



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

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### Abstract

**Introduction:** This 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.

**Materials and Methods:** 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 criterion was developed to assess the radiological outcome.

**Results:** With a 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.

**Conclusion:** 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 with delayed presentation.

**Keywords:** Supracondylar Humeral Fracture; Delayed Presentation; Gartland; Radiological Outcome

### Introduction

Supracondylar Humeral fractures (SHF) are the most common elbow fractures in children and surgical fixation to those fractures is the most common operation in pediatric orthopedic Trauma. There is an agreement specially with SHF type 3 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 [1]. But a little had been written on how late can fractures be reduced closely if there was no cause for emergency [2].

Most of the pediatric orthopedic surgeons in US and Canada will treat surgical close reduction SHF in the next morning shift when there's no cause for emergency [3] which rises the level of subjectivity of how long it can wait without increase risk of shifting to open reduction.

Thus, contra version didn't end in spite of the risk of shifting from close to open technique and lots of research was done to compare starting from less than, or equal to eight hours in comparison with more than eight hours [1,4], 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 [4-7].

A hospital based long study with data from 1998 till 2006 with almost 190 cases (after excluding all patients with emergency operations), has defined time of surgery (TS) as from injury to operation entrance, it also 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 protocols to shift from close reduction to an open one; to which the two surgeons obligated.

Interestingly, unintended delay occurs when SHF type 2 is treated conservatively for a week with unsatisfactory result, which will need operative reduction. A research in SHF type 2 did a comparison between a group which had surgery within the first seven days and another group that had surgery after seven days, there was no statistical significance for the need to shift for an 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 [9].

Addressing those fractures correctly from the start will reduce most common serious complication which is cubitus varus, that 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 close reduction and percutaneous pinning (CRPP).

The great difference in the outcome between CRPP and ORPP (open reduction and percutaneous pinning) was reported traditionally in neurological injury, elbow stiffness, ugly scarring and myositis ossificans, but had been minimized [1-10]. But still there is statistically 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 [11]. 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 one cluster was chosen out of three cluster geographical areas, then stratified random sampling was used to cover the three categories of hospitals. 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 a 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, see table 1.

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, any case which hadn't any assessable component was excluded from the criterion, all cases which got a score of 4 or more were recognized as acceptable reduction.

Second criterion to assess fixation outcome through the well-known method, K-wires should hold both sides of fracture (should have a firm hold from both fragments and no wire should be intramedullary).

When we joint the two-above criterion, with overall score 9, that's what we call 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.

Ethical approval had been taken from Sudan Medical Specialization board "Ethical committee" and written consent had been taken with each child caregiver.

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

**Table 1:** Shown the Blue Nile criteria.

**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 which underwent CRPP, males are dominant with 71%, most of trauma occurred at left arm with 71% and 70% in the non-dominant hand side, one case had associated an injury in the head. Almost 95% of cases were present at the health system in the first 24 hours where 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, 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 a maximum delay of 384 hours. 71% of these delays were due to waiting for schedule list, 20% of cases had no delay and 9% of cases were due to other causes.

According to Gartland classification 46% of patients had type 2

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) (See table 2). 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, 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.

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%
	Missin	4	10%
Overall criteria	Inacceptable	16	39%
	Acceptable	21	51%
	Total	37	90%
	Missing	4	10%

**Table 2:** Frequencies analysis for different categorical data.

Those operations had been carried out by different levels of surgeons, 58% by orthopedic trainees, Registrars, 15% by specialist, so we can say that 63% of operations were done by Junior surgeons, where 12% of operations were done by consultant orthopedic surgeons other than pediatric specialty; and 15% of cases by pediatric orthopedic surgeons making the percentage for operations done by senior surgeons 27%.

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) which was significant in seniors' group (See table 3). With further analysis, we tested the original surgeon levels group (with 4 levels of surgeons) against the fixation outcome criteria, due to the relatively small size that 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 whom have adequate fixation in one quarter of cases. That rose up the query that we should test the pediatric orthopedic surgeons' group against other surgeons. Interestingly, it was significant (See table 4). Then the delay more than 32 hours and Gartland classification were both tested against both criteria as possible confounders and the variables weren't significant (See table 5).

		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

**Table 3:** Test between reduction outcome criteria and surgeon level.

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

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

**Table 4:** Tests between overall outcome criteria and surgeon level (Pediatric orthopedic surgeon versus other surgeons).

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

		Reduction outcome criteria		Overall outcome criteria	
		Not acceptable reduction	Acceptable reduction	Not acceptable	Acceptable
Delay more than 32 hours $\Psi$	No delay	1	6	2	5
	De-layed	12	18	14	16
Gartland classification $\Phi$	Type II	5	12	5	12
	Type III	8	12	11	9

**Table 5:** Tests between (reduction outcome and overall outcome) criteria and different variables.

$\Psi$ : Fisher's Exact Test P values are 0.383 and 0.674 for reduction outcome and overall outcome respectively, (insignificant).

$\Phi$ : Chi-Square for P value are 0.501 and 0.117 for reduction outcome and overall outcome respectively, (insignificant).

### Discussion

The mean delay from trauma to surgery was 99 hours (SE, 13), with maximum delay of 386 hours, this is 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 in case it was not an emergency, but never deal with it as an elective operation [1-7]. Although no study gave an exact figure for delay with CRPP; our 4 days' delay is considered a long delay and was close to CRPP after 7 days study (done for patients with acceptable Gartland type 2 SHF failed in conservative management), which implies a minimum reduction defect unlike our research which had more patients with Gartland type 3 [12].

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, (See table 5). Maximum delay 386 hours (16 days) with an acceptable closed reduction and overall outcome criteria occurs in 8 years-old female with SHF Gartland 2 operated by orthopedic trainee, also in SHF Gartland 3 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 orthopedic trainee, and all surgeon levels had operations at the delayed group, with the acceptable reduction outcome criterion in more than half of cases in the 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, 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 pediatric orthopedic surgeons had acceptable overall outcome criterion with significant result Fisher's Exact Test P value of 0.027 (See table 4) this finding may not be that important because all patients will have above elbow cast.

### Conclusion

This 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, where 71% of these delays was due to waiting 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 compared with the delay more than 32 hours and Gartland classification; both weren't significant with P values of 0.383 and 0.501 respectively.

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