Ulnar Nerve Management with Distal Humerus Fracture Fixation: A Meta-Analysis

Jonathan W. Shearin, MD[a], Talia R. Chapman, MD[b,*], Andrew Miller, MD[b], Asif M. Ilyas, MD[c]

KEYWORDS

• Humerus • Internal fixation • Ulnar nerve • Meta-analysis • Transposition • Decompression

KEY POINTS

- Ulnar neuropathy is common after distal humerus fracture repair surgery, with an overall incidence of 19% postoperatively.
- The ulnar nerve is typically managed intraoperatively with in situ neurolysis or transposition during fracture fixation.
- Postoperative ulnar neuropathy was increased in patients who underwent transposition versus in situ management of the ulnar nerve.
- It is unclear if the higher prevalence of neuropathy in cases with a transposition is due to greater fracture severity, iatrogenic injury during dissection or transposition, or subsequent postsurgical scarring with fracture healing. However, the authors can conclude transposition does not have a protective effect against the development of late ulnar neuropathy after distal humerus fracture repair surgery.

INTRODUCTION

Fractures of the elbow account for approximately 7% of adult fractures,[1] and distal humerus fractures comprise 30% of all elbow fractures.[2] When open reduction and internal fixation (ORIF) is indicated, several operative complications such as nonunion, loss of functional motion, and ulnar neuropathy have been reported.[3,4] Sodergard and colleagues[5] discussed complications following ORIF of distal humerus fractures, including fixation failure, nerve injury, and infection. Furthermore, Gofton and colleagues[6] reported complication rates up to 48%, which included heterotopic ossification (17%), infection (9%), and olecranon nonunion (9%).

Ulnar neuropathy in particular poses a unique challenge, as it can be a product of the initial injury, surgical management, or postoperative rehabilitation. The rate of ulnar neuropathy following ORIF of distal humerus fractures has been reported between 0% and 51% in previously described studies.[7,8] It is currently not well understood what the best method is for managing the ulnar nerve during ORIF between leaving the nerve in situ or transposing it.

Huang and colleagues[8] conducted a retrospective evaluation of distal humerus fractures treated operatively at a level 1 trauma center between 1997 and 2005 in patients older than 65 years. At the final follow-up (range 20–99 months), the

Disclosure Statement: The authors have no relevant disclosures.

[a] Hand & Upper Extremity Surgery, Department of Orthopedic Surgery, Arnot Health, Elmira, NY, USA; [b] Department of Orthopedic Surgery, Thomas Jefferson University Hospital, 1025 Walnut Street, Suite 516, Philadelphia, PA 19107, USA; [c] Department of Orthopedic Surgery, Rothman Institute at Thomas Jefferson University, 925 Chestnut, Philadelphia, PA 19107, USA

* Corresponding author.

E-mail address: Talia.chapman10@gmail.com

Hand Clin 34 (2018) 97–103

https://doi.org/10.1016/j.hcl.2017.09.010

mean Mayo Elbow Performance score was 83 (range 55–100) with 6 excellent (95–100), 3 good (75–90), 3 fair (60–74), and 2 poor (less than 60) results. They reported a postoperative rate of ulnar neuropathy of 0%.

Similarly, Doornberg and colleagues[9] conducted a retrospective study looking at 30 adult patients who underwent operative treatment of complete articular fractures of the distal humerus. The average age of this cohort was 35 years. The average length of the follow-up was 19 years (range 12–35 years). They used multiple surveys to assess functional outcomes. Ultimately, they found that at the follow-up, the average flexion arc was greater than 100°, the average Disabilities of Arm, Shoulder, and Hands (DASH) score was comparable with the average score in the general US population and that arthrosis was present in most (80%) of the patients; these outcomes were not independent predictors of patient-rated disability (DASH score) or surgeon-rated elbow function. They also described only a 3% rate of postoperative ulnar neuropathy.

On the other hand, Vazquez and colleagues[10] retrospectively evaluated 69 distal humerus bicolumnar fractures treated with ORIF. In 47 patients, the nerve was left anterior in the subcutaneous tissues; in the remainder of the patients, it was placed back in the cubital tunnel. They reported 14 patients with documented ulnar nerve dysfunction at either the immediate postoperative period or at the final evaluation. In the immediate postoperative period, 7 patients had neuropathy and 4 had been transposed. In 3 of these patients, symptoms resolved at the 1-year point; but 7 additional patients developed neuropathy and, among those, 5 had been transposed. Ultimately, there was no significant difference between the two strategies of handling the ulnar nerve and the development of ulnar neuropathy.

Chen and colleagues[11] performed a retrospective review of 137 consecutive patients who underwent ORIF of an Orthopedic Trauma Association 13A or 13C distal humerus fracture by one of 3 orthopedic trauma surgeons at 2 institutions between 1996 and 2005. Two cohorts were identified: 89 patients (mean age 48.6 years) who had not undergone an ulnar nerve transposition and 48 patients (mean age 43.2 years) who had undergone a transposition during ORIF. The decision for transposition was based on surgeon preference and implant position. They found that symptoms of ulnar neuritis occurred 4 times more frequently in patients who had undergone transposition. The incidence of postoperative ulnar neuritis in patients who had undergone transposition was 16 of 48 (33%) and only 8 of 89 (9%) in patients who underwent in situ decompression. Based on this study, the investigators do not recommend routine transposition of the ulnar nerve at the time of ORIF of distal humerus fractures.

Ruan and colleagues[12] evaluated 117 consecutive patients who sustained an Arbeitsgemeinschaft für Osteosynthesefragen (AO) type C fracture of the distal humerus and were treated with ORIF. They found that 29 of the patients (24.8%) presented with ulnar nerve symptoms before operative treatment. They then divided that cohort into 2 groups: one group received ORIF in conjunction with anterior subfascial transposition of the ulnar nerve and the other group received ORIF in conjunction with in situ decompression. All patients were followed up for an average of 29.5 months postoperatively, and all fractures healed appropriately. They found that in the transposition group, 12 of 15 patients recovered completely and 3 patients recovered partially. In the in situ decompression group, they found that 8 of 14 nerves recovered completely and 6 patients recovered partially. They concluded that transposition of the nerve may have benefits with respect to postoperative recovery of nerve function.

In the Canadian Orthopedic Trauma Society's randomized trial of ORIF versus total elbow arthroplasty for bicolumnar fractures of the distal humerus, 20 patients were randomized to receive ORIF and 20 were randomized to receive total elbow arthroplasty (TEA). Five of the patients randomized to the ORIF group were converted intraoperatively to TEA. They routinely transposed the ulnar nerve in both cohorts and reported that the rate of postoperative ulnar nerve symptoms was 20% (5 patients in the ORIF group and 3 in the TEA group).[3]

Worden and Ilyas[13] conducted a retrospective chart review of all patients aged 18 years and older who underwent ORIF for a distal humerus fracture between 2004 and 2008 at a level I urban academic medical center. Patients were excluded if they had a preinjury history of ulnar nerve dysfunction. The ulnar nerve was either managed with an in situ release or anterior transposition. McGowan[14] staging was used to assess the severity of ulnar nerve dysfunction. Grade I was defined as minimal lesions with no motor weakness of the ulnar intrinsics and paresthesia in the ulnar nerve distribution. Grade II was defined as intermediate lesions with weak interossei and decreased sensation. Grade III was defined as a severe lesion with interossei paralysis and marked hypoesthesia. They included 24 cases and found that 50% of the cases had undergone in situ release and 50% were anteriorly transposed. Ultimately, they reported a 38% incidence of postoperative ulnar

neuropathy in surgically treated distal humerus fractures with 55% graded as McGowan stage 1 and 44% McGowan stage 2. Among the patients with persistent ulnar neuropathy at the final follow-up, 44% (4) had undergone an in situ release and 56% (5) had undergone an anterior transposition. This difference was not statistically significant.

Wang and colleagues[15] evaluated 20 patients with distal intracondylar humerus fractures treated with dual-plate internal fixation and anterior subcutaneous transposition of the ulnar nerve between 1986 and 1990. Olecranon osteotomy was used in all cases. The average age of the cohort was 47 years, and the average follow-up was 26 months. They described 75% of patients attained excellent or good results. They reported no cases of postoperative nerve compression symptoms in the follow-up period.

Lastly, Holdsworth and Mossad[7] reviewed 57 adult patients at an average of 37 months after early internal fixation for displaced fractures of the distal humerus from 1980 to 1986. The surgical approach was varied based on the type of fracture. They reported an incidence of 50% of postoperative ulnar neuropathy, but they noted only 2 patients with symptoms at the latest follow-up.

Despite this relatively high and somewhat varied prevalence, there is no clear consensus regarding the best method for managing the ulnar nerve during ORIF. Given the paucity and contradictory nature of the data, the authors set out to perform a meta-analysis to evaluate whether a best method exists for handling the ulnar nerve, specifically whether in situ management versus transposition results in a lower incidence of postoperative ulnar neuropathy. As a secondary goal, the authors attempted to evaluate whether the hardware location also influenced postoperative ulnar neuropathy.

METHODS

The guidelines set forth by the Preferred Reporting Items for Systematic Reviews and Meta-analyses guided the authors' investigation. The articles were judged based on the following aspects: (1) equality of baseline characteristics, (2) adequate description of inclusion/exclusion criteria and interventions, (3) validity of outcome tools, (4) duration of follow-up, and (5) primary outcome measure. Specifically, studies that reported on the management of the ulnar nerve in distal humerus fracture fixation were included. The main operative treatments had to be distal humerus fracture ORIF. The management of the ulnar nerve had to be documented and then categorized as either in situ or transposition. The following database was searched: PubMed MEDLINE (1950 through March 2016). The search strategy involved the terms *distal humerus*, *open reduction internal fixation*, and *ulnar nerve*. A total of 46 studies were identified by the initial search and assessed. Studies that did not report on how the ulnar nerve was handled or did not report on patients' symptoms as related to the ulnar nerve postoperatively were excluded, yielding 5 studies for inclusion. Also, studies discussing the management of distal humerus fractures with arthroplasty were also excluded. Extracted data from the eligible studies included patient characteristics, sample size, fracture type, length of follow-up, surgical fixation, intraoperative management of the ulnar nerve, and outcomes related to ulnar nerve function. The weighted effect size was calculated (Cohen D) and used as it pertained to in situ versus transposition as well as the presence or absence of a medial plate. Cohen D is an effect size that is used to indicate the standardized difference between 2 means. It expresses this difference of specified means in standard deviation units.

RESULTS

All 5 included studies on distal humerus fractures treated with ORIF with either in situ management or anterior transposition reported on postoperative symptoms of ulnar neuropathy. Study characteristics can be seen in **Table 1**. All 5 studies were retrospective studies, totaling 366 distal humerus fracture cases that underwent ORIF and either ulnar nerve in situ management or anterior transposition. In total, 187 patients were treated with in situ management, whereas 179 underwent transposition. The incidence of ulnar neuritis based on handling of the ulnar nerve can be seen in **Table 1**. The overall incidence of ulnar neuropathy in all cases included in the meta-analysis was 19.3% (range 16%–37% in 362 cases). The meta-analysis found that the incidence of neuropathy in the transposition group was higher (23.5%) as compared with the in situ group (15.3%).

Ruan and colleagues[12] demonstrated that of their 29 patients with type C distal humerus fractures and preoperative ulnar nerve symptoms who underwent ORIF, 3 of the 15 ulnar nerves that were transposed did not recover. Of the 14 that underwent in situ management, 6 continued to have postoperative ulnar neuropathy. Vazquez and colleagues[10] demonstrated in their cohort of type A and type C distal humerus fractures that 7 of 47 patients undergoing transposition developed postoperative ulnar neuritis, whereas 4 of 18 developed neuropathy after in situ management. Worden and Ilyas[13] showed that 5 of 12 patients

Table 1
Characteristics of the studies included in the meta-analysis

Study, Year	In Situ	Transposed	Postoperative Ulnar Neuritis	AO Fracture Classification
Ruan et al, 2009	14	15	3 of 15 Patients with transposition 6 of 14 Patients with in situ management	117 Patients type C
Vazquez et al,[10] 2010	22	47	7 of 47 Patients with transposition 4 of 18 Patients with in situ management	69 Patients type A or C
Worden and Ilyas,[13] 2012	12	12	5 of 12 Patients with transposition 4 of 12 Patients with in situ management	7 Patients AO type A, 2 type B, 15 type C
Chen et al,[11] 2010	89	48	16 of 48 Patients with transposition 8 of 89 Patients with in situ management	4 Patients type A2, 4 type A3, 18 type C1, 61 type C2, 50 type C3
Wiggers et al,[16] 2012	50	57	11 of 57 Patients with transposition 6 of 50 Patients with in situ management	12 Patients type A, 46 type B, 49 type C

who underwent transposition developed postoperative ulnar neuritis and, similarly, 4 of 12 patients who were managed in situ developed postoperative neuropathy. Worden and Ilyas[13] included all types of distal humerus fractures (AO type A, B, C). In a slightly larger cohort, Chen and colleagues[11] described an incidence of postoperative ulnar neuritis in 16 of 48 patients who underwent transposition and 8 of 89 patients who underwent in situ management. All types of distal humerus fractures were included. Lastly, Wiggers and colleagues[16] demonstrated in their cohort of all types of distal humerus fractures that 11 of 57 patients who underwent transposition developed neuritis, whereas 6 of 50 who underwent in situ decompression developed postoperative ulnar neuropathy.

Of the available data from Wiggers and colleagues[16] and Worden and Ilyas,[13] the authors ascertained that, in total, 83 patients underwent medial plating and 23 of these developed postoperative ulnar neuritis: 14 of 62 in the Wiggers and colleagues[16] cohort developed ulnar neuropathy and 9 of 21 in the Worden and Ilyas[13] cohort.

The weighted effect size was calculated (Cohen D) in **Table 2** and used to determine the chance that a person picked at random from the treatment group (transposition group) versus the control group (in situ release) will have a higher incidence of ulnar neuropathy. Similarly, the weighted effect size was calculated (Cohen D) in **Table 2** and used to determine if the presence of a medial plate affected the incidence of postoperative ulnar neuropathy. A calculated weighted effect size (Cohen D value) of 0.427 was interpreted for handling of the ulnar nerve as follows: 66% of the transposition group will be greater than the mean as compared with the control group and, therefore, will have a higher incidence of ulnar neuropathy and 84% of the 2 groups will overlap. There is a 61% chance that a person picked at random from the transposition group will have a higher incidence of ulnar neuropathy as compared with the control group. Furthermore, in order to have an unfavorable outcome in the treatment group, at least 8 people need to be transposed; if 100 people undergo treatment with transposition or in situ management, 13 more patients will experience ulnar neuropathy in the transposition group than in the in situ group.

A weighted effect size (Cohen D value) of 0.6 was calculated and interpreted for the placement of a medial plate and its effect on postoperative ulnar neuropathy. Seventy-three percent of the group receiving a medial plate will be greater than the mean of the control group (no medial plate). There is a 66% chance that a person picked at random from the treatment group (medial plate group) will have an incidence of ulnar neuropathy compared with a person picked at random from

Table 2
Calculated weighted effect size for transposition versus in situ management of the ulnar nerve and for medial plating of distal humerus fractures

	Effect Size Calculations			
Transposition vs Nontransposition	**Individual Effect Size (d)**	**Correlation**	**Sample Size**	**Individual Effect Size (d)**
Ruan et al,[12] 2009	0.89	0.41	29	0.89
Chen et al,[11] 2010	0.62	0.3	137	0.62
Vazquez et al,[10] 2010	0.26	0.13	69	0.26
Worden and Ilyas,[13] 2012	0.49	0.24	24	0.49
Wiggers et al,[16] 2012	0.15	0.07	107	0.15
	Weighted effect size (Cohen D) 0.427			
Medial Plating Studies	**Cohen D**	**Medial Plate**	**Postoperative Ulnar Neuritis**	***P* Value**
Wiggers et al,[16] 2012	0.597	107	14	.02
Ilyas	0.863	21	8	.051
	Weighted effect size (Cohen D) 0.64			

the control group (no medial plate) based on a probability of superiority. In order to have one more unfavorable outcome in the treatment group compared with the control group, 5 patients would need to be treated; if 100 people go through the procedure with medial plating, 21 more people will have ulnar neuropathy with a medial plate as compared with the control group.

DISCUSSION

Despite advances in the management of distal humerus fractures, complications, such as ulnar neuropathy, continue to pose a challenge. The development of ulnar neuropathy has many potential causes. The ulnar nerve may be contused or lacerated at the time of the initial trauma. Iatrogenic causes of ulnar nerve injury include excessive retraction or inadvertent injury during surgical exposure, fracture manipulation, or hardware placement. Surgeon-related technical causes of a postoperative ulnar nerve injury, whether managed in situ or transposed, can include inadequate decompression, aggressive decompression with devascularization of the nerve, or traumatic handling of the nerve during its dissection. Similarly, swelling and hematoma formation in the immediate perioperative period may also contribute to injury to the ulnar nerve. Delayed causes of ulnar neuropathy can be related to limitations in motion and in particular loss of terminal extension, soft tissue scarring, heterotopic ossification, and prominent hardware. As evidenced from the earlier discussion, the ulnar nerve is at risk preoperatively at the time of the injury, intraoperatively during exposure and fixation, and even postoperatively during healing. Although most studies report the incidence of ulnar neuropathy between 0% and 38%, one study reported a rate of 51%.[7] Because of this high prevalence, careful planning and management of the ulnar nerve is necessary. Unfortunately, no prospective cohort studies or randomized trials exist that reliably and objectively diagnose preoperative ulnar nerve dysfunction, immediate postoperative function, and delayed postoperative ulnar nerve dysfunction. Moreover, the surgical handling of the ulnar nerve has also not been standardized and is often not well documented in published series.

The findings of this meta-analysis yield that in situ management of the ulnar nerve resulted in less postoperative ulnar neuropathy than with transposition. The potential advantages and disadvantages of in situ management of the ulnar nerve are less nerve manipulation and compromised vascularity but more risk of direct nerve injury during fracture fixation. In contrast, the potential advantages and disadvantages of transposition are greater nerve protection by moving it away from the fracture site but with more risk of nerve injury, devascularization, and scar formation

following greater nerve manipulation. Overall, the authors found the overall incidence of ulnar neuropathy of 19.3% reasonable but were surprised that transposition resulted in greater postoperative neuropathy than in situ management. This surprise was based on 2 assumptions: first, that equality exists between in situ decompression and transposition in primary nontraumatic ulnar neuropathy of the elbow[17] and, second, that a transposition would minimize direct nerve injury during fracture manipulation perioperatively and that transposition would protect better against swelling and prolonged flexion postoperatively.

Regarding the fixation strategy, often medial and lateral plates are needed to manage distal humerus fractures. Based on the authors' data using weighted effect sizes (see **Table 2**), more patients will have postoperative ulnar neuropathy with a medial plate. They found this result to be intuitive, as the plate would likely require more manipulation of the nerve intraoperatively and could potentially cause irritation and perineural scarring postoperatively. Ultimately, the decision to apply a plate medially will be based on the needs of adequate fracture fixation. However, the findings of this meta-analysis can be considered to avoid medial plating, if not absolutely necessary for fracture fixation.

This meta-analysis, like most, has several shortcomings. The primary limitation is the heterogeneity of the included retrospective studies as well as the deficiency in the number of studies. Specific to this meta-analysis, preexisting ulnar nerve dysfunction is not clearly defined in all of these studies nor is the total recovery time from ulnar nerve injury. Furthermore, the degree of injury that the ulnar nerve suffered in each case is not clear, as it was not reliably classified in a consistent manner. Lastly, the surgeon's rationale of choosing either in situ management or transposition was no well documented and the surgical technique that was used was not always well described.

SUMMARY

There is a substantial incidence of postoperative ulnar nerve dysfunction following open reduction and plate and screw fixation of the distal humerus. The goal of this meta-analysis was to assess if a best method exists for handling the ulnar nerve, specifically whether in situ decompression versus ulnar nerve transposition results in a lower incidence of postoperative ulnar neuropathy. A secondary goal was to assess if the plate position contributed to nerve dysfunction. The authors found that postoperative ulnar neuropathy was more prevalent in those patients who underwent a transposition as opposed to in situ management. The authors can draw the conclusion that transposition of the ulnar nerve during this procedure does not have a protective effect, and instead in situ release may be more advantageous. Moreover, the findings of this meta-analysis discourage the placement of a medial plate when mechanically allowed.

REFERENCES

1. Galano GJ, Ahmad CS, Levine WN. Current treatment strategies for bicolumnar distal humerus fractures. J Am Acad Orthop Surg 2010;18(1):20–30.
2. Zlotolow DA, Catalano LW III, Barron OA, et al. Surgical exposures of the humerus. J Am Acad Orthop Surg 2006;14:754–65.
3. McKee M, Veillette CJ, Hall JA, et al. A multicenter, prospective, randomized, controlled trial of open reduction-internal fixation versus total elbow arthroplasty for displaced intra-articular distal humeral fractures in elderly patients. J Shoulder Elbow Surg 2009;18:3–12.
4. Ring D, Jupiter JB. Complex fractures of the distal humerus and their complications. J Shoulder Elbow Surg 1999;8:85–97.
5. Sodergard J, Sandelin J, Bostman O. Postoperative complications of distal humerus fractures. Acta Orthop Scand 1992;63(1):85–9.
6. Gofton WT, Macdermid JC, Patterson SD, et al. Functional outcome of AO type C distal humeral fractures. J Hand Surg Am 2003;28(2):294–308.
7. Holdsworth BJ, Mossad MM. Fractures of the adult distal humerus. Elbow function after internal fixation. J Bone Joint Surg Br 1990;72(3):362–5.
8. Huang JI, Paczas M, Hoyen HA, et al. Functional outcome after open reduction internal fixation of intra-articular fractures of the distal humerus in the elderly. J Orthop Trauma 2011;25(5):259–65.
9. Doornberg JN, van Duijn PJ, Linzel D, et al. Surgical treatment of intra-articular fractures of the distal part of the humerus. Functional outcome after twelve to thirty years. J Bone Joint Surg Am 2007;89(7):1524–32.
10. Vazquez O, Rutgers M, Ring DC, et al. Fate of the ulnar nerve after operative fixation of distal humerus fractures. J Orthop Trauma 2010;24(7):395–9.
11. Chen RC, Harris DJ, Leduc S, et al. Is ulnar nerve transposition beneficial during open reduction internal fixation of distal humerus fractures? J Orthop Trauma 2010;24(7):391–4.
12. Ruan HJ, Liu JJ, Fan CY, et al. Incidence, management, and prognosis of early nerve dysfunction in type C fractures of distal humerus. J Orthop Trauma 2009;67(6):1397–401.
13. Worden A, Ilyas AM. Ulnar neuropathy following distal humerus fracture fixation. Orthop Clin North Am 2012;43(4):509–14.
14. McGowan A. The results of transposition of the ulnar nerve for traumatic ulnar neuritis. J Bone Joint Surg Br 1950;32-B(3):293–301.

15. Wang KC, Shih HN, Hsu KY, et al. Intercondylar fractures of the distal humerus: routine anterior subcutaneous transposition of the ulnar nerve in a posterior operative approach. J Orthop Trauma 1994;36(6):770–3.
16. Wiggers JK, Brouwer KM, Helmerhorst GTT, et al. Predictors of diagnosis of ulnar neuropathy after surgically treated distal humerus fractures. J Hand Surg Am 2012;37(6):1168–72.
17. Macadam SA, Gandhi R, Bezuhly M, et al. Simple decompression versus anterior subcutaneous and submuscular transposition of the ulnar nerve for cubital tunnel syndrome: a meta-analysis. J Hand Surg Am 2008;33A:1314–24.