

To Determine the Functional Outcome Resulting from Changes in the Carrying Angle after Supracondylar Humeral Fractures in Children: A Retrospective Study

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Received: 11-02-2024 / Revised: 14-03-2024 / Accepted: 24-04-2024

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Conflict of interest: Nil

Abstract

Aim: To determine the functional outcome resulting from changes in the carrying angle after supracondylar humeral fractures in children.

Material and Methods: This retrospective study was conducted in the Department of Orthopaedics, SKMCH, Muzaffarpur, Bihar, India for six months. 21 children aged more than 5 years to 12 years old, having supracondylar humeral closed fractures within one week from the injury and treated by closed reduction and fixed by two percutaneous K-wires applied from the lateral side, had change of elbow carrying angle in contrast to the other side at the end of minimum follow up period (twelve months after fixation of the fracture) were included in this study. All patients were subjected to clinical assessment, physical examination, and radiological evaluation. All patients had treatment utilizing a closed reduction and two Kirschner wires inserted from the side.

Results: The study involved 21 patients with an average age of 6.81 years (SD \pm 1.60 years). The majority were boys (57.14%) compared to girls (42.86%). Fractures were predominantly on the right side (61.90%), and all patients were right-handed. Most fractures were of the extension type (90.48%), commonly caused by a fall on an outstretched hand (FOOSH) at ground level (90.48%). Surgical fixation occurred mostly on the first day of the fracture (57.14%), with some on the second (38.10%) or third day (4.76%). The mean operative time was 54.52 minutes (SD \pm 6.87). Patients typically wore splints for 4.10 weeks (SD \pm 0.44) and had pins removed on average after 2.62 weeks (SD \pm 0.50). Regarding elbow changes post-treatment: Carrying Angle Change: Most patients (80.95%) had a change of 0-5 degrees, indicating minimal deviation. Elbow Flexion Change: The majority (76.19%) experienced an improvement of 0-5 degrees. Elbow Extension Change: Similarly, 71.43% showed improvement of 0-5 degrees in extension.

Conclusions: The carrying angle changes following supracondylar humeral fractures managed by closed reduction and K-wires fixation are resulting in satisfactory outcomes represented in good functional outcomes.

Keywords: Carrying angle changes, Supracondylar, Humeral fractures, Children.

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Introduction

The carrying angle is an important determinant of elbow joint alignment and functional results in children with supracondylar humeral fractures. Supracondylar humeral fractures are often occurring injuries in paediatric orthopaedics, which may lead to severe morbidity and probable long-term effects if not treated adequately. The carrying angle, which is the angle produced between the humerus and ulna at the elbow joint, is crucial for the biomechanics and stability of the upper limb. Changes in this angle caused by fractures may result in conditions such cubitus varus or valgus, which can impact the range of motion and general

function of the joint. Recent research has examined different facets of these alterations, including their influence on patient recuperation, surgical results, and rehabilitation approaches. [1,2] Contemporary studies emphasize the significance of accurate fracture reduction and stabilization methods in order to restore the typical carrying angle and avoid abnormalities. The objective of advancements in surgical methods, such as less invasive procedures and early mobilization guidelines, is to reduce problems and enhance functional recovery in paediatric patients. Furthermore, research has investigated the prognostic indicators for alterations in carrying angle, including

characteristics such as the kind of fracture, initial displacement, and the time of surgical intervention. There has been a longstanding assumption that alterations in CA are consistent with favourable functional results of the elbow. It is useful to examine this assumption and establish the extent of permissible alterations. [3-6] The objective of this research was to examine alterations in the carrying angle of the elbow after supracondylar humeral fractures in children, in comparison to the unaffected side. Additionally, the study aimed to evaluate the functional results associated with these potential changes.

Material and Methods

This retrospective study was conducted in the Department of Orthopaedics, SKMCH, Muzaffarpur, Bihar, India for six months. 21 children aged more than 5 years to 12 years old, having supracondylar humeral closed fractures within one week from the injury and treated by closed reduction and fixed by two percutaneous K-wires applied from the lateral side, had change of elbow carrying angle in contrast to the other side at the end of minimum follow up period (twelve months after fixation of the fracture) were included in this study.

Exclusion criteria were patients younger than 5 years and older than 12 years of age, neglected cases more than 7 days, Gartland type-I cases, irreducible fractures that necessitated open reduction, any other ipsilateral upper limb injury, open fracture, neurological and or vascular injuries. All patients were subjected to clinical assessment, physical examination, and radiological evaluation. All patients had treatment utilizing a closed reduction and two Kirschner wires inserted from the side. The approach was standardized with regard to the pin's position, size (1.6 mm–2 mm), stability on the table, elbow posture during lateral pin placement, and postoperative course. Because the patient's elbow was so little, it was suitable for surgery to place the wounded elbow on an image intensifier plate. The technique of reduction: Closed reduction was completed and verified with an image intensifier. Manual traction was used to reduce the fracture, and the medial and lateral humeral epicondyles were used to restrict the fracture's rotation while the elbow was bent at 20 degrees. The fracture was then locked in place by pronation of the forearm during flexion. Reduction acceptability was confirmed by the achievement of a normal Baumann angle on the AP view and normal anterior humeral line on the lateral view and two oblique planes to observe the medial and lateral columns under the image intensifier then, the initial K-wire is positioned against the lateral condyle without piercing the skin for fixation, and the starting point is verified under anteroposterior fluoroscopic guidance (the center of lateral condyle). Before starting the drill, press the wire into the cartilage through

the skin for optimal control. The pin is aimed 35° upwards and 10° posterior, and then the second K-wire is placed parallel, divergent or convergent to the first one and engages both medial and lateral columns. Pins should cross 1-2 cm proximal to the fracture at an angle of about 30° to the humeral shaft to engage sufficient bone in proximal and distal fragments, the reduction, the radial pulse and its quality, carrying angle are again checked. Depending on oedema and neurovascular condition, the elbow was immobilized with a posterior above-elbow splint with the elbow bent in a range of 70 to 90 degrees. K-wires (1.6 mm to 2 mm) and a Key were also utilized. Post-operative care and immobilization: For all patients we provided parenteral broad-spectrum antibiotics (Cephalosporins) started before the surgery and ended 48 hours after the surgery followed by oral antibiotics (Amoxicillin/clavulanic acid) one week postoperatively. Patients were observed for a pulse, vascular perfusion and hand swelling to exclude compartment syndrome.

Post-operative radiographs (AP & lateral & oblique views) were obtained to check fracture reduction and the position of the wires. The first postoperative visit usually was 1 week after surgery for assessment of fracture stability and pin configuration through radiographs.

Pins were taken out about 3 weeks postoperatively when radiological healing was noticed. The period of immobilization was about 4 to 5 weeks postoperatively then the slab was removed with an x-ray evaluation to ensure stability. Following the removal of the last pin, a final follow-up appointment was often made three to four weeks later. If there was a normal range of motion and no pain, the child was free to resume all activities and sports without any limitations. Methods of assessment of results and rating of outcome: With the arm fully extended and supinated, two lines were made; the first one between the midpoint of the head of the humerus (or the acromion) and the midpoint of the cubital fossa and the second one between the last point and midpoint of the wrist. A goniometer is used with its proximal arm aligned with the first line and its distal arm aligned with the second line. The resultant angle is the carrying angle this method was performed on both sides and the change between them was recorded.

Radiologically: Measured with a manual goniometer between a line passing through the mid-axis of the lower third of the humerus and another line along the mid-axis of the upper third of the forearm between the radius and ulna, passing through the superior radio-ulnar joint on the anteroposterior view. As previously noted, the two lines were stretched to meet at the center of the Trans-Epicondylar Distance (TECD). On both sides, this was done, and the difference between them was

recorded. Range of motion: Degrees of elbow flexion and extension were measured on both sides and any change was recorded using [Zero, 0-5, 5-10, 10-15, > 15 degrees] pattern. The stability of the elbow joint was assessed using Varus, Valgus stress, and Lateral Pivot Shift tests and compared to the healthy side. Muscle power was assessed by active flexion-extension of the elbow against resistance. Hand power and grip strength were measured using a handheld dynamometer. Any change between both hands was recorded. Assessment of the ulnar nerve functions: The elbow flexion test is used to check for symptoms of cubital tunnel syndrome, the patient is asked to fully flex the elbow, supinate the forearm, and extend the wrist; Results

are considered favorable if the discomfort returns or if paresthesia develops within two to three minutes. Clinical evaluation was graded utilizing the criteria of Flynn, et al. depending on carrying angle change and elbow range of flexion-extension motion loss as excellent = 0-5, good > 5-10, fair = > 10-15, poor = > 15.

Statistical Analysis: The SPSS version 26 statistical analysis program was utilized (IBM Inc., Chicago, IL, USA). Mean and standard deviation were employed to present quantitative variables (SD). Frequency and percentages (%) were employed to depict qualitative variables.

Results

Table 1: Demographics, fracture type and displacement among the studied patients

Parameters		Mean \pm SD / Range N / (%)
Age (years)		6.81 \pm 1.60
Sex	Boy	12 (57.14%)
	Girl	9 (42.86%)
Side of the arm	Right hand	13 (61.90%)
	Left hand	8 (38.10%)
Dominant hand	Right-handed	21 (100.0%)
	Left-handed	0 (0.0%)
Type of fracture	Extension Type	19 (90.48%)
	Flexion Type	2 (9.52%)
Mechanism of injury	FOOSH at ground level	19 (90.48%)
	FOOSH from a height	2 (9.52%)

The study involved 21 patients with an average age of 6.81 years (SD \pm 1.60 years). The majority were boys (57.14%) compared to girls (42.86%). Fractures were predominantly on the right side

(61.90%), and all patients were right-handed. Most fractures were of the extension type (90.48%), commonly caused by a fall on an outstretched hand (FOOSH) at ground level (90.48%).

Table 2: Surgical fixation and operative time, splint duration and post-operative pin removal among the studied patients

		Mean \pm SD / Range N / (%)
Time of surgical fixation	First day of fracture	12 (57.14%)
	On the second day of the fracture	8 (38.10%)
	On the third day of the fracture	1 (4.76%)
Operative time (min)		54.52 \pm 6.87
Splint duration (weeks)		4.10 \pm 0.44
Time of post-operative pin removal (weeks)		2.62 \pm 0.50

Surgical fixation occurred mostly on the first day of the fracture (57.14%), with some on the second (38.10%) or third day (4.76%). The mean operative time was 54.52 minutes (SD \pm 6.87). Patients typically wore splints for 4.10 weeks (SD \pm 0.44) and had pins removed on average after 2.62 weeks (SD \pm 0.50).

Table 3: Elbow changes among the studied patients compared to the opposite side

		N / (%)
Carrying angle change (degree)	> 0-5 degree	17 (80.95%)
	> 5-10 degree	3 (14.29%)
	> 10-15 degree	1 (4.76%)
Elbow flexion change (degree)	0 degree	1 (4.76%)
	> 0-5 degree	16 (76.19%)
	> 5-10 degree	4 (19.05%)
Elbow extension change (degree)	0 degree	4 (19.05%)
	> 0-5 degree	15 (71.43%)
	> 5-10 degree	2 (9.52%)

Regarding elbow changes post-treatment: Carrying Angle Change: Most patients (80.95%) had a change of 0-5 degrees, indicating minimal deviation. Elbow Flexion Change: The majority (76.19%) experienced an improvement of 0-5 degrees. Elbow Extension Change: Similarly, 71.43% showed improvement of 0-5 degrees in extension.

Table 4: Post-operative complications among the studied patients

		N / (%)
Pain	When lifting heavy objects	3 (14.29%)
	None	18 (85.71%)
Pin tract infection		1 (4.74%)
Pin migration		0 (0.00%)
Ulnar nerve affection		0 (0.00%)
Elbow joint stability	Stable	21 (100%)
	Unstable	0 (0.0%)

Post-operatively, the majority of patients reported no pain (85.71%) or experienced mild pain when lifting heavy objects (14.29%). Pin tract infection occurred in one patient (4.74%), but there were no instances of pin migration or ulnar nerve affection. All patients achieved stable elbow joint stability (100%).

Discussion

Fractures among children gain special attention due to the considerable growth potential and remodeling capacity of bones at this age. [4] The mean age of patients was 6.81 ± 1.6 years, and all of the patients were right-handed. The study showed male dominance and supracondylar fractures are more predominant among pediatric males. Similarly, Ucar, et al. [5] found that males were more predominant. In the present study the most affected arm was the dominant arm (right arm), in contrast to these findings, Baidoo, et al. [6] in their study demonstrated that the non-dominant arm (left) was the most injured. The current study showed that regarding the fracture types, the extension type was the major type of fracture. The major mechanism of injury-caused fractures was FOOSH at ground level. More than one-half of the patients in the present study had fracture fixation was on the first day of injury. The mean operative time was 55 minutes, the splint duration was 4 weeks, and for pin removal was 2.6 weeks. In this study, all 21 patients were treated with closed reduction and percutaneous fixation with 2 Kirschner wires from lateral side. Pretorius, et al. [7] in 53 pediatric patients with displaced supracondylar fractures treated with closed reduction and plaster back slab. The mean follow-up time was 12 weeks. The study demonstrated that most of the patients had satisfactory results. The study revealed that the strategy used in the treatment resulted in less satisfactory outcomes compared to closed reduction and fixation using Kirschner wires. In terms of the restoration of the carrying angle, the procedure likewise produced overall satisfactory outcomes, however only 60% of cases matched the entire Flynn criterion. Sibinski, et al. [8] there was no difference in the out-

comes between the two groups of 131 children who had crossing wires or lateral wires fixed, either clinically or radiologically. Shamma, et al. [9] Thirty children with supracondylar humerus fractures were treated using the lateral divergent (15 patients) and lateral parallel (15 patients) techniques. It was determined that both techniques produced satisfactory results in all cases and that there was no statistically significant difference between the two groups in terms of the functional outcome. Ozuturkmen, et al. [10] have evaluated closed reduction and lateral pin fixation in 39 children with displaced supracondylar fractures of the humerus. They observed that none of the children experienced problems like pinworm infections, myositis ossificans, compartment syndrome, or nerve damage and that the functional and radiological outcomes were all good (100%). Flynn et al. [11] The fixation pins do not interfere with the distal end of the humerus' ability to grow, according to a sixteen-year long-term research. On long-term follow-up, 98% of the 52 fractures had satisfactory results. There were no Volkmann's contractures observed, and there were only minimal vascular and neurological problems. As stated by Flynn's criteria for grading, the final outcomes in the present study: All cases achieved satisfactory outcomes 16(76.19%) patients had excellent outcomes, 4(19.05%) patients had good outcomes and 1(4.76%) patients had fair results whereas no cases were graded as unsatisfactory outcomes. The low changes in carrying angle, flexion and extension of the elbow reflect good cosmetics and functional outcomes these minor changes were found in patients of the current study. Changes of carrying angle from the other normal side were varus angulation in (52.38%) of patients while (47.62%) of patients had valgus change. The majority of patients in this study showed changes in carrying angle estimated between > 0-5 degrees of change and > 5-10 degrees of change, respectively; only one patient showed > 10-15 degrees of change in the carrying angle. Elbow flexion also showed a few changes; most of the patients showed changes estimated between 0-5 degrees, and the same was

found regarding elbow extension. Mehlman, et al. [12] according to Flynn's supracondylar rating scale 83% of cases had excellent and good outcomes, 14% had fair outcomes, and 3% had poor outcomes.

Baidoo, et al.⁶ reported that the majority of pediatric patients 98% with supracondylar humeral fractures showed satisfactory outcomes according to Flynn's criteria also found that Patients' quality of life decreased at the time of injury but restored to normal 6 months later; the current study showed that all parents were satisfied about the outcomes and the performance of daily activities like (comb hair, feed, hygiene, wear clothes and shoes) and during playing sports of the patients. In the present study, there was low rate of complications only one patient had a pin tract infection that resolved on oral antibiotics and three patients occasionally reported a minimal degree of dull pain that just appears when lifting heavy objects regarding to the other side which didn't affect the function. All patients showed stable elbow joint and there was no ulnar nerve affection found among the current sample. It was reported that peripheral nerve injury occurs among 10- 15% of cases having a supracondylar fracture. Moreover, anterior interosseous nerve is the most affected nerve in extension types; however, the ulnar, radial and median nerve injuries can occur. Ulnar nerve injuries are most common among patients with flexion type of supracondylar fractures. [13]

Conclusions

The carrying angle changes following supracondylar humeral fractures managed by closed reduction and K-wires fixation are resulting in satisfactory outcomes represented in good functional outcomes.

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