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Incidence of malunion in displaced supracondylar fracture of humerus in children after open reduction with K. wire fixation versus closed reduction with K. wire fixation

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Abstract

Background and objective: commonest fracture of pediatric elbow is the fractures of supracondylar of humerus. Gartland type II and type III Management is preferably operation, either with closed reduction and K. wire pinning or with open reduction and K. wire fixation. Some of the patients will get post-operative complications including Malunion. The aim of this study is to sort out the incidence of malunion in management of fractures of supracondylar in children by closed reduction and K. wire pinning versus open reduction-lateral approach and K. wire pinning.

Methods: Forty nine children were included, who had Gartland type II and Type III Supracondylar fractures and underwent operative management, been enrolled using convenient sampling method. Patients are followed up after 12 weeks. During the review, assessment of the patient done for possible complications postoperatively and measured any possible change of degrees of carrying angle and movement loss at the elbow considering malunion complication.

Results: 12% of the patients who are treated with close reduction and K. wire pinning developed malunion, while none of the patients who are treated with open reduction-lateral approach and K. wire pinning developed malunion.

Conclusion: Incidence of malunion after treatment of supracondylar fracture of humerus in children with close reduction and K. wire pinning is more than the incidence by open reduction-lateral approach and K. wire pinning.

Keywords: Supracondylar humerus fracture; Close reduction; Open reduction; Malunion.

Introduction

Fractures in children preserve a special consideration because bones in the pediatric age group have an enormous growth beside the ability of remodeling.[1] fractures of humeral Supracondylar are among the common children fractures,[2] accounts of 3% of all fractures,[3,4] and makes of 60% of and most common fractures around the elbow.[5,6] The highest incidence occur between age 5-6 years old,[7] also the nondominant upper limb is affected often.[8] There is no difference in the gender of the children.[9] Vast majority or 97% of the cases are extension type while flexion type makes only 3%.[10,11]

The mechanism of injury is by fall on outstretched hand, while elbow is in hyperextension, olecranon process will be directed into the olecranon fossa and the anterior humeral cortex fails in tension.[12] The most common classification used is the modified Gartland classification for extension type,[13] which divided into; type I is nondisplaced transverse fracture, type IIA has intact posterior hinge with angulation only while type IIB has rotation also, type IIIA has a posteromedial displacement and type IIIB has a posterolateral displacement, finally type 4 is a displaced fracture with multidirectional instability.[14,15] Affected children usually present with pain and there maybe swelling,[16] deformity and skin puckering

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which indicate the severity of the fracture pattern,[17] but may present with open fracture also.[18] Neurovascular assessment is critical,[19] palpating the distal pulses and the hand perfusion and quick screening test for the integrity of the nerves using "Rock, Paper, Scissor and OK" tests for evaluation of Median, Radial, Ulnar and anterior interosseus nerves respectively can be used.[20,21] Radiological evaluation done by assessing Baumann's angle bilateraly,[22] the Ulno humeral angle and any medial or lateral displacement on the Anteroposterior view in the plain radiograph and on the lateral view, assessing the anterior humeral line and presence of fat pad sign.[23,24] Supracondylar fracture treatment involves; type I treated conservatively by long arm immobilization cast,[25] type IIA also be treated conservatively but treatment of type IIB is preferably surgery,[26] treatment of both subtypes of type III with type IV and flexion type is should be surgery,[27,28] operative treatment is either by close reduction with percutaneous pinning, or open reduction with percutaneous pinning using different approaches depending on the fracture pattern including; lateral approach, anterior approach, medial approach.[29]
Complications of supracondylar fractures may be present before or after management and consists of neurovascular injury, compartment syndrome, pin migration, infection, elbow stiffness, malunion and myositis ossificans.[30] Malunion is the most common late complication after supracondylar fracture,[31] fortunately with the modern surgical techniques, the incidence of Malunion decreased to around 3%, Malunion after surgical treatment is usually occur because of under correction of the sideways angulation and rotation.[32,33]
In this study, we did study the occurrence of malunion complication after management of the supracondylar fracture type II and type III Gartland by closed reduction and k. wire pinning compared to open reduction via lateral approach with k. wire pinning. We used Flynn's criteria system for grading of the outcome (Figure 1).[34]

Result	Rating	Cosmetic factor (carrying angle loss) (degrees)	Functional factor (motion loss) (degrees)
Satisfactory	Excellent	0–5	0–5
	Good	5–10	5–10
Unsatisfactory	Fair	10–15	10–15
	Poor	Over 15	Over 15

Figure 1 Flynn's criteria for grading of the outcome

Methods

Study design

The study is a prospective comparative clinical study, aimed to compare the incidence of Malunion after surgical treatment of children supracondylar humeral fracture by close reduction and K. wire fixation versus open reduction-lateral approach and K. wire fixation. The study carried out at East Erbil Emergency Hospital, conducted for a period of 1 year from March 2021 to March 2022 on 49 selected children (divided into 2 groups); The first group comprised 25 children who underwent closed reduction and K-wire fixation, while the second group included 24 children treated with open reduction via a lateral approach and K-wire fixation.
Children, who presented to emergency department with Gartland type II and Type III fracture Supracondylar, underwent treatment by operation and surgical consent taken from parents and agreed to be included in this study, have been enlisted via method of convenient sampling. Information according to a questionnaire collected from the parents of the patients, more data taken from the file of the patients about the intra operative details from the operation data sheets, then after subjected them to data analysis. Patients followed up and reviewed after 12 weeks, during these reviews, assessment of the patient done for possible complications postoperatively and

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measured any possible change of degrees of carrying angle and movement loss at the elbow considering the malunion (cubitus varus) complication.

Inclusion Criteria

1. Children who have extension category of fracture supracondylar of the humerus.
2. Children who have Gartland type II and type III fracture supracondylar of the humerus.
3. Patients who had operative treatment of their fractures and parents gave assent to be included in the study.

Exclusion Criteria

1. Patients who had fractures bilaterally.
2. Open fracture.
3. Presence of vascular injury before operation.
4. Presence of injury of nerve before operation.
5. Patient whose parents refused to be enrolled or withdrew from the study.

Dependent Variables

1. Evaluation of cosmetic factor by Flynn's Criteria after 12 weeks.
2. Evaluation of functional factor by Flynn's Criteria after 12 weeks.

Independent Variables

1. Age.
2. Gender.
3. Injury Mechanism.
4. Affected limb swelling.
5. Gartland classification of the fracture.
6. Surgical approach.

Operative Procedure

Operative technique in group 1 (closed reduction and K. wire pining)

After induction of general anesthesia, we positioned the patient supine and the elbow on an inverted image intensifier, humeral countertraction plus forearm traction applied for reduction, fracture examined using image intensifier and visual comparison with the normal side to check the carrying angle. With elbow in extension, rotational malalignment, medial and lateral translation corrected. Once this is corrected, traction kept on the elbow and gently flexed to 120 degrees. While flexing elbow, pressure put on the olecranon directed anteriorly to correct extension of the distal fragment. Maximal elbow flexion and forearm pronation used for locking medial and posterior soft-tissue hinges, distal pulse checked for competency. After reduction, the fracture fixed by either two or three lateral parallel K. wires or two medial and lateral crossing K. wires percutaneous. K. wires cut short, bent, and left prominent to be removed easily. Long arm splint for flexed elbow to 80° and neutral rotation of forearm applied. Postoperative radiographs obtained and documented. After 4 weeks the K. wires removed then started physiotherapy.

Operative technique in group 2 (open reduction via Lateral Approach and K. wire pinning)

The patients operated in supine position. General anesthesia induced, and then tourniquet applied to the arm. After preparation and draping, a lateral incision made starting from lateral epicondyle and extending proximally for 3-4 cm. Dissection between the triceps and the origin of the brachioradialis muscles done, hematoma evacuated, fracture site exposed and open reduction performed the fixed by K. wires like what done for first group. Tourniquet removed, the wound washed with saline, hemostasis done then closure of muscle and fascia done in layers by interrupted vicryl sutures. Subcutaneous tissue closed by vicryl then skin by continuous nylon sutures. Wires cut short, bent, and for easy removal left proud.

Long arm splint for flexed elbow to 80° and neutral rotation of forearm applied. Postoperative X-ray obtained and documented. 4 weeks later, wires removed and physiotherapy started.

Follow up Plan: Patients had been followed-up after 12 weeks from the surgery and assessment by goniometer of the functional and cosmetic factors using Flynn's criteria recorded. A data collection sheet had been used in the review. Management outcomes assessed as per Flynn's criteria in terms of cosmetic and functional factor, with angles documented

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by goniometer, to assess for malunion complication.

Ethical consideration

Ethical approval obtained (meeting code: 8, paper code: 16, date: 11/9/2022) from Hawler Medical University, Medical College, post graduate department, General Surgery department. Permissions obtained from Management department and Orthopedic Department of East Erbil Emergency hospital to carry out the research and informed parental assent obtained. Information pertaining to patient identity (name, age and file number) kept confidential. There are no any anticipated ethical risks because standard methods of care for operative management are employed. Study information had been made clear for the parents and it had been explained that their participation in the study is purely voluntary and there are no monetary benefits for them or for researcher. They were able to withdraw from the study at any time, without any prejudice to further medical care. Patients meeting eligibility criteria been recruited. Only serially coded numbers are used to identify all data entry on data collecting forms.

Statistical analysis

Data were analyzed using the Statistical Package for Social Sciences (SPSS, version 25). Chi square test of association was used to compare proportions. Fisher's exact test was used when the expected frequency (value) was less than 5 of more than 20% of the cells of the table. Mann Whitney test was used to compare the mean ranks of the scores of two groups. A *P*-value of ≤0.05 was considered as statistically significant.

Results

Forty-nine patients with supracondylar fracture of humerus took part in the study, 25 were treated by closed reduction, and 24 were treated with open reduction. The mean age (SD) of patients was 5.7 (2.5) years, the median was 5.5 years, and the age range was 2-10 years. The largest proportion of the sample (38.8%) were aged 5-7 years, but no significant difference between the study groups noticed in the age distribution (*P* = 0.452). Around half (49%) of the patients were males, and most of the fractures (69.4%) were on the right side, but there were no significant differences between the two groups regarding gender and side of the fracture (*P* = 0.477 and *P* = 0.830 respectively) as presented in (Table 1).

More than half (58.3%) of the fractures treated with open reduction were of type III, compared with 24% of type III fractures treated with closed reduction (*P* = 0.008). Around half (46.9%) of the fractures were operated in the same day, and the rest were managed next day, but the difference was not significant between the groups (*P* = 0.674) as presented in (Table 1).

It is clear in Table 2 that there were no significant differences between the two groups about the differences in the mean ranks of the following variables: right carrying angle (*P* = 0.676), left carrying angle (*P* = 0.943), right flexion range (*P* = 0.497), and left flexion range (*P* = 0.261) (Table 2).

[Extension range will not be affected by cubitus varus].

The flexion range of motion was excellent in 61.2% of the patients, but no significant difference observed between the two management methods (*P* = 0.661).

Carrying angle was excellent in 93.9% of the patients (100% in open reduction and 88% in closed reduction groups) but the difference was not significant (*P* = 0.235) (Table 3).

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Table 1 Basic characteristic

	Closed reduction No. (%)	Open reduction No. (%)	Total No. (%)	*P**
Age (years)				
2-4	8 (32.0)	10 (41.7)	18 (36.7)	
5-7	9 (36.0)	10 (41.7)	19 (38.8)	
8-10	8 (32.0)	4 (16.7)	12 (24.5)	0.452
Gender				
Male	11 (44.0)	13 (54.2)	24 (49.0)	
Female	14 (56.0)	11 (45.8)	25 (51.0)	0.477
Side				
Right	17 (68.0)	17 (70.8)	34 (69.4)	
Left	8 (32.0)	7 (29.2)	15 (30.6)	0.830
Fracture type				
Type 2A	9 (36.0)	1 (4.2)	10 (20.4)	
Type 2B	10 (40.0)	9 (37.5)	19 (38.8)	
Type 3	6 (24.0)	14 (58.3)	20 (40.8)	0.008
Time to surgery				
Operated in the same day	11 (44.0)	12 (50.0)	23 (46.9)	
Operated next day	14 (56.0)	12 (50.0)	26 (53.1)	0.674
Total	25 (100.0)	24 (100.0)	49 (100.0)	

*By Chi square test.

Table 2 Means of carrying angle and flexion range by type of management

	Closed reduction		Open reduction		
	Mean	(SD)	Mean	(SD)	*P**
Carrying angle (right)	6.76	(7.24)	9.21	(1.86)	0.676
Carrying angle (left)	9.20	(1.91)	9.25	(2.04)	0.943
Flexion range (right)	135.40	(4.98)	134.58	(4.14)	0.497
Flexion range (left)	135.80	(5.89)	134.17	(4.08)	0.261

*By Mann Whitney test.

Table 3 Outcomes of management by closed and open reduction

	Closed reduction No. (%)	Open reduction No. (%)	Total No. (%)	*P- value*
Flexion range of motion				
Excellent	14 (56.0)	16 (66.7)	30 (61.2)	
Good	10 (40.0)	8 (33.3)	18 (36.7)	
Fair	1 (4.0)	0 (0.0)	1 (2.0)	0.661*
Carrying angle				
Excellent	22 (88.0)	24 (100.0)	46 (93.9)	
Poor	3 (12.0)	0 (0.0)	3 (6.1)	0.235*
	25 (100.0)	24 (100.0)	49 (100.0)	

*By Fisher's exact test.

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Discussion

In our study, 49 child patients with fracture supracondylar type II and III were enrolled who were treated surgically, 25 of them were treated by closed reduction and K. wire fixation (group 1) and 24 patients been treated by open reduction by lateral approach then fixed with K. wires (group 2). The age distribution of this study ranged from 2-10 years with the mean age of 5.7 years and most of the patients' age been distributed from 5-7 which is correspondence with the peak age incidence of supracondylar fractures is children.[22] As the *P* value of the age distribution was (*P* = 0.452), so it show significant difference in the age distribution between the groups in the study. 49% of the patients were males and 51% were female which comparable to the results of LiBrizzi, Christa L et al. that showed 48% of the patients were males, and it is not as what had been thought previously that this injury does occur more often in male gender, but there was no significant difference between the groups as the *P* value showed (*P* = 0.477).[35] More than 69% of the affected side is right side, which is not like Barr et al. who found majority of the affected side were left side, but in our study, did not show significant difference between the groups.[36] Fracture patterns included are type IIA, type IIB and type III, and the result showed that most of the cases were type III with a significant *P* value (*P* = 0.008), and the distribution of the fracture type were (20.4%, 38.8% and 40.8%) respectively for type IIA, IIB and III. The mean rank of the following variables; right carrying angle, left carrying angle, right flexion range and left flexion range were not significant between the two groups as the P values were: (*P* = 0.676), (*P* = 0.943), (*P* = 0.497), (*P* = 0.261) respectively. In this study, evaluation of the outcomes of the surgery has done using Flynn's criteria system (Figure 1).[34] the evaluation concerned about functional (range of flexion of elbow joint) and cosmetic (carrying angle) parameters.

According to Flynn's criteria, the measurement parameters being categorized as following; 0-5 degree difference from the affected side to the normal side, regarded as excellent, difference of 5-10 degrees regarded as good, 10-15 degrees is fair and >15 degrees difference with the normal side is poor outcome. In our study, about outcome of the first group, the result showed as follow; 56% of the cases showed excellent result concerning the range of flexion of elbow (functional range of motion) with 40% good results and only 4% fair results, but there is no poor results, and concerning the carrying angle (cosmetic factor), the result showed 88% excellent results with 12% poor results but there is no good and fair results. In the second group, the result is as follow: 66.7% showed excellent results about range of flexion comparing to the normal side and 33.3% showed good results by comparison with the range of flexion of the normal side, there is no fair and poor results in this group about the range of flexion of elbow. Regarding the cosmetic factor (carrying angle), the result showed; all the cases had excellent result in comparison to the normal side.

As it is shown in the result, there are 12% poor outcomes in cosmetic factor in the first group which means that the first group has 12% malunion complication, but no significant difference observed between the two groups as *P* value shows (*P* = 0.235). The *P* value could be because of small sample size, but if we consider the incidence of malunion complication postoperatively which is about 3%, then we must pay attention to the results.

Conclusion

Our study concluded that the incidence of malunion in the treatment of supracondylar fracture of humerus in children treated by close reduction and K. wire fixation is more than in cases treated with open reduction, lateral approach with K. wire fixation, although that in our study, statistically not

significant which is could be because of small sample size. Although, none of the cases showed any other complications at the time of review like nerve injury, compartment syndrome or infection, but we did consider mainly Malunion in this article. Our recommendations will go for researching with bigger sample size, also, Surgeons pay attention to any case with difficulty in reduction or stabilization and consider malrotation and angulation and if needed proceed for open reduction and K. wire fixation via lateral approach.

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Competing interests

The authors declare that they have no competing interests.

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