TREATMENT OF NONUNION OF OLECRANON FRACTURES

PANAYIOTIS J. PAPAGELOPOULOS, BERNARD F. MORREY

From the Mayo Clinic and Mayo Foundation, Rochester, USA

We report the results in 24 consecutive patients treated from 1976 to 1991 for nonunion of olecranon fractures. Their mean age was 42 years, and the mean interval from fracture to treatment for nonunion was 19 months. Management was by rehabilitation and activity as tolerated for three, continued immobilisation for one, and operative treatment for 20. Operations included excision of the olecranon fragment (1), osteosynthesis (16), and joint replacement (3). Four patients also had distraction arthroplasty.

At a mean follow-up of 18 months no patient had severe residual elbow pain but three had moderate and six had mild symptoms. The mean arc of motion was 98° representing an average improvement of 11°. Twelve patients had an excellent result, four good, six fair, and two a poor result. Union had been achieved in 15 of the 16 patients treated by osteosynthesis.

Received 5 July 1993; Accepted 21 December 1993

The most common complications of fractures of the proximal ulna and olecranon are decreased range of elbow motion, ulnar neuropathy, post-traumatic arthritis, instability, and nonunion (Cabanela 1985). The last is relatively rare but has been reported to occur in 5% of all olecranon fractures (Mayer and Everts 1978). Nonunion may now be less common but it is challenging to treat because pain is usual and there is often some instability and limitation of motion leading to considerable functional disability (Gartsman, Sculco and Otis 1981). Little has been published on the treatment of nonunion of the proximal ulna and most papers are case reports (Pavlov et al 1981; Coonrad 1985; Waldram and Porter 1987; Fekete and Detre 1990; Kulenkampff and Rustemeier 1990; Wilker-

son and Johns 1990). We have therefore reviewed our experience with this uncommon but serious complication in 24 patients.

PATIENTS AND METHODS

From 1976 to 1991, we treated a total of 24 patients at the Mayo Clinic for nonunion of olecranon fractures. There were 14 men and ten women; their mean age was 42 years (15 to 78). The right side was involved in eight and the left in 16; ten patients had the dominant side involved. Only four had had their initial fracture treatment at the Mayo Clinic.

Two mechanisms of injury predominated: a direct fall on the elbow or on the outstretched hand (18), and high-energy trauma from a motor-vehicle accident (6). The fractures were classified according to our recently developed system (Table I; Morrey 1985). One patient also had a radial head fracture and another a coronoid fracture. Twenty-one fractures were closed and three were open. In all six cases resulting from motor-vehicle accidents there were also other fractures, involving the patella (2), clavicle (1), humerus (2), and contralateral elbow (fracture-dislocation, 1).

The initial management had been by early motion as tolerated (3), splitting (3) and operative treatment (18). At this operation, after open reduction, internal fixation had been by Kirschner (K) wires (1), K wires and a figure-of-eight wire loop using the AO tension-band technique (9), cancellous screws (2), cancellous screws with tension-band wiring (3), plate and screws (2), and partial excision of the olecranon fragment (1). Other than the nonunion, complications included functionally disabling loss of motion (8), reflex sympathetic dystrophy (2), median and ulnar neuropathy (1), and screw fracture (1).

Table I. The Mayo classification of 24 nonunions of olecranon fractures according to displacement, comminution, and stability

<table>
<thead>
<tr>
<th>Fracture type</th>
<th>Description</th>
<th>Number of patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Undisplaced</td>
<td>2</td>
</tr>
<tr>
<td>II A</td>
<td>Displaced, not comminuted</td>
<td>4</td>
</tr>
<tr>
<td>II B</td>
<td>Displaced, comminuted</td>
<td>6</td>
</tr>
<tr>
<td>III A</td>
<td>Fracture dislocation, not comminuted</td>
<td>7</td>
</tr>
<tr>
<td>III B</td>
<td>Fracture dislocation, comminuted</td>
<td>5</td>
</tr>
</tbody>
</table>

©1994 British Editorial Society of Bone and Joint Surgery 0301-620X/94/4804 $2.00

P. J. Papageopoulos, MD, Special Fellow in Orthopedics, Mayo Graduate School of Medicine; Assistant Professor of Orthopedics, Mayo Medical School
B. F. Morrey, MD, Chairman, Department of Orthopedics, Mayo Clinic and Mayo Foundation; Professor of Orthopedics, Mayo Medical School Mayo Clinic and Mayo Foundation, 200 First Street SW, Rochester, Minnesota 55905, USA.

Correspondence should be sent to Professor B. F. Morrey.
Anteroposterior and lateral radiographs of painful olecranon nonunion in a 60-year-old woman who had been treated initially with K-wire fixation for a fracture-dislocation. At nine months the pins had been removed.

Fig. 1a

Three years after open reduction, screw fixation and corticocancellous bone plating. The elbow was stable with mild pain, flexion from 30° to 140° and full pronation and supination.

Fig. 1b
The time between the initial fracture and treatment of the nonunion averaged 19 months (6 to 86). The main indication for treatment of the nonunion was pain in 16 patients and stiffness with less than 50° of flexion in eight.

Treatment for nonunion was by rehabilitation and activity as tolerated in three patients, continued immobilisation for four months in one, and operation in 20. Three types of operative treatment were used: excision in one patient, attempted osteosynthesis in 16, and prosthetic replacement in three. After open reduction, five methods of internal fixation were used; the classical AO tension-band technique with K wires and figure-of-eight wire loop was used in one patient, a single intramedullary screw and wire loop in three, transfixion with a single intramedullary compression screw in three, and plate and screw fixation in two.

Seven patients had a bone graft used with screws as a ‘bone plate’. All seven had some additional fixation: one had cancellous screw fixation and radial head resection (Fig. 1); one had radial head resection, cancellous screw fixation, and distraction arthroplasty; two had intramedullary screw fixation (Fig. 2), in one combined with double

Anteroposterior and lateral radiographs of a 60-year-old woman with a painful nonunion six months after a fracture of the left olecranon treated initially with K-wires and a tension band.

Fig. 2a

Twenty-three months after internal fixation with an intramedullary cancellous screw and corticocancellous bone plating. The result was a stable painless elbow with flexion from 45° to 145° and full pronation and supination.

Fig. 2b
bone plating; two had a supplementary AO plate; and one had both an AO plate and intramedullary compression screw.

Four patients having operative treatment also had release of soft-tissue contractures; all had a distraction device applied. They also had a resection procedure (1), screw fixation (1), a dynamic compression plate and screw fixation (1), and radial head resection, a corticocancellous bone plate, and cancellous screw fixation (1).

Of the 16 patients having open reduction and internal fixation, eight were immobilised in splints or braces for a mean of 8.5 weeks; the duration depended on the type of fracture and fixation. Three patients had no immobilisation, and two used only a sling for three weeks. The four patients who had been treated by the external fixator distraction device (three had internal fixation) used a splint or brace for an average period of six months after removal of the distraction device at four weeks.

Three elderly patients had total elbow arthroplasty. Their ages were 69, 71, and 78 years; one had severe rheumatoid arthritis, one had significant osteoporosis, and one had developed severe post-traumatic arthritis. In one

Fig. 3a

Anteroposterior and lateral radiographs of a 75-year-old woman one year after failed osteosynthesis.

Fig. 3b

Ten months after right total elbow replacement preserving the olecranon. The fracture line is still visible.
Technique of bone plating. We use a midline incision over the posterior aspect of the elbow unless the earlier incision is suitable. The proximal ulna is exposed and the medial and lateral aspects of the olecranon are identified to reveal the site of nonunion. The ulnar nerve is identified, dissected, and protected. The medial and lateral proximal surfaces of the ulna are flattened by removing prominent callus, and the fibrous pseudarthrosis is excised to allow adequate bone grafting. The fragments are reduced: a large proximal fragment is fixed with either a cancellous intramedullary screw or a contoured DCP plate on the medial cortex of the ulna. Great care is taken to avoid narrowing the distance between coronoid and olecranon.

A corticocancellous bone plate, about 60 by 10 mm, is taken from the anterior iliac crest (Fig. 4), carefully placed over the radial aspect of the fragments and secured with one or two 2.7 mm mini-cortical screws on each side of the nonunion. Cancellous bone graft is then packed around the nonunion site (Fig. 5).

Distraction device. When a distraction device is to be applied, a threaded pin is placed across the distal humerus by using a specially designed targeting guide (Fig. 6). This spans from the midpoint of the lateral epicondyle, which is the projected centre of the capitellum, to provide an axis of rotation which passes through the anteroinferior aspect of the medial epicondyle. The ulnar nerve is identified and protected at the time of the placement of the threaded humeral pin.

Two additional pins are placed through the ulna distal to the fixation provided for the nonunion. The three pins are then coupled and the distraction is adjusted to allow ulnohumeral motion while neutralising or protecting the area of osteosynthesis (Fig. 7).

Evaluation of outcome. All patients were clinically evaluated at the Mayo Clinic by senior staff consultants before treatment for nonunion and at the latest follow-up. Pain, motion, stability and function were assessed. Twenty-three of 24 patients had a minimum 12-month clinical follow-up; the mean follow-up was 18 months (12 to 44). The remaining patient had persistent partial nonunion of a complex comminuted fracture and required reoperation at 11 months. The 11-month result was

Fig. 3c

At 28 months the result was excellent with no pain.

the olecranon fragment was excised; in the second the olecranon was fixed with K wires and a wire tension band; and in the third, the olecranon was secured with absorbable sutures to the distal ulna and fixed with the cemented ulnar component of the prosthesis, taking care to avoid placing cement in the nonunion site (Fig. 3).
follow-up, no patient had severe pain, three had moderate pain (12%), six had mild pain (25%), and 15 had no pain (63%). The mean pain score before treatment was 22.5 (0 to 45); at latest follow-up it was 37.5 (15 to 45; p < 0.0001).

Range of motion. Before operation, the average arc was 31° to 118° of flexion; postoperatively, it was 25° to 123°, giving a mean improvement of 6° of extension and 5° of flexion (p < 0.05). The eight patients with less than 55° arc of motion had a mean improvement from 46° to 72°. Of the 24 patients, motion improved in 15, decreased in seven, and remained the same in two. In the four patients who had soft-tissue release and distraction arthroplasty, the arc improved from a mean of 48° (31 to 55) to 95° (80 to 130). Before operation mean pronation was 57° and mean supination 61° and there was no mean change after treatment.

Stability. Before treatment seven elbows were graded as unstable (29%) but after treatment only one was unstable. The mean score was 7 points (0 to 10) before and 9.5 points after treatment (p < 0.02).

RESULTS

Pain relief. Before treatment three patients had no pain (12%), three had severe pain (12%), nine had moderate pain (38%), and nine had mild pain (38%). At latest

Fig. 6
A target device is used to place a pin across the distal humerus through the axis of rotation (by permission of the Mayo Foundation).
Function. Before treatment, patients’ daily activities were limited mainly by pain, with a mean score of 11 out of a possible 25. At latest follow-up the mean score for daily function was 19 (p < 0.01). The total mean elbow function score before treatment was 54 points (0 to 100); at latest follow-up it was 84 points (30 to 100) (p < 0.0001).

Result related to method of treatment
Activity or rehabilitation (3 patients). One patient developed a fibrous non-painful nonunion, and in one the fracture healed with mild pain. The third patient refused any further treatment and continued to have nonunion and moderate pain. At the latest follow-up, these three patients all had a stable elbow with a mean arc of motion of 123° and performance indices of 100, 85, and 70 points.

Splint immobilisation (1 patient). This 16-year-old patient had nonunion of a stress fracture through the olecranon epiphyseal plate after splint immobilisation for ten weeks. The fracture eventually healed after continued splint immobilisation for a further four months, giving an excellent result.

Excision (1 patient). In this patient, excision of the olecranon was combined with distraction arthroplasty and anterior capsular release. At latest follow-up the result was excellent, with no pain, normal stability, and a motion from 0° to 130°.

Osteosynthesis (16 patients). At latest follow-up, ten patients (63%) had no pain, four had mild pain, and two had moderate pain. The mean arc of motion was 89° (30 to 130) with mean extension 29° (0 to 60) and flexion 118° (80 to 145). Fifteen elbows (94%) were stable. The average performance index was 81 points (30 to 100). Seven patients (44%) had an excellent result, three (19%) good, four (25%) fair, and two (12%) had a poor result. Both patients with a poor outcome had been treated for nonunion of a comminuted fracture-dislocation by open reduction, internal fixation, and bone grafting. One patient had a healed fracture, but instability and severe stiffness left a range from 50° to 80° of flexion only. The other had partial union but required a second operation to achieve full healing and a third operation for stiffness. Pain persisted two years after the last operation.

Joint replacement (3 patients). Two of the three patients who had elbow replacement had no pain, and one had mild pain. The arc of motion averaged 103° (35 to 138). All three elbows were stable, giving an excellent result in two and a good result in a 78-year-old woman with rheumatoid arthritis, although she had functional problems with her shoulder and hand.

Radiographic results. At latest follow-up 17 patients showed radiographically solid union and three had persistent nonunion. Severe post-traumatic arthritis had developed in three patients and two had heterotopic ossification. All three patients treated by elbow replacement had stable cement-bone interfaces at 26, 28, and 31 months after operation. In the two with preservation of the olecranon, the nonunion had healed.

Complications. No patients had any permanent neurovascular damage but two had paraesthesia of the ulnar and medial nerves, respectively. Transient reflex sympathetic dystrophy was seen in two patients. Three had severe post-traumatic arthritis, two had heterotopic ossification, and one had an olecranon bursitis. There were no infections.

Two of the three patients with persistent nonunion required no specific treatment. One refused further treatment and continued to have moderate pain. The second had no pain and the third healed after reoperation, as described below. All three had stiffness with ranges of motion of 55°, 40°, and 30° respectively.

Reoperation. Five patients had removal of metal, and two required soft-tissue release for persistent stiffness. In one this was successful with improvement of arc from 55° to 80°. The other patient had two reoperations including a distraction-interposition arthroplasty but the final result was poor.

The final performance index, by the described criteria, was excellent in 12 (50%), good in four (17%), fair in six (25%), and poor in two (8%).

DISCUSSION
Nonunion has been reported to occur in 5% of all olecranon fractures (Mayer and Evarts 1978). At the Mayo Clinic, however, 196 olecranon fractures were treated from 1980 to 1990 with only two nonunions (1%). One of these patients had an avulsion fracture managed by rehabilitation and activity as tolerated. The second had a comminuted fracture dislocation treated initially by osteosynthesis with a plate and screws; nonunion was treated successfully by a cancellous screw and a corticocancellous ‘bone plate’. Nonunion may follow an osteotomy of the olecranon to expose a distal humeral fracture (Wadsworth 1976); during the same ten-year period we had one such patient who was excluded from this study.

As with other fractures, there is no accepted time before a definite diagnosis of nonunion should be made, but it is usually diagnosed when there has been no clinical or radiographic progression of healing for at least six months (Coonrad 1985). We used this criterion.

Factors which may predispose to nonunion include distraction, compound fracture, infection, comminution, loss of blood supply, defects between the fragments, interposition of soft tissue, and abnormalities of the electrochemical or cellular physiological mechanisms involved in fracture healing (Adler, Fay and MacAusland 1962; Mayer and Evarts 1978; Bassett 1982). Inadequate fixation, premature motion or a combination of these may contribute.

Olecranon nonunion usually causes tenderness, some degree of instability, and limitation of motion but a few patients may have good function. Tomography may help with the diagnosis.

The integrity of the ulna is important for elbow function, and nonunion also disturbs articular congruity.
and stability. Nonunion may be compounded by infection, bone loss, osteoporosis, soft-tissue contracture, and neurovascular damage. In our series, 88% of patients had some pain and 29% had instability, but the mean arc of motion, 31° to 118°, was acceptable.

Previous reports on the treatment of olecranon nonunion include only a small number of cases (Pavlov et al 1981; Waldram and Porter 1987; Fekete and Detre 1990; Kulenkampff and Rustemeier 1990; Wilkerson and Johns 1990). We discuss several treatment options; this is necessary because nonunion has complex expressions. Coonrad (1985) discussed treatment on the basis of the presence or absence of articular damage. Where articular cartilage has not been severely damaged, the aims of treatment are similar to those of management of a primary fracture, with restoration of congruity, ligamentous stability (mainly of the medial collateral ligament), triceps extensor function and mobility (Coonrad 1985). Electrical stimulation (Jacobs et al 1981; Sharrard et al 1982) is not recommended because the prolonged immobilisation required can lead to elbow stiffness (Coonrad 1985).

**Treatment options**

Excision of the proximal fragment with meticulous reattachment of the triceps tendon may be used for older patients with a small avulsion fragment involving less than 50% of the trochlear surface (McKeever and Buck 1947; MacAusland and Wyman 1975; Gartsman et al 1981). We used this method in only one case and combined it with a distraction arthroplasty to give an excellent result.

Osteosynthesis is appropriate for younger patients or older individuals in whom the proximal fragment involves over 50% of the trochlear notch. The mode of rigid fixation will depend on the characteristics of the fracture. Tension-band wiring by the AO technique can be combined with bone grafting, and a modification of this technique with excision of a comminuted or depressed central part of the articular surface may be useful (Colton 1973). We used a tension-band technique successfully in four of the 16 patients who had open reduction and internal fixation.

Rigid fixation can be achieved by the use of a tubular dynamic compression plate or a 3.5 mm reconstruction plate: this allows early motion. Nonunion of the Monteggia type requires rigid fixation with plating and bone grafting, but in chronic injuries of this type no attempt is made to reduce the dislocation and the radial head is resected. We used a plate alone in two of our patients: both healed. We found that a corticocancellous bone graft fixed with screws is a useful technique.

Lag screw fixation with a longitudinal intramedullary screw is useful, but bicortical screws provide better fixation where this is possible (Wadsworth 1976). Maleable or flexible screws (Leinbach or Pritchard intramedullary screws) are not recommended because they have high rates of breakage and nonunion (Cabanela 1985; Coonrad 1985). We used an intramedullary screw in eight cases, all successful, but it can only be used in fractures in which axial compression will stabilise the fracture without narrowing the olecranon to coronoid distance. Distraction device. In cases in which the congruity or stability of the ulnohumeral joint was in doubt, we used a distraction device consisting of a threaded pin across the axis of rotation of the distal humerus linked to two ulnar pins placed distal to the fixation for nonunion. The coupling can be adjusted for tension and space across the ulnohumeral joint, allowing ulnohumeral motion while protecting the internal fixation. This has been used since the mid-1980s for treating stiff elbows and its most useful role is after soft-tissue release for contracture (Morrey 1990). We used distraction arthroplasty after internal fixation and bone grafting in four patients. All achieved union with improvement of a mean range from 48° to 95°. Joint replacement. We used joint replacement in three elderly patients with nonunions that precluded osteosynthesis. One had severe rheumatoid arthritis, another had osteoporosis which contraindicated internal fixation, and the third had severe post-traumatic arthritis. In all treatment was successful after a rehabilitation period which averaged three months.

Conclusions. Treatment for olecranon nonunion depends on the age of the patient, the fracture shape, the quality of bone, and the condition of the soft tissues, and an acceptable result can be anticipated in about 70% of patients. Painless 'fibrous nonunion' with 90° flexion requires no treatment. Prolonged immobilisation may succeed for stress nonunion in adolescents.

Osteosynthesis is indicated for other young patients and those without severe comminution, and the combination of bone grafting and corticocancellous bone plating with a DCP plate or cancellous screws is the treatment of choice. Marked stiffness may require soft-tissue release and the use of a distraction fixator. Total elbow arthroplasty is indicated for elderly patients with coexisting severe arthritis or osteoporosis.

No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

REFERENCES


