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Retrospective Cohort Study

Low risk of postoperative ulnar nerve affection in surgically treated distal humeral fractures when the nerve is released *in situ*

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Abstract

BACKGROUND

Adult distal humeral fractures (DHF) comprise 2%-5% of all fractures and 30% of all elbow fractures. Treatment of DHF may be technically demanding due to fracture complexity and proximity of neurovascular structures. Open reduction and internal fixation (ORIF) are often the treatment of choice, but arthroplasty is considered in case of severe comminution or in elderly patients with poor bone quality. Ulnar nerve affection following surgical treatment of distal humerus fractures is a well-recognized complication.

AIM

To report the risk of ulnar nerve affection after surgery for acute DHFs.

METHODS

We retrospectively identified 239 consecutive adult patients with acute DHFs who underwent surgery with ORIF, elbow hemiarthroplasty (EHA) or total elbow arthroplasty (TEA) between January 2011 and December 2019. In all cases, the ulnar nerve was released *in situ* without anterior transposition. We used our institutional database to review patients' medical records for demographics, fracture morphology, type of surgery and ulnar nerve affection immediately; records were reviewed after surgery and at 2 wk and 12 wk of routine clinical outpatient follow-up. Twenty-nine percent patients were excluded due to pre- or postoperative conditions. Final follow-up examination was a telephone interview in which ulnar nerve affection was reported according to the McGowen Classification Score. A total of 210 patients were eligible for interview, but 13 patients declined participation and 17 patients failed to respond. Thus, 180 patients were included.

RESULTS

Mean age at surgery was 64 years (range 18-88 years); 121 (67.3%) patients were women; 59 (32.7%) were men. According to the AO/OTA classification system, we recorded 47 patients with type A3, 55 patients with type B and 78 patients with type C fractures. According to the McGowen Classification Score, mild ulnar nerve affection was reported in nine patients; severe affection, in two. A total of 69 patients were treated with ORIF of whom three had mild temporary ulnar nerve affection and one had severe ulnar nerve affection. In all, 111 patients were treated with arthroplasty (67 EHA, 44 TEA) of whom seven had mild ulnar nerve affection and one had severe persistent ulnar nerve affection. No further treatment was provided.

CONCLUSION

The risk of ulnar nerve affection after surgical treatment for acute DHF is low when the ulnar nerve is released *in situ* without nerve transposition, independently of the treatment provided.

Key Words: Humeral fracture; Arthroplasties; Internal fixation; Ulnar nerve affection; *In situ* release

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Core Tip: Ulnar nerve affection after surgery for distal humerus fractures (DHF) is a known complication. We retrospectively reviewed a consecutive series of 180 patients with acute DHF treated either with open reduction and internal fixation (ORIF), total elbow arthroplasty (TEA) or elbow hemiarthroplasty (EHA). According to the McGowan Classification Score, 11 patients reported ulnar nerve affection symptoms (nine patients with mild affection and two patients with severe affection). The risk of ulnar nerve affection after surgery for acute DHF is low when the ulnar nerve is released *in situ* without transposition, independently of the treatment provided (*i.e.*, ORIF, EHA, or TEA).

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INTRODUCTION

Adult distal humeral fractures (DHF) comprise approximately 2%-5% of all fractures and 30% of all elbow fractures[1,2]. Open reduction and internal fixation (ORIF) is often the treatment of choice, but arthroplasty [elbow hemiarthroplasty (EHA) or total elbow arthroplasty (TEA)] may be considered in case of severe comminution or in elderly patients with poor bone quality[3-5]. Ulnar nerve affection is a known complication associated with surgical treatment of distal humerus fractures[6]. The development of ulnar affection has many potential aetiologies[7]. The ulnar nerve may be contused or lacerated at the time of the initial trauma or at the time of the surgical intervention, particularly from excessive retraction during fracture exposure or fixation. Swelling in the immediate posttraumatic or postoperative setting may also contribute to ulnar nerve affection. Postoperatively, soft tissue scar formation, heterotopic ossification and prominent hardware may represent aetiological factors for ulnar nerve affection. During surgery, mobilisation of the ulnar nerve is often necessary for protection and to reduce and fixate the fracture or to perform a joint arthroplasty. Most injuries are described to give temporary paraesthesia without motoric affection[8,9]. In some rare cases, severe ulnar affections are seen with weakness and atrophy of one or more of the ulnar intrinsic muscles, leading to claw hand deformity, which compromises the outcome[10]. Some surgeons perform anterior transposition of the ulnar nerve, which has theoretical advantages including moving the nerve away from the implants, preventing kinking of an incompletely released nerve, avoiding subluxation over the medial epicondyle, limiting entrapment in scar tissue and allowing nerve-free excursion[11-13]. On the other hand, transposition requires further nerve dissection with a potential risk of additional trauma, devascularisation and prolonged operative time[12,14]. How the ulnar nerve is best protected during surgery is still debated[9].

This study aimed to report the risk of ulnar nerve affection after surgery for acute DHF with *in situ* release and protection of the ulnar nerve without anterior transposition. The secondary outcome was to investigate if the type of surgery performed is a risk factor for postoperative ulnar nerve affection.

MATERIALS AND METHODS

Study design

This was a retrospective study conducted within a consecutive cohort of patients surgically treated for distal humerus fracture. The study was conducted in accordance with the STROBE guidelines[15].

Study population

We used our institutional database to identify all adult patients surgically treated for acute DHF during the nine-year period from 2011 to 2019. A total of 239 patients were identified (Figure 1). Twenty-nine percent patients were excluded due to pre-operative nerve affection, postoperative infection and reoperation, other fractures adjacent to the elbow and pathological fractures. Additionally, we excluded patients whose data could not be retrieved due to immigration and cognitive impairment. Thus, 210 patients were eligible for the final telephone interview. In all, 13 patients opted out of participating, and 17 patients failed to respond to the phone calls. According to the medical records, four of these 30 patients had mild paraesthesia without motoric affection in the immediate postoperative period, which resolved spontaneously during the first 12 postoperative weeks. Thus, 180 patients were included in the study.

Participants included 121 (67.3%) women and 59 (32.7%) men. The mean age was 64 years (18-88 years). The mean follow-up was six years (3-11 years). According to the OTA/AO Classification, we recorded 47 patients with type A (7 type A2 and 40 type A3), 55 patients with type B (15 type B1, 18 type B2, and 22 type B3) and 78 patients with type C (19 type C1, 30 type C2, and 29 type C3). The fractures were classified by the first author using conventional X-rays supplied with computed tomography (CT) if available. A total of 69 patients were treated with ORIF, 67 with EHA and 44 with TEA.

Treatment, surgical technique and rehabilitation

According to our treatment algorithm, conservative treatment is indicated for non-displaced fractures and in patients with severe comorbidities where the risk of surgery outweighs its benefit. Arthroplasty is considered for comminuted intra-articular fractures unamenable for ORIF. EHA is preferred in active patients, whereas TEA is preferred in elderly and low-demanding patients and patients with radiographic signs of osteoarthritis. Conventional radiographs were performed in all cases, and CT was used for preoperative planning in selected cases.

All patients were operated in the lateral decubitus position with a standard posterior midline approach. All operations were performed in general anaesthesia. Tourniquets were used in all cases. All patients were operated within two weeks from their injury (range 2-14 d). The ulnar nerve was identified, released *in situ* and protected. The ulnar nerve was not transposed. All procedures were performed using a triceps split with a reverse Y-shaped incision in the triceps[16] except for OTA/AO type 13A fractures where a triceps-sparing approach with medial and/or lateral windows was adopted at the surgeon's discretion and the fracture comminution. In the ORIF group, all patients were operated with double plates [Synthes Locking Plate System (West Chester, PA, United States), VariAx Locking Plate System (Stryker, Kalamazoo, MI, United States), or Acumed Elbow Plating System (Hillsboro, OR, United States)]. The Latitude (WRIGHT, Memphis, TN, United States) was used as EHA and the Coonrad-Morrey elbow arthroplasty (Zimmer Biomet, Rochester, MN, United States) as TEA.

All patients performed oedema prophylactic exercises of the hand and fingers during the time of immobilisation. In ORIF and EHA groups, a posterior splint was used for two weeks. Passive exercises were allowed from week two to week six, and light weight bearing was permitted after six weeks. Full weight-bearing exercises were allowed after three months. In TEA, group mobilisation was initiated on the first postoperative day or as soon as discomfort allowed, with retention of the bulky dressing. Mobilisation was proceeded incrementally according to the patient's level of discomfort. Patients were instructed to keep the arm in a sling, except when they were exercising it. They were also instructed specifically to avoid resisted extension and lifting during the first six postoperative weeks. Thereafter, they were advised to stretch the elbow into full extension and full flexion daily, progressively increasing their level of activity as their discomfort decreased. They were advised to indefinitely refrain from strenuous manual activities such as carrying more than 5 kg loads with the treated arm.

Outcome

Medical records were reviewed for demographics, fracture morphology, type of surgery and ulnar nerve affection immediately after surgery and at 2 wk and 12 wk of routine clinical outpatient follow-up. All patients participated in a final telephone interview, and ulnar nerve conditions were reported. Ulnar nerve affection was categorised according to the McGowan Classification Score[17]. Mild affection was identified as paraesthesia in the 4th and 5th fingers aggravated by elbow flexion (grade 1). Paraesthesia with additional weakness and clumsiness of the interossei was graded as moderate (grade 2); and severe symptoms in form of interossei paralysis and marked hypoesthesia in the 4th and 5th fingers were identified as severe affection (grade 3). Routine electromyographic studies were not performed.

Statistical analysis

Descriptive statistics for continuous variables were presented as mean, minimum and maximum values. Categorical variables were presented by frequencies and percentages. A binary logistic regression model was used to compare the risk of ulnar nerve affection for different types of surgery. The results were presented as odds ratio (OR) with 95% confidence intervals (CI) and *P* values. The ORIF group was used as a reference. *P* values < 0.05 were considered statistically significant. The analyses were performed using SPSS software (version 25.0, IBM, Armonk, NY, United States).

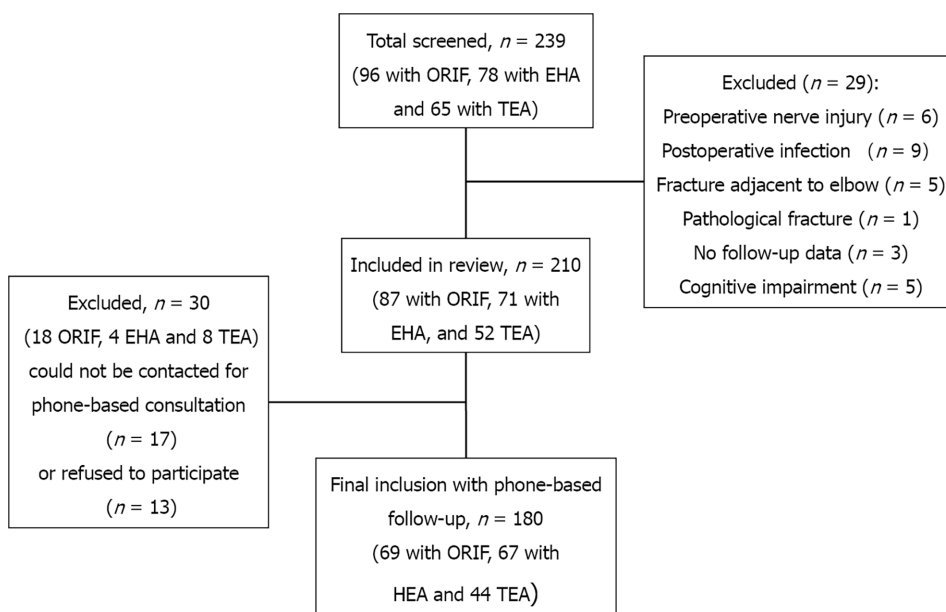
RESULTS

Eleven patients (6%) had post-operative ulnar nerve affection during the follow-up period; seven women and four men. Four of these patients were treated with ORIF, four with EHA and three with TEA (Table 1).

Table 1 List of patients with ulnar nerve affection

Patient number	AO fracture classification	Gender	Age at surgery	Surgery type	The onset of affection postoperatively	McGowan grade
1	A3	F	67	ORIF	Two weeks	3
2	C3	F	73	EHA	Two years	3
3	C3	F	63	EHA	Immediately	1
4	C2	M	61	EHA	Immediately	1
5	C3	F	70	TEA	Immediately	1
6	C2	F	79	EHA	Two weeks	1
7	C3	M	68	TEA	Two weeks	1
8	C1	F	66	ORIF	Immediately	1
9	A3	M	53	ORIF	Immediately	1
10	B1	M	48	ORIF	Two weeks	1
11	B3	F	82	TEA	Immediately	1

AO: Arbeitsgemeinschaft für osteosynthesefragen; ORIF: Open reduction and internal fixation; EHA: Elbow hemiarthroplasty; TEA: Total elbow arthroplasty.



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Figure 1 Study flowchart summarizing screening, inclusion, exclusion and final phone-based patient follow-up. ORIF: Open reduction and internal fixation; EHA: Elbow hemiarthroplasty; TEA: Total elbow arthroplasty.

Six patients had ulnar nerve affection immediately after surgery. The symptoms were mild paraesthesia in the 4th and 5th fingers (McGowan grade 1, which resolved spontaneously before the 12-wk follow-up examination).

Four patients had ulnar nerve affection with onset around the two-week follow-up. Three of these patients had mild symptoms with paraesthesia in the 4th and 5th fingers (McGowan grade 1), which resolved spontaneously before the 12-wk follow-up examination. The fourth patient had persistent severe symptoms in the form of interossei paralysis and marked hypoesthesia in the 4th and 5th fingers (McGowan grade 3).

One patient had persistent, severe symptoms (McGowan grade 3) in the form of interossei paralysis and marked hypoesthesia in the 4th and 5th fingers with onset during the second year.

No difference was observed in the risk of ulnar nerve affection between patients treated with ORIF or EHA (OR = 1.03, 95%CI: 0.25, 4.31, $P = 0.97$) or between patients treated with ORIF or TEA (OR = 1.19, 95%CI: 0.25, 5.59, $P = 0.83$).

DISCUSSION

In this study, 11 out of 180 patients (6%) had ulnar nerve affection after surgery for distal humerus fractures. However, only two patients (1%) had severe and persistent ulnar nerve affection (McGowan grade 3). Ulnar nerve affection may occur due to excessive retraction during exposure, or the nerve may become affected after surgery due to hardware irritation or scar tissue formation. This may explain the late symptom onset in some patients. In this study, we focused on per- and post-operative nerve affection. We excluded patients with pre-operative ulnar nerve affection and patients complicated by postoperative infection. Surgery of the ulnar nerve may consist of either subcutaneous anterior transposition or *in situ* release retaining the nerve in its original position. However, which method should be preferred is debatable. Several retrospective studies have reported a risk of ulnar nerve affection after surgery for DHF where the nerve was either anteriorly transposed or released *in situ*, but they have drawn different conclusions[6]. We used the McGowan Classification Score[17] to evaluate the postoperative ulnar nerve affection and to grade the severity of the nerve affection. We chose this classification system to ensure the comparability of our results to the results of those previously published studies.

However, the true prevalence of ulnar nerve affection after elbow injury remains unknown as studies have not successfully differentiated between acute injury-related, acute surgery-related and delayed (subacute or chronic) ulnar affections. Furthermore, in most of these retrospective case series, careful evaluation of ulnar nerve function was not reported[18].

Wiggers *et al*[19] retrospectively analysed a cohort of 107 consecutive adult patients with surgically treated distal humerus fractures to determine risk factors for development of ulnar affection. These risk factors included age, sex, implant over or below the medial epicondyle and total number of surgeries. They found that columnar fracture and application of a medial plate were the only potential risk factors for iatrogenic postoperative ulnar affection.

To identify factors related to ulnar nerve affection, Vazquez *et al*[20] retrospectively evaluated 69 DHF treated with or without ulnar nerve transposition. They reported 14 patients with documented ulnar nerve affection either in the immediate postoperative period or at the final evaluation; and the prevalence of post-operative affection reached 16%. They concluded that transposition of the nerve did not significantly decrease the risk of iatrogenic ulnar affection. However, the optimal handling of the ulnar nerve remains uncertain even though anterior transposition in the acute surgical treatment of displaced distal humerus fractures seems to be associated with a high risk of ulnar nerve affection [20].

Chen *et al*[21] retrospectively investigated the risk of ulnar nerve affection in 170 patients who underwent ORIF for acute distal humeral fracture. The study groups consisted of patients who did not undergo ulnar nerve transposition at the time of fracture fixation and a control group of patients who did undergo ulnar nerve transposition during fracture fixation. They reported that the risk of ulnar nerve affection was four times higher after transposition (33%) than (9%) in the *in situ* release group. They suggested three explanations for this observation. The first was devascularisation of the nerve during transposition, the second was iatrogenic compression resulting from an overlying tight transposition and the third was an inadequate proximal release of the arcade of Struthers or the medial intermuscular septum. The study was limited by selection bias that was potentially introduced by the surgeon's decision to perform a transposition. Even so, the decision to transpose was based on a best practice scenario.

Likewise, in a retrospective series of 83 total elbow arthroplasties, Dachs *et al*[22] observed a lower incidence of ulnar nerve affection when they used *in situ* release of the nerve than when they used transposition. They recommended that transposition of the nerve should be reserved for cases with marked limitation of preoperative elbow flexion or when deemed necessary at intraoperative assessment, like abnormal tracking or increased tension on the nerve after insertion of the prosthesis.

Ahmed *et al*[12] conducted a retrospective cohort study of 97 consecutive patients with distal humerus fractures who underwent ORIF where subcutaneous ulnar nerve anterior transposition was compared with no transposition at the time of ORIF. They found a five-fold increase in ulnar nerve affection following transposition (35.7% for transposition; 14.5% for no transposition). However, this study may suffer from selection bias because nerve transposition was not conducted systematically.

In the present study, we found that *in situ* release and protection of the ulnar nerve without transposition produced a low prevalence of postoperative ulnar nerve affection for both ORIF and arthroplasty surgery following distal humerus fracture. The potential advantage of *in situ* management of the ulnar nerve is less manipulation of the nerve and its vascularity. In contrast, the potential disadvantages of transposition are a higher risk of nerve affection, devascularisation and scar formation.

The present study is primarily limited by its retrospective design. Additionally, the data collection process depended on the accuracy of follow-up reports from the outpatient clinic during the initial follow-up period. Another limitation is that electromyographic examination was generally not used to confirm ulnar nerve affection. This may lead to information bias due to, *e.g.*, misclassification of ulnar nerve affection.

In addition, the study comprised initial follow-up examinations only at two and 12 wk, which makes it difficult to report the exact time of onset and when the symptoms resolved. Furthermore, we had no information about the length of tourniquet time, which may possibly have influenced ulnar nerve affection.

The main strength of this study is its large sample. Further strengths include that all eligible patients were reviewed, that the surgeries were performed by speciality-trained surgeons in a single centre, that the follow-up period was mean seven years and that an independent reviewer conducted the final telephone interview. In contrast to the previously published studies, we were able to compare the risk of ulnar nerve affection after ORIF, EHA, and TEA.

CONCLUSION

The risk of ulnar nerve affection after surgery for acute DHF is low when surgeons use *in situ* ulnar nerve release without nerve transposition, regardless of the treatment provided (*i.e.*, ORIF, EHA, or TEA).

ARTICLE HIGHLIGHTS

Research background

Ulnar nerve affection following surgical treatment of distal humerus fractures (DHF) is a well-recognized complication. Surgery of the ulnar nerve may consist of either subcutaneous anterior transposition or *in situ* release retaining the nerve in its original position. However, which method should be preferred is debatable. We believe that *in situ* release and protection of the ulnar nerve without transposition produced a low prevalence of postoperative ulnar nerve affection for both Open reduction and internal fixation (ORIF), Total elbow arthroplasty, (TEA) and elbow hemiarthroplasty (EHA) surgeries of distal humerus fracture. In contrast to the previously published studies, we were able to compare the risk of ulnar nerve affection after ORIF, EHA, and TEA.

Research motivation

Several retrospective studies have reported a risk of ulnar nerve affection subsequent to surgery for distal humeral fractures (DHF), where either the nerve was anteriorly transposed or released *in situ*. However, these studies have arrived at differing conclusions. As a result, we were motivated to conduct a detailed investigation into the prevalence of pre- and post-operative ulnar nerve affection when the nerve is released *in situ*. To this end, we excluded patients who were presented with pre-operative ulnar nerve affection, as well as those who were afflicted with postoperative infection.

Research objectives

To report the risk of ulnar nerve affection after surgeries (ORIF, TEA, and EHA) for acute DHF when the ulnar nerve is *in situ* released without transposition.

Research methods

We retrospectively reviewed a consecutive series of 180 patients with acute DHF treated either with ORIF, TEA, or EHA.

Research results

Our study found a low risk of ulnar nerve affection following surgical treatment for acute DHF when the ulnar nerve was released *in situ* without nerve transposition. Of the 180 patients included in the study, only nine reported mild ulnar nerve affection and two reported severe affection according to the McGowen Classification Score. The study also found that the type of surgery (ORIF, EHA, or TEA) did not significantly affect the risk of ulnar nerve affection. Three out of 69 patients treated with ORIF had mild temporary ulnar nerve affection, while seven out of 111 patients treated with arthroplasty (67 EHA, 44 TEA) had mild ulnar nerve affection and one had severe persistent affection.

Research conclusions

The findings of our study suggest that releasing the ulnar nerve *in situ* without transposition during surgical treatment of acute DHF may help minimize the risk of ulnar nerve affection, regardless of the type of surgery performed.

Research perspectives

Further research may be needed to confirm these results and explore other potential risk factors for ulnar nerve affection in DHF patients.

FOOTNOTES

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