Complex distal humerus trauma
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CHAPTER 9

Osteonecrosis of the Capitellum and Trochlea
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Abstract

Purpose: The purpose of this study was to test the hypothesis that comminuted fractures of the capitellum and trochlea with posterior comminution (Dubberley Type 3B) have a greater risk of nonunion than other types of capitellum and trochlea fractures.

Methods: Thirty patients with operatively treated fractures of the capitellum and trochlea were followed for an average of 34 months (range, 12 to 75 months). Eighteen fractures with comminution of the capitellum and trochlea and posterior comminution (Type 3B according to Dubberley and colleagues) were compared to 12 fractures consisting of single large anterior fracture fragments with (6 patients; Dubberley Type 2B) or without (6 patients; Dubberley Type 2A) posterior comminution.

Results: Eight of eighteen patients (27%) with type 3B fractures were noted to have nonunion. No patients with type 2 fractures had a nonunion.

Conclusions: Nonunion is more common in patients with comminuted fractures of the capitellum and trochlea with posterior comminution (Dubberley Type 3B).

Level of Evidence: Prognostic IV
Introduction
Several recent case series have emphasized that fractures of the capitellum and trochlea can be complex injuries with fragmentation, fracture of the posterior part of the lateral column or posterior trochlea, and limited soft tissue attachments. In spite of these challenges, nonunion has been rare, and osteonecrosis was suspected in only 2 of 21 patients in the series of Ring and colleagues, 3 of 38 patients in the series of Dubberley and colleagues, and none in the series of Guitton and colleagues.

We tested the hypothesis that comminuted fractures of the capitellum and trochlea with posterior comminution (Dubberley Type 3B) have a greater risk of nonunion than other types of capitellum and trochlea fractures.

Methods
Over an eight-year period from 2000 to 2008, 2 surgeons operated on 35 adults with a fracture of the distal humeral articular surface as follows: 1) the main fracture fragments primarily involved the articular surface (these have been described as coronal shearing fractures, complex articular fractures, or fractures of the capitellum and trochlea (1-4); 2) any metaphyseal component of the fracture was at or distal to the base of the olecranon fossa; and 3) the fracture was treated with open reduction and internal fixation. During this 8-year period, neither surgeon operated on a fracture of the capitellum alone.

Under a protocol approved by our Human Research Committee we invited patients to return for a research-specific follow-up visit. Thirty patients with a minimum of one-year follow up were evaluated.

The cohort of patients followed for at least one year consisted of 21 women and 9 men with an average age of 49 years (range, 17 to 75 years) at the time of surgery. Twenty were injured in a fall from a standing height, four in a fall from a greater height. Four fractures were sports related, and two patients were injured in car accidents. Eight patients had concomitant dislocation of the involved elbow, 2 with associated radial head fractures and 2 with an associated open wound (Gustilo Type 2 and 3A). Two patients who did not have dislocation had a fracture of the radial head.

Six patients had fractures of other limbs. One patient had several fractures of the ipsilateral limb: proximal humerus, diaphyseal humerus, distal radius, scaphoid, fracture, trapezium. One other patient had an ipsilateral distal radius fracture.

Classification
According to the classification of Dubberley et al. there were 6 2A fractures (involving the capitellum and the trochlea as 1 piece without posterior condylar fracture/comminution), 6 2B fractures (involving the capitellum and the trochlea as 1 piece with posterior condylar fracture/comminution) and 18 3B fractures (consisting of fractures of both the capitellum and the trochlea as separate fragments with posterior condylar comminution).
Operative Technique
The average time between injury and surgery was 7 days (median, 4 days; range, 0 to 40 days). One patient had a delay of 40 days because he was very ill with multiple injuries. One patient with multiple injuries and a complex open fracture had an initial debridement and stabilization with an external fixator and then open reduction and internal fixation 5 days after injury.

In 13 patients the fracture was repaired with small headless countersunk screws and wires alone. Standard plates and screws were used in 4 patients, and a combination of plates and ancillary headless countersunk screws and wires were used in 13 patients. It was not usually possible to obtain rigid fixation of Dubberley Type 3B fractures. The lateral epicondyle was repaired with a 22-gauge stainless steel figure-of-8 wire in 11 patients. (Figure 1)

One patient received autogenous cancellous bone from the iliac crest, and 2 patients received demineralized bone matrix.

Post-operative Management
Sixteen patients began self-assisted active elbow exercises the morning after surgery, and 3 began exercises within 7 days. Eleven patients (9 Type 3B, 1 Type 2A, and 1 Type 2B) were immobilized in 90 degrees of flexion and neutral rotation for an average of 17 days (range, 10 to 31 days) because there was concern regarding tenuous fixation due to articular fragmentation, osteoporotic bone, and involvement of the posterior aspect of the humerus so that the fragments could not be compressed and stabilized to intact parts of the humerus. Eight patients who had difficulty regaining range of motion through exercises alone used a dynamic or static progressive splint to increase range of motion starting an average of 6 weeks after surgery (range 4 to 13 weeks).

Evaluation
Nonunion was diagnosed radiographically on the basis of a persistent fracture line, loose or broken implants, loss of alignment, or resorption of fragments. (Figure 1)

Statistical Analysis
To identify factors associated with non-union we performed bivariate analysis. The independent (or explanatory) variables were dislocation, duration of immobilization, gender, age, mechanism of injury, days between injury and surgery, Dubberley classification, operative approach, and open wound. Associations between explanatory variables and the response variable, nonunion, were evaluated using the Mann Whitney U-test for continuous variables and Fischer’s Exact Test for dichotomous variables. Associations with a p-value less than 0.05 were considered statistically significant.

Among patients that retained their native elbow, we compared Dubberley Type 3B and Type 2 fractures for final ulnohumeral motion, forearm rotation, DASH, ASES, MEPI, and Broberg and Morrey scores using Student’s T-test.
A 28-year old man had a complex fracture of the articular surface of the distal humerus. The fracture created numerous small articular fragments with limited subchondral bone and impaction and comminution of the posterior aspect of the lateral column.

A and B: Anteroposterior and lateral radiographs 2 months after surgery demonstrates fixation of the fracture with numerous buried headless screws, threaded Kirschner wires, one headed screw, and a tension band wire on the lateral epicondyle.

C: Six months later an anteroposterior radiograph shows that two Kirschner wires had migrated and were removed, and many of the capitellar fragments had failed to heal and are starting to be resorbed.

Results
Nonunion
Eight patients (all with Type 3B fractures) were noted to have nonunion. Three had concomitant infection (one left with heterotopic bone causing ulnohumeral ankylosis after resection of the articular fragments, one left with a resection arthroplasty after treatment of the infection, and one that retained the native ulnotrochlear joint after resection of ununited capitellum fragments). Two patients had surgery to remove loose implants and ununited fracture fragments. Three patients were diagnosed with nonunion and did not have additional surgery. Fractures classified as Type 3B according to Dubberley and colleagues (those with fragmentation of the articular surface and loss of an intact posterior humerus to compress the fragments against) had a significantly higher rate of nonunion than those classified as Type 2A or B (0 out of 12 Type 2 versus 8 out of 18 Type 3; \( p < 0.01 \)). The time between injury and definitive open reduction and internal fixation was not significantly associated with nonunion (union: 4.4 days, 95%CI 2.2 to 6.6, range 0 to 18; nonunion: 12.5 days, 95%CI 2.3 to 23, range 0 to 40; \( p = 0.11 \)). Dislocation and open fractures were not associated with the development of nonunion.

Among the eight patients with nonunion, 2 patients with concomitant infection did not retain their native elbow and were considered failures. Among the remaining 6, 2 patients had an excellent result according the Broberg and Morrey scale, 1 patient had a good result and 3 patients had fair results with 85 points on average (range, 65 to 100), and the average ulnohumeral range of motion was 115 degrees (range, 65 to 145 degrees). Among patients that retained the native elbow, there was no significant difference in ulnohumeral range of motion.
between patients with or without nonunion. Three elbows with nonunion had slight joint-space narrowing with minimum osteophyte formation, 3 elbows had moderate joint-space narrowing with moderate osteophyte formation, and 2 elbows were not retained.

Among patients who retained their native elbows, there were no differences between patients with and without nonunion in terms of ulnohumeral motion, forearm rotation, Broberg and Morrey, DASH, MEPI and ASES scores.

**Discussion**

The main finding of this series was that nonunion after open reduction and internal fixation of capitellum and trochlear fractures was significantly more common in fractures with involvement of the posterior part of the lateral column or posterior trochlea. Many of the small ununited fracture fragments subsequently resorbed. A posterior fracture may preclude stable fixation, which relies on the anterior articular fragments being rigidly compressed against the posterior aspect of the distal humerus. In addition, as the blood supply to the capitellum and lateral trochlea comes mainly from the posterior condylar perforating vessels\(^5^\text{-}^8\), extension of fractures posteriorly may at least partially devascularize the lateral column, predisposing to nonunion. Because over half of the patients in this series had complex fractures with posterior comminution (Dubberley type 3B fractures), it may not be directly comparable to prior reported series describing patients with simpler fractures of the capitellum and trochlea.

There were also more infections in this series than in prior series (five total, two associated with open wounds), which might also have contributed to a greater risk of nonunion, although this did not achieve statistical significance with the numbers available. It is possible that the increased rate of infection may have been due to the devascularization caused by the more complex fractures found in this series. This series should be interpreted in light of several shortcomings. First, by virtue of the fact that it is a small series of an uncommon injury treated by two surgeons in a referral center, it may not be representative of the true spectrum of capitellum and trochlea fractures. Second, again related to the small numbers, some of the findings may be spurious and the statistical comparisons may be underpowered.

Some authors\(^9\) still describe the treatment of simple capitellum fractures, but it seems that most of the other recent series are consistent in noting that it is unusual for a capitellar fracture not to involve some portion of the trochlea or some degree of impaction of the posterior aspect of the lateral column. While nonunion is less common than one might expect with completely or nearly completely devitalized fragments, it does occur, sometimes in association with infection, and a higher risk seems to be associated with posterior condylar comminution. The authors are cautious about using primary arthroplasty for fractures of the capitellum and trochlea in all but the most infirm and inactive of patients; however, it is possible that some of these fractures may have been better treated by prosthetic arthroplasty—perhaps even hemiarthroplasty (replacement of the humerus alone) than by open reduction and internal fixation, and more study is merited.
References