Results of parallel plate fixation of comminuted intra-articular distal humeral fractures

Tapio Flinkkilä, MD, PhD*, Juhana Toimela, BM, Kai Sirniö, MD, Juhana Leppilahti, MD, PhD

Division of Orthopedic and Trauma Surgery, Department of Surgery, Oulu University Hospital, Oulu, Finland

Background: This study investigated the results of parallel plate fixation of comminuted distal humeral fractures in a consecutive series of patients.

Methods: Parallel plate fixation was used in 47 patients (30 women), mean age 60 years (range 18-98 years), with Arbeitsgemeinschaft für Osteosynthesefragen (AO) type C distal humeral fractures during 2007 to 2011. Medical records and radiographs were retrospectively assessed. Thirty-five patients completed Disabilities of Arm, Shoulder and Hand (DASH) outcome measure and the RAND Medical Outcomes Study 36-Item Short Form (SF-36) Health Survey. Twenty-seven patients underwent clinical examination, Mayo Elbow Performance Score (MEPS) rating, and radiography after 3.9 years (range, 1.6-7.9 years) of follow-up.

Results: The mean flexion arc was lower on the affected side vs the unaffected elbow (123° vs 140°, P = .03). The mean MEPS was 88; the result was excellent in 14, good in 8, fair in 3, and poor in 2 patients. DASH results indicated slight impairment of upper extremity function compared with the reference value (26 vs 10, P = .001). RAND SF-36 scores indicated normal quality of life compared with reference values from the Finnish population. Forty-four fractures united uneventfully. One case each of nonunion and malunion occurred. One olecranon osteotomy failed to unite. There were 3 cases of infection. Prominent hardware was a common late problem, and plates often required removal. The complication rate was 7 of 47 (15%); 4 of these patients (9%) required reoperation. The hardware removal rate was 13 of 47 (28%).

Conclusion: Parallel plate fixation is an effective method to treat comminuted distal humeral fractures. Good elbow function can be restored in most cases with minor impairments that do not worsen quality of life.

Level of evidence: Level IV, Case Series, Treatment Study.

Keywords: Distal humeral fractures; plate fixation; treatment outcome; comminuted fractures; intra-articular fractures; elbow function; complications

Comminuted distal humeral fractures are complex injuries, and open reduction and internal fixation (ORIF) is usually indicated. The goal of treatment is to reduce the fracture anatomically and fix the fragments rigidly enough to allow early motion. The most accepted operative method is plate fixation of both columns of the distal humerus. This
technique usually restores satisfactory function of the elbow joint even in severely comminuted fractures.20

There are, however, several controversial issues regarding the treatment of these fractures. Owing to complex anatomy, surgical exposure is difficult. Olecranon osteotomy usually results in the best exposure of articular fragments and is regarded as the gold standard.20,26,33 Some have suggested that even comminuted fractures can be anatomically reduced and fixed using parapatellar incisions (extensor-on approach) to avoid potential adverse effects associated with olecranon osteotomy.5,8,9 Although many techniques (including plates) can be used to fix the olecranon osteotomy, only a few studies have reported the results of plate fixation.14,35 Other controversial issues include plate configuration (parallel or perpendicular) at the distal humerus and management of the ulnar nerve. Some clinicians recommend anterior transposition; however, its role in reducing postoperative ulnar nerve symptoms remains unclear.38

Elderly patients with a comminuted distal humeral fracture may experience better function if they are primarily treated with total elbow replacement (TER) instead of fixation.25 Although several clinicians recommend TER as the first-line treatment if the fracture is not amenable to fixation, no real information exists regarding how often TER is needed.

The availability of computed tomography (CT) scanning with 3-dimensional (3D) image reconstruction has helped preoperative planning, and new fixation strategies, precontoured plates, and small screws have expanded indications for ORIF. Even highly comminuted fractures of osteoporotic bone that were previously considered not amenable to fixation can be treated with success using ORIF.

The study’s aim was to investigate fracture union, complications, and functional results of precontoured parallel plate fixation of comminuted intra-articular, Arbeitsgemeinschaft für Osteosynthesefragen (AO) type C distal humeral fractures in a consecutive series of patients.

Methods

A computer search of our hospital’s files identified 57 consecutive patients with comminuted distal humeral fracture (AO type C)28 between 2007 and 2011 (Fig. 1). Ten patients were excluded: 1 patient refused the operation and was treated nonoperatively, 1 was treated with percutaneous pinning, 6 with rheumatoid arthritis (RA) with moderate to severe elbow joint destruction were treated primarily with total elbow replacement (TER), and 2 lived abroad and were lost to follow-up at an early stage (<6 weeks). In the remaining 47 patients (30 women, 17 men), who were a mean age of 60 years (standard deviation [SD], 19; range, 18-98 years), parallel plate fixation was used to treat comminuted intra-articular AO type C distal humeral fractures.

Patients

The patients’ medical records and radiographs were reviewed retrospectively. The mechanisms of injury comprised falling from standing height in 29, bicycle accident in 7, falling down stairs in 3, falling from a height in 3, sports-related in 3, motor vehicle accident in 1, and a machine injury in 1. The left elbow was affected in 16 and the right in 31. There were 8 open fractures, all assessed as Gustilo-Anderson grade 1.13 According to AO classification, the fractures were classified from plain radiographs as C1 in 16, C2 in 23, and C3 in 8 patients. Five patients had additional fractures, including a distal radius fracture in 2, scaphoid fracture in 1, acetabulum fracture in 1, and proximal humeral fracture in 1. Primary radial nerve palsy was diagnosed in 2 patients. Surgical details, possible complications, and reoperations were recorded from the medical files.

Operative technique

Preoperative CT imaging was used if the operating surgeon considered it necessary (Fig. 2). The patient was placed in the lateral decubitus position, a sterile tourniquet was used, and a posterior midline incision was made with medial and lateral full-thickness skin flaps. The ulnar nerve was identified and decompressed. The medial and lateral borders of the triceps muscle were identified and opened. Olecranon osteotomy was performed in 36 patients to view and reduce the articular surface; however, reduction of the articular fragments without osteotomy was possible in 11 patients. The operating surgeon decided on the exposure type.

Parallel plating with Mayo elbow plates (Acumed, Hillsboro, OR, USA) was used in all cases (Fig. 3). Distal and proximal fixation both used 3.5-mm cortical screws. The olecranon osteotomy was fixed with a posterior plate from the same implant system in 29 patients. An Olecranon Rod (Acumed) was used in 3 patients. Although Olecranon Rod fixation was attempted in 1 additional patient, a large drill bit broke the ulnar diaphysis and a long posterior plate was used to fix the iatrogenic fracture and osteotomy. An Olecranon Osteotomy Nail (Synthes, Oberdorf, Switzerland) was used in 2 cases and was attempted in 1 additional patient; however, it failed to compress the osteotomy, and a posterior plate was used instead. The ulnar nerve was returned to its anatomic position, and the wound was closed. No drains were used.

Postoperative management

The arm was supported with a sling or cast for 2 weeks postoperatively. After the swelling had subsided, the wound was healing, and sutures were removed, a physiotherapist initiated guided, gentle range of motion (ROM) exercises. Patients routinely visited the outpatient clinic at 6 and 12 weeks. Formal physiotherapy was initiated if ROM was not progressing at the 6-week postoperative visit. Progressive splinting at night was used if extension did not progress. Additional visits were scheduled if necessary.

Outcome measures

Function

The Disabilities of Arm, Shoulder and Hand (DASH),17 to assess upper arm function and symptoms, and the RAND Medical Outcome Study 36-Item Short Form (SF-36) questionnaire, to assess quality of life (QOL),1 were mailed to patients. Thirty-five
patients returned these questionnaires: 4 patients had severe dementia, 1 had a severe psychiatric disorder and were unable to understand or complete the forms, and 6 patients had died of causes unrelated to their elbow injury. One patient was lost to follow-up and did not respond to repeated letters or telephone calls. RAND SF-36 scores were compared with age-matched (5-year intervals) and sex-matched reference values from the Finnish population. The DASH score in the normal population was regarded as 10.

Twenty-seven patients were re-examined at a follow-up visit by an independent examiner (J.T.). ROM (flexion, extension, pronation, and supination) of both elbow joints was measured using a goniometer. The mass grip strength of both hands was measured using a Jamar hand dynamometer (Bolingbrook, IL, USA). The Mayo Elbow Performance Score (MEPS) was calculated. Anteroposterior and lateral view radiographs were obtained. The mean follow-up interval was 3.9 years (standard deviation, 2.0; range 1.6-7.9 years). Patients who were unable to come to the outpatient clinic for re-examination were contacted by telephone. Six of these patients underwent radiography at primary health care centers, and the image files were sent to us for assessment. Our hospital’s files indicated that patients who were unable to complete questionnaires, were unable to come to a follow-up visit, or were lost to follow-up did not contact our hospital due to their elbow fracture and no reoperations had been performed.

Radiography
Radiographs were routinely performed at the outpatient clinic at 6 and 12 weeks after the operation. The patients came for additional visits until fracture union. At follow-up, the degree of degenerative change was graded from 0 to III (none, mild, moderate, severe) using the system described by Broberg and Morrey.

Statistical methods
Summary measurements are expressed as the mean, SD, and range, unless otherwise stated. Paired t tests were used to assess the mean differences in functional parameters between the affected and unaffected sides. The Student t test was used to compare the mean RAND SF-36 parameters and mean DASH scores with normative values. Analysis of variance was used to assess the mean differences among several groups. Calculations were performed using IBM SPSS 20 software (IBM Corp, Armonk, NY, USA). A P value of <.05 was considered statistically significant.

Results
Function
The mean flexion arc was significantly lower in the affected elbow than in the unaffected elbow (123° vs 140°, P = .03) but was considered functional (>100°) in 25 of 27 patients (Table I). The mean MEPS was 88 (SD, 15). MEPSs were graded as excellent in 14, good in 8, fair in 3, and poor in
2 patients. One “poor” result occurred in a patient with a congenital deformity of the elbow joint with poor ROM before the fracture, and the other patient had malunion, complex regional pain syndrome, and restricted ROM. DASH results indicated slight impairment of upper extremity function compared with the population reference value (26 [SD, 22; range, 0-76] vs 10, \( P = .001 \)). Mean mass grip strength did not differ vs the unaffected side (26 [SD, 9] vs 27 [SD, 11] kg, \( P = .3 \)). All preoperative radial nerve palsies recovered during follow-up. Fracture type (AO class), patient age, olecranon osteotomy, and open or closed fracture had no effect on DASH or ROM parameters. RAND SF-36 health scores demonstrated similar QOL compared with age- and sex-matched reference values from the Finnish population (Table II).

### Complications and reoperations

Infection occurred in 3 patients. Two cases were wound dehiscence with wound infections that led to exposure of the olecranon plates. One case was a pressure wound over the lateral epicondyle caused by the cast, which led to skin necrosis, infection, and exposure of the lateral plate. Surgical revision, antibiotics, vacuum aspiration, and secondary suturing of the wound was successful in all patients. One case of postoperative iatrogenic ulnar nerve palsy was recorded; it resolved spontaneously during follow-up. Three patients experienced sensory symptoms of the ulnar nerve at follow-up. Prominent hardware was a common late problem, and hardware removal was required as follows: olecranon plates alone in 8, all hardware in 3, medial plate alone in 1, and a single screw in 1. To date, no elbow replacement has been performed for any of the patients. The overall complication rate was 15% (7 of 47), the reoperation rate owing to complications was 9% (4 of 47), and the overall reoperation rate was 36% (17 of 47).

### Discussion

Parallel plating of comminuted distal humeral fractures resulted in satisfactory function of the elbow joint, minor

---

**Table I** Range-of-motion measurements of affected and unaffected elbows

<table>
<thead>
<tr>
<th>Variable</th>
<th>Affected degrees</th>
<th>Unaffected degrees</th>
<th>( P^* )</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean (SD) range</td>
<td>Mean (SD) range</td>
<td></td>
</tr>
<tr>
<td>Flexion arc</td>
<td>123 (21) 60-150</td>
<td>140 (9) 120-150</td>
<td>.03</td>
</tr>
<tr>
<td>Flexion</td>
<td>137 (18) 70-155</td>
<td>144 (8) 130-155</td>
<td>.07</td>
</tr>
<tr>
<td>Extension</td>
<td>14 (11) 0-40</td>
<td>5 (6) 0-15</td>
<td>.1</td>
</tr>
<tr>
<td>Forearm rotation arc</td>
<td>147 (22) 80-175</td>
<td>152 (8) 145-160</td>
<td>.6</td>
</tr>
<tr>
<td>Pronation</td>
<td>77 (11) 40-90</td>
<td>78 (6) 70-90</td>
<td>.8</td>
</tr>
<tr>
<td>Supination</td>
<td>70 (13) 40-85</td>
<td>73 (5) 65-80</td>
<td>.4</td>
</tr>
</tbody>
</table>

\( SD \), standard deviation.

* Paired \( t \) test.
subjective impairments, and normal QOL. Complication and reoperation rates were acceptable. Several minor problems led to reoperations, however; in particular, olecranon osteotomy fixation plates often required removal because of prominent hardware.

Our functional results are comparable to those of previously published studies of AO C type distal humeral fractures (Table III). Although parallel plating may have better biomechanical properties compared with orthogonal plate configuration,\(^2\) clinical case series of both techniques have resulted in similar functional results, bony union, and complications (Table III). Two prospective randomized studies that compared parallel and orthogonal plating,\(^2\) found the functional results, union, and complications did not differ statistically in either study. The authors concluded that both plate configurations provided adequate stability to the fracture.

Although locking plates and screws may have better biomechanical properties,\(^2\) the fixed angle of the screws may make it difficult to insert long enough screws into the distal fragment. Two case series, by Kaiser et al\(^3\) (n = 7) and Schmidt-Horlohe et al\(^4\) (n = 31), that used perpendicular locking plates to stabilize AO type C distal humeral fractures, reported good results that were comparable with previous reports in which nonlocking implants were used.

The type of surgical approach did not affect functional results. This finding was contrary to that of Chen et al,\(^5\) who reported inferior functional outcome if a triceps-sparing approach was used. However, we experienced several problems with plate fixation of the osteotomy. The plates were often prominent, and patients found the subcutaneous plates uncomfortable; in contrast to the study by Hewins et al,\(^6\) the olecranon plates often had to be removed. Lee et al\(^7\) reported removal rates that were similar to ours. In their study, parallel plate fixation was associated with a higher removal rate than orthogonal plate fixation. Coles et al\(^8\) used tension band wiring to fix the osteotomy and reported 5 hardware removals (8%) in their study of 67 patients. Although the olecranon plates were not necessarily responsible for the wound problems and superficial infections, dehiscence or superficial infection always led to exposure of the plate, and surgical revision was needed. New intramedullary osteotomy fixation devices might be better in this respect.

We often experienced technical problems when using 2 different designs of osteotomy nails, possibly because of a learning curve, but possibly because the instruments and implants are still evolving. The only study of intramedullary nail fixation of olecranon osteotomies and simple fractures resulted in a union rate of 19 of 21.\(^9\) Although triceps-sparing approaches are likely associated with fewer wound problems, reduction and fixation of articular fragments are technically more difficult, especially in cases involving a central fragment of the trochlea or in which the medial epicondyle and trochlea are in separate fragments.\(^5\)

During our study period, all patients with AO type C distal humeral fractures were treated with parallel plate fixation; only patients with RA with joint destruction received TER primarily, as suggested by Jost et al.\(^1\) The indications for primary TER in comminuted distal humeral fractures are often cited as fractures not amenable to fixation.\(^2\) According to our experience, this situation is extremely rare if RA is excluded. With preoperative 3D CT, precontoured parallel plate fixation, and small headless compression screws, it is possible to fix even very low distal humeral fractures in osteoporotic bone. The prospective randomized study of McKee et al\(^2\) had reoperation rate as the primary outcome measure; they used old implants, which may be why they had to convert ORIF to TER in approximately 25% of their cases.

Additional high-quality comparative studies that use modern imaging techniques and fixation devices to compare ORIF and TER are needed to compare both methods regarding functional results, time of recovery, and total costs, including implants, postoperative rehabilitation, and the need of social resources during the period of convalescence. Another interesting point is that elderly people are often medically fit and active and may not tolerate the activity restrictions that are often recommended after TER.

Recent studies have suggested that anterior transposition of the ulnar nerve does not prevent late symptoms.\(^4\) Wiggers et al\(^5\) studied several potential risk factors of postoperative ulnar nerve dysfunction in different types of distal humeral fractures and their surgical treatment. The only risk factor was columnar fracture of the distal humerus, regardless of whether the ulnar nerve was transposed. We left the ulnar nerve at its anatomic location, and the frequency of ulnar nerve symptoms was comparable to previous studies.

Our study has several weaknesses. The design was retrospective, and the data from the medical files were not as accurate as they would have been in a prospective study.

<table>
<thead>
<tr>
<th>Table II</th>
<th>Results of RAND 36-Item Short Form Health Survey of patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Domain</td>
<td>Measured Mean (SD)</td>
</tr>
<tr>
<td>General health</td>
<td>54 (26)</td>
</tr>
<tr>
<td>Physical functioning</td>
<td>68 (32)</td>
</tr>
<tr>
<td>Mental health</td>
<td>72 (15)</td>
</tr>
<tr>
<td>Social functioning</td>
<td>78 (24)</td>
</tr>
<tr>
<td>Vitality</td>
<td>60 (25)</td>
</tr>
<tr>
<td>Bodily pain</td>
<td>77 (21)</td>
</tr>
<tr>
<td>Role functioning/physical</td>
<td>56 (44)</td>
</tr>
<tr>
<td>Role functioning/emotional</td>
<td>67 (40)</td>
</tr>
</tbody>
</table>

SD, standard deviation.
* Finnish population reference values from Aalto et al,\(^1\) 1999.
\(t\) Student t test.
We were unable to get all patients to a follow-up visit, mainly because the patients were old or medically unfit to travel to our clinic.

The strength of our study is that we had a consecutive series of patients and used valid outcome measures. We used the same implants in all cases. Our hospital is the only center treating complex elbow injuries and their sequelae, including TER. We would be aware if patients who were lost to follow-up but still living within our hospital’s catchment area had late reoperations.

There is a need for a high-quality prospective, randomized, multicenter study to define appropriate indications for TER in comminuted fractures of elderly patients. Modern 3D CT imaging should be used to select patients, and the outcome measures should consist of functional results, time to recovery, and total costs of the methods.

### Conclusions

Parallel plate fixation is an effective method to treat comminuted distal humeral fractures. Good elbow function can be restored in most cases with minor impairments that do not worsen QOL.

### Disclaimer

The authors, their immediate families, and any research foundations with which they are affiliated have not received any financial payments or other benefits from any commercial entity related to the subject of this article.

### References


### Table III

Results of plate fixation of comminuted (Arbeitsgemeinschaft für Osteosynthesefragen [AO] type C) distal humeral fractures

<table>
<thead>
<tr>
<th>Study</th>
<th>No.</th>
<th>Follow-up (mo)</th>
<th>Plate *</th>
<th>Nonunion rate</th>
<th>Infection rate</th>
<th>Reoperation rate</th>
<th>Mean flexion arc (°)</th>
<th>Mean DASH</th>
<th>Mean MEPS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pajarinen,31 2002</td>
<td>18</td>
<td>25</td>
<td>90, nonlocking</td>
<td>2/18</td>
<td>1/18</td>
<td>2/18</td>
<td>106</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gofton,12 2003</td>
<td>23</td>
<td>45</td>
<td>90, nonlocking</td>
<td>3/23</td>
<td>2/23</td>
<td>8/23</td>
<td>122</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>Huang,16 2005</td>
<td>19</td>
<td>97</td>
<td>90, nonlocking</td>
<td>0/19</td>
<td>1/19</td>
<td>2/19</td>
<td>112</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sanchez-Sotelo,34 2007</td>
<td>34</td>
<td>24</td>
<td>180, nonlocking</td>
<td>1/34</td>
<td>2/34</td>
<td>9/34</td>
<td>99</td>
<td>85</td>
<td></td>
</tr>
<tr>
<td>Ek,8 2008</td>
<td>7</td>
<td>35</td>
<td>180, nonlocking</td>
<td>0/7</td>
<td>0/7</td>
<td>2/7</td>
<td>90</td>
<td>18</td>
<td></td>
</tr>
<tr>
<td>Liu,6 2008</td>
<td>32</td>
<td>25</td>
<td>Posterior, nonlocking</td>
<td>0/32</td>
<td>2/32</td>
<td>103</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Athwal,2 2009</td>
<td>37</td>
<td>27</td>
<td>180, nonlocking</td>
<td>0/37</td>
<td>4/37</td>
<td>12/37</td>
<td>97</td>
<td>24</td>
<td></td>
</tr>
<tr>
<td>Huang,15 2011</td>
<td>14</td>
<td>51</td>
<td>90, nonlocking</td>
<td>0/14</td>
<td>0/14</td>
<td>1/14</td>
<td>100</td>
<td>38</td>
<td></td>
</tr>
<tr>
<td>Schmidt-Horlohe,35 2012</td>
<td>31</td>
<td>12</td>
<td>90, locking</td>
<td>0/31</td>
<td>0/31</td>
<td>20/31</td>
<td>102</td>
<td>24</td>
<td></td>
</tr>
</tbody>
</table>

DASH, Disabilities of Arm, Shoulder and Hand; MEPS, Mayo Elbow Performance Score.

* 90, perpendicular; 180, parallel.

† Including hardware removal.

‡ Median value.


