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ORIGINAL ARTICLE

Gartland Type III Supracondylar humerus fractures in children: Impact of fracture level on outcomes

Sancar Bakircioglu[1]
ORCID: 0000-0001-5403-3324

Ulas Can Kolac[2]
ORCID: 0000-0003-0502-3351

Mert Polat[3]
ORCID: 0000-0002-3329-8558

Abdulsamet Emet[4]
ORCID: 0000-0001-5415-218X

A. Mazhar Tokgozoglu[2]
ORCID: 0000-0002-1375-8115

M. Cemalettin Aksoy[2]
ORCID: 0000-0003-0295-7028

Saygin Kamaci[2]
ORCID: 0000-0002-8887-9333

[1]TOBB ETU University Department of Orthopedics and Traumatology, Ankara, Türkiye.

[2]Hacettepe University, Department of Orthopedics and Traumatology, Ankara, Türkiye.

[3]Lokman Hekim University, Faculty of Medicine, Ankara, Türkiye.

[4]Etlik City Hospital, Department of Orthopedics and Traumatology, Ankara, Türkiye.

Corresponding Author: Saygin Kamaci
E-mail: sayginkamaci@gmail.com

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ABSTRACT

Objective: Functional limitation or radiological failure after the treatment may rarely be seen after the surgical treatment of Gartland type 3 supracondylar humerus fractures (SCHF). The present study aims to investigate whether the level of fracture relative to the isthmus of the humerus affects the outcomes.

Materials and Methods: Children who underwent closed reduction and percutaneous pinning (CRPP) due to Gartland typle III SCHFs between 2010 and 2017 were investigated. There were 108 elbows treated with a mean age of 6.1 years (range, 1.4 to 11.2 yrs.). The radiological (Carrying Angle, Baumann Angle, Humerocapitellar Angle), clinical (Flynn grade with elbow range of motion) and complications were used to evaluate outcomes including fracture level. A reference line connecting medial epicondyle, olecranon fossa and lateral epicondyle was drawn on Anteroposterior (AP) and lateral x-rays. The level of the fracture line was decided based on the reference line. Low fractures included the fractures below or involving the reference line, whereas high fractures included those above the reference line.

Results: There were 80 High and 28 Low fractures according to A reference line connecting medial epicondyle, olecranon fossa and lateral epicondyle and passing through the isthmus. Fractures below the humeral isthmus had significantly low Flynn grade (p:0.049) at the latest follow-up of 2.1 years (range, 1 to 5.1 yrs.). There was no statistically significant difference regarding postoperative sixth week Baumann`s angle, carrying angle and humerocapitallar angle between low and high fracture groups.

Conclusions: The present study demonstrates the importance of fracture analysis. Surgeons may consider more stable pin configuration in the low type fractures and future research should aim to analyze the SCHF in terms of fracture morphology.

Keywords: Supracondylar Humerus Fracture, Fracture Morphology, Pediatric Fracture.

INTRODUCTION

Supracondylar humerus fractures (SCHF) in pediatric population are injuries commonly encountered in orthopedic surgery. SCHF accounts for 16% of all pediatric fractures and 60% of all pediatric elbow fractures (1). The injury occurs most commonly in children between 5 and 7 years of age on the non-dominant side as a result of a fall into outstretched hand with the elbow fully extended, causing an extension-type supracondylar fracture (2, 3). Despite the high frequency of SCHF in children, there are no consensus guidelines today. The choice of treatment modality and fixation, patient positioning, timing of surgery, hardware removal, postoperative immobilization, clinical and radiographic follow-up and the need for postoperative physical therapy (PT) are often left to the individual surgeon (4, 5). The treatment of SCHFs can be challenging even for the experienced surgeon, and the complication rate for this type of injury is not negligible (6).

SCHFs are classified by Gartland`s classification system based on the intact periosteum and direction of the displaced distal fragment. Most of the Gartland type III fractures are treated surgically with closed reduction and percutaneous fixation (CRPP) and has been shown to improve outcomes (7). Many studies report satisfactory clinical outcomes after SCHF in children (7, 8). Although elbow stiffness is less common in pediatric population, some surgically treated patients, gain elbow range of motion (ROM) slowly or even with a deficit which might be concerning for the parents and the surgeon (9, 10). Some studies reported that age of the patient and the severity of the fracture have prognostic value in predicting the final ROM of the elbow (10, 11). Vascular and neurologic status of the extremity also plays an important role in surgical decision making. Fracture characteristics like medial column disruption and sagittal orientation was shown to influence outcomes (12). Thus, a more detailed subclassification system is needed to study the prognostic indicators of clinical outcomes (12, 13).

The importance of understanding the fracture level lies in its potential implications on the biomechanical stability of the fixation. Different fracture levels in the coronal plane could lead to varying degrees of displacement and instability, which may significantly influence the overall clinical outcomes in patients with SCHF.

The present study aims to determine whether level of the fracture line in coronal plane affects functional and radiological outcomes following surgical treatment of Gartland-type III SCHF

MATERIALS AND METHOD

After obtaining the institutional review board's approval (GO 23/44), a retrospective review of the medical records of patients who underwent surgical treatment between the years of 2010 and 2017 for extension type III SCHF using the Gartland classification was performed. Patients with Gartland type I or II SCHF, T-condylar fractures, patients who had less than twelve months follow-up, fractures involving both high and low area or who underwent open reduction were excluded. A total of 108 patients included to the study.

All fractures were stabilized with k-wires following closed reduction. two divergent k-wires were placed laterally and a third k-wire was placed medially depending on the intraoperative stability assessment. The wires were cut, bent and remained over the skin. The elbow joint was immobilized in a long arm splint in neutral position. Patients were routinely monitored and radiographs were obtained postoperatively at 1st, 2nd, 4th, 6th, 8th, 12th weeks than annually. The K-wires were removed when the callus appeared or fracture line blurred usually around third or fourth weeks in outpatient setting. Appropriate fracture healing was determined by the presence of visible fracture callus adjacent to the cortices on both frontal and lateral views. After wire removal no patients received routine physical therapy. However, patients were encouraged active and passive movement of the elbow and strenuous activities were restricted for and additional month

A reference line connecting medial epicondyle, olecranon fossa and lateral epicondyle was drawn on Anteroposterior (AP) and lateral x-rays (Figure 1). The level of the fracture line was decided based on the reference line. Low fractures included the fractures below or involving the reference line, whereas high fractures included those above the

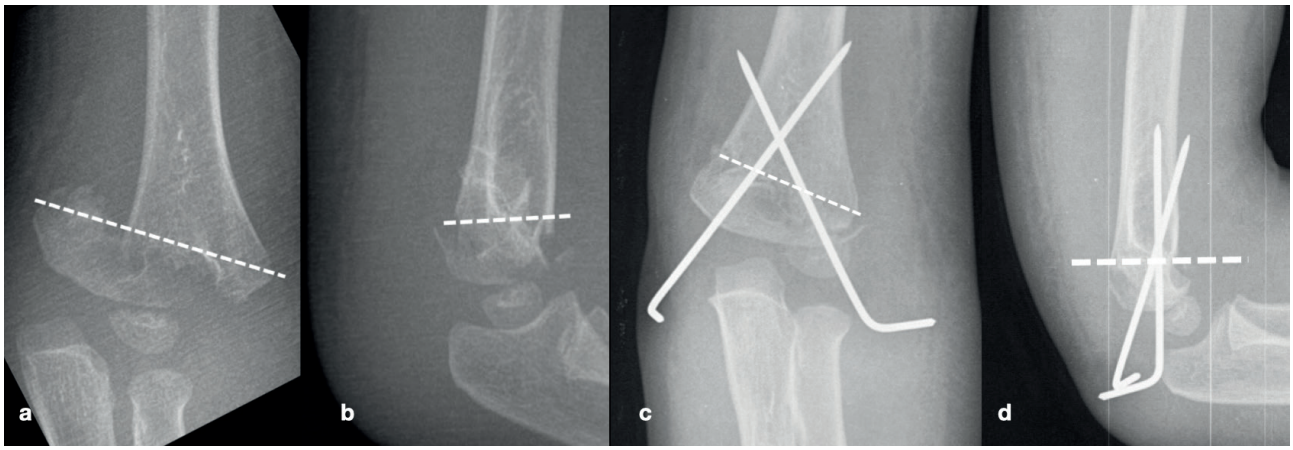

Figure 1. a) Anteroposterior (AP) and b) lateral elbow radiographs demonstrating 3 years old girl with low fracture. c) AP and d) lateral radiograph after K wire fixation with 1 medial 1 lateral pin construct.

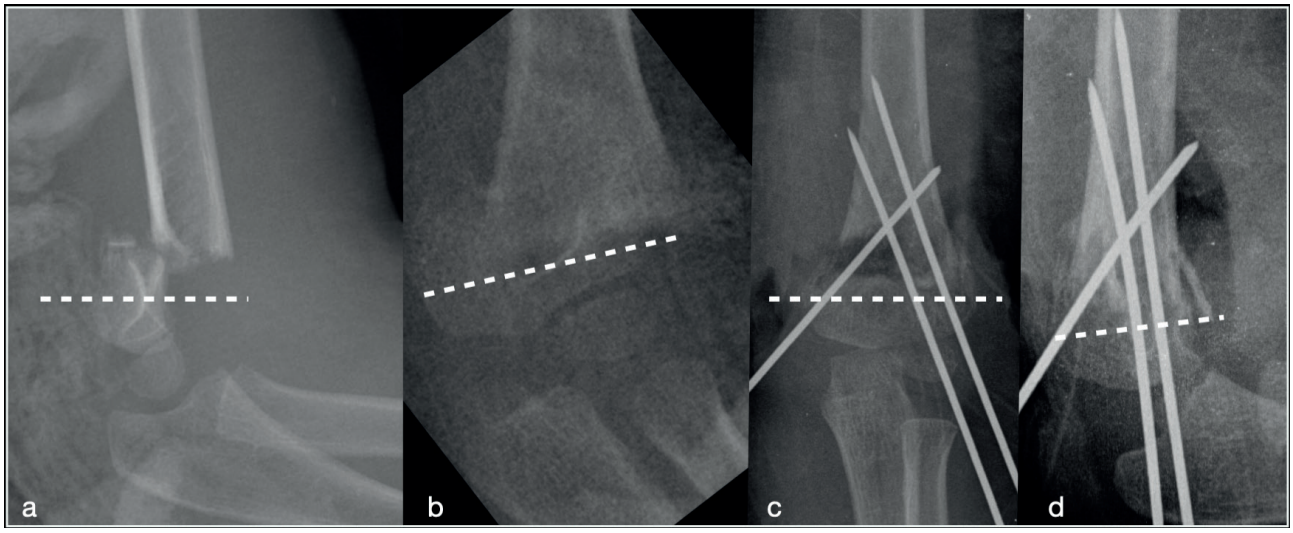

Figure 2. a) Anteroposterior (AP) and b) lateral elbow radiographs demonstrating 5 years old boy with high fracture. c) AP and d) lateral radiograph after K wire fixation.

reference line (Figure 2). Assessments were made on both pre- and intra-operative radiographs to avoid fracture imposition by experienced orthopedic surgeon (S.K).

Age at surgery, gender, level of fracture, pin removal day, loss of reduction and postoperative complications were recorded. The Baumann`s angle, carrying angle and humerocapitellar angle were also measured at the sixth post-operative week (14). Clinical outcomes were recorded based on the modified Flynn`s grading at the latest follow-up (15). Elbows were classified according to Flynn's grades, considering the worst cosmetic/functional outcome (fair or poor) and the best cosmetic/functional outcome (excellent or good)." (Table 1). Postoperative progress notes were evaluated to assess neurovascular status or presence of compartment syndrome.

Table 1. Flynn's criteria

	Functional (Loss of movement (°)	Cosmetic (Loss of carrying angle (°)
Outcomes Satisfactory		
Excellent	0 to 5	0 to 5
Good	6 to 10	6 to 10
Unsatisfactory		
Fair	11 to 15	11 to 15
Poor	>15	>15

The data obtained in the research were analyzed using the SPSS (Statistical Package for Social Sciences) for Windows 22.0 program. Number, percentage, mean and standard deviation were used as descriptive statistical methods in the evaluation of the data. Differences between the ratios of categorical variables in independent

groups were analyzed with Chi-square and Fisher's exact tests. The t-test was used to compare quantitative continuous data between two independent groups. Dependent groups t-test was used to compare within-group measurements.

RESULTS

There were 28 low and 80 high fractures in the cohort. There were 55 males and 53 girls with a mean age of 6.12 (range, 1.4 to 11.2 yrs.). The mean follow-up duration was 2.1 years (range, 1 to 5.1 yrs.). The demographics of the groups were demonstrated in table 2. Eight patients had preoperative nerve palsy (5 radial, 3 Anterior interosseous nerve). There were only 5 complications (%4.62); 3 patients with superficial infection at the pin site, one case with loss of reduction and one case with postoperative anterior interosseous nerve palsy. The patient with loss of reduction had a low type fracture and underwent revision surgery after the first visit (7th days). All the infection with pin site resolved a week after pin removal and anterior interosseous nerve palsy resolved by the twelve post-operative weeks.

In our cohort, Flynn's criteria were used to evaluate both cosmetic and functional results. After 2.1 years of follow-up, 73 (%67.6) of the patients had excellent and 26 (%24.1) patients had good results. 9 patients (%8,3) had unsatisfactory (poor/fair) results due to limited range of motion of the elbow joint. None of the patients had cubitus varus or valgus deformity. There was a significant difference according to Flynn's criteria (satisfactory and unsatisfactory elbows) between low and high fracture groups (p: 0.049). Seven peripheral nerve injury (%) (5 radial, 3 Anterior interosseous) which were observed in the first admission preoperatively resolved spontaneously after an average of 14 weeks (range, 7 to 24 weeks). There was no statistically significant difference regarding postoperative sixth week Baumann`s angle, carrying angle and humerocapitallar angle between low and high fracture groups (Table 3).

DISCUSSION

Most of the patients with type III SCHF treated with closed reduction and percutaneous pinning shows good to excellent outcome. However, there is still poor outcome in selected patients (8, 16). There are many doubts about the Gartland classification predicting the optimal fracture configuration and the clinical outcomes. (17, 18). Therefore, many studies were performed to reveal new classification systems or anatomical analyzes of SCHF. Previously Bahk et al. evaluated 203 children with SCHF and mentioned that the anatomical properties of the fracture may play an effective role in surgical decision making. They stated that more oblique fractures in both coronal and sagittal plane are more prone to comminution, rotational malunion and additional injuries. In our cohort there were no significant difference in terms of complications between low and high fractures. However, future studies with more detailed anatomical

Table 2. Demographics of the patients

	Low Fractures	High Fractures	P value
Number of Patients	28	80	p=0,068
Age			
<5 years	10	26	p=0,464
≥5 years	18	54	
Gender			
Male	16	39	p=0,293
Female	12	41	
Side			
Right	14	27	p=0,098
Left	14	53	
Preoperative Nerve Palsy			
Radial	1	4	p=0,547
Medial	2	1	
Ulnar	0	0	

Table 3. Outcomes and complications

	Low Fractures	High Fractures	Total	p value
Postoperative (4th week)				
Carrying Angle (°)	10.4 (range, 4-19)	10.4 (range, 4-19)		
Baumann Angle (°)	71 (range, 58-79)	71 (range, 58-79)		p=0,692
Humerocapitellar Angle (°)	38 (range, 12-63)	38 (range, 12-63)		
Flynn's Grade				
Satisfactory	76 (%95)	76 (%95)		**p=0,049**
Unsatisfactory	4 (%5)	4 (%5)		
Flynn's Grade				
Excellent (%)	56 (%70)	56 (%70)	73 (%67,6)	
Good (%)	20 (%25)	20 (%25)	26 (%24,1)	p=0,189
Fair (%)	3 (%3,8)	3 (%3,8)	6 (%5,6)	
Poor (%)	1 (%1,2)	1 (%1,2)	3 (%2,8)	
Complications				
Nerve palsy	1	1	1	
Compartment Syndrome	0	0	0	p=0,481
Loss of reduction	2	2	4	
Infection	1	1	3	

subclassification should be conducted to reveal the effect of the fracture biomechanics (17)

In our study, radiological measurement was calculated at the sixth post-operative week to evaluate the quality of the surgical reduction and the Flynn`s grade was obtained at the latest follow-up routine visits. There was a significant difference in favor of high fractures compared to the low fractures between Flynn grades in the short-term follow-up. The most likely explanation is the reduction of the small distal fragment in the low fractures increase instability which makes anatomical reduction more challenging. Moreover, the small distal fragment might be thought to increase the risk of instability and cause loss of reduction. We believe that; presence of a small distal fragment also contributes to the fixation's dynamic instability, posing a higher risk of reduction loss specifically within the low fracture type group. However, we had only one loss of reduction in our cohort but, slight rotational deformity especially in older children may affect the outcomes. Thus, more stable fixation methods may be considered in high or low fracture subtypes to improve outcomes. Additionally, low fractures can be considered as intracapsular fractures and more prone to cause joint stiffness since the surrounding soft tissues are prone to be injured (19). Yet, still the remodeling capacity of the growing child causes mostly final good to excellent outcomes in both low and high SCHF after a year. Previously Kang et al. studied 230 children with Gartland type III supracondylar humeral fracture and reported that low fracture types were significantly seen in children above ten years old. They stated that the increase in the low fracture frequency with age may be related to the ossification stage or higher energy injuries (18). In our study, relationship between high or low fracture type and age during the fracture was also investigated but no significant difference was seen according to the age cut off 5 years.

There are some limitations of the present study; First, it is a retrospective cohort study. Second, the surgeries were performed by different surgeons. Thus, a couple pinning techniques were utilized during surgical fixation. However, in our study all fractures stability were confirmed under fluoroscopy

In conclusion, subclassification of the SCHF according to the anatomical properties of the fracture may be beneficial for the preoperative planning and identifying the patients and parents excepted outcomes. Moreover, surgeons may be aware of the difficulty in low fractures and may want to struct a more stable pin configuration. However, long term prognosis of low type SCHF is comparable with the high type fractures. Future studies on biomechanics of the SCHF subclassification should be verified.

Author contribution

All authors contributed to the study conception and design. Surgical treatment of the patients was performed by SK, SB and CA. Data collection and analysis were performed by UK, AE, SB, and MP. The first draft of the manuscript was written by SB, MP and UK; and MT, CA and SK participated in the reviewing and editing of the manuscript before submission.

Ethical approval

Ethical approval for this study was obtained from the Hacettepe University Faculty of Medicine local ethics committee (GO 23/44, 24.01.2023).

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Conflict of interest

The authors declare that there is no conflict of interest.

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