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ORIGINAL ARTICLE

Postoperative results and complications of total elbow arthroplasty in patients with rheumatoid arthritis: three types of nonconstrained arthroplasty

Akitoshi Tachihara · Hiroshi Nakamura · Taro Yoshioka · Yosuke Miyamoto · Minoru Morishita · Tairo Koyama · Kayo Iwakawa · Manabu Sakane · Atsuo Nakajima · Shinichi Yoshino

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Abstract Postoperative results and complications of total elbow arthroplasty (TEA) conducted for rheumatoid arthritis (RA) patients at our institute were studied. Primary TEAs were performed in 72 patients. The mean follow-up period was 3.5 years. Three types of prostheses were implanted: JACE prosthesis in 34 elbows, STABLE prosthesis in 13 elbows, and KUDO prosthesis (type 5) in 32 elbows. The outcome was evaluated by the change in the range of motion and the Japanese Orthopaedic Association functional evaluation score for the elbow joint (JOA score). The arc of motion and the JOA score at discharge and at final examination significantly improved in patients with the three types of prosthesis. The loosening rates for the JACE, STABLE and KUDO prostheses were 15, 23, and 0%, respectively, although the follow-up periods were different. The loosening rate decreased to 2.5% when the humeral component was fixed with cement. Intraoperative fractures occurred in eight (10.1%) elbows and ulnar nerve palsy in six. Deep infection developed in three (4.8%) elbows and was treated by removing the prosthesis. Although there were considerable complications, the marked improvements in pain and function favor TEA in patients with rheumatoid elbow.

Keywords Rheumatoid arthritis · TEA · Surgical results · Complications

A. Tachihara · H. Nakamura (✉) · T. Yoshioka · Y. Miyamoto · M. Morishita · T. Koyama · K. Iwakawa · M. Sakane · A. Nakajima · S. Yoshino
Department of Joint Disease and Rheumatism, Nippon Medical School, 1-1-5 Sendagi, Bunkyo-ku, Tokyo 113-8603, Japan
e-mail: ra-s@nms.ac.jp

Introduction

Multiple joint involvement causes disability in patients with rheumatoid arthritis (RA). In the upper extremity, joint pain, deformity, and a decreased range of motion in the shoulder, elbow, wrist, and finger joints result in functional disability. The elbow joint links the upper arm and forearm and provides the upper extremity with a reach function [1]. Advanced arthropathy of the elbow joint disrupts this function and results in functional disorder of the upper extremities. In general, rheumatoid elbow is treated conservatively with medication and intra-articular injection of corticosteroids at the early stage. Synovectomy of the elbow may be recommended in early rheumatoid elbow and provides satisfactory results [2]. However, advanced articular destruction of elbows with fibrous ankylosis, painful stiffness, and painful instability is an indication for total elbow arthroplasty (TEA) [3]. Although the complication rates of TEA are still reported to be high [4], the recent long-term outcome has shown good results [5, 6]. In this study, we retrospectively studied the results of TEAs conducted at our institute in terms of operative results and complications.

Patients and methods

Patients and prosthesis

From 1998 through 2006, TEA was performed in 79 elbows of 72 patients with RA (5 men and 67 women; mean age, 61.1 years; mean disease duration, 22 years at the time of operation) at our institution. The mean follow-up period was 3.5 years. Three nonlinked types of prosthesis were implanted: the JACE prosthesis (Kyocera and Kobe Steel Ltd., Japan) in 34 elbows (Fig. 1); the STABLE prosthesis

(Kyocera Ltd., Kyoto, Japan) in 13 elbows (Fig. 2); and the KUDO prosthesis (type 5; Biomet Ltd., Dallas, TX, USA) in 32 elbows (Fig. 3). The STABLE prosthesis was a non-linked elbow prosthesis designed to provide more stability. In this study, all patients met the diagnostic criteria of the American Rheumatism Association [7]. Selection of the prostheses depended largely on the time of the operation, except that the STABLE type tended to be used for unstable cases. The elbows were diagnosed as having fibrous ankylosis, painful stiffness, or painful instability with severe joint pain and/or deformity [3]. Their Larsen scores were graded as 4 or 5. Medical records were reviewed, and all peri- and postoperative complications were noted.

Fig. 1 JACE prosthesis

Surgical technique

All procedures were performed as described by Kudo et al. [3]. Using the posterior approach, the ulnar nerve was exposed and protected. A triangular flap of the triceps tendon was raised and the anconeus muscle was detached from the ulnar to explore the joint. The joint was explored by excision of proliferative synovium. Ulnar soft tissue was gradually released to gain access to the joint and the ulnar collateral ligaments were cut to allow dislocation, if needed. After the prosthesis was implanted with or without bone cement, the triceps tendon and the dorsal fascial layer were firmly sutured to prevent dislocation. When pronation or supination was restricted by impairment of the wrist joint, the Darrach operation [8] or the Sauve–Kapandji procedure [9] was also performed.

Postoperative management

Postoperatively, a suction drain was inserted for 48 h and a long arm splint was applied for one week. After removal of the splint, free mobilization and functional exercises were administered by physiotherapists. The period of fixation was extended when the condition of the wound was poor or the elbow was unstable.

Clinical assessment

Clinical outcomes were assessed based on the Japanese Orthopaedic Association functional evaluation score for

Fig. 2 STABLE prosthesis

Fig. 3 KUDO prosthesis

the elbow joint (JOA score) [10], which comprises pain (0–30 points), daily function (0–20 points), range of motion (0–30 points), stability (0–10), and deformity (0–10) (Table 1). The range of motion of the elbow joint was also assessed. Data were collected at baseline, at the time of discharge, and at final examination.

Statistical analysis

Demographic data were analyzed using Student's *t* test. Differences in range of motion and JOA score at baseline between the groups were evaluated with the Mann–Whitney test. The Wilcoxon signed rank test was used to compare baseline and follow-up values. *P* values of less than 0.05 were considered to indicate a significant difference.

Table 1 JOA functional evaluation of the elbow

Category	Scoring guidelines
Pain	30 points
	None, 30 points; slight after overuse, 25 points;
	Mild, 20 points; moderate, 10 points: severe, 0 points
Function	20 points
	Activities of daily living [11]: washing face, feeding, clothing, drinking, hygiene, putting on socks, each 0–2 points
	Muscle strength [3]: flexion 0–5 points, extension 0–3 points
Range of motion	30 points
	Flexion/extension (22): >136°, 22 points; 121°–135°, 18 points; 91°–120°, 15 points; 61°–90°, 10 points; 31°–60°, 5 points; 16°–30°, 3 points; <15°, 0 points
	Pronation/supination [3]: <151°, 8 points; 121°–150°, 6 points; 91°–120°, 4 points; 31°–90°, 2 points; <30°, 0 points
Instability	10 points
	None, 10 points: mild instability, 5 points: severe instability, 0 points
Deformity	10 points
	Carrying angle <15°, 10 points;
	16°–20° valgus or 1°–10° varus, 7 points;
	21°–30° valgus or 11°–15° varus, 4 points; >31° valgus or >16°, 0 points
	Total 100 points

Results

Demographic data

Demographic details are presented in Table 2.

Clinical results

The arc of motion improved significantly with all types of TEA (Table 3). On average, the improvement was 11°. The range of flexion improved from 111° to 128° at discharge and 128° at follow-up with JACE prosthesis; from 122° to 131° at discharge and to 133° at follow-up with STABLE prosthesis; and from 112° to 122° at discharge and to 122° at follow-up with KUDO prosthesis. These improvements were statistically significant and the improvement was maintained until the final examination. The average fixed flexion was 33.3° and no significant improvement was shown with any of the prostheses. Pronation and supination were significantly improved with all three types of TEA (Fig. 4a–c).

Clinical outcomes assessed with the JOA score were also improved at discharge and the latest follow-up (Fig. 5). Total JOA score improved from 44 ± 11 at baseline to 80 ± 10 at discharge and 79 ± 10 at the latest follow-up with the JACE; from 46 ± 11 at baseline to 70 ± 10 at discharge and 74 ± 10 at the latest follow-up with the STABLE prosthesis; and from 45 ± 11 at baseline to 71 ± 10 at discharge and 73 ± 11 at the latest follow-up with the KUDO prosthesis. The improvement was significant and continued until the latest follow-up except in patients with complications, including infection or loosening. Postoperative improvement of individual items (pain, ADL, ROM, instability and deformity) included in the JOA score was also noted (Fig. 5).

Complications

Aseptic loosening

Aseptic loosening was defined as the presence of a radiolucent line wider than 2 mm around the prosthesis, or a change in the position of the implant in the bone. The rate of loosening was 15% (5), 23% (3) and 0% (0) in the

Table 2 Demographic data

	Prosthesis		
	JACE	STABLE	KUDO
No. of TEA	34	13	32
Mean age (year)	59.7 (32～76)	60.6 (38～70)	62.7 (28～76)
Mean disease duration at TEA (TEA)	19.9 (8～48)	22.9 (8～38)	24.5 (5～41)
Mean follow-up period (months) (range)	55.7 (21～104)	59.5 (16～104)	28.2 (6～54)

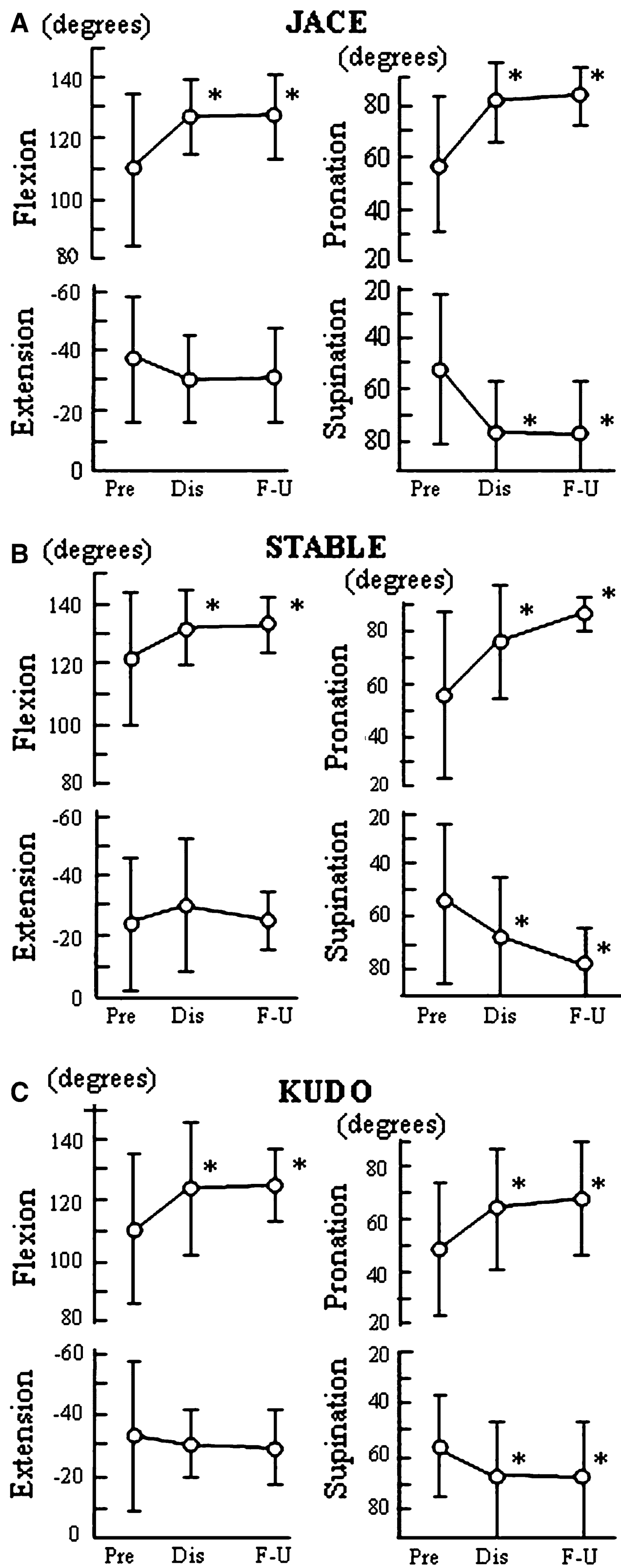

Fig. 4 Range of motion at baseline, discharge and the latest follow-up for JACE (a), STABLE (b) and KUDO (c). *Pre* preop, *Dis* at discharge, *F-U* at the latest follow-up. *$P < 0.05$ versus preop.

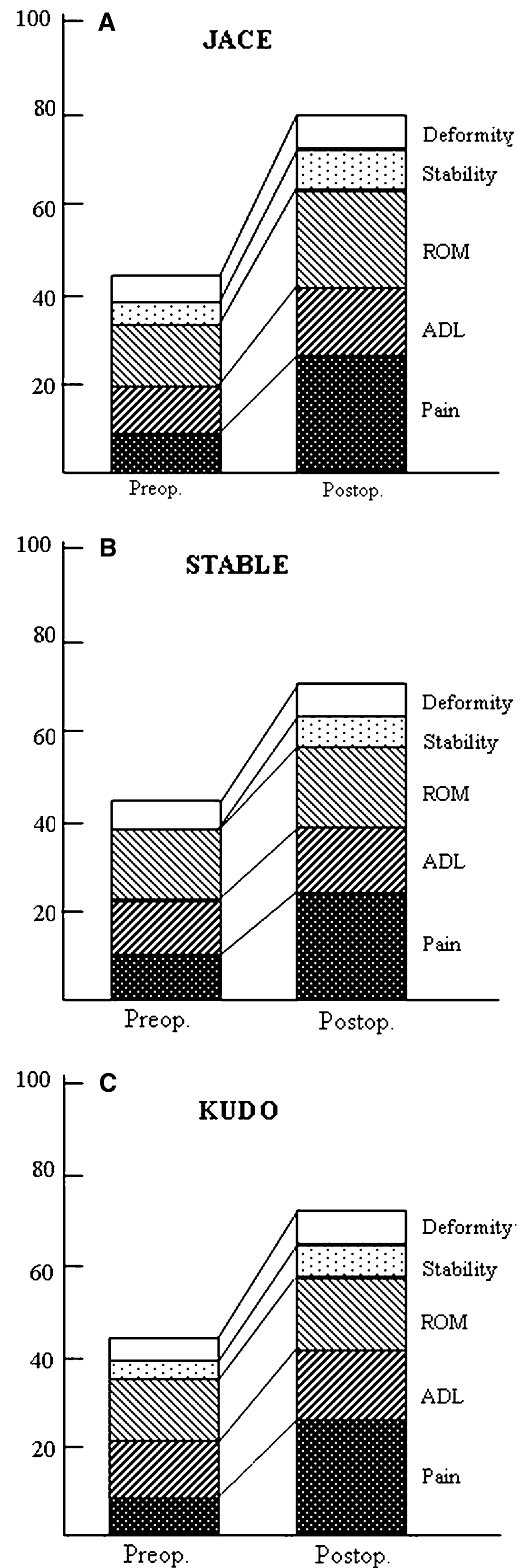

Fig. 5 Improvement of pre- and post-operative JOA scores and individual items

Table 3 Pre- and post-operative arcs of motion

	Prosthesis		
	JACE	STABLE	KUDO
Preop.	72 ± 31	87 ± 40	97 ± 41
At discharge	99 ± 26*	92 ± 17*	101 ± 34*
At the follow-up	97 ± 25*	92 ± 19*	108 ± 17*

*$P < 0.05$ versus preop.

Table 4 Loosening rates of humeral components

Prosthesis	JACE		STABLE		KUDO	
	n	Loosening	*n*	Loosening	*n*	Loosening
Cemented	16	1 (6.5%)	11	1 (9.1%)	17	0 (0%)
Cementless	18	4 (22.0%)	2	2 (100%)	15	0 (0%)

humeral components of the JACE, STABLE, and KUDO prostheses, respectively; however, the follow-up period was shorter for the last type compared with the other two types. The loosening rate was higher when the component was inserted without cement; the loosening rates of cementless humeral components were 22 and 100% for the JACE and STABLE prostheses, respectively, whereas those of cemented humeral components were 6.1 and 9.5%, respectively. All ulnar components were fixed with cement and no loosening was found (Table 4).

Intraoperative fracture

Intraoperative condylar fracture occurred in 10.1% of TEAs: 5.9% for JACE, 15.4% for the STABLE and 12.5% for the KUDO. All fractures were fixed using K-wire and/or screws (Fig. 6), except one in which the humeral component of the KUDO was inserted without cement. In this case, the humeral component was reinserted using bone cement. Osteosynthesis was conducted during the same surgery and sufficient fixation was achieved. The clinical outcome and postoperative treatment were not affected by this complication.

Deep infection

Deep infection developed in three (4.8%) elbows. One patient treated with the JACE had an infection in which *Enterobacter cloacae* was isolated from the exudate of the surgical wound. Two patients treated with the KUDO had a late infection 18 and 24 months after the index arthroplasty. The former infection was followed by a stitch abscess with *Staphylococcus aureus* and the latter was a hematogenous infection caused by *Pseudomonas aeruginosa*. The implants were removed after complete debridement as soon as the deep infection was diagnosed. Resection of prostheses with complete debridement was performed with administration of appropriate antibiotics. The infection was successfully suppressed and an elbow brace was prepared for the unstable joint.

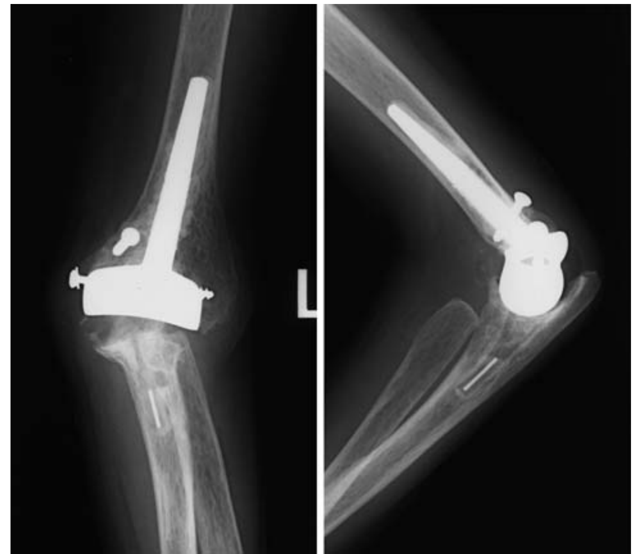

Fig. 6 Radiological findings of TEA associated with fracture of the medial condyle fixed with two screws

Paralysis

The following nerve palsies developed: ulnar nerve palsy in three patients; radial nerve palsy in one patient; and posterior interosseous palsy in one patient. The palsies were transient and the patients had almost completely recovered at the time of discharge. The palsies were caused by intraoperative traction, except for one in which the ulnar nerve was compressed by the fracture fixation device.

Dislocation

Dislocation of the prosthesis occurred in two patients (5.9%) with the JACE and two (15.4%) with the STABLE prostheses. As the stable device was developed for more stability, the dislocated JACE prosthesis was revised with the STABLE type. The cases of dislocated STABLE prosthesis were treated by soft tissue reinforcement. No dislocation was found in patients receiving the KUDO prosthesis thus far.

Discussion

Early total elbow prostheses were developed in the 1960s. They had a firm link between the humeral and the ulnar components. Their constrained motion caused early aseptic loosening and these prostheses fell out of use in the

mid-1970s. Subsequently, two types of total elbow prostheses, a nonconstrained and a semiconstrained type, were developed. The surgical outcome of TEA has improved with the accumulation of experience regarding and modifications of the prostheses themselves. However, there do seem to be considerable complications compared with total knee arthroplasty (TKA) and total hip arthroplasty (THA) [4].

In this series, the indication for TEA was painful stiffness, painful instability and ankylosis, as advocated by Kudo et al. [3]. The elbow joints showed advanced articular destruction graded as Larsen 4 or 5, with severe joint pain and dysfunction. We used three types of nonconstrained-type elbow prosthesis to minimize bone cutting for future revision. A semiconstrained type of TEA has also been used in specific cases, such as revision or severe bone loss, but was not included in this study. The selection of prosthesis depended on the time of the operation and the STABLE prosthesis tended to be used for the more unstable cases. Although demographic data showed no differences among the three types of prosthesis, this study was not conducted to compare the results of the three types of prostheses.

The clinical outcome was excellent and was maintained when the prostheses were retained. The arc of motion improved for all types of TEA, despite the flexion contracture. Flexion contracture was reported as a feature of nonconstrained elbow prostheses that did not affect clinical results.

The most common complication of elbow prosthesis was aseptic loosening. It preferentially occurred in the humeral component when it was fixed without cement, especially for the JACE and STABLE types. This tendency has also been noted previously [11]. These prostheses are rigid at the trochlear joint in the anterior–posterior direction, and the humeral stem may incur excess load. Moreover, progressive osteoporosis caused by RA, aging, corticosteroids and disuse might be involved in loosening. The bone quality in mutilans-type RA is particularly devastating.

No long-term survival data are available for the JACE and STABLE prostheses; the survival rate of the KUDO prosthesis with loosening and revision as the end-point was 100% for the metal-backed ulnar component and 72% for the all-polyethylene ulnar component at 13 years [12].

Intraoperative fracture of condyles occurred frequently, especially with the STABLE and KUDO prostheses. With the STABLE type, a relatively large portion of the intercondylar bone is cut off. This results in the formation of a thin cortex just proximal to the condyles. Osteotomy should be done very carefully without cutting too much when an oscillating saw is used. With KUDO prostheses, in the present study, occasional fractures of the medial condyle were seen when the trochlear portion of the humerus was cut using a specific osteotome. It particularly occurred when the ulnar collateral ligament was tight. The ligament should be sufficiently released and osteotomy needs to be performed delicately piece-by-piece. As the quality of bone is poor in RA, fractures are likely to occur. Although this complication may increase the time taken for the surgery, it does not affect the clinical outcome [4].

Deep infection was found in three of 79 (4.8%) elbows. According to a review article, the infection rate was 5.8% in all TEA cases, with an average follow-up period of 5.7 years [4]. This figure is higher than those for THA (1.3%) and TKA (2%) [13]. One of the reasons for this may be that elbow prostheses are located more superficially than knee and hip prostheses. Even when the elbow prosthesis was removed, the results obtained were not so detrimental, because the elbow joint is not considered a weight-bearing joint. There are no consistent procedures for the treatment of infected TEAs. To prevent recurrence, no revision surgery was conducted in our cases.

Even though we always transposed the ulnar nerve anteriorly under the fat of the skin in TEA, three cases showed ulnar nerve palsy. The palsy was transient and recovered spontaneously by the time of discharge without the need for neurolysis. It might have been caused by excess traction during surgery. Accordingly, this is a minor complication with our procedure.

Dislocation of the elbow prosthesis is a major concern for surgeons who advocate semiconstrained TEA [14]. Two elbows with the JACE dislocated and were revised with a STABLE prosthesis, and the dislocated STABLE was treated by soft tissue reinforcement with satisfactory results. The dislocation rate was 5.9 and 15.4% for the JACE and STABLE prostheses, respectively. These values are higher than in other reports, with values ranging from 2.3 to 3.9% [4]. The STABLE was preferentially used in unstable cases, which might cause a relatively high loosening rate. In the JACE, which is less constrained, extensive soft tissue release might cause dislocation. An adequate surgical indication and an appropriate surgical procedure to match the characteristics of each prosthesis are needed to obtain the best clinical outcome. We prefer to use surface replacement prostheses, because they need less bone-cutting, resulting in easier revision. However, since excellent survival has been reported for a semiconstrained prosthesis recently [14], it is preferable to use this type of prosthesis in cases in which there are extremely unstable joints or massive bone loss.

In conclusion, although there are considerable complications with TEA, the improvements in pain and function seem to outweigh them. Several lines of evidence show that survival has become comparable to that of TKA and THA. With further refinements of the prostheses themselves and surgical techniques, TEA is expected to prove a

reliable procedure for the reconstruction of the rheumatoid elbow.

Conflict of interest There are no conflicts of interests.

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