Mid-term results of complex distal humeral fractures.

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ORIGINAL ARTICLE

Mid-term results of complex distal humeral fractures

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Abstract The aim of this study was to assess outcomes following open reduction and internal fixation in complex fractures of the distal humerus. Between 2000 and 2006, 34 patients were operated for complex fractures of the distal humerus. Bone fixation was obtained with a reverse Y-shaped reconstruction plate in 13 cases and with double plating in 21 cases. At final follow-up, all the patients were assessed with the Mayo Elbow Performance Score. Satisfactory results were observed in 71% of the cases despite a high rate of complications. Age over 65 years is correlated with increased risk for an inferior postoperative result. Complex distal humeral fractures are difficult to treat and are associated with a high incidence of complications. It is therefore mandatory to obtain good anatomical reduction and a stable fixation of lateral and medial columns of the distal humerus. The results observed in older patients suggest that an alternative treatment for these patients may be joint replacement.

Keywords Distal humerus · Complex fractures · Fixation · Osteosynthesis · Reverse Y-shaped plate · Dual plating

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Introduction

Distal humerus fractures in adults are relatively rare and are considered to be serious injuries [1–6]. They represent 2% of elbow fractures [7], although more recent data [8, 9] confirm that overall incidence is rising all over the world, especially in elderly subjects. Many different classifications exist in the literature. The most cited are those of Jupiter and Mehne [10], and the AO/ASIF classification of Müller [11] which classifies Type C fractures as complex.

The complexity of these fractures, their articular involvement and concurrent osteoporosis in older patients challenge even the most experienced orthopedic surgeons. Conservative treatment through closed reduction and cast immobilization with use of traction [12, 13] or early mobilization techniques (bag of bones) [14, 15], is rarely indicated because the results are notoriously poor [16–18]. The majority of the authors agree that the best treatment for these fractures is surgical even if stable fracture fixation may be technically difficult [19–23]. Among the different techniques and fixation devices available, today open reduction and internal fixation (ORIF) with plate and screws is considered the gold standard, and various ways of plating have been described [24–27]. This method allows reaching anatomical reduction and stable fixation of the medial and lateral distal humeral columns and of the articular surface, thus allowing early joint mobilization. A realistic long-term goal should be a total arc of motion (TAM) of 100°, with no more than 30° of elbow active extension deficit and at least 130° of active flexion. These ranges of motion (ROM) were found to be sufficient to carry out a large part of a person's activity of daily living (ADL's) [28]. Total elbow replacement has been used, with good results, for elderly patients in which complex fractures could not be appropriately treated with ORIF or in

cases where the elbow was affected by a pre-existing degenerative and inflammatory disease [29–32].

The aim of this retrospective study is to present mid-term results following surgical treatment of complex distal humerus fractures (Type C of the AO/ASIF classification) [11] and analyze outcomes in these fractures according to fixation device used (dual plating or single reverse Y-shaped reconstruction plate), gender, and age.

Materials and methods

Between January 1st 2000 and December 31st 2006, 84 adult patients were treated surgically for distal humerus fracture (48 men and 36 women). Thirty-seven (44%) fractures were complex (type C according to the AO/ASIF classification). Of these, 3 patients older than 65 years of age (Type C3.3 fractures) were excluded from the study as they underwent primary elbow arthroplasty with a semi-constrained prosthesis. Thirty-four patients (19 men and 15 women) were treated with ORIF. Mean age at the time of injury was 50 ± 22 years (range, 19–80 years). Twenty-three (68%) patients had less than 65 years and 11 (32%) were older than 65 years. Men had a mean age of 46 ± 22 years (range, 19–75 years) and women had 52 ± 24 years (range, 34–80 years).

At admission, all patients underwent radiographic investigation (anterior-posterior and lateral views of the elbow). A computerized tomography (CT) scan was done on 27 patients.

Fractures were subdivided according to the AO/ASIF classification [11] as follows: 13 Type C1 (38%), 9 Type C2 (26%), and 12 Type C3 (36%).

One Type C3 fracture presented as open Type II fracture according to the Gustilo–Anderson Classification [33].

In 19 cases (56%), injury was caused by high energy forces (13 motor vehicle accidents, 6 sport accidents) and the remaining 15 cases (44%) sustained low energy trauma (accidental fall from less than 2 meters of height).

In all cases except one, antibiotic prophylaxis was administered before to and after surgery using a 2nd generation cephalosporin. In the patient with the open fracture gentamicin, ampicillin, and metronidazole were administered. This patient was immediately treated and the fracture was initially stabilized with a bridged axial external fixator (AEF). Ten days later AEF was removed and replaced with a reverse Y-shaped plate and free screws.

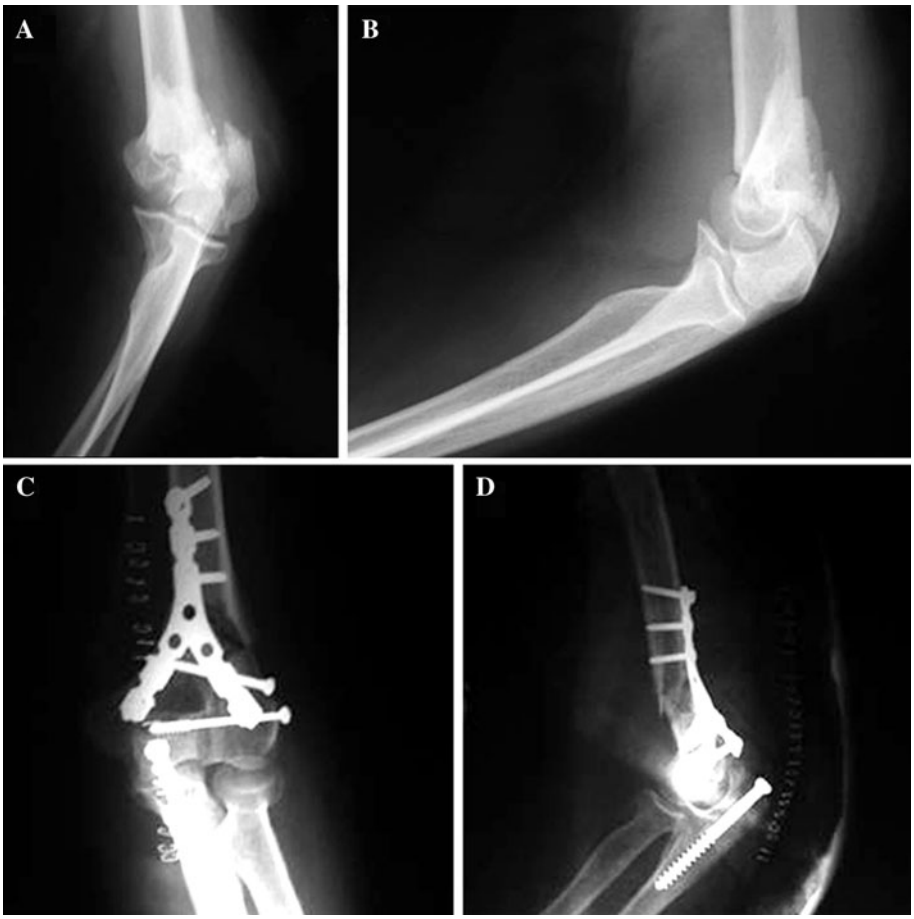

Fig. 1 Type C1 fracture of the left distal humerus. **a**, **b** Pre-operative X-ray; **c**, **d** post-operative X-ray after reverse Y-Shaped plate and free screws fixation through olecranon osteotomy

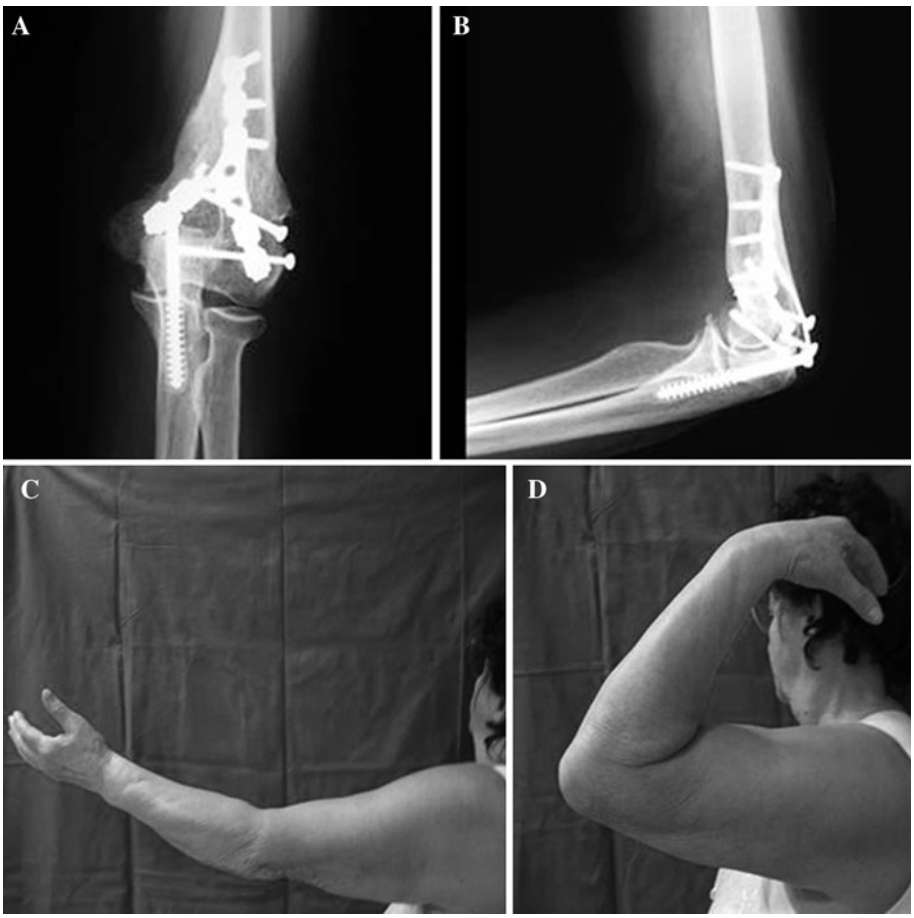

Fig. 2 **a**, **b** X-ray after consolidation despite fracture of the plate and **c**, **d** outcome at 3 years from surgery

In the other patients, surgery was done on average at 4 days from injury (range, 1–10 days). Patients laid prone and had a tourniquet at the base of the involved upper extremity. The fracture was reached by standard posterior access at the elbow. In 26 cases, a "chevron" type olecranon osteotomy was necessary to access the fracture site (21 patients with Type C2 and C3 fractures, and 5 patients with Type C1 fractures). In the remaining 8 cases (Type C1 fractures), a trans-tricipital approach was used. Internal fixation was achieved with reverse Y-shaped plates (Figs. 1 and 2) in 13 cases and with dual plating in 21 cases (Figs. 3 and 4). In these cases, the dual-plate fixation method involves placing the hardware perpendicular to one other, applying a radial plate dorsally and an ulnar plate medially. In 18 cases, free screws or Kirschner wires were associated to the plates. The ulnar nerve was identified and protected in all patients, and in 15 cases (43%) anterior nerve transposition was necessary. The olecranon osteotomy was synthesized in 18 cases with tension band wiring and in 8 cases with a compression screw. A wound aspiration drain was inserted intra-operatively in all cases and was removed 2 days later. Following surgery, a univalve cast was applied to immobilize the elbow and wrist, placing the elbow in 90° of flexion and the forearm in slight pronation for an average of 25 days (range, 18–45 days). Rehabilitation began on average after 10 days (range, 2–18 days). Active-assisted elbow flexion and passive extension was controlled by the therapist in a pain-free limited arc-of-motion. Active and passive prono-supination exercises were also done. The arc-of-motion progressively increased as bone consolidation was confirmed on radiographs. Strengthening began after 8 weeks from surgery.

At final follow-up (mean 53 months; range, 24–84 months), all the patients were assessed with the Mayo Elbow Performance Score (MEPS) [34]. The authors considered the results to be satisfactory for excellent and good scores, and unsatisfactory for fair and poor scores. Anterior-posterior and lateral X-ray views were used to assess the amount and severity of osteoarthritis, according to the Knirk and Jupiter classification [35], and the presence of heterotopic ossifications, according to the Hastings classification [36]. The MEPS results were also analyzed in function of the type of fixation hardware utilized (dual plate or reverse Y-shaped plate) and of gender and age of the patients.

Data analysis

All scale variables except the mean age were tested for normality with the Chi Square Test ($X^2_{(1)}$) with the Yates correction $\left(= {}^1\!/_2\ \mathrm{n}\right)$. The mean age was tested for normality with the 1-way analysis of variance (ANOVA) with the Tukey method.

The Chi Square Test ($X^2_{(1)}$) with the Yates correction $\left(= {}^1\!/_2\ \mathrm{n}\right)$ was used to establish statistical significance of results according to gender, age (> or <65 years) and fixation devices utilized.

The Spearman's rank test (Spearman = r) was used to analyze the correlation between patient age increase and the evaluation scores. Tests were considered significant with $P < 0.05$.

All statistical analysis was done with the software StatPlus 2009 Professional ® (Analyst Soft Inc.-Vancouver, Canada).

Results

Seventy-one percent (71%) of the cases had satisfactory results (9 excellent and 15 good) and 29% had unsatisfactory results (8 fair and 2 poor) with a mean score of 78 ± 11 points (range, 55–100 points). Patients with Type C1 fractures had satisfactory results in 85% of the cases, patients with Type C2 fractures in 78% of the cases, and patients with Type C3 fractures in 50% of the cases. Mean active elbow flexion was 114 ± 22° (range, 50°–140°) with an active extension deficit of 25 ± 13°(range, 0°–60°). Five (15%) patients suffering from Type C3 fracture presented with less than 100° of TAM. Eighteen (53%) patients had no pain, 11 (32%) mild pain, 3 (9%) moderate pain, and 2 (6%) severe pain. Fracture consolidation occurred in 33 (97%) patients, on average at 120 days from surgery (range, 60–180 days).

Patients treated with double plating had 71% and those treated with the Y-shaped plate had 69% of satisfactory results. The differences were not statistically different ($P \sim 1.00$). Both groups were similar for gender ($P = 0.380$) and age ($P = 0.787$).

Men and women were of similar age ($P = 0.466$). Men had 74% and women had 67% of satisfactory results ($P = 0.502$).

Patients below 65 years of age had 83% and those older than 65 years had 45% of satisfactory results. The differences were statistically different ($P = 0.014$). Both age groups were similar for gender ($P = 0.224$).

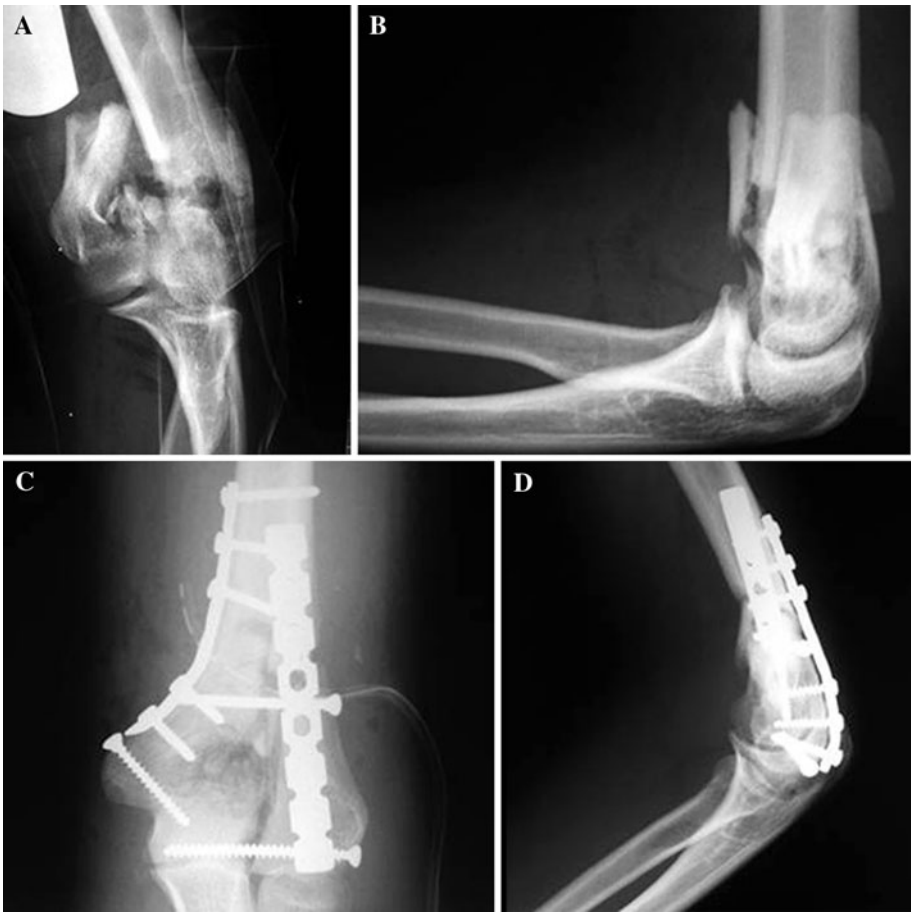

Fig. 3 Type C2 fracture of the left distal humerus. **a**, **b** Pre-operative X-ray; **c**, **d** post-operative X-ray after double plating and free screws fixation

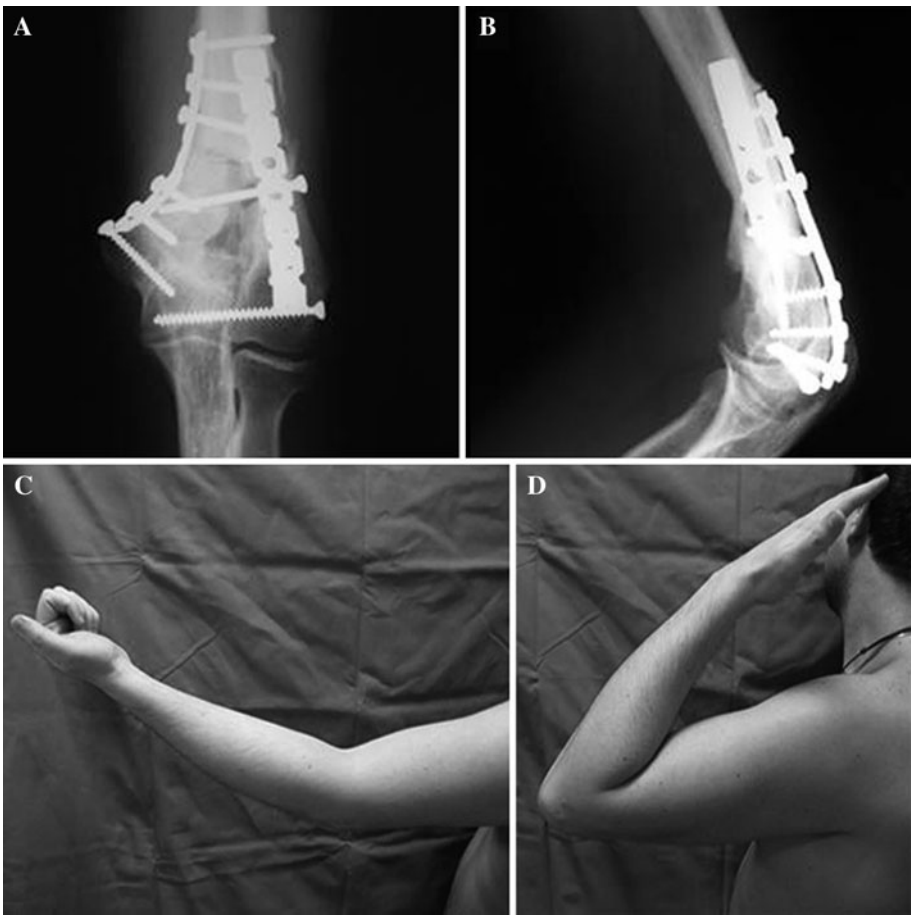

Fig. 4 **a**, **b** X-ray showing fracture consolidation and **c**, **d** functional outcome at 2 years from injury

The grade of osteoarthritis observed on the follow-up X-ray was: grade 0 in 9 (26%) patients, grade 1 in 19 (56%) patients, grade 2 in 5 (15%) patients, and grade 3 in 1 patient. In this latter case, the MEPS result was unsatisfactory, TAM was below 50° with moderate to severe pain and required elbow arthroplasty 3 years from injury. A Coonrad–Morrey semi-constrained total elbow prosthesis was used and resulted in good clinical outcome.

Four cases had heterotopic ossifications, of which 3 were Class I without any form of ROM restriction, and the other was a Class IIA with limited flexion and extension and with TAM <100°. In this latter case, secondary surgery was necessary to remove the hardware and heterotopic ossifications, and perform a soft tissue release. Following surgery, 100° TAM was obtained (Figs. 5 and 6).

Other complications included superficial wound infection (*Staphylococcus epidermidis*) in a Type C3 open fracture with associated traumatic ulnar nerve lesion (1 case) which was treated with specific intravenous antibiotics, postoperative ulnar nerve neuropraxia (2 cases) which resolved spontaneously after 3 months, deep infection (*Staphylococcus aureus*) which occurred 50 days after surgery in another Type C3 fracture (1 case) and required hardware removal and debridement, and 1 case of non-union of the distal humerus resulting in joint replacement (Coonrad–Morrey semi-constrained prosthesis). Furthermore, 2 cases of cubital tunnel syndrome required hardware removal and nerve transposition, and 6 cases required hardware removal for soft tissue irritation.

Discussion

The treatment goal of these fractures should be to reduce and stabilize both columns of the distal humerus and of the articular surface. This allows for early post-operative mobilization, which in turn reduces the risk of joint stiffness [26, 27, 37, 38].

Various ways of plating methods have been described but there is general agreement that a stable osteosynthesis is obtained with double plating on both columns of the distal humerus [7, 23–26, 38–41] or with reverse Y-shaped plate [3, 40, 42–44]. Corresponding to prior reports, 78% (range, 50–100%) of patients treated with these fixation devices obtain satisfactory results [3, 6, 7, 23, 45, 46]. In

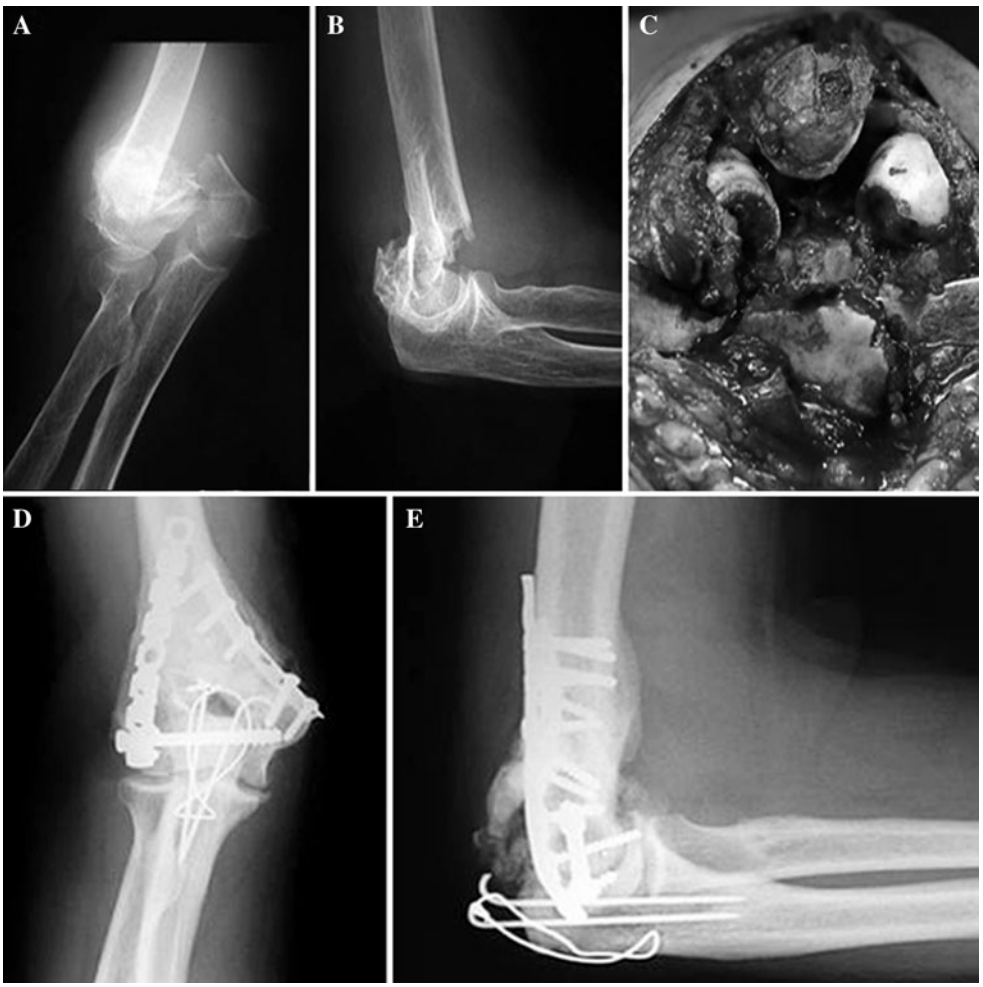

Fig. 5 Type C3 fracture of the right distal humerus. **a**, **b** Pre-operative X-ray; **c** intra-operative image of the fracture site and fragmentation; **d**, **e** X-ray after 1 year from surgery with Class IIA heterotopic ossification

our series, 71% of the patients obtained satisfactory results, with a mean TAM of 114° and no pain in 86% of the cases. Several biomechanical studies have proved that double plating provides good stable fixation [24, 38]. However, controversy still exists concerning plate position in terms of providing optimal stability for distal humerus fractures (orthogonal vs. parallel plating system). Few comparative studies [24, 26, 37, 43] of different types of osteosynthesis exist (i.e., double plating vs. reverse Y-shaped plate). This latter technique, as demonstrated by Fornasieri in 1997 [40], offers fracture stability similar to that associated with medial and posterior-lateral plating. In 1996, Kundel [3] reported satisfactory outcomes in using this plate for Type B and C fractures. In 2008, Luegmair [43] reported 14 satisfactory results in 17 Type C fractures using "Lambda" plate. According to our data analysis, there were no significant differences in outcomes between the double and single reverse Y-shaped plate fixation, respectively resulting in 71 and 69% of satisfactory outcomes.

Different theories have been proposed in regard to the most suitable surgical approach. In 1994, Olson [47] criticized the trans-olecranon approach because of potential complications (non-union, delayed union, loosening or breaking of hardware) recommending a trans-tricipital approach even for most distal fractures. Merle–D'Aubergine [48], Södergård [4], Lecestre [49] and Eugene [50] have all obtained successful outcomes with the reversed "V" trans-tricipital or triceps-sparing approach. On the other hand, other authors such as Jupiter [37], Wang [51] and Wildburger [52] reached similar results for complex fractures with the trans-olecranon intra-articular chevron approach, reporting only 4% of complications related to olecranon osteotomy [6]. These latter authors favor the trans-olecranon approach because it provides better exposition of the humeral trochlea than the trans-tricipital approach and because it allows for more accurate reduction without compromising the extensor apparatus of the elbow. According to our literature review, as indicated by

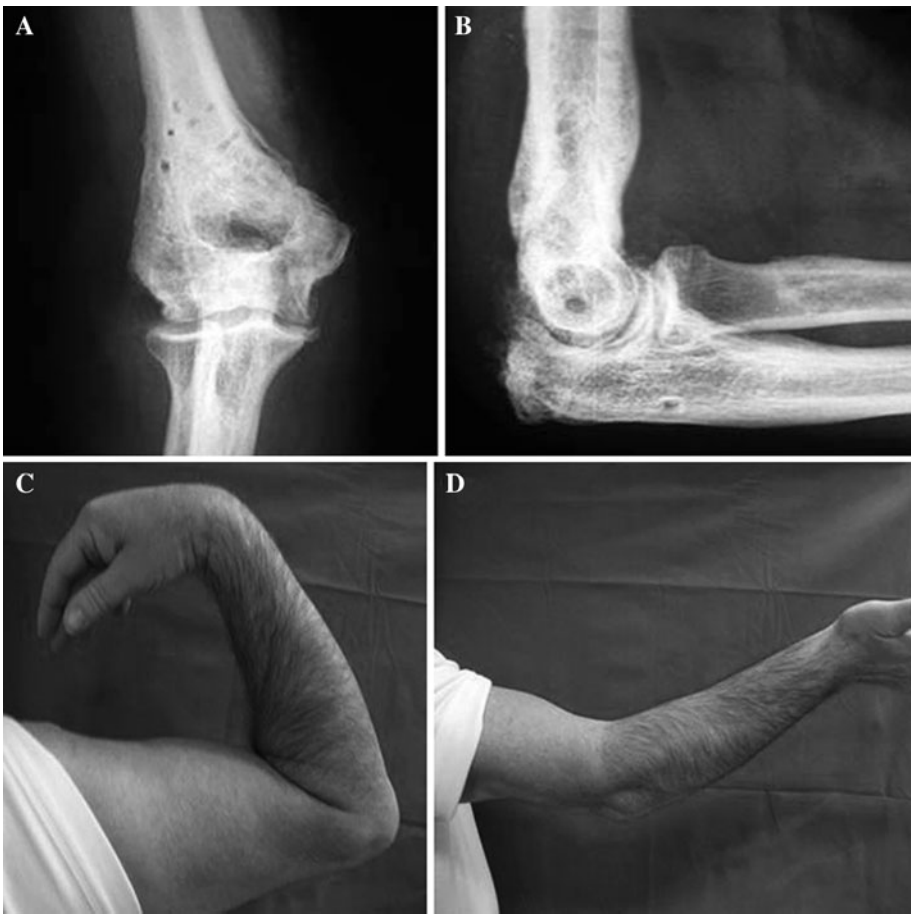

Fig. 6 **a**, **b** Radiographs and **c**, **d** clinical examination at 2 years from injury and 2 months after removal of the hardware and ossifications

Holdsworth [7] and Elhage [53] a posterior approach can be used for more simple bi-condylar fractures (Type C1) preserving the extensor mechanism, while in cases of major complexity or comminuted fractures (Type C2 and C3), it is recommended to use the intra-articular olecranon osteotomy. In our series, the trans-tricipital approach was used in 8 of the 13 Type C1 fractures, while the remaining C1 cases and the C2 and C3 fractures were all treated through a trans-olecranon intra-articular approach. No complications could be correlated to the surgical approach and the single case of non-union was of the distal humerus.

Several studies report worse outcomes in patients older than 65 years of age [7, 27, 54–59]. This is due to poor bone quality which prevents strong fixation and increases the risk of hardware loosening or non-union [60, 61]. Furthermore, in these patients final outcomes can be compromised by pre-existing osteoarthritis. In our series, outcomes worsened with age and a statistical significant difference was found between patients 65 years old or less and those above 65 years of age. For this reason, many authors [29–32, 62–65] have successfully opted for total elbow arthroplasty for elderly patients presenting with complex fractures of the elbow which could not be appropriately treated with ORIF or with associated pre-existing degenerative or inflammatory diseases affecting the elbow. In our experience, only 3 patients, excluded from this study, had this primary treatment with the Coonrad–Morrey semi-constrained prosthesis. These patients were all over 70 years of age, suffered from severe osteoporosis, had low functional needs and presented with Type C3.3 fractures. Satisfactory results were obtained according to the MEPS at a mean follow-up of 25 months (range, 14–36 months). Despite using this technique in only a few cases, we believe it to be a valid treatment for older osteoporotic patients presenting with complex fractures.

The severity of these injuries and their consequent treatment difficulties explain alone the high incidence of complications that varies between 10 and 50% of the cases. In our experience, the percentage of complications is 47%. In general, 23% (range, 0–42%) of these fractures are open [5, 6], 6% (range, 0–26%) are associated to acute nerve [6, 55], and/or vascular injuries (3%) [5, 64, 66]. Even delayed complications are frequent. Three percent (range, 0–12%) of these fractures lead to deep post-operative infections [3, 6, 30], 10% to residual instability [67], 6% (range, 0–25%) to non-union [6, 19, 39], and 5% (range, 0–17%) to delayed neurological palsy [5, 6, 67]. This latter complication, although not excessively invalidating, can be particularly annoying for the patient, and in the majority of the cases

involves the ulnar nerve in the cubital fossa. Wang [51] always recommends anterior transposition of the ulnar nerve during the osteosynthesis surgery. We do not use this procedure systematically but assess each case individually during surgery. In our series, 15 ulnar nerve transpositions were done in conjunct to osteosynthesis and in 2 cases, it was done during hardware removal for patients which presented with cubital tunnel syndrome diagnosed through electromyography.

Residual joint stiffness is present in approximately 10% of the cases [68] and increases proportionally to the fracture complexity. A TAM of 100° ranging between 30° and 130° of flexion is needed to enable the patient in most ADL's [28]. In our series, mean TAM gain was 114° with a mean extension deficit of 25° and all 5 patients which presented less than 100° of TAM suffered from a Type C3 fracture.

Secondary osteoarthritis is frequent and more frequently affects ROM than residual pain (10% of cases have been reported in the literature) [30]. This can be explained by the fact that the elbow is not a weight-bearing joint. In our series, 25 cases had secondary osteoarthritis. Of these, only a single patient presented with increased pain which compromised the final outcome and required secondary arthroplasty.

Heterotopic ossification formation occurs in up to 31% of the cases according to the literature (range, 0–31%) [6, 19, 21]. Type II Hastings ossifications are associated with joint motion limitation and often necessitate implant removal. Indeed, the Type II case we observed, required hardware and ossifications removal in addition to soft tissues release.

Conflict of interest None.

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