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Research Paper

Comparing Surgical Outcomes of Distal Humerus Fractures Between Dominant and Non-dominant Upper Limbs in Adults: A Retrospective Study

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ABSTRACT

Background: Distal humerus fractures are relatively rare, accounting for about one-third of humeral fractures and approximately 2% of all fractures in adults. These injuries can significantly impact upper limb function, particularly when the dominant limb is affected.

Objectives: This study aimed to assess whether involvement of the dominant upper limb, along with factors such as gender and smoking, influences postoperative disability measured by the disabilities of the arm, shoulder, and hand (DASH) score.

Methods: In this cohort study, patients with surgically treated distal humerus fractures were prospectively followed. Data on demographic variables, hand dominance, smoking status, and DASH scores at follow-up were collected. The primary outcome was the postoperative DASH score. Statistical analysis was performed to determine the relationship between dominant limb involvement and DASH score, adjusting for confounders such as sex and smoking.

Results: A total of 116 patients were included. DASH scores were significantly higher in patients with dominant limb involvement (Mean±SD: 37.96±36.25) compared to non-dominant limb involvement (26.21±23.27) (P=0.03), indicating greater disability. Female gender (mean DASH: 38.36 vs 25, P=0.01) and smoking (mean DASH: 45.37 vs 27.53, P=0.007) were also significantly associated with higher disability scores.

Conclusion: Upper extremity disability, as measured by the DASH score, is significantly greater when the dominant limb is involved in distal humerus fractures. Female sex and smoking are also associated with worse functional outcomes. These findings highlight the importance of considering dominance and modifiable risk factors in prognosis and rehabilitation planning.

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Introduction

Distal humerus fractures are relatively uncommon, accounting for approximately one-third of all humeral fractures and about 2% of all fractures in adults. The age distribution of these fractures is bimodal, with a peak incidence among males aged 12–19 years and another in females over 80 years of age [1]. According to the Orthopedic Trauma Association (OTA) and association for the study of internal fixation (AO) classification system, distal humerus fractures are categorized into three types: extra-articular (type A), partial intra-articular (type B), and complete intra-articular fractures (type C). Intra-articular fractures can further be subdivided into unicondylar, bicondylar, capitellum, and trochlear fractures [2].

Simple radiographs in anteroposterior and lateral views are typically sufficient for diagnosing complete intra-articular fractures; however, partial intra-articular fractures often require CT scans with 3D reconstruction for thorough assessment [1].

Open reduction and internal fixation (ORIF) remains the gold standard for managing these injuries, but it is associated with several complications. Common postoperative complications include osteoarthritis, implant failure (loosening, breakage, or migration), discomfort at the implant site, heterotopic ossification (HO), ulnar, median, and radial neuropathies, elbow stiffness or contracture, nonunion or malunion, varus or valgus deformities, avascular necrosis, hematoma, triceps detachment, triceps weakness, and superficial or deep infections, including septic arthritis [3]. The ultimate goal of treatment is to minimize complications, restore upper limb function, and achieve maximum elbow range of motion [4].

Numerous factors may influence the risk of complications and functional outcomes, such as patient demographics (age, sex, body mass index [BMI], Charlson comorbidity index [CCI], smoking status), injury details (mechanism, soft tissue condition, AO/OTA fracture classification, associated fractures), and surgical management (type of fixation, timing of surgery). Smoking, for instance, significantly increases the risk of nonunion [5-7].

Upper limb dominance is a known determinant of muscle strength and fine motor skills [8], yet its role in predicting surgical outcomes of upper limb fractures remains underexplored. A few studies have suggested poorer outcomes for fractures involving the dominant limb, whereas others have found no significant association between limb dominance and prognosis [6]. Given this uncertainty, our study aims to compare the surgical outcomes and complication rates of distal humerus fractures in dominant versus non-dominant upper limbs in adult patients who underwent ORIF at Rasool Akram Hospital between 2017 and 2021.

Methods

This retrospective cohort study was conducted at the Orthopedic Department of Hazrat Rasool Akram Hospital in Tehran City, Iran. After obtaining ethical approval from the institutional review board and registration of the study protocol, the researchers designed a structured questionnaire containing variables relevant to the study objectives. Patient data were extracted from archived medical records, and additional information was collected through structured telephone interviews.

Eligible participants were patients aged 18 years or older who had undergone ORIF for distal humerus fractures between the years 1396 and 1400 in the Iranian calendar (equivalent to 2017–2021 Western calendar). Patients were identified by reviewing the orthopedic surgery archive. Medical records were screened, and demographic and surgical details were extracted. Cases meeting the inclusion criteria were recorded, and their contact information was collected for follow-up.

During the telephone interviews, after obtaining verbal consent, patients were asked questions related to the dominant or non-dominant side of the affected upper limb, age, sex, postoperative complications (including neuropathy, pain, and implant-related issues), and time to initial elbow mobilization. Functional outcome was assessed using the disabilities of the arm, shoulder, and hand (DASH) questionnaire. The DASH score was calculated using the Equation 1:

1. [(Sum of n responses/n)−1]×25

yielding a score from 0 (no disability) to 100 (most severe disability). Scores were not calculated for questionnaires with more than three missing items.

Patients were divided into two groups based on whether the dominant or non-dominant upper limb was affected. The collected data were then analyzed and compared between the two groups. The final analysis included 116 patients after excluding 11 patients due to missing data on limb dominance, bilateral involvement, or insufficient responses for DASH scoring.

The minimum required sample size was calculated based on prior literature [6]. Considering an 80% power and 95% confidence level, yielding 58 patients per group (116 in total). A census sampling method was used to include all eligible patients within the defined period.

Descriptive statistics were used to summarize the data. For continuous variables, measures of central tendency and dispersion (Mean±SD) were reported. Categorical variables were summarized using frequencies and percentages. The normality of quantitative variables was assessed, and appropriate parametric (t-test, analysis of variance) or non-parametric (Mann–Whitney U test, Kruskal–Wallis test) methods were used for group comparisons. The chi-square test was applied for categorical variables. All statistical analyses were performed using SPSS software, version 28.

Ethical considerations were strictly followed throughout the study. Approval was obtained from the Institutional Research Ethics Committee, and hospital authorities granted permission. Patient data were handled confidentially, and no misleading information or undue expectations were conveyed during interviews. Efforts were made to ensure respectful and informative communication to encourage patient participation in follow-up assessments.

Results

In this retrospective cohort study, 116 patients who underwent ORIF for distal humerus fractures at Rasool Akram Hospital, Tehran, between 2017 and 2021 were included. The cohort consisted of 58 males and 58 females. Among them, 54 patients had involvement of the dominant upper limb, while 62 had injuries on the non-dominant side.

Regardless of fracture type, sex, or age, all patients required a minimum of four weeks to return to daily activities and regain functional use of the arm following surgery and physiotherapy. The mean time to recovery was 11 weeks. However, involvement of the dominant limb did not significantly affect the duration of recovery, as only 37.7% of patients with dominant limb involvement recovered in less than the mean duration.

The mean DASH score across all patients was 32. In patients with dominant upper limb involvement, the mean DASH score was significantly higher (37.96) compared to those with non-dominant limb involvement (26.21) (P=0.038, t-test), indicating poorer functional outcomes in the former group. When further subdividing by laterality, no significant differences in DASH scores were found between right-dominant (36) and left-dominant (36) cases, or between right (27) and left (27) non-dominant cases; hence, these subgroups were not further statistically analyzed.

Gender also had a significant influence on functional outcome. Female patients had a significantly higher mean DASH score (38.36) than males (25) (P=0.017, t-test), indicating worse prognoses in women.

Smoking status was another influential factor. Among the 27 patients who were smokers, the mean DASH score was 45.37, significantly higher than the 27.53 observed in non-smokers (P=0.007, t-test), suggesting that smoking adversely affects functional recovery.

In terms of range of motion, the mean flexion-extension arc reached 76% of the normal 135° in all patients. The average was 76% in the dominant limb group and 75% in the non-dominant group. Reduced flexion-extension angle was observed in 74.19% of patients with dominant limb involvement and in 59.25% of those with non-dominant limb involvement.

Chronic pain unrelated to activity was reported in 46 patients, of whom 34 had dominant limb involvement and 12 had non-dominant limb involvement. This corresponds to 54.83% of dominant-side patients and 22.22% of non-dominant-side patients.

Neuropathy, including cold sensitivity and paresthesia, was present in 42 patients: 28 in the dominant group and 14 in the non-dominant group. This represents 45.16% and 25.92% of the respective groups.

Triceps muscle weakness was observed in 80 patients. Among them, 42 had dominant limb involvement (70.37%) and 38 had non-dominant involvement (67.74%).

Upper limb deformities were documented in 66 patients: 37 with dominant and 28 with non-dominant side involvement. This figure accounts for 64.51% of dominant-side cases and 51.85% of non-dominant ones.

Table 1 summarizes the relationship between the DASH score and various demographic and clinical variables, indicating that higher DASH scores; reflecting poorer upper limb function, were significantly associated with dominant upper limb involvement, female gender, and smoking status (all P<0.05), while the side of limb involvement (right vs left) had no significant impact within either the dominant or non-dominant groups.

Table 1. The relationship between the DASH score and various demographic and clinical variables

Variable	Group	No. (%)	Mean±SD (range) DASH	P
Dominant Upper Limb Involvement	Yes	54	37.96±36.25 (0–96)	<0.05 (0.038)
	No	62	26.21±23.27 (0–92)	
Dominant Side (Among Dominant Cases)	Right	48	36±22 (0–96)	>0.05
	Left	6	36±18 (6.8–77)	
Dominant Side (Among Non-Dominant Cases)	Right	54	27±20 (0–92)	
	Left	8	27±19 (0–86)	
Gender	Female	58	38.36± 34.48 (0-96)	<0.05 (0.017)
	Male	58	25±24.33 0-93)	
Smoking status	Smoker	27	45.37±33.99	<0.05 (0.007)
	Non-smoker	89	27.53±28.21	

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Discussion

Distal humerus fractures are relatively uncommon, accounting for approximately one-third of all humeral fractures and about 2% of all fractures in adults [9]. This study examined the null hypothesis that there is no difference in DASH scores between patients with dominant and non-dominant upper limb involvement. However, the findings rejected this null hypothesis: On average, a small but statistically significant difference was observed. Involvement of the dominant limb was associated with more severe symptoms and greater functional disability, as reflected by higher DASH scores.

Several limitations and complications were more frequent in cases involving the dominant limb, including both activity-independent and activity-related pain, neuropathy and cold sensitivity, deformity, and reduced flexion-extension range. In addition to limb dominance, gender also influenced DASH scores, with female patients experiencing significantly worse outcomes, an observation consistent with previous studies.

In our study, we observed that involvement of the dominant upper limb in distal humerus fractures led to significantly worse functional outcomes, as measured by the DASH score, which aligns with the findings of a study involving 948 patients from 12 prospective studies. Both studies found that the dominant limb involvement was associated with higher disability scores, indicating worse recovery. In the study by Kachooei et al. multivariable analysis showed that traumatic diagnosis, arm and shoulder involvement, and female sex were significant factors contributing to higher DASH scores. Still, these factors only accounted for 10% of the variability in scores. Similarly, in our study, dominant limb involvement significantly impacted recovery, with patients experiencing more severe symptoms and disability, including higher DASH scores. Additionally, we found that female sex and smoking also negatively influenced recovery, which were not addressed in the other study, suggesting that smoking could be an additional factor affecting recovery outcomes in patients with dominant limb injuries. Overall, both studies emphasize that while the effect of dominant limb involvement on disability is statistically significant, the overall impact on recovery outcomes may still be modest, influenced by a range of factors including gender and lifestyle habits [10].

While previous research on shoulder injuries did not show a clear impact of dominance on DASH scores [11], studies on the hand and wrist often report significant differences [10, 12]. This contrast suggests that proximal injuries, such as those to the distal humerus, may present greater challenges in functional adaptation, likely due to the central role of these regions in gross motor control and daily activity.

It may be expected that dominant limb injuries have a more significant impact on disability, depending on the injury type and anatomical location, especially when measured using tools like the DASH, which do not

specifically account for limb dominance. Considering growing evidence that psychological factors play a key role in the perception of symptoms and functional disability, dominant limb involvement may reflect, at least in part, a psychological burden rather than purely physical impairment. In other words, emerging evidence suggests that, on average, perceived disability and symptom severity are more influenced by cognitive and emotional context than by the underlying pathophysiology or type of injury, including limb dominance.

This study has several strengths that enhance the validity of its findings. It is among the few investigations specifically assessing the impact of dominant versus non-dominant upper limb involvement on functional outcomes after distal humerus fracture surgery using the validated DASH questionnaire. The inclusion of both sexes in equal numbers allowed for a balanced analysis of gender-related differences, and the evaluation of multiple clinical factors, such as pain, neuropathy, range of motion, deformity, and cold sensitivity, provided a more comprehensive understanding of postoperative disability. Additionally, the consideration of smoking status as a contributing variable added further depth to the analysis of prognostic factors. However, this study also has limitations. The retrospective design and reliance on telephone interviews and self-reported data may introduce recall and reporting bias. The relatively small sample size and single-center setting may limit the generalizability of the findings. Furthermore, potential psychological factors that may influence patient-reported outcomes, such as mood, coping style, or fear of movement, were not assessed, despite growing evidence of their relevance in upper limb disability.

However, a prospective study focusing on specific clinical conditions, particularly those with more defined pathophysiology and objective physical impairments such as stiffness, weakness, or numbness, may provide more detailed insights into the impact of dominant limb involvement on DASH scores. Additionally, it is recommended that future studies explore the psychological factors associated with dominant hand involvement and their influence on the outcomes of distal humerus surgery.

Conclusion

Upper extremity disability, as measured by the DASH score, is significantly greater when the dominant limb is involved. Additionally, female gender has a negative impact on the prognosis of distal humerus surgery. Moreover, smoking is significantly associated with poorer surgical outcomes and prognosis in patients undergoing distal humerus procedures.

Ethical Considerations

Compliance with ethical guidelines

The necessary information was provided to the participants, and they were given the right to withdraw from the study freely.

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Authors' contributions

All authors contributed equally to the conception and design of the study, data collection and analysis, interpretation of the results, and drafting of the manuscript. Each author approved the final version of the manuscript for submission.

Conflict of interest

The authors declared no conflict of interest.

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