Complications and revisions after semi-constrained total elbow arthroplasty: a mono-centre analysis of one hundred cases

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Abstract

Background The complication rate after total elbow arthroplasties is higher than for other arthroplasties.

Purpose The purpose of this study was to evaluate the complications and revision rate after 100 semi-constrained total elbow arthroplasties from various types of aetiologies performed in our university hospital.

Methods One hundred linked semiconstrained total elbow arthroplasties were performed and were reviewed with 24-months minimum follow-up. Indications were rheumatoid arthritis (45), trauma (33), revisions (16) and others (6).

Results At five years average follow-up (range, 2–11), the complication rate was 37 %. Most frequent complications were ulnar nerve involvement (9 %) and triceps insufficiency (7 %). Five implants were aseptically loosed. The infection rate was 4 % with loosening of the implant in two. Four fractures were observed, including three at the ulna and one at the humerus proximal or distal to the stem. The radial nerve was injured in two cases. Failure of the locking system of the prosthesis was noted in one case and a fracture of the ulnar component was found in another patient. A revision surgery was performed in 13 cases (13 %). At follow-up 94 prostheses were still in place and the survival rate was 98 % at five years and 86 % at ten years.

Conclusion Total elbow arthroplasty remains a difficult procedure with sometimes a high rate of complications necessitating revision procedures. Selection of the patients, a rigorous surgical technique, and a systematic follow-up are prerequisite to limit this incidence.

Type of study/level of evidence: Therapeutic IV

Keywords Total elbow arthroplasty · Survival rate · Complications · Revisions · Loosening

Introduction

Total elbow arthroplasty (TEA) has been used in various types of indications with satisfactory results. However, complications are more common than after other arthroplasties [1]. An explanation is related to the fact that the elbow joint is a superficial joint, with relatively little soft-tissue envelope. The main indications concern rheumatoid arthritis, often in patients with immune-compromised medical status, or post-traumatic arthritis, often with multiple previous operations performed. Furthermore, the elbow joint can be considered as a weight-bearing joint with a resultant force that can range from one to three times body weight that accounts for the high loosening rate seen in the early constrained arthroplasties. Gschwend et al. [2], in their systematic review, analysed 828 procedures. Of these, 43 % had

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complications. In recent years, there have been many advances in prosthetic design and surgical technique. The goal of our study was to evaluate the complications and revisions rate after 100 semi-constrained total elbow arthroplasties performed from various types of aetiologies in our university hospital.

Patients and methods

A prospective cohort study was conduced in our department since July 1997. All patients who underwent a Coonrad-Morrey TEA from July 1997 to March 2008 regardless of indication were included in this study. Only two experienced surgeons performed the surgery (MR; PM). A minimum of two-year follow-up was necessary for the patients to be included. Institutional review board approval was not required at the time the patients were included in the study, but all patients had given their agreement to use their clinical and radiographic data for this study.

Ninety-one consecutive patients (100 elbows) were included. There were 74 women and 17 men with a mean age at the time of the operation of 63±14 years (range, 22–90 years). Thirty-eight patients (45 elbows) had inflammatory arthritis, 32 (33 elbows) a traumatic condition—18 acute fractures of the distal humerus, ten nonunion of the distal humerus, and five post-traumatic arthritis—and 15 (16 elbows) a revision procedure. In six cases the prosthesis has been performed for another aetiology.

The Coonrad-Morrey prosthesis (Zimmer, Warsaw, Indiana) was used in all patients. During the study period, two surface preparations were used for the ulna component, i.e. from 1997 to 2001, the polymethyl-methacrylate (PMMA) precoated ulnar component was used in 41 elbows, and from 2002 to 2008, the titanium plasma-spray coating ulnar component was used in 59 elbows.

Operative procedure and post-operative management

A standard procedure was performed for all primary surgeries [3], whereas specific steps were necessary in revision cases [4]. The different surgical steps are summarized in Table 1. Average time of surgery was 144±41 minutes on average (range, 60–360). An antibiotics prophylaxis of 48 hours was systematically prescribed. It was prolonged in ten cases because of suspicion of deep infection. An anterior splint was performed with the elbow in extension for two days, and the patients were allowed to start moving their elbow according to their pain level. No therapy was prescribed. The patients were discharged from the hospital after five to seven days (range, 5–26 days) according to the wound aspect with the elbow protected with a sling. The patients were encouraged to move their elbow avoiding all weight lifting during the first three months. Recommendations were then given related to limitation of weight lifting, e.g. no more than 1 kg on a repetitive basis or 5 kg on a single event.

Table 1 Different surgical steps of the 100 total elbow arthroplasties

Different surgical steps	Number of occurrences
Approach	
Bryan-Morrey	96
Gschwend	2
Trans-olecranon	2
Ulnar nerve	
Identified	100
Anteriorly transposed	87
Humeral component	
Stem size	
X-Small	30
Small	55
Regular	15
Stem length	
10-cm	81
15-cm	17
20-cm	2
Anterior flange	
Normal	98
Extended	2
Ulnar component	
Stem size	
X-small	3
Small	85
Regular	12
Stem length	
Standard	96
Extra-long	4
Locking system	
C-ring	14
Pin-within-pin	86
Cement restrictor	
Humerus	26
Ulna	11
Type of cement	
Without antibiotics	43
With antibiotics	57
Cement injection	
Syringe	21
Specific gun	79
Number of steps for cementation	
One step	80
Two steps	20

Follow-up evaluation

An evaluation of the pre-operative medical history of each patient was performed, and each had a physical examination. Pre-operative anterior-posterior and lateral radiographs as well as at the time of the latest follow-up were reviewed. None of the patients were lost for follow-up. The results of the pre-operative and post-operative clinical evaluation were rated using the Mayo Elbow Performance Score (MEPS) [3]. The quick-DASH score was also used to evaluate the post-operative functional results [5]. The cement technique was assessed on the immediate post-operative radiographs of both the ulnar and the humeral components [6]. Implant loosening was assessed on radiographs and was graded on a scale of 0 to 4, as previously described [7]. Bushing wear was assessed on anterior-posterior radiographs made at the time of the latest follow-up and was graded as none, partial or complete [7].

Statistical analysis

Analysis of the data was done with the use of statistical software that allowed analysis of each variable separately and to study their interrelationship. Comparisons between different groups were performed with use of the Student's t test, Mann–Whitney U test or Kruskal-Wallis test. The chi-square test was used to compare categorical values. The level of significance was set at $p<0.05$. Survival 'free of revision surgery' was estimated as a function of time since it was the index procedure with the use of the Kaplan-Meier method with 95 % confident interval.

Results

Overall results

At five-year average follow-up, up to 11 years, the MEPS increased from 30±18 points pre-operatively to 85±15 points (range, 30–100) post-operatively ($p<0.001$, Student's t-test). According to the MEPS, results were rated as excellent in 55 cases, good in 26, fair in 12, and poor in seven. The satisfaction rate was 81 %. The quick-DASH score reached 40±24 points (range, 0–97) at final follow-up. Better results were obtained in rheumatoid arthritis (90±13 points and 41±18 points, respectively) compared to trauma (80±17 points and 44±29 points) or revisions (80±12 points and 40±22 points) ($p=0.002$, Kruskal-Wallis test) (Table 2).

Complications

There were 37 (37 %) complications. Younger age was correlated significantly with occurrence of complications (59±13 versus 66±14 years—$p=0.016$, Mann–Whitney U test), whereas follow-up was not ($p=0.293$, Mann–Whitney U test). Number of previous operations before TEA also had no significant influence ($p=0.347$, Mann–Whitney U test). Duration of surgery for TEA was correlated with occurrence of complications (135±34 vs 159±47 min—$p=0.008$, Mann–Whitney U test) (Table 3).

The most common complication was ulnar nerve involvement observed in nine cases, all having been anteriorly transposed at surgery. None of these patients had pre-operative symptoms. Ulnar nerve involvement was mainly limited to numbness in the fifth finger in eight cases and to motor and sensitive deficit in one case. The radial nerve was involved in two cases after a revision procedure. In the two cases the involvement was definitive.

Weakness of the triceps was diagnosed in seven cases, in all cases after a Bryan-Morrey approach. It was more frequent in a traumatic context or revision procedures among patients having already presented a trans-tricipital approach. However, in all cases, triceps weakness was well tolerated and none required surgical revision.

Five cases of aseptic loosening were observed, one on the humeral side, two on the ulnar side, and two on both sides

Table 2 Overall clinical and functional results of the 100 total elbow arthroplasties related to aetiology

Etiology	N	F/u (months)	MEPS (points)	DASH (points)	Ext/flex	Pron/Sup	Complication	Revision
RA	45	62	90	41	108°	140°	15 (33 %)	7 (15 %)
Trauma	33	49	80	44	96°	138°	12 (36 %)	2 (6 %)
Fract	18	42	78	50	96°	135°	3	1
NU	10	41	88	36	112°	154°	5	1
PTA	5	89	72	46	64°	117°	4	0
Revision	16	62	80	40	98°	133°	10 (62 %)	4 (25 %)
Others	6	61	93	25	102°	143°	0	0
Stats	NS	NS	$P=0.02$	NS	NS	NS	NA	NA

RA rheumatoid arthritis, *Fract* acute fracture, *NU* nonunion, *PTA* post-traumatic arthritis, *F/u* follow-up, *NS* non significative, *Ext/flex* extension/flexion, *Pron/Sup* pronation/supination

Table 3 Complications and revision rate after 100 total elbow arthroplasties according to the aetiology

Aetiology	Rheumatoid arthritis	Trauma	Revision	Other
Total number	45	33	16	6
Follow-up (months)	62	49	62	61
Complication	15	12	10	0
Ulnar nerve	5	2	2	
Triceps weakness	0	5	2	
Loosening	3	1	1	
Fracture	1	0	3	
Infection	3	0	1	
Radial nerve	0	2	0	
Implant fracture	1	0	0	
Axle failure	0	1	0	
Ossification	0	1	0	
Wound / haematoma	2	0	1	
Revision	7	2	4	0
Ulnar nerve	0	1	0	
TEA removal	3	0	0	
TEA revision	3	0	0	
Debridement	0	0	1	
Osteosynthesis	0	0	2	
Axle change	0	1	0	
Wound closure	1	0	0	
Ossification removal	0	0	1	

(Fig. 1). Incidence was more frequent on rheumatoid patients, with no statistical difference between etiologies. Follow-up did not influence the loosening rate. Loosening of the ulna component with PMMA coating was more common ($p=0.021$, Mann–Whitney U test). No case of complete radiolucency was found around the more recent titanium plasma-spray coating ulnar component. However, follow-up was longer for the PMMA coating component ($p<0.001$, Mann–Whitney U test) (Table 4). There was no statistical correlation between the quality of the cement technique and the presence of lucent lines around the humeral component or the ulnar component.

Wound complication was noted in three cases, which resolved with a local treatment. A deep infection was diagnosed in four cases with loosening of the prosthesis in two. In three cases it concerned a rheumatoid patient whereas in one case it was secondary to a revision procedure. Cement without antibiotics was used in three.

There were three cases of ulnar fracture distal to the prosthesis and one case of humeral fracture proximal to the stem, all occurring after a fall (Fig. 2). In none of the cases the implant was loose. A locking pin failure at the level of the hinge was observed in one case of nonunion of the distal humerus with valgus deformity eight years after the initial surgery (Fig. 3). One case of ossification into the brachialis muscle was observed after a TEA performed for fracture. Finally, there was one case of fracture of an extra-small ulnar component in a juvenile rheumatoid arthritis patient (Fig. 4). The quality of the cement technique was not adapted because of the narrow medullary canal. The fracture appeared four years after the initial procedure at the junction between the stem and the metaphyseal part of the component.

Fig. 1 Polyethylene bushing wear with lucent lines around polymethylmethacrylate ulnar component 11 years after the initial procedure for post-traumatic arthritis

Revision

Thirteen of the 37 (35 %) complications required a revision surgery 52±39 (range 2–122) months on average after the initial procedure. Revision was more frequent in younger patients (51±12 vs 65±13 years old—$p=0.002$, Mann–Whitney U test), and after TEA performed for revision of a previous TEA, or for rheumatoid patients, compared to patients treated for trauma ($p=0.154$, Mann–Whitney U test). Revision was not correlated with follow-up ($p=0.238$, Mann–Whitney U test).

In three cases the prosthesis has to be removed to treat a deep infection and the elbow was left in resection. In three other cases the prosthesis had been changed on both sides in one case, and only at the ulna in two cases to treat aseptic loosening of the components. A simple debridement with prosthesis retention was performed in one case of acute infection with success. An osteosynthesis was performed on the humeral side in one case, and on the ulnar side in another case to treat a peri-prosthetic fracture with well-fixed component

Table 4 Lucent lines around the humeral and ulnar components according to follow-up and component coating according to Schneeberger et al. [7]

Lucent lines	Follow-up	None	Type 0	Type I	Type II	Type III	Type IV
Humerus	58 months	80	2	11	2	1	4
Ulna		79	1	8	4	2	6
PMprecoat	80 months	28	0	3	2	2	6
Ti coating	43 months ($p<0.001$)	51	1	5	2	0	0

PMprecoat polymethyl methacrylate precoated, *Ti coating* titanium plasma-spray coating

(Fig. 5). The broken pin had been changed without revision of the prosthesis. An ulnar nerve neurolysis was required in one case because of painful dysesthesiae. A simple wound closure was performed under local anaesthesia in one case. Finally, removal of an ossification at the proximal radio-ulnar joint was indicated in one case to restore forearm rotation.

Survival analysis

At the last follow-up, 94 prostheses were still in place. The survival rate was 98 % at five years (95 % confident interval, 87.1–99.7 %) and 85.9 % at ten years (95 % confident interval, 69–94 %) if we consider all implant revisions, septic and aseptic, as an end point. The survival rate was 98.1 % at five years (95 % confident interval, 87.1–99.7 %) and 92.4 % at ten years (95 % confident interval, 78–97.6 %) if we consider only revisions for aseptic loosening as an end point.

Discussion

Complications after total elbow arthroplasty have been largely published and are well recognized [1, 2, 8–10]. In 2005, reviewing a total of 3,618 total elbow arthroplasties, Little et al. [8] reported a complication rate of 33 %. In 2011, Voloshin et al. [9], describing the outcome of 2,938 total elbow procedures, found a complication rate of 24.3±5.8 %. It was greater for primary total elbow arthroplasty for post-traumatic arthritis (37.5±9.2 %) than for rheumatoid arthritis (24.3±5.8 %) or acute distal humerus fracture (21.5±9.2 %). The overall complication rates in the linked and unlinked groups were 25.9±8.4 % and 27.2±6.2 %, respectively. The complication rate observed in our series is comparable to results published in different recent meta-analyses. However, it was lower than results published by Gschwend et al. [2] who reported a 43 % complication rate with 18 % revision rate. Since that time, reliability of total elbow arthroplasty has improved as well as the surgical technique and patient selection.

Fig. 2 Peri-prosthetic humeral fracture proximal to the stem of the prosthesis

Fig. 3 Locking pin failure eight-years after the initial procedure for distal humerus nonunion

Fig. 4 X-small ulnar component fracture in a juvenile rheumatoid arthritis patient four years after the initial procedure

Younger age and aetiology was correlated with the occurrence of complications. Rheumatoid arthritis remains the main indication of total elbow arthroplasty [11, 12]. However, indications have expanded to traumatic conditions, like acute fracture in elderly patients [13], distal humerus nonunion [14], or post-traumatic arthritis in younger patients [7, 14–16]. As the number of total elbow arthroplasty procedures increased, the number of revision cases increased proportionally. In our series complications and revisions rates were more frequent after revision procedure than after others indications.

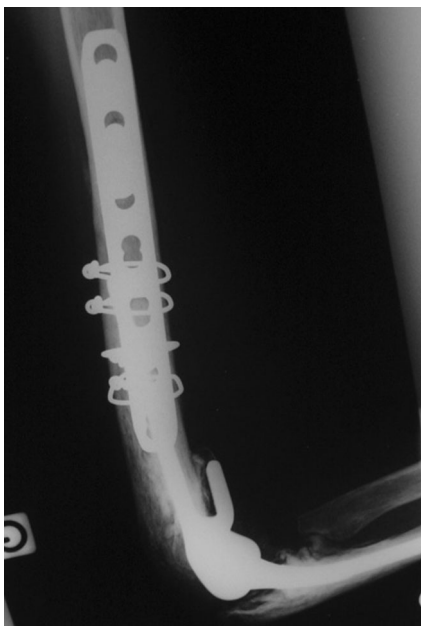

Fig. 5 Osteosynthesis of a humeral fracture proximal to the stem of the prosthesis without removing the implant

In literature, complication rate was similarly higher after a revision procedure. However, complications were usually more frequent after post-traumatic arthritis in young patients than for rheumatoid patients [9, 15, 16].

Ulnar nerve involvement was the most frequent complication in our series with a 9 % rate. It was greater than results published by Little et al. [8] (5 %) and Voloshin et al. [9] (2.9±2.4 %). In all cases it was associated with anterior transposition of the nerve. It was mainly observed in rheumatoid patients. If some authors advocated routine anterior transposition of the nerve, our results could not confirm this assumption. Most authors agreed that the nerve should be transposed only if there are pre-existing deficits or if its path is compromised or if the nerve is unstable after insertion of the prosthesis. Radial nerve involvement was iatrogenic in the two cases observed in our series, in the context of revision surgery. In both cases it was related to humeral cortex penetration and direct injury to the nerve. Throckmorton et al. [17] have outlined the need to expose systematically the radial nerve when doing a revision surgery and not just feel the nerve to protect it against instruments violation or thermal injury by extravasation of cement.

Triceps weakness was observed in 7 % of the cases in our series. It is greater than results published by Little et al. [8] (3 %) and Voloshin et al. [9] (2.4±2.4 %). All cases were noted after a Bryan-Morrey approach. However, in literature there was not a statistically significant difference in the incidence of triceps-related complications between TEAs performed using Bryan-Morrey, Gschwend or v-inverted approaches. The only predisposing factor outlined in our study was a previous surgery that has involved triceps tendon insertion. In these cases, triceps could be left intact on the olecranon [18] if possible or protected postoperatively by an immobilization during the healing period.

Aseptic loosening was observed in 5 % of the cases. Loosening rate was between 5.1±3.4 and 9 % in the different meta-analyses [8, 9]. In a comparative study, Little et al. [19] have shown, in rheumatoid arthritis, better survival rate with the Coonrad-Morrey semi-constrained total elbow arthroplasty compared to two unlinked implants. They concluded that component linkage with the Coonrad-Morrey implant prevented dislocation without increasing the risk of loosening. The same results were found by Plaschke et al. [20] with 90 % five-year and 81 % ten-year survival rates, with a higher revision rate for the unlinked design and primary TEA due to fracture sequelae. In our series, incidence of loosening was correlated to follow-up and to aetiology, with greater incidence in rheumatoid patients. The survival rate, whatever the etiology, was 98.1 % at five years and 92.4 % at ten years if we consider only revisions for aseptic loosening as an end point. In the study of Gill and Morrey [11], the

survival rate was 94 % at five years and 92 % at ten years. In the study of Aldridge et al. [21], the average survival rate of the Coonrad implant or Coonrad/Morrey total elbow arthroplasty was 17.5 years.

Ulnar stem loosening has been shown to be one of the long-term failure modes of the Coonrad-Morrey total elbow arthroplasty [22]. Loosening seemed to occur more often in the ulnar than the humeral stem [12]. Loosening of the ulna component with PMMA coating was more common. No case of complete radiolucency was found around the more recent titanium plasma-spray coating ulnar component. Hildebrand et al. [22] noted increased osteolysis around ulnar stems relative to humeral stems, with a rate of 32 % at 50±11 months follow-up. 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 [23]. The implant covered with PMMA had the highest failure rate in comparison to the new implant introduced in 2002 confirming our results. The survival rate at seven years was 83 versus 100 %.

Deep infections have been reported to be higher after TEA than after other arthroplasties. We reported an incidence of 4 % in our study, whereas it was 8.1 % in the report of Gschwend et al. [2], 5 % in a review by Little et al. [8] and 3.3±2.9 % in the meta-analysis of Voloshin et al. [9]. It seems that the incidence has decreased since the first reports but still stays higher than for other joint surgeries. Selection of the patient, preoperative infectious assessment, discontinuing disease modifying anti-rheumatic drugs in the rheumatoid patients at least four weeks before surgery, systematic antibiotics prophylaxis, use of antibiotics impregnated cement, appropriate surgical technique preserving soft tissues, and rigorous postoperative wound management can explain this evolution. However, TEA remains an at risk procedure because of the particular characteristics of the elbow joint, the status of the patient and the type of indications.

A peri-prosthetic fracture has been observed in four cases, proximal or distal related to the stem of the prosthesis. In three cases, the fracture occurred after a revision procedure that could have weakened the cortical bone. In the other case, it was on a rheumatoid patient with osteoporosis and poor bone quality. The implants were well fixed in all cases. Implications of treatment and results naturally follow from the fracture type and location, the stem status, and the bone quality. If the stem is not involved, discussion is often made between conservative treatment and ORIF. If the stem is involved, and if it is well-fixed, the same treatment can be applied; if the stem is loose revision to a long-stemmed implant must be preferable [24].

Bushing wear is a specific complication of the Coonrad-Morrey TEA , sometimes with axle failure [25, 26]. Lee et al. [27] underlined the risk factor of this feature: young age (lesser than 60 years old), marked distorted joint and marked varus or valgus deformity pre-operatively. The presence of substantial mal-rotation of components at the time of implantation, even without deformity, can also contribute to increase bushing wear. Wright and Hastings [28] have identified post-traumatic arthritis, supracondylar nonunion, male sex, young age, and high activity level as associated factors of bushing wear. These investigators have implicated failure of the "C" ring, which allowed the axis pin to back out as an additional factor of accelerated bushing wear. Since 1998, the C-ring locking system has been changed to a pin-within-the pin system, which so far has given satisfactory results. However, one case of this new locking system failed in our series and has been changed [24]. If severe bushing wear is observed without implant loosening isolated bushing exchange can give satisfactory results [25].

Conclusion

In spite of several improvements in surgical technique within the last decade, including improvement of implant reliability, complication and revision rates after TEA were not uncommon and remained higher than all major joint arthroplasties. Younger patients, post-traumatic and revision aetiologies were particularly at risk for occurrence of complications. Information must be given to the patient before deciding on a TEA. Careful selection of the patient, pre-operative planning and assessment, as well as rigorous surgical technique by an experienced surgeon with elbow surgery and systematic follow-up are pre-requisites to decrease this incidence.

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Compliance with ethical standards

Conflict of interest The authors declare they have no competing interests.

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