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Functional evaluation of comminuted intra-articular fractures of the distal humerus (AO type C). Long term results in twenty-six patients

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The authors present the results achieved in 26 patients who presented with intra-articular fractures of the distal humerus (8 AO type C1, 8 C2 and 10 C3) and who were operatively treated between 1999 and 2001 ; they were retrospectively evaluated after a mean follow-up period of 70.2 months. There were 12 males and 14 females with a mean age of 46.1 years. After a standard posterior approach with olecranon osteotomy, internal fixation was achieved with unilateral or bilateral plates and screws, or isolated screws and/or Kirschner wires. Anterior intramuscular transposition of the ulnar nerve was performed in 14 of the patients. The results were evaluated using the criteria of Morrey.

The results were graded as excellent in 6 patients (23.1%), very good in 15 (57.6%) and fair in 5 (19.3%). Complications included postoperative ulnar nerve palsy (1), wire migration (4), heterotopic ossification (3), infection (2) and material failure (2). The overall re-operation rate was 38.4%.

The authors conclude that careful preoperative planning, transolecranon approach for good visualisation, routine ulnar nerve exploration and stable internal fixation facilitating early active rehabilitation, remain the gold standard for the treatment of intra-articular fractures of the distal humerus.

INTRODUCTION

Intra-articular fractures of the distal humerus comprise 1% of all fractures in adults. Most authors advocate surgical treatment in order to restore the joint surface and stabilise the fracture, thus allowing early motion (*4, 6, 7, 9, 16, 17*). Adherence to meticulous surgical technique has been stressed. However surgical intervention is associated with a high incidence of complications such as nonunion, malunion, decreased range of motion, instability, posttraumatic osteoarthritis, heterotopic ossification, neurapraxia and avascular necrosis (*1, 10, 11, 18*).

In this study we used the Morrey *et al* (*14*) score to evaluate the results of such fractures treated operatively with the same approach in all cases.

MATERIAL AND METHODS

Between 1992 and 2001, 31 patients (31 limbs) with intra-articular fractures of the distal humerus (AO type C), were surgically treated by various surgeons with open reduction and internal fixation. One patient had died from a condition not related to the fracture, one had left the country permanently, and three patients could not be reached by phone or other means ; 26 patients were thus available at the last follow-up examination. There were 12 males and 14 females with a mean age of 46.1 years (range 17-76 years). The mean follow-up period was 70.2 months (range : 22 to 130 months).

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Fig. 1. — **(**A) AO type C3 fracture (case nº 25). (B) Intraoperative view after olecranon osteotomy. (C) Restoration of articular congruity.

A fall on the elbow was the most common mode of trauma (14 cases) followed by road traffic crashes (11 cases) and one fall from stairs. Ten of the patients (38,4%) had associated injuries elsewhere, including additional ipsilateral upper limb trauma (5 patients) and one partial brachial artery injury. Eight of the patients (30.7%) had compound open injuries of Gustilo-Anderson *(5)* type I (5 patients) or type II (3 patients). As per Müller *et al (15)* classification, 8 fractures were of C1 type, 8 of C2 and the remaining 10 of C3 type. All but four of the patients were operated on within 48 hours from the injury. Delay in surgery usually resulted from late presentation of the patients, though in some of the cases it was due to associated injuries.

The surgical technique was identical in all cases. The patient lay in semi-lateral position (45°) with his/her arm hanging by the side. A posterior midline approach was used and the ulnar nerve was isolated 5 cm above the cubital tunnel to the point it enters between the two heads of the flexor carpi ulnaris. An intra-articular "chevron" osteotomy of the olecranon was done with a sharp osteotome to reflect the triceps proximally and visualise the distal humerus. Restoration of the articular congruency and temporary stabilisation with small K-wires was the next step (fig 1). We then used cortical or Herbert screws crossing the fracture line, trying to avoid interfragmentary compression when comminution at the fracture site was present. A pre-contoured DCP 3.5 mm reconstruction or one-third semitubular plate of adequate length, was used to stabilise the larger of the articular fragments to the corresponding-medial or lateral column (fig 2). The remaining articular fragments were either fixed to the other pillar or to the already reconstructed pillar or both, as determined by the stability obtained intra-operatively. This was achieved by either an additional plate on the opposite column (11 cases) or

Fig. 2. — (A, B) AO type C2 fracture (case nº 1). (C,D) Good result 3 years postoperatively.

by using free screws and/or K-wire fixation (19 cases) (fig 3). In 7 of the patients, the fracture was stabilised by multiple cortical and/or Herbert screws only. When a plate was used on the cubital tunnel (14 cases), anterior intramuscular transposition of the ulnar nerve was necessary after completion of the fixation. In two cases, allografts were used to fill the gap in the metaphysis. Olecranon osteotomy was fixed with the tension band technique using two K-wires (24 cases) or a 6.5 mm cancellous lag screw (2 cases). Soft tissues were closed in layers. A suction drain and an above-elbow plaster cast were applied in all patients.

In three (11.5%) patients with no clinical signs of nerve dysfunction preoperatively, we found contusion of the ulnar nerve intra-operatively. In these 3 patients and in another 11 in which a medial plate was applied, anterior intramuscular transposition of the ulnar nerve was performed. Another patient (nr° 23) had preoperative clinical findings of radial nerve lesion but the nerve was not explored. The symptoms resolved after 4 months.

Active mobilisation of the elbow was allowed on the second postoperative day. The slab was discharged after 2-3 weeks depending upon the fracture pattern, the stability of fixation and the patient's cooperation. A program of extensive active physiotherapy of the elbow was then initiated. Patients were examined with regard to pain, activities of daily living, range of motion and fracture union. The Morrey score was used for the last clinical evaluation. In addition, any deficit of ulnar nerve function, whether early or late, and evidence of secondary osteoarthritis were specifically looked for.

RESULTS

All the fractures including osteotomies of the olecranon healed by 10–12 weeks. The results were evaluated using the criteria of Morrey *et al* (table I). The final result was graded as excellent in 6 (23.1%) patients, good in 15 (57.6%) and fair in 5 (19.3%). Two of these (nr° 2 and 9) had less than 60º of elbow flexion due to delayed union and development of significant heterotopic ossification respectively. The former was slightly improved after hardware removal and arthrolysis while the latter refused any further treatment, as he was able to perform some of the activities of daily living. Patient nr° 12 with a fair grading and a history of insulin-dependent diabetes mellitus had an early deep infection treated with surgical drainage, continuous irrigation and culture-based intravenous antibiotic therapy. Patient nr° 26 developed scar breakdown at the site of tension band wiring of the olecranon, which healed with wire removal 4 months after surgery. Another patient (nr° 25) had superficial infection at the site of surgical incision, which was treated conservatively with intravenous antibiotics for one week. Other complications included ulnar nerve paraesthesias in 4 patients in the immediate post-operative period. In three of them no specific aetiologic factor could be identified and the paresis recovered completely by the fourth postoperative week. In the fourth patient (nr° 21) the lesion was caused intra-operatively by excessive prolonged angulation of the ulnar nerve

Fig. 3. — (A, B) AO type C2 fracture (case No 16). (C, D) Excellent result 3.2 years postoperatively

on a K-wire. Spontaneous resolution was noted after 4 months. One patient (nr° 1) had signs of preoperative ulnar nerve impairment but regained full function after 5 months without exploration. None of the patients had any clinical or radiological sign of secondary osteoarthritis in the long term follow-up in the majority of cases. In three patients (nrs° 6, 14, 18) the K-wires at the site of olecranon osteotomy migrated proximally and were removed 3-4 months after surgery. Hardware removal and open arthrolysis of the elbow was necessary in three patients (nrs° 3, 19, 23) because of an extension gap of up to 30°- 40. The flexion-extension arc of the elbow improved by 10-15°. Inadequate reduction was observed in patient nr° 15 immediately after the operation and a revision osteosynthesis was performed on the 10th postoperative day. One patient (nr° 13) presented in the 12th postoperative week with a broken medial one-third tubular plate, which had been used along with another tubular plate. Callus formation was in progress and the arm was immobilised in an above-elbow cast for a month. The functional result was excellent and the patient refused hardware removal. Three patients developed heterotopic ossification around the elbow (nrs° 2, 9, 23). In one of them (nr° 23) it was clinically not significant because it did not interfere markedly with the range of motion, while in the other two patients (nr° 2 and 9) the range of motion was restricted with a mean flexion-extension arc of 60°. The overall re-operation rate was 38.4% (10 patients). In 4 patients, re-operation was indicated by the K-wires migration : in 3 by the proximal migration of the wires used in tension

Table I. — Overview of clinical data

Case	Age, gender	Side	Mechanism of injury	Type of fracture (AO classification)	Associated injuries	Type of fixation	Duration of follow-up (months)	MORREY SCORE	Complications
1. GA	68, F	L	Fall to the ground	C2		1 medial reconstruction plate, 2 transcondylar KW	33	90	Preop. ulnar nerve damage
2. SP	44,M	R	Fall to the ground	C1		1 DCP medial plate, 1 transcondylar & 3 free screws	91	66	Delayed union, Heterotopic ossification hardware removal, arthrolysis
3. MI	22,M	L	Traffic accident	Open C1	Distal radius fracture	1lateral reconstruction plate, 2 transcondylar & 2 free screws	72	85	Hardware removal, arthrolysis
4. NP	32,F	R	Fall to the ground	C1		1 lateral semitubular 1/3 plate, 1 transcondylar & 1 free screw	122	96	
5. MC	70,F	L	Fall to the ground	C3	Left patella fracture	1 transcondylar & 2 free screws & 3 KW	87	82	
6. GA	25,M	L	Traffic accident	C1	Scapular fracture, radial head fracture, intertrochanteric fracture, rib fractures	2 transcondylar & 1 free screw	69	80	KW-migration - tension band removal
7. PG	66,F	L	Fall to the ground	C1		1 lateral semitubular 1/3 plate, 1 transcondylar & 1 free screw	59	78	
8. LC	76,F	L	Fall from stairs	C2	Left Colles fracture	2 semitubular 1/3 plates, 1 transcondylar screw	72	84	
9. SA	46,M	R	Fall to the ground	C2		2 DCP plates, 1 transcondylar screw	67	51	Heterotopic ossification
10. XB	76,F	L	Fall to the ground	C1		1 lateral semitubular plate, 1 transcondylar & 2 free screws	130	88,25	
11. PB	66,F	L	Fall to the ground	C3	Left olecranon fracture	1 transcondylar and 3 free screws	130	96	
12. NG	66,M	L	Fall to the ground	C3		2 transcondylar and 3 free KW	75	75	Early deep wound infection
13. AN	45,M	L	Traffic accident	Open C2		1 lateral reconstruction plate, 1 medial semitubular plate, 3 KW, 1 transcondylar screw	82	100	Plate breakage, KW migration (of the humeral fixation)
14. TS	21,F	L	Traffic accident	Open C2	Brachial artery injury	2 semitubular plates, 1 transcondylar & 1 free screw	30	91,75	KW-migration - tension band removal

Table I. — Overview of clinical data (continued)

15. MS	21, M	R	Traffic accident	Open C3	Open tibial plateau fracture, Bilateral femoral fractures	1 transcondylar, 2 Herbert & 2 free screws, 3 KW	77	84,5	Revision osteosynthesis (10 d pop)
16. BM	25, M	L	Traffic accident	C2		2 reconstruction plates, 2 transcondylar screws	38	99	
17. PE	35, M	L	Traffic accident	Open C3		2 semitubular plates, 1 KW 1 transcondylar & 1 free screw,	125	91	
18. KN	17, F	L	Fall to the ground	C1		4 Herbert screws	78	100	KW-migration - tension band removal
19. LM	70, F	L	Fall to the ground	C2	Left patella fracture	2 semitubular 1/3 plates	88	89	Hardware removal
20. MM	57, M	R	Traffic accident	Open C3	Open right patella fracture	1 lateral reconstruction plate, 1 medial semitubular plate, 1 transcondylar & 1 free screw	68	100	
21. PM	34, F	L	Traffic accident	C2		2 reconstruction plates, 1 transcondylar screw, 2 KW	68	76	Postop ulnar nerve palsy, KW removal, arthrolysis
22. SP	22, M	R	Traffic accident	C1		2 transcondylar and 2 free screws, 1 KW	126	94	
23. KG	29, M	R	Traffic accident	C3	Distal 1/3 humeral shaft fracture	2 reconstruction plates, 2 transcondylar screws	40	90	Heterotopic ossification, hardware removal, arthrolysis
24. KT	46, F	L	Fall to the ground	Open C3		1 lateral reconstruction plate, 1 medial LCP, 1 transcondylar & 2 free screws	20	88,5	
25. KA	45, F	R	Fall to the ground	C3		1 lateral reconstruction plate, 2 free screws, 1 transcondylar Herbert screw	22	88	Superficial wound infection
26. ZB	76, F	L	Fall to the ground	Open C3		1 medial reconstruction plate, 4 KW, 1 transcondylar & 2 free screws	27	90	Scar breakdown, K-wire migration - removal

band stabilisation and in one by the distal migration of a K-wire used in the humeral fixation. No significant loss of power in the triceps was observed in any of our patients.

DISCUSSION

The treatment of distal humeral fractures presents a real challenge to the orthopaedic surgeon. The conservative approach does not ensure anatomic reconstruction of the articular surface nor does it permit early mobilisation of the elbow (*2, 19*). On the other hand the surgeon choosing operative treatment has to obtain good access to the fracture site and has to restore the peculiar anatomy of the region while protecting the delicate neurovascular structures. Moreover the surgeon experiences difficulties to obtain a stable fixation of small fragments when the bone is osteoporotic and the fracture severely comminuted. Complications like heterotopic ossification, joint stiffness and ulnar neuropathy are constantly reported (*11, 18*). However various studies (*3, 4, 11, 13, 16*) adequately emphasised that satisfactory results are to be expected in 65 to 100% of cases with rigid fixation and early rehabilitation. The importance of the surgical approach has also been stressed.

The semi-lateral position of the patient with the arm hanging by the side saves one assistant, offers convenient patient access to the anaesthetist, is comfortable to the surgeon and allows good view of the articular surface of the distal humerus. Gupta and Khanchandani (*4*) have treated some of their cases without olecranon osteotomy ; however no details are given and our experience is that plain radiographs often fail to depict the comminution of the fracture preoperatively, while CT scan may cause undue delay in our institution. We therefore resort to a transolecranon chevron type osteotomy, which is the best-known procedure to ensure good exposure of the distal humerus and is our method of choice in all cases. In only one case (nr° 11) with an anteriorly displaced fracture (AO type C3), we were not able to gain visual access to the fracture site and had to reduce it by palpation instead. The olecranon osteotomy was carried out with a sharp osteotome taking care to crack the articular surface, so that the irregular and interdigitating bone ends could be easily repositioned at the end of the operation. We did not have in our series any non-union at the osteotomy site but, as in other series, 3 patients (11.5%) complained of irritation by proximally migrated K-wires. This complication occurred when the K-wires had been inserted in the medullary canal and did not penetrate the opposite cortex, as recommended by the AO.

Ulnar nerve preparation and mobilisation preceded the osteotomy to facilitate intraoperative maneuvers and hardware application. We performed anterior intramuscular transposition of the ulnar nerve whenever it had been contused by the original injury or intraoperative retraction or when a metal implant was likely to cause mechanical irritation (*8, 18*). This was necessary in 14 cases (53.8%).

We did any reasonable effort to restore the articular surface, because this was the most critical part of the procedure but in some cases we had to accept an intra-articular step-off of 1 mm at the end of surgery. Abrasions of the cartilage or denuded areas were noted in some cases. However no signs of early osteoarthritis were detected probably due to early active postoperative mobilisation of the elbow.

DCP 3.5 reconstruction plates were our preference. They are easily contoured and applied either posteriorly or laterally (*7, 12*) while offering stable fixation. The semitubular 1/3 plate is less strong and thus susceptible to break. We abandoned its use early in our series after a case with plate breakage (nr° 13). Fixation of the fracture with K-wires should be used exceptionally, because of the risk of migration. Before closure of the wound, stability of the fixation was checked by observing the fracture site throughout the full range of motion.

Clinical assessment was performed, as in many other series, according to the Morrey *et al* rating score, relating to pain, motion, strength, stability and overall function. Good to excellent results were achieved in 21 patients (80.7%) with a mean total Morrey score of 90.8 points. Normal flexion-extension arc was established in 19 of the patients, though loss of the last 10°-25° of extension with almost normal flexion was observed in the other

7 patients. No limitation of supination or pronation of the forearm was observed in any patient. Regaining elbow function was noted to depend on early mobilisation, i.e. stable fixation, and the extent of physiotherapy performed by the patients.

The final outcome was observed to be better in younger patients, although it was probably more on account of their better physiotherapy record rather than their chronological age. Less favourable results were recorded in patients with poor performance of physiotherapy exercises (*8, 12*).

Early surgery is usually associated with a low incidence of heterotopic ossification. Although most of our patients were operated within the first 48 hours from the accident we found an 11.5% incidence (3 patients) of heterotopic ossification in our study. Our findings emphasise that not all heterotopic ossifications require removal of the ectopic mass but only those severely interfering with elbow motion as in patients nrs° 2 and 9.

The incidence of re-operation in our series (38.4%) compares well with other series available in the literature. Re-operation may be attributed to either iatrogenic causes, i.e. inadequate reduction or material failure or to non-specified factors (heterotopic ossification, infection).

In conclusion we think that careful preoperative planning, transolecranon approach for good visualisation, routine ulnar nerve exploration and stable internal fixation facilitating early active physiotherapy, remain the basic principles in the treatment of intra-articular fractures (AO type C) of the distal humerus. However, even with strict adherence to these principles, complications requiring further surgical action cannot be completely avoided.

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