

Immobilization after pediatric supracondylar humerus fracture surgery: Cast or splint?

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ABSTRACT

Objective: While surgical treatment is the most accepted treatment method for displaced supracondylar humerus fractures in children, there is little data about immobilization method after surgery. The aim of the study is to determine whether there is any difference in preventing loss of reduction between long-arm cast and long-arm splint following pediatric supracondylar humerus fracture surgery.

Patients and Methods: We conducted a retrospective analysis of pediatric patients with supracondylar humerus fractures treated operatively between 2012 and 2019 at a university hospital. According to Skaggs criteria, early postoperative and 3rd-week follow-up X-rays were evaluated for the loss of reduction (LOR). Postoperative immobilization method; splint or cast was compared in the context of LOR.

Results: Cast immobilization was found to be superior in preventing LOR in the first three weeks postoperatively ($p < 0.05$). There was no significant difference for other factors like fracture configuration, patient age and surgical technique.

Conclusion: Cast immobilization is superior to splint immobilization in preventing radiologic LOR after pediatric supracondylar humerus fracture surgery however, clinical relevance of this conclusion is yet to be proved.

Keywords: Supracondylar humerus fracture, Postoperative immobilization, Loss of reduction

1. INTRODUCTION

Supracondylar fractures of the humerus are the most common type of elbow fractures in children, accounting for more than 80% of all fractures [1, 2]. The typical mechanism of injury has been described by Farnsworth et al. as a fall on an outstretched hand, and thus, 98% of these fractures are extension-type injuries [3]. Closed or open reduction followed with percutaneous fixation with K-wires is widely accepted as optimal treatment. In previous studies, this treatment has been reported to have good and excellent results [4-6].

Loss of reduction (LOR) is reported in 2.9 to 18.2% of cases [5, 7]. Many factors affecting early LOR have been investigated. Factors about fracture itself, like coronal plane obliquity, proximal fractures, comminution, Gartland classification, or surgical technique factors like pin configuration, pin spread ratio (PSR), bicortical fixation have been questioned by many studies [8,9]. Even though, the cast is considered to be more

stable than the splint, there is not enough evidence to choose either a long-arm cast or splint after pediatric supracondylar humerus fracture surgery.

Our study aims to determine whether there is any difference in the LOR between using splint or cast after pediatric supracondylar humerus fracture fixation.

2. PATIENTS and METHODS

After the approval for this study was obtained from Marmara University, School of Medicine Ethics Committee (09.2020.388), we retrospectively evaluated the medical records and radiographs of all children treated surgically for distal humerus fracture at a university hospital between 2012 and 2019.

Children operated for Gartland type II, III, IV fractures were included in the study. The Gartland classification is divided

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into 4 types: I: nondisplaced fracture, II: minimally displaced fracture, III: completely displaced fracture, posterior cortex intact, IV: fully displaced fracture, posterior cortex separated [8]. Patients with intraarticular extension and associating arm fracture on the ipsilateral side were excluded from the study. Patients who underwent early revision surgery due to unacceptable reduction were excluded from the study. Patients who did not have regular follow-up, proper X-rays for radiologic measurements – as positional changes can cause a difference in measuring Baumann angle – or missing data in their files were also excluded from the study.

All preoperative medical records were checked for patient's age, neurologic compromise and ipsilateral upper extremity fracture. Perioperative X-rays were evaluated for fracture type, according to Modified Gartland Classification [8]; and presence of medial or lateral comminution, the existence of more than 20° obliquity on the coronal plane, or proximal fracture to the olecranon fossa as defined in Johns Hopkins Classification [8, 9]. Fractures were not classified as flexion and extension types due to the high number of patients referred from different hospitals with a splint. However, flexion type fractures are proven to be more “difficult” fractures. This data was considered not accurate enough and left out of the statistical analysis [10].

Data about whether a closed or open reduction was performed and which pin configuration was chosen for fixation were collected from the operation files. The mean delay of operation after fracture was also noted. Six different surgeons with similar years of experience in paediatric orthopaedic traumatology performed the operations. The preference for postoperative immobilization with either casting or splinting was chosen according to these surgeons habits. Because of the retrospective nature of our cohort, cast and splint group were not randomized.

Early postoperative X-rays were evaluated for PSR (as a percentage), bicortical fixation, Baumann angle, Anterior humeral line crossing capitellum, and Gordon rotation percentage [4]. PSR for patients with more than two pins was calculated as a percentage of pins' highest distance to the bone diameter at the fracture site.

Third week control X-rays measurements for Baumann angle, anterior humeral line, and Gordon rotation percentage were repeated to determine LOR. Baumann angle and anterior humeral line were measured, but the Gordon rotation percentage was excluded because of the data's inconsistencies due to bone union.

Loss of reduction was taken according to Skaggs criteria. Skaggs criteria is more than 6 degrees change in Baumann angle or a change in the anterior humeral line crossing the capitellum (Figure 1) [11].

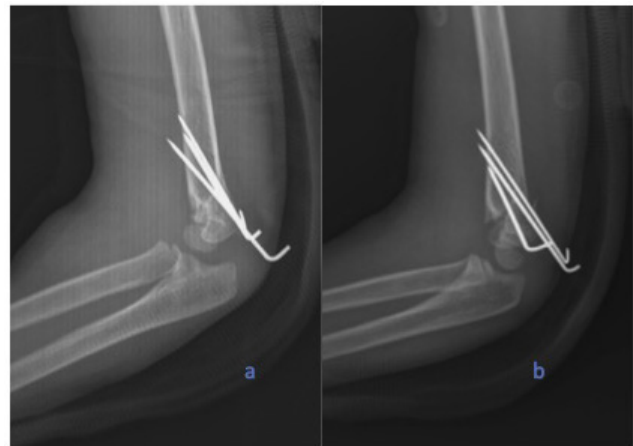


Figure 1-a. Early postoperative lateral X-ray, showing that the anterior humeral line is crossing the capitellum, **1-b.** 3rd-week X-ray of this patient, distal fragment is displaced posteriorly. Although, both X-rays are not taken exactly from the same angles, it is obvious that the anterior humeral line is not crossing the capitellum.

Patient's ages were classified into two groups as younger than five years and older than five years. Pin configuration were classified into 3 groups: lateral configuration (2 lateral pins or 3 lateral pins), medial+ lateral (1 medial pin+ 1 lateral pin) and medial+ multiple lateral (1 medial pin + 2 lateral pins or 1 medial + 3 lateral pins) (Figure 2).



Figure 2. Radiographic images demonstrating pin configuration: (a) Only lateral entry, multiple pinnings; (b) 1 lateral pin and 1 medial pin; (c) 2 lateral pins and 1 medial pin.

Patients with and without LOR within three weeks were compared for postoperative immobilization methods and other risk factors.

Patients with postoperative cast and splint were compared statistically for risk factors (age, Gartland classification, presence of comminution or proximal fracture, ipsilateral upper extremity fracture, neurovascular compromise, time between fracture and operation, pin configuration, PSR at the fracture site, presence of bicortical fixation).

Postoperatively elbows were immobilized on 90 (±5) degrees flexion with standard casting or simple posterior fiberglass splint (Figure 3). Pin site infection, pin removal time, and cast

removal time data were kept out of the analysis because they were not a part of this cohort.

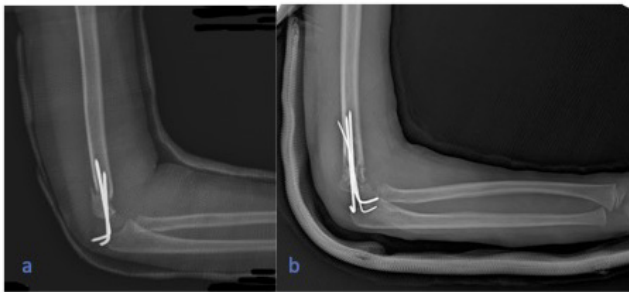


Figure 3-a/b. Two examples for standard long-arm cast and splint made at 90 degrees of elbow flexion.



Fig 4-a/b/c/d. Example for splint loosening at two different patients during 3 weeks follow-up period.

Statistical Analysis

The data analysis was carried out using the Statistical Package for Social Sciences (SPSS v. 22.0 software, Chicago, USA). The study data were evaluated using descriptive statistical methods (mean, standard deviation, median, interquartile range, frequency, ratio, minimum, maximum). The Kolmogorov-Smirnov test was used to test the normality of distribution of the quantitative data. The Mann-Whitney U test was used to compare the non-normally distributed quantitative variables. Pearson's Chi-square test, Fisher's Exact test and Fisher-Freeman-Halton test for an agreement were used in order to compare the qualitative variables. A p-value <0.05 was considered statistically significant.

3. RESULTS

Complete medical records and true anteroposterior radiographs of the distal part of the humerus and lateral radiographs of the elbow made perioperatively and at the time of fracture-healing were available for 232 patients who were treated for surgically displaced Gartland type II, III, IV fractures at the institution.

The mean age of patients was 5.59 ± 2.45 . On the initial evaluation, there were 30 patients with comminution on either of the cortices, 20 patients with coronal obliquity on the fracture line, and 16 patients with proximal fracture. According to modified Gartland supracondylar humerus fracture classification, the number of patients with Type II, III and IV fractures was 59, 144, and 29, respectively. Eight patients had ipsilateral distal radius fractures.

The mean delay of operation after fracture was 0.91 days, while most patients were operated on the same or the next day after admission. The most prolonged delay was four days for two patients because of associated medical conditions.

During surgical intervention 33 patients required open reduction, bicortical bone fixation were achieved on all except 8 patients. Pin configurations were; 2 lateral pins 26 (11.2%), 3 lateral pins 11 (4.7%), 1 medial pin + 1 lateral pin 64 (27.6%), 1 medial + 2 lateral pins 119 (51.3%), 1 medial + 3 lateral 4 (1.7%), 2 medial + 2 lateral 8 (3.4%). To make a better statistical subgroup analysis, we combined groups as isolated lateral pin configuration 37 (15.9%), medial + 1 lateral pin configuration 64 (27.6%); medial + multiple lateral pin configuration 131 (56.5%). Mean Perceived State Rating: (PSR) was 37 (28-48%).

After surgical intervention, 132 patients were immobilized with a long-arm cast, while 100 patients had a long-arm splint for immobilization.

At the third week follow-up, a total of 17 patients had LOR according to Skaggs criteria (Figure 1). There was no surgical revision after the third week. Eight patients had postoperative ulnar nerve palsy.

Splint and cast immobilization groups were homogenous for other factors except for open or closed surgery. Patients with open reduction and fixation were immobilized mostly with a splint ($p < 0.001$). Patients with postoperative splint immobilization had a higher value for median PSR, which was not significant ($p = 0.053$) (Table I).

All parameters were compared between patients with and without LOR. The only statistically significant parameter was the choice of postoperative immobilization. Patients with splint immobilization tend to have more LOR rate compared to cast immobilization group ($p = 0.017$). Patients requiring open reduction had a remarkably higher LOR rate than patients with closed reduction, but this difference was not significant statistically ($p = 0.075$) (Table II).

Table I. Statistical analysis of risk factors between patients who had cast or splint for immobilization.

Parameter		Cast	Splint	p
LOR	+	5	12	0.017 ^a
	-	127	88	
Age (years)	<5	69	48	0.519 ^a
	>5	63	52	
Surgery	open	8	25	<0.001 ^a
	closed	124	75	
Pin configuration	Only lateral	23	14	0.223 ^c
	1 medial, 1 lateral	41	23	
	1 medial, multiple lateral	68	63	
Bicortical pin fixation	+	126	98	0.471 ^b
	-	6	2	
Ipsilateral fracture	+	129	95	0.295 ^b
	-	3	5	
Preoperative nerve damage	+	8	6	0.985 ^a
	-	124	94	
Modified Gartland Classification	2	36	23	0.701 ^c
	3	81	63	
	4	15	14	
Proximal fracture	+	6	10	0.104 ^a
	-	126	90	
Coronal obliquity	+	9	11	0.261 ^a
	-	123	88	
Comminution	+	18	12	0.713 ^a
	-	114	88	
Pin spread ratio Median (IQR)		0.40(0.30-0.49)	0.35(0.24-0.47)	0.052 ^d

^a Pearson's chi square test, ^b Fisher's exact test, ^c Fisher Freeman Halton Test, ^d Mann-Whitney U Test, IQR: Interquartile range

Table II. Statistical analysis of risk factors between patients with or without LOR.

		LOR-	LOR+	p value
Age	<5 years	110	7	0.428 ^a
	>5 years	105	10	
Comminution	-	188	14	0.468 ^b
	+	27	3	
Proximal fracture	-	200	16	1.000 ^b
	+	15	1	
Coronal obliquity	-	196	16	1.000 ^b
	+	19	1	
Modified Gartland Classification	2	57	2	0.260 ^d
	3	130	14	
	4	28	1	
Preoperative nerve damage	-	202	16	1.000 ^b
	+	13	1	
Ipsilateral fracture	-	208	16	0.461 ^b
	+	7	1	
Bicortical pin fixation	-	8	0	1.000 ^b
	+	207	17	
Pin configuration	Only lateral	35	2	0.412 ^d
	1 medial, 1 lateral	57	7	
	1 medial, multiple lateral	123	8	
Surgery	Closed	187	12	0.075 ^a
	Open	28	5	
Pin Spread Ratio Median (IQR)		0.43(0.23-0.54)	0.37(0.28-0.48)	0.352 ^c

^a Pearson's chi square test, ^b Fisher's exact test, ^c Mann-Whitney U Test, ^d Fisher Freeman Halton Test, IQR: Interquartile range

4. DISCUSSION

There are various techniques that describe immobilization after surgically treated supracondylar humerus fractures. The two most commonly used fixation methods are a simple posterior splint or a circular long-arm cast. Our results suggest that overall, long-arm cast is superior in protecting reduction than simple long-arm splint in the first three weeks postoperatively. The difference between both groups is probably due to subtle motion and loosening of the cotton and bandage with time (Figure 4).

Surgery is accepted as the most successful treatment method for displaced pediatric supracondylar humerus fractures, but differences between immobilization methods after surgery are not studied. Many studies mention circular casting or bivalved circular casting as postoperative immobilization method. Maintaining elbow flexion under 90° is suggested to decrease compartment syndrome risk [12]. Numerous studies defined LOR's risk factors for supracondylar humerus fractures in children, but none of them took the postoperative immobilization method as a parameter [11].

Mulpuri and Wilkins investigated 44 papers in their review article in 2012, where casting was mentioned as the sole immobilization method without comparing with other methods [13]. Baratz, et al., used splinting with the elbow flexed at 60°, whereas Kim and Sponseller did not mention postoperative immobilization at all [14, 15]. McKeon et al., used an A-frame cast for postoperative immobilization to leave the antecubital fossa free of casting material and stated that this technique provided enough stability without the risk of compartment syndrome [16]. Azzolin, et al., used a posterior plaster splint and a simple sling worn for 4 weeks, and also stated this as a simple and effective method for postoperative immobilization [17]. However, they did not compare their methods with another immobilization method. All studies mentioned above were Level IV studies (a report of multiple patients with the same treatment, but no control group or comparison group), while our retrospective cohort study is Level III (a study in which patient groups are separated non-randomly by exposure or treatment, with exposure occurring before the initiation of the study).

The overall LOR rate in this study was 7.3%. Various values for LOR were reported; like Balasubramanian 18.2%, Reisoglu, et al., 13.6%, Pennock, et al., 4.2% [4, 7, 18]. Although, our LOR rate correlated with other studies, many different criteria were taken into account in different studies. It would not be appropriate to compare all of them in this aspect. As for LOR, we used Skaggs criteria, which took a change in Baumann angle for more than 6 degrees and deviation of the intersection of the anterior humeral line with the capitellum taken into account [19]. We also excluded seven patients who required early revision (in the first three days) postoperatively due to LOR caused by K-wires' misplacement or another poor perioperative technique. As a result, we were able to provide homogeneity between splinting and casting groups. Thus, there was a slight decrease in overall LOR but still correlated with previously published results [4,7,18].

Seventeen patients were assumed to have radiologic LOR at the third-week follow-up but did not undergo any revision procedure. As the study was designed in a retrospective manner, we did not call back the patients and perform a functional scoring. The only clue about the patients' functional level was obtained from patient files and families whether or not they stated any complaints, but we do not think this data to be enough to make inferences. Our results indicated that postoperative circular cast was only more protective against LOR radiologically. We could not make any implication for the mid-and long-term functional results, a fact which could only be evaluated by performing a long-term cohort study.

The only existing parameter between using either a circular long-arm cast or a simple splint was whether an open or closed surgical method was chosen. We accepted this as a natural phenomenon due to the need for dressing change and edema observation after an open surgery where immobilization with a rigid circular cast was avoided.

Although, there was no statistically significant difference between the open and closed surgery methods in terms of LOR, the difference was still remarkable. This was an expected event as the open surgery applied cases were much more complicated. Despite this difference, the splint and circular cast applied groups were assumed to be homogenous.

We did not perform any revision surgery for patients who sustained LOR at the third-week follow-up. This data supported studies questioning follow-up radiographic examinations published by Zusman, et al., Thompson, et al., and Tuomilehto, et al. [20-22].

The mean PSR of patients with postoperative splint was remarkably higher than the mean PSR of patients with a cast, but this difference was not statistically significant. As the group with higher PSR had less LOR, this result was supporting the study published by Aarons, et al., who failed to identify an optimal amount of PSR to prevent LOR [23].

Retrospective nature is a limitation of the study which we try to overcome, with homogenous groups for splint and cast. Another limitation is that we did not have accurate data for flexion-type injuries. We also did not calculate power of our retrospective study. It was observed that the choice for postoperative immobilization was absolutely surgeon dependent as the education of these surgeons were pointing out different training centers, so they all used their personal habits. We accept that as a limitation of our study.

Our results only indicated that circular casting was much more protective against LOR. However, we do not have any objective data referring these results clinical convenience. Further long-term follow-up results are required that should mainly focus on whether these reduction losses cause any restriction of joint motion or result in cubitus varus deformity.

Compliance with Ethical Standards

Ethical Approval: Ethical approval for this study was obtained from the Ethics Committee of Marmara University, School of Medicine. (Approval number: 09.2020.388).

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