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CHAPTER 10

Predictors of Diagnosis of Ulnar Neuropathy after Operatively Treated Distal Humerus Fractures
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Abstract

**Purpose**: Ulnar nerve dysfunction is a common sequella of operative treatment of fractures of the distal humerus. We analyzed consecutive patients with operatively treated distal humerus fractures to address the primary null hypothesis that different types of distal humerus injuries have comparable rates of diagnosis of ulnar neuropathy.

**Methods**: We assessed diagnosis of ulnar neuropathy in 107 consecutive adult patients that had an operatively treated fracture of the distal humerus followed at least six months after injury. Diagnosis of ulnar neuropathy was defined as documentation of sensory or motor dysfunction of the ulnar nerve in the medical record. Explanatory variables were age, sex, general fracture classification (both column, single column, capitellum/trochlea), AO Type, associated wound, associated elbow dislocation, mechanism of trauma, ipsilateral skeletal injury, release of the ulnar nerve, mobilization of the ulnar nerve, transposition of the ulnar nerve, olecranon osteotomy, implant over or below the medial epicondyle, parallel versus perpendicular plating, infection, treating surgeon, time from injury to surgery, the number of surgeries within 4 weeks and 6 months of injury, and the total number of surgeries.

**Results**: Post-operative ulnar neuropathy was diagnosed in 17 of 107 patients (16%), including 14 of 62 bicolumnar fractures (23%). The only risk factor for ulnar neuropathy was bicolumnar fracture (p=0.04, OR 8.75).

**Conclusion**: Patients with bicolumnar fractures are at higher risk for the development of postoperative ulnar neuropathy than patients with single column or capitellum and trochlea fractures. Intraoperative handling of the ulnar nerve had no effect on the rate of postoperative ulnar neuropathy in this study.

**Level of evidence**: Prognostic, Level 2, retrospective study.

**Keywords**: Distal humerus fracture; ulnar neuropathy
Introduction
The reported incidence of postoperative ulnar nerve dysfunction after open reduction and internal fixation (ORIF) of distal humerus fractures varies substantially between 0% and 51% with an average of 12.3%. A recent prospective randomized clinical trial comparing total elbow arthroplasty and ORIF documented post-operative ulnar neuropathy in 20% of patients.

The majority of studies are retrospective and do not specifically evaluate the ulnar nerve. Our experience treating patients with distal humerus fractures indicates that both patients and surgeons often overlook ulnar nerve dysfunction post-operatively—perhaps it’s a relatively minor thing compared to the pain and stiffness associated with the fracture itself. In addition, most studies don’t distinguish among pre-existing nerve dysfunction from cubital tunnel syndrome, injury-related ulnar nerve palsy, postoperative iatrogenic ulnar nerve palsy, and delayed-onset ulnar nerve palsy.

Potential contributions to post-operative iatrogenic ulnar neuropathy include the proximity of the nerve to the injury zone and handling of the nerve (stretch, compression, devascularization) during surgical intervention. Delayed onset postoperative ulnar neuropathy is believed to be related to heterotopic ossification or scarring around the implants and surgical site. Data on the effect of anterior subcutaneous transposition of the ulnar nerve during surgery is inconclusive. In a prior multicenter retrospective study of bicolumnar fractures that included some of the patients from the current study, no significant predictors of ulnar neuropathy were identified.

The purpose of this study is to analyze a cohort of consecutive adult patients with a full spectrum of operatively treated distal humerus fractures to determine risk factors for the development of ulnar neuropathy. Our primary null hypothesis is that different types of distal humerus injuries have comparable rates of ulnar neuropathy.

Methods
Under a study protocol approved by our Human Research Committee we used billing records and a trauma database to identify 604 consecutive patients that had an operatively treated fracture of the elbow between 2001 and 2007. Inclusion criteria included fracture of the distal humerus treated with ORIF, age 18 or greater, and minimum follow-up of six months in the medical record. Exclusion criteria included gunshot fracture, pathological fracture, sharp injury, and revision surgery.

Patients
There were 115 patients with distal humerus fractures, 107 that satisfied the inclusion and exclusion criteria. There were 67 women and 40 men with an average age of 57 at the time of injury (range, 23 to 95 years, interquartile range 33). Sixty-two patients had a bicolumnar fracture; 13 a single column fracture (9 lateral, 4 medial); 31 a fracture of the capitellum and trochlea; and one patient had a fracture of the medial epicondyle. According to the AO comprehensive
classification of fractures, 12 fractures were classified as type A, 46 fractures as type B, and 49 fractures as type C. According to the Dubberley classification of capitellar and trochlear fractures, 3 were type 2A (involving the capitellum and extensive involvement of the lateral part of the trochlea as one fragment, but no posterior fracture), 4 were type 2B (the same as type 2A but with a posterior fracture), 1 was type 3A (fractures of both the capitellum and the trochlea as separate fragments, without posterior fracture), and 23 were type 3B (same as Type 3A with a posterior fracture). In 15 patients the fracture was associated with an open wound. Seven patients had associated complete ulnohumeral dislocation of the elbow. Twenty-one patients had another fracture of the ipsilateral arm: 5 involved the proximal humerus, 4 the humeral diaphysis, 6 the distal radius, 2 the radial head, 5 the proximal ulna, 2 the scaphoid, and 1 a metacarpal.

The mechanism of injury was a motor vehicle collision in 16 patients, a fall from standing height in 58 patients, a fall from a greater height in 24 patients, and 9 sports injuries. The average time between injury and operative treatment was 5 days (range, 0 to 60 days).

The operative exposure was posterior in 81 patients (66 olecranon osteotomies, 1 triceps split, and 14 paratricipital approaches); a lateral or extended lateral exposure in 23 patients; and a medial exposure in 3 patients. In 24 patients the ulnar nerve was not handled during surgery, in 12 patients it was released in situ, in 14 it was mobilized and returned to its normal anatomical location, and in 57 it was mobilized and left in an anterior subcutaneous position at the end of the surgery. Among the capitellar and trochlear fractures, the ulnar nerve was transposed in 9 patients, released in 6 patients, mobilised in 3 patients, and not handled in 14 patients. All patients with capitellar and trochlear fractures that had transposition of the ulnar nerve were Dubberley Type 3B fractures. Among bicolumnar fractures, the ulnar nerve was transposed in 44 patients, released in situ in 3 patients, mobilised and returned to it’s normal position in 8 patients, and not handled in 6 patients.(Figure 2) Bicolumnar fractures were secured with perpendicular plating in 38 patients, parallel plating in 19 patients, three plates (one medial and two lateral plates) in 7 patients, and one medial plate in 1 patient. Thirty-four patients had one or more additional surgeries (average 1.9, range 1 to 11), and 20 patients had additional surgery within 6 months (average 2.0, range 1 to 8). Additional surgeries consisted of irrigation and debridement in 5 patients, implant removal in 18 patients, elbow contracture release in 12 patients (all but one of whom had removal of heterotopic bone), ulnar nerve transposition in 6 patients, and total elbow arthroplasty in 1 patient.

**Ulnar neuropathy**

Post-operative ulnar neuropathy was defined as motor or sensory dysfunction of the ulnar nerve noted in the medical record.

**Variables**

Post-operative ulnar neuropathy was the response variable. Explanatory variables were age, sex, general fracture classification (both column, single column,
capitellum/trochlea), AO Type, associated wound, associated elbow dislocation, mechanism of trauma, ipsilateral skeletal injury, release of the ulnar nerve, mobilization of the ulnar nerve, transposition of the ulnar nerve, olecranon osteotomy, implant over or below the medial epicondyle, infection requiring surgical debridement, treating surgeon, surgeon subspecialty, the number of surgeries within 4 weeks, and the total number of surgeries. In subgroup analysis of bicolumnar fractures, patients treated with parallel, perpendicular, or three plates were compared.

**Statistical Analysis**
Continuous data are presented as the median and interquartile range because of non-normal distribution of the data. Several categorical variables appeared not applicable to Chi-squared analysis, taking a maximum of 20% of cells with counts below 5 as rule of thumb. Bivariate analysis was therefore adjusted, and associations between explanatory variables and the response variable, ulnar neuropathy, were evaluated using a separate binary logistic regression model for each explanatory variable. P-values < .05 were considered significant. Significant and near significant (p<.10) variables in bivariate analysis were entered into a backwards stepwise logistic regression model for multivariable analysis.

**Results**
**Ulnar Neuropathy**
There were 9 women and 10 men with a median age of 58 years old (range, 22 to 85 years, interquartile range 35) diagnosed with post-operative ulnar neuropathy. Six of 19 patients with ulnar neuropathy had a second surgery consisting of implant removal in 2 patients, contracture release with removal of heterotopic bone in 4 patients, and nerve transposition in 5 patients.

One of 31 patients with a capitellar and trochlear fracture developed postoperative ulnar neuropathy, 14 of 62 patients with a bicolumnar fracture, and 2 of 13 patients with a single column fracture. The patient with a medial epicondyle fracture did not develop ulnar neuropathy.

Bivariate analysis indicated that bicolumnar fractures had significantly more postoperative ulnar neuropathy than capitellar and trochlear fractures (p=0.04, OR 8.75, CI 1.09 – 70.0). Pearson chi-square analysis showed a significant difference in handling of the nerve between bicolumnar and capitellar/trochlear fractures (p<0.001). None of the other explanatory variables were significant in bivariate analysis.

As there was only one significant explanatory variable in bivariate analysis, we did not proceed to multivariable analysis.

**Discussion**
Sixteen percent of all patients that had operative treatment of a fracture of the distal humerus (and 23% of patients treated for a bicolumnar fracture) were diagnosed with ulnar neuropathy in the medical record. Fracture type was the only predictor for the development of postoperative ulnar neuropathy. In
secondary analyses, handling of the ulnar nerve was not a risk factor for ulnar neuropathy.

In contrast, a recent report comparing operatively treated distal humerus fractures with or without ulnar nerve transposition based on surgeon preference showed a four times higher rate of ulnar neuropathy when the nerve had been transposed.\textsuperscript{11} Selection bias is likely, however, given that some fractures are difficult or impossible to secure without moving the ulnar nerve at least temporarily. One of the strengths of our investigation is that we accounted for a large number of potential risk factors for iatrogenic post-operative ulnar neuropathy including fracture and fixation type.

Anterior transposition of the ulnar nerve theoretically provides a new bed for the nerve away from prominent hardware, posttraumatic scar tissue, or heterotopic bone. On the other hand, transposition requires further dissection of the nerve with potential for additional stretch, pressure and devascularization.\textsuperscript{11, 12} Most authors support routine anterior transposition of the nerve,\textsuperscript{3, 8, 13-15} but some authors advocate placing the nerve back into its epicondylar groove after internal fixation is completed.\textsuperscript{16, 17} Others transpose the nerve only when it is contused or if it lies directly on the medial plate.\textsuperscript{18-20} Potential issues associated with ulnar nerve transposition include impaired blood supply or inadequate release (e.g. retained medial intermuscular septum or inadequate facial release proximally or distally).\textsuperscript{21-23}

This study has all the drawbacks that are standard for a retrospective study. Inherent to the study design, we were not able to stratify patients for injury-related, sub-acute or late onset ulnar neuropathy, and a few patients may have developed ulnar neuropathy only after a reconstructive procedure. Even more important, given that ulnar nerve dysfunction can be subtle and go unrecognized in the early post-operative period, a prospective study is necessary to determine the true incidence of ulnar neuropathy. In our opinion, a prospective study using a diagnostic test such as Semmes-Weinstein monofilament testing would identify a substantially greater incidence of ulnar neuropathy.

Recent investigations addressing the operative fixation of a fracture of the distal humerus consistently note a high rate of post-operative ulnar neuropathy. The risk factors for ulnar neuropathy are incompletely defined. At our institution, the only risk factor was bicolumnar rather than single column or capitellar/trochlea fracture. Patients and surgeons should understand that post-operative iatrogenic ulnar neuropathy is an aspect of the routine management of these fractures that, to date, cannot be predicted or controlled. The optimal handling of the ulnar nerve is unclear. No treatment, in situ release, mobilization and return, and anterior subcutaneous transposition are all options, but it’s unclear if all of these options are possible with complex fractures or fractures with small distal fragments where low medial implants are needed.
References