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Research Article

Does Emergency Department Closed Reduction Reduce the Need for Surgery in Children Under Four with Supracondylar Humerus Fractures? A Retrospective Study

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Abstract

Objectives: To determine whether emergency department closed reduction reduces the need for surgical intervention in children under four years of age with supracondylar humerus fractures.

Methods: This retrospective study included children aged 0–4 years treated for supracondylar humerus fractures between January 2019 and December 2024. Demographic characteristics, Gartland classification, performance and quality of closed reduction, loss of reduction during follow-up, and surgical intervention were recorded. Reduction quality was categorized as anatomic, acceptable, or unacceptable based on predefined radiographic criteria. Multivariable logistic regression analysis was performed to identify independent predictors of surgical intervention.

Results: Thirty-four patients (mean age 2.8±1.1 years) were included. Closed reduction was performed in 15 patients (44.1%) without sedation. Anatomic or acceptable reduction was achieved only in Gartland Type I–II fractures, whereas unacceptable reduction occurred exclusively in Type III fractures. Overall, 16 patients (47.1%) required surgery. Surgical rates increased with poorer reduction quality and higher Gartland classification. Gartland classification and reduction quality were identified as independent predictors of surgical intervention.

Conclusion: Emergency department closed reduction without sedation may reduce the need for surgery in selected children under four years of age, particularly in Gartland Type I and II supracondylar humerus fractures.

Keywords: Closed reduction, Gartland classification, Pediatric elbow fracture, Supracondylar humerus fracture

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Supracondylar humerus fractures are the most common elbow traumas in childhood and account for approximately 50–60% of all pediatric elbow fractures.[1] These injuries usually occur after a fall, and due to the anatomical characteristics of the supracondylar region, the relative weakness of the epiphyseal plate, and metaphyseal narrowing, they tend to demonstrate instability.[2,3] The treatment approach is determined according to factors such as the degree of fracture displacement, radiological features, neurovascular status, and the age of the patient.

The Gartland classification is the most commonly used system for the evaluation of pediatric supracondylar humerus fractures. While Type I fractures are considered stable and treated conservatively, in Type II fractures, posterior cortical

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integrity and angulation determine the treatment decision.[4] Type III fractures are completely displaced and biomechanically unstable and usually require surgical treatment; surgical rates in this group have been reported to range between 85% and 100%.[5–7]

In recent years, interest has increased regarding which patient groups can be safely treated conservatively. Evspecially in younger children, the thickness of the periosteum, high bone elasticity, and pronounced remodeling capacity suggest that stability can be preserved after closed reduction.[8, 9] It has been reported that these biological advantages contribute to easier application of reduction maneuvers and allow fracture fragments to be restored to an anatomical position.[10]

However, there is no consensus in the literature as to whether closed reduction procedures performed in the emergency department—most often without sedation—reduce the need for surgical intervention. While some studies have reported successful outcomes with conservative treatment in Gartland Type II fractures in which anatomical alignment was achieved,[11] others argue that the risk of post-reduction displacement is high and that surgery is a more reliable option.[12, 13] Studies evaluating the effectiveness of emergency department closed reduction and its contribution to the treatment process in children under four years of age are particularly limited.

In this study, it was hypothesized that closed reduction performed in the emergency department would reduce the need for surgical intervention in selected children under four years of age. By analyzing the relationship between reduction quality, Gartland classification, and surgical requirement, it was investigated in which patient groups closed reduction has the potential to reduce the need for surgery.

Methods

Study Design and Ethical Approval

This retrospective descriptive study was approved by Kutahya Health Sciences University Non-Interventional Ethics Committee (Approval No: 2025/01 / Date: 17.01.2025) and was conducted in accordance with the Declaration of Helsinki.

Patient Selection

Patients aged 0–4 years who presented to the emergency department with supracondylar humerus fractures between January 2019 and December 2024 were retrospectively reviewed. Inclusion criteria were defined as: (1) age under four years, (2) presence of a traumatic supracondylar humerus fracture, (3) availability of anteroposterior and lateral elbow radiographs at presentation, and (4) at least six weeks of clinical and radiological follow-up.

Exclusion criteria included isolated medial or lateral epicondyle fractures, associated ipsilateral upper extremity fractures, pathological fractures, as well as incomplete medical records or inadequate follow-up radiographs.

Data Collection

By reviewing electronic patient records and radiographic archives, demographic data (age, sex, side), mechanism of trauma, Gartland classification on initial radiographs, whether closed reduction was performed in the emergency department, reduction quality, need for surgical intervention, loss of reduction during follow-up (weeks 1, 3, and 6), pin configuration (in surgically treated patients) and complications (loss of reduction, malunion, avascular necrosis) were recorded.

Radiological Evaluation

Radiographic evaluation was performed according to predefined acceptability criteria. Sagittal and coronal angulation ≤10°, translation ≤2–3 mm, deviation of the Baumann angle ≤5° from normal, preservation of the anterior humeral line–capitellum relationship, and absence of rotational deformity were considered acceptable. Rotational deformity was evaluated using the method defined by Henderson et al.[14] (Fig. 1). Rotational malalignment was considered an absolute indication for surgical treatment (Table 1).

Indications for Closed Reduction

Closed reduction in the emergency department was not applied as a standard protocol to all patients. The decision to perform reduction was made by the responsible pediatric

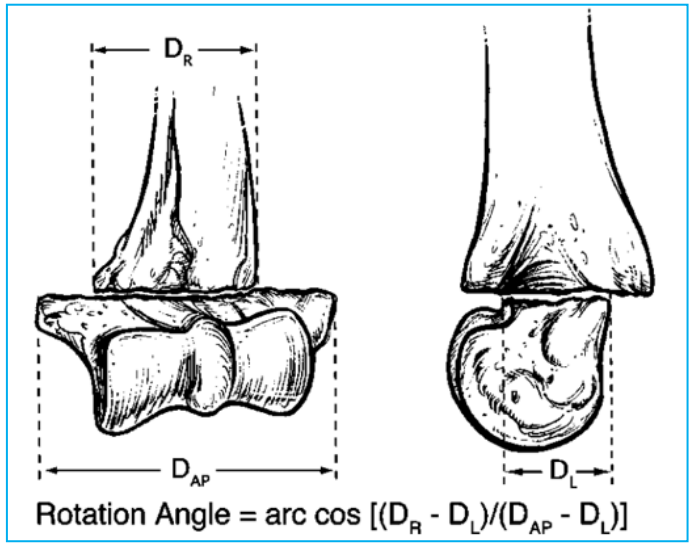

Figure 1. Radiographic method for measuring rotational alignment as defined by Henderson ER et al.

Table 1. Clinical and radiological treatment algorithm for supracondylar fractures in the pediatric population

Radiological Parameter	Acceptable Limit	Clinical Note
Sagittal angulation (extension/flexion)	≤ 10°	Remodeling capacity is particularly high in children under 4 years of age
Coronal angulation (varus/valgus)	≤ 10°	Varus >10° → increased risk of cubitus varus
Translation	≤ 2–3 mm	
Baumann angle	Deviation ≤ 5° from normal	Most critical parameter
AHL–capitellum relationship	Anterior humeral line must intersect the capitellum	
Rotation	0° tolerance	Absolute indication for surgery

orthopedic surgeon by considering factors such as fracture displacement pattern, clinical instability, patient cooperation and pain tolerance, and parental consent. Severely displaced Gartland Type III fractures with marked posterior cortical loss, patients with pain levels that did not allow manipulation, or fractures in which the need for surgery was clearly evident on initial radiographs were treated surgically without attempting reduction. This approach was adopted to reflect real-life emergency department practice rather than a randomized intervention. The radiological and clinical course of a case with a Gartland Type III supracondylar humerus fracture that was suitable for reduction is shown in Figure 2.

Reduction Technique and Treatment Algorithm

Closed reduction was performed without sedation by a physician experienced in pediatric orthopedics, using gentle longitudinal traction followed by flexion and pronation maneuvers in order to benefit from posterior periosteal support. Reduction quality was classified as anatomic, minimal displacement (acceptable), or unacceptable based on post-reduction radiographs.

Patients in whom anatomic or acceptable alignment was achieved were followed conservatively with immobilization and close radiological follow-up. Patients with unacceptable alignment or those who developed secondary loss of reduction during follow-up were treated surgically with closed reduction and percutaneous pinning or, when necessary, open reduction.

Statistical Analysis

Statistical analyses were performed using SPSS version 25.0 (IBM Corp., Armonk, NY, USA). Continuous variables were presented as mean±standard deviation, and categorical variables as number and percentage. Due to the limited sample size, univariate comparative analyses were not performed. Multivariable logistic regression analysis was applied to identify independent factors predicting the need for surgical intervention. Gartland classification, reduction quality, age, sex, mechanism of trauma, and severity of displacement were included in the model. Results were reported as odds ratios (OR) and 95% confidence intervals (CI); a p value <0.05 was considered statistically significant.

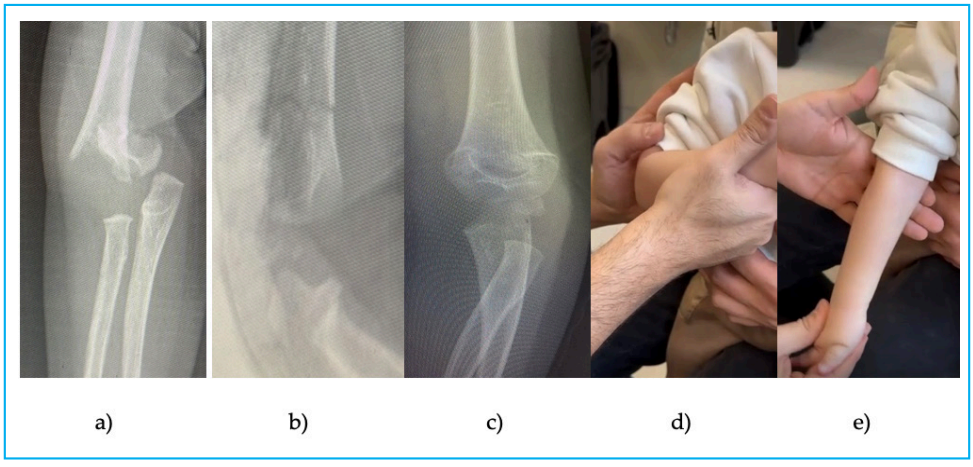

Figure 2. Radiographic and clinical follow-up of a Gartland Type III supracondylar humerus fracture.
(a) Oblique radiograph at presentation to the emergency department, **(b)** Post-reduction oblique radiograph showing anatomic alignment of the fracture fragments, **(c)** Anteroposterior radiograph after fracture union, **(d)** No limitation of supination or pronation in full flexion, **(e)** No limitation of supination or pronation in full extension; no elbow deformity observed.

Table 2. Evaluation of reduction quality according to Gartland classification after reduction in supracondylar fractures

Alignment Code	Definition	n	%	Gartland Type I	Gartland Type II	Gartland Type III
1	Anatomic alignment	19	73.1	12	6	1
2	Minimal displacement (acceptable)	3	11.5	0	3	0
3	Unacceptable alignment	4	15.4	0	0	4

Table 3. Patients with loss of reduction during conservative follow-up (One patient underwent open surgery and pinning due to loss of reduction at Week 1.)

Time Point	Detected Loss of Reduction (n)	Total Patients (n)	Displacement Rate (%)
Week 1	2	19	10.5
Week 3	2	18	11.1
Week 6	0	18	0

Results

Patient Characteristics

A total of 34 patients were included in the study. The mean age of the patients was 2.8±1.1 years, and all were under four years of age. Fifty-nine percent of the patients were female (n=20) and 41% were male (n=14). Sixty-two percent of the fractures involved the left side.

According to the Gartland classification, fracture distribution was as follows: Type I 35.3% (n=12), Type II 32.3% (n=11), and Type III 32.3% (n=11). The rate of closed reduction in the emergency department was 44.1% (n=15), and the procedure was performed without sedation in all reduced patients.

Reduction Quality

In patients who underwent closed reduction, reduction quality was evaluated based on post-reduction radiographs. The distribution of reduction outcomes according to Gartland classification is presented in Table 2.

- Anatomic alignment: 73.1% (n=19)
- Minimal displacement (acceptable): 11.5% (n=3)
- Unacceptable alignment: 15.4% (n=4)

All cases with anatomic or acceptable reduction consisted of Gartland Type I–II fractures, whereas all cases with unacceptable alignment were Gartland Type III fractures. In one Gartland Type II fracture, despite achieving anatomic alignment initially, loss of reduction occurred at the 1-week follow-up, and surgical treatment was initiated.

Loss of Reduction During Conservative Follow-up

Among 18 conservatively followed patients, loss of reduction rates were evaluated according to follow-up weeks. Loss of reduction was detected at a rate of 10.5% (2/19) at the first week and 11.1% (2/18) at the third week, while no new displacement was observed at the sixth week. One of these patients underwent surgical treatment due to significant loss of reduction at the first week (Table 3).

At the eighth-week evaluations, mild rotational deformity was observed radiologically in two patients (n=1 rotational deformity, n=1 with a 5° extension deformity).

Surgically Treated Patients

A total of 16 patients (47.1%) were treated surgically. Fourteen of these patients underwent closed reduction and percutaneous pinning, and two underwent open reduction and pinning. No revision surgery was required in surgically treated patients, and unacceptable reduction was not observed (Table 4).

In the surgical group, loss of reduction was detected at rates of 12.5% at the first week and 25% at the third week, while no new displacement was observed at the sixth week. Avascular necrosis developed in one patient who underwent open reduction. No statistically significant relationship was found between pin configuration and loss of reduction or complications.

Reduction Quality and Surgical Requirement

A clear relationship was identified between reduction quality and the need for surgical intervention:

Table 4. Weekly rates of loss of reduction in 16 surgically treated patients

Time Point	Number of Displacements (n)	Total Patients (n)	Displacement Rate (%)
Week 1	2	16	12.5
Week 3	4	16	25
Week 6	0	16	0

Table 5. Logistic regression analysis

Variable	β (Coefficient)	OR (Odds Ratio)	95% CI	p-value
Gartland type	+4.11	61.0	1.28–289.7	0.037*
Reduction quality	+2.69	14.7	1.09–102.3	0.042*

Table 6. Pin configurations used during surgical treatment

Pin Configuration	n
2 Lateral + 1 Medial	10
3 Lateral	1
3 Lateral + 1 Medial	1
2 Lateral	1
1 Lateral + 1 Medial	2
2 Medial + 2 Lateral	1

- Anatomic alignment: surgical requirement 16.7%
- Minimal displacement: surgical requirement 42.9%
- Unacceptable alignment: surgical requirement 100%

Gartland Type and Surgical Requirement

According to the Gartland classification, surgical requirement rates were as follows:

- Type I: 0%
- Type II: 54.5%
- Type III: 90.9%

Logistic Regression Analysis

In logistic regression analysis, two independent variables predicting the need for surgical intervention were identified. Gartland type (OR=61.0; 95% CI: 1.28–289.7; p=0.037) and reduction quality (OR=14.7; 95% CI: 1.09–102.3; p=0.042) were found to be statistically significant predictors of surgical requirement (Table 5). Age, sex, side, mechanism of trauma, and initial displacement severity were not significant (p>0.05).

Union

Union time was not directly measured. In all patients, radiological stability was observed by the eighth week, and no significant effect of pin configuration or treatment method on union time could be demonstrated (Table 6).

Discussion

This study is one of the limited number of studies evaluating the effect of unsedated closed reduction performed in the emergency department on the need for surgical intervention in supracondylar humerus fractures in children under four years of age. While most of the literature focuses on the 4–7-year age group, the role of reduction in younger children has not been sufficiently investigated. In this respect, our study provides an original contribution by demonstrating the potential of closed reduction to reduce surgical intervention in selected cases in this younger age group.[15,16]

Gartland classification is a fundamental tool in predicting stability and guiding treatment strategies in supracondylar humerus fractures. While it is generally accepted that Type I fractures are treated conservatively due to their stable nature, Type II fractures require more careful evaluation because of their heterogeneous characteristics. Coupal et al. emphasized the risk of early loss of reduction in Type I fractures and highlighted the importance of appropriate immobilization.[17] In contrast, McCartney et al. reported that selected Gartland type IIa supracondylar humerus fractures may be successfully managed nonoperatively when an acceptable anatomical reduction is achieved and maintained with close radiographic follow-up.[18] In our study, the absence of surgical requirement in Gartland Type II fractures with anatomic alignment is consistent with this literature.

Reduction quality is one of the most critical factors determining treatment success. Surd et al. reported high success rates with conservative treatment in children with anatomic alignment. Similarly, in our series, no loss of reduction or conversion to surgery was observed in cases where anatomic reduction was achieved. This finding suggests that, particularly in children under four years of age, post-reduction stability may be better preserved due to thicker periosteum and high remodeling capacity.[8]

It is well described in the literature that Gartland Type III fractures may remain biomechanically unstable despite reduction. Omid et al.[7] reported surgical treatment rates of 85–100% in these fractures.In our study, the high surgical requirement observed in Type III fractures similarly indicates that post-reduction stability is often insufficient and that surgery is frequently unavoidable.

The fact that closed reduction was not applied to all patients may represent a potential selection bias. However, the feasibility of unsedated reduction in the emergency department depends on clinical factors such as pain tolerance, patient cooperation, and fracture pattern. Therefore, reduction decisions were individualized to reflect real-life practice. Most patients who did not undergo reduction had severely displaced fractures with clear surgical indications on initial radiographs. Evaluation of all patients by the same center and surgical team may be considered a factor limiting operator-dependent variability.

Previous studies have emphasized the need for careful monitoring of post-reduction stability, particularly in Gartland Type II fractures. Yıldırım et al. demonstrated that the risk of secondary displacement depends on fracture pattern.[19] In our study, although the low displacement rate in minimally displaced Type II fractures supports conservative management, these findings cannot be generalized due to the limited sample size.

From a clinical perspective, our findings suggest that closed reduction performed in the emergency department may serve as a useful decision-making step in selected young children with supracondylar humerus fractures. Early assessment of reduction quality may help identify patients in whom surgery can be safely avoided, while also allowing timely recognition of fractures requiring surgical treatment. This approach may reduce unnecessary surgical exposure in a vulnerable age group while maintaining fracture stability.

The main limitations of this study include its retrospective design, small sample size, and the absence of a standardized reduction algorithm. In addition, the lack of long-term functional and radiological outcomes represents an important limitation. Due to the nature of unsedated reduction, individual differences in patient cooperation and pain tolerance may influence reduction quality. Therefore, the main message to be derived from this study is that closed reduction should only be applied in cooperative and appropriately selected patients.

Conclusion

In conclusion, this study demonstrates that unsedated closed reduction performed in the emergency department may reduce the need for surgical intervention in selected and cooperative children under four years of age with supracondylar humerus fractures, particularly in Gartland Type I and Type II fractures. While conservative treatment can be safely applied in cases where acceptable reduction quality is achieved, surgical treatment appears to be frequently unavoidable in Gartland Type III fractures.

Disclosures

Authorship Contributions: Concept– S.K.; Design – S.K.; Supervision – S.K., R.K.; Fundings – S.K.; Materials –S.K.; Data collection &/or processing – R.K., S.K.; Analysis and/or interpretation – S.K.; Literature search – S.K.; Writing – S.K.; Critical review – R.K.

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Conflict of Interest Statement: The authors declare that they have no conflict of interest.

Ethical Statement: All procedures were performed in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments. and approved by the Non-Interventional Clinical Research Ethics Committee of Kutahya Health Sciences University (Approval No: 2025/1 / Date: 17/01/2025). Written informed consent was obtained from all participants and/or their legal guardians prior to inclusion in the study.

Data Availability Statement: All data generated or analyzed during this study are included in this published article.

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