

Epidemiological characteristics and distribution of pediatric supracondylar fractures in South China: a retrospective analysis of 760 cases

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To evaluate demographic characteristics and distribution of pediatric supracondylar fractures (SCFs) at a tertiary hospital in South China. A retrospective observational study was conducted on children aged 15 years or younger with a diagnosis of SCFs during the period from January 2016 to December 2018. Patients' medical records and radiographs were retrospectively analyzed for age at the time of injury, sex, site and mechanism of traumatic injury. A total of 760 patients with 761 SCFs were reviewed (453 males, 59.6%, and 307 females, 40.4%). There were 748 extension-type fractures (98.3%) and 13 flexion-type fractures (1.7%). Associated injuries were identified in 30/760 (3.9%) patients: associated fracture ($n = 15$; 2%), nerve injury ($n = 12$; 1.6%), open fracture ($n = 2$; 0.2%) and compartment syndrome ($n = 1$; 0.1%). Age at the time of fracture has a bimodal pattern with a first peak around the age of 1 year and a second peak around the age of 4–5 years. The fractures occurred mostly around 11 a.m. and between 4 and 9 p.m. in the evening. Most fractures occurred at home (50.7%), and falling down (62.2%) was the most frequent mechanism of injury. SCFs occurred most frequently

in children aged 1 and 4–5 years, and during daylight hours. In about 96% of cases, these were isolated injuries, and falling down was found to be the most frequent traumatic mechanism. Based on our findings, targeted educational efforts and interventions can be set up in order to prevent the occurrence of SCFs in South China. Level of evidence: III. *J Pediatr Orthop B* 33: 136–141 Copyright © 2023 The Author(s). Published by Wolters Kluwer Health, Inc.

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Introduction

Supracondylar fractures (SCFs) are the most common elbow fracture in children [1–3]. Understanding the epidemiological characteristics and distribution of SCFs in different settings and countries is critical to implementing tailored prevention and treatment strategies such as raising awareness and focused health education programs on the causes of childhood accidents and home safety enhancement for parents and teachers in the Kingdom of Saudi Arabia, playground safety education and policy change in Korea and national action in China [4–6]. Several studies have evaluated the distribution of SCFs in many regions and countries and found that SCFs are more frequent in older children such as 55% (320/589, median age 7.4) reported by Landin *et al.* and 58% (209/355, median age 7.9) reported by Houshian *et*

al., and involve the nondominant, left side in most cases [3,7–12].

However, data inherent in other epidemiological characteristics such as season, month and time of injury, traumatic mechanism, presence of an associated injury, and Gartland subtype are very limited [7,11–13]. In addition, epidemiologic data on SCFs in South China, an area of 2.4 millions of square kilometers with 680 millions of inhabitants, are unknown.

This article used the hand registry of Guangzhou Women and Children Medical Center to examine the data of all children <15 years with SCFs treated between January 2016 and December 2018. The aim of this study is to evaluate the epidemiological characteristics of SCFs at a tertiary hospital in South China based on age at the time of injury, sex, site and type of fracture, and mechanism of traumatic injury, in order to facilitate comparison with data from other countries or regions as to implementing tailored prevention policies.

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Materials and methods

After securing Institutional Review Board approval, we retrospectively reviewed the medical records of 760 consecutive children who were diagnosed with SCFs from January 2016 to December 2018 at our Institution.

The inclusion criteria were as follow: (1) confirmed diagnosis of SCF; (2) complete clinical and radiographic data; (3) treatment exclusively performed at our Institution; (4) age <15 years at the time of injury. Patients with incomplete clinical and radiographic data, pathological or fractures and those managed elsewhere were excluded.

Data regarding sex, age, laterality, season and month, time of the day, mechanism of injury, location of injury and associated injuries were retrieved from the medical charts. Plain radiographs were used to classify SCFs according to Gartland's classification based on severity of displacement and the presence or absence of an intact posterior cortex: type I (not displaced), type II (displaced with intact posterior cortex) and type III (displaced with no cortical contact) and to distinguish extension or flexion-type based on direction of displacement [13].

Radiographs and medical charts were also used to retrieve presence and type of associated injury.

According to age at injury, patients were divided into four groups: (1) infant (<3 years), (2) preschool (3–5 years), (3) school (6–9 years) and (4) adolescent (10–14 years).

Based on the month, day and time of trauma, the following subgroups were identified:

- (1) Season: spring (March 21st to June 20th), summer (June 21st to September 20th), autumn (September 21st to December 20th) and winter (December 21st to March 20th);
- (2) Time of day: morning (6.00 a.m. to 1.59 p.m), afternoon/evening (2.00 p.m. to 7.59 p.m.) and night (8.00 p.m to 5.59 a.m).

Statistical analysis

All statistical analyses were performed using the statistics package SPSS 22.0 (SPSS, Chicago, Illinois, USA). Categorical parameters are expressed as frequencies and percentages. Quantitative data are expressed as the mean $\pm$ SD and range. Statistical analyses were performed using the Chi-square test for categorical variables. The level of statistical significance was set at $P < 0.05$.

Results

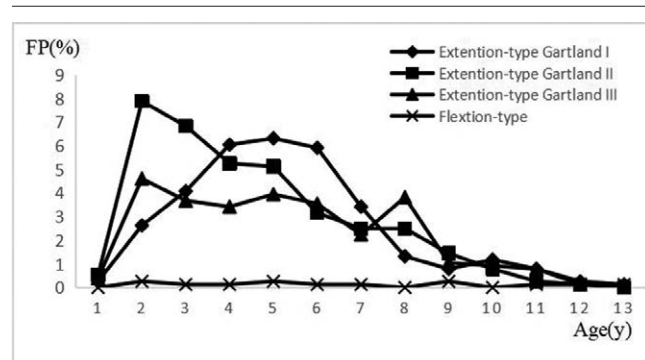
The total number of pediatric patients admitted for elbow trauma during study period was 841. Of this total, 790 (93.9%) patients (317 girls and 473 boys) met the inclusion criteria; 18 (six girls and 11 boys) were excluded due to incomplete data and 12 (four girls and nine boys) because they were treated in another institution.

Among the 760 patients available for review (761 fractures), 453 were males (59.6%) and 307 were females (40.4%); there were 748 extension-type (98.3%) and 13 flexion-type fractures (1.7%). Among extension-type fractures, 253 were Gartland type I (33.8%), 277 type II (37.0%) and 218 type III (29.2%) (Table 1).

Table 1 Clinical characteristics of supracondylar fractures in children

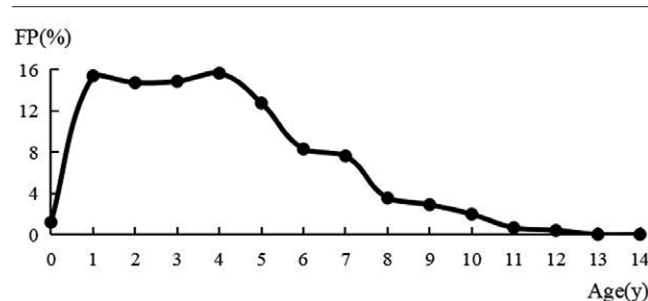
Parameter		Extention-type			Flexion-type
		Gartland I, N (%)	Gartland II, N (%)	Gartland III, N (%)	
Sex	Male	158 (62.5%)	163 (58.8%)	130 (59.6%)	3 (23.1%)
	Female	95 (37.5%)	114 (41.2%)	88 (40.4%)	10 (76.9%)
Age (years)	0–2	53 (21.0%)	116 (41.9%)	66 (30.3%)	3 (23.1%)
	3–5	140 (55.3%)	122 (44.0%)	100 (45.9%)	5 (38.5%)
	6–9	51 (20.2%)	36 (13.0%)	44 (20.1%)	2 (15.3%)
	10–14	9 (3.5%)	3 (1.1%)	8 (3.7%)	3 (23.1%)
Season	Spring	60 (23.7%)	62 (22.4%)	50 (22.9%)	4 (30.8%)
	Summer	65 (25.7%)	54 (19.5%)	64 (29.4%)	3 (23.0%)
	Autumn	63 (24.9%)	88 (31.8%)	65 (29.8%)	4 (30.8%)
	Winter	65 (25.7%)	73 (26.3%)	39 (17.9%)	2 (15.4%)
Time of day	Moring	89 (35.2%)	89 (32.1%)	66 (30.3%)	1 (7.7%)
	Afternoon/evening	103 (40.7%)	118 (42.6%)	89 (40.8%)	10 (76.9%)
	Night	61 (24.1%)	70 (25.3%)	63 (28.9%)	2 (15.4%)
Location of injury	Home	126 (49.8%)	145 (52.4%)	108 (49.5%)	6 (46.1%)
	Playground	77 (30.4%)	89 (32.1%)	49 (22.5%)	2 (15.4%)
	School	32 (12.7%)	18 (6.5%)	38 (17.4%)	4 (30.8%)
	Other places	18 (7.1%)	25 (9.0%)	23 (10.6%)	1 (7.7%)
Mechanism of injury	Falling down	209 (82.6%)	151 (54.5%)	103 (47.2%)	11 (84.6%)
	Falling from height	20 (7.9%)	88 (31.8%)	73 (33.5%)	1 (7.7%)
	Sports injuries	16 (6.3%)	23 (8.3%)	31 (14.2%)	1 (7.7%)
	Traffic accident	2 (0.8%)	12 (4.3%)	8 (3.7%)	-
	Fights	3 (1.2%)	3 (1.1%)	1 (0.5%)	-
	Other injuries	3 (1.2%)	-	2 (0.9%)	-
	Associated fracture	5	3	6	1
Associated injury	Nerve injury	-	1	11	-
	Open fracture	-	-	2	-
	Compartment syndrome	-	-	1	-

Fig. 2



The proportion of different types of fractures at different ages.

Fig. 1



The proportion of fractures in different ages. FP, fracture percentage.

The right side was involved in 334 patients (44%) and the left in 425 (55.9%) with a right-to-left ratio was 1:1.35; one patient had bilateral involvement (0.1%). The average age at the time of injury was 4.1 ± 2.3 years (range, 0.8–13). The average time to presentation was 15.6 h after the injury (range, 0.3–52.6). Overall, 537 patients (70.7%) were referred from nearby institutions and 223 cases were admitted via our Emergency department (29.3%). The Guangzhou-to-non-Guangzhou ratio and urban-to-rural ratio was 1.88:1 and 2.23:1, respectively.

Age characteristics

The age distribution of SCFs showed a bimodal curve, with a peak at 1 and 4–5 years of age. Specifically, the peak of fractures was reached at the age of 4 years, began to decrease between the ages of 6 and 9 years, and decreased significantly after the age of 10 years (Fig. 1). Infant and preschool age children were had the high incidence of SCFs. Our analysis found that Gartland type I fractures were particularly frequent between 3 and 7 years of age (174 patients, 68.8%), Gartland type II between 2 and 5 years of age (155 patients, 56.0%) and Gartland type III between 1 and 7 years of age (192 patients, 88.1%); no significant difference in the

incidence of flexion-type fractures at all ages could be found (Fig. 2).

Sex characteristics

The incidence of SCFs was higher in boys than in girls at all ages except in patients younger than 1 year of age (Fig. 3). The lowest male-to-female ratio was in the <1 year of age group (1:2) while the highest was observed in the 10 years of age group (7.5:1) (Fig. 4). There was a significant difference in the male-to-female ratio at all ages ($\chi^2 = 33.08$, $P < 0.05$); and the incidence of all types of fractures was higher in boys than in girls at all ages except for flexion-type SCF ($\chi^2 = 17.64$, $P < 0.05$).

Season, month and time characteristics

SCFs were highly prevalent in October and November, reaching the highest peak in November (Fig. 5). The number of fractures is 1.14 times higher during summer and autumn (June to November) than during winter and spring (December, January to May).

Fractures were more frequent during the afternoon/evening (2.00 p.m. to 7.59 p.m.; 320 patients, 42.1%) than during the night (8.00 p.m. to 5.59 a.m.; 245 patients, 32.2%) and during the morning (6.00 a.m. to 1.59 p.m.; 195 patients, 25.7%); the highest incidence of fractures was recorded at 11.00 a.m., 4.00 p.m. and 8.00 p.m. (Fig. 6).

Location and mechanism of injury

Most of the fractures occurred at the patient's home (domestic accident; 385 patients, 50.7%), the others at the playground (216 patients, 28.4%), school (92 patients, 12.1%) and other places (supermarket, road and hospital) (67 patients, 8.8%).

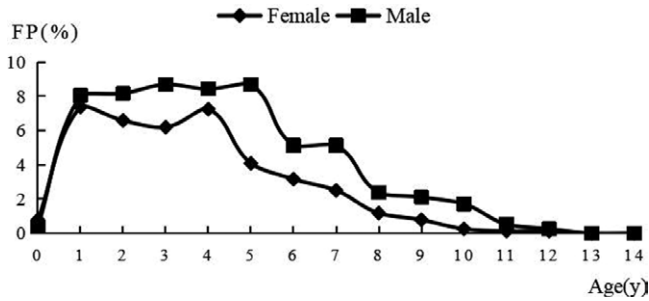
The most common mechanism of injury was falling down (473 patients, 62.2%) followed by falling from height (182 patients, 23.4%), sports injuries (71 patients, 9.3%), traffic accident (22 patients, 2.9%), fights (pushing, tripping and bruising; seven patients, 0.9%) and other injuries (five patients, 0.7%).

Fall from height was the main mechanism of injury in Gartland type I (82.6%), type II (54.5%), type III (47.2%) and flexion-type SCFs (84.6%), and fall from height was also the common mechanism of injury in Gartland type II (31.8%) and type III (33.5%) SCFs.

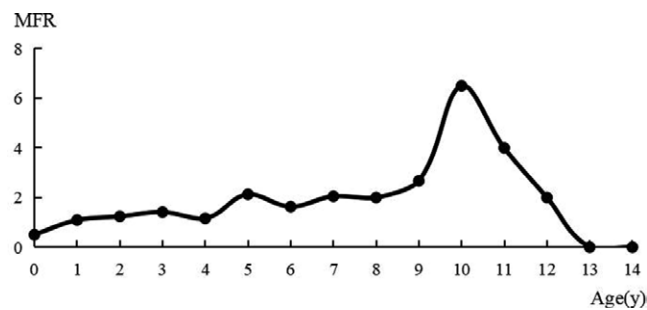
Associated injury

Associated injuries were recorded in 30/760 (3.9%) patients: associated fracture ($n = 15$; 2.0%), nerve injury ($n = 12$; 1.6%), open fracture ($n = 2$; 0.2%) and compartment syndrome ($n = 1$; 0.1%).

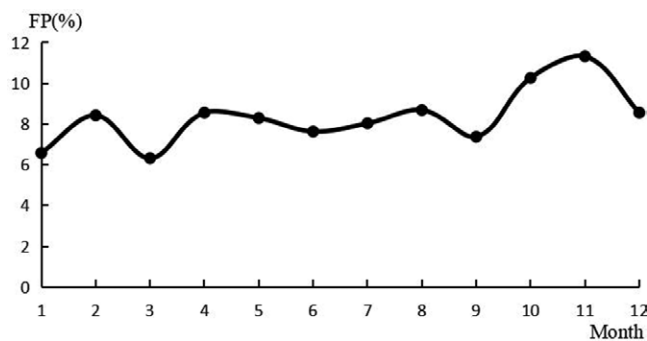
In particular, five Gartland type I, three type II, six type III and one flexion-type had an associated injury; these included three fractures of radius and ulna

Fig. 3

The proportion of male and female fractures in different age groups.

Fig. 4

The male-female ratio (MFR) of different ages.

Fig. 5

The proportion of fracture in different months.

(0.4%), eight cases of isolated fracture of the ulna (1%), two isolated fractures of the radius (0.3%), one lateral condylar fracture (0.1%); one patient had >1 associated injury (0.1%).

Nerve injury was detected in 12 patients (11 Gartland type III and one type II); radial nerve was involved in 10 cases (1.6%), ulnar nerve in one case (0.1%) and median nerve in one case (0.1%); only one vascular injury (brachial artery) was recorded (0.1%).

Two patients sustained an open injury (0.3%); in one case, the patient fell from the stairs; in the other, the patient fell while carrying some loads; both injuries were Gartland type III. In addition, one patient with Gartland type III SCF developed a compartment syndrome.

Discussion

The present study from a large tertiary hospital of Southeast China found SCFs occurred more frequently in boys younger than 5 years of age during daily hours. Gartland type II was the most common type of SCFs and about 96% of fractures are isolated injuries mostly secondary to falling down. Associated injury is relatively rare; in particular, forearm fracture (single or both bones) and radial nerve injury are the most frequently associated injuries.

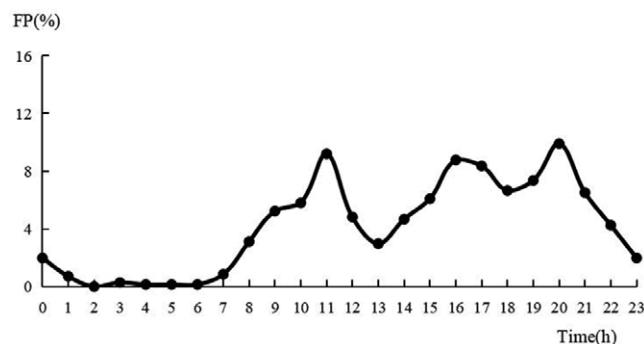
According to the literature, extension-type fractures are frequent, with a reported incidence of 95%, including 39–45% of Gartland type III, 30–40% of type I, 21–24% of type II and 1–5% of type IV [7–9]. However, in the present study, 36.5% of SHFs were type II, 33.2% type I, 28.7% type III and 1.7% were type IV; these may be related to the age and other demographic characteristics of children living in this part of the world [11,12,14]. In addition, previous studies have pointed out the left side is more likely to be affected, which is consistent with our findings.

Our findings showed SCFs are highly prevalent in boys, which is consistent with previous reports [12,14]. In particular, Landin *et al.* and Valerio *et al.* reported a male-to-female ratio ranging between 1.5/1.7 and 1 while the ratio in our series ranged between 1.5 and 1. However, a slightly larger proportion of females in some regions has been reported by Sinikumpu *et al.* [15]. Despite this finding, the higher incidence of SCFs in boys may be related to the fact that boys tend to be more active than girls and to participate in more high-risk activities [11,14].

Most studies have reported that SCFs are highly prevalent between the age of 4 and 12 years [10,11,16,17]. However, our study found that SCFs are highly prevalent between the age of 1 and 5 years. This is probably related to the limited protection of children in this age group, which is consistent with Goulding *et al.* (<5 years) and Wu *et al.* (1 and 3–6 years) [18,19].

Previous studies have also shown that the occurrence of SCFs follows a seasonal trend, with a high incidence during summer months (July and August) when the weather is warm and number of daylight hours is higher compared to winter months [15,20–22]. However, our study found that most fractures occurred in autumn, with the incidence being the highest in October and November. This finding is related to the outdoor temperature during the summer season in South China. During summer

Fig. 6



The proportion of fractures at different times.

months outdoor temperature can exceed 40° with high level of humidity, thus preventing outdoor activities. On the other hand, temperature is mild during autumn (25° on average) and outdoor activities are common. In addition, we found that most of the fractures occurred around 11.00 a.m. and between 4.00 p.m. and 9.00 p.m., which was considered to be related to the increased activities of children without parental care, when parents were busy preparing lunch and dinner; in addition, during the afternoon and evening, children often engage in extra-school sports activities. Our study also found that most injuries occurred at home, followed by playground and school. In particular, it has been shown that children under 36 months of age typically sustain a SCF after a fall from a height of less than one meter (typically a fall from a bed or couch, at home); on the other hand, most fractures in older children result from high energy mechanisms such as falls from playground equipment [18–21]. In our study falling down was the most mechanism of injury, which is consistent with reports by Goulding *et al.* and Wu *et al.* [18,19]. Thus, surveillance of children by parents, guardians and teachers is particularly important to prevent SCFs from occurring. We also need to pay attention to the establishment of safety facilities, such as installing fences and putting up eye-catching warning signs in homes, schools and playgrounds, so as to alert the people in charge of supervising children and to reduce the occurrence of accidental injuries in children [2]. In addition, because as many as seven cases of SCFs that occurred as a result of disputes between children (pushing, tripping, and bruising) were identified in our patient cohort, and that such an occurrence has rarely been reported by other studies, it is very important that parents, teachers, and supervisors properly guide and educate children so as to reduce the occurrence of such misbehaviors [3,10–12].

In this study, the overall rate of associated injury was 3.9%. Presence of associated fracture and neurovascular injury were relatively rare, 2 and 1.6%, respectively. Interestingly the rate of neurovascular injury was significantly lower than that reported in foreign studies

(12.0–20.0%) [23,24]. A total of 1.6% of radial nerve injury was the most common nerve injury, which was consistent with the findings of Zhang *et al.* [25]. At the same time, this study also found that Gartland type I and II were often associated with forearm fractures while type III were often associated with radial nerve injury; this finding is probably related to the mechanism of trauma and resulting instability which may stretch the radial nerve [3,19].

We encountered some limitations in the analysis of our results. This is a retrospective review. However, it includes a large cohort of patients. Patients are from Southeast China, so it is possible that some differences may exist among countries. Although the data from the present study may not be universally accepted, they can be used for comparison with other Asian and not-Asian countries. It is necessary to conduct large multicenter studies in order to precisely describe the epidemiological characteristics of SCFs in children and to tailor prevention programs.

Conclusion

SCFs occurred most frequently in children aged 1 and 4–5 years, and during daylight hours. In about 96% of cases, these were isolated injuries, and falling down was found to be the most frequent traumatic mechanism. Based on our findings, targeted educational efforts and interventions can be set up in order to prevent the occurrence of SCFs in South China.

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Conflicts of interest

There are no conflicts of interest.

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