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Adult distal humerus trauma with surgical intervention: CT analysis of fracture pattern, causes, and distribution

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ABSTRACT

This multicenter cross-sectional study aimed to determine the differences in distribution and fracture pattern between low-energy and high-energy groups in distal humeral fractures in Japan. Retrospectively, 133 patients (48 males, 85 females) with distal humeral fractures were enrolled in this study. The age, sex, fracture classification, injury mechanism, preoperative therapy for osteoporosis, and nature of soft-tissue injury were recorded for all patients. The Mann-Whitney U test and chi-square test or Fisher's exact test were used for non-normally distributed variables and categorical variables, respectively, to compare differences between the two groups. The mean age of the patients at the time of surgery was 66 years (range 21–99 years). Marked differences were observed between the two groups in terms of age, sex, and fracture pattern. The mean age of patients with AO classification type A2 fractures was significantly higher than that of the patients with other fracture types. In contrast, the mean age of patients with AO classification type C2 fractures was slightly lower than that of the remainder of the population. In the low-energy trauma group, females accounted for 72.2% of fractures and their mean age at the time of surgery was 76 years. Low-energy trauma among elderly individuals was prominent.

Keywords: distal humeral fracture, fracture pattern, injury mechanism, osteoporotic fractures, low-energy injury

INTRODUCTION

Fractures of the distal humerus are relatively uncommon in adults, comprising approximately 2% of all fractures and one-third of all humeral fractures.[1,2] Previous studies regarding distal humeral fractures have focused mainly on the surgical aspects. The epidemiology of these fractures is well known in children, but it is not well described in adults.[3,4] Distal humeral fractures in adults tend to progress to non-union or functional impairment when managed nonoperatively.[5] Clinical results of comminuted epiphyseal fractures and intra-articular fractures are often worse than those of uncomminuted fractures or metaphyseal fractures. Furthermore, these comminuted epiphyseal fractures and intra-articular fractures are difficult to treat or end up in non-union or implant failure due to osteoporosis.

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Distal humeral fractures fall under the umbrella of osteoporotic fractures, as do proximal femur, proximal humeral, and distal radius fractures. These fractures occur because of low-energy trauma in elderly patients. The incidence of distal radius fractures peaks in younger individuals who injure themselves through sports and road-traffic accidents and in the elderly population, in whom osteoporotic fractures are often due to simple falls.[6] Few studies have focused on the bimodal distribution of distal humeral fractures. In addition, most studies used radiological classification with X-ray. To the best of our knowledge, no study has classified fractures with computed tomography (CT). This multicenter cross-sectional study sought to determine the difference in distribution and fracture patterns between the low-energy and high-energy groups in distal humeral fractures in Japan. In other words, we determined the effect of the mechanism of distal humeral fractures on fracture classification.

MATERIALS AND METHODS

Enrollment

We retrospectively reviewed 144 patients who underwent surgery for a distal humeral fracture at our five affiliated hospitals (Anjo Kosei Hospital, Nagoya Ekisaikai Hospital, Ichinomiya Municipal Hospital, Shizuoka Saiseikai General Hospital, and Nishichita General Hospital) between April 2010 and May 2016. The institutional review board of each hospital reviewed and approved this study. The inclusion criteria were (1) age of at least 20 years, (2) presence of acute distal humeral fractures that were treated with osteosynthesis, (3) confirmed medical and radiological records, and (4) availability of serial radiography and preoperative CT results. Radiograms were taken in an anteroposterior view with elbow extension and in a true lateral view with elbow flexion. Axial 64-multidetector CT images were obtained with 0.5 mm-thick sections at 0.5 mm intervals. CT scans were performed preoperatively (Aquilion CX, Toshiba, Japan). Exclusion criteria included an age of less than 20 years, multiple fractures, and lack of CT images. Two and nine patients were excluded due to multiple fractures and lack of CT images, respectively.

Overall, 133 patients (48 males, 85 females) with distal humeral fractures were enrolled in this study. The mean age of the patients at the time of surgery was 66 years (range 21–99 years).

Outcome Assessment

The age, sex, fracture classification, injury mechanism, preoperative therapy for osteoporosis, and soft-tissue injury of the patients were recorded. The CT images of fractures were classified using the Arbeitsgemeinschaft für Osteosynthesfragen (AO) systems.[7] Open fractures were also classified using the method of Gustilo and Anderson.[8]

The mechanism of injury was grouped into simple falls from standing height or lower, falls from greater height, road-traffic accidents, sports, and others. Simple falls from standing height or lower were defined as low-energy trauma (Group L), and all others were high-energy trauma (Group H).[5]

Statistical Analysis

The Mann-Whitney U test and chi-square test or Fisher's exact test were used for non-normally distributed variables and categorical variables, respectively, to compare differences between the two groups. Statistical analysis was conducted using SPSS version 19J (IBM Japan, Tokyo, Japan). $P < 0.05$ was considered statistically significant.

RESULTS

Patient data, including fracture patterns of Groups H and L, are summarized in Table 1. Falls from greater height were the main cause of injury among patients in their 40s, and road-traffic accidents were the main cause of injury among those in their 50s and 60s. Sports were the most common cause of injury among patients in their 20s and 30s. Marked differences were observed between the two groups in terms of age, sex, and fracture pattern. The number of males in Group H was higher ($P < 0.001$). The largest number of patients in Group L indicated AO type A2 fractures. In Group H, type C2 fractures were the major reason for surgery. Preoperative therapy of osteoporosis was performed for 2 patients in Group H and 16 patients in Group L. A significant difference was identified in terms of age ($P < 0.001$). Difference in distribution between high-energy trauma in young individuals and low-energy trauma in elderly individuals is shown in Fig. 1. The incidence in Group L peaked among patients in their 80s. In Group H, the proportion was slightly high in the 20–40s, although no spike was identified.

The mean ages of patients with A2 and A3 fractures were higher than that of the patients with other fracture types, and the number of cases in Group L was greater than that in Group H (Table 1). By contrast, the mean age of patients with type C2 fractures was slightly lower than that of the remainder of the population.

Table 1 Summary for each group

		Group H	Group L	P
N		50	83	
Age (years)		50±19	76±14	< 0.001
Sex (male)				
N (%)		25 (50.0%)	23 (27.7%)	< 0.001
AO classification	Age (years)			< 0.001
A1	71	1	0	
A2	78±14	11	50	
A3	79±9	2	3	
B1	61±17	3	4	
B2	52±13	4	1	
B3	57±16	3	5	
C1	61±22	4	9	
C2	52±22	17	8	
C3	56±22	5	3	
Therapy for osteoporosis (N)		2	16	0.017

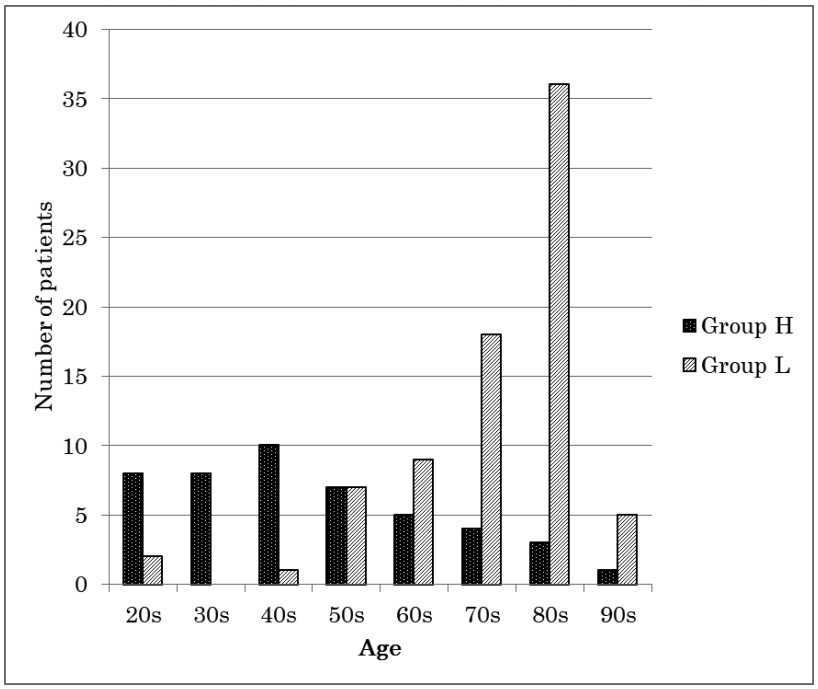

Fig. 1 Distribution of Groups H and L

Comparison between Groups H and L Regarding Sex

In the male population, the number of cases in Groups H and L was almost the same (Table 2). The patients in Group L were significantly older than those in Group H ($P < 0.001$). A significant difference was identified in terms of AO classification ($P < 0.001$). The C2 subtype was prominent in Group H, but the A2 subtype was the most prominent in Group L.

In the female population, the number of cases in Group L was twice as high as that in Group H (Table 2). Patients in Group L were significantly older than those in Group H, similar to the male population ($P < 0.001$). A significant difference was not identified in terms of AO classification ($P = 0.202$). However, the A2 subtype in Group L was the most prominent in the female population.

Other Features

No significant difference was noted in the frequency of open fracture between the two groups. Eight fractures were open according to the Gustilo and Anderson classification. Five of these fractures were classified as simple type Gustilo I puncture wounds. One case of Gustilo II was AO type C3, which was due to a fall from the stairs. Two cases of Gustilo IIIa were AO type C2. The mean age of the patients who sustained an open fracture was 60.8 years (range 38–96 years).

DISCUSSION

Marked differences were observed between the two groups in terms of age, sex, and fracture pattern. The differences in age distribution were particularly prominent for low-energy trauma

Table 2 Fracture pattern in males and females

	Males			Females		
	Group H	Group L	P	Group H	Group L	P
N	25	23		25	60	
Age (years)	44±17	76±16	< 0.001	57±19	76±13	< 0.001
AO classification			< 0.001			0.202
A1	0	0		1	0	
A2	2	18		9	32	
A3	1	1		1	2	
B1	1	1		2	3	
B2	2	0		2	1	
B3	2	1		1	4	
C1	2	1		2	8	
C2	10	1		7	7	
C3	5	0		0	3	

elderly individuals. However, a typical bimodal distribution was not found between high-energy trauma in the young and low-energy trauma in the elderly. This finding is probably due to the exclusion of patients under the age of 20 years in this study.

In recent years, we have observed an increase in the number of active elderly patients with distal humeral fractures. This is likely due to the aging of our society. Most distal radius fractures that occur in the elderly are the result of trauma due to a low-energy force, with falls from standing height being the leading cause of injury.[9,10] A study defined that low-energy fracture is a result of falling from a standing height or less, whereas high-energy fracture is any other type of trauma (e.g., falling from a height higher than standing height and motor vehicle accident).[5]

Women with good neuromuscular control and faster walking speeds have higher risk for distal radial fracture as they tend to reach out to break a fall rather than falling onto the side of their arm or leg which could result in a proximal humeral or hip fracture.[11] Therefore, distal humeral fractures may occur in patients who fall onto the side of their elbow.

The characteristics of each fracture group seem to result from the difference in recreation and lifestyles between elderly and young adults. Our data showed that elderly people tended to have extra-articular fractures (types A2 and A3) rather than intra-articular fractures. This finding is not in agreement with that reported by Robinson *et al.*[5] They showed that type C (complete articular) fractures occur in 37.2% of patients. The mean age of patients in the type C fracture group was slightly higher than that of the remainder of the population, and the majority of the group was female.[5] The difference in our results from Robinson *et al.* may be attributed to their inclusion of patients under the age of 20 years and to differences in race. However, we could not find any study that focuses on fracture difference among races.

We suggest that CT images are more precise than plain X-ray alone, particularly in cases involving more comminuted fractures. Jacquot *et al.* showed the utility and reliability of two- and three-dimensional CT scanning in patients over 65 years of age with distal humeral fractures.[12]

The strength of our research is that all fracture classification was done using CT images.

Several reports about open fracture are available. Robinson *et al.* reported that 7.2% of the fractures were open, and the injuries tended to be either simple type I puncture wounds or severe type IIIb injuries with soft-tissue loss.[5] On the other hand, Charissoux *et al.* reported that 16% were open, but 95% of them were Gustilo I or II fractures.[6] The present results agree with those reported by Charissoux *et al.*

A group from Tottori University investigated the incidence of fragility fractures from 2010 to 2012 in Sakaiminato, Japan.[13] They reported that osteoporosis-related fragility fractures usually involve the hip, distal radius, proximal humerus, and vertebrae. However, data about distal humeral fracture were not provided. Approximately 30% of people 65 years of age or older living at home and more than 50% of those living in nursing homes or retirement homes fall every year, of which approximately half do so repeatedly.[14] Our findings support the view that distal humeral fractures should also be treated as fragility fractures, because low-energy trauma easily leads to distal humeral fracture in elderly female patients.

The increase in low-energy fracture with age may be explained by the increasing number of patients with osteoporosis, particularly women.[15] Nevertheless, preoperative therapy for osteoporosis was performed for only 16 patients in Group L. If the hypothesis is correct, therapy or early intervention for osteoporosis could reduce fragility associated low-energy fracture, including of the distal humerus. However, the study from Tottori University showed that previous hip fractures were detected in 34% of patients and that previous vertebral fractures were detected in 43% of patients, compared with distal radius fractures in 11% of patients who were treated for hip fractures during the study period.[13] Therefore, early intervention against osteoporosis after distal radius fracture remains controversial. Further studies are necessary to determine whether we should intervene in fragility fractures in not only distal radius but also distal humerus.

The limitations are as follows. First, we could not assess the bone mineral density data of all patients. Further studies that assess the association between distal humeral fractures and dual-energy X-ray absorptiometry are needed to clarify this issue. Second, we could not investigate the incidence because patients could freely select their preferred hospitals. Third, patients treated nonoperatively were not included because we tended to perform conservative treatment without a CT scan. Therefore, not all adult patients with distal humeral fractures were included in this study.

In conclusion, this study assessed the clinical features of patients with distal humeral fractures. In the low-energy trauma group, females comprised 72.2% and their mean age at the time of surgery was 76 years. The mean age of patients with A2 fractures was significantly higher than that of patients with other fracture types in Group L. These extra-articular fractures in elderly individuals may reflect today's aging society in Japan.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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