

# Timing and Outcome of Surgical Treatment in Supracondylar Humeral Fractures in Pediatric Patients, Khartoum, Sudan

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## Research article

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# Abstract

A study aims to evaluate the timing of close surgical treatment in supracondylar humeral fractures in pediatric patients and to know the radiological outcome of its management, through measuring the mean delay per hour and assessing post-surgical radiological outcome for reduction.

A cross-sectional hospitals based study carried out in Khartoum state, through randomized cluster sampling, both data sheets and pre/post-surgical images were filled and collected. A well-constructed criteria were developed to assess the radiological outcome.

With sample size of 41 cases, we found that the mean delay from trauma to surgery was 99 hours [SE, 13], equivalent to 4.13 days. The reduction outcome criterion was significant when comparing it with the surgeon level P value of 0.015, but when comparing it with the delay more than 32 hours and Gartland classification both weren't significant with P values of 0.383 and 0.501 respectively.

These results are refuting the current concepts about the impossible reduction after a delay more than 32 hours and filled the current gap of knowledge about the outcome of supracondylar humeral fractures Gartland III with delayed presentation.

## Background

Supracondylar Humeral fractures are the most common elbow fractures in children, and surgical fixation to those fractures is the most common operation in pediatric orthopedic Trauma. Sudan and developing countries in general have a lot of struggles which delay the presentation of this common operation, neither the international research; due to lack of cases, nor the local one; due to lack in research activities, had address outcome in these special situation.

SHF is the most common fracture in children that will need surgical management, in spite of that, time for surgery still a contra versed issue (1). There is an agreement specially with SHF type III to be an emergency, if there is vascular insufficiency for the limb, open fracture or skin puckering, evolving compartment syndrome or floating elbow, median nerve palsy, young age and if a child has cognitive disability. (2) But if there was no indication to rush to the operation room, there is a big doubt for most surgeons to do it as emergency, as shown in a survey involving 309 pediatric orthopedic surgeons in US and Canada who had been asked about their practice, 81% of them will do the operation next morning shift if there was no apparent cause for emergency. (3)

Thus, contra version didn't end in spite the risk of shifting from close to open technique and a lot of researches were done to compare starting from less than, or equal to eight hours in comparison with more than eight hours (4,1), then in a comparison delay 12 hours and delay of 21 hours; all of them found no statistical difference with P value of "0.55", "0.37" and "1.7" respectively, which indicates the need for shifting to open technique (4,5,6,7).

In a hospital based long study with data from 1998 till 2006 with almost 190 cases after excluding all patients with emergency operation, it defined time of surgery (TS) as from injury to operation entrance, it divided the time into four quartiles to which open reduction versus close reduction operations were tested through logistic regression, it found that the probability to shift from close reduction to open reduction will increase by a factor of four after the first 15 hours post injury with statistical significant P value < 0.001, thus a close reduction becomes impossible after 32 hours. (8) This study is well controlled; the researchers did their best to control all possible factors even surgeon's interest or mood had been controlled through defined protocol to shift from close reduction to open one to which the two surgeons obligated.

Interestingly, unintended delay occurs when SHF type II is treated conservatively for a week with unsatisfactory result it will need operative reduction. A research in SHF type II did a comparison between a group which had surgery within the first seven days and another group had surgery after seven days, there was no statistical significance for the need to shift for open reduction but the mean difference was statistically significant for carrying angle degree and pin tract granuloma with  $-1.5$  (CI  $-2.5$  to  $-0.5$ ) and  $-8.9$  (CI  $-11.8$  to  $-5.9$ ) respectively

Addressing those fractures correctly from the start will reduce most common serious complication of it cubitus varus, which is related to the adequate reduction and fixation more than the initial trauma for which it's better to make the concern about having a good reduction rather than jeopardizing it for doing a CRPP.

The great difference in the outcome between CRPP and ORPP reported traditionally in neurological injury, elbow stiffness, ugly scarring and myositis ossificans, had been minimized (1,9). But still there is statistical significant difference between close and open reduction with lesser restriction in movement, better functional result and less time to unite with P value of 0.03, 0.03 and 0.01 respectively, towards the close reduction. (10) That makes CRPP a golden standard treatment of SHF which is the goal for all surgeons dealing with it.

## Methods

We design a Cross-sectional hospitals based study, we collect 41 cases through a cluster sampling to ensure an appropriate way of probability sampling technique, because Khartoum state is a large geographical area a random selection of the three cluster geographical areas where one cluster was chosen, then stratified random sampling was used to cover the three categories of hospitals and to be more precise, the private hospitals were classified in two broad groups according to the level of luxury. All stratified groups have had random selections in all of them to make a group of hospitals, which will be representative to the cluster making the result generalizable for the whole state.

All cases which fulfilled the including criteria were identified through the sentinel persons there, then data sheet was filled from both; a child caregiver and the doctor who

performed the surgery or participated on it, and pre/post images were collected.

Through Gartland classification, all preoperative images were classified because Gartland type 4 is an intraoperative diagnosis, therefore we classified the patients as type 3, so we have only two types to consider (2 and 3).

Up to the researcher's knowledge, no criteria to score the reduction in SHF, We created criteria to classify the postoperative images and to assess the radiological outcome for the surgeries, two important factors were used; the reduction and fixation, we called it The Blue Nile Criteria.

In the first criterion to assess the reduction outcome, four factors were used; Baumann angle, anterior humeral line, translation and the tear drop profile. Total score was 7, Baumann angle (measured through Protractor application) score is 2 when an angle between 9 and 26 degrees is obtained, if the angle was more than 26 degrees or less than 9 degrees the score is zero. The score was 2 when the anterior humeral line crosses the center of capitellum, if it passes through the anterior third the score is 1, and if it passes through posterior third or anterior to the anterior third, it scored zero. As for translation, if there is no translation (both medial and lateral columns maintain the continuity) scores of 2, if it has lateral displacement less than 5 mm the score is 1, and if it has medial displacement or excessive lateral the score is zero. For tear drop profile the full score is 1 if restored and zero if not. Any case which hadn't any assessable component was excluded from the criterion, all cases got a score of 4 or more were recognized as acceptable reductions.

Second criterion to assess fixation outcome through the well know method, K- wires should hold both sides of fracture (should have a firm hold from both fragments and no wire should be intramedullary), and they should not cross at fracture side to have a score of 1 for each. It is either adequate fixation (scored 2) or inadequate fixation (scored 1 or zero).

When we joint the two above criterion, with overall score 9, we call it the Blue Nile criteria for assessing SHF, we assessed the case as acceptable radiological outcome when the score is 6 or more. Having a score of 6 was chosen based on the fact that any case to have acceptable overall outcome must have acceptable reduction, which needs a score of 4. Fixation has a minimum consideration because any fixation would be augmented by posterior plaster of Paris slab as routine in all cases

Table (1) shown The Blue Nile Criteria

<b>Humann angle</b>	Above 26 or below 9 degree	0	<b>Reduction outcome criterion with total of 7</b>	<b>Overall outcome criterion with total score of 9</b>
	Between 9 and 26 degree	2		
<b>Anterior lateral line</b>	Crossing posterior third or anterior to capitellum	0		
	Crossing the anterior third of capitellum	1		
	Crossing the center of capitellum	2		
<b>Translation</b>	Medially displaced or excessive lateral	0		
	Laterally displaced (<5mm)			
	Not displaced	2		
<b>Articular drop profile</b>	Not restored	0		
	Restored	1		
<b>Two fragments are fixed</b>	Yes	1	<b>Fixation outcome criterion total of 2</b>	
	No	0		
<b>Crossing fracture line</b>	K. wires are a part from each other	1		
	K. wires are crossing	0		

## Results

In a cross-sectional hospitals based study, related cases in the hospitals which had been collected through sentinel persons were 41 cases, 4 cases failed to fulfil components needed for criteria making the total number for the measuring outcome 37 cases.

A well control research done with internal validity statistical test for reliability (Cronbach's alpha) is 0.766. The mean age for patients is 6.1 years-old [SE, 0.4] range from 2 to 13 years-old, all of them underwent CRPP, males are dominant with 71%, most of trauma occurred at left arm with 71% and 70% that side is their dominant hand side, one

case had associated injury which was head injury. Almost 95% of cases presented to the health system in the first 24 hours and only 5% had significant delay due to bone-setter.

The mean delay in hours before reaching the health facility was 4.6 hours [SE, 1.4] the maximum delay was 48.5 hours and the minimum delay was 15 minutes. 63% of patients had their first presentation to ER centre, 5% to Primary Health Care clinic, makes a total of 68% of cases sought immediate care to health system and only 32% sought help at bone-setters.

Dreadfully the mean delay from trauma to surgery was 99 hours [SE, 13], equivalent to 4.13 days, the minimum delay was 5 hours and the maximum was 386 hours, equivalent to 16 days. Most of these delays occurred after reaching the health system with mean delay within health system of 94 hours [SE, 13.1], equivalent to 3.9 days, with maximum delay of 384 hours, table {2}. 71% of these delays were due to waiting for schedule list, 20% of cases had no delay and 9% of cases was due to other causes.

According to Gartland classification 46% of patients had type II SHF, and as we set 32 hours as a cut - point for CRPP, any CRPP carried out after 32 hours was considered as delayed operation, only 7 cases had their operation in the first 32 hours (17% of cases) and the rest 83% of cases had delayed operation, table {3}. Those operations had been carried out by different levels of surgeons, 58% by orthopaedic trainees, Registrars, 15% by specialist so we can say that 63% of operations were done by Junior surgeons, 12% of operations were done by consultant orthopaedic surgeons other than paediatric speciality, and 15% of cases by paediatric orthopaedic surgeons making the percentage for operations done by senior surgeons 27%.

To measure the outcome in the reduction outcome criterion from full score of 7 and acceptable score of at least 4, the mean score was 4.5 [SE, 0.39] with minimum score of zero and maximum score of 7 and only 58% of patients (24 cases) had an acceptable reduction outcome, those with unacceptable reduction outcome were 32% and 4 cases were identified as missing which is only 10%. The picture is gloomy in the overall outcome criterion with mean score of 5.9 [SE, 0.46]. From a full score of 9 and an acceptable score of at least 6, the minimum score was also zero and the maximum was 9, making those who have an acceptable overall outcome 51% of cases, with 10% missing cases who failed to fulfil the criterion and 39% of cases had unacceptable overall outcome criteria. Table {3}

Regarding the fixation, the two fragments were perfectly fixed in 54% of cases (22 cases out of 41). Failed (either not catching the two fragments or K. wire was intramedullary) in 44% and only one case wasn't assessable. Unfortunately, K. wires were crossing at fracture side in 73% of cases and only 27% had a satisfactory firm hold by K. wires at the fracture side.

The reduction outcome criteria had significant result when comparing it with the surgeon level (2 groups; seniors versus junior surgeons) with a Fisher's Exact Test P value of 0.015, table {4}. With further analysis, we tested the original surgeon levels group (with 4 levels of surgeons) against the fixation outcome criteria, due to the relative small size it wasn't significant with Chi-Square Test P value of 0.125, but the data suggested a problem with fixation in consultant orthopedic surgeons group as they have adequate fixation in one quarter of cases. That rose up the query that should we test the pediatric orthopedic surgeons group against other surgeons. Interestingly, it was significant with Fisher's Exact Test P value of 0.027. Table {5}

The delay more than 32 hours and Gartland classification were both tested against reduction outcome criterion as possible confounders through Fisher's Exact and Chi-square Tests respectively; both weren't significant with P values of 0.383 and 0.501, table {6}. The same picture was for the overall criteria and both variables weren't significant. Table {7}

Table (2) Descriptive analysis for different delays.

Variables	Minimum	Maximum	Mean	
			Mean	Std. Error
<b>Delay before reaching health facility in hours</b>	0.25	48.5	4.6	1.4
<b>Delay from trauma to surgery in hours</b>	5	386	99	13
<b>Delay from trauma to surgery in days</b>	0.21	16	4.13	0.5
<b>Delay after reaching health facility in hours</b>	4.5	384	94	13.1
<b>Delay after reaching health facility in days</b>	0.19	16	3.92	0.5

Table (3) Frequencies analysis for different categorical data

Variables		Frequency	Percent
Gartland Classification	Type II	19	46%
	Type III	22	54%
Delay more than 32 hours	No delay	7	17%
	Delayed	34	83%
Reduction criteria	Inacceptable reduction	13	32%
	Acceptable reduction	24	58%
	Total	37	90%
	Missing	4	10%
Overall criteria	Inacceptable	16	39%
	Acceptable	21	51%
	Total	37	90%
	Missing	4	10%

Table (4) Test between reduction outcome criteria and surgeon level.

		Surgeon level		Total
		Senior Surgeons	Junior surgeons	
Reduction outcome criteria	Not acceptable reduction	0	13	13
	Acceptable reduction	9	15	24
Total		9	28	37

Fisher's Exact Test, P value is 0.015 (significant)

Table (5) Tests between overall outcome criteria and surgeon level (Paediatric orthopaedic surgeon versus other surgeons).

		Surgeon level		Total
		Pediatric orthopedic Surgeons	Other surgeons	
Overall outcome criteria	Not acceptable	0	16	16
	Acceptable	6	15	21
Total		6	31	37

Fisher's Exact Test, P value is 0.027 (significant)

Table (6) Tests between reduction outcome criteria and different variables.

		Reduction outcome criteria		Total
		Not acceptable reduction	Acceptable reduction	
Causes of delay before arriving health system	No delay	11	24	35
	Bone-setter	2	0	2
Total		13	24	37
Delay more than 32 hours	No delay	1	6	7
	Delayed	12	18	30
Total		13	24	37
Gartland classification	Type II	5	12	17
	Type III	8	12	20
Total		13	24	37

Fisher's Exact Test for Causes of delay before arriving health system, P value is 0.117 (insignificant)

Fisher's Exact Test for Delay more than 32 hours, P value is 0.383 (insignificant)

Pearson Chi-Square for Gartland classification, P value is 0.501 (insignificant)

Table (7) Tests between overall outcome criteria and different variables.

		Overall outcome criteria		Total
		Not acceptable	Acceptable	
<b>Causes of delay before arriving health system</b>	No delay	14	21	35
	Bone-setter	2	0	2
Total		16	21	37
<b>Delay more than 32 hours</b>	No delay	2	5	7
	Delayed	14	16	30
Total		16	21	37
<b>Gartland classification</b>	Type II	5	12	17
	Type III	11	9	20
Total		16	21	37

Fisher's Exact Test for Causes of delay before arriving health system, P value is 0.180 (insignificant)

Fisher's Exact Test for Delay more than 32 hours, P value is 0.674 (insignificant)  
 Pearson Chi-Square for Gartland classification, P value is 0.117 (insignificant)

## Discussion

The research was intended to address the gap in knowledge in regard to SHF in paediatric patients in Khartoum, Sudan. For that a cross sectional study was designed to study closed management of SHF and to know the outcome of it and to facilitate generation of hypothesis for further researches

The mean delay from trauma to surgery was 99 hours [SE, 13], with maximum delay of 386 hours, this too huge as most of literatures talking about 8 hours and 21 hours' delay as cut between CRPP and ORPP, and some authors put a delay more than 32 hours as cut point for CRPP (8). With a concept of dealing with SHF as an urgent operation if it was not an emergency but never as an elective operation. (1,7) Although no study gave an exact figure for delay with CRPP; our 4 days' delay is a long delay and it is close to study for CRPP after 7 days done for patients with acceptable Gartland type II SHF failed in conservative management which implies a minimum reduction defect unlike our research which had more patients with Gartland type III (11)

Based on literatures, shift from close reduction to open reduction will increase by a factor of 4 after the first 15 hours post injury with statistical significant P value < 0.001, thus CRPP became impossible after 32 hours. (7) we grouped our sample in two groups those who had surgery before 32 hours (no delay group) consisting 17% of the cases, and those after 32 hours (delay group) consisting 83% (majority). We

failed to find a statistical significance when comparing those groups with reduction or overall outcome criteria, table {6,7}. Maximum delay 386 hours (16 days) with an acceptable closed reduction and overall outcome criteria occurs in 8 years-old female with SHF Gartland II operated by orthopaedic trainee, also in SHF Gartland III an acceptable CRPP for both criteria achieved with maximum delay of 111 hours, 4.6 days, occurred in 4-year-old boy operated also by orthopaedic trainee, and all surgeon levels had operations at delayed group, with the acceptable reduction outcome criterion in more than half of cases delay group through CRPP, and perfect full score in 39% of them, those results refute the current hypothesis about impossible reduction after 32 hours.

Going through the data after refuting the delay more than 32 hours as a cause for unacceptable reduction outcome criterion table {6}, the effect of different surgeon levels was very clear. We found a significant result comparing senior versus junior surgeons, with a Fisher's Exact Test P value of 0.015, table {4}. We didn't find a supporting paper for that finding and in contrast junior surgeons found not to have inferior performance to consultants in a research, (12) making this result special for our situation and alarming about the learning curve in our training program.

When adding the fixation factor only paediatric orthopaedic surgeons had acceptable overall outcome criterion with significant result Fisher's Exact Test P value of 0.027. Table {5} this finding may not be that import as mentioned before, because all patients will have above elbow cast.

## Conclusion

In a cross sectional hospitals based study aims to study the timing of close surgical treatment in SHF in pediatric patients and to know the radiological outcome of its management, through measuring the mean delay per hour and identifying the causes. And assessing post-surgical radiological outcome for reduction.

We found that the mean delay from trauma to surgery was 99 hours [SE, 13], equivalent to 4.13 days, 71% of these delay was due to wait for schedule list within the health system. The reduction outcome criterion was significant when comparing it with the surgeon level P value of 0.015, but when comparing it with the delay more than 32 hours and Gartland classification both weren't significant with P values of 0.383 and 0.501 respectively.

## Table Of Abbreviations

AHL	Anterior humeral line
CRPP	Close reduction and percutaneous pinning
K. wires	Kirschner wires
ORPP	Open reduction and percutaneous pinning
PCCF	Pediatric Comprehensive Classification of Long-Bone Fractures
SHHS-2	Sudan's household survey round two
SHF	Supracondylar humeral fracture

## Declarations

## Ethical approval

Had been taken from Sudan Medical Specialization board. Ethical committee, and file had been attached as supplementary material (Ethical clearance) show an image from the committee approval.

## Consent for publication

Not applicable

## Availability of Data and Material

Data had been collected through data sheet and then enter in SPSS program. A form from the data sheet and the whole original data which had been enter to the SPSS had been attached as supplementary material

## Competing interests

No competing of interest as this article is a part of my partial commitment to have the clinical MD, in Trauma and Orthopedic Surgery, Me (Corresponding Author) was a trainee and the other authors are my supervisors to do the research.

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## Authors contributions

All authors were part in all steps from the title till this manuscript.

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