The role of total elbow arthroplasty in traumatology

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Original article

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Abstract

Fractures of the distal humerus account for 5% of osteoporotic fractures in subjects older than 60 years. A history of osteoporosis, co-morbidities, and joint comminution make their management difficult. The therapeutic options are limited to functional treatments, osteosynthesis, or either partial or total arthroplasty. Functional treatment of distal humerus fractures in the elderly subject provide inconsistent results, often with persistence of pain with a stiff or unstable elbow. Osteosynthesis remains the reference treatment for these fractures, following the principle of stable and rigid osteosynthesis allowing early mobilization. However, joint comminution and a history of osteoporosis occasionally make it impossible to meet this objective, with a considerable rate of complications and surgical revisions. Total elbow arthroplasty remains an alternative to osteosynthesis with very satisfactory immediate results restoring a painless, stable, and functional elbow. These results seem reproducible and sustainable over time. The complication rate is not uncommon with an approximately 10% surgical revision rate. Elbow hemiarthroplasty remains to be validated in this indication.

Level of evidence: V.

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1. Introduction

The goal of an elderly patient presenting distal humerus fracture is to rapidly recover a painless, stable, and functional elbow so as to resume daily activities and maintain autonomy. However, treatment of these fractures is often difficult and compromised by poor bone quality and periarticular tissue involvement [1,2]. Osteosynthesis in these patients results in a 2–10% non-union rate often related to material failure[3]. In 1997, total elbow arthroplasty was presented as an alternative to osteosynthesis to treat distal humeral fractures in elderly subjects [4]. Since this study, several series have been published that have allowed identification of the ideal patient for this treatment and prediction of the expected results.

2. Background

The goal of treatment is to restore the elbow's rotational axis while providing joint stability despite loss of bone stock and mediocore bone quality. Unlinked implants have been used in this situation, but linked implants and semi-constrained implants make it possible to obtain better joint stability.

Different linked implants exist, but the most widely used implant is the Coonrad-Morrey® (Zimmer, Warsaw, IN, USA). It restores the elbow's rotational axis even when the fracture extends up to the roof of the olecranon fossa. It can restore the length of the humerus with the anterior flange of the humeral implant, which will resist rotational forces and anteroposterior stresses. Different sizes are available, which allow surgeons to manage most clinical situations.

In a traumatology patient, total elbow arthroplasty should not be performed in an emergency setting. The skin should be in good condition, and if dermabrasions or hematomas are present, it is preferable to wait a few days before performing surgery. The patient must understand the type of surgery to be performed and its demands, as well as the postoperative protocol.

Indications for total elbow arthroplasty in traumatology:

- Fracture that cannot be fixed;
- Osteoporosis;
- Inflammatory rheumatism;
- Patient older than 70 years;
- Sedentary.
Contraindications for total elbow arthroplasty in traumatology:

- infection;
- cutaneous lesions;
- neurological involvement;
- noncompliant patient;
- dementia.

3. Presentation, work-up, and therapeutic options

Total elbow arthroplasty is reserved for patients with osteoporosis who are older than 70 years, presenting a distal humerus fracture. However, in presence of inflammatory rheumatism, severe osteoporosis, or reduced life expectancy, the prosthesis can be proposed to younger patients if the fracture cannot be fixed.

The mechanism of injury is generally a fall. The patient presents an edematous, painful, and disabled elbow. Mobilization of the elbow exacerbates pain. The clinical examination includes an evaluation of the cutaneous cover and the neurovascular status. The standard radiographic work-up is essential to classify the fracture. However, it minimizes the degree of comminution. A CT work-up with 3D reconstruction can provide a more accurate assessment of the fracture, its degree of comminution, and the joint injury, allowing a more reliable therapeutic decision.

4. Alternatives to arthroplasty

The functional treatment of fractures of the distal humerus in elderly subjects gives inconsistent results often with persistence of pain on a stiff or unstable elbow. Although this treatment can be acceptable in debilitated patients, Lecestre et al. showed that this therapeutic option provides satisfactory results in less than 40% of cases [5].

Osteosynthesis remains the reference treatment in these fractures, based on the principle of stable and rigid osteosynthesis to allow early mobilization. However, joint comminution and osteoporosis do not always allow for a stable fixation, requiring additional interventions that are a source of elbow stiffness. Lecestre et al. demonstrated that osteosynthesis provided satisfactory results in 61% of cases [5]. In 2002, Bonnevialle and Ferron found 25% loss of function in the upper limb in elderly subjects after fracture of the distal humerus [6]. Kocher et al. reviewed the results of 169 patients treated for fracture of the distal humerus, 32 of whom were over 65 years of age (mean, 78 years). Satisfactory results were obtained in 75% of the cases [7]. In their meta-analysis, Helfet and Schmeling found 25% unsatisfactory results [8], and in a population of subjects aged more than 75 years, John et al. found 20% unsatisfactory results [9]. One-third of the patients presented persistent pain. Pereles et al. demonstrated that only 25% of the patients were without pain [10]. More recently, Pajarinen and Bjorkenheim found that patient age and osteoporosis were the determinant prognostic factors in obtaining unsatisfactory results. Srinivasan et al. reported their experience in the use of osteosynthesis in 21 patients with a mean age of 85 years (range, 75–100 years) and found poor or fair results in 43% of the cases [11,12]. In 2007, Proust et al. operated on 34 patients (36 fractures) whose mean age was 78 years using osteosynthesis to treat AO type C fractures [13]. A mean of 35 months of follow-up, only 58% of the patients presented a satisfactory result. The mean range of motion in extension/flexion varied from 38° to 116°. The complication rate was 56%, with nine cases of non-union and four material failures. In Toulouse, 53 patients were operated on for a fracture of the distal humerus. The Mayo Elbow Performance Score (MEPS) reached 86 points for the overall group, 79 points for patients who were older than 65 years, and 76 points for patients older than 65 years with an AO type C fracture.

5. Surgical technique and rehabilitation [14,15]

The patient is installed in the dorsal decubitus position with the forearm placed on the abdomen. An 18–cm posterior incision is made slightly laterally in relation to the summit of the olecranon (Fig. 1). The ulnar nerve is identified and released up to the division of its first motor branch (Fig. 2). The extensor apparatus is then detached from the olecranon and pulled away medially and laterally, progressively dislocating the elbow (Fig. 3). The triceps can be left intact on the olecranon and by excising the fractured fragments through lateral-tricipital openings.

Preparation of the humerus is simple. The fractured fragments are excised (Fig. 4). The humeral canal is prepared with the different rasps. The depth that the humeral implant is inserted is guided by the anterior keel of the implant, which is blocked by the roof of the olecranon fossa.

The ulna is then prepared with the adapted rasps. To facilitate this preparation, the summit of the olecranon must be resected, which also provides direct access to the axis of the ulna’s medullary canal. The top of the coronoid process must be resected to prevent any impingement in flexion with the anterior flange of the humeral implant.
Fig. 3. Triceps detachment from medial to lateral according to Bryan and Morrey.

Fig. 4. Excision of fractured fragments.

Fig. 5. Cement injection into the medullary canal.

Fig. 6. Triceps re-attachment.

Fig. 7. Postoperative radiographic verification.

The fracture is then reduced with the trial implants. An obturator is usually inserted at the medullary canal of the humerus and a bony fragment at the medullary canal of the ulna for better cement pressurization. After washing and drying the canals, low-viscosity cement with antibiotics is injected with an adapted injector gun first in the humeral canal and then in the ulnar canal (Fig. 5). The ulnar component is then inserted and impacted so that the joint part is at the center of the large sigmoid cavity of the ulna, between the top of the coronoid process and the top of the olecranon. A 3-mm-thick bone fragment is place behind the anterior flange of the humeral implant before its impaction. The implants are then assembled and the axis is placed in the center of the hinge so that they can be locked. The elbow is placed in extension while the cement is polymerized.

If the triceps have remained inserted on the olecranon, the extensors are sutured on the lateral edge of the triceps and the flexors on the medial edge. If the triceps were detached from the olecranon, it is reinserted using transosseous sutures of no. 5 non-resorbable suture (Fig. 6). An x-ray is taken to confirm the proper position of the implants.

Postoperatively, an anterior splint is placed to keep the elbow in extension. The limb is raised for 48 h and then the Redon drain is removed and the patient is allowed to move the elbow as pain permits. A simple sling is prescribed. No rehabilitation is required (Fig. 7).
6. Particularities of the Coonrad-Morrey prosthesis in trauma
tomy

The Coonrad-Morrey implant is for the moment the choice implant for treating fractures of the distal humerus in the elderly. McKee et al. demonstrated that with this prosthesis, excision of the humeral condyles had no consequence on the strength of the forearm, the wrist, and the hand, and no effect on the MEPS [16].

The intrinsic stability induced by the hinge can compensate the loss of bone stock. If the fracture does not extend beyond the roof of the olecranon, a standard 4-in. (10-cm) implant is used. If the fracture extends proximally above the fossa, shortening the humerus as much as 2 cm is not detrimental and can be compensated by the implant. However, if bone stock loss exceeds the roof of the olecranon fossa by more than 2 cm, a 6-in. (15-cm) implant must be used with a lengthened anterior flange [15].

When an olecranon fracture is associated with the distal humerus fracture, the olecranon must be osteosynthesized after the ulnar implant has been sealed. If the fracture extends distally beyond the olecranon, an ulnar implant with a long stem must be used. Marra et al. demonstrated that a functional range of motion as well as a satisfactory clinical result could be expected despite fibrous union of the olecranon fracture [17]. If osteosynthesis of the olecranon is not possible, the fragment is excised and the triceps are advanced and attached directly to the ulna.

7. Results of total elbow arthroplasty in trauma
tomy

Total elbow arthroplasty for the treatment of fractures of the distal humerus in elderly subjects was initially proposed by Cobb and Morrey in 1997 [4]. In their retrospective study of 21 cases with a mean follow-up of 3.3 years, they reported 15 excellent and five good results. The extension/ flexion range of motion varied from 25 to 130° with the MEPS equal to 95 points. The complications included a fracture of the ulnar component in one patient, ulnar nerve injury in three cases, and a complex regional pain syndrome in one case. More recently, this study was updated by Kamineni et al. [18]. Forty-nine fractures of the distal humerus in 48 patients were treated with total elbow arthroplasty and reviewed with a mean follow-up of 7 years. The extension/flexion range of motion extended from 24 to 131° with the MEPS equal to 93 points. Fourteen elbows (29%) presented a complication. Additional surgery was required in ten cases, five of which were implant revisions. In five cases, the complication affected the periarticular tissues and five other patients experienced a complication involving the bone or the implant (Table 1).

Five other studies confirmed these preliminary results [19–23]. In all cases, a Coonrad-Morrey implant was used. The mean age of the patients was 70 years, and the fractures were mainly AO type C fractures. The MEPS was higher than 90 points in all cases recuperation of a functional range of mobility. In these studies, at the mean follow-up of 2 years, there were six complications: superficial infections in two cases, triceps insufficiency in one case, heterotopic ossification in one case, complex regional pain syndrome in one case, and one case of aseptic loosening of the ulnar implant.

In 2004, the SOFCOT conducted a multicenter study assessing the results of total elbow arthroplasty in traumatology. Thirty-one elbows were analyzed with a mean follow-up of 17.4 months. The complication rate was evaluated at 16% with a 10% revision rate, with no implant revisions [24]. Another multicenter study conducted within the Société d’orthopédie de l’Ouest (SOO) in 2007 on 36 patients with a mean age of 80 years and a mean follow-up of 24 months reported 84 points on the MEPS and 25 points on the Disabilities of the Arm, Shoulder, and Hand (DASH) questionnaire. There were five complications (14%), requiring surgical revision in two cases (5%) [25].

In 2012, at the SOFCOT symposium, Mansat et al. reported the largest study in the literature evaluating the results of 87 total elbow arthroplasty procedures for fractures of the distal humerus in patients older than 65 years (mean age, 79 years) [26]. These were AO type C fractures in 80% of the cases. At the mean follow-up of 37.5 months, the MEPS was 86 points, the quick-DASH 25, and the Katz score 5.3 points. No pain or minimal pain was presented by 87% of the patients. The range of mobility varied from a 29° extension deficit to 125.5° flexion. Twenty complications (23%) were found: seven (8%) neurological injuries, one (1%) infection, and 2 cases of loosening. One fracture of the humeral stem and one fracture of the humeral diaphysis should be noted. These complications required revision in eight cases (9%), including replacement of one broken stem and one prosthesis replacement for loosening.

Unlike implants have been proposed by certain authors to treat these fractures. In 2001, Ikävalko and Letho reported their experience with the Souter implant to treat fractures of the distal humerus in patients with rheumatoid arthritis [27]. The problems reported with this implant concerned the need to use fixation for the humeral condyles to obtain a stable humeral implant. Out of 32 fractures, only 20 healed. Additional interventions were required in 12 patients to stabilize the implant. Six patients presented late complications, including three who presented radiographic loosening of the prosthesis. In 2008, Kalogrianitis et al. reported their experience with the IBP implant for this same indication [28]. All patients presented a stable elbow at the last follow-up and were able to resume daily activities. The mean MEPS reached 95 points (range, 65–100). The authors concluded that the IBP prosthesis could be used in traumatology as long as one column was preserved.

The literature also seems to show that the results of first-line total elbow arthroplasty to treat a distal humeral fracture are better than those obtained after material failure (Table 2). Mighell et al. reported 28 cases of second-line total elbow arthroplasty performed after fixation failure [29]. At the 3-year follow-up, the clinical results were favorable. However, 21% (6/28) of the patients...
required surgical revision. Five patients required revision for aseptic loosening, and one arthrodesis was necessary in one case for septic loosening. These results are less favorable than those published in series of first-line total elbow arthroplasty.

Frankle et al. were the first to report better results after total elbow arthroplasty compared to internal fixation [30]. In 2007, the SOO confirmed these results with better MEPS and DASH scores [25]. The complication rate was 14% in the arthroplasty group versus 26% in the internal fixation group. In 2008, Mansat et al. also compared these two treatments [31]. Group 1 included nine patients aged a mean of 72 years (range, 65–83 years) treated with osteosynthesis for AO type C fractures. Group 2 included 22 patients with a mean age of 81 years (range, 65–90 years) treated with Coonrad-Morrey total elbow arthroplasty for the same type of fracture. At the mean follow-up of 34 months (range, 15–63 months), the MEPS was 76 points for the osteosynthesis group with range of motion recuperation ranging from 30 to 119°. There were three fixation material failures, with non-union in two cases, but no revisions were performed. In group 2, at the mean follow-up of 21 months (range, 6–64 months), the MEPS was 81 points with a range of mobility ranging from 29 to 125°. There were two cases of deep infection, which required ablation of the prosthesis in one case, and joint lavage in the other case. There was no implant loosening in this series. McKee et al. [32] conducted a randomized prospective study comparing the results of the two treatment options. Fifteen patients were treated with internal fixation and 25 with total elbow arthroplasty. The latter patients had a better MEPS at 3 months (83 vs 65), 6 months (86 vs 68), 12 months (88 vs 72), and 2 years (86 vs 73) compared to the patients treated with internal fixation. Similarly, the patients treated with arthroplasty presented a better DASH score at 6 weeks (43 vs 77) and 6 months (31 vs 50), but not at 12 months (32 vs 47) and 2 years (34 vs 38). The extension-flexion range was 107° in the prosthesis group vs 95° in the osteosynthesis group. The revision rate was 12% (3/25) in the prosthesis group vs 27% (4/15) in the osteosynthesis group. The authors concluded that implants for treatment of comminuted fractures of the distal humerus in patients older than 65 years gave more reliable results than with osteosynthesis. Finally, during SOFCOT 2012, in a multicenter retrospective study, 181 osteosynthesis cases were compared to 70 implant cases for the treatment of AO type C fractures [33]. The population compared was identical, as was the follow-up time. Although the clinical results were close, with no truly significant difference, 95.7% of the patients who had undergone implant treatment had no complications versus 80.5% of the patients treated with osteosynthesis.

8. Role of hemiarthroplasty of the elbow

The option of hemiarthroplasty has been recently proposed. The only studies published to date had short follow-up times (10 months) [34–38]. The hemiarthroplasty used should be anatomical. This implant is indicated only if the columns are preserved so as to ensure implant stability or if the columns can receive fixation material. The approach used is usually the transolecranon approach. The short-term results seem favorable; however, complications have been observed, such as wear on the olecranon opposite the humeral implant, non-union of the olecranon, impingement with the fixation material required to set the columns, and implant instability. This option still needs to be validated (Fig. 8).

Conclusion

Osteosynthesis is the treatment of choice for AO type C fractures of the distal humerus. However, in patients older than 65 years, presenting a comminuted fracture on osteoporotic bone, osteosynthesis fixation can be compromised. In these cases, linked total elbow arthroplasty is a treatment alternative that allows rapid recuperation of a painless, stable, and functional elbow.

Disclosure of interest

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

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