

## Research Article

# Comparison of 4 surgical approaches in pediatric Gartland type 3 supracondylar humerus fractures treated by open reduction and pinning: A multicenter study

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## ABSTRACT

**Objective:** This study aimed to compare the outcomes of medial, lateral, posterior, and anterior approaches in pediatric Gartland type 3 supracondylar humerus fractures treated with open reduction and pinning.

**Methods:** Gartland type 3 supracondylar humeral fractures treated by open reduction and pinning in 4 different centers with different surgical approaches were divided into 4 groups according to the surgical approach. Each trauma center applied the surgical approaches with which it had the most experience. Specifically, patients treated with medial, lateral, posterior, and anterior approaches were classified as groups 1, 2, 3, and 4, respectively. The demographic characteristics of the patients and the complications were compared. The findings were evaluated according to the Flynn criteria.

**Results:** A total of 198 pediatric patients, 114 (57.6%) male and 84 (42.4%) female, with a mean age of  $6.27 \pm 2.03$  (range = 1-12) years, were included in this study. They were all treated with open reduction and pinning, 51 (25.8%) by the medial approach, 49 (24.7%) by the lateral approach, 66 (33.3%) by the posterior approach, and 32 (16.2%) by the anterior approach. No significant differences in age, gender, side, or complication status were found between the groups ( $P > .05$ ). There were also no significant differences between the groups regarding the Flynn cosmetic and functional criteria ( $P > .05$ ).

**Conclusions:** Superior functional and cosmetic results can be achieved with fewer complications with surgical techniques applied by experienced surgeons in the open reduction of supracondylar humeral fractures in children. It is recommended that surgeons choose the approach with which they have the most experience.

**Level of Evidence:** Level III, Therapeutic study

## Introduction

Supracondylar humeral fractures constitute 50%-75% of elbow fractures in childhood.<sup>1-5</sup> Conservative treatment is reported to be most preferred for undisplaced fractures, whereas closed reduction and percutaneous pinning are chosen for displaced fractures.<sup>2,6-8</sup> In the literature, the indications of open reduction were reported as insufficient reduction with the closed method, the absence of a fluoroscopy device, and a lack of sufficient experience with a closed reduction on the part of the surgeon.<sup>7,9,10</sup> The open reduction rate in cases of supracondylar fractures is reported to be approximately 2%-16% in the literature, and it is emphasized that surgeons should be prepared for an open reduction in the treatment of irreducible supracondylar humeral fractures.<sup>10,11</sup>

It is possible to perform surgical approaches via 4 different anatomic planes. The advantages and disadvantages of these 4 different approaches compared to each other have been reported in previous studies. In general, as a result of such studies, the anterior approach is suggested for suspected vascular injury for further evaluation. Medial and lateral approaches

are recommended according to the displacement of the proximal part. Due to the difficulty of controlling 2 columns via a unilateral approach, some authors suggest the posterior approach.<sup>12-14</sup> There are many publications in the literature examining open surgical approaches both individually and in comparison with each other. However, to date, there has been no study comparing all 4 different surgical approaches and their results.

The purpose of this study is to evaluate the results of the 4 basic approaches in the open surgical treatment of displaced supracondylar humeral fractures and to determine whether there is a difference between the approaches in terms of functional and cosmetic results and complications. Our hypothesis in this study is that the different approaches have no effects on clinical results in the treatment of patients with displaced supracondylar humeral fractures.

## Materials and Methods

After receiving the approval of the Fatih Sultan Mehmet Training and Research Hospital (date: 25/06/2020, no: 2020/45), patients with supracondylar

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humeral fractures admitted to 4 different trauma centers between March 2010 and June 2020 were evaluated retrospectively. Inclusion criteria were pediatric patients with Gartland type 3 supracondylar humeral fracture according to the Gartland classification<sup>15</sup> who underwent open reduction and were followed for at least 12 months after surgery. Patients with open fractures or vascular injuries requiring open surgery, patients with preoperative nerve injury, patients with a history of previous elbow fracture or surgery, and patients with a follow-up period of fewer than 12 months were excluded.

Four level-1 trauma centers were included in this retrospective study, having performed the same surgical approach regardless of the fracture displacement side. A single surgical team performed the treatment at each trauma center under the guidance of an experienced senior author. Patients were operated on using 1 of the 4 approaches with which the surgeon at each trauma center had the most experience. Although the closed reduction techniques were different at each trauma center, the indications for an open surgical approach were the same. An open surgical approach was used for patients who were thought to have had insufficient reduction during surgery.

The patients were divided into 4 groups according to the surgical approach applied. Specifically, patients treated by medial, lateral, posterior, and anterior approaches were classified as groups 1, 2, 3, and 4, respectively.

#### Surgical technique

Closed reduction and percutaneous pinning were attempted under fluoroscopy for all patients. For patients who could not achieve adequate reduction with closed reduction, an open surgical approach was applied. All open surgical approaches were performed under general anesthesia with the patient in a supine position on a radiolucent table. No tourniquets were used. First-generation cephalosporin prophylaxis was routinely applied for all patients 30 min before the operation at dosages depending on their age and weight.

In the first group, the medial approach began with a skin incision extending from 5 cm proximal to the medial epicondyle distal of the joint line. The ulnar nerve was found and protected. The incision passed the intermuscular septum and reached the distal humerus. In the second group, the skin incision was a lateral incision extending from approximately 2 cm proximal to 1 cm distal of the lateral epicondyle. To see the lateral edge of the humerus, the area between the extensor carpi radialis longus, triceps brachii, and brachialis muscles was used. In the third group, a posterior midline incision was made extending from 5 cm proximal to the olecranon to 1 cm distal of the olecranon in the midline. The ulnar nerve was explored, and to see the humeral distal area, it was opened from both sides of the triceps muscle without cutting any muscles. In the fourth group, the incision

was made over the elbow flexion crease from the lateral part of the biceps brachii attachment with an anterior approach. After reduction was achieved by entering between the usually pierced brachialis muscle and the periosteum, fixation was achieved. All surgeons applied at least one medial and lateral K-wire fixation in accordance with the cross-pin configuration in all cases.

#### Follow-up and clinical evaluation

All patients underwent a standard postoperative follow-up protocol. A long arm splint was used postoperatively, which was removed within 3 weeks after the operation to allow elbow movements. In follow-up, all patients were told to perform daily pin care. An average of 4 weeks after the operation, the pins were removed after callus formation was seen on standard anteroposterior and lateral radiographs. Although there were slight differences between the clinical and radiographic follow-ups of the different centers, radiographic and clinical follow-up examinations of the patients were routinely performed during the sixth week, third month, sixth month, and twelfth month in all centers. The findings obtained from the final examination were evaluated according to the criteria of Flynn (2) (Table 1). According to Flynn's criteria, cosmetic satisfaction is evaluated by loss of carrying angle degrees and functional results are evaluated by loss of motion degrees. In both cosmetic and functional evaluations, 0-5° indicates excellent results, 6-10° indicates good results, 11-15° indicates fair results, and ≥16° indicates poor results. The evaluations according to the Flynn criteria were performed in the 12th postoperative month. These evaluations were conducted in the conditions of the outpatient clinic by the orthopedic assistant doctor and specialist on that day with both radiographic and physical examinations and the results were recorded.

#### Statistical analysis

IBM's Statistical Package for Social Sciences Statistics 22 (IBM SPSS Corp.; Armonk, NY, USA) was used in the statistical analysis of the results obtained in this study. The Shapiro-Wilk test was applied for continuous variables, which were found to be in accordance with normal distribution. As descriptive statistics, mean ± standard deviation values were given for continuous variables, and frequencies and percentages were given for categorical variables. One-way analysis of variance was used for the comparison of quantitative data and comparisons between groups for variables with normal distribution. Qualitative data were compared with the use of the chi-square test. Statistical significance was set at  $P < .05$ .

#### Results

A total of 1194 cases of supracondylar humeral fractures in children were reviewed retrospectively. Of these cases, 225 (18.8%) patients with supracondylar humeral fractures were treated with open reduction after closed reduction failed. Due to a lack of follow-up in some cases, only 198 (16.6%) patients met the inclusion criteria and were included in the review. Of these patients, 84 (42.4%) were female and 114 (57.6%) were male, and the mean age was  $6.27 \pm 2.03$  (1-12) years. All patients were treated with open reduction, with 51 (25.8%)

#### HIGHLIGHTS

- Supracondylar humeral fractures are common fractures in childhood. Surgical treatment is indicated for displaced fractures which can be performed via 4 different anatomic planes. Aim of this study was to evaluate the results of these four basic approaches in terms of function and cosmetics.
- The results showed no significant differences in Flynn's cosmetic and functional outcomes which were both negatively influenced by complication rates. Additionally, there were no significant differences in complication rates between the groups.
- The results indicate that good results can be obtained with any four approaches in closed irreducible pediatric supracondylar humerus fractures in terms of cosmetics and function. It is also recommended that the surgeon applies the most experienced approach.

Table 1. Flynn's criteria

| Flynn criteria | Functional loss of range of motion | Cosmetic loss of cubitus angle |
|----------------|------------------------------------|--------------------------------|
| Perfect        | 0-5°                               | 0-5°                           |
| Good           | 6-10°                              | 6-10°                          |
| Fair           | 11-15                              | 11-15°                         |
| Poor           | >15°                               | >15°                           |

**Table 2.** Evaluation of parameters of patients according to treatment groups

|                                  | Medial<br>n (%) | Lateral<br>n (%) | Posterior<br>n (%) | Anterior<br>n (%) | P     |
|----------------------------------|-----------------|------------------|--------------------|-------------------|-------|
| <sup>1</sup> Age, Mean $\pm$ SD  | 6.69 $\pm$ 1.67 | 6.10 $\pm$ 2.40  | 5.82 $\pm$ 1.79    | 6.81 $\pm$ 2.54   | .535  |
| <sup>2</sup> Gender              |                 |                  |                    |                   |       |
| Female                           | 23 (45.1%)      | 20 (40.8%)       | 31 (47.0%)         | 10 (31.2%)        | .494  |
| Male                             | 28 (54.9%)      | 29 (59.2%)       | 35 (53.0%)         | 22 (68.8%)        |       |
| <sup>2</sup> Side                |                 |                  |                    |                   |       |
| Right                            | 21 (41.2%)      | 25 (51.0%)       | 30 (45.5%)         | 15 (45.5%)        | .803  |
| Left                             | 30 (58.8%)      | 24 (49.0%)       | 36 (54.5%)         | 17 (54.5%)        |       |
| <sup>2</sup> Complications       |                 |                  |                    |                   |       |
| Yes                              | 5 (9.8%)        | 3 (6.1%)         | 8 (12.1%)          | 3 (9.4%)          | 0.759 |
| No                               | 46 (90.2%)      | 46 (93.9%)       | 58 (87.9%)         | 29 (98.5%)        |       |
| <sup>2</sup> Pin tract infection |                 |                  |                    |                   |       |
| Yes                              | 7 (13.7%)       | 6 (12.3%)        | 6 (9.1%)           | 3 (9.1%)          | 0.852 |
| No                               | 44 (86.3%)      | 43 (86.7%)       | 60 (80.9%)         | 29 (80.9%)        |       |

<sup>1</sup>One-Way analysis of variance; <sup>2</sup>Chi-square test.**Table 3.** Evaluation of Flynn's criteria of patients according to treatment groups

|                                 |         | Medial<br>n (%) | Lateral<br>n (%) | Posterior<br>n (%) | Anterior<br>n (%) | P    |
|---------------------------------|---------|-----------------|------------------|--------------------|-------------------|------|
| <sup>1</sup> Flynn's cosmetic   | Poor    | 0(0.0%)         | 1(2.0%)          | 0(0.0%)            | 0 (0.0%)          | .722 |
|                                 | Fair    | 4 (7.8%)        | 2(4.1%)          | 8 (12.1%)          | 3 (9.4%)          |      |
|                                 | Good    | 13 (25.5%)      | 15 (30.6%)       | 13 (19.7%)         | 8 (25.0%)         |      |
|                                 | Perfect | 34 (66.7%)      | 31 (63.3%)       | 45 (68.2%)         | 21 (65.6%)        |      |
| <sup>1</sup> Flynn's functional | Poor    | 2 (3.9%)        | 1 (2.0%)         | 3 (4.5%)           | 2 (6.3%)          | .495 |
|                                 | Fair    | 4 (7.8%)        | 1 (2.0%)         | 7 (10.6%)          | 2 (6.3%)          |      |
|                                 | Good    | 15 (%29.4)      | 19 (38.8%)       | 13 (19.7%)         | 11 (34.3%)        |      |
|                                 | Perfect | 30 (%58.9)      | 28 (57.1%)       | 43 (65.2%)         | 17 (53.1%)        |      |

<sup>1</sup>Chi-square test.

treated with a medial approach, 49 (24.7%) with a lateral approach, 66 (33.3%) with a posterior approach, and 32 (16.2%) with an anterior approach. No statistically significant differences in mean age, gender distribution, or treated side were found between treatment groups ( $P > .05$ ) (Table 2). The mean follow-up period was  $21.54 \pm 8.47$  (12-56) months. There were no statistically significant differences in follow-up periods between the groups ( $P > .05$ ).

The distributions of cosmetic and functional results of the patients according to surgical approach are shown in Table 3. No statistically significant differences in Flynn's cosmetic and functional outcomes were found between treatment groups ( $P = .722$  for Flynn's cosmetic score,  $P = .495$  for Flynn's functional score) (Table 3). The complication rate negatively influenced these scores ( $P = .001$  and  $P < .01$ , respectively).

Surgery-related complications were observed in 20 cases, with cubitus varus deformity in 6 cases (3 in the medial, 2 in the lateral, and 1 in the anterior approach group), cubitus valgus deformity in 12 cases (8 in the posterior, 2 in the anterior, 1 in the medial, and 1 in the lateral approach group), avascular necrosis in 1 case (1 patient in the posterior approach group developed both avascular necrosis and cubitus valgus), and ulnar nerve hypoesthesia in 1 case (medial approach group), as detected in follow-up. Full recovery of the ulnar nerve was observed in follow-up within 3 months after the surgery. On the other hand, complications such as pin tract infection not related to the surgical approach were observed in 22 cases (7 in the medial, 6 in the lateral, 6 in the posterior, and 3 in the anterior approach group); these cases were treated with local debridement and prolonged antibiotherapy. There was no statistically significant difference between the groups in terms of complications related to surgery ( $P = .759$ ). Moreover, there was also no statistically significant difference between the groups in terms of pin tract infection ( $P = .852$ ).

## Discussion

Although closed reduction and percutaneous fixation are reported as the gold standard in the early period for Gartland type 3 pediatric supracondylar humeral fractures, open reduction is recommended for patients for whom adequate reduction cannot be achieved.<sup>2,6-10</sup> In the literature, there is no consensus on the preferred surgical approach for open reduction in the treatment of supracondylar humeral fractures. The most important finding of this study is that cosmetic and functional results were statistically similar among all four surgical approaches as a result of the surgeons applying the approaches with which they had the most experience in cases of pediatric supracondylar distal humeral fractures with open reduction. Moreover, this study is one of the studies with the highest number of patients to date in the orthopedic literature, it presents multicenter findings, and it has compared the results of the four surgical approaches with each other.

There are many studies in the literature reporting each surgical approach and its results. The posterior approach has been reported to be advantageous because it provides a wide view of the fracture, reduces the risk of ulnar nerve injury, and has high rates of excellent and good results.<sup>16,17</sup> However, authors who have shown excellent and good results with the application of a medial approach have argued that this approach has the advantages of being less likely to cause ulnar nerve injury and of leaving more esthetically acceptable medial incision scars.<sup>18-21</sup> The use of a lateral approach in the treatment of supracondylar fractures has also been cited to have 82% excellent and good results.<sup>22</sup> For the anterior approach, limited studies have indicated that it is easy to reach the fracture line, there is less scar tissue, and the results are good.<sup>23-25</sup> In the studies mentioned here, the cosmetic and functional results were found to be good with almost all applied approaches. In our study, the results were similar to those

in the literature, with 90.9% good and excellent cosmetic results and 88.9% good and excellent functional results.

Contrary to studies in the literature reporting the results of a single approach, there are limited studies comparing groups for which different approaches were applied. Bombaci et al underlined that in cases treated by lateral approach, adequate reduction and adherence cannot be achieved in the medial cortex because the lower end of the humerus is not fully disclosed in the anterior. Therefore, they emphasized that the posterior approach is more advantageous.<sup>16</sup> Eren et al<sup>18</sup> compared the results of surgical treatment between the lateral and medial approaches. They found no significant difference in functional and cosmetic results between the two groups; however, they reported that the medial approach may be preferred because it has a lower possibility of ulnar nerve injury and medial incision scars are more acceptable aesthetically.<sup>18</sup> Most recently, Kizilay et al<sup>26</sup> compared the long-term outcomes of 70 patients who underwent different surgical approaches. They came to the conclusion that the medial and lateral approaches yielded better functional results than the posterior and triceps transection approaches.<sup>26</sup> Onder et al evaluated a total of 84 patients who were treated by lateral and anterior approaches, and, as a result, they stated that the anterior approach may be preferred to lateral incisions because it provides the advantages of a smaller scar and easier access to structures that could be injured between the fractured parts.<sup>27</sup> In the present multicentre study, the results of 198 cases treated with open reduction by 4 different approaches were evaluated retrospectively. It was found that there was no statistically significant difference between the medial, lateral, posterior, and anterior approaches in terms of both cosmetic and functional results ( $P = .722$  and  $P = .495$ , respectively).

Despite good functional and cosmetic satisfaction scores in our series, cubitus varus deformity developed in 6 (3.1%) cases, cubitus valgus deformity in 12 (6.2%) cases, avascular necrosis in 1 (0.5%) case, transient ulnar nerve hypoesthesia in 1 (0.5%) case, and pin tract infection in 22 (11.1%) cases. These complication rates were similar to those in the literature.<sup>6,12,20,22,28</sup> When these complications were compared according to the surgical approach applied, no statistically significant difference was found between the groups ( $P > .05$  for all).

Our study has several limitations. First, this study used data obtained from retrospective screening. Although the number of patients treated by anterior approach was similar to the number of patients in other studies, the number of patients treated by anterior approach was still low when compared to the other approaches in this study. Other limitation of this retrospective study was the inability to analyze the operative time, time from injury to surgery, and medial-lateral displacement of the fractures. Finally, although the functional/cosmetic evaluation was made according to the Flynn classification in all centers, the fact that the observers were not the same in this study conducted in four different centers may be a limitation.

In conclusion, the cosmetic and functional results and complication rates of the medial, lateral, posterior, and anterior approaches were found to be similar in cases of pediatric supracondylar humeral fractures requiring open reduction. We recommend considering criteria other than surgical approach to achieve good results in cases of pediatric supracondylar humeral fractures requiring open reduction.

**Ethics committee approval:** Approval was obtained from the Hospital Ethics Committee for the study (Hospital Ethics Committee Number: 2020/45 Date:25/06/2020).

**Informed consent:** Informed consent was not obtained because it was a retrospective study.

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