



## Retrospective Study

# Time of surgery and surgeon level in supracondylar humerus fractures in pediatric patients: A retrospective study

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**Specialty type:** Orthopedics

**Provenance and peer review:**

Unsolicited article; Externally peer reviewed.

**Peer-review model:** Single blind

**Peer-review report's scientific quality classification**

Grade A (Excellent): 0

Grade B (Very good): 0

Grade C (Good): 0

Grade D (Fair): 0

Grade E (Poor): 0

**P-Reviewer:** Zhang Y, China

**Received:** August 23, 2023

**Peer-review started:** August 23, 2023

**First decision:** September 14, 2023

**Revised:** September 18, 2023

**Accepted:** October 8, 2023

**Article in press:** October 8, 2023

**Published online:** November 18, 2023



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## Abstract

### BACKGROUND

Supracondylar humerus fractures account for more than 60% of all elbow fractures and about 1/5 of all pediatric fractures. Unfortunately, these fractures can be associated with risk of complications including neurovascular injuries, malunions and limb deformities. Controversy exists regarding the effect of time of surgical intervention and/or level of surgeon performing the surgery on outcome of these fractures.

### AIM

To determine whether time of surgical intervention and/or surgeon level influence the outcomes of surgically managed pediatric supracondylar humerus fractures.

### METHODS

We retrospectively studied 155 pediatric patients presenting with a supracondylar humerus fracture in a level 1 trauma center from January 2006 to December 2019. The data extracted included demographic data, fracture characteristics, surgical data, and follow-up outcomes. The collected data was analyzed and *P* values of < 0.05 were considered statistically significant.

### RESULTS

Of the cohort, 11% of patients had documented post-operative complications, of which the majority occurred in surgeries performed after day time working hours and in fractures requiring open reduction. While the lowest complication rate was

found in surgeries performed by pediatric orthopaedic surgeons, this did not reach statistical significance.

## CONCLUSION

In pediatric patients undergoing surgery for supracondylar fractures, we found a higher complication rate when surgeries were not performed during working hours. Surgeon level and training had no significant effect on the risk of post-operative complications.

**Key Words:** Supracondylar humerus; Fracture; Time of surgery; Level; Complications

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**Core Tip:** In our pediatric cohort of surgically treated supracondylar humerus fractures we found a higher complication rate when surgeries were not performed during working hours. Surprisingly, surgeon level and training had no significant effect on the risk of post-operative complications.

**Citation:** Albrahim IA, AlOmran AK, Bubshait DA, Tawfeeq Y, Alumran A, Alsayigh J, Abusultan A, Altalib A, Alzaid ZA, Alsabaie SS, Alzahrani MM. Time of surgery and surgeon level in supracondylar humerus fractures in pediatric patients: A retrospective study. *World J Orthop* 2023; 14(11): 791-799

**URL:** <https://www.wjgnet.com/2218-5836/full/v14/i11/791.htm>

**DOI:** <https://dx.doi.org/10.5312/wjo.v14.i11.791>

## INTRODUCTION

Supracondylar humeral fractures (SCHF) account for 16% of all paediatric fractures and are commonly sustained by children younger than eight years of age[1-4]. These injuries commonly occur after a fall on an outstretched hand irrespective of forearm position[5-7]. The majority of these fractures require closed reduction and pinning, while open reduction is reserved for some complex patterns, delayed presentation or when closed reduction fails[8-10]. When compared to closed reduction and fixation, open reduction carries higher risk of complications, especially infection and loss of elbow range of motion[8,11-13].

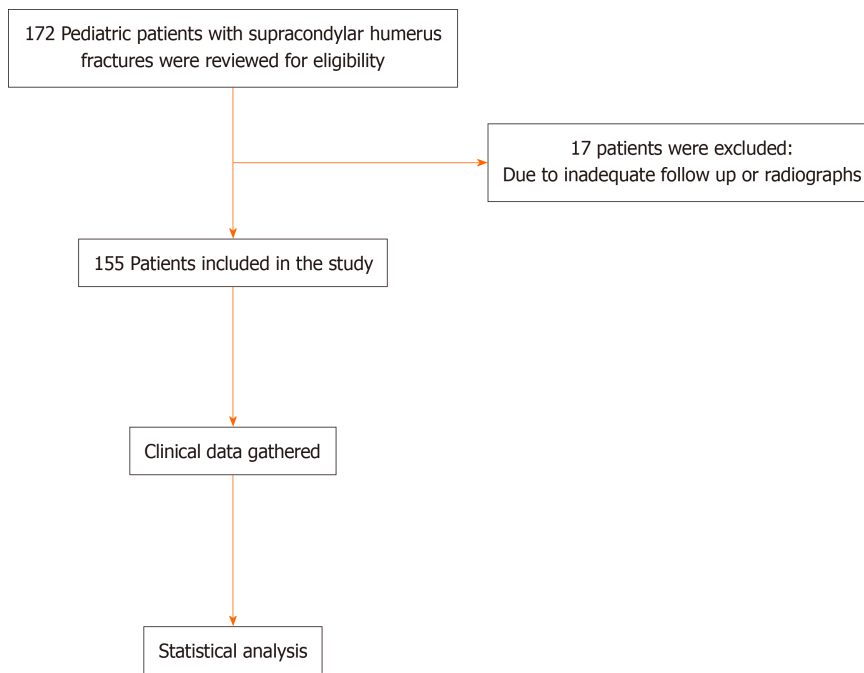
Timing of surgical intervention for these injuries is an area of controversy, as proponents for emergent intervention prefer it before any surgical site swelling occurs to minimize complications including nerve injury and compartment syndrome. In addition, it is believed that early surgical management can improve the success of closed reduction in these patient[12]. Surgeons who prefer a more delayed but urgent approach believe that operating on these fractures with an experienced team and during the daytime hours will lead to a quicker and more efficient surgical experience and decrease the associated post-operative complications[14,15].

The purpose of our study was to explore outcomes of surgical management of SCHF in pediatric patients and to assess if timing of surgical intervention and/or surgeon level would influence the outcomes of these patients post-operatively.

## MATERIALS AND METHODS

This is a retrospective cohort study conducted in a level 1 trauma center from January 2006 to December 2019. After ethical approval was obtained from the institutional review board in our institute (IRB-UGS-2019-01-333), all pediatric patients 1 to 14 years old who sustained a SCHF and were treated surgically with a follow up period of at least 24 mo were included. Exclusion criteria were patients who were lost to follow up, had incomplete data points in their charts or had inadequate radiographs. In addition, Gartland type I fractures were excluded as these all were managed non-surgically in our institution.

All surgeries were performed by pediatric orthopaedic trained consultants, board certified orthopaedic consultants, fellows, or residents (with consultant supervision). Cases were booked in the dedicated emergency room by the admitting consultant and surgery is performed according to urgency level decided by the admitting consultant. Cases admitted after day time working hours by non-pediatric orthopaedic consultants are repatriated to a pediatric orthopaedic consultant the next morning if not done. Operative fixation was performed under general anaesthesia, with the patients in supine position. The operative extremity was prepped and draped in standard fashion and pre-operative weight appropriate prophylactic antibiotics were administered. A trial of closed reduction was performed and if adequate percutaneous fixation with k-wires was performed (configuration and number were left to surgeon discretion). If closed reduction was unsuccessful, an open reduction was performed. After fixation, a sterile dressing was applied to the pin sites and an above elbow back-slap was applied in neutral position. Patients were followed up in clinic at 2 wk post-operatively, then at the 6-week post-operative mark where pins were removed, and patients were allowed to start range of motion of the elbow. Patients were then seen at 3-, 6- and 12-mo post-surgery.



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**Figure 1** Patient flowchart.

Data was extracted from the hospital electronic medical records, which included patient demographics data (age and gender), in addition to fracture characteristics and outcome variables. The collected variables included Gartland classification, time of surgery (during working hours “08:00-15:00” *vs* after day time working hours “15:00-8:00”), surgeon level (trainees “fellows or residents under supervision”, non-pediatric orthopedic surgeons, and pediatric orthopedic surgeons), nerve or vessel injury (both pre- and post-operative), associated complications (including compartment syndrome and pin site infection) and fixation construct. Post-operative radiographic alignment was assessed on plain antero-posterior and lateral elbow radiographs. Inadequate reduction was defined according to Flynn’s criteria (Baumann angle  $< 10^\circ$ , displacement  $> 4$  mm and anterior humeral line not bisecting the capitellum)[16].

A power analysis was performed with data from Saarinen *et al*[17], using a power of 80% and  $\alpha = 0.05$ , we estimated that we would require a sample size of 59 patients. Data was analyzed using Statistical Package for Social Sciences version 27 (IBM Corp, 2017). Categorical variables were described as frequencies and percentages, while continuous variables were described as mean and standard deviation. Bivariate analysis was tested using Chi-square test and ANOVA were applicable, with a *P* value of less than 0.05 considered as significant. Odds ratios with 95% confidence intervals were calculated to examine the association between the outcome variables and patient or fracture factors.

## RESULTS

A total of 172 patients were reviewed and 155 were included in the study with a mean age of 5.36 years old (range 1-13 years old) (Figure 1). More than half of the patients were males 105 (67.7%). Of the patients included in the cohort, 2.6% had a documented nerve injury pre-operatively (half of which were managed during working hours), these injuries included two cases of median and two cases of radial nerve palsies. An absent radial pulse was found in 9% of patients (half of which were also managed during working hours), all patients regained pulses after manual reduction during the operative procedure (Table 1). More than half of patients (56.1%) were managed during working hours, while 43.9% were managed after day time working hours. The majority of fractures were managed by closed reduction and k-wire fixation (84.5%) and parallel K-wires were the most applied construct (48.4%) (Table 1).

Twenty-four cases (15.5%) required an open reduction, 3 of which had an absent pulse pre-operatively which was regained after fracture reduction. More than half of the open reduction cases were performed by trainees with consultant supervision (58.3%), while 20.8% were performed by pediatric orthopaedic surgeons and 20.8% performed by non-pediatric orthopaedic surgeons.

Of the cohort, 17 patients (11%) had documented post-operative complications. These complications included four cases of nerve palsy post-operatively, three of which were fixed with two lateral and one medial k-wires (two had a median nerve injury and one ulnar nerve injury) and one fixed with two lateral parallel k-wires (sustained a median nerve injury). The remaining complications were 12 cases of unacceptable angular deformity post-fixation and one case of bony spur requiring operative management. Patients who were managed after day time working hours were associated with more complications when compared with daytime surgeries (5.7% *vs* 17.6%, *P* value  $< 0.05$ ). Patients who had their surgeries done after day time working hours were nearly at a 3 times higher risk of developing complications (OR = 2.8, *P*

**Table 1** Demographic data of supracondylar fracture cohort

Variables, n (%)		
Time of surgery	During working hours	87 (56.1)
	After working hours	68 (43.9)
Surgeon level	Pediatric orthopedic consultant	44 (28.4)
	Non-pediatric orthopedic consultant	38 (24.5)
	Trainee	73 (47.1)
Gender	Male	105 (67.7)
	Female	50 (32.3)
Mechanism	Fall on outstretched hand	112 (72.3)
	Fall on flexed elbow	17 (11)
	Direct	15 (9.7)
	Motor vehicle accident	8 (5.2)
	Others	3 (1.9)
Pre-operative nerve injury	Yes	4 (2.6)
	No	151 (97.4)
Pulse	Intact	141 (91)
	Absent	14 (9)
Classification	Gartland type 2	32 (20.6)
	Gartland type 3	115 (74.2)
	Flexion type	8 (5.2)
Procedure	Open reduction	24 (15.5)
	Close reduction	131 (84.5)
K-wire arrangement	Parallel	75 (48.4)
	Medial & lateral	35 (22.6)
	Two lateral & one medial	34 (21.9)
	Others	11 (7.1)

value < 0.05) when compared to surgeries done during the daytime.

In addition, patient who required an open reduction had a higher rate of complications (33.3%) when compared to closed reduction (6.9%,  $P$  value < 0.001) (Table 2). Complications recorded with open reduction were 5 cases of angular deformity, one case of ulnar nerve palsy and one case of bony spur. The odds of a complication occurring was more than 6 times greater with an open reduction when compared to a closed reduction (OR = 6.8,  $P$  value < 0.005). We found no difference in rate of complication between Gartland type 2, type 3 and flexion type SCHFs.

Interestingly, although the lowest rate of complications was in surgeries performed by pediatric orthopaedic surgeons, this was not statistically significant (Table 2). There was no significant difference in Gartland classification, K-wire arrangement, pre-operative nerve injury and absent pulse between cases done by different levels of surgeons. Concerning timing of surgery and the surgeon performing the surgery, the majority (57.4%) of after day time working hours surgeries were performed by trainees, while only 25% were performed by non-pediatric orthopaedic surgeons and 17.6% by pediatric orthopaedic surgeons ( $P$  value < 0.05).

We also assessed the effect of surgeon level on complication rate in surgeries performed during working hours and surgeries performed after day time working hours, separately, and found no statistically significant difference.

## DISCUSSION

The aim of this study was to investigate and analyze factors that could have an influence on outcomes of SCHF in pediatric patients, including time of surgery and surgeon level. In our cohort, we found that majority of complications occurred in cases performed after day time working hours, this may be attributed to that more severe injuries or cases with associated neurovascular compromise may be taken more urgently during the night. Aydoğmuş *et al* [18] reported

**Table 2 Percentages of complications by variable and *P* value**

Variables		Complication, <i>n</i> (%), <i>n</i> = 155		
		Yes, <i>n</i> = 16 (10.3)	No, <i>n</i> = 139 (89.7)	<i>P</i> value
Time of surgery	During working hours	5 (5.7)	82 (94.3)	0.019
	After working hours	12 (17.6)	56 (82.4)	
Surgeon level	Pediatric orthopaedic consultant	4 (9.1)	40 (90.9)	0.841
	Non-pediatric orthopaedic consultant	5 (13.2)	33 (86.8)	
	Trainee	8 (11)	65 (89)	
Gender	Male	10 (9.5)	95 (90.5)	0.404
	Female	7 (14)	43 (86)	
Classification	Gartland type 2	2 (6.3)	30 (93.7)	0.308
	Gartland type 3	13 (11.3)	102 (88.7)	
	Flexion type	2 (25)	6 (75)	
Procedure	Open reduction	8 (33.3)	16 (66.7)	0.001
	Close reduction	9 (6.9)	122 (93.1)	
K-wire arrangement	Parallel	6 (8)	69 (92)	0.154
	Medial & lateral	4 (11.4)	31 (88.6)	
	Two lateral & one medial	7 (20.6)	27 (79.4)	
	Others	0 (0)	11 (100)	

inferior fixation of 91 pediatric patients with operatively managed SCHF during after-hours when compared to cases performed during the daytime. In their cohort, they found no difference operative time, requirement of open reduction nor patient outcomes. When comparing early (< 12 h) and delayed (> 12 h) surgical fixation of pediatric SCHF, Suganuma *et al*[19] and Gupta *et al*[20] found no difference in rate of open reduction, post-operative complications nor surgical time between the two groups. In addition, Mehlman *et al*[15] found no difference in rate of open reduction, pin tract infection nor iatrogenic nerve injury between pediatric SCHF performed within 8 h of injury and more than 8 h of injury. Multiple other studies explored differences in outcomes and complication rates when surgery is done early or in a delayed fashion for SCHF, with the majority finding no statistically significant differences (Table 3).

Considering the higher complication rate in after day time working hours surgery and the lack of increased risk of adverse events in delayed fixation of SCHF, it seems clear that unless the extremity is pulseless with lack of perfusion, the fracture is open or there are signs of compartment syndrome, SCHF in pediatric patients should preferably be done during a reasonable time of day and not late after day time working hours.

While the majority of the complications in our cohort were in the surgeries that were conducted by trainees and non-pediatric orthopaedic surgeons, this was not statistically significant. When exploring the literature, we find that this is an area of controversy, as several studies have shown that the level and training of the surgeon has a significant effect on both outcome and complication rate of pediatric SCHF (Table 4). In addition, studies have also shown that when the procedure is supervised by a pediatric orthopedic surgeon, the outcomes are excellent with very low complication and revision rates irrespective of the level of the surgeon performing the surgery[21,22]. On the other hand, several studies have shown no difference in complication rate and risk of malreduction when the surgery is performed by a trained orthopaedic surgeon without pediatric fellowship training[17,23,24].

Limitations of the study include that it is a retrospective cohort, but we believe that we were successful in data collection from the patients' medical records with good accuracy. Another possible limitation is the small sample size, but we believe that our study is adequately powered based on the sample size analysis using previous published studies. In addition, the number of complications in our study was relatively low, but the proportion of complications was similar in previously published studies.

## CONCLUSION

In pediatric patients undergoing surgery for SCHF, we found a higher complication rate when surgeries were not performed during working hours, or when an open reduction is required. Although pediatric orthopaedic surgeons had the lowest rate of complications, this difference did not reach statistical significance. We believe the data presented in this study can help in reaching a better-informed decision about the timing of surgery for pediatric patients with SCHF.

**Table 3 Previous studies assessing effect of time of surgery on outcomes of pediatric supracondylar humeral fractures**

Ref.	Sample size	Groups	Results
Suganuma <i>et al</i> [19], 2020	120 Gartland type II and III SCHF	Surgeries within 12 h of injury and > 12 h	No difference in: Operative time; Early complications; Post-operative radiographic parameters
Aydoğmuş <i>et al</i> [18], 2017	91 Gartland type III SCHF	Daytime <i>vs</i> after hours surgery	Poor fixation rate in after hour surgery; No difference in operative time or residual deformity
Schmid <i>et al</i> [25], 2015	343 Gartland type II and III SCHF	Surgeries within 6 h, 6-12 h, 12-24 h and > 24 h from injury	No difference in: Outcome; Complications; Requiring open reduction
Mayne <i>et al</i> [26], 2014	115 Gartland type II and III SCHF	Surgeries within 12 h of injury and > 12 h	No difference in: Infection rate; Iatrogenic nerve injury; Requiring open reduction
Larson <i>et al</i> [27], 2014	399 Gartland type II SCHF	Surgeries within 24 h of injury and > 24 h	No difference in complication rate
Yildirim <i>et al</i> [28], 2009	190 Gartland type III SCHF	Time from injury to surgery	4 fold increase in requiring open reduction for each 5 hour delay
Walmsley <i>et al</i> [29], 2006	171 Gartland type III SCHF	Surgeries within 8 h of injury and > 8 h	No difference in complication rate; Higher risk of requiring open reduction in > 8 h group
Sibinski <i>et al</i> [30], 2006	77 Gartland type III SCHF	Surgeries within 12 h of injury and > 12 h	No difference in: Operative time; Outcome; Risk of open reduction
Gupta <i>et al</i> [20], 2004	150 operatively treated SCHF	Surgeries within 12 h of injury and > 12 h	No difference in: Pin tract infection; Iatrogenic nerve injury
Mehlman <i>et al</i> [15], 2001	198 operatively treated SCHF	Surgeries within 8 h of injury and > 8 h	No difference in: Pin tract infection; Iatrogenic nerve injury
Iyengar <i>et al</i> [31], 1999	58 Gartland type III SCHF	Surgeries within 8 h of injury and > 8 h	No difference in: Open reduction rate; Clinical outcomes

SCHF: Supracondylar humeral fractures.

**Table 4 Previous studies assessing effect of surgeon level on outcomes of pediatric supracondylar humeral fractures**

Ref.	Sample size	Groups	Results
Fisher <i>et al</i> [23], 2021	231 patients who underwent CRPP for SCHF	Pediatric orthopaedic fellowship trained <i>vs</i> other orthopaedic surgeons	Shorter operative and fluoroscopy time; No difference in complications
Osateerakun <i>et al</i> [32], 2019	87 Gartland type II and III SCHF	Pediatric orthopaedic fellowship trained <i>vs</i> other orthopaedic surgeons	Higher risk of complications in Gartland type III when not performed by pediatric orthopaedic surgeon; Overall complication rate and acceptable alignment were similar
Saarinen <i>et al</i> [17], 2019	108 operatively treated SCHF	Residents, pediatric surgeons and orthopaedic surgeons	Orthopaedic surgeons had the least complications and inadequate reductions; Residents had less complications and inadequate reductions when compared to pediatric surgeons
Pesenti <i>et al</i> [33], 2018	236 Gartland type III SCHF	Surgeons with < 1 yr <i>vs</i> > 1 yr experience	Less experienced had longer operative time; No difference in complication and malalignment rate
Tuomilehto <i>et al</i> [34], 2018	210 operatively treated SCHF	Consultants <i>vs</i> registrars	Higher complications and poorer outcomes in surgeries done by registrars
Liu <i>et al</i> [22], 2011	654 operatively treated SCHF	Fellows progression through fellowship training	No difference in complications and malunions throughout the fellowship year; Spike of malreductions at case 7 which improves at case 15
Padman <i>et al</i> [21], 2010	71 Gartland type II and III SCHF	Consultants <i>vs</i> trainees	Poorer outcome and more complications in surgeries performed by trainees without consultant supervision
Farley <i>et al</i> [24], 2008	444 operatively treated SCHF	Pediatric orthopaedic surgeon <i>vs</i> non-pediatric orthopaedic surgeon	No difference in complication rate and outcomes

CRPP: Closed reduction percutaneous pinning; SCHF: Supracondylar humeral fractures.



## ARTICLE HIGHLIGHTS

**Research background**

Pediatric supracondylar humerus fractures can be associated with risk of complications including neurovascular injuries, malunions and limb deformities. Surgical timing and level of surgeon performing the surgery may have an effect on outcome of these fractures.

**Research motivation**

Explore the effect of time of surgery and level of surgeon on pediatric supracondylar humerus fractures.

**Research objectives**

The objective of this study was to determine whether time of surgical intervention and/or surgeon level influence the outcomes of surgically managed pediatric supracondylar humerus fractures.

**Research methods**

We retrospectively studied 155 pediatric patients presenting with a supracondylar humerus fracture in a level 1 trauma center from January 2006 to December 2019. The data extracted included demographic data, fracture characteristics, surgical data, and follow-up outcomes. The collected data was analyzed and *P* values of  $< 0.05$  were considered statistically significant.

**Research results**

Of the cohort, 11% patients had documented post-operative complications, of which the majority occurred in surgeries performed after day time working hours and in fractures requiring open reduction. While the lowest complication rate was found in surgeries performed by pediatric orthopaedic surgeons, this did not reach statistical significance.

**Research conclusions**

In pediatric patients undergoing surgery for supracondylar fractures, we found a higher complication rate when surgeries were not performed during working hours. Surgeon level and training had no significant effect on the risk of post-operative complications.

**Research perspectives**

We believe the data presented in this study can help in reaching a better-informed decision about the timing of surgery for pediatric patients with supracondylar humeral fractures.

## FOOTNOTES

**Author contributions:** Albrahim IA, Alomran AK, and Bubshait DA contributed to concept; Albrahim I, Alomran AK, Bubshait DA, Tawfeeq Y, Alsayigh J, Abusultan A, Altalib A, Alzaid ZA, Alzahrani MM contributed to design; Albrahim I, Alomran AK, and Bubshait DA, Tawfeeq Y, Alomran A, Alsayigh J, Abusultan A, Altalib A, Alzaid ZA, and Alsubaie SS contributed to study execution; Albrahim I, Alomran AK, and Bubshait DA, Tawfeeq Y, Alomran A, Altalib A, Alzaid ZA, Alsubaie SS, Alzahrani MM contributed to manuscript writing and review; Alomran A contributed to statistical analysis; Alsubaie SS contributed to statistical analysis.

**Institutional review board statement:** Ethical approval was obtained from the Imam Abdulrahman Bin Faisal University review board (IRB-UGS-2019-01-333).

**Informed consent statement:** No informed consent was required for patients in this study as it was a retrospective chart review.

**Conflict-of-interest statement:** All the authors have no relevant conflict of interests.

**Data sharing statement:** Raw data and material are available as needed.

**Open-Access:** This article is an open-access article that was selected by an in-house editor and fully peer-reviewed by external reviewers. It is distributed in accordance with the Creative Commons Attribution NonCommercial (CC BY-NC 4.0) license, which permits others to distribute, remix, adapt, build upon this work non-commercially, and license their derivative works on different terms, provided the original work is properly cited and the use is non-commercial. See: <https://creativecommons.org/licenses/by-nc/4.0/>

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