

Short-Term Management Outcomes of Supracondylar Fractures of the Humerus and Their Associated Factors in Children Managed at Mulago National Referral Hospital

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Purpose: Supracondylar fractures (SCF) of the humerus is one of the commonest global health concerns among children and need a rigorous management process to obtain satisfactory outcomes. It is of paramount importance to use systematic guidelines to aid abate bad fracture outcomes. The study primarily sought to determine the functional and radiological management outcomes of SCF of the humerus in children at Mulago National Referral Hospital (MNRH) and associated factors to the outcomes.

Methods: We conducted a hospital-based, cross-sectional study among children managed for SCF of the humerus at MNRH. Using Flynn's criteria, current flexion and extension at the elbow joints, humeroulnar angle and the neurology were assessed and compared to the contralateral limb to get the functional outcomes. The pre-management digital radiographs of the elbow joint were compared with the current radiographs to assess radiological outcomes. Bivariate and multivariate analyses were used to determine the associated factors.

Results: Of the 77 children, 46 (60%) were male with a mean age of 7.86 ± 2.30 years. Gartland type I fracture constituted 55.8% (43), type II was 29.9% (23) and type III was 14.3% (11). About 88.3% of the patients were managed non-operatively and 11.7% were managed operatively. The overall satisfactory functional outcome was 46.7%, while 81.8% of the patients had a satisfactory radiological outcome at 6 months after the intervention. Delay in seeking treatment, type I fracture, and prolonged duration of immobilization were significantly associated with unsatisfactory functional management outcome. Type II fracture and prolonged duration of immobilization were significantly associated with unsatisfactory radiological management of SCF of the humerus.

Conclusion: The short-term functional outcome was unsatisfactory, while a satisfactory radiological outcome was found in most of the patients. Duration of immobilization, type of fracture, and seeking late medical care had a negative impact on the outcome of these fractures.

Keywords: supracondylar, fracture, children, management, outcome

Introduction

Globally, supracondylar fracture (SCF) of the humerus is the most common fracture amongst the pediatric population with musculoskeletal injuries.¹ They account for around 13% of all pediatric fractures globally.² A pilot study in Mulago National Referral Hospital (MNRH) showed that 16.55% of musculoskeletal injuries in pediatrics were supracondylar fractures of the humerus (Hospital records). Gartland described a treatment algorithm to allow a variety of management methods to improve treatment outcomes.³ Different treatment guidelines were derived from this algorithm and all of them give to a satisfactory outcome in managing SCF of the humerus.⁴ Management depends on the fracture type where non-displaced fracture shows high satisfactory functional and radiological outcomes in closed reduction and casting.^{4,5}

Displaced fractures, particularly type II have conflicting approaches in their management, but a satisfactory functional result has been reported in most patients and over 90% of radiological satisfaction in closed reduction and percutaneous pinning.⁶ In low-resource settings, fracture treatment delays can be several hours, days, or even weeks due to inadequate resources and patients' delay to seek medical treatment, and these increase the risk of complications and poor outcomes.^{7,8}

The outcomes of Gartland type I fractures are generally satisfactory and are rarely associated with poor outcomes.^{3,9} Patients are usually stable, and immobilizing them with a cast for 2–4 weeks is sufficient.⁹ On the other hand, other types of SCF of the humerus need operative management to have a satisfactory outcome and which in turn depends on the timing of surgery and the size of the pins used for stabilization.^{10,11} Pediatric fractures hold special attention attributable to the fact that bones in children have remodeling ability and infinite growth.¹

A high degree of unsatisfactory outcome including malunion, and/or elbow stiffness have been observed by clinicians while reviewing patients with supracondylar fractures of the humerus. In the clinical evaluation of a patient with SCF of humerus, neurovascular evaluation is carefully done, as injury to those structures is an orthopedic emergency.^{12,13} Neurovascular injury can lead to long-term disabilities and the cost of managing complications could go up to five times or more compared to the cost of the initial management.^{13,14}

Radiographic evaluation of the stage of a supracondylar humerus fracture is of paramount importance in the management of SCF of the humerus.^{3,15} The lateral radiograph should be taken with the patient's arm flexed at a 90-degree angle, the humerus horizontal and the elbow on the same plane with the shoulder and the wrist being in a lateral position.¹⁶ Management of these fractures in children is associated with a big challenge related to patient factors, fracture-related factors, and treatment-related factors, and any of these can contribute to a high complication rate and unsatisfactory outcome.¹⁷ This study, therefore, sought to describe the functional and radiological outcome of SCF of the humerus and their associated factors in children managed at Mulago National Referral Hospital.

Methods

Study Design and Setting

This was a hospital-based cross-sectional study conducted at the orthopedic outpatient clinic of Mulago National Referral and Teaching Hospital, Kampala, Uganda, between May 2020 and November 2020. The pediatric orthopedic clinic is run in the department of orthopedics by a team comprising orthopedic surgeons, residents, and orthopedic officers every Monday. The total number of patients seen per day ranges from 30 to 50 patients.

Study Populations

All consenting parents of children with SCF, who were managed at MNRH and attending the pediatric orthopedic outpatient clinic, were recruited in the study. All participants were at the age of 5 to 14 years at the time of the study. Participants with bilateral SCF of the humerus were excluded from the study.

Sample Size

To determine the sample size for the functional and radiological outcomes, and for the modifiable factors associated with the outcomes of SCF of humerus, we used Kish Leslie and Fleiss formula, respectively. Based on the patient inflow and designated period, the sample size was adjusted by applying the finite population correction factor. Results from a pilot study in MNRH carried out from April to June 2019, 42 patients with SCF of the humerus were seen in the department. This means that for 6 months, only 84 patients with SCF of the humerus can be seen in the hospital. Using this formula;
$$NN = \frac{n}{1 + \left(\frac{n-1}{N}\right)}$$
 a sample size of 70 was obtained. Considering non-response, we used a sample size of 77 participants.

Study Procedure

Patients who presented with SCF of the humerus 6 months before the study (November 2019–April 2020) were identified from the records department at the Accident and Emergency Unit of MNRH. For those who consented, initial radiographs were obtained from the patient to assess fracture type according to Gartland classification. The independent

Table I Social Demographic Characteristics of Study Participants

Characteristics	Frequency (n=77)	Percentage (%)
Age in years (Mean±SD)	7.86±2.30	
5–9	63	81.82
10–14	14	18.18
Gender		
Male	46	59.74
Female	31	40.26
BMI (in percentile range)		
5th to <85th	72	93.51
85th to <95th	05	06.49
Time from injury to presentation		
Same day of injury	11	14.29
1–2 days	21	27.27
≥3 days	45	58.44
Limb involvement		
Left	57	74.03
Right	20	25.97
Dominant hand		
Yes	26	33.77
No	51	66.23
Type of fracture		
Type I	43	55.84
Type II	23	29.87
Type III	11	14.29
Method of management		
Closed reduction and casting	68	88.31
Closed reduction and percutaneous pinning	02	02.60
Open reduction and cross pinning	07	09.09
Duration of immobilization		
4 weeks (28 days)	23	29.87
6 weeks (42 days)	54	70.12

Notes: Mean±SD, mean and standard deviation; %, percentage; th, percentile.

variables – age, gender, BMI, dominant hand, method of management, the time between injury and management – were obtained and recorded on the questionnaire. The weight and the height of the patients were assessed and BMI calculated. The neurological assessment was done, including sensory and motor. Current flexion and extension of the affected elbow joint were assessed using a digital goniometer, and it was compared to the non-affected contralateral limb. New digital radiographs of anteroposterior and lateral views of both affected and non-affected elbow joints were taken aiming at assessment of the carrying angle, using humeroulnar angle. The dependent variables were functional outcomes that were assessed using Flynn's criteria score which had two key elements – range of motion and carrying angle. The radiological outcome was assessed using a digital goniometer, which mainly focused on the humeroulnar angle.

Statistical Analysis

Data was exported to STATA version 14.0 for cleaning and analysis. For descriptive statistics, categorical data were summarized as proportions and percentages, while continuous variables were summarized using means and standard deviation for the normally distributed data and using medians and interquartile ranges for the non-normally distributed data. The radiological outcome was calculated as the proportion of the participants who have documented evidence in which parameters of recovery such as fracture union and normal carrying angle have been seen radiologically. The functional outcomes were categorized into satisfactory and unsatisfactory outcomes based on the degree of flexion, and

degree of extension. The functional outcomes were summarized as proportions or percentages of individuals in each of the categories. To assess factors associated with SCF of humerus, bivariate analysis was done using chi-square, and variables with P-values less than 0.2 and those with biological significance were considered for multivariate analysis. Logistic regression was used at multivariate, and variables with a p-value of less than 0.05 were considered as statistically significant.

Ethical Considerations

This study was performed in compliance with the Declaration of Helsinki.

Ethical approval to conduct the research was sought from the Department of Orthopaedics, School of Medicine, Research and Ethics Committee (SOMREC), Makerere University, and administrative clearance was obtained from Mulago Hospital before commencement of the study. Written informed consent was obtained from the participants through caregivers. Enrolment was voluntary, and participants received an imbursement for their transportation as well as refreshments during the process. Participants may withdraw from the study at any time without consequences to the participant. Data was handled with extreme confidentiality, and double-entry was done to check uniformity and accuracy.

Results

Of the 77 patients with supracondylar fractures of humerus recruited in the study, 46 (59.7%) were males. Although all upper limbs were affected, more than half 57 (74%) had the left upper limb affected and only 20 (26%) had their right upper limb affected. Of those limbs affected, 26 (33.8%) involved the dominant hand, while 51 (66.2%) involved the non-dominant hand. The majority of the patients 43 (55.8%) had Type I fracture, 23 (30%) had Type II fracture and a very few 11 (14.2%) had Type III fracture. More than half of the patients 45 (58.4%) presented for treatment after 72 hours (≥ 3 days) 21 (27.3%) presented for treatment within 24–48 hours (1–2 days) and only 11 (14.3%) presented for treatment on the same day of injury (Table 1) (Figures 1–3).

In this study, more than half of the patients 68 (88.3%) were managed through closed reduction and casting, 9.1% were managed through open reduction and cross pinning, while only 2 (2.6%) were managed through closed reduction and percutaneous pinning (Table 2) (Figure 4).

At bivariate analysis, time from injury to presentation (>3 days; $p=0.047$), type I fracture ($p=0.013$), and delayed duration of immobilization (6weeks, $p=0.011$) were found to have an independent association with a range of motion.

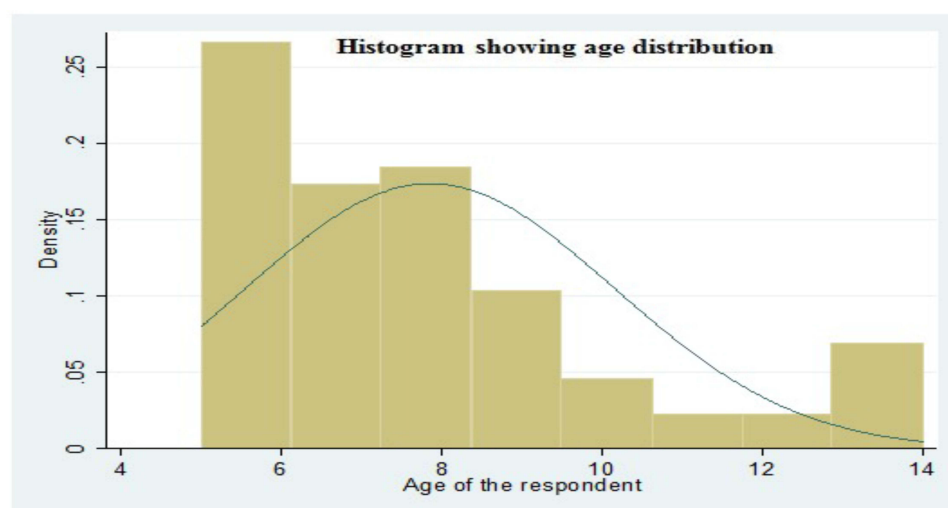


Figure 1 Histogram showing age distribution. The Mean \pm SD age was 7.86 \pm 2.30 years. Most patients, 63 (81.82%) lied between 5 and 9 years of age while few, 14 (18.18%) were in the age category of 10–14 years old as per the study age group. The youngest participants were 5 years old, while the oldest was 14 years old. The above histogram shows a positive tailed distribution because there were more participants with age above the mean age.

Pie-chart showing type of fracture

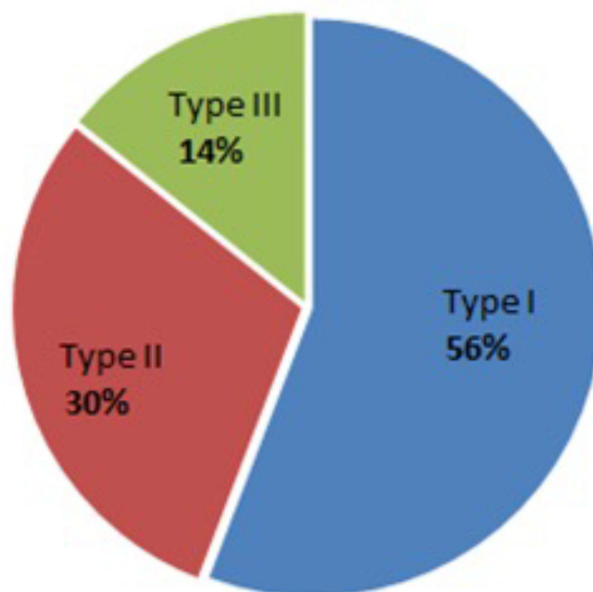


Figure 2 Pie-chart showing proportion of study participants according to type of fracture. Majority of the patients [43 (55.84%)] had Type I fracture while few of the patients [23 (29.87%)] had Type II fracture and very few [11 (14.29%)] had Type III fracture. The pie-chart shows the proportion of study participants according to the fracture type.

Pie-chart showing time from injury to presentation

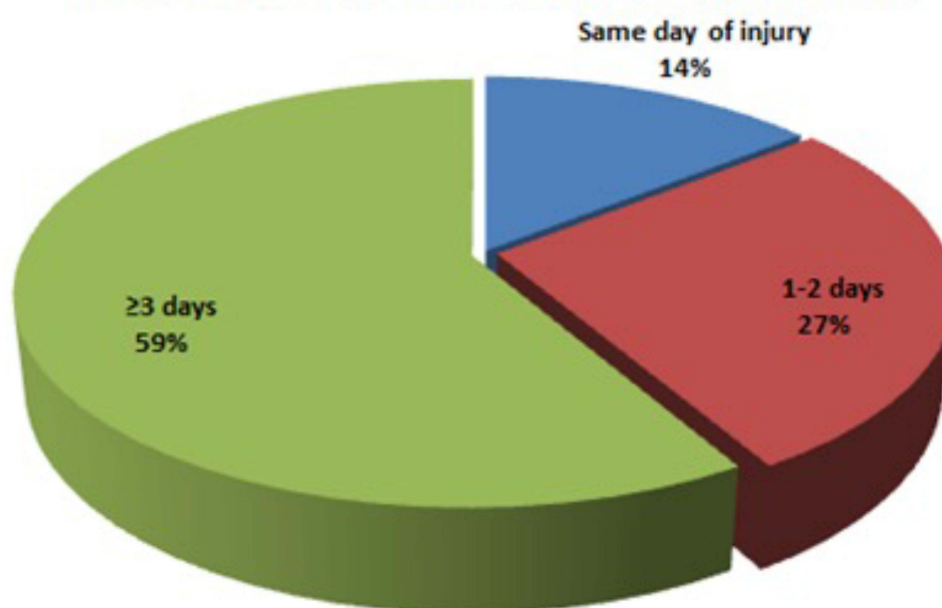


Figure 3 Pie-chart showing time from injury to presentation. More than half of the patients [45 (58.44%)] presented for treatment after 72 hours (≥3 days) with few patients [21 (27.27%)] who presented for treatment within 24–48 hours (1–2 days) and very few patients [11 (14.29%)] presented for treatment on the same day of injury.

Type II fracture ($p = -0.028$) and delayed duration of immobilization (6 weeks; $p = 0.001$) were also found to have an independent association with the degree of carrying angle (Tables 3 and 4).

At multivariate, age [OR = 10.12 (95% CI; 0.03–0.58, $P = 0.008$)], limb involvement [OR = 13.42 (95% CI; 1.78–101.18 $P = 0.012$)], duration of immobilization [OR = 10.74 (95% CI; 2.69–42.92 $P = 0.001$)], and dominant hand [OR =

Table 2 Comparison Type of Fracture and the Method Used for Its Management

Method of Management	Type of Fracture (n, %)			Total
	Type I (n=43)	Type II (n=23)	Type III (n=11)	
Closed reduction and casting	37 (86.05)	22 (95.65)	09 (81.82)	68 (88.31)
Closed reduction and percutaneous pinning	01 (02.33)	00 (00.00)	01 (09.09)	02 (02.60)
Open reduction and cross pinning	05 (11.62)	01 (04.35)	01 (09.09)	07 (09.09)
Functional Outcome				
Satisfactory	24 (55.81)	9 (39.13)	03 (27.27)	36 (46.75)
Unsatisfactory	19 (44.19)	14 (60.87)	08 (72.73)	41 (53.25)
Carrying Angle				
Satisfactory	35 (81.40)	18 (78.26)	10 (90.91)	63 (81.82)
Unsatisfactory	08 (18.60)	05 (21.74)	01 (9.09)	14 (18.18)

Notes: Chi-square P-value for method of management is (0.480), for functional outcome is (0.163), carrying angle is (0.666).

13.8 (95% CI; 2.09 to 91.02 P= 0.006)] were found to have statistically significant associations with range of motion (Table 5). None of the patient factors was found to have an association with the degree of carrying angle at multivariate analysis.

Discussion

This study sought to determine the functional and radiological management outcomes of SCF of the humerus in children at MNRH and associated factors. We found that more than half of the participants had unsatisfactory functional outcomes, but more than 80% satisfactory radiological outcomes. Delay in seeking treatment, type I fractures, and

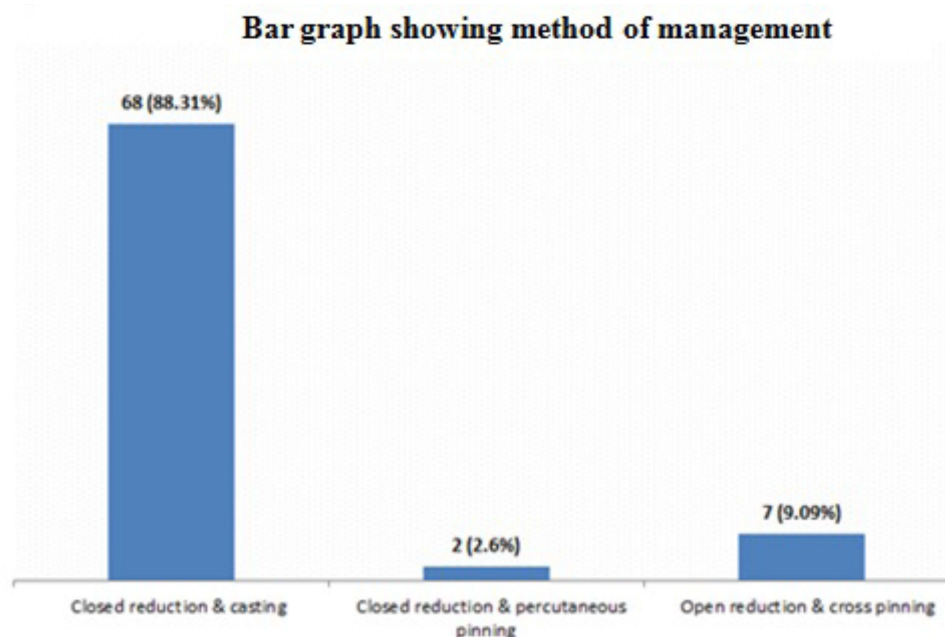


Figure 4 Bar graph showing method of management. From the graph, more than half of the patients [68 (88.31%)] were managed through closed reduction and casting followed by 7 (9.09%) were managed through open reduction and cross pinning and only 2 (2.60%) were managed through closed reduction and percutaneous pinning.

Table 3 Bivariate Analysis of Patient Factors and Range of Motion

Characteristics	Satisfactory (n=36)	Unsatisfactory (n=41)	OR (95% CI)	P-value*
Age in years (Mean±SD)	7.58±2.63	8.09±1.96		
5–9	28 (77.78)	35 (85.37)	1.67 (0.52–5.37)	0.392
10–14	08 (22.22)	06 (14.63)	Ref	
Gender				
Male	20 (55.56)	26 (63.41)	Ref	
Female	16 (44.44)	15 (36.59)	0.72 (0.29–1.79)	0.483
BMI (percentile range)				
5th to <85th	32 (88.89)	40 (97.56)	0.20 (0.02–1.88)	0.159
85th to <95th	4 (11.11)	1 (2.44)	Ref	
Time from injury to presentation				
Same day of injury	04 (11.11)	07 (17.07)	3.50 (0.76–16.12)	0.108
1–2 days	14 (38.89)	07 (17.07)	Ref	
≥3 days	18 (50.00)	27 (65.85)	3.00 (1.01–8.85)	0.047*
Limb involvement				
Left	27 (75.00)	30 (73.17)	Ref	
Right	09 (25.00)	11 (26.83)	1.10 (0.39–3.06)	0.855
Dominant hand				
Yes	15 (41.67)	11 (26.83)	1.95 (0.75–5.07)	0.172
No	21 (58.33)	30 (73.17)	Ref	
Type of fracture				
Type I	26 (72.22)	17 (41.46)	0.07 (0.01–0.56)	0.013*
Type II	09 (25.00)	14 (34.15)	0.16 (0.02–1.43)	0.100
Type III	01 (02.78)	10 (24.39)	Ref	
Method of management				
CR & casting	32 (88.89)	36 (87.80)	0.45 (0.08–2.48)	0.359
CR&P pinning	02 (5.56)	00 (00.00)	Ref	
OR & cross pinning	02 (5.56)	05 (12.20)	-	-
Duration of immobilization				
4 weeks (28 days)	16 (44.44)	07 (17.07)	Ref	
6 weeks (42 days)	20 (55.56)	34 (82.93)	3.89 (1.37–11.06)	0.011*

Notes: P-value (bold)* for a logistics regression, statistically significant values (p-value <0.05).

Abbreviations: CR, closed reduction; CR&P, closed reduction and percutaneous; OR, open reduction.

prolonged duration of immobilization were significantly associated with unsatisfactory functional management outcomes, and type II fractures and prolonged duration of immobilization were significantly associated with unsatisfactory radiological management of SCF of the humerus.

These unsatisfactory functional outcomes could be due to lack of knowledge about the gravity of the injury, delay to seek medical assistance, lack of anesthesia and fluoroscopy during fracture reduction, absence of pediatric orthopedic surgeons at emergency units and some patients could not afford radiographic fees in the hospital for diagnosing the fracture, monitoring the reduction and follow-up.^{18–21} The satisfactory radiological outcome could be considered a good outcome compared to a retrospective study conducted by Dowd, who reported a loss of carrying angle and varus development in 54% of the patients with a displaced fracture type.²²

In this study, more than half of the patients were aged between 5 and 8 years and only a few were 9–years. This indicated that the occurrence of fractures decreased as the age increased. This explains that the supracondylar region of the humerus is thin particularly in young children, which makes them more prone to these injuries as opposed to older children, where the bone becomes thicker as the child continues to grow. Similar findings were found in retrospective studies conducted by Ndour who found the occurrence of these fractures to increase with age.²³ Our findings show that

Table 4 Bivariate Analysis of Patient Factors and Degree of Carrying Angle

Characteristics	Satisfactory (n=63)	Unsatisfactory (n=14)	OR (95% CI)	P-value*
Age in years (Mean±SD)	7.75±2.33	8.36±2.13		
5–9	53 (84.13)	10 (71.43)	02.12 (0.55–8.11)	0.272
10–14	10 (15.87)	04 (28.57)	Ref	
Gender				
Male	39 (61.90)	07 (50.00)	Ref	
Female	24 (38.10)	07 (50.00)	1.63 (0.51–5.21)	0.414
BMI (percentile range)				
5th to <85th	58 (92.06)	14 (100.00)	-	-
85th to <95th	05 (7.94)	00 (00.00)	Ref	
Time from injury to presentation				
Same day of injury	10 (15.87)	01 (7.14)	0.60 (0.05–6.59)	0.675
1–2 days	18 (28.57)	03 (21.43)	Ref	
≥3 days	35 (55.56)	10 (71.43)	1.71 (0.42–7.02)	0.454
Limb involvement				
Left	45 (71.43)	12 (85.71)	Ref	
Right	18 (28.57)	02 (14.29)	0.42 (0.08–2.05)	0.282
Dominant hand				
Yes	22 (34.92)	04 (28.57)	1.34 (0.38–4.78)	0.650
No	41 (65.08)	10 (71.43)	Ref	
Type of fracture				
Type I	35 (55.56)	08 (57.14)	2.29 (0.25–20.51)	0.460
Type II	18 (28.57)	05 (35.71)	2.78 (0.28–27.21)	0.028*
Type III	10 (15.87)	01 (07.14)	Ref	
Method of management				
CR & casting	56 (88.89)	12 (85.71)	0.21 (0.01–3.67)	0.288
CR&P pinning	01 (1.59)	01 (7.14)	Ref	
OR & cross pinning	06 (9.52)	01 (7.14)	0.17 (0.01–5.45)	0.314
Duration of immobilization				
4 weeks (28 days)	21 (33.33)	02 (14.29)	Ref	
6 weeks (42 days)	42 (66.67)	12 (85.71)	3.00 (0.61–14.65)	0.001*

Notes: P-value (bold)* for a logistics regression, statistically significant values (p-value <0.05).

Abbreviations: CR, closed reduction; CR&P, closed reduction and percutaneous; OR, open reduction.

majority of the patients were males compared to females, and this could be that boys always expose themselves to danger and adventure more than their female counterparts. Our findings are similar to the results found in other studies, which indicated more males as opposed to females.²³

Among our study participants, over 90% had a normal BMI and 6% were overweight. There was no statistical significance between the outcome and BMI. A retrospective study was done in China,^{24,25} and another in the United States²⁶ showed a significant association between the outcome of supracondylar fractures and BMI. Obesity is a challenge in fracture reduction and is associated with poor outcomes and a higher complication rate.²⁵ The increased fat content accompanied by swelling which follows the injury creates a challenge not only for the orthopedist to identify the landmarks but also maintaining the reduction after it has been achieved.^{24,26} This discrepancy could be explained by the discrepancy in the characteristics of the study population where we had very few overweight children.

In this study, almost three-quarters of the injuries affected the left upper limb, while one-quarter affected the right upper limbs with the non-dominant hand most affected. The dominant hand is always clinging and the body uses the non-dominant hand for protection. Hence, it is more likely to strike the ground and prone to injury. Similar results have been

Table 5 Multivariate Analysis of Patient Factors with Degree of Range of Motion

Characteristics	Odds Ratio	95% CI	P-value*
Age in years			
5–9	10.12	0.03–0.58	0.008*
10–14	Ref		
Gender			
Male	Ref		
Female	1.33	0.40–4.46	0.639
Limb involvement			
Left	Ref		
Right	13.42	1.78–101.18	0.012*
Dominant hand			
Yes	13.78	2.09–91.02	0.006*
No	Ref		
Type of fracture			
Type I	0.27	0.05–1.37	0.114
Type II	0.35	0.08–1.55	0.169
Type III	Ref		
Duration of immobilization			
4 weeks (28 days)	Ref		
6 weeks (42 days)	10.74	2.69–42.92	0.001*

Notes: P-value (bold)* for a logistics regression, statistically significant values (p-value <0.05).

reported where the non-dominant limb was involved more often than the dominant limb.²⁷ However, the study did find a statistically significant relationship between hand dominance and outcome, which is similar to a study done in China.²⁵

In our study, most patients presented to the hospital 3 or more days after the injury. This could be due to financial constrain or poor prehospital facilities. This is consistent with other studies that found that patients with fractures or dislocations take an average of 96 hours before seeking medical care.¹⁹ This shows that presentation after 2 days could affect the functional outcome. This was also observed in a retrospective study that observed the outcome of supracondylar fractures of the humerus in children, where the outcome was dependent on presentation with a fracture after day 2.^{28,29}

More than two-thirds of the patients were managed through closed reduction and casting, while the rest were managed through open reduction and cross pinning, and closed reduction, and percutaneous pinning. In addition, more than half of the fractures were managed non-operatively. This is different from the ideal way of treating these fractures, where most type II and type III fractures are treated with closed reduction and pinning or open reduction and pinning.^{25,30}

The limitations of the study were that it was a hospital-based study and those with radiographs at the time of management were only recruited to the study, and as a result, selection bias was introduced. The study also assessed the current BMI (6 months after injury/management) which was different from the BMI at the time of injury.

Conclusion

Our system of management of SCF of the humerus is not efficient. The short-term functional outcome of SCF of the humerus was generally not good, but a satisfactory radiological outcome was found in most of the patients. We demonstrated that the duration of immobilization, type of fracture, and seeking late medical care had a negative impact on the outcome of these fractures. We, therefore, recommend developing policies and guidelines for managing these fractures to avoid a long-term disability and early mobilization of the elbow joint to minimize the risk of reduced joint motion.

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Disclosure

The authors report no conflicts of interest in this work.

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