

Incidence of flexion-type supracondylar fractures at a single Australian level one Paediatric Trauma Centre

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Introduction

Supracondylar fractures are the most common elbow fracture in the paediatric population.^{1,2} They account for 15% of all paediatric fractures³ and are the second most common fracture in childhood. The majority of these are extension-type fractures (up to 98%) commonly caused by falling onto an outstretched hand.² In contrast, the much less common flexion-type supracondylar fractures usually result from a direct fall on the elbow, leading to anterior angulation of the distal fragment which places the ulnar nerve at risk.^{3,4} Studies, including Flynn *et al.*¹ suggest that flexion-type supracondylar fractures are a more significant injury than extension-type fractures. Higher rates of open reduction internal fixation in flexion-type frac-

Abstract

Background: Supracondylar fractures are the most common elbow fracture. There have been no studies published analysing flexion-type fractures in the Australian paediatric population. This paper aims to investigate flexion-type supracondylar fractures in an Australian paediatric population. Eight hundred and three paediatric supracondylar elbow fractures were retrospectively reviewed at one hospital over a 5 year time period. The focus was on flexion-type fractures.

Methods: Supracondylar fractures that presented to the Women's and Children's Hospital Emergency Department between 2015 and 2020 were retrospectively reviewed. Fractures were classified on plain radiographs according to the Modified Gartland Classification System. Injury and treatment data were collected for flexion-type fractures.

Results: Twenty-one (2.6%) of fractures were flexion-type. The average age of injury was 6.8 years old. Flexion-type fractures were more common in females (62%) and with high energy mechanisms (81%). Ulnar nerve palsies occurred in five cases (24%). Two ulna nerve palsies did completely resolve at 3 months follow up. One open fracture occurred. No vascular injuries occurred. Ten of the 21 flexion-type fractures (48%) were treated surgically.

Conclusions: The authors conclude that: flexion fractures are uncommon, they occur more often after high energy mechanisms such as falls from monkey bars, swings, or trampolines. Flexion-type fractures occur more often in slightly older females. The ulnar nerve is most frequently injured and in the current study—exclusively injured. At 3 month follow up, spontaneous nerve recovery had occurred in three of the five cases (60%).

tures^{1,3} have been reported, as well as higher rates of complications such as ulnar nerve palsies.^{1,3}

As flexion-type supracondylar fractures account for only two to 10 % of all supracondylar fractures, literature analysing these injuries^{2,3,5,6} especially regarding the recovery of any nerve palsies is extremely limited. A review study by Sharma⁶ highlights the variation in incidence of flexion-type supracondylar fractures with incidence documented between one and 10%, however does not elaborate on this. Sedentary behaviour has been on the rise over the last decade with a significant proportion of children not meeting the recommended physical activity guidelines.⁷ No paper is yet to analyse whether the changes in children's activity type have influenced the incidence and mechanisms of injury of flexion-type

supracondylar fractures. Additionally, no studies have been published analysing flexion-type supracondylar fractures in the Australian paediatric population. Australians comparatively spend more time outdoors and it is yet to be reported whether this influences the incidence and mechanisms of flexion-type supracondylar fractures.

This study aims to investigate the incidence of flexion-type supracondylar fractures in an Australian paediatric population over the past 5 years. Of particular interest is injury and fracture patterns, as well as incidence and recovery of ulnar nerve palsies, which has not previously been reported upon. It is hypothesised that greater than 50% of flexion-type supracondylar fractures will require internal fixation due to the severe nature of this injury.

Methods

This study utilizes an epidemiology cohort study design to analyse supracondylar fractures presenting to a single level one paediatric trauma centre. The Women's and Children's Hospital is a public hospital and the catchment population includes paediatric patients from newborn to 18 years old located in the Adelaide Metropolitan area and rural areas throughout the state of South Australia. There are no private paediatric emergency departments within the Adelaide Metropolitan area. Small numbers of supracondylar fractures are managed at two other metropolitan hospitals.

A common electronic database was created for all supracondylar fractures that presented to the Women's and Children's Hospital Emergency Department between first January 2015 and the 29th February 2020. These fractures were for retrospective review following ethics approval from the Women's and Children's Health Network (WCHN) Human Research Ethics Committee (HREC). Cases for inclusion in this study were identified and included in the database using the International Classification of Diseases-10 code (ICD-10 code) for supracondylar fractures. The inclusion criteria for this study was: ages one to 16 years old, and a supracondylar fracture diagnosed on conventional elbow anteroposterior and lateral radiographs. Exclusion criteria included fractures with previous bony deformity around the elbow, previous elbow fractures with ongoing non-union, supracondylar fractures as part of a high energy multi-trauma, and closed distal humeral physes on plain radiography.

The initial radiographs of each fracture identified for inclusion were reviewed to confirm and classify the fracture. Fractures were classified as either extension or flexion-type by referring to the position of the anterior humeral line and anterior or posterior fracture displacement. As per previous studies including those by De Boeck,⁸ Garg *et al.*⁴ and Kim *et al.*² the flexion-type supracondylar fractures were then graded according the Modified Gartland Classification System; Type I is minimally displaced, Type II is displaced with some integrity of anterior cortex and Type III is displaced with no cortical contact.^{2,4,8}

Patient demographic data including age and sex was then collected for all supracondylar fractures. To allow further analysis of flexion-type fractures, additional data collected for these injuries included mechanism of injury, fracture characteristics,

neurovascular status, initial and operative management, complications, and follow-up.

A Chi-Square test was utilized to analyse whether the gender mix between flexion and extension groups was statistically significant. The SPSS statistics programme was used to determine whether the data for age of was statistical significance. The descriptive statistics for age is present in Figure 1. For age, skewness results indicated normal distribution, so a *t*-test was used. Statistical significance was also confirmed with Mann–Whitney *U* Test ($p = 0.03$).

Results

Between the 1st January 2015 and 29th February 2020 there were 803 supracondylar fractures that met the inclusion criteria for this study (Table 1). Extension-type supracondylar fractures accounted for 97.4% ($n = 782$), and flexion-type fractures accounted for 2.6% ($n = 21$). For extension-type fractures, 51.3% were male ($n = 401$) and 48.7% were female ($n = 381$). For flexion-types fractures, 38% were males ($n = 8$) and 61.9% were female ($n = 13$). Extension-type supracondylar fractures occurred at a mean age of 5.49 years old. Flexion-type supracondylar fractures occurred at a mean age of 6.76 years old (Fig. 2).

Flexion-type supracondylar fractures

Twenty-one flexion-type supracondylar fractures were analysed. The seasonal distribution of flexion-type fractures was analysed. The highest number of fractures occurred in the month October with four fractures recorded. Over the 5 year time course seven fractures occurred throughout Spring (months September, October and November). This was followed by six fractures recorded in Autumn (months March, April and May). Winter resulted in the least amount of fractures recorded with only three fractures occurring in months June, July and August over the 5 year time course. According to the Modified Gartland Criteria, seven flexion-type supracondylar fractures were Type I, nine were Type II and five were Type III.

High-energy injuries were defined as a fall from greater than standing height. A high-energy injury was the cause of fracture in 80.95% ($n = 17/21$). The most common mechanism was fall from monkey bars (29.4%; $n = 5/17$), followed by fall from swing and fall from trampoline, both 11.76% ($n = 2/17$). One fracture was an open fracture. All four low-energy fractures were reported to be the result of fall on outstretched hand at standing height. Simple fractures, as opposed to comminuted fractures accounted for 85.7% ($n = 18/21$) of flexion-type supracondylar fractures.

Neurological deficits were identified on presentation to the Emergency Department in five of the 21 (23.8%) flexion-type

	EXTENSION	FLEXION
MEAN	5.50	6.76
STANDARD DEVIATION	2.369	2.844
SKEW	0.324	0.482

Fig. 1. Descriptive statistics for age of extension and flexion-type supracondylar fractures.

Table 1 Demographic and injury variables for extension and flexion-type supracondylar fractures

Variable	Level	Extension (n = 782)	Flexion (n = 21)	Statistical comparison
Mean age		5.49 years	6.76 years	$P = 0.017$ (t-test)
Gender	Male	51.3% (n = 401)	38% (n = 8)	$P = 0.23$ (Chi-Square)
	Female	48.7% (n = 381)	61.9% (n = 13)	
Side	Left		57.2% (n = 12)	
	Right		42.9% (n = 9)	
Mechanism	High-energy		80.95% (n = 17)	
	Low-energy		19.05% (n = 4)	
Gartland classification	Type I		33.3% (n = 7)	
	Type II		42.86% (n = 9)	
	Type III		23.81% (n = 5)	
Comminuted versus simple fracture	Comminuted		14.3% (n = 3)	
	Simple		85.7% (n = 18)	
Open versus closed fracture	Open		4.8% (n = 1)	
	Closed		95.3% (n = 19)	
Presence of radial pulse			100% (n = 21)	
Nerve palsy on presentation to Emergency Department			23.8% (n = 5)	
Non-operative casting			47.6% (n = 10)	
Operating theatre required			57.1% (n = 12)	
			9.5% (n = 2)	
Closed reduction			47.6% (n = 10)	
Internal fixation			47.6% (n = 10)	
Recovery of nerve palsy	After surgery and before discharge		20% (n = 1)	
	4–6 weeks post discharge from hospital		40% (n = 2)	
	Residual symptoms at 3 month review		40% (n = 2)	

Age Distribution of Extension and Flexion-Type Supracondylar Fractures

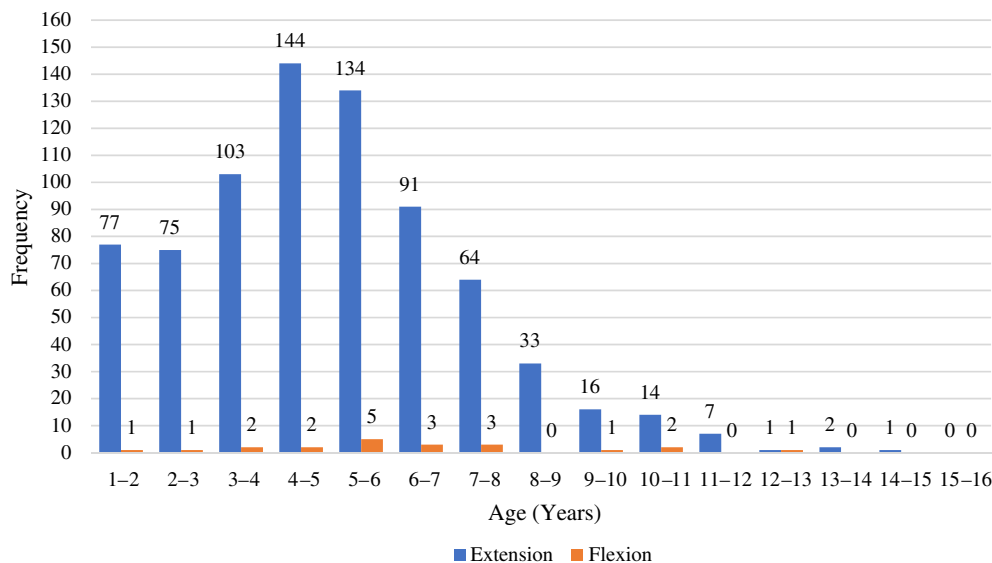


Fig. 2. Age distribution of extension and flexion-type supracondylar fractures.

supracondylar fractures. All of the neurological deficits identified were in the ulnar nerve distribution. All had sensory changes and two of the five fractures with nerve palsies also had a motor deficit. All of patients with a nerve palsy had a high-energy mechanism of injury. A nerve injury was more common in Gartland Type III injuries, comminuted fractures and open injury. All fractures had a palpable radial pulse on presentation.

Internal fixation in theatre through either percutaneous or open approaches was required in 10 of the 21 (47.6%) flexion-type supracondylar fractures.

Percutaneous fixation was required for three of the 10 flexion-type fractures with three lateral pins, two crossed pins and two lateral plus one medial pin. Alternatively, seven flexion-type fractures were managed with open fixation. Of those flexion fractures managed with open fixation, five required two crossed pins, one required two medial and one lateral and one required two lateral pins. One nerve palsy case was managed with percutaneous fixation and four nerve palsy cases were managed with open fixation. No ulnar nerve palsies were noted post operatively after placing of a medial pin, all cases of ulnar nerve palsy were noted pre-operatively. Internal fixation was required in nine of the 17 high-energy fractures compared to only one of the four low-energy fractures. Of those high-energy fractures, all fractures with ulnar nerve palsy required internal fixation, compared to four of the 12 high-energy fractures without nerve palsy. Internal fixation was not required in 11 of the 21 (52.4%) flexion-type fractures. These fractures were managed with a cast with the elbow in slight flexion, with or without closed reduction. Of the five fractures with ulnar nerve palsies, one recovered after surgery and before discharge, two recovered between four to 6 weeks and two experienced residual symptoms at 3 month review. Flexion-type fractures with residual nerve palsy symptoms at 3 month review reported both sensory and motor symptoms.

Discussion

This study shows that the incidence of flexion-type supracondylar fractures in an Australian paediatric population is consistent with international populations (two to 3 %).^{2,3,5} Prior to this study, data regarding the incidence of flexion-type supracondylar fractures has not been reported past 2015. Our study analysing patients between 2015 and 2020 determined that flexion-type supracondylar fractures were more common in females (61.9%) than in males. This may reflect an increase in girls' participation in physical activities or reflect an anatomical difference between paediatric male and female elbows, however neither has been investigated in the literature.

This study reports the mean age of flexion-type supracondylar fractures to be 6.76 years. The mean age of extension-type supracondylar fractures was 5.49 years. A statistically significant difference in the mean age of flexion and extension fractures was proven ($p = 0.017$) and additionally, the comparative age and gender statistics of flexion and extension-type supracondylar fractures are in keeping with prior studies.^{1,2,9} One such reason for this age disparity may be differences in children's activities. Older children may engage in activities more likely to predispose them to a direct fall on elbow and subsequent flexion-type supracondylar fracture.

Of the limited number of papers that studied the incidence of flexion-type supracondylar fractures, only few reported on the mechanism of injury. The findings of this study were in keeping with both Garg *et al.* and Mahan *et al.* findings that flexion-type fractures were most commonly due to a fall from monkey bars or swings.^{4,9} Neither study differentiated injuries as either high or low mechanisms of injury. This study reported 'fall from trampoline' as a cause of 11.76% of flexion-type supracondylar fractures; equal with 'fall from swing'. Neither Mahan *et al.* or Garg *et al.* listed fall from trampoline.^{4,9} Trampolines have become an increasingly popular activity over the past decade with many reports citing an increase in trampoline related injuries globally.¹⁰⁻¹² To determine whether there has been a change in children's activities from previous studies with trampoline related injuries causing a large proportion of flexion-type supracondylar fractures, a multi-hospital study with larger sample size is recommended.

This study reported Gartland Type II to be the most common classification of flexion-type supracondylar fractures (42.86%) followed by Type III (23.8%). This finding differs from that of Kim *et al.* who reported that out of 23 flexion-type supracondylar fractures 65.2% were classified as Gartland Type III². The lower grade of injuries seen in this study may reflect a difference in children's activity type or be a result of Australia's strict playground safety guidelines. The Australian Standard for Playground Safety objective (AS 4685.0) was introduced in 2017 with the aim of minimizing the risk of playground injuries through increasing the thickness of surface of impact area, adjusting free heights of fall and removing obstacles.

This study found that 47.6% of all flexion-type fractures required internal fixation, which was lower than expected considering that flexion-type fractures have previously been demonstrated to be a more severe injury than the extension subtype with reports of more frequent operative management as per Flynn *et al.*¹ One may question whether the lack of surgery for flexion-type supracondylar fractures represents a general trend for more conservative fracture treatment at our South Australian Tertiary Paediatric Hospital. A multi-centre analysis of management of flexion-type supracondylar fractures may provide further insight into this finding. This study also found the incidence of ulnar nerve palsies in flexion-type supracondylar fractures to be 23.8%. This is in keeping with previous international data, which reports the incidence of ulnar nerve palsy following flexion-type supracondylar fractures to vary between 10.5% and 26%.^{1,2,9} In comparison, the literature had found the incidence of nerve palsies in extension-type supracondylar fractures to be 11%.¹³ Gartland Type III fractures were more likely to have an ulnar nerve palsy (60%). No patients presented with an anterior interosseous nerve palsy, the most common nerve injury in extension-type supracondylar fractures. Given the finding that only one ulnar nerve palsy recovered before discharge, and two experienced residual symptoms at 3 months, parents of children with ulnar nerve palsies should be carefully counselled about the expected recovery.

This study has several limitations, many inherent to its retrospective nature. Data collection relied on clinician documentation which was not always consistent, making comparisons difficult. In addition, patients were often discharged at the 3 month mark post injury

and therefore long term follow-up data was not available. This is a limitation of the study, as discharge of patients was determined by clinician's judgement when no further symptom management could be achieved. Furthermore, the database inclusive of all supracondylar fractures presenting to the Women's and Children's Hospital Emergency Department was created by utilizing the ICD-10 classification for supracondylar fractures. Some fractures may have been initially mis-classified and therefore not included in the databased. Small sample size was also a limitation of this study. Despite analysis occurring over a 5 year period, the low incidence of flexion-type supracondylar fractures meant a sample size of only 21 fractures were reported. Statistical analysis was unable to prove that there was any difference in gender mix between flexion and extension groups with a Chi-Square Test. There is however a statistically significant difference in the mean age of the flexion and extension groups. It is recommended that a multi-hospital cohort study of larger sample size be conducted to further evaluate flexion-type supracondylar fractures in the Australian paediatric population.

This study provides an insight into the severity of flexion-type supracondylar fractures within an Australian paediatric population. It has found the incidence of supracondylar fractures to be 2.6%, which is consistent with previous international literature. Compared to more common extension-type fractures, flexion-type fractures are more frequent in females and occur in a slightly older age group. Falls from trampoline are noted to be a mechanism for flexion-type supracondylar fractures, which has not previously been reported.

This study also reports that the incidence of internal fixation in flexion-type supracondylar fractures is 47.6%, which is lower than hypothesised considering the reported severity of these injuries. Moreover, recognition of a supracondylar fracture as the more unusual flexion-type is important as the nerve injury pattern differs from extension-type fractures, with ulnar nerve palsies identified in 23.8% of flexion-type fractures. Only one of the five ulnar nerve palsies recovered after surgery and before discharge and two patients had residual symptoms at 3 months, highlighting the importance of parental counselling at the time of presentation to ensure adequate management of expectations.

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Author contributions

April De Silva: Data curation; formal analysis; investigation; visualization; writing – original draft; writing – review and editing.

Angela C. Alder-Price: Conceptualization; methodology; supervision; writing – review and editing. **Paul Allcock:** Conceptualization; formal analysis; methodology; supervision; writing – review and editing.

Conflict of interest

None declared.

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