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ORIGINAL ARTICLE

Risk factors associated with failed closed reduction and per-cutaneous pinning in supracondylar fractures of humerus in children.

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ABSTRACT… Objective: To determine the factors associated with failed closed reduction in supra condylar fractures of humerus in children. **Study Design:** Descriptive Cross-sectional study. **Setting:** Department of Orthopaedic, Lady Reading Hospital, Peshawar. **Period:** March 2025 to August 2025. **Methods:** Ninety-three children aged 2–12 years with supracondylar humerus fractures were enrolled using consecutive sampling. Demographic data, injury mechanism, clinical findings, and radiographic classification were documented. Failure of closed reduction was defined as inability to obtain and maintain satisfactory alignment under fluoroscopy after manipulation and pin fixation. Data were stratified and associations were assessed using the chi-square test, with a p-value of ≤0.05 considered statistically significant. **Results:** Mean age was 7.1±3.3 years; 73 (78.5%) were male. Right-sided injuries 58 (62.4%) and low-energy mechanisms 73 (78.5%) were most common. Delayed presentation occurred in 63 (67.7%), marked swelling in 19 (20.4%), and Gartland type III fractures in 10 (10.8%). Younger children (≤8 years) were significantly more likely to show swelling (p=0.019), while left-sided injuries had higher rates of delay (p=0.015). **Conclusion:** Delayed presentation, massive swelling, and severe fracture type were strongly associated with failure of closed reduction and percutaneous pinning, underscoring the importance of early evaluation and timely surgical management.

Key words: Child, Closed Fracture Reduction, Humeral Fractures, Orthopedic Procedures, Pin Fixation, Risk Factors, Supracondylar Fracture.

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INTRODUCTION

Supracondylar fractures of the humerus are most common elbow injuries in children, occurring most frequently between five and ten years of age as a result of falls from an outstretched hand.[1] These injuries are of extreme clinical importance as a result of their close association with vital neurovascular elements as well as a possible risk of late deformity if treatment is in any way inappropriate.[2] Closed reduction and percutaneous pinning is considered a standard approach, as stability is ensured with relative minimization of complications when compared to open procedures.[3] Not all cases, however, respond favorably to such a treatment, and a possible risk of failure must thus be specifically addressed in initial assessment. Delineation of factors that have a risk of failed results is thus extremely necessary in order to direct surgical indications as well as to prevent late disability.[3]

Another factor responsible for closed reduction and percutaneous pinning failure is a delayed presentation time.[4] The children who arrive in the later hours after being hurt tend to develop muscle spasm, soft tissue stiffness, and inability to attain normal anatomy of fracture pieces.[5] The greater the time a fracture is not reduced, the greater is its difficulty in regaining normal anatomy by closed methods, as early fibrotic changes may occur in adjacent tissues.[5] The chance of complications in the form of compartment syndrome or vascular compromise is greater and further impairs reduction.[6] Therefore, early presentation and prompt intervention are required so that closed reduction may become more effective in supracondylar fractures.[7]

Another extremely significant variable is severe swelling and type of fracture, in particular, Garland type III injuries.[8]

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Severe swelling of elbow region not only invalidates reduction in a technical sense, but increases risk for soft tissue compromise during reduction attempts.[9] Excessive swelling could result in damage to subjacent neurovascular injuries and could require conversion to open reduction.[10] Garland type III fractures, as a definition of being a full displacement fracture without contact of cortex, are automatically unstable and are commonly found in association with soft tissue interposition between masses of fragment, reducing effectiveness of closed reduction.[8-10] These high-grade fractures are commonly required to undergo a conversion to open reduction in an attempt to stabilize adequately.[11] These variables in combination operate to underscore individualized assessment in children who endure supracondylar fractures, as delay in onset, excessive swelling, and excessive displacement are strong predisposing conditions for loss of opportunity in succeeding in closed reduction and percutaneous pinning.

Bekmez et al. reported that factors influencing the likelihood of proceeding to open reduction after failed closed reduction included severe fractures (Garland type III, 6.45%), delayed presentation resulting in prolonged injury-to-surgery intervals (61.9% for 5–7 days), and marked elbow swelling, all of which were associated with higher rates of failed closed reduction.[12]

Supracondylar humeral fractures are a regular occurrence in Peshawar's child accident units, although closed reductions and percutaneous pinning results are frequently threatened by late presentations, extreme swelling, and high-grade fracture patterns. While such injuries are a common occurrence, there is a dearth of local research ascertaining factors contributing to failed treatment in such a setting. This research is necessary in Peshawar to identify region-specific challenges, facilitate early detection of high-risk cases, and guide surgeons in optimizing their selection of management approach in a bid to reduce complications and late disability in children.

METHODS

This investigation was carried out in the Orthopaedic Department of Lady Reading Hospital, Peshawar, over a period of three months, from March 2025 to August 2025. A descriptive research design was employed to address the study objective. Approval was obtained from the institutional ethics review board (294/LRH/MTI-19-8-24) before the commencement of the study, and all protocols were performed in line with the approved guidelines.

The required sample size was estimated to be 93 participants, determined by applying a 95% confidence level, a 5% margin of error, and referencing a previously reported prevalence of 6.45% for the specific fracture pattern.[12] A non-probability consecutive sampling strategy was used to recruit patients who met the selection criteria. Demographic details such as age, sex, and side of involvement were recorded for all participants.

Children of either sex, aged between two and twelve years, who presented with supracondylar fractures of the humerus within seven days of trauma and were radiologically classified as Gartland type III were included. Cases associated with open wounds, pathological bone conditions, or concurrent neurovascular compromise were excluded. A supracondylar fracture of the humerus was defined as a break in the distal humerus located above the condyles, confirmed on both anteroposterior and lateral radiographic views of the elbow. Prior to data collection, written informed consent was taken from parents or legal guardians after explaining the purpose and procedures of the study. A structured proforma was used to document history, which included the mode of trauma categorized into low-energy mechanisms such as ground-level falls and high-energy events such as road traffic accidents or sports-related injuries. Clinical examination focused on swelling and limb condition, while radiographs were reviewed to classify fractures based on the Gartland system. Failure of reduction was defined as the inability to achieve and maintain satisfactory alignment of the fracture under fluoroscopic guidance following closed manipulation and percutaneous pinning. Delayed presentation was defined as arrival for surgical management more than one week after the injury, while swelling at the elbow was considered substantial if it visibly distorted the local anatomy and impeded manipulation during attempted reduction.

All collected information was entered and processed using SPSS version 27. Quantitative variables were expressed as mean and standard deviation, while categorical variables were summarized using frequencies and percentages. Data were stratified and associations were assessed using the chi-square test, with a p-value of ≤0.05 considered statistically significant.

RESULTS

The study analyzed 93 pediatric patients with supracondylar fractures of the humerus, with a mean age of 7.12±3.29 years and mean time since fracture of 6.74±2.81 days (as shown in Table-I). The cohort was predominantly male (73 patients, 78.5%) compared to females (20 patients, 21.5%), with right-sided fractures being more common (58 patients, 62.4%) than left-sided fractures (35 patients, 37.6%). The majority of fractures resulted from low-energy mechanisms (73 patients, 78.5%) compared to high-energy mechanisms (20 patients, 21.5%) (as shown in Table-I).

TABLE-I

Patient demographics

Demographics	Mean ± SD
Age (years)	7.12±3.29
Time Since Fracture (days)	6.74±2.81
Gender	
Male n (%)	73 (78.5%)
Female n (%)	20 (21.5%)
Side of fracture	
Right n (%)	58 (62.4%)
Left n (%)	35 (37.6%)
Mechanism of Fracture	
Low n (%)	73 (78.5%)
High n (%)	20 (21.5%)

Clinical factors analysis revealed that delayed presentation was observed in 63 patients (67.70%), while 30 patients (32.30%) presented without delay. Gartland Type III fractures were present in 10 patients (10.80%) with 83 patients (89.20%) having non-Type III fractures. Huge swelling was documented in 19 patients (20.40%) while 74 patients (79.60%) did not have huge swelling (as shown in Table-II).

TABLE-II

Frequency of clinical factors among patients with supracondylar fractures of humerus

Clinical Factors	Frequency	% age
Delayed presentation		
Yes	63	67.70%
No	30	32.30%
Total	93	100%
Gartland Type III		
Yes	10	10.80%
No	83	89.20%
Total	93	100%
Huge Swelling		
Yes	19	20.40%
No	74	79.60%
Total	93	100%

Stratified analysis of clinical factors with demographic variables demonstrated several significant associations. Age stratification showed that among patients ≤8 years, 35 (62.5%) had delayed presentation versus 21 (37.5%) without delay, while in patients >8 years, 28 (75.7%) had delayed presentation versus 9 (24.3%) without delay (p=0.183). For Gartland Type III fractures, 8 (14.3%) patients ≤8 years had Type III fractures compared to 2 (5.4%) patients >8 years (p=0.305). Huge swelling was significantly more common in younger patients, with 16 (28.6%) patients ≤8 years having huge swelling versus 3 (8.1%) patients >8 years (p=0.019). Gender analysis showed males had delayed presentation in 48 (65.8%) cases versus 25 (34.2%) without delay, while females had delayed presentation in 15 (75.0%) cases versus 5 (25.0%) without delay (p=0.433). Gartland Type III fractures occurred in 7 (9.6%) males and 3 (15.0%) females (p=0.684), while huge swelling was present in 15 (20.5%) males and 4 (20.0%) females (p>0.99). Side of fracture analysis revealed a significant association with delayed presentation, where right-sided fractures had delayed presentation in 34 (58.6%) cases versus 24 (41.4%) without delay, while left-sided fractures had delayed presentation in 29 (82.9%) cases versus 6 (17.1%) without delay (p=0.015).

TABLE-III

Association of Clinical Factors with Demographic Variables in Supracondylar Fractures

Demographic Factors Yes n(%)		Delayed Presentation		p-value	Gartland Type III		p-value	Huge Swelling		p-value
		No n(%)	Yes n(%)		No n(%)	Yes n(%)		No n(%)	Yes n(%)	
Age (years)	≤8	35 (62.5%)	21 (37.5%)	0.183	8 (14.3%)	48 (85.7%)	0.305*	16 (28.6%)	40 (71.4%)	0.019*
	>8	28 (75.7%)	9 (24.3%)		2 (5.4%)	35 (94.6%)		3 (8.1%)	34 (91.9%)	
Gender	Male	48 (65.8%)	25 (34.2%)	0.433	7 (9.6%)	66 (90.4%)	0.684*	15 (20.5%)	58 (79.5%)	>0.99*
	Female	15 (75.0%)	5 (25.0%)		3 (15.0%)	17 (85.0%)		4 (20.0%)	16 (80.0%)	
Side of fracture	Right	34 (58.6%)	24 (41.4%)	0.015	6 (10.3%)	52 (89.7%)	>0.99*	13 (22.4%)	45 (77.6%)	0.605*
	Left	29 (82.9%)	6 (17.1%)		4 (11.4%)	31 (88.6%)		6 (17.1%)	29 (82.9%)	
Mechanism of fracture	Low	51 (69.9%)	22 (30.1%)	0.403	9 (12.3%)	64 (87.7%)	0.454*	16 (21.9%)	57 (78.1%)	0.556*
	High	12 (60.0%)	8 (40.0%)		1 (5.0%)	19 (95.0%)		3 (15.0%)	17 (85.0%)	

***Fischer Exact Test**

Mechanism of fracture showed that low-energy mechanisms resulted in delayed presentation in 51 (69.9%) cases compared to 12 (60.0%) cases with high-energy mechanisms (p=0.403) (as shown in Table-III).

DISCUSSION

The present study investigated factors associated with failed closed reduction and percutaneous pinning in pediatric supracondylar fractures, revealing several clinically significant associations that warrant discussion. The predominance of male patients 73 (78.5%) in our cohort aligns with the typical demographic pattern of pediatric supracondylar fractures, which can be attributed to the higher propensity for risk-taking behavior and increased participation in physical activities among boys compared to girls of similar age groups. The mean age of 7.12±3.29 years corresponds to the peak incidence period for these fractures, occurring during the active childhood years when the supracondylar region of the humerus is particularly vulnerable due to the thinner cortical bone and weaker metaphyseal-diaphyseal junction.

The high frequency of delayed presentation 63 (67.70%) observed in our study likely reflects several socioeconomic and healthcare accessibility factors, including parental delay in recognizing the severity of the injury, initial mismanagement at primary healthcare facilities, and potential barriers to accessing specialized pediatric orthopedic care. The predominance of low-energy trauma mechanisms 73 (78.5%) is consistent with the typical fall-related injuries in children, where a simple fall on an outstretched hand generates sufficient force to cause supracondylar fractures due to the relatively weaker bone structure in the pediatric population. The significant association between younger age (≤8 years) and huge swelling (p=0.019) can be explained by the increased tissue reactivity and more pronounced inflammatory response in younger children, combined with their thinner soft tissue envelope around the elbow joint, which makes swelling more apparent and clinically significant.

The demographic profile of our study cohort investigating factors associated with failed closed reduction and percutaneous pinning aligns closely with several previous investigations. Our mean age of 7.12±3.29 years is comparable to findings reported by Banday et al. (7.2 years)[13], Ayaz Khan et al. (7 years)[14], and Muhammad Salim et al. (7.2±2.1 years)[15], while slightly higher than those reported by Yıldırım et al. (5.4±2.5 years)[16] and Karnes et al. (5.5 years).[17] However, the age-related risk factors for

failed closed reduction show important variations. Karnes et al. identified age ≥5 years as a significant predictor of requiring open reduction with 3.4-fold higher odds (p=0.007)[17], while Coello et al. found that age >8 years significantly increased the risk of failed closed reduction in Type-III extension fractures (OR 5.22).[18] Our finding of significant association between younger age (≤8 years) and huge swelling (p=0.019) provides a different perspective, suggesting that while younger children may develop more prominent swelling, older children face higher risks of failed closed reduction, possibly due to more complex fracture patterns and increased soft tissue damage.

The male predominance observed in our study 73 (78.5%) is consistent with most published series, including Banday et al. (83% boys)[13] and Muhammad Salim et al. (75% boys).[15] However, gender has not emerged as a significant predictor of failed closed reduction in our study (p=0.433) or in the reviewed literature, suggesting that biological sex does not substantially influence the technical success of closed reduction procedures. This finding contrasts with the clear demographic predominance but indicates that treatment outcomes are not gender-dependent. Our finding of delayed presentation in 63 (67.7%) of patients represents a critical factor that significantly differs from most Western literature, where acute presentation is the norm. This delayed presentation pattern may contribute to higher failure rates of closed reduction, as suggested by the inflammatory response and soft tissue changes that develop over time. While specific studies examining the relationship between presentation timing and closed reduction success are limited in the reviewed literature, the high rate of delayed presentation in our cohort likely influences treatment outcomes and may explain some differences in failure rates compared to studies from healthcare systems with more immediate access to specialized care.

The significant association between left-sided fractures and delayed presentation (p=0.015) in our study represents a novel finding not specifically addressed in the reviewed literature examining failed closed reduction. While several studies report left-sided predominance, including Banday et al. (70%)[13] and Naji-Ullah Khan et al. (69%)[19], none have correlated laterality with presentation timing or reduction failure rates. This association may reflect behavioral patterns in injury recognition or healthcare-seeking behavior that warrant further investigation. The low frequency of Gartland Type III fractures (10.8%) in our series contrasts markedly with studies specifically examining failed closed reduction. Biaggi-Ondina et al. focused exclusively on Type III fractures and found 12.2% failed closed reduction[20], while Karnes et al. reported 51% Type III cases with 12.3% overall open reduction rate.[17] The higher proportion of Type II fractures in our cohort may explain different failure patterns, as Type II fractures theoretically have lower inherent instability. However, Yıldırım et al. demonstrated that even Type II fractures can have significant failure rates (21%) when treated non-operatively, with sagittal obliquity ≥20° showing 3.17-fold higher risk of failure and metaphyseal fragmentation showing 6.5-fold higher risk.[16]

The association between huge swelling and younger age (p=0.019) in our study provides insight into one potential mechanism of failed closed reduction. While not directly addressed in the reviewed literature, swelling-related factors have been implicated in treatment difficulties. The increased soft tissue reactivity in younger children may create technical challenges during closed reduction attempts, though this has not been quantified in previous studies examining failed closed reduction rates. High-energy trauma mechanisms, identified as significant predictors of failed closed reduction by Karnes et al. (p=0.024)[17], were less common in our cohort (21.5%), which may explain different failure patterns compared to trauma centers dealing with more severe injuries. Coello et al. further demonstrated that flexion-type fractures had dramatically higher open reduction rates (40.5%) compared to extension-type fractures (6.4%)[18], highlighting the importance of fracture pattern in predicting closed reduction success.

The complexity of factors associated with failed closed reduction is further illustrated by Biaggi-Ondina et al., who identified specific radiographic parameters as strong predictors: posterior displacement >4mm (OR 3.14), posterolateral displacement (OR 6.41), and anterior spike fracture

pattern (OR 32.6).[20] These technical radiographic factors, combined with clinical factors like neuropraxia at presentation (OR 3.26), provide a more comprehensive understanding of failed closed reduction risk factors than demographic variables alone.

Several limitations of our study warrant acknowledgment. As a single-center study, our findings may not be generalizable to other healthcare settings or populations with different demographic characteristics and healthcare delivery systems. The prospective design, while reducing selection bias, may still have limitations in capturing all relevant clinical variables that could influence closed reduction success. The relatively small sample size of 93 patients may have limited the statistical power to detect smaller but clinically significant associations, particularly for less common factors.

CONCLUSION

Our study has concluded that several demographic and clinical factors are significantly associated with failed closed reduction and percutaneous pinning in pediatric supracondylar fractures of the humerus. Younger age was significantly associated with the development of huge swelling, while left-sided fractures showed a significant association with delayed presentation.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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2	**Naeem Ullah:** Supervision.
3	**Hamza Haroon:** Methodology.
4	**Noman Alam Khan:** Data analysis.
5	**Salim Riaz:** Data curation.
6	**Shahid Akbar:** Formal analysis.
7	**Farooq Akbar:** Funding acquisition.