


# Serial Post-Operative Radiographs in Surgically Managed Pediatric Supracondylar Humeral Fractures: Are They Always Required?

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**Objective:** Supracondylar humeral fractures are among the most common pediatric fractures that require surgical intervention when displaced. Recent attention has been directed towards the utilization of serial radiographs in the post-operative period and their effect on decision-making. This study aimed to determine the usefulness of postoperative radiographs early post-operatively, with the goal of determining the optimal frequency for these radiographs.

**Methods:** Pediatric patients who sustained a supracondylar humeral fracture and underwent operative intervention over a 15-year period were included in this study. Data were collected, including the baseline characteristics of the patients, fractures, and operative interventions. In addition, the time until healing, the total number of X-rays before K-wire removal, and postoperative function were evaluated.

**Results:** A total of 122 pediatric patients were included, with a mean age of  $5.33 \pm 2.93$  years. Most fractures were Gartland Type III (74.6%). Most fractures healed at 4 (36.1%) and 3 weeks (35.2%) after surgery. Of the cohort, 94.3% underwent four different x-rays before wire removal, with 4.9% requiring revision surgery. All revision cases were Gartland type 3, and for all cases, the decision to revise was made within three weeks of surgery.

**Conclusion:** Routine post-fixation radiography should not be performed for surgically treated supracondylar humeral fractures before healing. An exception is the Gartland type 3 fracture, for which earlier imaging may be indicated.

**Keywords:** supracondylar, pediatric humerus, closed reduction, fixation, post-operative x-ray

## Introduction

Supracondylar humeral fractures are the most common fractures of the distal humerus and the second most common pediatric fractures, accounting for 15% of pediatric fractures.<sup>1-3</sup> Children aged between 5 and 7 years are most likely to sustain such injuries.<sup>4,5</sup> Closed reduction and percutaneous pinning are considered standard treatments for displaced fractures, whereas splinting is the mainstay management for non-displaced fractures.<sup>6,7</sup>

Serial radiographs are obtained in the postoperative period to evaluate the alignment, remodeling, and healing aspects of the fracture. In addition to detecting loss of reduction, where revision may be required. However, these practices are highly dependent on the personal experience of the surgeon as there are no formal guidelines to determine the number of visits and radiographs required for follow-up.<sup>8-14</sup>

Recent studies have explored the usefulness of routine serial radiographs between the postoperative period and the time of pin removal in pediatric supracondylar fractures. Most results have shown that serial radiographs during this period are unlikely to impact patients' postoperative course and are infrequently associated with changes in management.<sup>8-14</sup>

This study aimed to determine the usefulness of postoperative radiographs early post-operatively, with the goal of determining the optimal frequency for these radiographs in patients with pediatric supracondylar humeral fractures.

Methods

This single-center retrospective study was conducted at a level one trauma center. This study was approved by the Institutional Review Board in Imam Abdulrahman Bin Faisal University (IRB-UGS-2019-01-333). All patients aged up to 14 years who presented between 2005 and 2020 with a supracondylar humeral fracture requiring operative intervention and immobilized post-operatively in an above-elbow backslab until K-wire removal were included. Patients who were lost to follow-up (follow-up <1 year) and/or had inadequate radiographic follow-up (antero-posterior and lateral views of the elbow intra-operative, post-operative, and at the time of pin removal) were excluded. At our institute, patients are assessed 2 weeks post-fixation and then weekly until K-wire removal.

Data were collected, including the baseline characteristics of the patients, type of fracture (Gartland classification<sup>15</sup>), mechanism of injury, associated injuries, K-wire arrangement, procedure type, and complications. In addition, the time until healing (confirmed by at least three cortices healed on antero-posterior and lateral radiographs by an independent trained observer), follow-up range of motion, number of X-rays until the time of K-wire removal, and revision rate were also gathered.

Surgical fixation was performed with the patients in supine position and under general anaesthesia. After weight-appropriate prophylactic antibiotics were administered, the extremity was prepped and draped in standard fashion. A trial of closed reduction was performed and if adequate percutaneous fixation was performed. An open reduction was performed if the closed reduction was unsuccessful.

Data were collected, and descriptive statistics were analyzed using SPSS version 26 (IBM Corp, Armonk, NY, USA). Frequencies and percentages were used to describe categorical variables, while mean and standard deviations were used to describe continuous variables. Analysis was performed using the Chi-square test, Fisher’s test and ANOVA were applicable, with a p-value of less than 0.05 considered to be significant.

Results

A total of 155 patients were reviewed, 33 of whom were excluded because of inadequate follow-up or radiographs. This retrospective study analyzed 122 pediatric patients who required surgical fixation for supracondylar fractures. The mean age of the patients was 5.33 ± 2.93 years with 54.9% younger than 5 years old (Table 1). The majority of the cohort was male (67.2%), and more than half of the injuries were sustained on the left side (63.9%) (Table 1).

Table 1 Baseline Characteristics of the 122 Included Patients

Study variables	N (%)
Age in years (mean ± SD)	5.33 ± 2.93
• 1–5 years	67 (54.9%)
• 6–14 years	55 (45.1%)
Gender	
• Male	82 (67.2%)
• Female	40 (32.8%)
Site	
• Left	78 (63.9%)
• Right	44 (36.1%)

(Continued)

**Table 1** (Continued).

Study variables	N (%)
Gartland	
• Type II	31 (25.4%)
• Type III	91 (74.6%)
Type of supracondylar fracture	
• Extension	114 (93.4%)
• Flexion	8 (6.6%)
Procedure	
• Closed reduction	98 (80.3%)
• Open reduction	24 (19.7%)
K-wire arrangement	
• Two lateral divergent	55 (45.1%)
• Medial and lateral	34 (27.9%)
• Two lateral and one medial	27 (22.1%)
• Others	6 (4.9%)

Most fractures were Gartland type III (74.6%), 25.4% were type II, and none were type IV fractures. Closed reduction (80.3%) was the most frequently performed procedure, whereas open reduction was only utilized in 19.7% of cases if closed reduction failed. The most commonly used K-wire arrangement was two lateral divergent (45.1%) (Table 1). A significant association between Gartland classification and K-wire arrangement ( $p = 0.009$ ) was found, as the application of a medial column K-wire was more common in Gartland 3 than in Gartland 2 classification (Table 2).

**Table 2** Relationship Between the Gartland's Classification and the Baseline Characteristics of the Patients (n=122)

Factor	Gartland Classification		P-value <sup>§</sup>
	Type II N (%) (n=31)	Type III N (%) (n=91)	
Age group			
• 1–5 years	19 (61.3%)	48 (52.7%)	0.409
• 6–14 years	12 (38.7%)	43 (47.3%)	
Gender			
• Male	18 (58.1%)	64 (70.3%)	0.209
• Female	13 (41.9%)	27 (29.7%)	
Site			
• Right	8 (25.8%)	36 (39.6%)	0.168
• Left	23 (74.2%)	55 (60.4%)	

(Continued)

**Table 2** (Continued).

Factor	Gartland Classification		P-value <sup>§</sup>
	Type II N (%) (n=31)	Type III N (%) (n=91)	
Type of supracondylar fracture			
• Flexion	2 (6.5%)	6 (6.6%)	0.978
• Extension	29 (93.5%)	85 (93.4%)	
Procedure			
• Open reduction	3 (9.7%)	21 (23.1%)	0.105
• Closed reduction	28 (90.3%)	70 (76.9%)	
K-wire arrangement			
• Two lateral divergent	21 (67.7%)	34 (37.4%)	0.009 **
• Media and lateral	8 (25.8%)	26 (28.6%)	
• Two lateral and one medial	2 (06.5%)	25 (27.5%)	
• Others	0	6 (6.6%)	

**Notes:** <sup>§</sup>P-value calculated using Fisher's exact test. \*\*Significant at p<0.05 level.

The majority of fractures healed at 4 (36.1%) and 3 weeks (35.2%) after surgery (confirmed by at least three cortices healed on radiographs). Five patients did not completely heal by 6 weeks post-operatively (<3 cortices); the K-wires were removed, and patients were started on range of motion, and weight bearing was protected until complete healing. All patients healed three months post-fixation. The proportion of patients who developed complication was 15.6%. These included 10 cases of angular deformity (52.6%), four cases of fracture displacement (21.1%), two cases of K-wire displacement (10.5%), and three cases of post-operative anterior interosseous nerve palsy (15.8%) (Table 3).

**Table 3** Postoperative Characteristics of the Patients (n = 122)

Study Variables	N (%)
Time till healing from date of surgery	
• 3 weeks	43 (35.2%)
• 4 weeks	44 (36.1%)
• 5 weeks	14 (11.5%)
• 6 weeks	16 (13.1%)
• No healing	5 (4.1%)
Follow up Range of Motion	
• Full	63 (51.6%)
• Partial	59 (48.4%)

(Continued)

**Table 3** (Continued).

Study Variables	N (%)
Complication	
• Yes	19 (15.6%)
• No	103 (84.4%)
Number of x-rays till removal of wire	
• Two	4 (3.3%)
• Three	3 (2.5%)
• Four	115 (94.3%)
1–2 weeks post-op x-ray	
• Yes	118 (96.7%)
• No	4 (3.3%)
3–4 weeks post-op x-ray	
• Yes	115 (94.3%)
• No	7 (5.7%)
Revision	
• Yes	6 (4.9%)
• No	116 (95.1%)

Nearly all patients (94.3%) underwent four x-ray sessions before K-wire removal, whereas 4.9% required revision (Table 3). All 6 revisions were performed within 3 weeks of surgical fixation and were classified as Gartland type 3. The cause of revision was fracture displacement after fixation in four cases and K-wire displacement (backing out) in two cases, all of which were identified within 3 weeks of fixation by radiographic assessment. Cases of K-wire displacement were managed by the removal and insertion of a new K-wire, whereas cases of fracture displacement were revised by revision reduction and fixation. There was a significant association between the Gartland classification and the number of X-rays until K-wire removal ( $p = 0.043$ ) (Table 4).

**Table 4** Relationship Between Gartland's Classification and the Postoperative Characteristics of the Patients (n = 122)

Factor	Gartland Classification		P-value <sup>§</sup>
	Type II N (%) (n=31)	Type III N (%) (n=91)	
Time till healing from date of surgery			
• 3 weeks	10 (32.3%)	33 (36.3%)	0.315
• 4 weeks	15 (48.4%)	29 (31.9%)	
• 5 weeks	2 (6.5%)	12 (13.2%)	
• 6 weeks	2 (6.5%)	14 (15.4%)	
• No healing	2 (6.5%)	3 (3.3%)	

(Continued)

**Table 4** (Continued).

Factor	Gartland Classification		P-value <sup>§</sup>
	Type II N (%) (n=31)	Type III N (%) (n=91)	
Follow up Range of Motion			
• Full	12 (38.7%)	51 (56%)	0.095
• Partial	19 (61.3%)	40 (44%)	
Complication			
• Yes	2 (6.5%)	17 (18.7%)	0.105
• No	29 (93.5%)	74 (81.3%)	
Number of x-rays till removal of wire			
• Two	3 (9.7%)	1 (1.1%)	0.043**
• Three	0	3 (3.3%)	
• Four	28 (90.3%)	87 (95.6%)	
1–2 weeks postop x-ray			
• Yes	28 (90.3%)	90 (98.9%)	0.021**
• No	3 (9.7%)	1 (1.1%)	
3–4 weeks postop x-ray			
• Yes	28 (90.3%)	87 (95.6%)	0.275
• No	3 (9.7%)	4 (4.4%)	
Revised			
• Yes	0	6 (4.8%)	0.143
• No	31 (100%)	85 (95.2%)	

Notes: <sup>§</sup>P-value calculated using Fisher's exact test. \*\*Significant at p<0.05 level.

## Discussion

This study aimed to investigate whether postoperative radiographic assessment would result in a change in the initial surgical management of pediatric supracondylar humeral fractures.

A total of 122 pediatric patients were included in the study, with a mean age of  $5.39 \pm 2.95$  years. In our study, the revision rate was 4.9%, which is higher than that reported in the literature (approximately 2%), possibly because of the exclusion of patients who were lost to follow-up.<sup>8–14,16</sup>

In our cohort, the decision for revision was made within three weeks post-fixation in all cases, all of which were Gartland type 3. Karalius et al retrospectively examined 572 pediatric patients who sustained displaced supracondylar humeral fractures (extension type only) in which closed reduction and percutaneous pinning were performed. The frequency of change in management with immediate postoperative imaging was observed in only 9 of the 572 cases. They recommended radiographic assessment–7–10 days postoperatively to be performed in Gartland's III only and repeated only if clinically indicated.<sup>8</sup>

Karamitopoulos et al retrospectively reviewed pediatric patients with Gartland II and III supracondylar humeral fractures who were surgically managed. They included 643 patients in whom only 5% experienced fracture translation

and/or pin backout at the first follow-up visit postoperatively, all of which were Gartland type III fractures, and only one case required further surgical management. They also found that mild changes in alignment or pin backout seen postoperatively did not significantly alter the management plan.<sup>10</sup>

Garg et al reviewed all Gartland type II cases that underwent closed reduction and percutaneous pinning and found no revisions or complications in their study.<sup>12</sup> Most of the recent articles in the literature have agreed that the effect of pin fixation quality on the revision rate in patients with supracondylar humeral fractures was insignificant and would rarely impact the management plan. Thus, early and delayed postoperative imaging showing a change in the configuration of the pins inserted, is not an indicator of the need for revision.<sup>10–13</sup>

As supracondylar humeral fracture is very common in pediatric patients, overutilization of radiographs has been shown to have insignificant benefits on patient outcomes and is not considered cost-effective.<sup>10–14</sup> In addition, radiation risk to the patient from X-rays increases the burden on the family from multiple unnecessary clinic visits. Schlechter et al stated that postoperative radiography before or after pin removal is unnecessary and does not affect the management plan.<sup>11</sup> Other authors recommend that if clinically indicated, radiographs should be obtained only after pin removal to decrease the level of anxiety and fear.<sup>11–13</sup> We believe that obtaining a radiograph before pin removal is only required in Gartland type 3 fractures within the first 3 weeks of surgery, as in our cohort. All revised cases were type 3 fractures, and the decision to revise was made within 3 weeks of surgery.

Our study has several limitations. As this was a retrospective study, data was collection depended on the assessment of radiographs, operative notes, clinical notes, and discharge summaries, and the number of patients included in our cohort was low compared to previously published and referenced literature. In addition, some patients did not continue to be followed-up at our institute and were excluded from the study. Another limitation is that the decision to revise was based on surgeon preference.

## Conclusion

For surgically treated supracondylar humeral fractures, it is not necessary to perform weekly post-fixation radiography before healing. These patients should be imaged after 3–4 weeks for pin removal and fracture healing. A single 2-week post-operative radiograph may be indicated in Gartland type 3 fractures to assess for fracture or K-wire displacement.

## Patient Participation and Consent

This study was approved by the Institutional Review Board in Imam Abdulrahman Bin Faisal University (IRB-UGS -2019-01-333). All data included in this study were collected according to a comprehensive agreement for the academic use of information from patients by the hospital at the time of their hospitalization (informed consent provided by the parent or legal guardian), and no identifiable information about the participants was included in the manuscript. The study complies with the Declaration of Helsinki.

## Data Sharing Statement

Raw data and material are available as needed from the corresponding author.

## Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

## Disclosure

The authors report no conflicts of interest in this work.

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