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ORIGINAL ARTICLE

Epidemiology of proximal humeral fractures: a detailed survey of 711 patients in a metropolitan area

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Background:: Literature lacks data concerning several epidemiologic aspects of proximal humeral fractures (PHFs).

Methods:: This retrospective study included 711 consecutive patients (209 men, 502 women) who sustained a PHF in the last 3 years. Participants were divided into 2 groups, adults and children. Data regarding age, sex, date, and fracture side were collected. According to the mechanism of injury, we arbitrarily distinguished 7 subgroups. PHFs were classified according to the head-greater-lesser-shaft (HGLS)-Hertel classification and to the Salter-Harris classification using x-ray and computed tomography imaging.

Results:: PHFs represent 5.03% of the overall fractures. The right side was involved in 389 patients (54.7%; $P = .6$). The mean age of male and female patients was 55.4 (standard deviation, 21.9) years and 67.0 (standard deviation, 16.1) years, respectively ($P = .0001$). Significant differences in the trauma mechanism between female patients (street/home low-energy trauma) and male patients (high-energy trauma) were found. A significant correlation between trauma mechanisms from 1 to 5 and fracture patterns H-G-L-S, HL-G-S, HGL-S, and HLS-G was observed. The occurrence of the same patterns significantly varied according to different age subgroups. Considering the pediatric population, a significant incidence of Salter-Harris 2 in both genders was found. No correlation was observed between the fracture patterns and the trauma mechanism.

Conclusions:: PHFs have a higher prevalence and incidence in females and in older age, respectively; they are more frequent in the winter months. In addition, male fractures are due to different traumatic events than those in females. A correlation between trauma and PHF pattern was evident only for adults. Some fracture patterns are correlated with different ranges of age in all patients.

Level of evidence: Descriptive Epidemiology Study

Keywords: Proximal humeral fractures; proximal humeral fractures epidemiology; shoulder fractures; Hertel classification; Salter-Harris classification; proximal humerus trauma mechanisms

Ethical approval statement

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Proximal humeral fractures (PHFs) are the seventh most frequent fractures in adults.[23] Prevalence varies from 4% to 10% of all fractures according to several studies performed in different countries and populations.[1,3,9,15,23] In patients aged

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older than 40 years, a linear increase in the incidence is present, and only wrist and femoral neck fractures are more frequent in the elderly population (>65 years).[14,25]

Although many epidemiologic studies on PHFs have been performed, literature still lacks clinical data about several aspects of these fractures, such as the correlation between the fracture pattern and patient demographics, the trauma mechanism, and the time of year in which the fractures occurred.

In the present study, we report a detailed epidemiologic survey of a large consecutive series of patients with PHFs, classified by radiograms and computed tomography scans, occurring in the 3 consecutive years in the population of a metropolitan area.

Materials and methods

All of the patients managed in the Emergency Department of our hospital for a PHF from September 1, 2013, to August 31, 2016, were considered eligible for the present retrospective study.

Patients with PHFs were identified from the clinical record, using the International Statistical Classification of Diseases and Related Health Problems, Ninth Version codes. In particular, we used the code for "closed proximal humeral fractures" (81200, 1, 2, 3; 81209) and "open proximal humeral fractures" (81210, 1, 2, 3; 81219). The total number of fractures treated in the same period in our Emergency Department was also registered to assess the prevalence of PHFs with respect to other fractures.

Clinical records of all patients were examined by 2 of the authors (P.D. and C.V.) to collect information regarding age, sex, date of fracture, fracture side, and mechanism of injury. According to the trauma mechanism, we arbitrarily considered 7 subgroups: 1, low-energy trauma occurred in the street (when walking, running) or on public transport; 2, low-energy trauma occurred at home; 3, sports trauma; 4, high-energy trauma resulting from car, motorcycle, public transport, and pedestrian accidents; 5, work-related injuries; 6, trauma resulting from assault, beatings, theft; 7, no trauma.

We arbitrarily divided the patients in 2 groups: the adult group if they were older than 16 years and pediatric group if they were younger than 16 years. Then, we used patient age to distinguish the adult population into 3 subgroups to evaluate the correlation between age, trauma mechanism, and fracture pattern: (1) patients aged between 16 and 45 years, (2) patients aged between 46 and 75 years, and (3) patients older than 76 years.

All PHFs were assessed by x-ray imaging according to a standard shoulder trauma series consisting of a true anteroposterior view (with the central ray tangential to the glenoid surface), a Velpeau axillary view (with the patient's arm held in internal rotation and the ray is superior to inferior with the patient leaning backward), and a scapular Y view (with the central ray perpendicular to the glenoid).

PHFs were classified according to the head-greater-lesser-shaft (HGLS)-Hertel classification for the adult group[26] and to the Salter-Harris classification for the pediatric group.[24] In about one-third of the cases (196 of 711), a CT with 2-dimensional and 3-dimensional reconstructions of the involved proximal humerus was available and was used to confirm the classification. Each fracture was classified twice by 3 authors (G.S., P.D., and C.V.) at 3-month intervals. When the examiners disagreed, the fracture was classified based on the majority of the opinions. Intrarater and inter-rater reliability were statistically assessed.

Statistical analysis

A descriptive analysis was performed for all of the assessed variables. The exact *F* Fisher test was used to assess any existing difference between age, fracture mechanism, fracture pattern classification, and the time of year of the fracture presentation when considering separately male and female patients. The χ^2 test was used to assess any existing differences between male and female patients for the trauma mechanism in adults and children and any existing difference in the fracture pattern distribution among patients when considering age, traumatic mechanism, and the time of year.

Intrarater and inter-rater reliability were assessed using κ statistics according to Cohen.[5] The κ values for intrarater reliability were calculated for each observer before the mean κ value was obtained. The κ values for inter-rater reliability were calculated for each possible pair of the 3 observers before the mean κ value was obtained.[27] The Landis and Koch criteria were used to assess the obtained data.[12] The κ values are reported as mean and 95% confidence interval (CI). The level of significance was set at alpha = 0.05. IBM SPSS Statistics for Windows 20.0 software (IBM, Armonk, NY, USA) was used.

Results

During the studied period, 711 patients, 209 males (29.4%) and 502 females (70.6%), with PHF were admitted to our Emergency Department. In the same period, 14,126 fractures in 13,955 patients were diagnosed. Maxillofacial or head fractures were not considered in the present study. PHFs represented 5.03% of the overall fractures. Three patients reported a bilateral PHF but were excluded because they had an associated distal humeral fracture.

The mean patient age was 63.6 (standard deviation [SD], 19.1) year, and men and women were aged 55.4 (SD, 21.9) years and 67 (SD, 16.1) years, respectively, which was significantly different ($P = .0001$). There were 682 older than 16 years and 29 patients younger than 16 years. The right side was involved in 389 (54.7%; $P = .6$).

Fig. 1 shows the distribution of PHFs in both genders according to a 2-month classification period: 37.5% of PHFs occurred in colder months (November to February), whereas only 28% occurred in warmer months (May to August). No significant differences were found ($P = .29$).

The distribution of PHFs in both genders according to the different trauma mechanism is presented in Fig. 2. A significantly higher rate was found of trauma mechanisms 1 and 2 in women ($P = .001$) and of mechanisms 3 and 4 in men ($P = .001$). No significant statistical differences were observed when separating the trauma mechanism in a 2-month period ($P = .26$; Fig. 3). A bimodal distribution of fracture mechanisms was found in the male patients when considering the patient's age. A high-energy mechanism of fracture (3 and 4) was found in 30.1% (n = 63) of the male patients

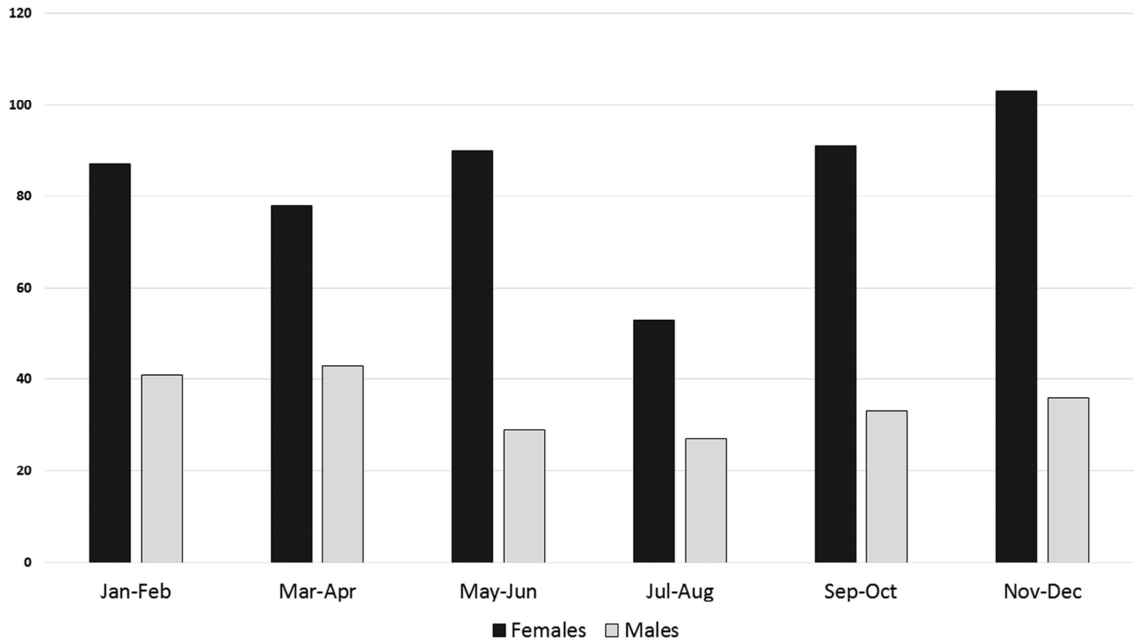

Figure 1 Yearly distribution of proximal humeral factures in both genders according to a 2-month classification period.

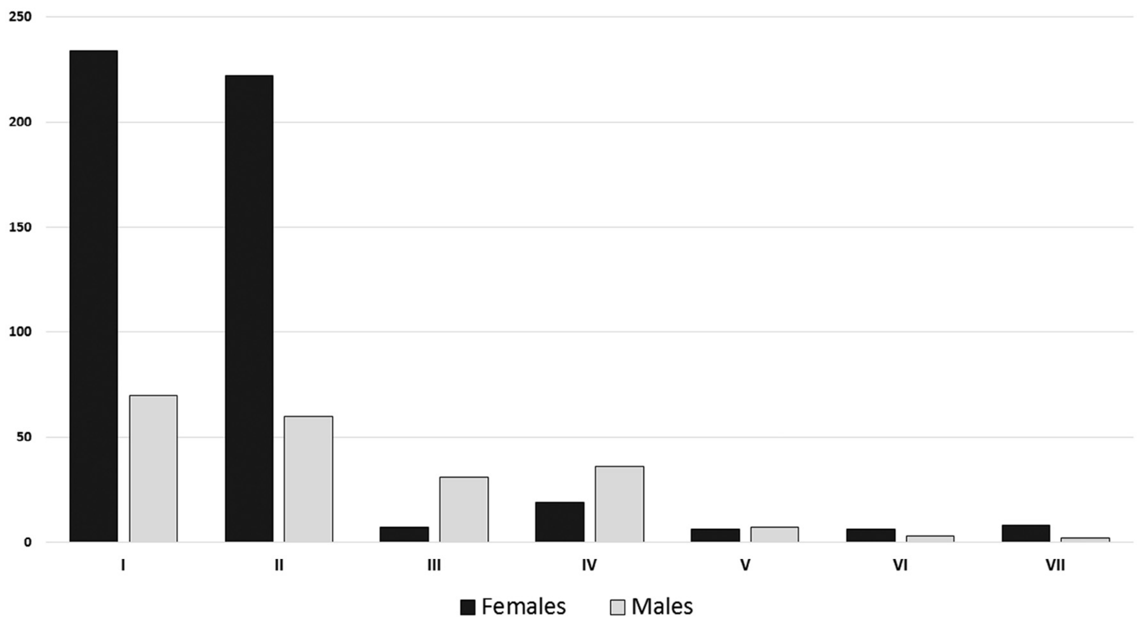

Figure 2 Distribution of proximal humeral factures in both genders according to the different trauma mechanism.

aged 18 to 60 years, and a low-energy mechanism (1 and 2) was observed in 39.7% (n = 83) of the male patients aged >65 years. A similar bimodal distribution was not observed in the female patients. The distribution of the trauma mechanism according to the days of the week is shown in Fig. 4.

We divided the 711 PHFs in 14 fracture patterns according to the HGLS Hertel classification[26] and in 5 fracture patterns according to Salter-Harris classification.[24] Data are shown in Fig. 5, in Table I, and in Fig. 6. According to the fracture pattern rate, the more frequent in ascending order were: HL-G-S, HLS-G, HGL-S, and H-G-L-S which represented 96% of all PHFs (657 of 682). Humeral head dislocation was found in 32 patients (5% of adult PHFs), and H-G-L-S and HLS-G were the most frequent associated patterns (24 of 32 dislocations [75%]).

The mean κ value for the intraobserver reliability assessment was 0.89 (95% CI, 0.81-0.99), and according to the Landis and Koch criteria, it was considered as almost perfect agreement. The mean κ value for interobserver reliability was 0.67 (95% CI, 0.59-0.75), and it was considered as substantial agreement according to the Landis and Koch criteria.[12]

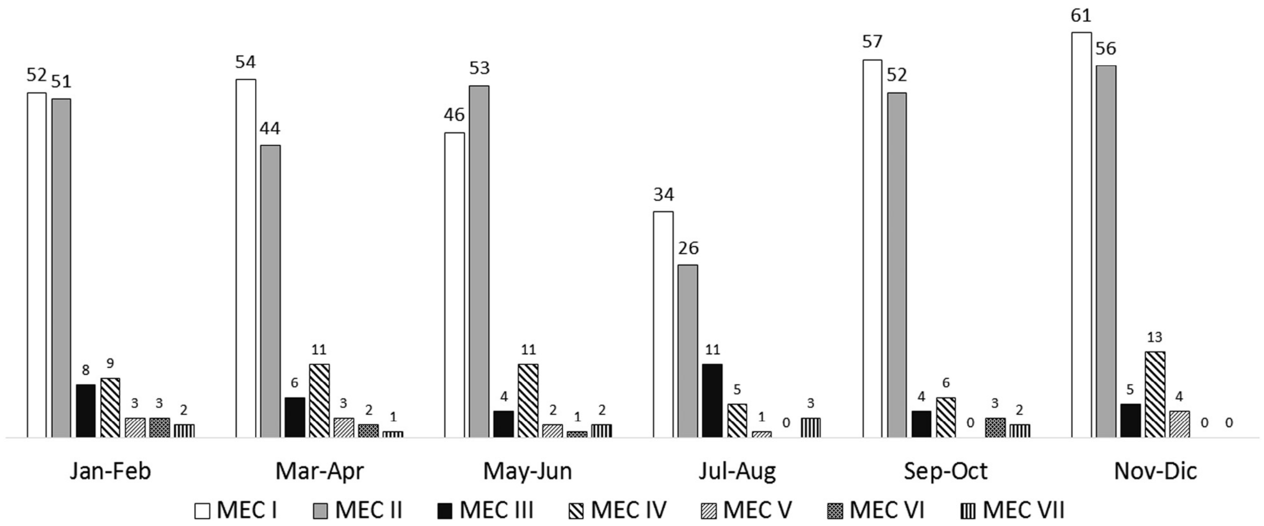

Figure 3 Yearly distribution of proximal humeral fractures according to trauma mechanism (*MEC*) in a 2-month classification period.

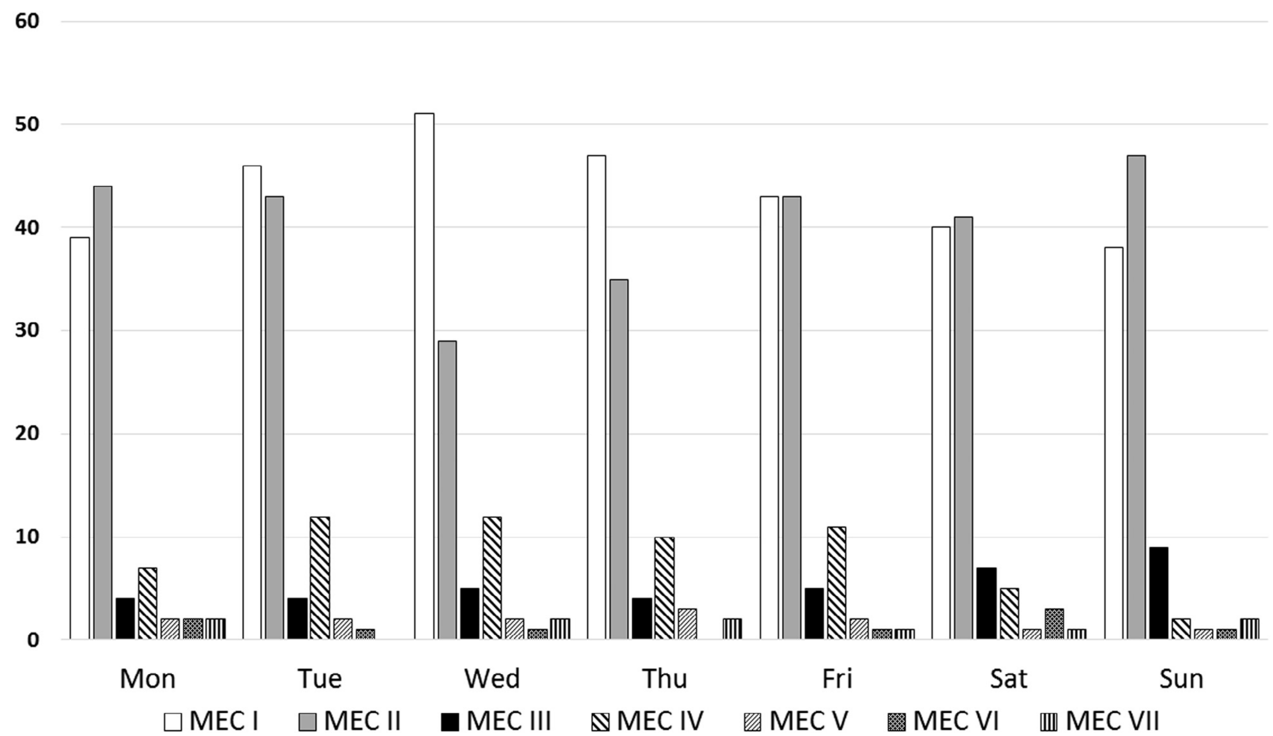

Figure 4 Distribution of the trauma mechanism according to the days of the week.

A significant correlation between trauma mechanisms, from 1 to 5, and fracture patterns H-G-L-S, HL-G-S, HGL-S, and HLS-G was found ($P = .001$; Table II).

The distribution of the different fracture patterns according to the 3 age-related subgroups is represented in Fig. 7. A significant difference was observed in the occurrence of pattern H-G-L-S, HL-G-S, HLS-G, and HGL-S in the 3 subgroups ($P = .001$).

When considering the 29 PHFs in the pediatric patients, the fracture distribution according to the Salter-Harris classification[9] is shown in Fig. 6. A significant incidence of Salter-Harris type 2 fracture was observed in both genders ($P = .047$), and was present in 86% (25 of 29) of all cases. No correlation was found between the fracture patterns and the trauma mechanism ($P = .8$; Table III).

Discussion

Many authors focused their attention on the epidemiology of PHFs. In 2012, Roux et al[23] classified 329 PHFs and concluded that they represent 5.7% of all fractures and are more

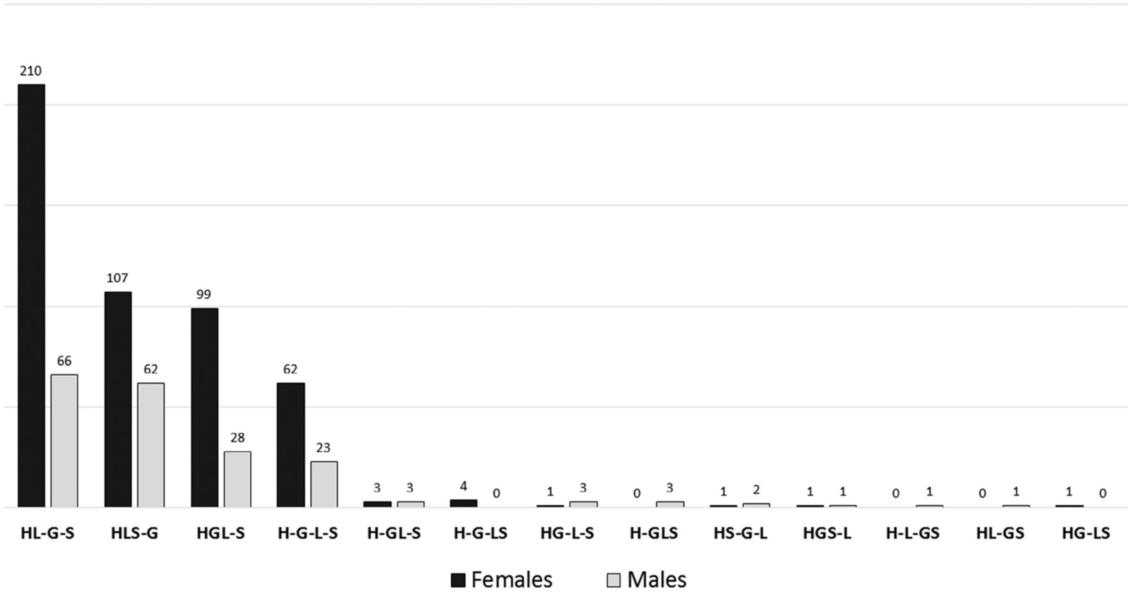

Figure 5 Fracture patterns according to the head-greater-lesser-shaft (*HGLS*) Hertel's classification.

Table I Proximal humeral fracture patterns in adult male and female patients

Pattern	Female (No.)	Male (No.)	D* (No.)	Total (No.)	*P* value
HL-G-S	210	66	3	276	
HLS-G	107	62	10	169	
HGL-S	99	28	1	127	
H-G-L-S	62	23	14	85	
H-GL-S	3	3		6	
H-G-LS	4	0		4	
HG-L-S	1	3		4	
H-GLS	0	3	2	3	
HS-G-L	1	2	1	3	
HGS-L	1	1		2	
H-L-GS	0	1		1	
HL-GS	0	1	1	1	
HG-LS	1	0		1	<.001†

HGLS, head-greater-lesser-shaft.
* Represents the pattern with a humeral head dislocation.
† Statistically significant. (Statistically significant for the whole comparison between males and females.)

frequent in the winter months. Bergdahl et al[2] came to similar conclusions; in their cohort of 1582 PHFs, the annual incidence was 18/10,000, and it increased with increasing age. PHFs were more frequent in winter and were principally caused by low-energy trauma.

According to the current literature,[3,6,9,15,23] we found that PHFs represent 5.03% of all fractures. It was predictable that no difference in prevalence between fractures of the left and right side was found and that PHFs were more frequent in women. These results can be explained by the trauma unpredictability and higher susceptibility to osteoporosis[17] and longer life expectancy in women.

According to Karl et al[10] and Kim et al,[11] the incidence in the United States population, based on age and gender of 128,605 and 184,000 PHFs, respectively, was 6/10,000; in detail, it was 1 to 2/10,000 in patients younger than 49 years, 7.5/10,000 between 50 and 64 years, and 25.3/10,000 in those older than 65 years. However, the studies were based on data from radiologic reports of the national registries, and no PHFs radiologic classification was used. Holloway et al[8] in 2015 came to the same conclusions based on radiologic reports.

In their epidemiologic study of 112,910 humeral fractures, Mahabier et al[18] stated that the PHFs incidence had increased by 277% from 1982 to 2012. Recently, Launonen et al[13] studied an extensive number of PHFs and concluded that the incidence of these fractures increased with age and observed a seasonal variation, with an increase in the colder months. Unfortunately, fractures were classified by x-ray reports and only adults were considered.

Lind et al,[16] in 1989, and Court-Brown et al,[6] in 2001, used Neer's classification[20] to radiographically study 730 and 1027 PHFs, respectively, and concluded that PHFs are more frequent in the colder months and that falls at home and in public areas are the most frequent trauma mechanisms in the elderly and young patients, respectively.

Analogously, in our study, we found that PHFs are more frequent in winter months, and no difference was found between men and women according to time of year in which they occurred. These data may be related to the climatic conditions (eg, rain, wind, snow, mud, and ice) and to fewer hours of sunlight that may increase the risk of falls or car accidents, or both, during the colder months. On the other side, we registered the lowest incidence of PHFs in July and August. These data can be justified by the fact that our study was

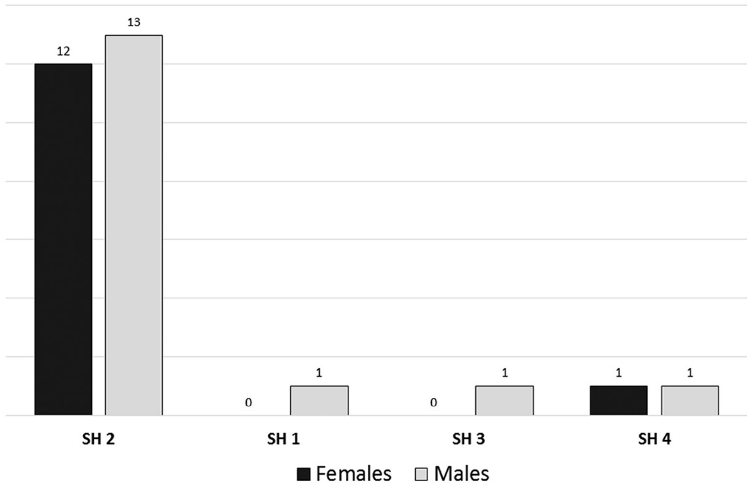

Figure 6 Classification of pediatric fracture patterns according to Salter-Harris (*SH*) classification system.

Table II Fracture patterns according to trauma mechanisms

Pattern	Mechanism*						
	1	2	3	4	5	6	7
H-G-L-S	28 (9.7)	45 (16.6)	3 (8.3)	5 (9.1)	1 (7.7)	2 (22.2)	1 (11.1)
H-GLS	1 (0.3)	1 (0.4)	n.o.	1 (1.8)	n.o.	n.o.	n.o.
HGL-S	47 (16.3)	64 (23.6)	6 (16.7)	7 (12.7)	1 (7.7)	n.o.	2 (22.2)
HGS-L	1 (0.3)	n.o.	1 (2.8)	n.o.	n.o.	n.o.	n.o.
HL-G-S	134 (46.4)	103 (38)	10 (27.8)	19 (34.5)	2 (15.4)	5 (55.5)	3 (33.3)
HLS-G	72 (24.9)	49 (18.1)	16 (44.4)	20 (36.4)	7 (53.8)	2 (22.2)	3 (33.3)
HS-G-L	2 (0.7)	1 (0.4)	n.o.	n.o.	n.o.	n.o.	n.o.
H-G-LS	3 (1)	1 (0.4)	n.o.	n.o.	n.o.	n.o.	n.o.
H-GL-S	1 (0.3)	4 (14.8)	n.o.	1 (1.8)	n.o.	n.o.	n.o.
H-L-GS	n.o.	n.o.	n.o.	1 (1.8)	n.o.	n.o.	n.o.
HG-L-S	n.o.	1 (0.4)	n.o.	1 (1.8)	2 (15.4)	n.o.	n.o.
HG-LS	n.o.	1 (0.4)	n.o.	n.o.	n.o.	n.o.	n.o.
HL-GS	n.o.	1 (0.4)	n.o.	n.o.	n.o.	n.o.	n.o.
Total	289	271	36	55	13	9	9
P value†	**.001**	**.001**	**.001**	**.001**	**.046**	.368	.748

HGLS, head-greater-lesser-shaft; *n.o.*, not observed.
* Data are shown as number with the values in parenthesis represent the percentage of each pattern.
† Bold values are statistically significant ($P < .05$).

Table III Patterns of proximal humeral fracture by different mechanism of fracture in the pediatric population

SH	Mechanism							Total	*P* value
	1 n = 15 (%)	2 n = 11 (%)	3 n = 2 (%)	4 n = 0 (%)	5 n = 0 (%)	6 n = 0 (%)	7 n = 1 (%)	n = 29 (%)	
2	13 (86.6)	10 (90.9)	1	0	0	0	1	25 (82.7)	
1	1	0	0	0	0	0	0	1	
3	0	0	1	0	0	0	0	1	
4	1	1	0	0	0	0	0	2	.35

SH, Salter-Harris.

conducted in a metropolitan area that tends to depopulate in summer months.

With respect to the trauma mechanism, we found a statistical difference between men and women: falls, in or outside the home, more frequently caused PHFs in women, whereas street and sport accidents were more frequently the cause of PHFs in men. No differences in incidence were found according to fractures caused by workplace traumas, aggressions,

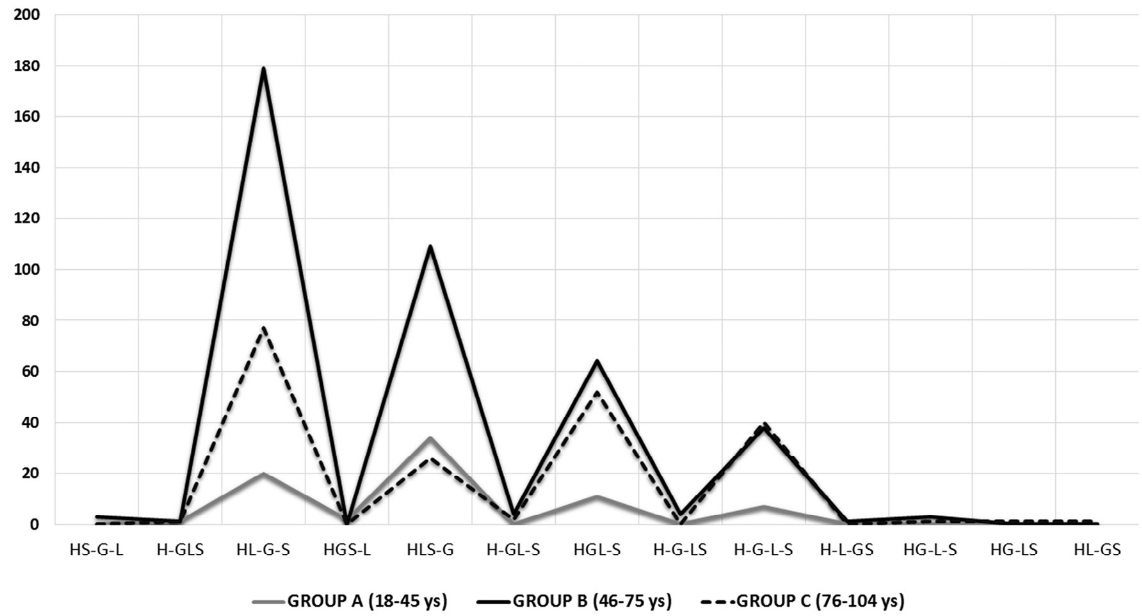

Figure 7 Fracture patterns according to age related subgroups. *HGLS*, head-greater-lesser-shaft.

and without evident trauma. These findings might be related to the fact that women spend more time at home and, together with a longer life expectancy, are at a greater risk of fractures caused by falls resulting from reduced muscular strength, higher incidence of severe osteoporosis, and balance and gait disorders.

In the male population, with a higher involvement in contact sports and driving cars or motorbikes, it was predictable that were they more frequently involved in car accidents and sport traumas. Indeed, as observed in other studies,[16,23] a bimodal fracture distribution according to energy mechanism and patient age was observed in men, with younger patients aged 18 to 60 years suffering higher-energy trauma mechanisms (type 3 and 4) than patients older than 65 years reporting PHFs due to low-energy trauma. Such data could be explained by also considering the progressive decrease in bone strength as a result of aging.

Moreover, no statistical correlation was found when considering the trauma mechanism and the time of year, as they seem to remain stable. As predictable, PHFs resulting from sport trauma were more frequent during the weekend (Saturday and Sunday), whereas street accidents were more frequent on working days (from Monday to Friday) as a greater number of people move due to life style. Workplace traumas were almost absent during the weekend, as expected.

Epidemiologic data on 448 PHFs were also reported by Chu et al.[4] The authors studied the risk factors associated with PHFs and concluded that falls, diabetes mellitus, and difficulty walking in dim light are frequent aspects related to these fracture types. Low dietary calcium intake, difficulty with activities of daily living, and lack of physical activity were also associated with increased risks of fracture. Unfortunately, their study group only consisted of patients older than 45 years.

Most of the cited authors did not classify PHFs or classified the fractures by Neer[20] or AO (Arbeitsgemeinschaft für Osteosynthesefragen [Association for the Study of Internal Fixation])[19]; the low interobserver reproducibility and a low intraobserver reliability of Neer and AO classifications has been underlined.[7,21] In 2013, Hertel et al[26] introduced a detailed topographic classification of PHFs that has good interobserver and intraobserver agreement and provided a more reliable description of PHFs.[26] In our study, we performed a meticulous classification of PHFs, on both pediatric and adult populations, according to Hertel[26] and to Salter-Harris,[24] using x-ray and CT.

Considering the adult population (682 patients), 13 of the 14 patterns of the Hertel classification were registered, and the trauma mechanisms (except for types 6 and 7) significantly influenced the fracture patterns due to the energy of the injury. A statistical difference between the patterns of PHFs was also shown dividing the patients in different age groups. In particular, the 3 groups were characterized by specific patterns of PHFs: fracture of the great tuberosity (HLS-G) was more common in young adults (45% of our population), fractures of the great tuberosity and surgical neck (HL-G-S) in adults (44%), and fractures of the surgical neck (HGL-S) and of 4-part PHF (H-G-L-S) in the elderly. This could be explained by the different mechanical resistance to traumas of the bone in the different age groups as a result of osteoporosis.

Our study has some limits. Fracture classification was performed by CT scans in only 28% of the patients. However, CT is a second-stage diagnostic tool and has been prescribed only in the case of displaced-comminuted fractures in which x-ray imaging was not sufficient for the choice of treatment. Another limitation is the small number in the pediatric group. However, proximal humeral epiphyseal detachments are very rare and represent only 0.5% of all children's fractures.[22]

Conclusions

This epidemiologic study, conducted on a large number of people with PHF, confirmed a higher prevalence in women, an increase in incidence with older age, and that it is more frequent during the winter months. In addition, the study showed that (1) men sustain fractures after traumatic events that differ from those that cause fractures in women, (2) a correlation between trauma and type of fracture is evident only for the adult population, and (3) some fracture patterns are correlated with different age ranges in all patients.

Disclaimer

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