

Total elbow arthroplasty following traumas: mid-term results.

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Abstract. *Background:* Total elbow arthroplasty (TEA) has been normally indicated for chronic inflammatory arthropathy. In the last decades this surgery has also evolved as an acceptable procedure following traumatic lesions of this joint. The aim of this study was to analyze the mid-term outcomes of TEA for the treatment of complex fractures and non-unions of the elbow in selected patients. *Methods:* Between May 2002 and December 2011, 34 patients with these indications were surgically treated with TEA and divided in two groups. Group 1 included 16 cases of fractures and Group 2 18 of non-union. All patients were clinically assessed using the Mayo Elbow Performance Score (MEPS). A statistical analysis was performed in order to investigate the outcomes of these patients and compare the two groups. *Results:* Similar results were observed in both groups between operated and non-operated arms. No differences in clinical results were documented between groups. *Conclusions:* TEA following traumas can be considered as a valid treatment in old patients in complex fractures of the elbow region with low functional demands and in non-unions. Outcomes are influenced by the collaborative capacities of the patients. (www.actabiomedica.it)

Key words: Elbow, fracture, non-union, distal humerus, prosthesis

Introduction

TEA is in constant evolution (1-3). Over the last 20 years, the natural history of inflammatory elbow arthropathy has changed. This may be the result of both an improvement in the general health of the population and the introduction of disease-modifying anti-rheumatic drugs (DMARDs), thus influencing the rate of elbow arthroplasty which has decreased for these pathologies (4). Nevertheless, TEA is currently used with good long-term results in chronic arthritis, osteoarthritis and it has also evolved as an acceptable treatment both for acute complex fractures around the elbow and their frequent sequelae, even if literature is scarce about these topics (5,6).

Complex fractures around the elbow involve mainly the distal humerus, thus representing less than

2% of all fractures (7). They usually occur in elderly female patients, making the surgical anatomical reduction and internal fixation more difficult, because of the osteoporotic bone and increased fragmentation of the fracture (8). Furthermore, these injuries are often characterized by high rate of complications such as non-union and residual instability which are as much challenging and complex to treat (9-11).

The aim of this study was to analyze the mid-term outcomes of TEA for the treatment of complex fractures around the elbow and non-unions in selected patients with no evidence of inflammatory arthropathy.

Moreover, the results in patients who underwent TEA for acute fractures were compared with those who underwent TEA after failed primary treatment.

Materials and Methods

This study is the result of a collaboration between the Orthopaedic Clinic of the Department of Surgical Sciences of the University of Parma and the Shoulder and Elbow Unit of the Rizzoli Orthopaedic Institute of Bologna.

Between May 2002 and December 2011, 36 patients affected by complex fractures of the elbow region or non-union, were surgically treated with the Coonrad-Morrey (Zimmer®) (21 cases) or Latitude (Tornier®) (15 cases) total elbow prosthesis. Informed consent relating to the surgical procedure was always obtained.

Patients affected by chronic arthritis or periprosthetic fractures were excluded. A total of 34 patients were thus included in the study. There were 2 subjects who had died from causes unrelated to the TEA.

All the patients were divided into two groups:

- Group 1; acute fractures: 16 cases.
- Group 2; non-unions following conservative or previous surgical stabilization: 18 cases.

For each patient in Group 1 age, gender, hospitalization, type of fracture according to Müller AO classification (12) and peri/post-operative complications were assessed.

For each patient in Group 2 age, gender, hospitalization, type of acute treatment [conservative or open reduction internal fixation (ORIF)], type of non-union according to the classification of Mitsunaga (13) and peri/post-operative complications were assessed.

All cases were also analyzed in order to detect associated diseases such as diabetes and cognitive impairment, which could adversely affect the clinical and functional outcome.

All operations were performed by two senior elbow surgeons. All patients received antibiotic preoperative prophylaxis with first generation cephalosporin. Surgery was always performed with subjects laying supine with the arm placed over the chest and having a haemostatic tourniquet at the base of the involved upper extremity. Triceps sparing approach or splitting posterior approach, after isolating and protecting the ulnar nerve, was used.

Coonrad-Morrey semiconstrained elbow prosthesis was implanted in 20 cases and the Latitude

model in 14. Prosthetic components were always fixed with antibiotic-loaded cement (tobramycin at Rizzoli Hospital and clindamycin + gentamicin at the University Hospital of Parma).

Postoperative management consisted in immobilizing the elbow in extension with an anterior univalve plaster of Paris cast or splint. Drains and the cast were removed 48h later to begin rehabilitation. The first 2 weeks of the early active mobilization programme consisted in gentle passive elbow extension within a pain-free range and active flexion reaching no more than 90°. Active pro-supination is possible with the elbow flexed at 90° after 7–10 days. Therapy sessions are short but frequent during this period to avoid elbow stiffness and triceps muscle activation. In the following 2 weeks, overall elbow range of motion (ROM) is gradually increased by actively flexing the elbow beyond 90° and by actively extending the elbow with the assistance of gravity (the patient is supine with humerus resting alongside the body and supported with cushions or towels). No forceful contractions are allowed, and patient education is mandatory in this phase as the triceps tendon still requires protection. The splint is still worn between sessions and at night. Following x-ray controls, the splint can be gradually dismissed during the day and worn at night for another 10–14 days. Therapy sessions become longer and more intensive as triceps strengthening is begun and passive stretching is applied to the joint. Mobilization splinting can be used after 3 months from surgery if ROM limits the patient's function. The final goal of rehabilitation is to reach a good mobility and stability of the elbow in all planes, remaining at least within the functional range of 130° of flexion and -30° of extension. The patient is instructed to avoid impact activities and a life-time lifting limitation of ≤8 kg.

All patients of Group 1 and 2 were clinically assessed after surgery, at a minimum follow-up of 12 months, both on the operated and non-operated side using MEPS (14). Patients of Group 2 were also clinically assessed before surgery on the affected arm with the same outcome measure.

Pre-operative antero-posterior (AP) and latero-lateral (LL) x-ray of the elbow were utilized in order to classify the type of fracture in Group 1 and of non-unions in Group 2. X-ray performed at follow-up

were used in both groups in order to evaluate the positioning of the prosthetic components and signs of mobilization in accordance with Morrey radiolucency criteria (5).

The results of Group 1 and 2 and of Group 1 versus Group 2 were compared and statistical analyses were elaborated using the SPSS software (20.0 version).

The Mann-Whitney test was used at follow-up to analyze differences between MEPS of the affected versus unaffected elbow in the Group 1 and Group 2 and to compare MEPS values of the Group 1 versus Group 2. The Mann-Whitney test was also used in patients of the second group to analyze differences between MEPS in the affected arm before surgery and at follow-up.

The difference was considered significant when P value was less than 0.05.

Results

Demographic data and comorbidities of the patients of Group 1 and 2 are reported in Table 1.

Group 1

Fourteen fractures of the distal humerus were complex (8 type C3.3 and 6 C3.2). In 2 cases distal humeral fracture (type B3.2) was associated with complex proximal radius/ulna fracture with residual instability.

In 12 patients a Coonrad-Monrey semi-constrained prosthesis was implanted and in 4 cases a Latitude implant was used.

Prosthetic components were positioned through a “sparing triceps approach” in 13 patients and a “pos-

terior splitting approach” in 3 cases. The average follow-up was 36 months (range: 12-96).

Mean MEPS at follow-up of the healthy side was 91.6 (range: 70-100) and of the operated side was 88.4 (range: 30-100). These scores were excellent in 12 cases (Figure 1), good in 3 cases and poor in one case. Fifteen out of 16 patients reported absence of pain. One subject complained of chronic pain at follow-up. Two out of 16 cases showed a mean ROM < 100°. The first case showed an ankylosis at 90° of flexion and the second had a ROM of only 40°.

On clinical examination all elbows were stable. In average, the patients were able to perform 4 out of 5 of the normal daily activities reported in MEPS, with a



Figure 1. Type C2-2 fracture of the right elbow; pre-operative x-ray (A, B), x-ray (C, D) and clinical evaluation (E, F) at follow-up. (excellent result).

Table 1. Demographic data and comorbidities of the patients.

	Group 1	Group 2
N° of patients	16	18
Age (years)	73.5 (68-86)	67.6 (50-84)
Gender (M/F)	0/16	3/15
Hospitalization (days)	17.6 (6-45)	12.3 (5-44)
Associated diabetes	5	2
Associated cognitive impairment	3	4

subjective improvement of the strength. The radiological analysis is summarized in Table 2. No prosthesis loosening or failing were observed.

In the post-operative period 6 patients developed complications. Three patients had post-surgical superficial infections which were treated with intravenous antibiotics and secondary wound debridement. Two patients developed a transitory impairment of the ulnar nerve which resolved spontaneously in less than six months from surgery. Finally in one case affected by cognitive impairment (poor result at follow-up) a deep early infections was observed and *Staphylococcus Aureus* was isolated. In this case antibiotics therapy and wound cleaning were unsuccessfully and further intervention could not be performed because of other comorbidities (Table 3).

Group 2

Non-unions, in agreement with Mitsunaga classification were:

- 2 “supracondylar”.
- 9 “T-condylar”.
- 2 “lateral condylar.”

Table 2. X-ray evaluation according to Morrey radiolucency criteria.

	Group 1	Group 2
No lines of radiolucency	13	10
Type 0	3	5
Type I	0	2
Type II	0	0
Type III	0	1
Type IV	0	0

Table 3. MEPS comparison of Group 1 vs. Group 2 and complications in both groups.

	Group 1	Group 2	p value
MEPS at follow-up (F.U.) affected side	88.4 (30-100)	85.8 (50-100)	0.458
Complications			
- superficial infections	3	2	
- transitory ulnar nerve impairment	2	2	
- deep infection	1	0	
- aseptic loosening	0	1	

- 3 “transcondylar”.
- 2 “medial condylar.”

Fractures were initially treated with ORIF in 11 patients and conservative (plaster immobilization) in 7.

The average time between fracture and TEA was 27.7 months (range: 1-96).

In 8 patients a Coonrad-Monrey semi-constrained prosthesis was implanted and in 10 cases a Latitude implant was used.

Prosthetic components were positioned through a “sparing triceps approach” in 14 patients and a “posterior splitting approach” in 4 cases.

The average follow-up was 30 months (range: 12-76).

Mean MEPS on the healthy side was 97.8 (range: 90-100). Mean MEPS on the operated side were respectively 50.3 (range: 20-80) and 85.8 (range: 50-100) before and after surgery. Considering post-operative MEPS the scores were excellent in 11 cases (Figure 2), good in 5 and poor in 2.

Fourteen out of 18 patients reported a complete resolution of pain. Four subjects referred the persistence of low-grade pain. Five out of 18 cases showed a mean ROM < 100°. Four patients showed a ROM between 50° and 100° and in one case was documented an ankylosis at 90° of flexion (poor result). On clinical examination all elbows were stable. In average, the patients were able to perform 4 out of 5 of the normal daily activities reported in MEPS, with a subjective improvement of the strength. The radiological analysis is summarized in Table 2. In the post-operative period 5 patients had complications. Two patients had post-surgical superficial infections which were treated just with intravenous antibiotics. One case (the second poor result) required removal of the implant at 16 months follow-up because of aseptic loosening of prosthesis and subsequent pros-



Figure 2. Type “T-condylar” non-union of the right elbow; pre-operative x-ray (A, B), x-ray (C, D) and clinical evaluation (E, F) at follow-up. (excellent result).

thetic revision. Finally, in two patients a transitory impairment of the ulnar nerve, which resolved spontaneously, was observed.

Analysis of results

Differences between MEPS of the Group 1 and Group 2 and MEPS value of Group 1 versus Group 2 are summarized in Table 3, 4 and 5.

Discussion

Surgical procedures such as arthrodesis, resection or interposition arthroplasty have been used in the past as the only available methods for improving elbow pain, joint instability and stiffness related to various pathologies and have been now abandoned (1).

During the second half of the 1900s total elbow joint replacement began its ascent (15). In the past four decades TEA has emerged as a viable surgical option for advanced elbow disorders particularly in arthritic diseases (16). Constrained hinged designs,

which were initially utilized, showed a high rate of loosening (42%) because of a kinematic mismatch (17). Improvements and modifications in implant designs based on an increased understanding of the biomechanics of the elbow joint, which favoured the introduction of semi-constrained and unconstrained models, have led to increasingly good clinical outcomes after elbow replacement, thus allowing a wider array of indications to other pathologies of this joint (16).

Complex fractures of the elbow region remain a management challenge. Open reduction and rigid internal osteosynthesis, preserving the elbow and allowing early mobilization, remains the gold standard of treatment in younger patients. However, adequate fixation of osteoporotic comminute bone may not always be feasible and additional bracing may be necessary, putting a strain on the functional prognosis (1).

Furthermore, this treatment is associated with a high rate of immediate and long term complications and generally yields poor results. These complications include heterotopic ossifications, infections, ulnar nerve impairment, failure of fixation, limited function and non-unions, which are seen in about 5% of patients after distal humeral fracture and are known to occur more often in elderly female patients (2). For all these reasons, nowadays TEA has also evolved as a valid option of treatment in selected patients both for complex fractures and post-traumatic deformities and non-unions of the elbow region, and many publications suggest that this procedure may be performed in the management of these injuries (2,3,18).

Table 4. Differences between MEPS of the affected vs. unaffected arm in Group 1 and 2.

	F.U. MEPS affected side	F.U. MEPS unaffected side	p value
Group 1	88.4 (30-100)	91.6 (70-100)	0.527
Group 2	85.8 (50-100)	97.8 (90-100)	0.004a

Table 5. Differences between MEPS of the affected arm before surgery vs. follow-up evaluation in Group 2.

	Pre-op. MEPS affected side	F.U. MEPS unaffected side	p value
Group 2	50.3 (20-80)	85.8 (50-100)	0.001

Some of these reports, that included patients with associated inflammatory arthropathy, showed good medium- and long-term results, but these maybe due partly to low functional demands. In the present study, in order to match these cases series, as described by Prasad (19) and Garcia (18), patients affected by inflammatory chronic arthritis were excluded. The study included two groups of patients who underwent TEA for acute fractures and after failed primary treatment. The authors' objectives were to obtain satisfactory functional recovery for the patients in the short- and mid-term period with a low complications rate and to compare the outcomes in patients of Group 1 versus Group 2.

MEPS results at follow-up were similar in both groups and majority of the patients had satisfactory outcomes; excellent and good results were 94% in Group 1 and 89% Group 2 and these were similar to other reports in the literature (1,2,5,16,19).

Complications incidence with TEA is higher than in hip and knee replacement, although the majority of these do not influence the final outcome (20). These findings are probably due to the fact that TEA is relatively aggressive and done in a smaller joint, which is covered by thin soft tissues. The overall rates of complications of this procedure range in the literature between 10 and 33% (21). In the present series complications encountered were similar in Group 1 (37%) and 2 (28%) (see Table 3). Amongst the various complications, infections remain the most feared morbidities (up to 10% of cases according to Morrey) (22). In this study problems related to infections were observed in 4 cases in Group 1 and in 2 cases in the second group but only one patient (the single poor result of Group 1) developed a deep infection. Another common complication encountered after TEA is ulnar nerve impairment, despite the fact that it is usually protected during the surgical procedure. Ulnar neuroapraxia occurs after surgery in as many as 20% of the patients, with the rate of permanent damage ranging from 0 to 10% (23). In this study, 2 ulnar nerve neuropathies in Group 1 and 2 in Group 2 occurred and resolved spontaneously in less than 6 months from surgery.

Morrey considers elbow range of motion (ROM) to be functional for most activities daily living with a

minimum of 100° of total arc of movement (TAM) of extension and flexion (range between 30° and 130°) and a minimum of 100° TAM of pronation and supination (range between 50° in pronation and 50° in supination) (1,5). Two patients (one in each Group) had poor ROM at follow-up with the elbow ankylosed at 90° of flexion. Both cases did not perform the post-operative rehabilitation program which was suggested after discharge, because of progressive cognitive impairment. Statistical analysis demonstrated in the second group a significantly ($p = 0.004$) worse outcome at follow-up of the affected side compared with the unaffected arm. Although the numerical MEPS difference was significant, the authors can not consider this datum "a true clinical" result. Actually the majority of the patients of the second group had excellent or good outcomes and were satisfied with the result of their operated elbow. Of 18 patients in the delayed group, all had a painful non-union of the distal humerus; 11 patients had undergone previous surgery which may have contributed to the poorer clinical results.

The limitations of this study include its small sample size and the absence of a control group for both patients operated with TEA acutely or after non-unions following primary therapy. Based on the review of the literature, as reported by Ducrot (24), only 3 studies have compared TEA and internal fixation. In all cases the results were favourable with arthroplasty, since faster and better recovery was achieved. However strength recovery was better after internal fixation.

Conclusions

TEA for complex elbow fractures and non-unions, although it is not a procedure which is routinely undertaken because of the higher complications incidence than in knee and hip replacement, such as infections and ulnar nerve impairment, may be considered an alternative to open reduction and internal fixation. On the basis of the satisfactory results observed, and because these are similar to others reported in the literature, the authors consider TEA to be indicated in selected patients older than 70 years with low functional demands affected by complex fracture

in which a stable osteosynthesis is usually difficult to obtain and non-union with residual pain of the elbow region. Associated cognitive impairment may influence negatively the outcomes.

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