



## Functional outcome following internal fixation of intraarticular fractures of the distal humerus (AO type C)

Nadim ASLAM, Keith WILLETT

The aim of this study was to evaluate the functional outcome following internal fixation of intraarticular fractures of the distal humerus (AO Type C) with a minimum follow-up of two years.

A retrospective evaluation with prospective clinical review was carried out.

Twenty-six consecutive patients with fractures of the distal humerus were treated over a 31-month period. Their mean age was 56 years (range, 18-82). Six patients were not available for final clinical review. Analysis of the results were based on the medical records, pre-operative and postoperative radiographs of all 26 patients and clinical review of 20 patients at a mean follow-up of 35 months (range, 24-48 months). Twenty-six fractures were fixed using the AO double column plating techniques. Radiographic evaluation of the quality of reduction was carried out using a grading system. Clinical outcome was assessed using the Broberg and Morrey functional rating index.

Fourteen patients (70%) had an excellent or good outcome, five patients (25%) a fair outcome and one patient (5%) had a poor result. Three patients (15%) underwent a second procedure for hardware removal. The mean arc of flexion was 112° (range, 85 to 122). Mean pronation was 75° (range, 60-82) and supination was 76° (range, 60-80). No patients had achieved normal grip strength; the mean grip strength was 82% (range, 46-90%) compared to the uninjured side. Fifteen patients (75%) were able to return to their pre-injury level of occupation and activity. Seventeen patients (85%) were satisfied with the final outcome.

We conclude that internal fixation of intraarticular fractures of the distal humerus is an effective procedure with an excellent or good functional outcome in most patient age groups. Patients have a high level of

satisfaction and the majority return to their previous level of activity.

### INTRODUCTION

Complex intraarticular distal humerus fractures are a considerable challenge to even the most experienced surgeon. Previous treatment methods of closed reduction with immobilisation, traction and limited internal fixation have led to significant functional impairment with loss of range of movement (4, 12, 17).

The functional outcome of distal humerus fractures is related to the ability to restore the normal anatomy and to allow early movement. Various methods of limited internal fixation have been described using Kirchner wires, screw fixation and single plates (2, 3, 10). These methods do not allow enough stability for early movement and have unpredictable results. The improved techniques for fixation recommended by the AO/ASIF have led

---

*From John Radcliffe Hospital, Headington, Oxford, U.K.*  
Nadim Aslam, FRCS, Specialist Registrar in Orthopaedics.  
Keith Willett, FRCS, Consultant Trauma Surgeon.

*Trauma Service, John Radcliffe Hospital, Headington, Oxford. OX3 9DU, U.K.*

Correspondence : Nadim Aslam, Compton Vectis, 49 Marlow Road, High Wycombe, BUCKS, HP11 1TG, United Kingdom.

E-mail : nadimaslam@hotmail.com.

© 2004, Acta Orthopædica Belgica.

---

to early mobilisation with predictable results. The plating of two columns with plates preferably at 90° to one another, has become the standard to compare other treatments to (18).

Fractures of the distal humerus are relatively rare and large case series are rarely reported. Comparison between the various studies is difficult owing to the variation in fracture classification, operative techniques and outcome measures used. Previous studies have used subjective measures of muscle strength, which have limitations.

The aim of our study was to evaluate the functional outcome of AO type C distal humerus fractures treated by AO double plating with a minimum of two years follow-up. An objective assessment was made of grip strength which correlates highly with hand function.

#### PATIENTS AND METHODS

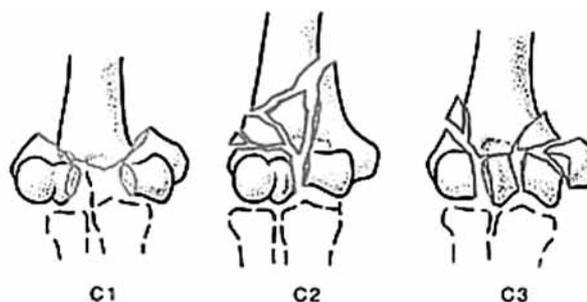
Twenty-six consecutive patients with 26 fractures of the distal humerus seen in our trauma service over a 31-month period underwent internal fixation of their fracture. A consultant trauma surgeon either performed surgery or supervised a trainee directly. The choice of fixation was the AO technique of double column plating based on the pattern of the fracture and presence of associated injuries as seen on standard antero-posterior and lateral radiographs of the elbow. The fractures were classified using the AO classification (table I).

All the fractures were displaced intraarticular fractures (AO type C). There were 23 closed fractures and three open fractures. Twenty-six fractures underwent double plate fixation (in 22 cases, two reconstruction plates and in four cases, one reconstruction and one dynamic compression plate).

The mean age for the plating group was 56 years (range 18 to 82 years). There were eight male patients and 16 female patients. The results were analysed using clinical and radiographic evaluation at a mean follow-up of 35 months. The quality of reduction was graded (A to C), based on the postoperative radiographs by the senior author. Grade A was an anatomical reduction, grade B a step or gap of the articular surface of less than 2 mm and grade C involved a step or gap of more than 2 mm. The quality of reduction was based on the immediate postoperative plain radiographs and operative findings.

Data from the clinical records, clinical review and examination were summarised in a weighted grading

Table I. — AO classification of intra-articular fractures of the distal humerus



|              |    | Clinical Evaluation | No Follow Up |
|--------------|----|---------------------|--------------|
| 13           | C1 | 6                   | 3            |
|              | C2 | 9                   | 1            |
|              | C3 | 5                   | 2            |
| <b>Total</b> |    | <b>20</b>           | <b>6</b>     |

scale (Broberg and Morrey functional rating index) (8) as shown in table II. The grading scale was weighted as follows: normal motion, 40 points; no pain, 35 points; normal strength, 20 points; and normal stability, 5 points. An objective assessment of grip strength of the hand was made using a torque dynamometer, which is recognised as the standard, reliable instrument for measuring grip strength. Standardised subject position and instructions were used to improve reliability.

#### Surgical technique

The patient was placed in a lateral decubitus or supine position and a midline posterior incision was made over the distal humerus, curving around the tip of the olecranon. The ulnar nerve was identified and protected but not routinely transposed. An olecranon chevron osteotomy was used for adequate exposure of the joint surface with the osteotomy being placed at the lowest point of the trochlear notch. The osteotomy was started with an oscillating saw but completed using a fine osteotome through the subchondral bone. The articular fragments were reduced and held with a partially threaded cancellous screw or cortical screw. They were then secured to the columns. In most cases two reconstruction plates (3.5 mm) were contoured to the distal humerus. One plate was placed on the medial column and one on the posterior aspect of the lateral column (90° to each other).

Table II. — Broberg and Morrey functional rating index

| Variable   | Points value  |
|--|---------------|
| <b>Motion</b>  |               |
| Degree of flexion (0.2 3 arc)                                  | 27            |
| Degree of pronation (0.1 3 arc)                                | 6             |
| Degree of supination (0.1 3 arc)                               | 7             |
| <b>Strength</b>  |               |
| Normal   | 20            |
| Mild loss (appreciated but not limiting, 80% of opposite side) | 13            |
| Moderate loss (limits some activity, 50% of opposite side)     | 5             |
| Severe loss (limits everyday tasks, disabling)                 | 0             |
| <b>Stability</b>   |               |
| Normal   | 5             |
| Mild loss (perceived by patient, no limitation)                | 4             |
| Moderate loss (limits some activity)                           | 2             |
| Severe loss (limits everyday tasks)                            | 0             |
| <b>Pain</b>  |               |
| None   | 35            |
| Mild (with activity, no medication)                            | 28            |
| Moderate (with or after activity)                              | 15            |
| Severe (at rest, constant medication, disabling)               | 0             |
| <b>Excellent</b>   | 95-100 points |
| <b>Good</b>  | 80-94 points  |
| <b>Fair</b>  | 60-79 points  |
| <b>Poor</b>  | 0-59 points   |

Tension band wiring was used to repair the osteotomy, using the technique described by the AO group. The fracture fragments were reduced and held with two parallel K wires (1.6 mm). A figure of eight wire (18 gauge) was passed transversely through a hole in the proximal ulna and beneath the triceps tendon. The wire was tightened using a two-knot technique. The proximal K wire ends were bent 180°, a longitudinal stab incision was made in the triceps tendon and the K wires were seated on the periosteum over the figure of 8 wire. This key step minimises proximal wire migration.

The stability and range of motion was assessed per operatively. Patients were initially placed in a plaster back slab for 48 hours, then in a removable thermoplastic cast. Early controlled mobilisation was started under the guidance of our physiotherapists from 48 hours. The range of motion was gradually increased depending on the documented stability and postoperative range of motion achieved.

## RESULTS

Six patients were lost to follow up, four patients had died and two could not attend for clinical evaluation. The clinical records and radiographs were available for all 26 patients. Twenty patients were assessed clinically and radiographically at a mean of 35 months postoperative (range 24 to 48 months). Fourteen out of 20 patients (70%) had an excellent or a good functional result. Five patients (25%) had a fair functional outcome and one patient (5%) had a poor result.

The mean arc of movement was 112° (range 85-122°). The mean pronation was 75° (range, 60-82°) and supination was 76° (range, 60-80°). The mean functional score for the group was 85 (range, 55 to 100). The mean grip strength of the injured side was 54 kgf (range, 20 to 95) and of the non-injured side 89 kgf (range, 32 to 148). The injured arm showed a lower grip strength as compared to its expected grip strength (paired t test,  $p < 0.01$ ). The expected grip strength was calculated depending on the dominance of the injured side, if dominant (non dominant arm plus 10%) or if non dominant (dominant arm minus 10%).

The quality of reduction based on the immediate postoperative plain radiographs and operative findings was grade A (14 cases), grade B (5 cases) and grade C (one case). On the functional rating index, nine out of fourteen fractures with an anatomical reduction (grade A) had an excellent outcome ; three had a good outcome and two a fair outcome. Out of five patients with a grade B reduction, two had a good outcome and three had a fair functional result. The one patient with loss of reduction (grade C) had a poor result. Fifteen patients (75%) were able to return to their preinjury level of occupation and activity. Seventeen patients (85%) were satisfied with the final outcome.

The complications are shown in table III. Three patients (15%) required a further procedure for removal of the olecranon wires because of symptomatic wire prominence. Three patients with open fractures required delayed primary closure. Two patients developed an early superficial wound infection. One patient required an anaesthetic for removal of sutures. There was one case of ulnar

Table III. — Complications

|                          | Number | Percentage |
|--------------------------|--------|------------|
| Metalwork Prominence     | 3      | 15         |
| Heterotopic Ossification | 2      | 10         |
| Wound Infection          | 2      | 10         |
| Suture Irritation        | 1      | 5          |
| Ulnar Nerve Palsy        | 1      | 5          |
| Osteotomy non-union      | 0      | 0          |

nerve neurapraxia, which resolved. There was evidence of moderate osteoarthritis in one elbow. There were no cases of olecranon osteotomy non-union.

### DISCUSSION

Complex intraarticular fractures of the distal humerus are still a considerable challenge to the experienced surgeon. Prior to the 1970's great emphasis was laid on conservative treatment of these fractures either by the use of plaster or by traction on the olecranon, which led to considerable stiffness and poor functional results (12, 17). However with advances in implants and surgical techniques, many surgeons have moved towards surgical reconstruction of these complex fractures (2, 12).

Many methods of internal fixation have been described using Kirschner wires, screw fixation and single plates with unpredictable results. The results of the various treatment methods are difficult to compare owing to the variability of the outcome scoring systems used. K-wire fixation alone rarely provides sufficient stability in these difficult fractures (16). In our series the AO recommendation for a two-plate construct at 90° with the medial plate and the lateral plate posterior was followed; this provides the most stable construct to allow early mobilisation (1, 3, 7).

Total joint arthroplasty as a primary modality of treatment is also an option in the elderly when the extent of fragmentation is beyond surgical reconstruction, when the quality of bone stock is poor due to osteoporosis or when antecedent arthritis (usually rheumatoid) is present in the joint (5). In our series no cases required arthroplasty, although

subsequently this has been undertaken in three cases.

The majority of patients had mild or no pain (85%), there were no cases of severe pain. There were good forearm rotational movements in these patients, the main restriction was in flexion to extension. The mean arc of movement was 112°, which is consistent with other studies (2, 3, 9). There was no correlation between age and the final functional outcome achieved. Patients with open fractures had a lower mean functional score, which is similar to previous studies.

Fourteen patients (70%) had an excellent or good functional outcome after these complex fractures. This is comparable with other series in the literature although there is considerable variation depending on the outcome scoring system used (9, 11, 13, 14, 20). There was one poor result in a 75-year-old lady who sustained a grade 2 open injury. She had an arc of flexion of 85° with considerable weakness and moderate pain at latest follow-up. She was unable to achieve her pre-injury level of activity. Overall, five patients (25%) were unable to return to their previous level of activity. Seventeen patients (85%) were satisfied with their final outcome.

Olecranon osteotomy for exposure and fixation of the distal humeral fracture was initially popularised by Cassebaum (3). Henley *et al* reported a 57% incidence of complications with the transverse osteotomy, including symptomatic prominence of the K-wire, broken tension band wire, delayed union and non-union (8). In 1982 Heim *et al* described the chevron osteotomy with the point of the "V" turned distally. In addition to providing mechanical stability to rotational stresses the larger area of contact between the ends of the osteotomy enhances bony union (7). We used this technique of chevron osteotomy in our study; we had two cases of metalwork prominence but no cases of non-union.

Wang *et al* recommend routine anterior subcutaneous transposition of the ulnar nerve using a posterior approach (20). We have not found it necessary to perform a routine anterior transposition and have performed an adequate mobilisation as described by Jupiter *et al* (11). Sodergard *et al* reported a 12.5% neural complication following the surgical

fixation, 3.1% of the patients had a permanent dysfunction of the ulnar nerve in a series of 96 adult patients at an average follow-up of 6 years (19). There was one case of ulnar nerve palsy in our series, which recovered by 6 months. Heterotopic ossification was seen in two cases although much higher rates have been reported in similar series. We believe that the olecranon osteotomy minimises triceps muscle trauma and combined with early mobilisation reduces this complication.

Fractures of the distal humerus are relatively rare and large case series are rarely reported. Comparison between the various studies is difficult due to the variation in fracture classification, operative techniques and outcome measures used. There is considerable variation depending on the outcome measures used. Most studies have used subjective measures of muscle strength which are unreliable. We made an objective assessment of grip strength of the hand using a torque dynamometer.

At a mean follow-up of 35 months no patients had achieved normal grip strength. The average grip strength was 82% compared to the uninjured side. All patients received postoperative physiotherapy the next day and were followed up regularly. These results are similar to those reported by McKee *et al* who showed a reduction in elbow extension strength of 25% based on isometric testing, at a mean follow-up of 37 months (15). This was independent of the type of posterior approach (olecranon osteotomy or triceps splitting) used.

Internal fixation of intra-articular distal humerus (AO type C) fractures using double column plating is an effective procedure with an excellent or good functional outcome in most patient age groups. There is a long-term reduction in grip strength in the injured arm, however patients have a high level of satisfaction and the majority return to their previous level of activity.

## REFERENCES

1. **Broberg MA, Morrey BF.** Results of delayed excision of the radial head after fracture. *J Bone Joint Surgery* 1986 ; 68-A : 669-674.
2. **Burri C, Henkemeyer H, Spier W.** Results of operative treatment of intraarticular fractures of the distal humerus. *Acta Orthop Belg* 1975 ; 41 : 227-234.
3. **Cassebaum WH.** Open reduction of T- and Y-fractures of the lower end of the humerus. *J Trauma* 1969 ; 9 : 915-925.
4. **Charnley J.** *The Closed Treatment of Common Fractures*, 3rd ed, 1961. Williams & Wilkins, Baltimore, pp 70-71.
5. **Cobb TK, Morrey BF.** Total elbow arthroplasty as primary treatment for distal humeral fractures in elderly patients. *J Bone Joint Surg* 1997 ; 79-A : 826-832.
6. **Gabel GT, Hanson G, Bennett JB, Noble PC, Tullos HS.** Intraarticular fractures of the distal humerus in the adult. *Clin Orthop* 1987 ; 216 : 99-108.
7. **Helfet DL, Hotchkiss RN.** Internal fixation of the distal humerus : a biomechanical comparison of methods. *J Orthop Trauma* 1990 ; 4 : 260-264.
8. **Henley MB.** Intra-articular distal humeral fractures in adults. *Orthop Clin North Am* 1987 ; 18 : 11-23.
9. **Holdsworth BJ, Mossad MM.** Fractures of the adult distal humerus. Elbow function after internal fixation. *J Bone Joint Surg* 1990 ; 72-B : 362-365.
10. **Johansson H, Olerud S.** Operative treatment of intercondylar fractures of the humerus. *J Trauma* 1971 ; 10 : 836-843.
11. **Jupiter JB, Neff U, Holzach P, Allgower M.** Intercondylar fractures of the humerus. An operative approach. *J Bone Joint Surg* 1985 ; 67 : 226-239.
12. **Keon Cohen BT.** Fractures at the elbow. *J Bone Joint Surg* 1966 ; 48-A : 1623-1639.
13. **Kundel K, Braun W, Wieberneit J, Ruter A.** Intra-articular distal humerus fractures. Factors affecting functional outcome. *Clin Orthop* 1996 ; 332 : 200-208.
14. **Letsch R, Schmit-Neuerburg KP, Sturmer KM, Walz M.** Intraarticular fractures of the distal humerus. Surgical treatment and results. *Clin Orthop* 1989 ; 241 : 238-244.
15. **McKee MD, Wilson T, Winston L, Schemitsch EH, Richards RR.** Functional outcome following surgical treatment of intra-articular distal humerus fractures through a posterior approach. *J Bone Joint Surg* 2000 ; 82-A : 1701-1707.
16. **McKee MD, Jupiter JB.** A contemporary approach to the management of complex fractures of the distal end of the humerus. *Hand Clin* 1994 ; 10 : 479-494.
17. **Riseborough EJ, Radin EL.** Intercondylar T fractures of the humerus in adult. *J Bone Joint Surg* 1969 ; 51A : 130.
18. **Self J, Viegas SF, Buford WL Jr, Patterson RM.** A comparison of double-plate fixation methods for complex distal humerus fractures. *J Shoulder Elbow Surg* 1995 ; 4 : 10-16.
19. **Sodergard J, Sandelin J, Bostman O.** Postoperative complications of distal humeral fractures. 27/96 adults followed up for 6 (2-10) years. *Acta Orthop Scand* 1992 ; 63 : 85-89.
20. **Wang KC, Shih HN, Hsu KY, Shih CH.** Intercondylar fractures of the distal humerus : routine anterior subcutaneous transposition of the ulnar nerve in a posterior operative approach. *J Trauma* 1994 ; 36 : 770-773.