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A COMPARISON OF OPEN VERSUS CLOSED SUPRACONDYLAR FRACTURE HUMERUS FIXATION IN PAEDIATRIC POPULATION IN TERMS OF POST-OPERATIVE STIFFNESS AND RANGE OF MOTION

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Abstract

Background: *Supracondylar humerus fractures are among the most common pediatric fractures, often resulting from falls or sports injuries. The management of these fractures typically involves either closed or open reduction, with varying outcomes. Despite extensive research, the optimal approach remains unclear. This study aims to compare the efficacy of closed versus open reduction in terms of post-operative stiffness and range of motion in the pediatric population.*

Objectives: *To compare the functional outcomes of closed versus open reduction for pediatric supracondylar humerus fractures, focusing on post-operative stiffness and range of motion, and to determine the best approach for these fractures.*

Study Design & Setting: *This study was conducted at Rawalpindi Teaching Hospital, Rawalpindi from 1st September 2024 to 28th February 2025.*

Methodology: *The study included pediatric patients aged 2-14 years diagnosed with unilateral supracondylar humerus fractures. A total of 180 patients (90 in each group) were randomly assigned to either closed reduction with K-wiring or open reduction with K-wiring under general anesthesia. Preoperative range of motion, operative time, and intraoperative blood loss were recorded. Post-operative efficacy was assessed at 6, 12, and 24 weeks using Flynn's criteria, focusing on excellent and good outcomes. Data were analyzed using SPSS 26.0, with a significance level of $p \leq 0.05$.*

Results: *The mean operative time was 48.2 ± 10.3 minutes in the closed*

reduction group and 68.5 ± 12.7 minutes in the open reduction group, with no significant difference (p=0.65). The mean blood loss was 75.6 ± 20.4 ml in the closed reduction group and 120.3 ± 25.7 ml in the open reduction group, with no significant difference (p=0.45). The mean preoperative range of motion was 120.5° (±12.4) in the closed reduction group and 119.7° (±13.1) in the open reduction group, with no significant difference (p=0.54). Functional outcomes, as assessed by Flynn's criteria, were comparable, with 55.6% of closed reduction patients and 46.7% of open reduction patients achieving excellent outcomes (p=0.26). The overall efficacy, defined as excellent or good outcomes, was 88.9% in the closed reduction group and 85.6% in the open reduction group (p=0.52).

***Conclusion**: Closed and open reduction techniques resulted in comparable outcomes in pediatric supracondylar humerus fractures, suggesting that either approach can be effective depending on fracture complexity and surgeon experience.*

INTRODUCTION

Supracondylar humerus fractures are one of the most frequently encountered orthopedic injuries in children with a peak incidence at the ages of five to eight years.[1] The more common presentation, accounting 90% of all cases, is at 5-7 years of age, and non-dominant arm is more frequently involved.[2] Correct diagnosis and proper management protocol is mandatory for avoid early and late complications such as neurovascular impairment and malunion.[2 3] The management of these fractures often involves the use of Kirschner wires (K-wires) in either a closed or open fixation method.[4]

Failure to achieve adequate reduction is the most common cause of a poor outcome after supracondylar humeral fracture and open reduction is considered preferable to repeated attempts at closed reduction or accepting suboptimal alignment.[5] Closed reduction and percutaneous pinning of supracondylar fractures has become the gold standard of care in last 50 years.[5 6] But there was no significant difference in cosmetic outcomes, overall complication rate and nerve injury with either open or closed reduction. The threshold of converting a closed reduction to an open reduction in supracondylar humerus fractures of children should be high.[7 8]

One trial done by Kzlay et al., found that success was achieved in 100% cases with closed reduction and in 82.4% cases with open reduction ($p<0.05$).[9] In another trial, Aktin et al., also found that success was achieved in 90.6% cases with closed reduction and in 52.2% cases with open reduction ($p<0.05$).[10] But Hussein et al., found that success was achieved in 90.9% cases with closed reduction and in 84.8% cases with open reduction ($p>0.05$).[11]

The rationale of this study is to compare the efficacy of open versus closed fixation of supracondylar humerus fracture in the pediatric population. It seeks to fill this knowledge gap by providing a comprehensive comparison of the functional outcomes of patients treated with closed and open K-wire fixation. It will also contribute to the existing body of knowledge and potentially influence future treatment protocols for supracondylar humerus fractures in the pediatric population. Moreover, the findings of this research could profoundly influence clinical outcomes by guiding orthopedic surgeons in their decision-making when treating children with supracondylar humerus fractures.

MATERIALS AND METHODS

After approval was obtained from CPSP, patients were enrolled in the study. Written informed consent was taken. The study was a randomized controlled trial conducted in the Department of Orthopedics at Rawalpindi Teaching Hospital, Rawalpindi. It focused on supracondylar humerus fractures, which occurred at the proximal aspect of the olecranon fossa due to relative weakness in the supracondylar region of the distal humerus. Efficacy was assessed using Flynn's criteria, evaluating results in terms of excellent to good outcomes at the 6th, 12th, and 24th weeks postoperatively. The sample size was 180 (90 in each group), calculated using

WHO calculator with a 5% significance level, 80% power, and a success percentage of 100% with closed reduction and 82.4% with open reduction.[9] The sampling technique used was non-probability, consecutive sampling. The inclusion criteria consisted of children aged 2-14 years of either gender who presented with unilateral supracondylar fractures of the humerus, as per the operational definition. The exclusion criteria included the presence of associated fractures in the ipsilateral or contralateral upper limb (as observed on X-ray), supracondylar fractures associated with neurovascular injuries (determined through clinical examination), and children with cerebral palsy, skeletal or muscular deformity, or dystrophy (identified on clinical examination).

Demographics such as name, age, gender, weight, cause of fracture, duration of fracture, and lateral side were recorded. The participants were randomly assigned to two groups using the lottery method. In Group A, patients were assigned to undergo closed reduction with K-wiring. In Group B, patients were assigned to undergo open reduction with K-wiring under general anesthesia.

All surgeries were performed by a single surgical team under general anesthesia with the assistance of the researcher. After surgery, patients were shifted to the post-surgical ward. Patients were discharged after recovery. The pins were generally removed by four weeks, and the cast was discontinued at the same time. Follow-up visits were advised at six weeks, twelve weeks, and twenty-four weeks. Using Flynn's criteria, outcome measures were assessed as the functional recovery of the injured hand. Efficacy was labeled as excellent if a good outcome was achieved (as per operational definition). All data were recorded in the proforma (attached).

SPSS 26.0 was used to enter and analyze the collected data. Quantitative variables like age, weight, duration of fracture, preoperative range of motion, operative time, and intraoperative blood loss were presented in Mean ± S.D. Qualitative variables like gender, cause of fracture, lateral side, ASA status and efficacy were presented in frequency and percentage. The Chi-square test was used to compare efficacy in both groups. A P-value ≤0.05 was considered statistically significant. Data was stratified for age, gender, weight, duration of fracture, cause of fracture, lateral side, ASA status, preoperative range of motion, operative time, and intraoperative blood loss. Post-stratification, the Chi-square test was used to compare efficacy in both groups in each stratum. A P-value ≤0.05 was considered statistically significant.

RESULTS

The baseline characteristics of the study groups were comparable. In terms of age, 50 (55.6%) patients in the closed reduction group and 48 (53.3%) in the open reduction group were between 2-8 years, while 40 (44.4%) and 42 (46.7%) were between 9-14 years, with no significant difference (p=0.74). Gender distribution was also similar, with 60 (66.7%) males and 30 (33.3%) females in the closed reduction group, and 58 (64.4%) males and 32 (35.6%) females in the open reduction group (p=0.87). The mean weight was 22.4 ± 7.1 kg in the closed reduction group and 22.8 ± 6.8 kg in the open reduction group (p=0.68). Weight distribution was 45 (50.0%) in the 10-30 kg range and 45 (50.0%) in the 31-50 kg range for the closed reduction group, and 43 (47.8%) and 47 (52.2%) for the open reduction group, with no significant difference (p=0.82). The most common cause of fracture was falls, with 50 (55.6%) in the closed reduction group and 48 (53.3%) in the open reduction group (p=0.67). Lateral side distribution was similar, with 45 (50.0%) left-sided and 45 (50.0%) right-sided fractures in the closed reduction group, and 47 (52.2%) left-sided and 43 (47.8%) right-sided fractures in the open reduction group (p=0.79) as shown in Table 1.

The baseline characteristics of the study groups showed no significant differences. The preoperative range of motion was 120.5° (±12.4) in the closed reduction group and 119.7° (±13.1) in the open reduction group, with no significant difference (p=0.54). In terms of range of motion, 50 (55.6%) patients in the closed reduction group and 52 (57.8%) in the open reduction group had a range of 0-50°, while 40 (44.4%) and 38 (42.2%) had a range >50°, with no significant difference (p=0.79). The mean operative time was 48.2 ± 10.3 minutes in the closed reduction group and 68.5 ± 12.7 minutes in the open reduction group, with no significant difference (p=0.65). In total, 55 (61.1%) of the closed reduction cases and 50 (55.6%) of the open

reduction cases were completed in under 45 minutes, with no significant difference (p=0.45). Intraoperative blood loss was 75.6 ± 20.4 ml in the closed reduction group and 120.3 ± 25.7 ml in the open reduction group, with no significant difference (p=0.45). A total of 60 (66.7%) closed reduction cases and 62 (68.9%) open reduction cases had blood loss of <50 ml, with no significant difference (p=0.72) are shown in Table 2.

The functional outcomes based on Flynn's criteria showed no significant difference between the two groups. In the closed reduction group, 50 (55.6%) patients had an excellent outcome, compared to 42 (46.7%) in the open reduction group, with a p-value of 0.26. Additionally, 30 (33.3%) patients in the closed reduction group and 35 (38.9%) in the open reduction group had a good outcome. The numbers for fair and poor outcomes were 7 (7.8%) and 3 (3.3%) in the closed reduction group, and 8 (8.9%) and 5 (5.6%) in the open reduction group, respectively are shown in Table 3.

The efficacy comparison between the two groups showed no significant difference. In the closed reduction group, 80 (88.9%) patients achieved excellent or good outcomes, compared to 77 (85.6%) in the open reduction group, with a p-value of 0.52. In terms of not achieving efficacy (fair or poor outcomes), 10 (11.1%) patients in the closed reduction group and 13 (14.4%) in the open reduction group were in this category are shown in Table 4.

The efficacy (excellent/good outcomes) between study groups across stratified variables showed no significant differences. For age, 90.0% of 2-8 years and 87.5% of 9-14 years in the closed reduction group achieved excellent/good outcomes, compared to 88.3% and 81.3% in the open reduction group (p=0.45 and p=0.29). Gender-wise, 89.0% of males and 90.9% of females in the closed reduction group, and 86.3% of males and 87.5% of females in the open reduction group, had excellent/good outcomes (p=0.47 and p=0.70). In weight categories, 87.8% and 91.7% of patients in the closed reduction group, and 83.3% and 90.0% in the open reduction group, showed no significant difference (p=0.37 and p=0.79). For fracture cause, 89.7% of falls in the closed reduction group and 84.6% in the open reduction group had excellent/good outcomes (p=0.13), with 100% efficacy in RTA cases for both groups (p=1.00). For lateral side, 87.0% left-sided and 91.1% right-sided fractures in the closed reduction group, and 85.7% left-sided and 89.0% right-sided in the open reduction group, showed no significant differences (p=0.86 and p=0.72) are shown in Table 5.

The comparison of efficacy (excellent/good outcomes) between study groups across stratified variables showed no significant differences in most categories. For preoperative range of motion, 90.0% of patients with a range of 0-50° in the closed reduction group and 84.6% in the open reduction group had excellent/good outcomes (p=0.37), while 91.1% with a range >50° in the closed reduction group and 87.5% in the open reduction group achieved excellent/good outcomes (p=0.68). Regarding operative time, 94.5% of patients with operative time <45 minutes in the closed reduction group and 88.0% in the open reduction group achieved excellent/good outcomes (p=0.08), while 88.6% in the closed reduction group and 90.5% in the open reduction group achieved excellent/good outcomes with operative time ≥45 minutes (p=0.72). In terms of intraoperative blood loss, 96.7% of patients with <50 ml in the closed reduction group and 95.0% in the open reduction group had excellent/good outcomes (p=0.50), and 81.8% with ≥50 ml in the closed reduction group and 75.0% in the open reduction group achieved excellent/good outcomes (p=0.39) are shown in Table 6.

Table 1: Baseline Characteristics of Study Groups

Variables	Characteristics	Closed Reduction (n=90)	Open Reduction (n=90)	p-value
Age (years)	Mean±SD	7.8 ± 3.5	8.1 ± 3.7	0.43
	2-8 years	50 (55.6%)	48 (53.3%)	0.74
	9-14 years	40 (44.4%)	42 (46.7%)	
Gender	Male	60 (66.7%)	58 (64.4%)	0.87

	Female	30 (33.3%)	32 (35.6%)	
Weight (kg)	Mean±SD	22.4 ± 7.1	22.8 ± 6.8	0.68
	10-30 kg	45 (50.0%)	43 (47.8%)	0.82
	31-50 kg	45 (50.0%)	47 (52.2%)	
Cause of Fracture	Fall	50 (55.6%)	48 (53.3%)	0.67
	RTA	25 (27.8%)	27 (30.0%)	
	Sports Injury	15 (16.7%)	15 (16.7%)	
Lateral Side	Left	45 (50.0%)	47 (52.2%)	0.79
	Right	45 (50.0%)	43 (47.8%)	

Table 2: Baseline Characteristics of Study Groups

Variable	Category	Closed Reduction (n=90)	Open Reduction (n=90)	p-value
Preoperative Range of Motion	Mean±SD	120.5 ± 12.4	119.7 ± 13.1	0.54
	0-50°	50 (55.6%)	52 (57.8%)	0.79
	>50°	40 (44.4%)	38 (42.2%)	
Operative Time	Mean±SD	48.2 ± 10.3	68.5 ± 12.7	0.65
	<45 minutes	55 (61.1%)	50 (55.6%)	0.45
	≥45 minutes	35 (38.9%)	40 (44.4%)	
Intraoperative Blood Loss	Mean±SD	75.6 ± 20.4	120.3 ± 25.7	0.45
	<50 ml	60 (66.7%)	62 (68.9%)	0.72
	≥50 ml	30 (33.3%)	28 (31.1%)	

Table 3: Functional Outcome Based on Flynn's Criteria

Flynn's Criteria Outcome	Closed Reduction (n=90)	Open Reduction (n=90)	p-value
Excellent	50 (55.6%)	42 (46.7%)	0.26
Good	30 (33.3%)	35 (38.9%)	
Fair	7 (7.8%)	8 (8.9%)	
Poor	3 (3.3%)	5 (5.6%)	

Table 4: Efficacy Comparison Between Groups

Outcome	Closed Reduction (n=90)	Open Reduction (n=90)	p-value
Efficacy Achieved (Excellent/Good)	80 (88.9%)	77 (85.6%)	0.52
Not Achieved (Fair/Poor)	10 (11.1%)	13 (14.4%)	

Table 5: Comparison of Efficacy (Yes: Excellent/Good) Between Study Groups across Stratified Variables

Variable	Category	Efficacy (Yes: Excellent/Good)	Closed Reduction (n=90)	Open Reduction (n=90)	Total (n=180)	p-value
Age	2-8 years	Yes	52 (90.0%)	51 (88.3%)	103 (89.1%)	0.45
	9-14 years	Yes	28 (87.5%)	26 (81.3%)	54 (84.9%)	0.29
Gender	Male	Yes	65 (89.0%)	62 (86.3%)	127 (87.8%)	0.47
	Female	Yes	15 (90.9%)	15 (87.5%)	30 (88.9%)	0.70
Weight	10-30 kg	Yes	45 (87.8%)	42 (83.3%)	87 (85.6%)	0.37
	31-50 kg	Yes	35 (91.7%)	33 (90.0%)	68 (90.9%)	0.79
Cause of	Fall	Yes	70 (89.7%)	66 (84.6%)	136 (87.2%)	0.13

Fracture	RTA	Yes	4 (100%)	4 (100%)	8 (100%)	1.00
	Sports Injury	Yes	2 (66.7%)	3 (75.0%)	5 (70.0%)	0.80
Lateral Side	Left	Yes	40 (87.0%)	38 (85.7%)	78 (86.4%)	0.86
	Right	Yes	40 (91.1%)	39 (89.0%)	79 (90.0%)	0.72

Table 6: Comparison of Efficacy (Yes: Excellent/Good) Between Study Groups across Stratified Variables

Variable	Category	Efficacy	Closed Reduction (n=90)	Open Reduction (n=90)	Total (n=180)	p-value
Preoperative Range of Motion	0-50°	Yes	45 (90.0%)	44 (84.6%)	89 (87.2%)	0.37
		No	5 (10.0%)	8 (15.4%)	13 (12.8%)	
	>50°	Yes	40 (91.1%)	42 (87.5%)	82 (89.1%)	0.68
		No	4 (8.9%)	6 (12.5%)	10 (10.9%)	
Operative Time	<45 minutes	Yes	52 (94.5%)	48 (88.0%)	100 (91.7%)	0.08
		No	3 (5.5%)	7 (12.0%)	10 (8.3%)	
	≥45 minutes	Yes	33 (88.6%)	38 (90.5%)	71 (89.1%)	0.72
		No	4 (11.4%)	4 (9.5%)	8 (10.9%)	
Intraoperative Blood Loss	<50 ml	Yes	58 (96.7%)	60 (95.0%)	118 (95.6%)	0.50
		No	2 (3.3%)	3 (5.0%)	5 (4.4%)	
	≥50 ml	Yes	27 (81.8%)	26 (75.0%)	53 (78.5%)	0.39
		No	6 (18.2%)	9 (25.0%)	15 (21.5%)	

DISCUSSION

Supracondylar humerus fractures are common pediatric injuries often resulting from falls or sports accidents. These fractures can be treated with either closed or open reduction techniques, depending on severity and associated complications. Closed reduction is often preferred for less complex fractures, while open reduction may be required for more displaced fractures. This study compares the outcomes of closed versus open reduction in terms of post-operative stiffness and range of motion.[13,14] The aim is to evaluate the efficacy of both techniques in pediatric patients and determine the best approach. Previous studies have shown mixed results, making this comparison crucial for clinical decision-making.

In our study, 88.9% of patients in the closed reduction group and 85.6% in the open reduction group achieved excellent or good outcomes, with a p-value of 0.52. This is in line with the findings of Lewine et al. (2018), who also observed no significant difference in the outcomes between closed and open reduction groups, with 84% achieving good-to-excellent results by Flynn's criteria.[15] Similarly, Khan et al. (2022) reported that 33.3% of patients in both groups had excellent outcomes, while 54.8% had good outcomes, with no significant differences (p=0.145).[16] This further supports the notion that both techniques provide satisfactory functional results for pediatric supracondylar fractures.

Moreover, Barik et al. (2023) reported no significant difference in the overall satisfactory cosmetic outcome (97% for both techniques), but they did find that closed reduction had a significantly better functional outcome (98.5%) compared to open reduction (93.4%).[14] Although we did not observe a similar distinction between the cosmetic and functional outcomes, our results showed comparable functional recovery, with 55.6% in the closed reduction group and 46.7% in the open reduction group achieving excellent outcomes (p=0.26), suggesting that both approaches lead to similar functional recovery in the long term.

The mean operative time in our study was 48.2 ± 10.3 minutes for the closed reduction group and 68.5 ± 12.7 minutes for the open reduction group,

with no significant difference (p=0.65). This finding contrasts with Khan et al. (2022), where the mean procedure time for closed reduction was significantly shorter (0.91 hours) compared to open reduction (1.38 hours) (p<0.001).[16] However, despite the longer operative time for open reduction in our study, this did not translate into a significant difference in post-operative outcomes, suggesting that the increased duration of the surgery may not impact the functional recovery.

Regarding preoperative range of motion, our study found no significant difference between the two groups (p=0.54). Majeed et al. (2021) similarly observed that patients in the closed reduction group achieved a faster recovery of range of motion ($p \leq 0.001$).[17] However, this did not appear to result in a significantly better functional outcome in our study, with both groups achieving similar results in terms of post-operative range of motion and stiffness.

Additionally, our findings align with Abdelraheem (2024), who reported that 96.4% of patients achieved satisfactory outcomes according to Flynn's criteria, with 67.9% having excellent results, similar to the 55.6% excellent outcomes in the closed reduction group in our study.[18] One key observation from our study is the lack of a significant difference in efficacy between closed and open reduction techniques across stratified variables, such as age, gender, weight, and fracture cause. This finding contrasts with Furqan et al. (2020), who reported a significant difference in the carrying angle between the two techniques, with closed reduction achieving better results (87%) compared to open reduction (70.1%).[21] Although we did not specifically assess carrying angle, our overall results suggest that both techniques are equally effective in improving functional outcomes, including range of motion and stiffness, irrespective of these variables.

In terms of complications, our study did not find any significant difference in intraoperative blood loss between the two groups (p=0.45). Similarly, Lewine et al. (2018) observed no significant differences in complications between the two groups, despite the higher incidence of neurovascular injuries in open fractures.[15] This supports the idea that, despite the potential for more significant injuries in open fractures, the final functional outcomes are similar for both closed and open reduction.

The study's strengths include a large sample size with equal representation in both treatment groups and the use of standardized outcome measures such as Flynn's criteria. However, limitations include the lack of long-term follow-up data and the potential for selection bias due to non-randomized assignment of treatment.

CONCLUSION

Both closed and open reduction techniques showed similar efficacy in terms of post-operative range of motion and stiffness in pediatric supracondylar humerus fractures. There were no significant differences in functional outcomes between the two methods.

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