

Epidemiology of paediatric elbow fractures: a retrospective multi-centre study of 488 fractures

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Keywords: elbow fracture; epidemiology; paediatrics; skateboard; caster-board

Abstract

Purpose Elbow fractures are common in children and occur during daily activities. The aim of this study is to evaluate the epidemiology of paediatric elbow fractures over a two-year period in Okinawa, a southern subtropical island in Japan.

Methods This was a retrospective study of 488 elbow fractures in children younger than 15 years old treated at 11 hospitals in Okinawa. Data included age, gender, calendar month, type of fracture, operation rate, mechanism of injury, and aetiology.

Results The most frequent age was 6 years old, with 47.5% of all elbow fractures occurring in an age range from 6 to 10 years old. The fracture rate for boys was 1.6 times higher than that for girls. The incidence was the highest in May (56 fractures) and the lowest in August (25 fractures). Supracondylar fractures were the most common type (44%), followed by lateral condyle fractures (22%); 45% of all fractures were treated operatively. Medial epicondyle fractures had the highest rate of operative treatment (91%). In the 6 to 10-year-old group, 19% of all fractures occurred while skateboarding or caster-boarding, the most frequent aetiology.

Conclusions Supracondylar fractures are the most common fracture type in 4 to 7-year-old boys. In the 6 to 10-year-old group, skateboarding and caster-boarding are the most frequent and increasing cause of elbow fractures. Therefore, some preventive measures are needed.

Level of evidence Level IV, case series

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Introduction

Elbow fractures are common in paediatric populations.^{1,2} Hussain et al³ reported that 28.4% of all paediatric fractures were elbow fractures, which were the most common type of fractures in India in 2015. The overall incidence of elbow fractures was reported at 30.8/10000 per year.⁴ Elbow fractures are rarely life-threatening, but may have serious complications, including neurovascular injuries, cubitus varus deformities, and Volkmann's contractures in supracondylar fractures; nonunion, valgus deformities, and late ulnar nerve palsies in lateral condyle fractures. Understanding common aetiologies is the first step in formulating preventive measures. Paediatric elbow fractures occur during daily life including participation in popular sports and leisure activities. Determining current aetiology is important because children's activities may differ drastically in different countries, and may change considerably within a short period even in the same country. Okinawa is a southerly subtropical Japanese island which constitutes approximately 1% of the area and population of Japan. Therefore, paediatric elbow fractures in Okinawa may have some unique characteristics and distributions. The aim of this cross-sectional study was to survey regional epidemiologic features of paediatric elbow fractures in Okinawa over a two-year period.

Methods

This retrospective multi-centre study was approved by our institutional review board. The informed consents were disclosed as an opt-out consent process. All elbow fractures in children under 15 years old presenting to emergency departments or orthopaedic outpatient departments at 11 hospitals in Okinawa in the period from 1 January 2015 to 31 December 2016 were included. The population of Okinawa during this study period was about 1,440,000, of whom 275,000 (19%) were children under 15 years old. Exclusion criteria were as follows: pathological fractures, fractures at birth, stress fractures, re-fractures within six

months and patients of complete growth plate closure. A total of three patients were excluded (two pathological fractures; one re-fracture within six months). All hospitals had emergency and orthopaedic departments and two or more board-certified orthopaedic surgeons of the Japanese Orthopaedic Association. All hospitals were equipped to perform emergency operations, and paediatric general anaesthesia was available in 10 of the 11 hospitals.

Age at time of injury, gender, calendar month of injury, type of fracture (open/closed, single/combined, and unilateral/bilateral), rate of surgery, fracture mechanism, and aetiology of injury were obtained from records and radiographs. All radiographs were carefully reviewed by two board-certified hand surgeons of the Japanese Society for Surgery of the Hand.

We classified the fracture mechanisms into six categories as follows: *tumble*, tumbled on outstretched elbow at ground level; *fall*, fall on outstretched elbow from above ground level; *lateral bend*, bent the elbow during sports or accidents; *direct hit*, smashed by an object or the elbow got caught in the door; *throw*, injured after throwing a ball or other object, and *unknown*. The aetiologies were categorized by the activity or location of the injuries (e.g. *tumble while playing football/skateboarding*, *fall from chair/bed*, or *lateral bend during Judo*). Subjects were classified into three age subgroups: 0 to 5 years, 6 to 10 years, and 11 to 15 years old.

In more common types of fractures, including supracondylar fractures, lateral condyle fractures, and medial epicondyle fractures, classification (Gartland classification in supracondylar fractures, Wadsworth classification in lateral condyle fractures, Watson-Jones classification in medial epicondyle fractures), and operation rates were extracted.

Results

There were 488 elbow fractures, of which 195 (40%) were on the right side, 293 (60%) on the left side, and none were bilateral. Nine combination fractures (1.8%) are summarized in Table 1. The most common combination was supracondylar fracture with distal radius (and ulna) fracture in six cases, and the remainder were unique with one case each. The age and gender distributions of paediatric elbow fractures are shown in Fig. 1. There were 310 boys (63.5%) and 178 girls (36.5%), making the fracture rate of boys 1.6 times higher than that of girls. The most frequent age was 6 years old, with 47.5% of all fractures occurring in children between 6 and 10 years old (Fig. 1a, Fig. 1b). The calendar-month fracture distribution is shown in Fig. 2. The number of elbow fractures was the highest in May (56) and the lowest in August (25). The six summer months (April–September) had 246 fractures and the six winter months (October–March) had 243. In Japan, the school year begins on 1 April and ends on 31 March. And the average temperature of the first six months (April–September) is higher than that of the last six months (October–March). So we classified the first six months as summer months and the last six months as winter months. This classification has also been used in a previous study.⁵

Type and number of fractures, and number requiring surgery are summarized in Tables 2 and 3. Supracondylar

Table 1 Combinations of fractures

Elbow fractures	Combined fracture	Number
Supracondylar	Distal radius (and ulna)	6
	Forearm shaft	1
Rt. lateral condyle	Lt. distal radius	1
Rt. proximal radius	Lt. distal radius	1

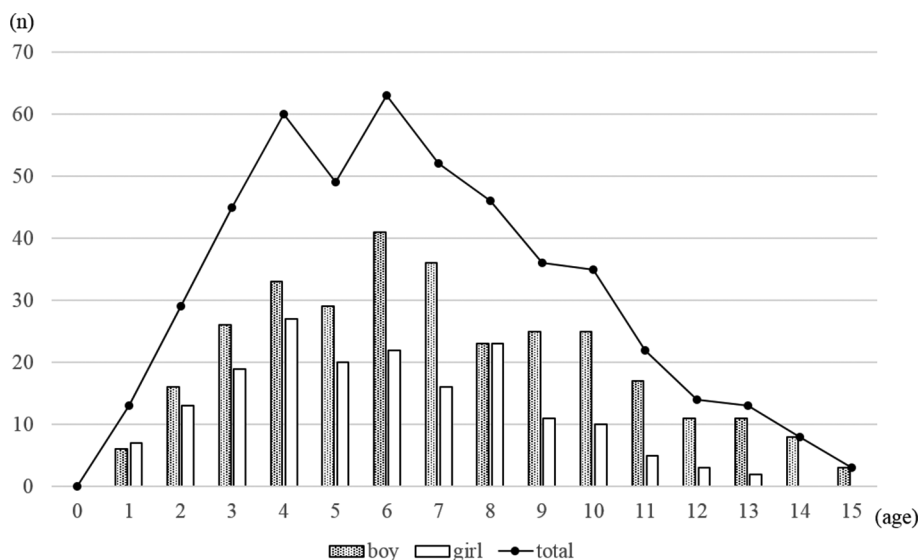


Fig. 1a Age and gender distributions; per year.

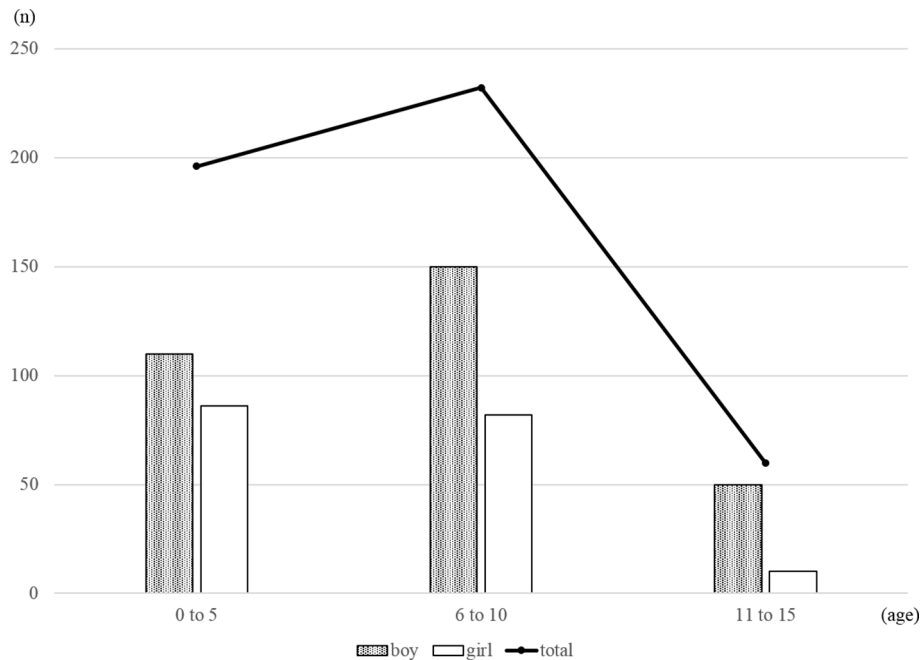


Fig. 1b Age and gender distributions; age subgroup.

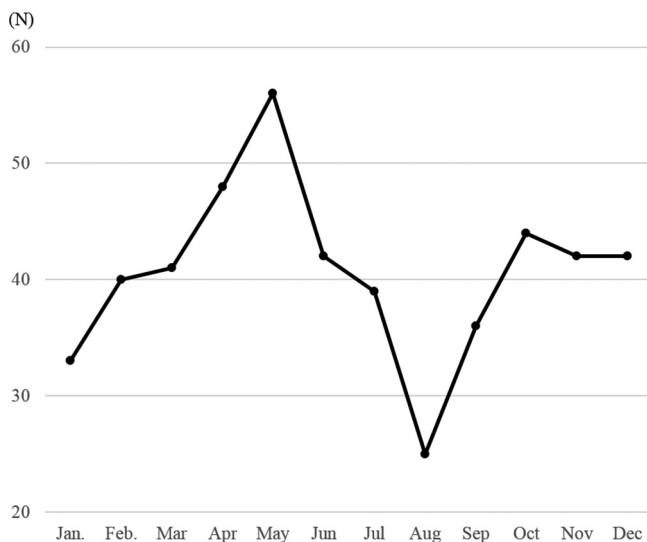


Fig. 2 Calendar-month distribution of elbow fractures.

fractures were the most common type (43.8%), followed by lateral condyle fractures (22.3%); 44.1% of all elbow fractures were treated operatively. Medial epicondyle fracture was the most commonly operated (85.7%), and olecranon fracture was the least (10.2%). Open fractures comprised only four cases (0.8%) and all of these were Monteggia fractures.

Fracture mechanisms are summarized in Table 4. Fall was the most common cause of injury (242 fractures, 49.6%). In the 0 to 5 years subgroup, fall (123 fractures) was the most frequent, and tumble for the 6 to 10 year subgroup (126 fractures). The major aetiology of falls in

Table 2 Fracture type, number of patients, number requiring surgery

Type of fracture	Number of patients (%)	Number requiring surgery (%)
Supracondylar	214 (43.8)	89 (41.6)
Lateral condyle	109 (22.3)	53 (48.6)
Olecranon	49 (10.0)	5 (10.2)
Medial epicondyle	35 (7.2)	30 (85.7)
Proximal radius	26 (5.3)	12 (46.2)
25 radial neck; 1 radial head		
Monteggia	23 (4.7)	14 (60.9)
Others	32 (6.6)	12 (37.5)
Total	488 (100)	215 (44.1)

Table 3 Fracture type, number of patients in each age subgroup

Type of fracture	Number of patients in age subgroup (%)			Total
	0 to 5 years	6 to 10 years	11 to 15 years	
Supracondylar	101 (47.1)	101 (47.1)	12 (5.6)	214
Lateral condyle	47 (43.1)	54 (49.5)	8 (7.3)	109
Olecranon	22 (44.9)	20 (40.8)	7 (14.3)	49
Medial epicondyle	0 (0.0)	15 (42.9)	20 (57.1)	35
Proximal radius	4 (15.4)	14 (53.8)	8 (30.8)	26
Monteggia	9 (39.1)	14 (60.9)	0 (0.0)	23

0 to 5 year olds were indoor falls (from a chair in 18 cases, a sofa in 11, and a bed in 6). In contrast, falls in 6 to 10 year olds were more often outdoor falls (from playground equipment in 14 cases, trees in 11, iron rod in 11, and aerial ladder in 10). The most frequent aetiology in 6 to 10 year olds was injury while skateboarding or caster-boarding (44 fractures, 19%). In 6 to 10 year olds, elbow fractures while skateboarding and caster-boarding were 4.9 times more common than those during bicycle injuries, the second most common aetiology.

Table 4 Fracture mechanisms

Age group (years old)	Tumble	Fall	Lateral bend	Direct hit	Throw	Unknown
0 to 5	55	123	4	5	0	9
6 to 10	126	101	1	2	1	1
11 to 15	33	18	4	4	1	0
Total	214	242	9	11	2	10

Note. Tumble, tumbled on outstretched elbow at ground level. Fall, fall on outstretched elbow from above ground level. Lateral bend, bent the elbow during sports or accidents. Direct hit, smashed by an object or the elbow got caught in the door. Throw, injured after throwing a ball or other object.

Table 5 Gartland classification of supracondylar fractures, number of patients, and number requiring surgery

Gartland classification	Number of patients	Number requiring surgery (%)
I	70	0 (0.0)
II	109	55 (50.5)
III	35	34 (100.0)*
Total	214	89 (41.6)

*One case transferred to another hospital.

Operation ratios of Gartland grade I, II, and III of supracondylar fracture were 0.0%, 50.5%, and 100.0%, respectively (Table 5). The ratios of Wadsworth grade I, II, III of lateral condyle fracture were 12.0%, 76.7%, and 100.0%, respectively (Table 6). The ratios of Watson-Jones grade I, II, III, IV of medial epicondyle fracture were 81.8%, 94.1%, 100.0%, and 100.0%, respectively (Table 7).

Discussion

This study is the first epidemiological study of paediatric elbow fractures in Okinawa and provided some unique information about such fractures' characteristics and aetiologies. The peak incidence of elbow fractures was at 6 years old, with the majority (47.5%) occurring in children in range from 6 to 10 years old, as has been noted in previous studies.^{4,6,7} The male:female ratio was 1.6:1.0 in our study, which was also similar to that in previous studies.^{6,7} Elbow fractures more commonly occur on the non-dominant side. This is likely because the dominant upper extremity is in use, and the non-dominant assumes the protective role during injury. Approximately 90% of Japanese people are right-handed. In our study, 40% of fractures were on the right side and 60% on the left, again similar to previous studies.^{4,7} General frequencies by age, gender, and fracture side were similar to earlier elbow fracture research findings, even in other countries or other generations (Table 8).

Some authors have reported that elbow fracture incidence rates were higher in the summer and lower in the winter in Denmark⁴ and Sweden.⁶ Khoshbin et al⁵ reported supracondylar fracture incidence in summer months (April–September) was 2.7 times greater than in winter

Table 6 Wadsworth classification of lateral condyle fractures, number of patients, and number requiring surgery

Wadsworth classification	Number of patients	Number requiring surgery (%)
I	57	12 (21.1)
II	44	33 (76.7)*
III	9	8 (100.0)*
Total	110	(48.6)

*One case transferred to another hospital

Table 7 Watson-Jones classification of medial epicondyle fractures, number of patients, number requiring surgery

Watson-Jones classification	Number of patients	Number requiring surgery (%)
I	11	9 (81.8)
II	18	16 (94.1)*
III	2	2 (100.0)
IV	4	3 (100.0)*
Total	35	(85.7)

*One case transferred to another hospital

months (October–March) from 2002 to 2010 in a population-based study in Canada. Some authors have attributed the increased incidence of elbow fractures during the summer to greater involvement in outdoor activities, or to the fact that many children leave the city during summer holidays.^{5,6} Masterson et al⁸ reported a positive correlation between sunshine hours and monthly fracture rates, with the prevalence of fractures in the summer being 2.5 times greater. In the current study, elbow fractures in August (25 fractures) were the lowest, and fractures in the summer months were almost equal to those in the winter months (246 versus 243). Okinawa is a southern subtropical island and the climate is warm. In 2015, the lowest average temperature in Okinawa was 17.0°C in January, and the highest was 28.9°C in August. And the average temperature of summer months is 6.7°C higher than that of winter months (27.5 vs. 20.5°C). Children are able to participate in outdoor activities throughout the year, due to the warm climate and lack of snow. We consider it likely that the elbow fracture incidence in summer in our study is low compared with that in the etiological studies of Sweden,⁶ Denmark,⁴ and Canada⁵ because of the warm climate throughout the year. And recently, the dangerousness of heat stroke has become well known. So children might avoid going outside when the temperature is so high. We consider avoidance of heat stroke is another reason for the decreasing incidence in August. However, we cannot attribute the pattern of seasonal variation only to temperature because there are many other factors influencing the fracture rate, including sunshine hours, culture, urban or rural location, summer holidays, and religious observances (Table 8).

Supracondylar fractures are the most common type of elbow fracture in children, with a reported incidence

Table 8 Comparison of previous and current studies

	Highest frequent age or age group (years old)	Male/female	Right/left	Calendar month	
				Highest	Lowest
Landin AL, et al ⁶	6	1.6	0.7	Jul.	Jan.
Houshian S, et al ⁴	5	0.9	0.7	Aug.	Dec.
Behdad A, et al ⁷	4 to 8	2.6	0.7*	–	–
Current study	6	1.7	0.7	May	Aug.

*Analysis of supracondylar, radius head, lateral condyle, radius neck, and olecranon fractures.

of 177.3/100,000 children.⁹ Among all elbow fractures, 55% to 58% were supracondylar fractures in previous studies.^{4,6,7} In the current study, the supracondylar fracture was the most common at 43.8%, followed by lateral condyle fracture at 22.3%. In previous studies, however, the second most frequent type was reported to be proximal radius fracture (radius neck and head) and the rates were reported to vary from 11% to 18%.^{4,6,7} In the current study, the rate of proximal radius fractures was only 5.3%, making it the fifth most common type of fracture. In contrast, the frequency of lateral condyle fracture was reported at 9% to 12% in previous studies,^{4,6,7} much lower than that in current study (22.3%). Looking at only Japanese articles and textbooks, however, lateral condyle fracture is the second most common type of fracture, followed by supracondylar fracture. Kang and Park¹⁰ reported the majority of cases with an injury mechanism of hyperextension with valgus stress caused proximal radius fractures, while hyperextension with varus stress caused lateral condyle fractures. They also reported that a more anatomically valgus-deviated elbow predisposed individuals to radial neck fracture, while a more varus-deviated elbow predisposed them to lateral condyle fracture. In other words, the carrying angle in elbows with radial neck fractures was significantly greater than that in elbows with lateral condyle fractures.¹⁰ In Japanese children, the elbow alignment may be more varus-deviated than in children of other nationalities or ethnicities. However, to our knowledge, there is no English-language scientific article describing differences in elbow alignment between national or ethnic groups.

In this study, injuries while skateboarding or caster-boarding were the most common cause of elbow fractures in 6 to 10 year olds (19%, 44/232 cases). A caster-board is a two-wheeled vehicle that resembles a skateboard. It has two narrow platforms joined by a bar, and one caster with a wheel is mounted to each platform. It moves forward when a rider stands with one foot on each platform and twists, as opposed to skateboards, which are moved by pushing with the rider's feet on the ground. It was awarded '2008 Toy of the Year' in the United States and released in November 2008 in Japan. It is more popular for primary-school children than skateboarding. It may

be that more elbow fractures while skateboarding or caster-boarding occurred in Okinawa because the children can ride the boards throughout a year due to the warm climate without snow. These board activities may help train children's sense of balance. However, board injuries were the most common elbow fracture aetiology in 6 to 10 year olds, so preventive measures (such as wearing protective elbow pads or e-learning a lecture how to ride and prevent injuries) to reduce elbow fracture while skateboarding or caster-boarding in this age group should be encouraged.

In this study, the operation rate of medial epicondyle fractures was the highest (85.7%). In medial epicondyle fracture, absolute indications for operative treatment are limited to open fractures and non-reducible incarcerated fracture fragments. Relative indications include ulnar nerve dysfunction, elbow instability, high-level upper extremity athletic participation, and displaced fractures.¹¹ Farsetti et al¹² have reported that nonsurgical management of displaced (5–15 mm) medial epicondyle fractures yields results similar to those of surgery, even when bone union is not achieved. When this fracture occurs, the capsular ligaments and anteromedial muscular structures can be damaged. Several studies have noted that injury to these medial stabilizing structures, far more than fragment displacement, can influence joint stability and eventual outcomes.^{13,14} Lee et al¹⁵ reported that more than 60% of patients have radiographic nonunion that commonly causes elbow stiffness and may cause valgus instability. Louahem et al¹⁴ recommend surgical intervention for such fractures, with anatomic reduction to achieve solid bone union and thus prevent valgus instability. Stepanovich et al¹⁶ reported in their prospective study that operative management resulted in higher rates of both fracture union and return to sport. These recent recommendations may have contributed to the high rate of operative intervention for medial epicondyle fractures in our study.

There was a limitation in this study that the fractures in the study population may be atypically severe because the children in this study were those who presented to hospitals with emergency departments. Some children, with no or minor displaced elbow fracture, went to orthopaedic clinics.

In conclusion, frequencies by age, gender, and fracture side for elbow fractures in Okinawa were similar to those in previous studies, even in other countries or other generations. Low frequency rates of elbow fractures in summer may be unique to Okinawa. Higher rates of lateral condyle fracture may be unique to Japan. Nineteen percent of all elbow fractures in 6 to 10 year olds during our study period were sustained while skateboarding or caster-boarding; therefore, use of protective equipment during these activities should be encouraged.

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COMPLIANCE WITH ETHICAL STANDARDS

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No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

OA LICENCE TEXT

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ETHICAL STATEMENT

Ethical approval: All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Institutional review board approval was obtained from our hospital for this retrospective multi-centre study.

Informed consent: Not required for this retrospective study.

ICMJE CONFLICT OF INTEREST STATEMENT

None declared.

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AUTHOR CONTRIBUTIONS

HO: Study conception, Data collection, Data analysis, Manuscript preparation.

MN: Study conception, Data analysis, Manuscript preparation.

MK: Data collection, Data analysis.

KO: Data collection, Data analysis.

CF: Data collection, Data analysis.

FK: Study conception, Manuscript preparation.

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