

Medial Spike and Obesity Associate with Open Reduction in Type III Supracondylar Humeral Fracture

Přítomnost mediálního hrotu a obezity vede k otevřené repozici u třetího typu suprakondylické zlomeniny humeru u dětí

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ABSTRACT

PURPOSE OF THE STUDY

Although supracondylar humeral fractures represent a major part of the pediatric fractures, no classification system or radiological characteristics describes which supracondylar fractures require open reduction. We aim to evaluate the factors that lead us to perform open reduction during operation.

MATERIAL AND METHODS

We retrospectively evaluated 57 patients who underwent operation for type III supracondylar fracture, and divided them into two groups; those with open reduction and internal fixation, and those with closed reduction and percutaneous fixation. The two groups were compared based on age, gender, BMI by age, medial spike angle of the fracture, medial spike-skin distance and rotation angle between the fractured fragments.

RESULTS

Of all patients, 46 (81.71%) underwent closed reduction and percutaneous fixation (CRPF) and 11 (19.29%) were treated with open reduction and internal fixation (ORIF). BMI by age was remarkably higher in the ORIF group ($p = 0.00$). And medial spike angle was smaller in the ORIF group ($p = 0.014$).

DISCUSSION

Closed reduction and percutaneous fixation is the main treatment of supracondylar humeral fractures. Open reduction in supracondylar humeral fractures could be associated with complications and cosmetic lesions. Many studies indicate that obesity is a high risk factor for complex fractures as well as preoperative and postoperative complications. A prominent medial spike could be associated with muscle entrapment, and obliquity of the fracture line. It could be also an indirect finding of instability of the fracture.

CONCLUSION

We suggest that a smaller medial spike angle and a higher BMI in children with Type III supracondylar humeral fractures may require open reduction, and it is unreasonable to avoid open reduction in cases where closed reduction is not achieved.

Key words: supracondylar humerus, open reduction, obesity, medial spike angle.

INTRODUCTION

Supracondylar elbow fractures represent 16.6% of all pediatric fractures (11). While type II and type III fractures can be successfully treated by 94% and 85% respectively with closed reduction and percutaneous fixation (CRPF) (4, 5), supracondylar fractures which can not be treated with closed reduction due to interposition of brachialis muscle, median nerve or brachial artery require open reduction (1). There are several studies which compared results from open reduction with those from closed reduction and percutaneous fixation, particularly in type II and type III fractures, however no classification system or radiological characteristics have described the type of supracondylar fractures that requires open reduction (12).

The present study retrospectively evaluated the parameters requiring open reduction that should have been used during pre-operative assessment in patients who presented with type III supracondylar fractures.

MATERIAL AND METHODS

The present study included the patients who underwent surgery for supracondylar fractures between 2012 and 2014 in our clinic. After approval by the local ethical board, the information was obtained from patient files and anaesthesia records of patients. The fractures were classified according to the Wilkins modification of the Gartland classification (21). We excluded patients with Gartland type I fractures because that can be treated conservatively and type II fractures because there is not

a consensus in literature that should be treated with conservatively or surgery, open fractures, intercondylar fractures, flexion type fractures and ipsilateral fractures of the humerus and of the forearm with pulseless extremity and fractures with neurovascular injury. Fifty seven patients who met these criteria included in the study. All patients were operated within the first 24 hours of their admission to the emergency service under supervision of senior surgeons. Fractures fixed with two lateral parallel kirschner wires and if needed for with additional one from medial side to increase stability.

The BMI was calculated by dividing body weight of patients in kilograms by square of their height in meters. The BMI by age was calculated based on the number of months of the injury in CDC(Centers for Disease Control and Prevention) growth charts. According to the BMI by age, < 5th percentile was considered underweight (Group 1); 5 to 85th percentile, normal weight (Group 2), 85 to 90th percentile overweight (Group 3); and > 95th percentile, obese (Group 4).

The true anteroposterior and lateral roentgenograms obtained at the time of admission to emergency service were reviewed, and rotation of the fracture line was calculated using the method described by Henderson et al. in 2007 (9). The interobserver and intraobserver values for this study indicate this method of calculating malrotation is accurate and reliable.

The medial spike angle was defined as the angle between the medial cortex line and oblique fracture line in proximal fragment of the fracture, and medial spike-skin distance was defined as the shortest distance between the medial spike and the skin in the radiograph that it signify the penetration of soft tissues because of displacement (12). (Fig. 1: Assessment of medial spike angle), (Fig. 2: Medial spike skin distance).



Fig. 1. Assessment of medial spike angle.

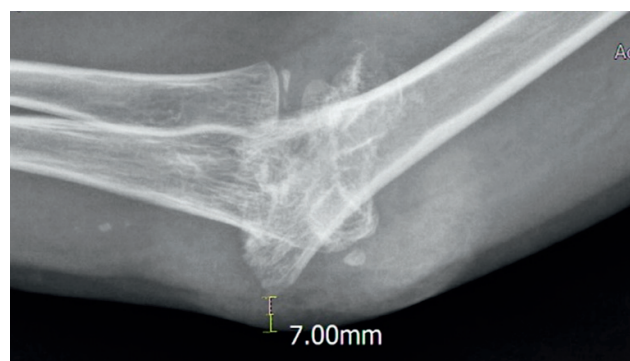


Fig. 2. Calculation of medial spike skin distance.

Following an initial attempt of closed reduction in all patients, an open reduction was performed if acceptable reduction was not achieved after repeating gentle manipulations for a few times. An unacceptable reduction was defined as excessive translational or rotational malalignment. Translational malalignment was defined on a lateral radiograph when less than 75% cortical contact existed between the proximal and distal fragments. Rotational malalignment was defined on a lateral radiograph when a 2 to 3 mm difference existed in the width of the bone at the fracture site between the proximal and distal fragments

Data were evaluated using the SPSS (version 21, USA) software package by the Student's t-test for quantitative data, and chi-square test for frequency analysis.

RESULTS

The study included 57 patients. Of these patients, 46 (81,71%) were treated with closed reduction and percutaneous fixation (CRPF), and 11 (19,29%) with open reduction and internal fixation (ORIF). Twenty three (40.4%) patients were male, 34 (59.6%) were female. The mean age of patients was 7.9 years (+/-1.51) in the ORIF group, and it was 6.5 years (+/-2.41) in the CRPF group.

No statistically significant difference was found between the ORIF and CRPF groups in age, gender, degree of rotation and medial spike-skin distance (Table 1).

Almost 19.3% of patients had a BMI by age over the 95th percentile. When the frequency and percentages between type of surgery and BMI index by age were compared using the chi-square test, the difference was very significant ($p = 0.00$). In the ORIF group, the BMI index by age was in the 3rd, and 4th groups, while in the

Table 1. Comparison of age, gender, and degree of rotation between the ORIF and CRPF groups

	ORIF			CRPF			p-value
	N	Mean	SD	N	Mean	SD	
Age	11	7.90	1.51	46	6.50	2.41	.070
Degree of rotation	11	45.90	6.64	46	45.89	12.35	.992
Medial spike – skin distance	11	8.63	2.90	46	8.32	5.97	.868

Table 2. The distribution of BMI index by age percentile for patients who underwent ORIF and CRPF

			BMI by age				Total
			below 5%	between 5% and 85%	between 85% and 95%	over 95%	
	ORIF	N	0	3	1	7	11
		ORIF rate	.0%	27.3%	9.1%	63.6%	100.0%
	CRPF	ORIF rate according to the BMI by age	.0%	8.6%	25.0%	63.6%	19.3%
		Total	,0%	5.3%	1.8%	12.3%	19.3%
		N	7	32	3	4	46
		CRPF rate	15.2%	69.6%	6.5%	8.,7%	100.0%
		CRPF rate according to the BMI by age					
			100.0%	91.4%	75.0%	36.4%	80.7%
		Total	12.3%	56.1%	5.3%	7.0%	80.7%
		Total					
	N	7	35	4	11	57	
	Total	12.3%	61.4%	7.0%	19.3%	100.0%	

CRPF group the BMI by age was mainly in the 1st and 2nd groups (Table 2).

The medial spike had a narrower angle in the ORIF group. The medial spike angle was 47.02° (+/- 8.05°) in the ORIF group vs. 59.78° (+/- 16.08°) in the CRPF group ($p = 0.014$). (Table 3).

Table 3. Medial spike angle between groups

	ORIF			CRPF			p-value
	N	Mean	SD	N	Mean	SD	
Medial spike angle	11	47.02	8.05	46	59.78	16.08	.014

DISCUSSION

The supracondylar humeral fractures are common fractures in childhood. Although CRPF is recommended for treatment of these fractures by many studies, open reduction is required in open fractures, pulseless extremities, flexion type injuries and neurovascular injuries. Besides, open surgery is performed in 13 to 17% of cases when closed reduction is not achieved (20). In this group of patients with failure of closed reduction, it is not easy to predict for which fractures open reduction should be used. A study by Shifrin et al. reported that the amount of displacement in a fracture line is an indication of open reduction (19). Nassar et al. suggests open reduction when reduction was not achieved after a single manipulation (15). Clinical practice guideline on the treatment of pediatric supracondylar humeral fractures published by AAOS in 2012 indicate type of fracture, soft tissue interposition, patient characteristics and experience of the surgeon as risk factors (14). In the present study, 19.29% of patients with type III supracondylar humeral fracture were treated with open reduction. We believe that our higher rate of open reduction compared to the literature is associated with limitation of manipulations to a few

times to achieve reduction not to damage the physis, and our intention to reduce the radiation dose associated with fluoroscopy use during the operation. A study by Esen et al. showed that prolonged attempts at closed manipulations increased the exposure to fluoroscopy in displaced supracondylar fractures (3).

The increase observed in the rate of open reduction as BMI increased was the most important result in our study. According to the data from the Centers for Disease Control and Prevention, the rate of obesity is 16.9% during childhood and adolescence (16). When this group of obese patients is compared to the peers with a normal weight, it has been reported that they have an increased risk of injury (8), and increased weight was associated with a 1.7

times increased fracture risk even in low-energy injuries (2). Fornari et al. indicated that childhood obesity is a risk factor for complex distal humeral fractures including lateral condylar fractures and intraarticular fractures (7). These patients have an increased rate of operative complications such as reduction loss, pin-tract infection and cosmetic lesions as well as non-operative complications like loss of reduction (17). Similarly, Seeley et al. demonstrated that obesity was associated with complex supracondylar fractures and preoperative and postoperative complications, however they defined the complex fractures as type III intraarticular eminence fractures, accompanying ipsilateral fractures and open fractures in their study (18). In the present study, 19.3% of patients (11/57) were above >95th percentile, and 63.6% of these patients (7/11) required open reduction. Our results are consistent with the literature.

The second important result of the present study was that the rate of open reduction increased with a smaller medial spike angle. Archibeck et al. reported that closed reduction was impossible in patients with interposition of the proximal tip of the fracture in the brachialis muscle or in patients with entrapping fracture tips at medial nerve or brachial artery (1). In a study defining the medial spike angle, Lim et al. reported that patients with a narrow medial spike angle experienced more intraoperative complications, prolonged surgery time and more restricted range of motion during the early postoperative period (12). The same study indicated that pediatric orthopedic surgeons have a high threshold value for open reduction, however patients with a shorter medial spike distance may require open reduction more than usual. In a series of 41 patients who underwent open reduction, Fleuriau et al. reported that the need for open reduction was associated with emergence of buttonhole phenomenon due to interpositioning of the fracture fragments in soft tissue in 31 patients and the oblique fracture line in 4 patients. The same study indicated that the posteromedial displacement

of the distal fragment was more common by 56%, and 16 of patients (39%) who required open reduction had a marked spike, but the authors did not report the spike angle or specify if it was a medial or lateral spike (6). In the present study, we believe that higher soft tissue entrapment in the fracture fragment with a narrow medial spike angle. It should be kept in mind that a smaller angle is also an indirect indication of obliquity and the fracture is unstable so that it may require open reduction. Although we try to obtain true anteroposterior and lateral X-rays before reduction of supracondylar humerus for better analysing the fracture configuration, rotation of humerus could change the measurements of medial spike angle and medial spike-skin distance. Internal rotation of the humerus can lead to incorrect decreased measurement of the medial spike angle. For evaluating the fracture optimum X-rays should be obtained.

In a series of 382 patients, Mitchelson et al. reported that children with type III supracondylar fractures were older than other children, but the rate of complex fracture did not differ due to gender, BMI or BMI by age (13). In the present study, the patients who underwent ORIF had a tendency to be older than the patients in the CRPF group ($p = 0.063$), however no difference was found in distribution of gender between the two groups. A Danish demographic study showed that the peak incidence was between 5 and 7 years, but there was no relation between gender and fracture incidence (10).

The present study had some limitations. First of all, this study is retrospective in nature and the accuracy of the data is determined by accurate recording of patient height and weight in the clinical or operative settings. Secondly, the group of muscles where fragments were entrapped was unknown in patients requiring open surgery since it was a retrospective study. Thirdly, number of cases for ORIF is small.

CONCLUSION

We believe that a smaller medial spike angle and a higher BMI in children with supracondylar humeral fractures may require open reduction and open reduction should not be avoided in this group of patients when closed reduction was not achieved.

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