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DISTAL HUMERAL FRACTURES TREATED WITH NONCUSTOM TOTAL ELBOW REPLACEMENT

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Background: The purpose of this study was to review the cases of patients with a distal humeral fracture that was treated with a noncustom total elbow arthroplasty. We hypothesized that, on the basis of the functional and clinical outcome, total elbow replacement is a reliable option for the treatment of elderly patients with a severe, comminuted fracture of the distal part of the humerus.

Methods: We retrospectively reviewed forty-nine acute distal humeral fractures in forty-eight patients who were treated with total elbow arthroplasty as the primary option. The average age of the patients was sixty-seven years. Forty-three fractures were followed for at least two years. According to the AO classification, five fractures were type A, five were type B, and thirty-three were type C. The average age of the forty-three patients was sixty-nine years and the average duration of follow-up was seven years. Fourteen patients died during the review period. Postoperative clinical function was assessed with use of the Mayo elbow performance score, and anteroposterior and lateral radiographs made at follow-up examinations were reviewed.

Results: At the latest follow-up examination, the average flexion arc was 24° (range, 0° to 75°) to 131° (range, 100° to 150°) and the Mayo elbow performance score averaged 93 of a possible 100 points. Heterotopic ossification was present to some extent in seven elbows, with radiographic abutment noted in two. Thirty-two (65%) of the forty-nine elbows had neither a complication nor any further surgery from the time of the index arthroplasty to the most recent follow-up evaluation. Fourteen elbows (29%) had a single complication, and most of them did not require further surgery. Ten additional procedures, including five revision arthroplasties, were required in nine elbows; five were related to soft tissue and five were related to the implant or bone.

Conclusions: Complex distal humeral fractures should be assessed primarily for the reliability with which they can be reconstructed with osteosynthesis. When osteosynthesis is not considered to be feasible, especially in patients who are physiologically older and place lower demands on the joint, total elbow arthroplasty can be considered. This retrospective review supports a recommendation for total elbow arthroplasty for the treatment of an acute distal humeral fracture when strict inclusion criteria are observed.

Level of Evidence: Therapeutic study, Level IV (case series [no, or historical, control group]). See Instructions to Authors for a complete description of levels of evidence.

The goal of treatment for a patient with a complex fracture of the distal part of the humerus is to regain a painless, stable, and functional joint, which, at a minimum, allows activities that maintain independence. A more exacting task is to return the patient to the preinjury state. In younger patients, these goals are more consistently achieved with open reduction and internal fixation, which remains the treatment of choice in this population. The quality of bone plays an important role in fracture fixation and screw purchase, with bone quality decreasing with age and disuse and after menopause. The goals stated above have been reported to be less reliably achieved with fracture fixation in patients with poor quality bone¹.

Total elbow arthroplasty has been documented as a suc-

cessful intervention for patients with inflammatory arthritis²⁻⁵ and distal humeral nonunion⁶. However, less predictable results have been reported in studies involving the treatment of primary osteoarthritis⁷ and secondary posttraumatic arthritis⁸. High rates of complications after total elbow arthroplasty for the treatment of posttraumatic conditions have been attributed in the past to the increased number of operations performed in this population prior to the replacement arthroplasty⁶. Recently, the use of arthroplasty to treat acute distal humeral fractures has been reported with greater frequency and encouraging results⁹⁻¹¹.

Our objectives were to review our practice over the past two decades, analyze the predictability of the results of primary total elbow arthroplasty for the treatment of selected



Fig. 1-A



Fig. 1-B

Figs. 1-A through 1-D A sixty-six-year-old man (Case 15 in the Appendix) who had a type-C3 distal humeral fracture that was treated with total elbow arthroplasty. Preoperative anteroposterior (Fig. 1-A) and lateral (Fig. 1-B) radiographs.

distal humeral fractures, and to assess the long-term outcome of this intervention.

Materials and Methods

Clinical Assessment

We retrospectively reviewed the records of 659 acute, non-neoplastic, distal humeral fractures in adults treated between 1982 and 2001. Three hundred and twenty-one fractures were in patients who were between thirty and fifty-nine years old, and 338 were in patients who were sixty years of age or older. In the younger group, seventy-seven (24%) of the 321 fractures were treated with open reduction and internal fixation and eight (2.5%), with a total elbow arthroplasty. In the older group, 105 (31%) of the 338 fractures were treated with open reduction and internal fixation and forty-one (12%), with a total elbow replacement. Overall, forty-nine fractures in forty-eight patients were treated with elbow replacement, but six fractures in five patients had less than two years of follow-up and were not included in the outcomes analysis. Therefore, forty-three elbow replacements in forty-three patients are included in the present study (see Appendix), but all forty-nine procedures were assessed for specific complications.

We analyzed the data for all forty-three acute, non-

neoplastic fractures (see Appendix) treated with total elbow arthroplasty as the primary treatment option at our institution (Figs. 1-A through 1-D). The average age was sixty-nine years (range, thirty-four to ninety-two years). There were thirty-one women and twelve men, and the injured extremity was dominant in twenty-four patients and nondominant in nineteen. The mechanism of injury was a low-energy fall onto the elbow or outstretched arm in forty patients. The other three fractures were due to a medium or high-energy injury, including a fall from a bicycle or a motor-vehicle accident. Two fractures had Gustilo type-I open wounds¹², which were thoroughly débrided immediately before the arthroplasty.

Coexistent pathological conditions were present in thirty patients. Nineteen patients had rheumatoid arthritis, and two of them were treated with steroids. Three other patients used steroids for the treatment of other diagnoses, and three patients had osteoporosis, as diagnosed with bone densitometry measurements. Other comorbidities included diabetes, dementia, asthma, obstructive airway disease, cardiomyopathies, and depression. In addition, two patients had a concurrent fracture of the shoulder and one patient each had a fracture of the forearm, hand, and hip.

The average delay from the time of the fracture to treat-



Fig. 1-C



Fig. 1-D

Postoperative anteroposterior (Fig. 1-C) and lateral (Fig. 1-D) radiographs.

ment with total elbow arthroplasty was 5.9 days (range, one to twenty-five days). Three patients were referred to us after treatment elsewhere with an attempted open reduction and internal fixation, which had failed at an average of twenty days (range, seventeen to twenty-five days). These patients are included because they reflect the outcome of an acutely fractured joint since no osseous union had occurred.

The operative technique and postoperative rehabilitation have been previously described¹⁰. The Coonrad-Morrey total elbow prosthesis (Zimmer, Warsaw, Indiana) was used in all elbows, but during the study period of nineteen years some design modifications were made in the prosthesis^{10,13}. These changes included alteration of the proximal coating on the ulnar component from titanium beads to a polymethylmethacrylate precoating to the current titanium plasma-spray coating. The titanium beads are known to be a source of stress-risers¹⁴, and the polymethylmethacrylate-precoated stems have been questioned as a cause of osteolysis. Finally, for elbows with distal humeral bone loss, a long flange was designed to capture the humeral shaft at a more proximal level.

Radiographic Assessment

Using the AO/ASIF system¹⁵, we classified the forty-nine frac-

tures as type A (six; 12%), type B (five; 10%), or type C (thirty-eight; 78%). Of the type-C fractures, five (10%) were classified as type C1; eight (16%), as type C2; and twenty-five (51%), as type C3 (Fig. 2). Radiographs of the elbow joint surface demonstrated mild osteoarthritis in three elbows and osseous changes related to rheumatoid arthritis in seventeen elbows.

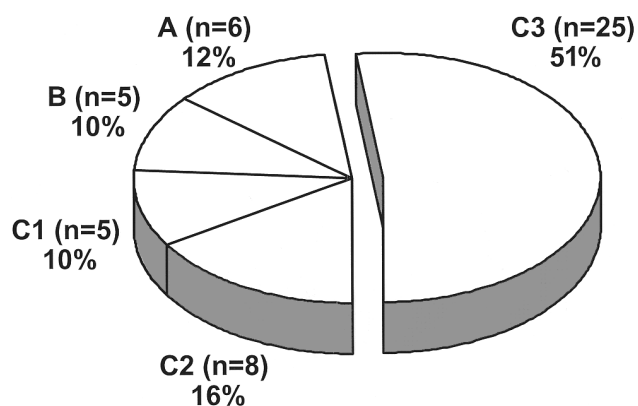


Fig. 2

Classification of the entire sample of forty-nine distal humeral fractures, according to the AO/ASIF system¹⁴.

Inclusion and Exclusion Criteria

The inclusion criteria for treatment with total elbow replacement were a fracture that was not amenable to open reduction and internal fixation because of extensive articular comminution (twenty-three elbows), a fracture that had been treated elsewhere with osteosynthesis and had subsequent failure within one month (three elbows), articular surface destruction by rheumatoid arthritis (seventeen elbows), preexisting arthritis (three elbows), or substantial osteopenia (three elbows). Proximal extension of the fracture into the distal humeral shaft was not a contraindication, as a combination of bone-shortening, fixation with circumferential cables, and plate-and-screw augmentation were used. Chronological age was not an absolute indication for replacement, although stronger consideration was given to physiologically older patients with lower activity levels and to younger patients with multiple comorbidities and articular surfaces destroyed by rheumatoid arthritis. The less comminuted type-A and type-B fractures were considered to be good candidates for arthroplasty when the articular surface was destroyed by a comorbid condition such as rheumatoid arthritis. Specific exclusion criteria for treatment with total elbow arthroplasty were a fracture that could be reconstructed reliably with osteosynthesis, a contaminated open fracture, ongoing infection, and any ongoing pathological disorder that impaired limb function. The decision to treat the fracture with a total elbow arthroplasty was, in the majority of patients, defined preoperatively with use of radiographs. Additional imaging techniques, such as tomography and magnetic resonance imaging, were used in elbows that were not obviously unreconstructable. For six elbows, the decision to proceed with arthroplasty was made intraoperatively when the comminution, bone qual-

ity, and fracture personality became more evident than was appreciated preoperatively.

Follow-up Review

None of the patients were lost to follow-up; however, at the time of the current review, fourteen patients had died of unrelated causes. For these patients, the follow-up data had been collected either by the treating surgeon when the patient returned for a routine visit or, more commonly, by the total joint registry with use of a questionnaire, which was completed and returned by mail or during a telephone interview, and radiographs sent to our institution. All forty-three patients were followed for a minimum of two years, or until death, with an average follow-up of seven years (range, two to fifteen years). The postoperative review consisted of both clinical and radiographic assessments. Clinical function was assessed with use of the Mayo elbow performance score¹⁶ and anteroposterior and lateral radiographs. Implant-loosening was assessed on radiographs and was graded from 0 to 4, as previously described¹⁷. Type 0 indicates a radiolucent line that is <1 mm thick and involves <50% of the interface; type 1, a radiolucent line that is 1 mm thick and involves <50% of the interface; type 2, a radiolucent line that is >1 mm thick and involves >50% of the interface; type 3, a radiolucent line that is >2 mm thick and involves the whole interface; and type 4, gross loosening.

Results

Symptomatic Outcome

The most predictable feature after the treatment of these acute fractures with a total elbow arthroplasty was painless function as depicted by the average pain score of 42 of a possible

Fig. 3

Mayo elbow performance score (MEPS) components and composites as a function of the age of the patients at the time of surgery. ADL = activities of daily living ≤ 45 .

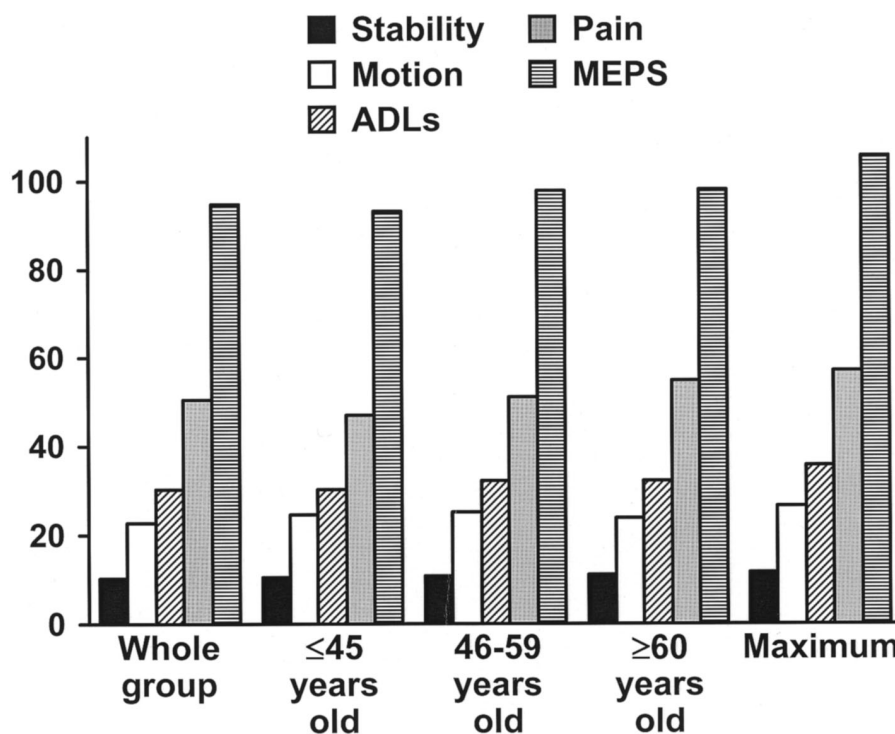




Fig. 4-A



Fig. 4-B

Anteroposterior (Fig. 4-A) and lateral (Fig. 4-B) radiographs of the patient shown in Figures 1-A through 1-D, made nine years postoperatively, demonstrating a solidly fixed implant, minor heterotopic ossification, minimal bushing wear, and well-incorporated bone graft behind the flange.

45 points on the Mayo elbow performance score¹⁶, with eight patients who had mild pain and thirty-five who had no pain. The mild pain occurred during activity in five patients and was associated with dysesthesias of the little finger in one patient. Only one patient was unable to feed herself because of severe rheumatoid involvement of the shoulders and wrists. According to the Mayo elbow performance score, functional results at the final assessment were good or excellent in forty of the forty-three patients. However, two of them (Cases 1 and 5) required additional surgery before they achieved a good or excellent result at the final assessment. Three had a fair result.

Range of Motion

The average arc of flexion achieved intraoperatively after the triceps had been reattached was 5° (range, 0° to 30°) to 138° (range, 120° to 150°). At the final review, the mean flexion arc had decreased to an average of 24° (range, 0° to 75°) to 131° (range, 100° to 150°). Thirty-two patients (72%) had achieved a minimum of a functional arc of motion (30° to 130°), and eleven patients had not. Of the latter eleven patients, four achieved an arc of motion of 90° to 100°, four achieved between 80° to 85°, and two achieved <80°. One patient with a flexion arc of <50° was

noted to have had a substantial wound complication postoperatively and development of heterotopic ossification. Only two patients had full extension at the final review, and the remainder had some degree of flexion contracture. Thirty-five patients (79%) achieved $\geq 50^\circ$ of pronation and supination.

Mayo Elbow Performance Score

The average Mayo elbow performance score for all forty-three patients at the latest follow-up examination was 93 points (range, 75 to 100 points) (Fig. 3). For three patients, the functional result was fair, with an average score of 75 points. Two of them had a complication; one had lateral flap necrosis, and the other had dysesthesias of the little finger, which persisted in a mild form at the time of the final review. The third had no complication.

Radiographic Outcome

Radiolucent lines were present in nine elbows at the time of the final follow-up review. Six of these elbows were deemed to be stable as the same lines had been seen postoperatively and had not progressed during follow-up (Figs. 4-A and 4-B). Three elbows had radiolucent lines that had not been present postoper-

actively; two of them had a type-2 (ulnar) lucency, and one had a type-1 (humeral) lucency. Two patients had an excellent functional result at five and three years postoperatively, and one patient with an ulnar radiolucency had mild pain with activity.

Heterotopic ossification was evident to some extent in seven elbows (16%). Two elbows had abutment of the ectopic bone between the humerus and ulna posteriorly (Fig. 5), and the other five elbows had either small islands within the soft tissue or small spikes from the humerus. Two additional patients had posterior impingement with extension deficits of 60° and 70°. Four patients had evidence of bushing wear as described by Ramsey et al.¹⁸, but three of them had no concurrent symptoms or radiolucent lines. Other radiographic features without any appreciable consequence were resorption of bone from behind the humeral flange in two elbows and lucency surrounding the yoke of the humeral component in one elbow. We were not able to determine whether these findings were early indicators of localized osteolysis or an aseptic loosening process.



Fig. 5
Radiograph of the elbow of a sixty-one-year-old woman, made six years postoperatively, showing heterotopic ossification with posterior abutment and a 75° flexion contracture. The patient had had a wound complication, and the final functional result was fair, the joint was pain-free, and there was no evidence of implant-loosening.

TABLE I Complications and Reoperations in Forty-nine Elbows After Initial Treatment with Prosthetic Replacement for an Acute Fracture

Type	No. of Complications	No. of Reoperations
Wound	11	5
Neural (all temporary)	3	0
Fracture		
Humeral component	1	1
Ulnar component	1	1
Ulna	1	0
Loose component	3*	3
Total	20	10

*One patient had two reoperations because of implant-loosening.

Complications

Data on complications were obtained from the records of all forty-nine patients who underwent arthroplasty, including the six who had been followed for less than two years. Thirty-two (65%) of the forty-nine elbows had no surgical complication or any further surgery from the time of the index arthroplasty to the current follow-up review. Fourteen (29%) of the forty-nine elbows had one complication, and three (6%) had two complications (Table I).

Perioperative complications of a medical nature included a frontal lobe infarct and a myocardial infarct in one patient each. A third patient had postoperative atrial fibrillation and a pulmonary embolus. Other complications arising as a consequence of surgical intervention included temporary dysesthesias of the little finger in one patient and a neuropathic pain evidenced by intrinsic weakness immediately after surgery in another. Both resolved at three months. One patient had a reflex sympathetic dystrophy. One other patient fell and sustained an ulnar shaft periprosthetic fracture one year after the arthroplasty and was treated successfully with immobilization of the elbow in a plaster cast.

Nine elbows required a total of ten additional operations; five were related to the soft tissue and five were related to the implant or bone. Three patients had decompression of a persistent hematoma, and two had secondary closure to treat a wound dehiscence. One patient had removal of a prominent Kirschner wire in the olecranon two months postoperatively. In another patient, a wound infection was found to have penetrated into the joint cavity at twenty-one days postoperatively. The humeral component was loose, thereby necessitating humeral component removal, three débridements and the use of antibiotic spacers, and then humeral component reimplantation.

Five patients required revision arthroplasty during the follow-up period. One patient, as mentioned above, had a revision because of wound infection and septic loosening of the humeral implant. Three patients sustained an injury from a

fall that required implant revision. One of them had a humeral shaft and humeral component fracture four years postoperatively; one had an ulnar component fracture twenty months postoperatively (the ulnar component had been coated with titanium beads and, as previously described by Schneeberger et al.¹⁴, was predisposed to fracture); and one, a thirty-four-year-old woman with rheumatoid arthritis, underwent two ulnar component revisions, the first because of a fall and the second because of aseptic loosening three years later. The fifth patient required a revision arthroplasty at nine years following the index arthroplasty because of aseptic loosening of the ulnar component. The average age of those undergoing revision arthroplasty was sixty-two years (range, thirty-four to eighty-three years).

Discussion

Selected fractures of the proximal part of the femur¹⁹, the proximal part of the tibia²⁰, and the proximal aspect of the humerus²¹ have been treated with prosthetic arthroplasty in elderly patients, with encouraging results. Osteosynthesis is widely considered the optimal treatment for distal humeral fractures, following the long-established principles of rigid internal fixation and early mobilization. However, studies in which these basic principles have been applied have not yielded universally good results^{22,23}. Comminution, especially of the articular surface, often confounds efforts to achieve stable fixation, thereby necessitating additional procedures that predispose the patients to elbow stiffness, such as external fixation or a period of cast immobilization. Other factors that may have an important influence on the success of internal fixation are the generally poorer patient health (comorbidities were present in 69% of our patients) and the poor bone quality. Screw fixation of osteoporotic bone is notoriously unreliable^{24,25}.


We know of only one report that has prospectively compared osteosynthesis and total prosthetic replacement for the treatment of an acute humeral fracture in patients over sixty-five years of age²⁶. Although that study had selection features, eleven of twelve patients treated primarily with arthroplasty had a good or excellent functional result compared with only eight of twelve treated with osteosynthesis. Our study provided a similar experience, as forty (93%) of the forty-three patients

had a satisfactory outcome at the time of the final assessment.

Intraoperative range of motion has not been reported in the literature as far as we know. While the mean extension at the time of surgery averaged 5°, the final extension loss was 24°. This reflects the insult to the soft tissue, which causes joint contracture, even with joint replacement. The complication of particular note during this analysis was the formation of heterotopic ossification, which appears to be of a similar magnitude as that reported for some series of fractures treated with osteosynthesis^{26,27}. This suggests that the host reaction to the original traumatic insult and the subsequent surgical intervention is similar for both treatments.

As the population lives longer, more osteoporotic fractures will be encountered with a greater impetus for better management of this challenging problem. Total elbow arthroplasty with the Coonrad-Morrey semiconstrained device is proving to be a reliable treatment option in older patients with an acute, comminuted, and osteoporotic distal humeral fracture. We believe that this is the procedure of choice in properly selected patients.

Appendix

 A table showing specific data on all forty-three elbows is available with the electronic versions of this article, on our web site at www.jbjs.org (go to the article citation and click on "Supplementary Material") and on our quarterly CD-ROM (call our subscription department, at 781-449-9780, to order the CD-ROM). ■

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