Journal of Population Therapeutics & Clinical Pharmacology

COMPARISON OF PARALLEL VERSES CROSS K-WIRE FIXATION IN DISPLACED SUPRACONDYLAR FRACTURE OF HUMERUS IN CHILDREN

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ABSTRACT

Introduction: Percutaneous K-wiring is the most widely advocated method to stabilize displaced supracondylar fractures after reduction. There is no clear consensus on the configuration of K-wiring. Commonly used configurations include a crossed configuration with a medial and a lateral K-wire, and lateral configuration with two lateral K-wires. Many investigators have used two crossed pins: one introduced medially and one laterally. Few have used two or three lateral pins without any medial pin. The optimal configuration of percutaneous pin fixation is however debatable.
Objectives: To compare the efficacy in cross and parallel k-wire fixation of supracondylar fracture of humerus in children.
Study design: Randomized Controlled Trial.
Settings: Department of Orthopaedics. Allied Hospital, Faisalabad.
Study duration: 20th July 2021 to 19th January 2022.
Materials & Methods: Total 220 (110 in each group) patients with supracondylar fracture of humerus of either gender with age range of 5-16 years were selected. Patients presented late after injury resulting in non-union or mal-union of fracture and hypocalcemia were excluded. They were divided into two equal groups: Group A: Cross K Wire fixation of supracondylar fracture of humerus. Group B: Parallel K Wire fixation of supracondylar fracture of humerus. Efficacy assessed according to flynn's criteria as mentioned in operational definitions and it was assessed

regularly at 12 weeks postoperatively on follow up
Results: My study has shown 91 (82.73%) patients with excellent results, 15 (13.64%) with good result, 04 (3.64%) had fair and 00 (0.0%) patients with poor result in cross k-wire fixation method (group A) whereas in patients who had parallel k-wire fixation (group B), 62 (56.36%) with excellent results, 28 (25.45%) had good results, 10 (9.09%) had fair and 10 (9.09%) had poor results (p-value=0.0001).
Conclusion: This study concluded that cross k-wire fixation method is better as compared to parallel k-wire fixation in terms of minimal loss of carrying angle of elbow and range of motion at elbow joint in patients with supracondylar fracture of humerus.
Keywords: supracondylar fracture of humerus, cross k-wire fixation, outcome.

INTRODUCTION

Distal humerus fractures in adults are relatively uncommon injuries, representing only about 3% of all fractures in adults. In a study of 4536 consecutive fractures in adults seen in the Massachusetts General Hospital emergency department, only 0.31% were supracondylar (bicolumn) fractures of the distal humerus. Although these injuries are relatively rare, most orthopedic surgeons are called upon to evaluate and treat patients with these injuries and, therefore, must be equipped to achieve optimal outcomes. [1, 2, 3]. Supracondylar fractures are common in children and are associated with significant morbidity.[4] Eighty-five percent of children are between 4-11 years of age. It accounts for around 6 % of all pediatrics fractures.[5] Management of these fractures aims at avoiding early and late complications.[6]
The efficacy of closed k-wiring in cross manner was 66.6% while in parallel k-wiring the efficacy was 50%. In 1936, Reich originally classified these fractures into T and Y variations.[8] In 1969, Riseborough and Raidin described four categories based on degree of displacement, comminution, and rotation.[9] Percutaneous K-wiring is the most widely advocated method to stabilize displaced supracondylar fractures after reduction. There is no clear consensus on the configuration of K-wiring. Commonly used configurations include a crossed configuration with a medial and a lateral K-wire, and lateral configuration with two lateral K-wires.[10]

HUMERUS ANATOMY:

The humerus is the largest bone of the upper extremity and defines the human brachium (arm). It articulates proximally with the glenoid via the glenohumeral (GH) joint and distally with the radius and ulna at the elbow joint. The most proximal portion of the humerus is the head of the humerus, which forms a ball and socket joint with the glenoid cavity on the scapula.[12] Continuing distally is the cylindrical-shaped shaft of the humerus, which contains a deltoid tubercle on its lateral aspect and a radial groove on its posterior aspect (also referred to as the spiral groove).[13] At the distal portion of the humerus, there exists a widening of the bone that forms the medial and lateral epicondyles. The distal portion of the humerus ends with an area referred to as the condyle, which is composed of the trochlea, capitulum, olecranon, coronoid and radial fossae.[14]
. The coronoid fossa is located superior to the trochlea and accommodates the coronoid process of the ulna and superior to the capitulum on the anterior surface of the condyle, which is the radial fossa which receives with the head of the radius, both upon flexion of the elbow joint. On the posterior surface of the condyle is the olecranon fossa, which articulates with the olecranon of the ulnar bone upon flexion of the elbow joint.[15]

Structure and Function:

The humeral head articulates with the glenoid fossa of the scapula and forms the glenohumeral joint, a synovial ball and socket joint.[16] The glenohumeral joint contains multiple synovial bursae that allow frictionless mobility, including the subacromial, subdeltoid, subcoracoid, and coracobrachial

bursae.[17] The coracoacromial and acromioclavicular ligaments stabilize the GH joint; these prevent proximal migration of the humerus.[18] Articulation of the capitellum and trochlea of the humerus with the head of the radius bone and trochlear notch of the ulna forms the elbow joint, a synovial hinge joint. This joint is stabilized by the ulnar (medial) collateral ligament and radial (lateral) collateral ligament complexes.[19]

Surgical Considerations:

Elderly patients who fall on their shoulders or land on their outstretched arm can sustain proximal humeral fractures.[44] This injury presents with shoulder pain and immobility of the extremity. Multiple fragmentations of these proximal fractures can also lead to post-traumatic osteonecrosis, which can cause long-term morbidity.[45] The majority of proximal humerus fractures receive non-operative treatment. However, elderly patients with severe displacement can benefit from operative intervention, as these patients have limited bone remodeling and growth. Internal fixation via smooth wires, threaded wires, cannulated screws and intramedullary nailing are interventional choices.[46] A reverse shoulder arthroplasty is also an option for proximal humerus fracture in the elderly, glenohumeral dislocations, rotator cuff tears, or joint disease.[47] Shoulder arthroplasty can also be indicated for shoulder osteoarthritis, inflammatory arthritis.[48] Anterior dislocation of the glenohumeral joint is common among young and active patients.[49] The greater tuberosity of the humerus is susceptible to displacement fractures, which can affect the rotator cuff muscles and also cause subacromial impingement. Surgical intervention is usually required with displacements greater than 3 mm.[50]

Conditions of the Shoulder:

Conditions such as calcific tendinitis of the rotator cuff and adhesive capsulitis of the shoulder (i.e., frozen shoulder syndrome) are relatively common conditions with controversial and/or multifactorial etiologies.[56] Treatment consists of rest and exercise, with little need for operative intervention. However, surgical management of frozen shoulder syndrome can occur via infiltration brisement under general anesthesia.

Metastatic Disease:

Metastatic bone disease causes destructive bone lesions and significant localized pain, most often in the humerus. Lesions can increase the risk of a fracture within the humerus.[57] In patients with lesions less than 50% of the cortex, treatment is done via external beam irradiation. However, with destructive lesions involving more than half the cortex, treatment consists of intramedullary nailing with postoperative external beam irradiation. Bone resection/reconstruction may be indicated in the instance where the disease persists.

Supracondylar Fractures of the Distal Humerus:

This fracture is the most common elbow fracture in the pediatric population. The fracture location is superior to the medial and lateral condyles and epicondyles. Supracondylar fractures of the distal humerus by the elbow joint can compromise nerve and vasculature depending on its displacement. Anterior displacement puts the median nerve and brachial artery at risk. Posterior displacement puts the radial artery at risk. Palpation of distal pulses and capillary refill should be part of the initial workup to survey for preserved blood supply. Anteroposterior and lateral radiographs are necessary for accurate diagnosis and treatment. Nondisplaced fractures are treated initially with a posterior splint and eventual casting. Displaced fractures are reduced, and pinned percutaneously. Malunion, compartment syndrome, and neurovascular complications are morbidities related to this fracture.[58]

OBJECTIVES

The objective of the study was:

"To compare the efficacy in cross and parallel k-wire fixation of supracondylar fracture of humerus in children."

OPERATIONAL DEFINITIONS:

Supracondylar Fracture: A supracondylar humerus fracture is a fracture of the distal humerus just

above the elbow joint. The fracture is usually transverse or oblique and above the medial and lateral condyles and epicondyles. It was diagnosed on plain X ray of arm.

Efficacy: It was assessed by using Flynn's criteria for loss of carrying angle and loss of range of motion at 12th week. Excellent outcome according to Flynn's criteria was taken as efficacy.

Grading	Loss of Carrying Angle of Elbow	Loss of ROM at Elbow
Excellent	0-5 ˚	0-5 ˚
Good	6-9 ˚	6-9 ˚
Fair	10-15 ˚	10-15 ˚
Poor	>15˚	>15˚

Table: Flynn's Criteria

HYPOTHESIS:

Cross k-wire fixation method is better as compared to parallel k-wire fixation in terms of minimal loss of carrying angle of elbow and range of motion at elbow joint in patients with supracondylar fracture of humerus.

MATERIALS & METHODS

STUDY DESIGN:

Randomized Controlled Trial.

SETTING:

Department of Orthopaedics, Allied Hospital, Faisalabad.

DURATION OF STUDY:

20th July 2021 to 19th January 2022.

SAMPLE SIZE:

By using WHO sample size calculator for 2 proportions

P1= 66.66%[5]

P2= 50%[5]

Power of Study= 80%

Level of Significance= 5%

Sample Size =220 (110 in each group)

SAMPLE TECHNIQUE:

Non-probability, consecutive sampling.

SAMPLE SELECTION:

Inclusion Criteria:

Children with supracondylar fracture of humerus of either gender with age range of 5-16 years.

Children with fracture either due to fall from height or road traffic accident.

Exclusion Criteria:

Patients presented late after injury resulting in non-union or mal-union of fracture.

Patients with hypocalcaemia.

DATA COLLECTION PROCEDURE:

Permission was sought from Hospital Ethical Committee. Children with diagnosis of supracondylar fracture of humerus were collected from Accident & Emergency Department of Allied Hospital, Faisalabad. Written informed consent was taken from all the patients undergoing surgery. The qualifying patients were informed of the risk and benefits of procedure and asked to sign a detailed informed consent in their respective native language. They were divided into two equal groups:

Group A: Cross K Wire fixation of supracondylar fracture of humerus.

Group B: Parallel K Wire fixation of supracondylar fracture of humerus.

110 patients were included in each group using a computer-generated random number.
Efficacy assessed according to flynn's criteria as mentioned in operational definitions and it was assessed regularly at 12 weeks postoperatively on follow up.

DATA ANALYSIS PROCEDURE:

All the collected information was analyzed by SPSS version 23. Mean and standard deviation were calculated for all quantitative variables like age and serum calcium level. Frequency and percentage were calculated for all qualitative variables like gender, mode of injury and efficacy. Chi-square test was used to compare efficacy between two groups.
Effect modifiers like age, gender, mode of injury and serum calcium level were controlled by stratification. Post stratification chi-square test was applied. p-value ≤ 0.05 was taken as significant.

RESULTS

Age range in this study was from 5 to 16 years with mean age of 10.32 ± 2.46 years. The mean age of patients in group A was 10.28 ± 2.45 years and in group B was 10.44 ± 2.54 years. Majority of the patients 119 (54.09%) were between 11 to 16 years of age as shown in Table II. Out of these 220 patients, 174 (79.09%) were male and 46 (20.91%) were females with ratio of 3.8:1 (Table III). Distribution of patients according to mode is shown in Table IV. Mean serum calcium levels were 9.57 ± 0.39 mg/dl (Table V).
My study has shown 91 (82.73%) patients with excellent results, 15 (13.64%) with good result, 04 (3.64%) had fair and 00 (0.0%) patients with poor result in cross k-wire fixation method (group A) whereas in patients who had parallel k-wire fixation (group B), 62 (56.36%) with excellent results, 28 (25.45%) had good results, 10 (9.09%) had fair and 10 (9.09%) had poor results as shown in Table VI (p-value=0.0001). Comparison of efficacy between both Groups is shown in Table VII.
Stratification of efficacy with respect to age groups and gender is shown in Table VIII & IX respectively. Table X & Table XI have shown Stratification of efficacy with respect to mode & calcium level respectively.

Table VI: Comparison of outcome between both Groups.

	Group A (n=110)		**Group B (n=110)**		
Outcome	Frequency	%age	Frequency	%age	**P-value**
Excellent	91	82.73	62	56.36	**0.0001**
Good	15	13.64	28	25.45	
Fair	04	3.64	10	9.09	
Poor	00	0.0	10	9.09	

Table VII: Comparison of efficacy between both Groups (n=220).

		Group A (n=110)		**Group B (n=110)**	
		No. of Patients	%age	No. of Patients	%age
EFFICACY	**Yes**	91	82.73	62	56.36
	No	19	17.27	48	43.64

P value is 0.0001 which is statistically significant

Table VIII: Stratification of efficacy with respect to age groups.

Age of patients (years)	**Group A (n=110)**		**Group B (n=110)**		**p-value**
	Efficacy		**Efficacy**		
	Yes	No	Yes	No	
5-10	45 (86.54%)	07 (13.46%)	31 (63.27%)	18 (36.73%)	**0.007**
11-16	46 (79.31%)	12 (20.69%)	31 (50.82%)	30 (49.18%)	**0.001**

Table IX: Stratification of efficacy with respect to gender.

Gender	Group A (n=110)		Group B (n=110)		p-value
	Efficacy		Efficacy		
	Yes	No	Yes	No	
Male	71 (82.56%)	15 (17.44%)	50 (56.82%)	38 (43.18%)	**0.0002**
Female	20 (83.33%)	04 (16.67%)	12 (54.55%)	10 (44.45%)	**0.034**

Table X: Stratification of efficacy with respect to mode.

Mode	Group A (n=110)		Group B (n=110)		p-value
	Efficacy		Efficacy		
	Yes	No	Yes	No	
RTA	26 (70.27%)	11 (29.73%)	23 (69.70%)	10 (30.30%)	**0.958**
Fall	65 (89.04%)	08 (10.96%)	39 (50.65%)	38 (49.35%)	**0.0001**

Table XI: Stratification of efficacy with respect to serum calcium levels.

Serum calcium (mg/dl)	Group A (n=110)		Group B (n=110)		p-value
	Efficacy		Efficacy		
	Yes	No	Yes	No	
≤9.5	36 (90.0%)	04 (10.0%)	27 (62.79%)	16 (37.21%)	**0.004**
>9.5	55 (78.57%)	15 (21.43%)	35 (52.24%)	32 (47.76%)	**0.001**

DISCUSSION

Supracondylar fractures of the humerus represent 50-70% of all elbow fracture in children in the first decade of life.[85] Current method of treatment of this fracture is based on Gartland classification. Flynn et al., reported the incidence of cubitus varus deformity after treatment was 5%, whereas Arino et al., reported that it was almost 21%, ulnar nerve deficit was found in 15% of patients who were treated with medial and lateral pin as per the report of chai.[86-89] Many different methods are described such as close reduction and long arm cast or slab, Dunlop skin traction, olecranon traction, but all of these methods had large complication rate.[85-90] The current preferred method of treatment for displaced Supracondylar fracture has been close reduction and percutaneous pin fixation. This method has given excellent results reported by various authors.[91-94]

I have conducted this study to compare the efficacy in cross and parallel k-wire fixation of supracondylar fracture of humerus in children. My study has shown 91 (82.73%) patients with excellent results, 15 (13.64%) with good result, 04 (3.64%) had fair and 00 (0.0%) patients with poor result in cross k-wire fixation method (group A) whereas in patients who had parallel k-wire fixation (group B), 62 (56.36%) with excellent results, 28 (25.45%) had good results, 10 (9.09%) had fair and 10 (9.09%) had poor results (p-value=0.0001). In a study, the efficacy of closed k-wiring in cross manner was 66.6% while in parallel k-wiring the efficacy was 50%.[4]

According to earlier studies, the advantage of medial–lateral entry pin fixation is that there is increased biomechanical stability as compared to the lateral pin[95,96], although iatrogenic ulnar nerve injury may result from placement of the medial pin.[97] On the other hand, the advantage of lateral entry pin fixation is avoidance of iatrogenic ulnar nerve injury, although the construct may be biomechanically less stable[98-100] It does not provide torsional stability. A biomechanical study by Zionts et al[101] demonstrated that crossed pinning is more stable than lateral pinning as far as rotational, varus and valgus stability is concerned. However, a study by Skaggs et al[102] demonstrated no clinical difference in stability between crossed and lateral pins.

According to a study in 2011, medial and lateral cross k-wires fixation group gave 72% excellent and 28% good results, while similar outcome were found in 2 lateral k-wires group.[103] The cross wires have been demonstrated in biomechanical studies and clinical trials to be more stable configuration than others. Conversely, lateral pins have been used by all except to avoid ulnar nerve injury, however it is considered less stable biochemically.[104]

Authors who advocate the use of crossed wires defend the high rate of satisfactory results, as a consequence of the greater stability with restored anatomy, due to the strength applied medially through elastic deformation of the wire, known as the “spring effect”.[105] A reduced arc of flexion-extension was observed in two patients (10%), who had 100° flexion at the time of assessment. It is believed that the short follow-up period of these patients (one year and six months, and two years and six months) is responsible for the high reduction rate of the observed flexion-extension, since mobility can be recovered partially or totally within a period of up to four years.[106]

In their study Kallio et al. showed a reduction loss in 14% (eleven) of eighty cases where fixation of fracture was done by two lateral pins.[107] According to the them loss of fixation was mainly due to technical errors, such as inability to engage the proximal and distal cortices and the K wires crossing at the fracture site. In contrast Skaggs et al. found not a single loss of reduction in fifty-five type-III fractures with the use of two or three lateral entry pins.[108] In a recent quantitative analysis that collected data of 1680 patients from thirty-three studies, all of

them passed the eligibility criteria, the displacement rate following lateral entry pin fixation was 2.1% (18). The risk of loss of reduction or displacement following lateral entry K wire fixation can be minimized by emphasizing proper pin-placement technique with the wires being divergent, pins should engage the lateral and central columns, and if required a third lateral wire can be used.[108]

Arino et al[109] reported that two lateral K-wires in fracture in parallel or divergent pattern could reduce the iatrogenic ulnar nerve injury. Srikumaran et al.[110] reported that K-wires in two lateral with 1 medial configuration provided more stable reduction than the two K-wires in a lateral divergent configuration Basaran et al. reported that according to Flynn's criteria, 32 (88.9%) in 36 patients presented excellent and good functional results by closed reduction and K-wires fixation.[111] Silva et al[112] reported two lateral adding a medial K-wires increased torsional stiffness and bending stiffness. Zionts et al[113] demonstrated that two crossed K-wires fixation could provide more stable torsional fixation than three lateral K-wires, which was similar to the result in Lee et al. study.[114]

Lee et al.[115] stated that the lateral pinning technique was found to be more beneficial than the medial and lateral crossed pinning technique for Supracondylar fractures of the humerus in children. Dua et al.[116] proposed that closed reduction and crossed pinning of displaced Supracondylar fractures of humerus in children is a safe and effective method even with delayed presentation. Erpelding et al.[117] stated that Open treatment of distal humeral fractures with an extensor mechanism-on approach results in excellent healing, a mean elbow flexion-extension arc exceeding 100°, and maintenance of 90% of elbow extension strength compared with that of the contra lateral, normal elbow. Woratanara et al[118] stated that lateral pinning is preferable to cross pinning for fixation of pediatric Supracondylar humerus fractures as a result of decreased risk of ulnar nerve injury. The main goal of the treatment of displaced paediatric Supracondylar humerus fractures is to achieve an anatomic reduction. This reduction should be supported by a fixation with a good stability and less morbidity. When all these are taken into consideration, we believe that closed reduction and percutaneous lateral pinning is an efficient, reliable and safe method.

CONCLUSION

This study concluded that the cross k-wire fixation method is better as compared to parallel k-wire fixation in terms of minimal loss of carrying angle of elbow and range of motion at elbow joint in patients with supracondylar fracture of humerus. So, we recommend that cross k-wire fixation method in supracondylar fracture of humerus in children should be used routinely in order to reduce the morbidity of community.

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