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Comparision of lateral, medial, and posterior approaches in the surgical treatment of pediatric supracondylar humerus fractures

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ABSTRACT

OBJECTIVE: The aim of this study was to compare the functional and radiological results of lateral, medial, and posterior surgical approaches in pediatric patients undergoing open reduction and internal fixation for supracondylar humerus fractures.

METHODS: A total of 86 patients were included in the study. The clinical and radiographic results of the treatment in patients who underwent open reduction and internal fixation with lateral, medial, and posterior approaches were evaluated. Flynn's criteria were used in the evaluation of cosmetic and clinical results. Comparisons were made between the groups in terms of Baumann angle, lateral capitellohumeral angle, and post-operative complications.

RESULTS: There was no statistically significant difference between the three groups in terms of complications. No statistically significant relationship was observed between Flynn's criteria and surgical approaches. When the relationship among post-operative range of motion (ROM) and surgical approach was evaluated, no extension defect was found in any of the patients, but a significant relationship was found between post-operative flexion ROM and surgical approach (p=0.011).

CONCLUSION: Closed reduction and percutaneous pinning are preferred in cases of pediatric supracondylar humerus fractures. However, when this method cannot be applied, lateral, medial, and posterior approaches are the possible open reduction methods, that can be safely preferred.

Keywords: Lateral/medial/posterior approach; open reduction; pediatric supracondylar humerus fractures; surgical approach.

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Pediatric supracondylar humerus fractures are among the most common upper extremity fractures in children aged between 3 and 10 years [1]. They are difficult to manage and have a high risk of complications rates. Fixation with closed reduction and percutaneous pinning is currently the most popular technique for treating displaced supracondylar humerus fractures [2]. However, closed reduction attempts do not always yield satisfactory outcomes. If reduction could not be achieved by closed intervention or the reduction remains unsatisfactory, open reduction and internal fixation are indicated, especially cases of open fracture or vascular injury require open reduction [1–3].

There is no consensus on which surgical approach should be preferred for open reduction of a displaced supracondylar humerus fracture. The proposed approaches include various data on post-operative complications and post-operative success rates [4]. The previous studies defined anterior, medial, lateral, and posterior approaches and their combinations [5].

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The medial approach has the advantage of better restoration of rotation by direct vision, preventing damage to the ulnar nerve during medial K-wire insertion [6]. The posterior approach can be considered relatively simple, with a broad view of the fracture line and minimal neurovascular dissection. However, posterior incision involves a risk of separation of the triceps muscle in the longitudinal axis, resulting in restricted movement [7]. The lateral approach has the advantage of involving less soft-tissue dissection and being less invasive [7].

The aim in this study was to compare the functional and radiological outcomes of lateral, medial, and posterior approaches in pediatric supracondylar humerus fractures treated with open reduction.

Highlight key points

- Postoperative flexion limitation is significantly higher in patients who underwent posterior approach compared to other approaches.
- High functional and cosmetic results were obtained in all three surgical approaches examined.
- There was no statistically significant difference between the three groups in any of the complications included in the evaluation and the complication detected with the highest frequency was cubitus valgus.

MATERIALS AND METHODS

Patient Selection

After obtaining approval from Haydarpaşa Numune Training and Research Hospital Clinical Research Ethics Committee (October 26, 2020, No: HNEAH-KAEK 2020/213–2959), the records of all patients aged 1–14 years who were operated for Gartland type 3 supracondylar humerus fracture between January 2016 and December 2019 were retrospectively reviewed to determine those eligible for our inclusion criteria [8]. Patients with a minimum of 12 months follow-up were included in the study. Patients with flexion type supracondylar fractures, open fractures, secondary ipsilateral fractures, and those younger than 1 year of age or older than 14 years. Patients who underwent closed reduction and percutaneous pinnig were not included in the study. After the retrospective review of patient files, 153 patients were detected to have been operated for supracondylar humerus fractures. Sixty-seven patients who did not meet the inclusion criteria were excluded from the study. Of these patients, 56 had closed reduction and percutaneous pinning, six had flexion type supracondylar humerus fractures, and six were Gustilo-Anderson type II or III open fractures [9]. After the exclusions, the remaining 86 patients were included in the study. The study group consisted of 62 (72%) males and 24 (28%) females with a mean age of 8.37±0.37 (range: 1–14 years). Mean follow-up period was 38.9 months (range: 12–94 months). Surgery was performed on the left side in 55 (64%) patients and on the right side in 31 (36%). The patients were divided into three groups according to the surgical approach used for open reduction. Group 1, 2, and 3 consisted of patients who underwent open reduction and pinnig by lateral, medial, and posterior approaches, respectively. Thirty patients underwent open reduction and pinning by lateral approach (group 1), 29 underwent open reduction and pinning by medial approach (group 2), and the remaining 27 had open reduction and pinning by posterior approach (group 3). All procedures were performed by surgeons experienced with the respective approaches. The randomization was made based on the experience of the surgeon who would carry out the procedure.

Surgical Technique

All patients were operated under general anesthesia, receiving a 75 mg/kg cefazolin sodium prophylaxis preoperatively. After performing the surgical intervention and achieving reduction, fixation was done using 1.6–2.0 mm Kirschner (K) wires.

For all patients undergoing open reduction by medial approach, after attempting a closed reduction maneuver and achieving no reduction, a 3–4 cm longitudinal incision was made on the medial epicondyle with the arm abducted at 90° in the supine position. The cutaneous, subcutaneous, and deep fascia were penetrated and the ulnar nerve was explored without loosening the ulnar groove. The fracture line was reached by monitoring the medial column between the brachialis and triceps muscles. The fracture was reducted after palpating with a finger. Percutaneous pinning was performed using a K-wire first from the medial and then from the lateral under C-arm fluoroscopy.

For all patients undergoing open reduction by lateral approach, after attempting a closed reduction maneuver and achieving no reduction, a 3–4 cm incision was made on the lateral epicondyle with the arm slightly adducted toward the body in the supine position. The fracture line was reached between the triceps and brachioradialis muscles after penetrating the fascia. The fracture was reducted after palpating. Fixation was done by sending

three K-wires to the fracture line, two to the lateral and the other to the medial by reducing elbow flexion under C-arm fluoroscopy.

For all patients undergoing open reduction by posterior approach, after attempting a closed reduction maneuver and achieving no reduction, an incision was made from 5 cm proximal to the olecranon to 1 cm distal to the midline olecranon with the arm abducted at 90° in the prone position, exposing the ulnar nerve, and after splinting the longitudinal fibers of the triceps muscle to observe the fracture line in the distal of the humerus the olecranon fossa was exposed. Fixation was achieved using a cross K-wire over the medial and lateral epicondyle without C-arm fluoroscopy.

The reduction and fixation of the fracture was re-evaluated under C-arm fluoroscopy after surgery for all approaches and, the ends of the K-wires were bent and corrected to remain on the skin. All patients were provided with long arm splints at the end of the surgery.

Post-operative Follow-up and Clinical Evaluation

All patients were followed-up based on the same protocol. Discharge was planned in the absence of any complications in the post-operative follow-up. Follow-ups were done at the 1st, 2nd, and 4th post-operative weeks. Follow-up was completed with a long arm splint at the 4th week. Active and passive elbow joint movements were initiated. On radiologically observing sufficient callus, the K-wires were removed at the outpatient clinic at the 6+ week. Patients with insufficient range of motion (ROM) in the 2nd post-operative month were referred to the physical therapy and rehabilitation clinic.

All patients were evaluated functionally and radiologically at their last follow-up. Radiological evaluation involved anteroposterior and lateral elbow radiographs on both the operated and healthy sides. Coronal plane alignment was evaluated by the change in Baumann angle (Fig. 1) and sagittal plane alignment by the change in lateral capitellohumeral angle (LCHA) (Fig. 2). The loss of carrying angle and joint ROM were measured and recorded for both sides using a goniometer at the last follow-up. To minimize interobserver variability, all patients were examined by a single orthopedic surgeon who was not involved in the procedures and was not informed about the approaches. Functional and cosmetic outcomes on the operated side were evaluated by the criteria defined by Flynn et al. [10], given in Table 1. Functional evaluations were based on ROM limitation degree and cosmetic evaluations on carrying angle measurement on both sides. The results were evaluated for their correlations with the surgical approaches. Post-operative complications, the time from trauma to surgery, and recurrent surgery were investigated and recorded. For post-operative complications, Volkmann's ischemic contracture, myositis ossificans, cubitus valgus, avascular necrosis of the trochlea, neurovascular injury, reduction loss, non-union, and pin site infection were investigated. Volkmann's ischemic contracture, myositis ossificans, and non-union were not encountered in any of the patients. Pin site infection was observed in five patients who recovered with oral antibiotic treatment and had no sequelae. Among these five patients, 2 (6.6%) patients were in group 1, 2 (6.8%) patients were in group 2, and 1 (3.7%) patient was in group 3. Among the all complications, cubitus valgus was observed with the highest frequency. It was observed in nine patients, two in group 1 (6.6%), two in group 2 (6.8%), and five in group 3 (18.5%). Cubitus varus was found in three patients in group 1 (10%) and two in group 2 (6.8%), and neurovascular injury was found only in two patients in group 3 (7.4%).

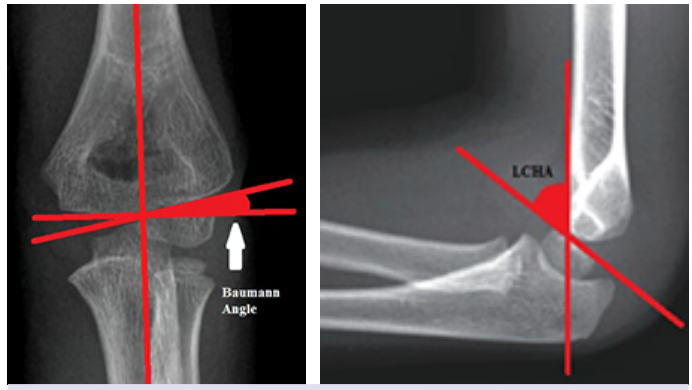

FIGURE 1. This illustration describes the measurement of the Baumann angle.

TABLE 1. Flynn's criteria

	Functional range of motion loss	Change in cosmetic carrying angle
Excellent	0–5°	0–5°
Good	6–10°	6–10°
Moderate	11–15°	11–15°
Poor	>15°	>15°

Table 2. Correlations between surgical approaches and Baumann angle, LCHA and carrying angle

	Surgical approach			p
	Lateral	Medial	Posterior	
Baumann angle (°)	3.93±0.65	4.45±0.79	4.26±0.76	0.180
Lateral capitellohumeral angle (°)	3.20±0.56	3.17±0.61	5.04±1.10	0.186
Carrying angle (°)	3.97±1.18	3.00±0.73	3.81±1.06	0.691

LCHA: Lateral capitellohumeral angle.

Statistical Analysis

The statistical analysis of patients' data was performed using SPSS 22.0 for Microsoft Windows (IBM SPSS Statistics, Chicago/USA). Basic statistics such as frequency, percentage, mean, and confidence interval were obtained for suitable variables. Correlation coefficients were calculated to determine the correlations between variables. Chi-squared tests were performed to determine the independence of nominal discrete variables. Non-parametric Kruskal–Wallis and Mann–Whitney tests were used to reveal the mean rank differences of independent groups based on the number of groups with non-normally distributed dependent variables. Level of significance to reject statistical hypotheses was taken as 0.05.

RESULTS

The correlations between the surgical approaches and Baumann angle, LCHA, and carrying angle are given in Table 2. Baumann angle, LCHA, and carrying angle differences between the operated side and the healthy side were calculated and their correlations with the surgical approaches were evaluated. No statistically significant correlation was found between these parameters.

Considering the correlation between post-operative ROM and the surgical approaches, no extension defect was detected in any of the patients. Only seven patients were observed to have flexion defect with a mean limitation of 8°. Of these patients, five were operated by posterior approach, with a mean flexion defect of 18°. The remaining two patients were operated by medial approach, with a mean flexion defect of 7°. No posto-perative flexion defect was found in any of the patients undering surgery by lateral approach. Statistical analysis revealed a significant correlation between post-operative flexion ROM and the surgical approaches (p=0.011).

According to the Chi-squared test results shown in Table 3, there was no statistically significant correlation between Flynn Criteria and the surgical approaches (p>0.05). All surgical approaches yielded very high rates of excellent cosmetic and functional outcomes, with functional outcomes being higher than cosmetic outcomes for all approaches.

The correlation analysis revealed no statistically significant correlation between the surgical method and the complications (p>0.05). The correlations between the complications and the surgical approaches are shown in Table 4.

No statistically significant correlation was found between time from trauma to surgery and post-operative complications. Furthermore, there was no statistically significant correlation between time from trauma to surgery and Flynn's criteria for either cosmetic or functional outcomes (p>0.05).

We found no statistically significant difference between the surgical approaches and the hospitalization and follow-up times. However, as seen in Table 5, the mean follow-up time was shorter in the medial approach group and the mean hospitalization time was longer in the posterior approach group.

Four of 86 (4.6%) patients were reoperated. Revision was performed on one patient in the lateral approach group, one patient in the medial approach group, and two patients in the posterior approach group. No statistically significant result was found in the analysis performed to evaluate the relationship between surgical approaches and reoperation (p=0.483).

Table 3. Correlation between Flynn criteria and surgical approaches

Flynn's criteria	Surgical approach						Total		p
	Lateral		Medial		Posterior				
	n	%	n	%	n	%	n	%	
Cosmetic outcomes									0.871
Excellent	26	86.7	25	86.2	23	85.2	74	86.0	
Good	1	3.3	2	6.9	1	3.7	4	4.7	
Moderate	0	0	1	3.4	1	3.7	2	2.3	
Poor	3	10.0	1	3.4	2	7.4	6	7.0	
Functional outcomes									0.116
Excellent	30	100	27	93.1	22	81.5	79	91.9	
Good	0	0	1	3.4	4	14.8	5	5.8	
Moderate	0	0	1	3.4	1	3.7	2	2.3	
Poor	0	0	0	0	0	0	0	0	

Table 4. Correlation between complications and surgical approaches

Complications	Surgical approach			Total	p
	Lateral	Medial	Posterior		
Non-union					–
No	30	29	27	86	
Yes	0	0	0	0	
Volkmann's ischemic contracture					–
No	30	29	27	86	
Yes	0	0	0	0	
Myositis ossificans					–
No	30	29	27	86	
Yes	0	0	0	0	
Cubitus valgus					0.158
No	28	27	22	77	
Yes	2	2	5	9	
Cubitus varus					0.113
No	27	27	27	81	
Yes	3	2	0	5	
Avascular necrosis of the trochlea					0.073
No	30	29	25	84	
Yes	0	0	2	2	
Neurovascular injury					0.073
No	30	29	25	84	
Yes	0	0	2	2	
Pin site infection					0.648
No	28	27	26	81	
Yes	2	2	1	5	

Table 5. Correlations between surgical approaches and hospitalization and follow-up times

Surgical approach	Follow-up time (months)	Hospitalization time (days)
Lateral		
Mean	42.50±26.85	2.80±1.13
n	30	30
Medial		
Mean	34.07±26.4	2.97±1.63
n	29	29
Posterior		
Mean	39.81±25.89	3.78±2.22
n	27	27
Total		
Mean	38.81±26.33	3.16±1.73
n	86	86
p	0.354	0.078

DISCUSSION

In this study, it was aimed to determine the functional and cosmetic results of the open reductions performed by lateral, medial, and posterior approaches in the treatment of pediatric humerus supracondylar fractures and to analyze the post-operative complications for each type of surgery. Successful functional and cosmetic results were achieved in all three surgical approaches. There was no statistically significant difference between the three groups in terms of complications which supports that, all three surgical approaches are safe methods.

There are plenty of studies in the literature on preferred approaches for open reduction in pediatric supracondylar humerus fractures, although with varying results. For open reduction, lateral, medial, anterior, and posterior approaches and combinations thereof can be used. Many studies report the medial and lateral approaches to be the most preferred [11, 12]. However, there are insufficient data on the posterior approach.

Considering outcomes using different approaches in open surgery based on the Flynn criteria, Barlas and Baga reported 90.69% good-excellent outcomes and Ramsey and Griz reported 95% good-excellent outcomes at a 4-year follow-up for the medial approach [13, 14]. Eren et al. [15] compared the lateral and medial approaches and found 95% functional and 100% cosmetic good-excellent outcomes for the lateral approach and 100% functional and cosmetic good-excellent outcomes for the medial approach. Bombaci et al. [16] compared the lateral and posterior approaches and found 76% functional and 94% cosmetic outomes for the lateral approach and 80% functional and 100% cosmetic outcomes for the posterior approach. We observed similar functional outcomes for the medial, lateral, and posterior approaches, consistent with the literature. We believe that all three methods can be preferred thanks to their high functional and cosmetic outcomes. We believe that great post-operative functional and cosmetic outcomes can easily be obtained by preferring the approach that the operating surgeon is experienced with.

As one of the complications in these surgical approaches, ulnar nerve injury can be observed frequently after open reduction and most cases can improve within a few months without additional intervention [17]. Complication rates can be further reduced by decreasing elbow flexion during percutaneous pinning on the medial side or by making a small incision exposing the ulnar nerve. Barlas et al. [13] examined 43 cases and reported no ulnar nerve injury by medial approach. In our study, post-operative ulnar nerve injury was observed only in two cases both that underwent open reduction by posterior approach. In the post-operative follow-up, the nerve injuries completely healed in both patients. The ulnar nerve injury occurred in the posterior approach group only in our study, this complication was associated with neuropraxia and thought to be due to the exploration of the ulnar nerve by posterior approach.

In the literature, pin site infection rates vary between 2 and 10% [18]. Studies on cases treated with closed reduction have reported rates up to 12.5%. The infection commonly regresses completely after the K-wire is removed [18]. We found a pin site infection rate of 8% in our patients. The infection in these cases healed with oral antibiotics, without any sequelae. There was no significant correlation between the surgical approach and pin site infection. Based on our findings, we believe that either of the three surgical approaches can be preferred, provided that the factors that increase infection risk are taken into account perioperatively and post-operatively.

Cubitus varus and valgus deformity are among the complications that may occur after supracondylar fracture surgery. Cubitus varus deformity has an incidence rate of 4–58% [19]. Smith reported cubitus varus deformity in 57% of cases operated by medial approach and Lal and Bhan reported an incidence of 35% in open

reduction by posterior approach [20, 21]. We observed a cubitus varus rate of 5.8% in our patients, consistent with the literature. Cubitus valgus deformity is a rather rare deformity. Studies have repoted incidence rates of 0–8.6% for cubitus valgus [22]. Gay and Love argue that, cubitus valgus, while less common, is a rather serious complication as it can lead to progressive damage to the ulnar nerve [23]. De Boeck and De Smet found that, 10 (5%) of 192 patients developed cubitus valgus deformity in the late follow-up period [22]. In our study, the incidence of cubitus valgus was found as 10%, which is higher than the findings in the literature. Although no statistical significance was observed between the type of surgery and cubitus valgus deformity, five patients among nine who developed cubitus valgus deformity, were operated by posterior approach. We believen that the higher incidence of cubitus valgus complications by posterior approach compared to other approaches is due to insufficient reduction during surgery.

Several studies evaluated the effect of preferred surgical approach on ROM in pediatric supracondylar humerus fractures. Gruber and Hudson reported good field of vision in posterior approach, but stated that, the scar tissue occurring in the post-operative follow-up caused movement limitations, leads to loss of extension [24]. Sibly et al. [25] compared patients undergoing closed versus open reduction by posterior approach and found no significant difference in terms of ROM postoperatively. Herein, we evaluated the correlation between post-operative ROM and the surgical approaches. No extension defect was detected in any of the patients. Flexion defect was observed in seven patients, with a mean limitation of 8°. Of these patients, five underwent surgery by posterior approach and had a mean flexion defect of 18°, with statistical significance. We think that this difference in the posterior approach may be due to the larger exploration on the incision line which leads to longer duration of wound healing post-operatively.

The impact of time from trauma to surgery on post-operative complications has been discussed in many studies in the literature. According to the available data in the literature, the recommended treatment timing of pediatric supracondylar fractures is within the first 8 h after trauma to reduce the risk of complications such as infection and nerve injury [21]. Some authors suggest that, an interval of 6–21 h after trauma causes no significant increase in complication rates or increase the requirement for an open reduction [18]. In the present study, we found no significant correlation between the time from trauma to surgery and post-operative complications. Furthermore, functional and cosmetic outcomes did not correlate with time from trauma to surgery. Based on these findings, we suggest that, pediatric patients with supracondylar humerus fractures should be operated as soon as possible after proper pre-operative preparations for anesthesia are completed. We also believe factors such as swelling on the surgical site and open injuries are crucial in determining the time of surgery.

The study comes with some limitations. The surgeries were performed by different surgeons, the randomization was done based on surgeon's preference despite the homogeneity between the groups, lack of records on surgery times between approaches, and the data on post-operative incision scar size was insufficient. The strenghts of this study include the similar sample sizes in each group which provided better statistical results for comparision and eliminated inconsistency. The clinical and radiological findings were all examined by a single orthopedist and traumatologist who was blinded to the surgical procedure type.

Conclusion

There are various surgical approaches that can be performed in pediatric humerus supracondylar fractures, still their effects on functional and cosmetic results are discussed. According to our study, while there was no difference between the lateral, medial, and posterior approaches in terms of functional and cosmetic results, the incidence of limitation of motion, cubitus varus, and ulnar nerve injury was higher in the posterior approach. Based on these results, we think that lateral and medial approaches can be safely preferred in open reduction. We believe that the posterior approach can be safely preferred in suitable patients according to the experience of the surgeon.

Ethics Committee Approval: The Haydarpasa Numune Training and Research Hospital Clinical Research Ethics Committee granted approval for this study (date: 26.10.2020, number: HNEAH-KAEK 2020/213–2959).

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