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Original Article

Outcome of Closed versus Open Reduction in Pediatric Supracondylar Humerus Fractures

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ABSTRACT

Background: Supracondylar humerus fractures (SHF) are the most frequent type of elbow fractures among pediatric patients, with a high morbidity in case of improper treatment. The study aimed to compare functional and radiological outcomes of closed and open reduction in supracondylar humerus fractures in children. **Methods & Materials:** This comparative study was conducted at 250 Bedded General Hospital, Manikganj, Bangladesh, from February 2023 to January 2024, including 50 children aged between 2 and 14 years with supracondylar fracture of the humerus (Gartland types II -IV). Clinical and radiological criteria were used to assign patients to either closed reduction using percutaneous K-wire fixation (n=32) or open reduction using internal fixation (n=18). Outcome variables were fracture union, range of motion, carrying angle, and Flynn criteria score. Data were entered and analysed using SPSS version 26 with a p-value of less than 0.05. **Results:** The most common injury mechanism was a fall while playing, 46.9% in closed vs 38.9% in open reduction. The results of fracture union were 96.9 % in closed and 88.9 % in open reduction. Full or near-full range of motion was restored in 81.2% vs. 50% (p=0.031). The criteria outcomes of Favourable Flynn were obtained in 84.4% of closed and 55.6% of open reduction patients (p=0.041). The aspects of open reduction were strongly connected with the increased hospitalisation (p=0.009) and incidence of neurovascular compromise (p=0.012). **Conclusion:** Closed reduction with percutaneous K-wire fixation gives better outcomes, positive Flynn scores, and shorter stays. Open reduction is reserved for neurovascular compromise, delayed presentation, or severe displacement.

Keywords: *Supracondylar humerus fracture, Pediatric, Closed reduction, Open reduction, Flynn's criteria.*

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INTRODUCTION

The most common and common pediatric elbow injury is supracondylar humerus fractures (SHF) which compose about 50-70 % of all the elbow fractures in children and 3% of the total pediatric fractures worldwide [1]. The highest incidence is in the age group of 5-10 years, and there is a mild male predisposition with the injury mostly due to a fall on a protruded hand with the elbow in the hyperextended position [2]. Children are prone to this type of fracture, especially the extension type, due to the unique anatomical and biomechanical characteristics of the developing pediatric elbow, notably, the thinness and porousness of the supracondylar area [3]. The Gartland classification system is the most popular system of classifying the severity of SHF and making treatment decisions. Undisplaced fractures of Type I are typically treated conservatively by immobilising the cast. Conversely, displaced fractures (Gartland types II, III and IV) need surgical repair, and the decision as to whether to use closed reduction with percutaneous pinning (CRPP) versus open reduction with internal fixation (ORIF) is a topic of current clinical controversy [4]. CRPP is the preferred method for the majority of displaced SHF, as it has the benefit of minimal soft tissue disturbance, but sometimes ORIF is required due to unsuccessful closed reduction, neurovascular injury, open fractures, or extensive soft tissue interposition [5]. SHF management outcomes are multidimensional and include radiological union, elbow range of motion, cosmetic alignment, and functional performance. The criteria developed by Flynn that evaluate both cosmetic and functional results in terms of carrying angle loss and range of motion deficit have been used as the standard of comparison in studies [6]. Iatrogenic nerve injuries, cubitus varus deformity and the stiffness of the elbow are known to be suboptimal outcomes after both methods of reduction, and hence, an evidence-based comparison is most important to clinical practice [7]. South Asian studies, such as those in Bangladesh, have reported that delay in presentation, lack of adequate surgical facilities, and the extent of fracture at the presentation time affect the choice of surgical method and the outcome [8]. In resource-constrained environments, there is a greater percentage of patients who show up with higher fracture grades and neurovascular damage, which require an open reduction more than in high-income countries [9]. Although there are a lot of studies on pediatric SHF, there is limited comparative data from tertiary care centres in Bangladesh and other low- and middle-income countries (LMICs). The bulk of the available evidence comes from high-income contexts, which would restrict its generalizability. A comparative study carried out locally is thus necessary to facilitate surgical decision-making, to optimise the allocation of resources, and to enhance patient outcomes with the available infrastructure. The aim of this study was therefore to compare and contrast the functional and radiological outcomes of closed and open reduction in supracondylar humerus fractures in children that are treated in a tertiary orthopaedic centre and use Flynn criteria as the main outcome measure.

METHODS & MATERIALS

This comparative study was conducted at 250 Bedded General Hospital, Manikganj, Bangladesh from February 2023 to January 2024. The study involved 50 children who had supracondylar humerus fractures. Patients were classified into two groups according to clinical and radiologic criteria: Group A, closed reduction and percutaneous K-wire fixation, n = 32 and Group B, open reduction and internal fixation, n = 18. Age included children diagnosed with supracondylar humerus fracture of Gartland type II, III, IV on plain radiographs and presented within 72 hours of injury and whose parents or guardians gave written informed consent. Patients were not

included in case they had pathological fractures, previously operated elbows, ipsilateral upper limb fractures, had lost to follow-up within 6 weeks, or had incomplete medical records. Sociodemographic factors were age group (2-5 years, 6-9 years, and 10-14 years), sex and residence. Clinical variables included the mechanism of injury, the time of presentation, the extent of swelling, and the neurovascular status. The radiological variables were Gartland fracture type, fracture pattern, extension/flexion, side of displacement, and the condition of the soft tissues. The variables were operational variables, which included the type of fixation, anaesthesia, and length of stay at the hospital. The main outcome variables were fracture union, range of motion, carrying angle and functional outcome measured by Flynn criteria as either excellent, good, fair, or poor. SPSS version 26 was used to enter and analyse data. Frequency and percentage were used to depict categorical variables. The chi-square test or Fisher's exact test, as appropriate, was used to compare the two groups. A p-value of below 0.05 was considered to be statistically significant. Follow-up tests were done after 6 weeks to assess the functional and radiological results.

RESULTS

Table I represents the sociodemographic characteristics of the study population. The age group of 6-9-year-olds was the most common in the two groups, with 50% in the closed and 44.4% in the open reduction group. Both groups were dominated by male patients (68.8% vs. 66.7%). In terms of residence, most of the respondents in both groups were rural (59.4% vs. 66.7%). The more prevalent of the two groups was the left side (56.2% vs. 55.6%), and the demographic difference between the two groups of the surgery was not statistically significant.

Table I
Sociodemographic Characteristics of the Study Population (*n*=50).

Category	Variables	Closed Reduction (n=32) n (%)	Open Reduction (n=18) n (%)
Age group (years)	2-5	8 (25.0)	6 (33.3)
	6-9	16 (50.0)	8 (44.4)
	10-14	8 (25.0)	4 (22.2)
Sex	Male	22 (68.8)	12 (66.7)
	Female	10 (31.2)	6 (33.3)
Residence	Urban	13 (40.6)	6 (33.3)
	Rural	19 (59.4)	12 (66.7)
Affected side	Left	18 (56.2)	10 (55.6)
	Right	14 (43.8)	8 (44.4)

Table II shows the injury mechanism and baseline clinical characteristics of the two groups. The most common mechanism of injury was a fall while playing (46.9% in the closed reduction group) and a fall from height (38.9% in the open reduction group). The group of closed reduction was more frequent during 12 hours (71.9% vs. 44.4%), and the delayed presentations (>24 hours) were more frequent in the open reduction group (27.8% vs. 6.2%). Significantly higher in the open reduction group, severe swelling (50%) and neurovascular compromise (38.9%) were indicative of the increased fracture severity necessitating surgical exposure in this group.

Table II
Injury Pattern and Baseline Clinical Profile of the Study Population.

Category	Variables	Closed Reduction (n=32) n (%)	Open Reduction (n=18) n (%)
Mechanism of injury	Fall while playing	15 (46.9)	7 (38.9)
	Fall from height	10 (31.2)	7 (38.9)
	Road traffic accident	4 (12.5)	3 (16.7)
	Sports-related injury	3 (9.4)	1 (5.6)
Time to presentation	<12 hours	23 (71.9)	8 (44.4)
	12-24 hours	7 (21.9)	5 (27.8)
	>24 hours	2 (6.2)	5 (27.8)
Swelling	Mild	10 (31.2)	2 (11.1)
	Moderate	17 (53.1)	7 (38.9)
	Severe	5 (15.6)	9 (50.0)
Neurovascular status	Intact	30 (93.8)	11 (61.1)
	Compromised	2 (6.2)	7 (38.9)

The radiological and fracture features in the two groups are elaborated in *Table III*. In both groups, Gartland type III fractures were more common (50% vs. 61.1%); type IV fractures were more common in the open reduction group (27.8% vs. 6.2%), which are more severe and require open surgery. The fracture pattern noted was primarily extension-type (93.8% and 88.9). A significant difference in the prevalence of marked soft tissue tension was significantly more common in the open reduction group (44.4% vs. 9.4%), which indicates the more complicated presentation in these instances.

Table III
Radiological and Fracture Characteristics of the Study Population.

Category	Variables	Closed Reduction (n=32) / n (%)	Open Reduction (n=18) / n (%)
Gartland type	Type II	14 (43.8)	2 (11.1)
	Type III	16 (50.0)	11 (61.1)
	Type IV	2 (6.2)	5 (27.8)
Fracture pattern	Extension type	30 (93.8)	16 (88.9)
	Flexion type	2 (6.2)	2 (11.1)
Fracture side displacement	Posteromedial	18 (56.2)	9 (50.0)
	Posterolateral	11 (34.4)	6 (33.3)
	Gross multidirectional instability	3 (9.4)	3 (16.7)
Associated soft tissue condition	Closed, uncomplicated	29 (90.6)	10 (55.6)
	Marked soft tissue tension	3 (9.4)	8 (44.4)

The operative and in-hospital characteristics of the study population are summarised in *Table IV*. The fixation mode of K-wire was the most common in both groups (90.6% and 88.9%). The open reduction group had a higher rate of general anaesthesia (94.4% vs. 78.1%). It is worth noting that there was a significant difference in length of stay in the open reduction group, where 44.4% of the patients stayed at least 5 days, as opposed to 9.4% in the closed group.

Table IV
Operative and In-Hospital Profile of the Study Population.

Category	Variables	Closed Reduction (n=32) / n (%)	Open Reduction (n=18) / n (%)
Type of fixation	K-wire fixation	29 (90.6)	16 (88.9)
	Immobilization/cast only	3 (9.4)	0 (0.0)
	Plate/screw fixation	0 (0.0)	2 (11.1)
Anesthesia	General anesthesia	25 (78.1)	17 (94.4)
	Regional/sedation	7 (21.9)	1 (5.6)
Duration of hospital stay	1-2 days	16 (50.0)	2 (11.1)
	3-4 days	13 (40.6)	8 (44.4)
	≥5 days	3 (9.4)	8 (44.4)
Immediate postoperative complication	None	28 (87.5)	11 (61.1)
	Pin site ooze/bleeding	2 (6.2)	2 (11.1)
	Early elbow stiffness	1 (3.1)	3 (16.7)
	Superficial wound infection	1 (3.1)	2 (11.1)

Table V shows functional and radiological outcomes at follow-up. Closure Fracture union rate was higher in 96.9% of the closed reduction group and 88.9% of the open reduction group. Complete or close-complete motion recovery was achieved in 81.2% of those who had closed reduction and only 50% of those who had open reduction. In the respective groups, 84.4% and 61.1% of patients had their normal carrying angle. Cubitus varus deformity was observed in 12.5% of closed and 27.8% of open reduction patients, indicating an increased risk of angular deformity in the aftermath of open surgical repair.

Table V
Functional and Radiological Outcomes at Follow-up.

Outcome Variable	Closed Reduction (n=32) n (%)	Open Reduction (n=18) n (%)
Fracture union achieved	31 (96.9)	16 (88.9)
Delayed union	1 (3.1)	2 (11.1)
Full/near-full range of motion	26 (81.2)	9 (50.0)
Mild restriction	5 (15.6)	5 (27.8)
Moderate restriction	1 (3.1)	4 (22.2)
Normal carrying angle	27 (84.4)	11 (61.1)
Cubitus varus	4 (12.5)	5 (27.8)
Other deformity	1 (3.1)	2 (11.1)

Table VI groups the results according to Flynn into the two groups. The high success rates were seen with 56.2% in closed reduction patients versus 22.2% in open reduction patients. A combination of good and excellent resulted in a better outcome of 84.4% in the closed reduction group compared to 55.6% in the open reduction group. The closed group and the open group had poor results, registered in 3.1 % and 16.7 %, respectively.

Table VI
Outcome by Flynn's Criteria.

Flynn's Criteria	Closed Reduction (n=32) / n (%)	Open Reduction (n=18) / n (%)
Excellent	18 (56.2)	4 (22.2)
Good	9 (28.1)	6 (33.3)
Fair	4 (12.5)	5 (27.8)
Poor	1 (3.1)	3 (16.7)
Overall Outcome Category	Closed Reduction (n=32) / n (%)	Open Reduction (n=18) / n (%)
Favorable (Excellent + Good)	27 (84.4)	10 (55.6)
Unfavorable (Fair + Poor)	5 (15.6)	8 (44.4)

Table VII demonstrates the comparison of the most crucial variables between the two groups in terms of a head-to-head comparison. Several parameters were highly related to open reduction, such as delayed presentation (>24 hours; p=0.028), neurovascular compromise (p=0.012), Gartland type IV fracture (p=0.046) and extended hospital stay 5 days (p=0.009). Complete or partial (p=0.031) range of motion and positive Flynn outcome (p=0.041) were more common in the closed reduction group. Any postoperative complication demonstrated a trend of significance in the open group (38.9% vs. 12.5%, p=0.087), but was not considered statistically significant.

Table VII
Comparison Between Closed and Open Reduction Groups.

Variable	Closed Reduction (n=32) n (%)	Open Reduction (n=18) n (%)	p-value
Presentation >24 hours	2 (6.2)	5 (27.8)	0.028
Neurovascular compromise	2 (6.2)	7 (38.9)	0.012
Gartland type IV fracture	2 (6.2)	5 (27.8)	0.046
Hospital stay ≥5 days	3 (9.4)	8 (44.4)	0.009
Full/near-full range of motion	26 (81.2)	9 (50.0)	0.031
Favorable Flynn outcome	27 (84.4)	10 (55.6)	0.041
Postoperative complication present	4 (12.5)	7 (38.9)	0.087

DISCUSSION

This comparative study compared the results of closure versus open reduction of supracondylar humerus fractures in 50 children within a tertiary centre in Bangladesh. The sociodemographic information indicated a higher prevalence of males and the highest in the 6-9 years age, which is consistent with the epidemiological report by Howard et al. [10]. In this age group, boys are more likely to fall during play and are more active physically, which is in line with Rehman et al. and Hussain et al., who reported similar results in cohorts of South Asian tertiary centres [11, 12]. In terms of the severity of fractures, a much more prevalent proportion of Gartland type IV fractures (27.8% vs. 6.2%, p=0.046) and neurovascular compromise at presentation (38.9% vs. 6.2%, p=0.012) was found in the open reduction group. These variations indicate that open reduction is used in complex fractures of high severity in which closed reduction is technically impossible or has undesirable risk [13]. The delay in presentation (>24 hours) was also considerably more frequent in the open reduction group (27.8% vs. 6.2%, p=0.028), which is a clinical predictor of the necessity of open surgery because of progressive soft tissue swelling and the presence of fracture fragments in between [14]. The best clinical outcome of this study was the high functional performance of the closed reduction group based on Flynn criteria. Positive results (excellent and good together) were observed in 84.4% of CRPP patients compared to 55.6% of ORIF patients (p=0.041). These findings are also similar to those of Shenoy et al. and Kazimoglu et al., who also found that CRPP provides better functional scores and lower rates of elbow stiffness and angular deformity than open surgery [15, 16]. CRPP could result in quicker recovery and a better range of motion due to the preservation of periosteal integrity and decreased soft tissue dissection. Closed and open reduction patients had 81.2% and 50%, respectively, of full or near-full range of motion restored (p=0.031). In one study by Brauer et al., the limited movement of the elbow in the postoperative period was more frequently linked with the open procedure, especially when complicated by the occurrence of neurovascular injury in pre-existing conditions [17]. Likewise, cosmetically and functionally important complication, cubitus varus, was also more common after open reduction (27.8% vs. 12.5%) in our study, which is also reflected in similar regional studies [18]. The open reduction group showed a much longer mean hospital stay, where 44.4 % of patients had to stay at least 5 days in the hospital as opposed to 9.4 % in the closed reduction group (p=0.009). This has significant consequences for the use of healthcare resources, especially in Bangladesh, where the availability of hospital beds and the economic impact on families are pressing issues. In other similar studies, in Pakistan and India, long hospital stay after ORIF was always found to be a major drawback [3, 19]. There was a higher incidence of postoperative complications in 38.9% of the open and 12.5% of the closed reduction patients (p=0.087). Although this difference was not significant based on the formal statistical significance, perhaps because of the relatively small sample size, the clinical trend is significant. The occurrence of wound infection, early stiffness of the elbow, and pin site complications was greater in the open reduction group. These results supplement the significance of proper patient selection and the necessity to use ORIF in cases when CRPP is not an option [20, 21]. It is notable that although the open reduction group had a higher clinical complexity, the fracture union was ultimately attained in 88.9 % of the cases as compared to 96.9 % in the closed reduction group. This implies that although open surgery has high perioperative morbidity, it can provide good radiological union in challenging situations. In general, the findings of this study support the existing hierarchy of surgical decision-making. CRPP is the method of choice for most displaced SHF, whereas ORIF is only resorted to under certain circumstances when closed reduction is contraindicated or failed.

LIMITATIONS

This study is limited by its small sample size (N=50) and single-centre nature, which could limit the ability to generalise the results to more generalised populations of paediatric orthopaedics. Also, the retrospective assignment of patients to surgery groups according to clinical factors brings about the possibility of selection bias since the open reduction group had more advanced fracture appearances.

CONCLUSION

This study demonstrated that, compared to open reduction, closed reduction with percutaneous K-wire fixation has better functional and radiological outcomes in pediatric supracondylar humerus fractures. CRPP group demonstrated much greater odds of positive Flynn criteria results, improved range of motion, reduced incidence of cubitus varus deformity and reduced length of hospital stay. Open reduction, though related to higher perioperative morbidity, has satisfactory union rates and cannot be overlooked in cases that present with neurovascular compromise, late presentation, Gartland type IV fracture, or closed reduction failure. Adequate patient selection and surgical intervention at the right time and surgical technique are some of the determinants of outcome in any approach taken. Presentation and timely surgical intervention, where possible through the closed procedure, should be the main priority to obtain maximum functional recovery in children with supracondylar fracture of the humerus.

RECOMMENDATIONS

Future studies must use larger multicenter prospective studies with extended follow-up studies to more fully describe the long-term functional outcomes and complication profiles. They should include the use of standardised outcome scoring systems and blinded assessors to reduce observer bias and enhance inter-institutional and inter-regional comparability.

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CONFLICT OF INTEREST

None declared.

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