

OUTCOME OF PAEDIATRIC SUPRACONDYLAR HUMERAL FRACTURES TREATED BY SURGERY AT THE UNIVERSITY TEACHING HOSPITAL OF KIGALI, RWANDA

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ABSTRACT

Background: Supracondylar humeral fractures are common elbow injuries in children. When these fractures are managed improperly, patients end up having complications that interfere with daily activities.

Objective: This study was conducted to evaluate the functional outcome of supracondylar humeral fractures treated with surgery at the University Teaching Hospital of Kigali, Rwanda.

Methodology: This was a combined retrospective and cross-sectional observational study. The sample size was 108. Theatre logs and OPD files were used to obtain patients' clinical information. Functional outcome was evaluated using QuickDASH score.

Results: Children having 6 to 10 years of age were predominant (54.6%). Male to female ratio was 1.9:1. The left elbow was most affected (60.2%). Seventy five patients (69.4%) were within normal range, 27 (25.0%) patients had mild disability, 5 (4.7%) patients had moderate disability, and 1 (0.9%) patient had severe disability. There were no patients with very severe disability. The most common complication was elbow stiffness (59.3%), followed by gunstock deformity (27.1%). The only determinant of functional outcome found was the time (within 4 days or beyond) from injury to management (OR: 0.993, 95% CI: {0.987-1.000}, p-value: 0.048).

Conclusion: For operable supracondylar humeral fractures in children, operation within 4 days and good follow up of patients in postoperative period are crucial for good functional outcome.

Key words: Humeral fracture, QuickDASH, Closed reduction, Open reduction

INTRODUCTION

Supracondylar humeral fractures are common in children. They often result from a fall on the outstretched arm. The extension type accounts for more than 95% of these fractures (1). Historically, these fractures were associated with complications such as malunion that resulted in cosmetically and functionally inferior results. However, over time, results have been improved and the frequency of these complications dramatically decreased with more modern techniques of treatment.

The Gartland classification, Lagrange and Rigault classification, and AO classification are different

classification systems used for paediatric supracondylar humeral fractures. The Gartland classification is a commonly used system for evaluation and treatment of supracondylar humeral fractures in children. It is based on the lateral radiograph and has good inter-observer and intra-observer reliability. It is based on the lateral radiograph. Gartland's Type I fractures are non-displaced. Type II fractures are displaced with angulation, but maintain an intact posterior cortex. Type III fractures are completely displaced and lack cortical contact (2).

In terms of management, an above elbow cast is used for three weeks to treat non-displaced supracondylar humeral fractures in children. Many of Type II fractures are stable after closed reduction and casting in 90 to 100 degrees of flexion. When more than 100 degrees of flexion is required to maintain reduction, percutaneous pinning is recommended, with immobilization in less than 90 degrees of flexion. Weekly follow-up for 2 weeks is recommended following closed management to diagnose and treat any loss of reduction. Primary closed reduction and percutaneous pinning under image intensifier guidance is the preferred treatment for Type III injuries, whereas open reduction will be performed in case closed method fails (3).

A supracondylar fracture of the humerus in children is a real public health concern. In the epidemiological study of elbow fractures in children, Houshian *et al.* (4) found that supracondylar fractures accounted for 58% of all paediatric elbow fractures, with a peak age range of 5 to 6 years. In a prospective descriptive study done at Kenyatta National Hospital in 2009, the most common types of fractures encountered in children who fall from a height were supracondylar humeral fractures (17.3%) followed by femoral fractures (11.8%) (5). The left or non-dominant side is the most frequently injured in almost all studies.

Infection (resulting in longstanding disability if not treated properly) and cubitus varus (which is a reverse of the normal carrying angle of the arm with prominence of the lateral aspect of the elbow) are other common complications in paediatric supracondylar humeral fractures; the latter is also known as a gunstock deformity. Skaggs *et al.* (6) have reported a rate of pin site infection of 2.1% on a series of 189 modified Type II supracondylar humeral fractures in a period of 7 years.

Documenting the management outcomes for the supracondylar fractures of the humerus using the QuickDASH score may help generate important missing data on the outcomes of the supracondylar fractures of the humerus. The QuickDASH score is a shorter version of the DASH score. It is a validated tool for functional evaluation, available in several languages (7). The DASH score has been used in patients with disorders of major areas of the upper extremity, such as the shoulder, elbow, wrist and hand.

The construct validity of the DASH score has been evaluated by establishing its correlation to SF-36, which is used for measuring health outcomes in patients with musculoskeletal ailments (8). The DASH questionnaire correlates moderately well to SF-36

and is a valid measure of health status in patients with a variety of upper extremity disorders (9).

The aim of this study was to evaluate and document the outcomes of surgical management of supracondylar fractures of the humerus in children managed at the University Teaching Hospital of Kigali (UTHK) between January 2013 and December 2016 using the QuickDASH score. This study was also conducted to generate data to inform science and guide practice changes towards improved care of supracondylar humeral fractures in Rwanda.

Study objectives

- i. To evaluate the functional outcome following surgery for supracondylar fractures of the humerus using the QuickDASH score.
- ii. To determine postoperative complication rates of paediatric supracondylar humeral fractures treated by surgery.
- iii. To determine factors associated with poor outcome.

Study design and settings

This is a combined retrospective and cross-sectional observational study done at University Teaching Hospital of Kigali (UTHK), located in Nyarugenge District, Kigali. The Department of Surgery (Orthopaedics unit) manages paediatric supracondylar humeral fracture cases and these include patients from different district hospitals. The hospital has also a Department of Physiotherapy. We reviewed the theater logs to identify children who underwent surgery for a supracondylar fracture of the humerus in the period stated. We reviewed patients' records to obtain phone contacts of the guardian, demographic information, clinical information, fracture classification and treatment option used. The patient was contacted via the guardian as per the hospital records, and requested to participate in the study, and an appointment for review in the Outpatient Department was planned as per patient and family's convenience. The total sample size was 108.

MATERIALS AND METHODS

Selection criteria: All paediatric patients (less than 16 years of age at the time of injury) with supracondylar humeral fractures who consulted and had surgical treatment at University Teaching Hospital of Kigali from January 2013 to December 2016. Patients,

whose pre-operative or operative records could not be found were excluded, including preoperative and postoperative X-rays.

Data analysis: The analysis was performed using descriptive statistics and association analysis was done using SPSS software; an omnibus test was used to test the significance of our model parameters. In order to identify the association, binary logistic regression was used and its goodness of fit was statistically tested using the Hosmer-Lemeshow test. For describing and summarizing the findings, figures and one-way frequency tables were generated. The following are the variables: Age, sex, referral, mechanism of injury, fracture type, affected limb, Gartland classification, open vs. closed fracture, time from injury to management, management option, time since management, infection, postoperative stiffness, cubitus valgus, gunstock deformity, QuickDASH score, and neurovascular injury.

Ethical considerations: Each participant was identified with a code. Questions were asked to the participant and/or guardian. The patient was assessed clinically, respecting the patient's rights. There were no extra care charges.

Participation was voluntary and participants did not receive any compensation apart from a ticket for transport for those living in remote areas. After a full explanation to the participant and next of kin about the purpose of this study, there was a written informed consent and assent in English and in Kinyarwanda to be signed by the participant/or next of kin. The participants had a right to withdraw from

our study at any time and without any consequence. This research protocol was presented to the Department of Surgery at the University Teaching Hospital of Kigali/IRB and to the College of Medicine and Health Sciences/IRB for review, and was approved.

RESULTS

During the entire study period, we identified 335 paediatric patients operated for supracondylar humeral fracture; among them 126 patients were excluded because their telephone numbers were not available, 89 patients were excluded because they didn't show up for the appointment given and 12 patients were excluded because there was no clinical information in their files. Sample size in this study was 108 participants.

In total we had 71 (66%) male participants and 37 (34%) female patients. The minimum period of follow up was 11 months; the maximum period was 59 months, and a mean of 33.9 months.

All fractures were displaced and treated operatively. We divided them into two types, depending on the direction of displacement of the distal fragment; flexion-type (4 patients) and extension-type (104 patients). There was no association that is statistically significant between fracture type and functional outcome. A half (54 patients) were treated by closed reduction and percutaneous pinning, the other half (54 patients) were treated by open reduction and pinning. There was no association that is statistically significant between management option and functional outcome.

Table 1
General characteristics

Sex	No.	(%)
Male	71	65.7
Female	37	34.3
Total	108	100
Age (Min. =2 years; Max. =15 years; Mean=7.07 years)		
0-5 years	35	32.4
6-10 years	59	54.6
11-15 years	14	13.0
Total	108	100
Referral - Referred	84	77.8
- Not referred	24	22.2
Total	108	100

Table 1 shows predominance of male (65.7%) over female (34.3%). The predominant age group was 6-10 years with 54.6%, followed by 0-5 years (32.4%)

and 11-15 years (13.0%). The majority of patients consulted after being referred from district hospitals.

Table 2
Mechanism of injury and fracture type

Mechanism of injury	No.	(%)
FOOSH	104	96.3
Other mechanism	4	3.7
Total	108	100
Fracture type	No.	(%)
Flexion type	4	3.7
Extension type	104	96.3
Total	108	100

Table 2 shows fall on outstretched hand (FOOSH) to be far the most common mechanism of injury with 96.3% and other mechanisms of injury has 3.7%.

Extension type of fracture (96.3%) predominates over flexion type (3.7%).

Table 3
Affected limb and closed vs. open fracture

Affected limb	No.	(%)
Left	65	60.2
Right	43	39.8
Total	108	100
Closed vs. open fracture	No.	(%)
Closed fracture	103	95.4
Open fracture	5	4.6
Total	108	100

Table 3 depicts the left upper limb (60.2%), commonly non-dominant, predominated over the right upper limb (39.8%). And compared to open fractures (4.6%), closed fractures predominated with 95.4%.

Table 4 shows that 69.4% of patients were operated within 96 hours (4 days) from the time of injury, whereas 30.6% of patients were operated after 4 days.

Table 4
Time from injury to management (Min. =5 hours, Max. =504 hours, Mean = 97.38 hours)

Time from injury to management	No.	(%)
Within four days	75	69.4
After four days	33	30.6

Figure 1
Complications

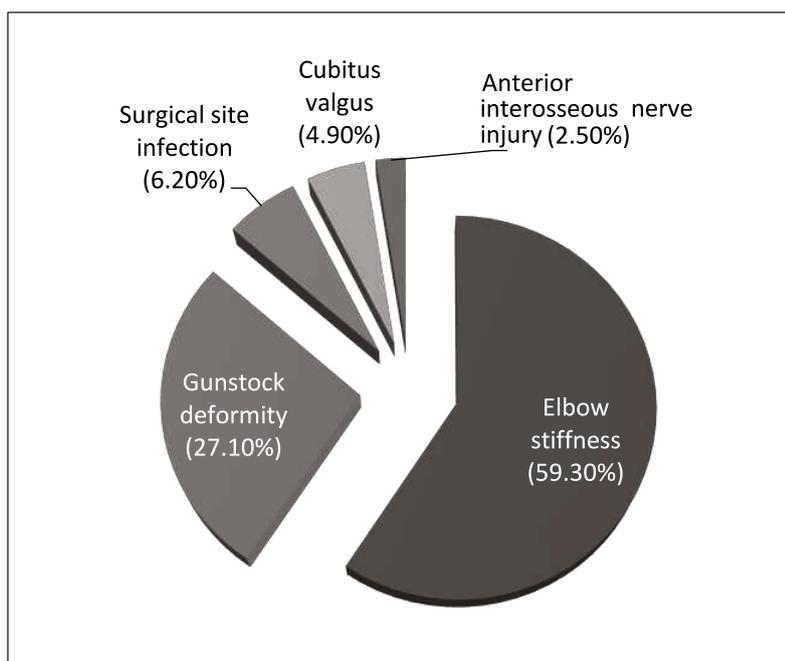


Figure 1 shows five complications which include: elbow stiffness, gunstock deformity, infection, cubitus valgus and anterior interosseous nerve injury which have the following percentages respectively: 59.30%, 27.10%, 6.20%, 4.90% and 2.50%.

Figure 2 shows that 75 (69.4%) patients were normal, 27 (25.0%) patients had mild disability, 5 (4.7%) patients had moderate disability, 1 (0.9%) patient had severe disability and no patient was found to have very severe disability.

Figure 1
Complications

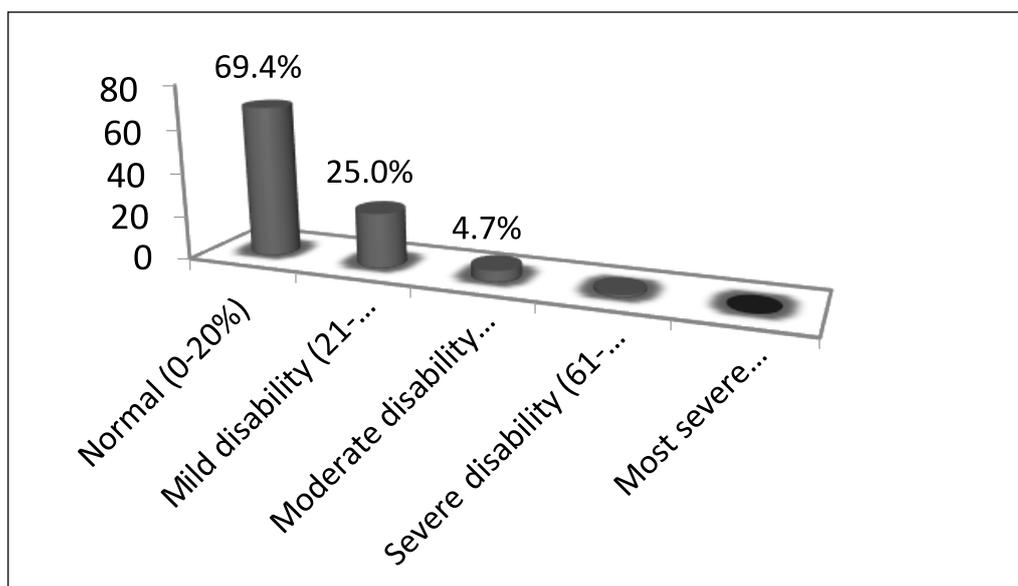


Table 5
Model fitting evaluation

Beginning block Classification Table					
			Predicted		Percentage correct
			Quick DASH score		
			Normal	Abnormal	
Step 0	QuickDASH score	Normal	75	0	100.0
		abnormal	33	0	0.0
Overall percentage					69.4
Block method = Enter					
Omnibus tests of model coefficients					
		Chi-square	Df	Sig.	
Step		8.490	5	0.131	
Step 1	Block	8.490	5	0.131	
	Model	8.490	5	0.131	
Model summary					
Step			-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1			124.458	0.076	0.107
Hosmer and Lemeshow Test					
Step			Chi-square	Df	Sig.
1			11.130	8	0.194
Classification Table					
			Predicted		Percentage correct
			QuickDASH score		
			Normal	Abnormal	
Step 1	QuickDASH score	Normal	74	1	98.7
		Abnormal	30	3	9.1
Overall percentage			71.3		

Table 5 shows that our model is better than the intercept-only model with $X^2(5, N=108) = 8.490$, p -value = 0.131, the variance between 8% and 11% which means that between 8% and 11% of the

variance in the QuickDASH score is explained by our predictors, good insignificant values with p -value = 0.194, and in 71.3% the prediction of our model is accurate.

Table 6
Relationship between the outcome and the predictors

	B	S.E.	Wald	df	Sig.	Exp(B)	95.0% EXP(B) Lower	C.I.for Upper
Age of the patient (1)	0.334	0.458	0.531	1	0.466	1.397	0.569	3.430
Open fracture vs. Closed fracture (1)	-1.680	1.040	2.610	1	0.106	0.186	0.024	1.431
Time from injury to management	-0.007	0.003	3.918	1	0.048	0.993	0.987	1.000
Step 1 ^a Management option (1)	-0.251	0.454	0.306	1	0.580	0.778	0.320	1.894
Sex of the patient (1)	0.455	0.481	0.896	1	0.344	1.577	0.614	4.046
Constant	0.971	1.125	0.745	1	0.388	2.639		

a. Variable(s) entered on step 1: Age of the patient, open fracture vs. closed fracture, Time from injury to management, management option, sex of the patient .

Among the five predictors in Table 6, only the time from injury to management is statistically and significantly associated with functional outcome (OR: 0.993, 95% CI: {0.987-1.000}, p-value: 0.048).

The following predictors are not significantly associated with functional outcome:

- Age of the patient (OR: 1.397, 95% CI: {0.569-3.430}, p-value: 0.466).
- Open fracture vs. closed fracture (OR: 0.186, 95% CI: {0.024-1.431}, p-value: 0.106).
- Management option (OR: 0.778, 95% CI: {0.320-1.894}, p-value: 0.580).
- Sex of the patient (OR: 0.1.577, 95% CI: {0.614-4.046}, p-value: 0.344).

DISCUSSION

Supracondylar humeral fractures are common in the paediatric population aged between 6 and 10 years (mean age of 7.07 years); which is almost similar to the findings of the study done by Rashid *et al.* (10) in

their study about epidemiologic pattern of paediatric supracondylar humeral fractures of humerus in a teaching hospital of rural India where they found that 5 to 8-year age group was predominant with a mean age of 7.9 years. This is because it is at this age most of children start to be engaged in activities putting them at risk of fall with less precaution, in addition to the supracondylar area which is undergoing remodeling with a typical thin and more slender cortex predisposing this area to fracture.

As shown by most of the studies done on paediatric supracondylar humeral fractures, our study shows that boys (65.7%) have outnumbered girls (34.3%). The reason for this being that boys are more involved in activities putting them at risk than girls. However, recent publications show an increasing ratio of girls sustaining supracondylar humeral fractures (11).

The fact that 77.8% of patients consulted after being referred from their District Hospitals shows that these hospitals have not yet acquired the capacity to offer definitive management to paediatric patients sustaining this type of fracture; and most of these patients are sent from their hospitals after having received the basics of fracture management; like making a clinical and radiological diagnosis, as well as immobilization of the affected limb.

Fall from height on outstretched hand is the most encountered mechanism of injury with the extension type (96.3%) being far the most common type of fracture compared to flexion type (3.7%), and in terms of limb involvement the left upper limb outnumbers the right upper limb. This is almost similar to the findings of Skaggs *et al.* (12) in their study about paediatric elbow trauma, where they found the extension type to count for approximately 97% to 99%, the non-dominant upper limb (60.8%) predominating over the dominant upper limb (39.2%). However, in the study done by Mangwani *et al.* (13) about supracondylar humeral fractures in children, they found the dominant hand to be more involved (61%) because many of their patients fell from ground level where a natural reflex tends to be landing on the dominant extended arm.

As findings in this study show, complications are common with paediatric supracondylar humeral fractures with elbow stiffness being the most common complication (59.3%). This may be explained by different factors including poor reduction technique, poor compliance to follow up appointments in OPD for pin and cast removal, and poor compliance to physiotherapy. We have not been able to know much about these factors because of inadequate documentation in patients' files, and this is one of the limitations of our study. Other complications encountered included: gunstock deformity (27.1%), surgical site infection (6.2%), cubitus valgus (4.9%) and the anterior interosseous nerve injury (2.5%).

In regards to the mean follow up time of our study (33.9 months), these patients with anterior interosseous nerve injury are less likely to have spontaneous nerve recovery. Anterior interosseous nerve injury has been found to be more related to trauma itself in extension type fractures as shown by Majid *et al.* (14). In their study, they found that nerve injuries occurred in 13.3% of patients (median nerve: 58.9%, radial nerve: 26.4% and ulnar nerve: 14.7%) with 80% of the median nerve injuries involving the anterior interosseous nerve. Similar findings are in the meta-analysis done by Jessica *et al.* (15) about nerve injuries associated with paediatric supracondylar humeral fractures, they concluded that the anterior interosseous nerve neuropraxia was the most associated with extension-type fractures (34.1%) whereas ulna nerve injury was mostly associated with flexion-type fractures (91.3%). This meta-analysis also concluded that ulna nerve was most likely to be injured with medial pinning compared to lateral-only pinning. Majid *et al.* (14)

found that most nerve injuries were neuropraxia (86–100%) and resolved on average time of 14 months following percutaneous pinning and the majority of these patients didn't have to be re-operated for nerve exploration. So, this can explain why in our study we have a low rate of nerve injuries compared to other studies; we may have seen these patients after they have recovered from their nerve injuries, prospective studies can give clarifications on this point.

In terms of functional outcome using QuickDASH score, 69.4% are within the normal range and 25.0% have mild disability which means that the majority of patients with paediatric supracondylar humeral fractures operated at UTHK are happy in terms of functional outcome. Pietro *et al.* (16) in their study concluded that within certain limits (clinical outcome as perceived by patients from the objective clinical outcome), functional and anatomical deficits do not negatively affect the quality of life of paediatric patients. This explains why the majority of our patients were satisfied in terms of functional outcome despite the rate of complications we have. So, clinical outcome as perceived by patients has to be differentiated from the objective clinical outcome (which is the real function of the elbow). However, the fact that 25% of patients had disability shows that the outcome of paediatric supracondylar humeral fracture is not exclusively benign. This disability has been shown by Sinikumpu *et al.* (17) to consist most in decrease of grip strength and range of movement.

In this study, we found that the only statistically significant determinant of functional outcome was the time patient spent from injury to management. However, in the study done by Sanpera *et al.* (18) on 169 patients, in which they wanted to know whether a delayed reduction of paediatric supracondylar humeral fractures is safe or not, they concluded that a delay in treatment didn't have an impact on functional outcome. This difference may be due to the fact that our studies give a different definition to the delay in surgical treatment; ours was beyond 96 hours whereas theirs was beyond 6 hours. Further studies are needed for reliable conclusion.

There are other factors that can affect functional outcome in paediatric patients operated for supracondylar humeral fractures but our study didn't include them; these include loss of fracture reduction secondary to poor reduction technique or poor immobilization technique, the fact that the patient is lost to follow up, the impact of physiotherapy, the impact of having another associated injury, the impact of not having a medical insurance, and this is a

limitation of our study. Other studies will help to show the impact of these factors on functional outcome.

Limitations

Because of the retrospective aspect of our study, it was not easy to have some information. This was due to the lack of good documentation. This was mitigated by the fact that we met patients physically for proper history taking and physical examination.

The majority of participants in this study were patients living in Districts of Kigali City, for patients living far from Kigali City the majority of them didn't show up at the time of the appointment we gave them, others refused the appointment to come in OPD on the pretext of living far from Kigali or being busy in their daily activities. Patients living in Kigali City are more likely to adhere to postoperative appointments; which plays a key role in good functional outcome.

CONCLUSIONS

The results of our study show that surgical treatment of the supracondylar humeral fractures in children generally results in good functional outcome especially when surgery is carried out as early as possible after the injury. However, complications like elbow stiffness and gunstock deformity that are noted in high numbers, indicate that there was a gap in the follow up of patients. We hope that a closer follow up after surgery could have minimized those complications and this would have resulted in better functional outcome.

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