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Surgeon factor in pediatric supracondylar humerus fractures

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Abstract

The surgeon and the surgical approach of the clinic where the surgeon was trained may have an impact on perioperative outcomes. In this study, among the surgeons with similar surgical experiences, we aimed to investigate the association of open-closed reduction rates, postoperative sagittal, coronal and axial plan deformities, and preference of open surgical approaches to surgeons and the clinics they were trained. We evaluated 90 cases retrospectively who underwent surgery upon diagnosis of Gartland type 3 pediatric supracondylar humerus fractures associated with extension deformity. Those whose surgery was performed after 24 hours, or patients with open fractures, flexion type supracondylar fractures, non-Gartland type 3 supracondylar fractures, fractures with neurovascular deficits, multiple comminuted fractures, pathologic fractures, or additional injury and fractures were not included to the study. All the surgeons who had >5 years of surgical experience as a specialist and >15 of pediatric elbow fracture surgery as an operator (n=12) were numbered between 1 and 12. The clinics of these surgeons were classified from A to F (n=6). Data on patients' age, gender, duration of surgery, follow-up time, postoperative sagittal, coronal angulation, postoperative rotational deformity, operation time, rates of open-closed surgery, the surgical approach in those open surgery was performed, the number and characteristics of the pins used were collected to analyze in relation with their assigned surgeons and the clinics they were trained. Among the 90 cases, 54 (59.3%) were male patients. The mean age was 6.21±3.03 years. There was no significant difference between the clinics in terms of sagittal and rotational deformities and open reduction rates ($p>0.05$). The clinics significantly differed in preference of the side of incisions (medial, lateral, posterior), ($p<0.05$). The number of pins, Baumann, and lateral humerocapitellar angles was similar between the clinics. The mean duration of the surgery (41.54±17.02 min) of the surgeons from the F clinic was lower than that of the other clinics (p: 0.004). In open surgeries, there was not a significant difference between surgeons in terms of single or double incision and side of the incision (medial, lateral, posterior) (p: 0.094). The number of pins also significantly differed among surgeons (p: 0.009). The type of surgical approach and treatment modality in pediatric supracondylar fractures is at the surgeon's discretion and therefore may be influenced by the approach of the clinic where the surgeon had specialty training. Nevertheless, within-clinic variations might also occur depending on the surgeon's preference or their role model advisor. Individual preferences may result in differences in operative time and case-specific complication rates.

Keywords: Surgeon factor, pediatric, supracondylar humerus fractures, surgical experiences

Introduction

Supracondylar humerus fractures are a very common type of elbow fractures and their treatment could be very compelling [1]. These fractures constitute 60% of all elbow fractures and 3% of all fractures in childhood [2].

Treatment of pediatric supracondylar fractures is controversial and technically difficult. The treatment aims to obtain a functional and cosmetically acceptable upper extremity with a normal range of motion [3]. Closed reduction and pinning is the preferred surgical treatment modality in these fractures [4-6].

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Open reduction is a reasonable alternative in cases where closed reduction is insufficient or in the presence of vascular injury or open fractures [7].

Several articles reported that surgeons' experience and their training might have an impact on the rate of open reduction and the success of postoperative surgical reduction in the surgical treatment of pediatric supracondylar humeral fractures [3,8-10]. Also, it was suggested that the tolerance shown by the surgeon towards angulation in closed reduction might also be important for observed open surgery rates [10].

In this case, one of the most important factors in surgery may be the surgeon itself and her/his approach to the condition. A surgeon's approach to the disease may also have been shaped by her/his characteristics and the training at which she/he was trained. Our

hypothesis is surgical approaches of the surgeons, open-closed reduction rates, preferences of surgeons pin application features and postoperative fracture reduction acceptances may vary by surgeons and the clinics they were trained. Therefore, among the surgeons with similar surgical experiences, we aimed to investigate the association of open-closed reduction rates, postoperative sagittal, coronal and axial plan deformities, and preference of open surgical approaches to surgeons and the clinics they were trained.

Materials and Methods

In this retrospective study, we examined medical records of 187 cases who underwent surgery due to pediatric distal humerus fracture in the orthopedics and traumatology clinic of our hospital between January 2011 and December 2018. After excluding those whose surgery was performed after 24 hours, or patients with open fractures, flexion type supracondylar fractures, non-Gartland type 3 supracondylar fractures, fractures with neurovascular deficits, multiple comminuted fractures, pathologic fractures, or additional injury and fractures; 90 cases with diagnosis of Gartland type 3 pediatric supracondylar humerus fractures associated with extension deformity were included to the study.

Baumann's angle was measured as the angle between lateral condylar physis and shaft of the humerus, where the values between 64° and 81° were regarded as normal [11]. Angulation above normal values was accepted as varus deformity and below those as valgus deformity.

As described by Singh et al., the difference of thickness between both cortices of proximal and distal fragments at anteroposterior and lateral elbow X-ray views was considered as rotation and measured in mm. Rotation of the distal part at coronal plane was grouped into three categories: values between 0-2 mm were accepted as good, those between 3-5 mm were moderate, and those >5 mm as poor (1).

All the surgeons had >5 years of surgical experience as a specialist and >15 of pediatric elbow fracture surgery as an operator (n=12). These surgeons were numbered between 1 and 12. The clinics of these surgeons were classified from A to F (n=6).

We collected data on patients' age, gender, duration of surgery, follow-up time, postoperative sagittal, coronal and axial angulation, operation time, rates of open-closed surgery, the surgical approach in those open surgery was performed, the number and characteristics of the pins used to analyze these variables concerning their assigned surgeons and the clinics they were trained.

Statistical analysis

Statistical analysis was performed with SPSS version 17.0 software. The normality test of the variables was analyzed with histogram graphs and the Kolmogorov-Smirnov test. Descriptive data were expressed as the mean, standard deviation, median, minimum, and maximum values, where appropriate. Comparisons were performed with Pearson Chi-square and Fisher's exact tests. For non-normally distributed variables, Mann Whitney-U and Kruskal Wallis tests were used for two or more groups, respectively. An overall 5% Type-I error level was used to infer statistical significance.

Results

Among the 90 cases, 54 (59.3%) were male patients. The mean age was 6.21 ± 3.03 years. The mean operative time was 55.86 ± 27.15 minutes. Open reduction was performed in 38 patients. The mean operative time of open surgery (78.47 ± 25.93 min) was significantly longer than that in closed surgery (39.33 ± 11.76min) (p: 0.001). The mean Baumann's angle was 70±8.85 degrees, and the lateral capitohumeral angle was 57.76± 15.47degrees. The rotation was present in 20 patients. Among these, eight patients were evaluated as good, five patients as moderate, and seven patients as poor. Three patients had >3-mm translation. While this did not occur in a closed reduction group, it constituted 7.9% of those who underwent open reduction (p=0.039).

Nine patients had varus, and 15 patients had a valgus deformity. The rate of the latter was significantly higher in those who underwent closed reduction (25.0%) than open reduction (5.3%), (p: 0.045). Four patients developed flexion deformity and eight patients had extension deformity.

There were five surgeons from Clinic D and three from Clinic F and one each from the remaining clinics. Characteristics of the clinics in terms of rates of the type of surgery, rotation, side of the incision, surgical incision, and coronal and sagittal deformity were demonstrated in Table 1. There was no significant difference between the clinics in terms of sagittal and axial deformities and open reduction rates (p>0.05). The clinics significantly differed in preference of the side of incisions (medial, lateral, posterior), (p<0.05). The rate of open surgery via a posterior incision (37.5%) was highest at Clinic F and all of these operations were performed by the same surgeon. The rate of single medial incision was highest (100.0%) at Clinic C. The rate of lateral incision was highest (66.7%) at Clinic B. The rate of postoperative valgus angulation in the coronal plane (44.44%) was higher for the single surgeon who was trained in Clinic E than for the surgeons from other clinics (p: 0.007). There was no significant difference between the clinics in terms of sagittal and axial deformities and open reduction rates (p>0.05). The clinics significantly differed in preference of the side of incisions (medial, lateral, posterior) (p: 0.041). While seven of the surgeons preferred to use lateral pin in the majority of cases, the remaining six were found to prefer applying cross-pinning. One of those surgeons who preferred the latter pinning style used a medial pin by preserving the ulnar nerve via the mini-open medial incision.

The number of pins, Baumann, and lateral humerocapitellar angles was similar between the clinics (p>0.05). The mean duration of the surgery (41.54±17.02min) of the surgeons from the F clinic was lower than that of the other clinics (p: 0.004) (Table 2).

In open surgeries, there wasn't a significant difference between surgeons in terms of single or double incision and side of the incision (medial, lateral, posterior) (p: 0.061). The number of pins also significantly differed among surgeons (p: 0.009) (Table 3).

Table 1. Rates of surgery type, rotation, incision and deformity by surgeons' clinics

		Clinics the surgeon was trained in												
		A		B		C		D		E		F		P
		n	%	n	%	n	%	n	%	n	%	n	%	
Type of surgery	Open	6	(40.00)	3	(42.86)	5	(71.43)	10	(38.46)	6	(66.67)	8	(30.77)	0.284
	Closed	9	(60.00)	4	(57.14)	2	(28.57)	16	(61.54)	3	(33.33)	18	(69.23)	
Rotation	None	8	(53.33)	5	(71.43)	4	(57.14)	22	(84.62)	8	(88.89)	23	(88.46)	0.071
	Present	7	(46.67)	2	(28.57)	3	(42.86)	4	(15.38)	1	(11.11)	3	(11.54)	
Type of incision	P	1	(16.67)	0	(.00)	0	(.00)	1	(10.00)	1	(16.67)	3	(37.50)	**0.041**
	M	1	(16.67)	1	(33.33)	5	(100)	0	(.00)	0	(.00)	2	(25.00)	
	L	3	(50.00)	2	(66.67)	0	(.00)	6	(60.00)	2	(33.33)	2	(25.00)	
	M-L	1	(16.67)	0	(.00)	0	(.00)	3	(30.00)	3	(50.00)	1	(12.50)	
	Closed	9	(60.00)	4	(57.14)	2	(28.57)	16	(61.54)	3	(33.33)	18	(69.23)	
Surgical incision	Single	5	(33.33)	3	(42.86)	5	(71.43)	7	(26.92)	3	(33.33)	7	(26.92)	0.168
	Double	1	(6.67)	0	(.00)	0	(.00)	3	(11.54)	3	(33.33)	1	(3.85)	
Anteroposterior Deformity	None	9	(60.00)	6	(85.71)	3	(42.86)	22	(84.62)	4	(44.44)	22	(84.62)	**0.007**
	Valgus	2	(13.33)	1	(14.29)	1	(14.29)	3	(11.54)	4	(44.44)	4	(15.38)	
	Varus	4	(26.67)	0	(.00)	3	(42.86)	1	(3.85)	1	(11.11)	0	(.00)	
Lateral deformity	None	14	(93.33)	6	(85.71)	6	(85.71)	22	(84.62)	8	(88.89)	22	(84.62)	0.921
	Extension	1	(6.67)	1	(14.29)	1	(14.29)	3	(11.54)	0	(.00)	2	(7.69)	
	Flexion	0	(.00)	0	(.00)	0	(.00)	1	(3.85)	1	(11.11)	2	(7.69)	

Pearson ve ExactChi-square test

Table 2. Duration of surgery, number of pins, and Baumann's and lateral humerocapitellar angles by surgeons' clinics

Clinics the surgeon was trained in	Duration of surgery, min		Number of pins used, n		Baumann's angle, degree		Lateral humerocapitellar angle, degree	
	Mean±SD	Median	Mean±SD	Median	Mean±SD	Median	Mean±SD	Median
A	53.67±23.49	55.00	2.33 ±.49	2.00	75.27 ±13.33	74.00	52.13 ±12.72	54.00
B	51.43±16.51	45.00	2.71 ±.49	3.00	69.14 ±4.06	71.00	53.29 ±13.90	61.00
C	77.43±28.22	75.00	2.71 ±.76	3.00	72.29 ±12.20	75.00	57.57 ±21.04	68.00
D	59.04±30.27	50.00	2.92 ±.80	3.00	68.73 ±7.46	70.00	58.88 ±14.53	60.50
E	78.33±31.02	80.00	3.11 ±.78	3.00	66.89 ±8.89	63.00	64.56 ±24.74	61.00
F	41.54±17.02	40.00	2.62 ±.57	3.00	68.92 ±5.82	70.00	58.77 ±12.58	62.00
p	**0.004**		0.081		0.326		0.450	

[1]Kruskal Wallis Test

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Table 3. Rates of surgery type, rotation, incision, and deformity by performing surgeons

		1		2		3		4		5		6		7		8		9		10		11		12		p
		n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%		%	
Type of surgery	Open	2	(18.18)	4	(50)	0	(0)	6	(37.5)	3	(33.33)	5	(71.43)	3	(50)	6	(66.67)	0	(0)	6	(75)	0	(0)	3	(50)	0,061
	Closed	9	(81.82)	4	(50)	1	(100)	10	(62.5)	6	(66.67)	2	(28.57)	3	(50)	3	(33.33)	1	(100)	2	(25)	8	(100)	3	(50)	
Rotation	None	8	(72.73)	8	(100)	1	(100)	8	(50)	9	(100)	4	(57.14)	5	(83.33)	8	(88.89)	1	(100)	7	(87.5)	5	(62.5)	6	(100)	0,072
	Present	3	(27.27)	0	(0)	0	(0)	8	(50)	0	(0)	3	(42.86)	1	(16.67)	1	(11.11)	0	(0)	1	(12.5)	3	(37.5)	0	(0)	
Type of incision	P	1	(50)	1	(25)	0	(0)	1	(16.67)	2	(66.67)	0	(0)	0	(0)	1	(16.67)	0	(0)	0	(0)	0	(0)	0	(0)	0,094
	M	0	(0)	0	(0)	0	(0)	1	(16.67)	0	(0)	5	(100)	1	(33.33)	0	(0)	0	(0)	0	(0)	0	(0)	2	(66.67)	
	L	1	(50)	2	(50)	0	(0)	3	(50)	1	(33.33)	0	(0)	2	(66.67)	2	(33.33)	0	(0)	4	(66.67)	0	(0)	0	(0)	
	M-L	0	(0)	1	(25)	0	(0)	1	(16.67)	0	(0)	0	(0)	0	(0)	3	(50)	0	(0)	2	(33.33)	0	(0)	1	(33.33)	
	Closed	9	(81.82)	4	(50)	1	(100)	10	(62.5)	6	(66.67)	2	(28.57)	3	(50)	3	(33.33)	1	(100))	2	(25)	8	(100)	3	(50)	
Surgical incision	Single	2	(18.18)	3	(37.5)	0	(0)	5	(31.25)	3	(33.33)	5	(71.43)	3	(50)	3	(33.33)	0	(0)	4	(50)	0	(0)	2	(33.33)	0,183
	Double	0	(0)	1	(12.5)	0	(0)	1	(6.25)	0	(0)	0	(0)	0	(0)	3	(33.33)	0	(0)	2	(25)	0	(0)	1	(16.67)	
	None	10	(90.91)	7	(87.5)	1	(100)	9	(56.25)	8	(88.89)	3	(42.86)	6	(100)	4	(44.44)	1	(100)	8	(100)	5	(62.5)	4	(66.67)	
Coronal plane	Valgus	1	(9.09)	1	(12.5)	0	(0)	3	(18.75)	1	(11.11)	1	(14.29)	0	(0)	4	(44.44)	0	(0)	0	(0)	2	(25)	2	(33.33)	0,111
	Varus	0	(0)	0	(0)	0	(0)	4	(25)	0	(0)	3	(42.86)	0	(0)	1	(11.11)	0	(0)	0	(0)	1	(12.5)	0	(0)	
	None	9	(81.82)	6	(75)	1	(100)	15	(93.75)	7	(77.78)	6	(85.71)	5	(83.33)	8	(88.89)	1	(100)	7	(87.5)	7	(87.5)	6	(100)	
Sagittal plane	Extension	2	(18.18)	1	(12.5)	0	(0)	1	(6.25)	0	(0)	1	(14.29)	1	(16.67)	0	(0)	0	(0)	1	(12.5)	1	(12.5)	0	(0)	0,800
	Flexion	0	(0)	1	(12.5)	0	(0)	0	(0)	2	(22.22)	0	(0)	0	(0)	1	(11.11)	0	(0)	0	(0)	0	(0)	0	(0)	

Pearson ve ExactChi-square test

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Discussion

As very common types of elbow injuries, supracondylar fractures constitute approximately 16.6% of all childhood fractures [12]. Treatment of these fractures depends on the degree of displacement of the fracture. The preferred method of surgical treatment is the closed reduction and percutaneous pinning whereas indications for open reduction include irreducible fractures, vascular injury and open injuries. Medial, lateral, posterior, anterior surgical approaches or combinations of these can be applied in open surgery. The fracture could be stabilized by fixation through lateral parallel or divergent or crossed Kirschner wire (K-wire), [13]. Surgical goals include anatomic reduction, stable fixation, good functionality, and good cosmetic appearance [14]. It was reported that rates of open-closed reduction and surgical success were associated with the surgical experience [3,10,15]. This experience may be affected by the region or the clinic at which surgeons received training or by their trainers. That was the reason for the fact that we investigated the effect of clinics or personal factors on the approach to pediatric supracondylar fractures among surgeons with similar experience in duration or number of cases.

The study by de Francisco et al. reported no association of the open reduction rates to the number of cases operated by the surgeon. The authors suggested that the rate of open reduction was strongly influenced by the surgeon's instructors and the clinics they were trained in [10]. In our study, there was no significant difference between surgeons or clinics in terms of open reduction rates.

Surgeon's tolerance and acceptance of the reduction is an important factor, and open reduction depends on the surgeon [10]. Cubitus valgus does not cause too many problems in these fractures whereas cubitus varus is associated with cosmetic problems and rarely results in a limited range of motion [16]. On the other hand, postoperative hyperextension deformity affects elbow function [17]. Although many angulations can be restored by remodeling of the pediatric bone, sagittal plane deformities and rotation may not be fully remodeled [8,17,18]. In our study, while sagittal and coronal plane deformities were similar across the clinics tested, valgus angulation at coronal plane significantly differed. This may be attributed to the fact that while no surgeon is likely to tolerate the deformities that would result in functional or cosmetic problems or fail to show remodeling, the tolerance to valgus angulation might vary on the individual or clinic basis.

There were significant differences in the duration of surgery and surgical approaches across the clinics the surgeons were trained in. For example, while the surgeons of the clinics with the shortest operation time mostly performed lateral incisions and applied two lateral parallel pins, other clinics also performed ulnar nerve dissection with the posterior or medical incision. This may be explained by the possible effect of the training on the surgical approach, which, in turn, might influence the operation time based on the clinic the training was received.

There are many different surgical approaches suggested for supracondylar fractures of the humerus in children [3,19]. Liu et al., in their study where they investigated the association of surgeon's experience to the surgery in supracondylar fractures, reported that reduction loss rates increased after a certain level of experience. The authors further reported that some of these were malreduction after reviewing the images in the operating room. They concluded that this might result from the fact that lack of instructor's emphasis on ideal angulations and rotations at the operating room could lead the former trainee surgeon to be likely to adopt this behavior as her/his experience increased later in the profession [9]. In orthopedic surgery, wide variations of surgical approaches can be seen among surgeons [20]. Flint et al. reported that the opportunity of trainee surgeons to choose his/her instructor was associated with an increased level of happiness [21]. Differences in preferences of surgical approaches and incisions across the clinics and surgeons may originate from the possible inheritance of the different surgical approaches of the clinics through surgeons. In our study, on the other hand, two out of three surgeons from the same clinic were found to perform the surgery routinely with lateral single or lateral-medial double incisions whereas the other surgeon was detected to perform the posterior incision. This may result from the variations in periods when the training was received or from different role model instructors.

Iatrogenic ulnar nerve injury is associated with closed reduction and crossed K-wire. This may be reduced only with lateral pinning or applying K-wire through the mini-medial incision [3,13,22]. Iatrogenic radial nerve injury can be seen with a lateral open approach [22]. On the other hand, posterior intervention may be associated with poor functional outcomes and joint stiffness [19,23]. In our study, while the lack of comparison of the pin configurations by surgeons and its complications was a shortcoming, the difference of surgeons in terms of surgical approaches and numbers of pins was significant. For instance, in cases where three pins were applied, medial pinning was also performed. Also, one of the surgeons applied the medial pin with a mini-open incision while preserving the ulnar nerve in closed interventions. The variation of surgical approaches and its application techniques may be associated with decreased or increased rates of complications depending on the practice. This might cause differences in types and rates of complications based on the operating surgeon.

Our study has several limitations, including retrospective design and lack of long-term follow-up and functional outcomes. Also, we did not compare pin configurations and had no information about the types and rates of its complications.

Conclusion

The type of surgical approach and treatment method in pediatric supracondylar fractures is at the surgeon's discretion. It, therefore, may be influenced by the approach of the clinic where the surgeon had specialty training. Nevertheless, within-clinic variations might also occur based on the surgeon's preference or their role-model advisor. Individual preferences may result in differences in operative time and case-specific complication rates.

Competing interests
The authors declare that they have no competing interest.

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Ethical approval
This study was approved by the Institutional Ethics Committee and conducted in compliance with the ethical principles according to the Declaration of Helsinki.

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