patient who had failure, progressive radiolucencies of the ulnar component were seen on radiographs; the prosthesis was not revised because the patient preferred to tolerate the symptoms. Multiple logistic regression analysis and the Cox proportional-hazards model were used to evaluate possible predictors of failure, including age, gender, side, dominant arm, diagnosis of rheumatoid arthritis, and preoperative Mayo score (Table IV). Among these factors, the preoperative Mayo score was the only significant predictor of failure ($p < 0.01$). A Kaplan-Meier survivorship curve was generated to depict the eleven failures among the thirty-seven primary total elbow replacements (Fig. 1). The five-year survival rate was 72% (95% confidence interval, 62% to 82%). Of the twenty-six primary total elbow replacements that did not fail, six elbows had a flexion contracture of >45°, one elbow had transient ulnar neuropathy (less than six months), one had persistent ulnar neuropathy (greater than one year), and one had triceps avulsion.

Revision Arthroplasties

In the thirty elbows that had revision arthroplasty, all range-of-motion measurements improved after the surgery (Table V), although not by as great a magnitude as they had in the primary arthroplasty group. Average flexion improved from 124° ± 22° to 131° ± 18° ($p = 0.19$). Average extension improved from –32° ± 27° to –22° ± 18° ($p = 0.17$). Average pronation improved from 66° ± 23° to 75° ± 25° ($p = 0.07$). Average supination improved from 64° ± 25° to 76° ± 21° ($p < 0.05$). Eighteen (64%) of the twenty-eight elbows with data available had moderate or severe pain preoperatively, and five (17%) had moderate or severe pain postoperatively ($p < 0.001$). When converted to a numerical measure, the average pain scores demonstrated a significant improvement from 18 ± 11 preoperatively to 36 ± 13 postoperatively ($p < 0.001$). The Mayo score increased from an average of 56 ± 17 preoperatively to an average of 85 ± 16 postoperatively ($p < 0.001$).

Among the thirty revision total elbow replacements, eleven failed (Table VI). Of the five that were revised, two had humeral component loosening, one had ulnar component loosening, one dislocated with a worn bushing, and one was precipitated by a fall that led to a nonunion of a mid-shaft humeral periprosthetic fracture. Moreover, five additional failures were detected radiographically and were treated nonoperatively because of patient preference and/or lack of symptoms. These included one with humeral loosening and a humeral allograft nonunion, one with a periprosthetic fracture of an ulnar graft and graft nonunion, one with loosening of the ulnar component, and two with loosening of both the ulnar and humeral components. Another patient with a loose humeral component and nonunion of a humeral allograft was scheduled for revision with a custom prosthesis. Multiple logistic regression analysis and the Cox proportional-hazards model were used to evaluate possible predictors of failure (Table VII), yet none proved to be significant. A Kaplan-Meier survivorship curve for the thirty revision total elbow replacements was generated to depict the eleven failures (Fig. 2). The five-year survival rate was 64% (95% confidence interval, 50% to 78%).

Of the nineteen revision total elbow replacements that did not fail, three elbows had a flexion contracture of >45°. Four elbows had a persistent ulnar neuropathy lasting more

TABLE V Range of Motion and Evaluation Scores for the Thirty Elbows That Had Revision Total Elbow Arthroplasty

Variable	Preop.	Postop.	P Value
Range of motion* *(deg)*			
Flexion	124 ± 22	131 ± 18	0.19
Extension	–32 ± 27	–22 ± 18	0.17
Pronation	66 ± 23	75 ± 25	0.07
Supination	64 ± 25	76 ± 21	<0.05†
Pain score*	18 ± 11	36 ± 13	<0.001†
Mayo score*	56 ± 17	85 ± 16	<0.001†
Level of pain‡			<0.001†
None	0 (0)	18 (60)	
Mild	10 (36)	7 (23)	
Moderate	14 (50)	4 (13)	
Severe	4 (14)	1 (3)	

*The values are given as the mean and the standard deviation. †The difference was significant. ‡The values are given as the number of elbows, with the percentage in parentheses. Preoperative pain scores were not obtained for two elbows.

than one year. Two elbows had an intraoperative humeral fracture, resulting in transient radial neuropathy in one of them and transient ulnar neuropathy in the other; these symptoms resolved within six months in both patients. One elbow had triceps avulsion.

Ulnar component loosening was examined because of reports by other investigators that precoated ulnar components had a higher rate of loosening[21]. At our institution, precoated ulnar components were used between February 1993 and June 2001, and six (12%) of fifty-one total elbow replacements had ulnar component loosening. Of the sixteen total elbow replacements with a beaded ulnar component surface, two had ulnar component loosening. With the numbers studied, there was no significant difference in the prevalence of loosening between the precoated and the beaded component surface components ($p = 0.94$).

TABLE VI Failed Revision Total Elbow Replacements

Case	Gender	Diagnosis	Allograft	Length of Survival of Total Elbow Replacement *(mo)*	Reason for Failure	Treatment
1	F	Rheumatoid arthritis		56.4	Fall led to mid-humeral fracture that led to nonunion of periprosthetic fracture	Revision
2	F	Rheumatoid arthritis		48.1	Loose humeral component	Revision
3	F	Rheumatoid arthritis		7.2	Worn bushing and dislocation	Revision
4	F	Rheumatoid arthritis		18.9	Loose humeral component	Revision
5	F	Rheumatoid arthritis		10.3	Loose ulnar component	Revision
6	F	Rheumatoid arthritis	Humerus	29.6	Allograft nonunion and loose humeral component	None
7	M	Trauma	Humerus and ulna	2.5	Allograft nonunion and periprosthetic fracture of ulnar graft	None
8	F	Rheumatoid arthritis		28.9	Loose ulnar and humeral components	None
9	F	Rheumatoid arthritis		36.7	Loose ulnar and humeral components, osteolysis	None
10	M	Rheumatoid arthritis		91.3	Loose ulnar component, plate fracture, and nonunion of periprosthetic fracture	None
11	F	Rheumatoid arthritis	Humerus	26.1	Allograft nonunion and loose humeral component	Scheduled for revision with custom prosthesis

TABLE VII Comparison of Revision Total Elbow Replacements That Failed and Those That Survived

Variable	Total Elbow Replacements That Survived (n = 19)	Total Elbow Replacements That Failed (n = 11)	P Value
Age* *(yr)*	66 ± 10	64 ± 8	0.59
Preop. Mayo score*	59 ± 15	53 ± 20	0.36
Gender			0.61
No. of elbows in female patients	17	9	
No. of elbows in male patients	2	2	
Diagnosis			0.37
Rheumatoid arthritis	14	10	
Other	5	1	
Dominant arm	13	6	0.70
Use of allograft	4	3	0.98

*The values are given as the mean and the standard deviation.

Discussion

The Mayo elbow performance scores in this study were compared with those reported in other studies. The mean postoperative scores for the patients who had primary total elbow arthroplasty (84 ± 16) and those who had revision total elbow arthroplasty (85 ± 16) were lower than the mean scores in the other published series. The investigators who studied patients with rheumatoid arthritis have reported Mayo scores in the range of 87 to 94[11,13,14,22]. Those who studied patients with traumatic or posttraumatic conditions have reported Mayo scores ranging from 84 to 95, with one outlier of 79[10,12,13,23,24].

A common complication in the present series was dysfunction of the ulnar nerve. In both complex primary and revision total elbow arthroplasty, we routinely identified the ulnar nerve and protected it during the procedure. Despite these efforts, six (13%) of the forty-five elbows in which the replacement did not fail had ulnar neuropathy develop postoperatively, and the neuropathy persisted beyond one year for five of the six elbows. This is consistent with the findings in other studies in which ulnar neuropathy occurred within a few days after surgery in as many as 21% of the patients, with the rate of permanent ulnar nerve dysfunction ranging from 0 to 10%[4,10,11,25].

Two elbows had intraoperative fracture of the humeral shaft; both were in the revision total elbow arthroplasty group and, in both elbows, the surgeon had noted particular difficulty with removal of the cement. Both patients were postmenopausal women, and underlying osteoporosis may have been a factor that contributed to the intraoperative fracture. This fracture rate is comparable with the reported frequency of this complication, which has ranged from 0% to 4%[4,11,12,22]. In addition, one of them had an ulnar neuropathy and the other had a radial neuropathy develop postoperatively; both neuropathies resolved within six months of surgery. Cement removal in revision total elbow arthroplasty can be extremely difficult, and we frequently identify the radial and ulnar nerves and protect them during the cement removal.

Triceps avulsion following total elbow arthroplasty is another common problem. In a recently published study of 887 arthroplasties, sixteen elbows (1.8%) had a triceps avulsion[26]. In the current series, two elbows experienced this complication. Both arthroplasties were performed with a modified Kocher approach, and the triceps tendon was reflected, leaving the medial head intact. One patient had a reconstruction of the triceps mechanism; however, the triceps was still not able to overcome gravity thirty months after the reconstruction. It is our opinion that release and repair of the medial head of the triceps is associated with substantial morbidity and meticulous repair is essential to preserve function.

Postoperative infection requiring implant resection occurred in three elbows (4%). This rate is comparable with other studies, in which the rate of deep infection has ranged from 0% to 9%[27]. All three patients were in the primary arthroplasty group, and all three were treated by resection arthroplasty. Two of the three patients remained on chronic antibiotic suppression.

The five-year survival rates for primary and revision total elbow replacements (72% and 64%, respectively) in the present study are notably lower than those reported in the Mayo Clinic series, in which elbow replacements in patients with rheumatoid arthritis had a five-year survival rate of 94.4% (95% confidence interval, 89% to 99.9%), with seventy-eight prostheses at risk, and those in patients with posttraumatic arthritis had a survival rate of 80% (thirty-three of forty-one elbows) at a mean follow-up of 5.6 years[11,12]. This is likely due to the broader definition of failure used in the present study and the characteristics of our patient population. Unlike many other reports that have defined failure as the need for additional surgery, our study also included radiographic and clinical failures that were treated nonoperatively because of the lack of patient symptoms, the preference of the patient, or anesthesia considerations. Moreover, at our institution, the Coonrad-Morrey prosthesis is reserved for patients

with gross elbow instability and/or poor bone stock, whereas at the Mayo Clinic it has been routinely used for most elbow arthroplasties.

In summary, the thirty-seven primary and thirty revision Coonrad-Morrey elbow replacements reviewed showed significant improvement in range of motion, function, and pain. The rates of common complications were comparable with those in other reports. The higher rates of failure may have been due to the broader definition of a surgical failure in this study and our practice of reserving the Coonrad-Morrey prosthesis for the more complex cases of elbows with severe bone loss and ligamentous laxity. ■

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