Original Article
Age- and gender-specific characteristics of the clavicular fractures, data from 83 hospitals in China

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Abstract: Objectives: This study aims to investigate the age- and gender-specific characteristics of clavicular fracture in adults. Material and methods: From January 2010 to December 2011, an epidemiologic study in randomized selected 83 hospitals of 31 provinces in China was performed. Data regarding patients' age, sex, side involved and seasons in which the fracture occurred were extracted. X-ray radiographs were retrieved and classified with AO/OTA system based on rigorous assessment criteria. All the analyses were performed by SPSS 16.0. Results: A total of 14157 acute clavicle fractures in 14078 patients were reviewed and analyzed, accounting for 3.78% of all the adult fractures and 47.05% of those in the shoulder girdle. Of them, most were men (70.8%) and the left side was involved in 55.4% of cases. 41-50 years was the most common age group for clavicular fractures (3363, 23.9%) followed by 31-40 (2798, 19.9%), 21-30 (2477, 17.6%) and 51-60 (2455, 17.4%). There was significant difference in aspect of gender distribution, with significant occurrence peak in males with 41-50 years, but none in females. AO 15-B was the most common (10307, 72.80%) type. There was significant difference of gender and age distribution among the overall three groups and in each group (P<0.001). However, there were no significant relationships observed between fracture complexity extent and the age or gender (P>0.05). Conclusion: This study demonstrates the age- and gender-specific characteristics of adult clavicular fractures. Complexity of clavicular fractures did not demonstrate significant age or gender difference, requiring further studies to investigate related risk factors for occurrence of complex clavicular fracture.

Keywords: Epidemiology, AO/OTA, Robinson classification, clavicular fractures

Introduction

The clavicular fracture is a relatively common fracture, accounting for 2-10% of all fractures and 40% of those around the shoulder girdle [1-4]. Regarding the diagnoses and treatment of clavicular fractures, there are few controversies and most patients could uneventfully reach a normal functional status [5-10]. Despite, there is in scarce of data on the investigation of clinical epidemiologic features of this type of injuries, which was deserved to be the primary task in preventive medicine. Detailed and comprehensive knowledge of the epidemiologic characteristic including incidence, age and gender-specific feature, fracture type, fracture severity and the vulnerable population is necessary for patients' counsel, community education, surgeons' intervention and medical resource allocation.

Intermittently, some studies have investigated its epidemiologic characteristics (incidence and prevalence) and fracture patterns classified by Allman or Robertson systems for anatomical sites and Neer classification system for lateral third fractures [1, 11-13]. However, these studies almost represented a relatively small sample; these studies referred to fractures that had occurred in the single-center hospital, in the 1990s or in earlier decades, when lifestyles, transportation modes and diagnostic imaging techniques were varied largely. Furthermore to date, no data could be obtained on age and gender-specific fracture patterns of clavicular classified by AO/OTA comprehensive classification system, which is the extensive clinically-relevant classification system and could provide adequate guidance for the clinical research and surgical decision making. Although some studies have demonstrated the clinical value of
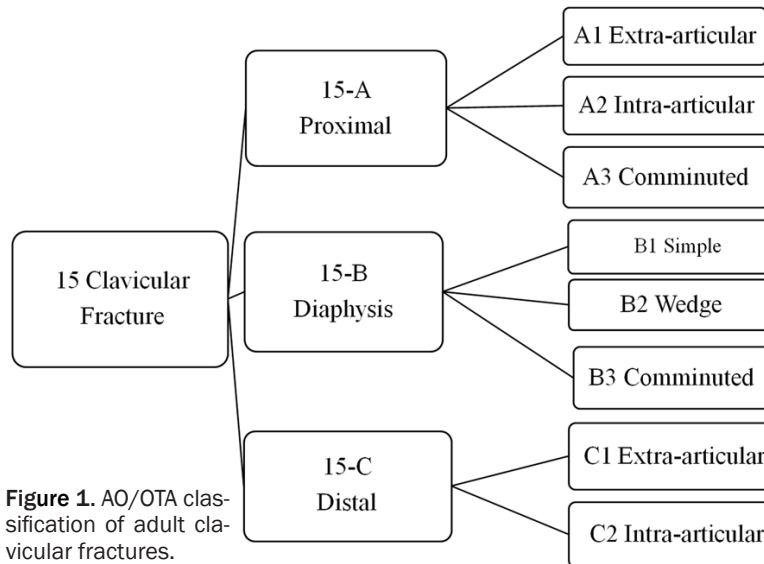
Figure 1. AO/OTA classification of adult clavicular fractures.

tion; old fractures and clavicular fractures due to neoplasm metastasis or other medical conditions.

Details of all the patients regarding their age, gender, involved side and injury date were recorded. The seasons of the fracture occurred were grouped according to the time based on the seasonal fluctuations suited for China, Spring from March to May, Summer from June to August, Autumn from September and Winter from October to January of next year.

Robinson classification for prognosis of patients with clavicular fractures, the relationships between potential risks factors and complex fracture types (2B and 3B) tending to cause non-union or delayed union have been investigated, up to now.

Given the existing limitations and the necessity of the updated data on this important injury, we designed this study and the data were extracted from 83 level I and II traumatology or general hospitals in China. The primary aim was to evaluate the clinical characteristics of clavicular fractures in terms of age, gender, side involved, seasonal variation and fracture patterns by AO/OTA classification, and the secondary aim was to investigate the associations between demographic characteristic and complex fracture patterns.

Materials and methods

From January 2010 to December 2011, X-ray radiographs of all adult patients admitted for clavicular fractures in the 83 Orthopaedic or General hospitals of 31 provinces in China were reviewed. These units were selected using the method of Multi-stage random sampling on the basis of the main following aspects: the geographical variation, social-economic development and population density.

The inclusion criteria were patient aged 16 or greater with fresh clavicular fractures. The exclusion criteria were patients under 16 years, those with only ligamentous injuries or disloca-

AO/OTA classification was firstly reported and evolved for the better clinical research and surgical decision making for adult fracture (age >16 years). According to this classification system, three groups including 15A, B and C were subdivided and 2 or 3 subgroups were further included in each group. The details on this classification for clavicular fracture were as follows: "15" for its anatomical location and three groups were divided as proximal (15A), shaft (15B), and distal (15C) according to the Heim Square method. **Figures 1** and **2** presented the classification and the detailed drawings for each type of fractures.

Robinson Classification was proposed in 1998, designed for clavicle fracture [14]. Based on fracture location and displacement extent, 3 types and 6 subtypes were classified including 1A, 1B, 2A, 2B, 3A and 3B. Furthermore, to better investigate the relationships between variables and fracture complexity, we subdivided the fractures into two groups, Group A (simple fractures including type 1, 2A and 3A) and Group B (complex fracture including type 2B and 3B), based on their prognostic discrepancy [14, 15]. Age was divided into two groups, 16-60 years and 60 years greater.

Fracture types were assessed by four orthopaedic surgeons. After strict training, 100 randomly selected series of radiographs were granted to each of them. They classified independently on the two occasions separated by a 2-week interval. Interobserver reliability and

15-A1

15-A2

15-A3

15-B1

15-B2

15-B3

15-C1

15-C2
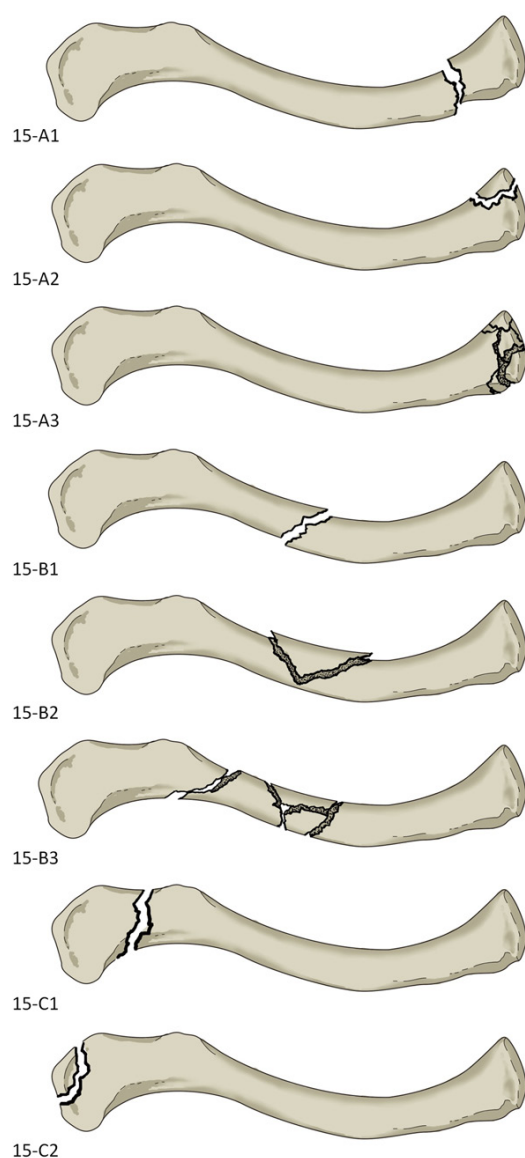
Figure 2. Drawings of the 8 type of clavicular fractures according to AO/OTA classification system.

intraobserver reproducibility were determined by calculating adjusted kappa coefficients (KC). Interpretation of the kappa coefficients were performed using he Landis and Koch guidelines [16]: a KC value of 1.00 indicated perfect agreement; 0.81 to 0.99, excellent; 0.61 to 0.80, substantial; 0.41 to 0.60, moderate; 0.21 to 0.40, fair; 0.00 to 0.20, slight; and less than 0.00, poor. When kappa coefficients reached to 0.6 and greater (excellent at least) both in interobserver reliability and intraobserver reproducibility, surgeons were allowed to classify the large quantity of radiographs.

Table 1. The basic characteristics of 14078 patients sustaining clavicular fracture

Age group	Male	Female	Total (%)
16~20 y	760	250	1010 (7.17)
21~30 y	1805	672	2477 (17.59)
31~40 y	2071	727	2798 (19.87)
41~50 y	2620	743	3363 (23.89)
51~60 y	1684	771	2455 (17.44)
61~70 y	616	549	1165 (8.28)
71~80 y	286	283	569 (4.04)
≥81 y	129	112	241 (1.71)
Total	9971	4107	14078 (100)

Statistical analysis

Continuous variable (age) was expressed as mean and standard deviation and the test was performed using Student t-test or Whiteny U-test, based on the normality status of data. Discontinuous variables regarding age (dichotomy), gender, side involved and seasonal variation were expressed as count and percentage and the results was analyzed by Chi-square test. A $P<0.05$ was considered as statistically significant. SPSS 16.0 software package was used to calculate the figures and perform all the tests (SPSS, Chicago, IL, USA).

Results

Overall results

A total of 14078 patients with 14157 acute clavicle fractures were reviewed and analyzed, accounting for 3.78% of all the adult fractures (374396) and 47.05% of those (30088) around the shoulder girdle with respect to all fractures of the clavicle, proximal humerus and scapula in this study period. Of them, 79 cases were simultaneous bilateral fractures with the proportion of 0.56% (79/14078), 7801 (55.41%) involved in left side and 6119 in right side (43.46%).

Regarding the gender- and age-specific characteristics of these 14078 patients, the predominant sufferers were males (9971, 70.8%), with 4107 females accounting for 29.2%; 41-50 years was the most common age group for clavicular fractures (3363 cases, 23.9%) followed by 31-40 (2798, 19.9%), 21-30 (2477, 17.6%) and 51-60 (2455, 17.4%) (**Table 1**). There was
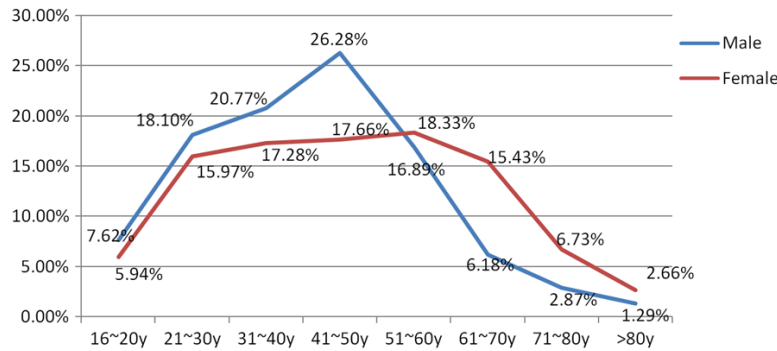
Figure 3. The gender distribution of 14078 patients with clavicular fractures.

Table 2. The seasonal distribution for 14078 patients with clavicular fracture with stratification of age and gender

	Male (16-60 y)	Male (>60)	Female (16-60 y)	Female (>60)	Total (%)
Spring	2336	278	695	229	3538 (25.13)
Summer	2470	292	921	301	3984 (28.30)
Autumn	1887	256	605	194	2942 (20.90)
Winter	2247	205	942	220	3614 (25.67)

significant difference in aspect of gender distribution. From **Figure 3** we could see that, both line charts in gender had a significant decline, in males at 60 years and in female at 70 years, respectively. Obvious fracture occurrence peak in men was 41-50 years, before and after which the line raised and declined sharply; while in females no obvious fracture occurrence peak was presented and the line remained stable with age from 21 to 80, with proportions ranging 13.37%-18.87%. The ratio of male to female fluctuated stably from 2.18 to 3.04 before 61 years and sharply decreased to 1.0 around after 61 years old (1.01 to 1.15).

There is no significant seasonal variation in the 2-year study period, with 3538 (25.1%) cases in spring, 3984 (28.3%) in summer, 2942 (20.9%) in autumn and 3614 (25.7%) in winter (**Table 2**).

Validation for fracture classification

The average interobserver kappa coefficients were 0.70 (0.53 to 0.82) and 0.74 (0.62 to 0.86), giving an overall mean of 0.72 indicating substantial reliability. The average individual intraobserver kappa coefficient was 0.82 (0.72 to 0.88), indicating excellent reproducibility.

Age and gender characteristics of fracture types

According to AO/OTA classification system, 15-B was the most common (10307, 72.80%) type, followed by 15-C (3607, 25.48) and 15-A (243, 1.72%). We could see that, there was significant difference of gender distribution among the overall three groups and in each group (P<0.001). In term of age distribution in 15-A, 15-B or 15-C, there was significant difference both in the form of either dichotomous (P< 0.001) or continuous variable (P<0.001). The age in type 15-B groups was 42.2± 15.5 years, significantly younger than those of 15-A (45.7±17.5) and 15-C (45.9± 16.9). The detailed information on age and gender distribution in AO fracture types was presented in **Table 3**. A further differentiation was performed to better describe the epidemiologic characteristics, with 2-3 subtypes in each type, and a total of eight subtypes were classified. There were 202 cases in 15A1, 29 in 15A2 and 12 in 15A3; 5852 in 15B1, 3340 in 15B2 and 1115 in 15B3; 2894 in 15C1 and 713 in 15C2 (**Table 4**).

The overall 14157 cases of fractures were divided according to the Robinson classification. Altogether, there were 5443 (38.4%) simple fractures and 8714 (61.6) complex fractures. No significant differences were investigated between age (dichotomous) and gender distribution and the fracture complexity, and the corresponding *P* values were 0.270 and 0.491, respectively. However, significant difference was investigated when age was analyzed in the form of continuous variable (P=0.010); age in the simple fracture group was 44.0±15.7 years (median, 44 years), older than that of 42.8±15.7 (median, 42) in complex fracture group.

Discussion

In previous reports providing epidemiologic and clinical data on clavicle fractures, no attempts

Table 3. The age- and gender-specific distribution of AO/OTA classification for 14157 adult clavicular fractures

AO/OTA classification	Number (%)		16-60 years (%)		>60 years (%)		P
	Male	Female	Male	Female	Male	Female	
15-A	183 (75.3)	60 (24.7)	155 (63.8)	40 (14.5)	28 (11.5)	20 (8.2)	0.002[a]
15-B	7472 (72.5)	2835 (27.5)	6834 (66.3)	2244 (21.8)	638 (6.2)	591 (5.7)	<0.001[a]
15-C	2370 (65.7)	1237 (34.3)	2002 (55.5)	903 (25.0)	368 (10.2)	334 (9.3)	<0.001[a]
Total	10025 (70.8)	4132 (29.2)	8991 (63.5)	3187 (22.5)	1034 (7.3)	945 (6.7)	<0.001[b]

Note: [a]the significance for the analysis of discrimination in gender distribution in each group; [b]comparison regarding the gender distribution among the groups, 15-A, B and C.

Table 4. Further differentiation of 15A, B and C of 14157 adult clavicular fracture (8 subtypes)

Fracture type	Male (16-60 y)	Male (>60)	Female (16-60 y)	Female (>60)	Total (%)
A1	134	20	32	17	203 (1.43)
A2	15	6	6	2	29 (0.20)
A3	6	2	2	1	11 (0.08)
B1	4098	348	1087	319	5852 (41.34)
B2	2152	224	749	215	3340 (23.59)
B3	584	66	408	57	1115 (7.88)
C1	1661	252	737	243	2893 (20.44)
C2	341	116	166	91	714 (5.04)

were made to investigate the AO/OTA classifications of the adult clavicular fractures and the relationships between demographic variables and complex fracture types. In this study with largest size from the national data of orthopaedics-specialized or general hospitals, we investigated the characteristics of adult clavicular fractures in term of gender, age, the involved side and season variations. The line charts of males and female presented obviously different characteristics, with typical fracture occurrence peak in males of 41-50 years but stable transition in females. Sufferers with distal (15-C) and proximal (15-A) fractures of the clavicles had greater age, and patients with complex fractures had no different age and gender distribution except for a slightly younger age (in continuous form).

A total of 14157 cases of fractures in 14078 patients were included in this study, accounting for 3.78% of all fractures and 47.05% of those in the shoulder girdle. The former proportion was in the range of the reported data (2.6%-10%) in the literature [4, 13, 14, 17], indicating the advantage of large sample study. The latter data (47.05) was slightly higher than

that of literature (29%-44%) [4, 13, 18, 19], and this was mainly caused by the different definitions that most studies incorporated ligamentous injuries or dislocation (acromioclavicular separations, glenohumeral joint injury). At the sixth decade and afterwards, there would be obvious decline of clavicular fracture occurrence either in females or males, which might be due to the decreased activities in persons of this age and overall age constitutions (decrease after 60 years). However, females and males demonstrated the significantly different features, with fracture occurrence peak in males of 41-50 years but not in females. It is speculated to be consistent with activity level in males and in 41-50 of men the level reached the peak (especially, violent traffic- and sports-related activities), and this was also proved in previous study [19, 20]. But in females there is no dramatic fluctuation of activity and after 50 years they have a decrease in bony density, which was also reflected by the line charts in this study.

According to AO/OTA classification system, there were altogether 10307 cases of 15-B fractures, accounting for 72.8% of the totality, which was consistent with the reported data of literature [4, 13, 14]. This high proportion was closely related with the lying "S" shape of the clavicle that, the middle third, or midshaft is the thinnest, least medullous area of the clavicle and is lack of muscular and ligamentous, thus most easily fractured at direct blow. There was significant difference of gender distribution among the overall three groups and in each group (P<0.001). The age in type 15-B groups was 42.2±15.5 years, significantly younger than those of 15-A (45.7±17.5) and

15-C (45.9±16.9). We could not explain this discrepancy by direct evidence and review from literature also could not provide potential explanations in the view of injury mechanism. Most studies described the mechanism of clavicular fractures regarding it as a whole, but not separated each type from other [19, 21-23]. So in the future, more mechanism-specific studies will be required to elaborate this discrepancy.

The prognosis of any injury or disease should be the most important event that deserves more consideration. For fractures of the clavicular fractures, Robinson classification has been confirmed to be the most clinically-related classification system and Robinson type 2B and 3B fractures were significantly associated with then increased complications of union [4, 14, 15]. In addition to displacement, the comminution extent of type 2B fractures was a risk factor for delayed and nonunion [14]. We made attempts to investigate the relationships between age and gender and the complex fracture types (type 2B and 3B), but failed. There were no significant differences observed in the case and control groups, either in term of age or gender. Therefore, attempt to understand the prognosis information from age and gender distribution was unrealistic, conversely, emphasizing the importance of clinical diagnosis and treatments.

There are several potential limitations in this study. The overall quality of medical research data depends on the completeness, validity, consistency, timeliness and accuracy. Despite the comprehensive nature of the injury data collected in database of each hospital, data quality issues cannot be overlooked. The hospitals in this study were distributed in 31 provinces (including municipality), and selected by multi-stage randomized sampling. However, the radiographs managing system was different in each hospital including PACS (picture archiving and communication system) and Compact disc with low photo quality, and in some hospitals outpatient radiographs were not registered in the managing system. In addition, errors such as miscoding or mis-retrieval of data may all impact the overall data quality. Secondly, although with excellent classification of fracture in intra- and inter-observers, the consistency could not approach to 100% and this was the existing limitation of all the classification

systems, the controversial fracture required CT to identify but filled in this study. The third issue was the lack of data on the fracture incidence, because the strict allocation for patients to one hospital was lacking and to which hospital for treatment depended on patients' demanding, economic condition and medical insurance system. Therefore, to obtain the incidence on a national scale might be impossible through the existing medical data storage systems.

Despite the limitations mentioned above, this study presented many advantages. First of all, data are collected on a national basis, through the multi-stage randomized sampling methods, insuring the reliability of data with such large sample. As far as we know, this is to date the largest sample study to investigate the characteristics of clavicular fractures, in term of AO/OTA classification and Robinson classification, providing information for preventive and clinical medicine for reference. These data could be applied in the primary medicine, providing populations of community with more comprehensive and detailed information about this injury including vulnerable population and age and gender-specific characteristics, especially in the universal health education. In addition, fracture type, severity and AO/OTA characteristics of clavicular fracture investigated in this study added to the overall knowledge on this commonly seen injury in clinical practice, aiding the rational allocation of medical resources in emergency department.

In summary, the epidemiologic characteristics of clavicle fractures in the nationwide patients were investigated in this study. Males and female demonstrated the significantly different fracture features, in term of age according to AO/OTA classification system. There were no obvious seasonal variations for this injury. Age and gender were not associated with the complex type of clavicle fracture. Future studies should focus on further identification of the risk factors (occupational, comorbidities, detailed mechanism) especially modifiable ones associated with the incidence of clavicle fractures.

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Disclosure of conflict of interest

None.

Authors' contribution

Yingze Zhang designed the study; Yanbin Zhu, Song Liu, Bo Liu and Hengrui Chang classified the X-rays; Wei Chen and Song Liu analyzed and interpreted the data; Song Liu and Bo Liu wrote the manuscript and Yingze Zhang approved the final version of the manuscript.

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