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ORIGINAL STUDY

Lateral versus crossed K wire fixation for displaced supracondylar fracture humerus in children: Our experience

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Lateral entry and crossed Kirschner (K) wire fixation configuration for treating displaced suprcondylar humerus fracture in children has always been shrouded in controversy as to which is superior. As the closed K wire fixation is the standard of treatment for these fractures, we performed a prospective study comparing the two methods.
A prospective study comparing any reduction loss between the two groups was undertaken. Major end points documented were loss of fracture reduction and ulnar nerve injury, in addition clinical alignment, Flynn grade, range of motion, function, and complications. The operative procedure was standardized.
Sixty two patients were studied, 32 and 30 in cross K wire and lateral K wire entry group respectively. Two cases of iatrogenic ulnar nerve injury was documented in crossed K wire fixation group but it was insignificant (p value=0.336). No significant difference was observed in terms of change in Baumann or humerocapitellar angle, carrying angle, elbow range of movement.
Both techniques are equally effective. Ulnar nerve injury can be minimized by taking certain precaution as in text.

Keywords: Supcondylar fracture humerus ; children ; fixation method ; lateral versus Cross K wiring.

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INTRODUCTION

Supracondylar fractures of humerus are the most common elbow fractures seen in children *(14)*. Most common in first decade of life and more in boys than girls *(12)*. Gartland classified these fracture as undisplaced fractures (Type I), hinged fractures with intact posterior cortex (Type II), and completely displaced fractures (Type III)7. Percutaneous K wire fixation has been the standard treatment for completely displaced supracondylar fractures of the humerus in children *(2)*.The lateral K wire configuration has the advantage of avoiding iatrogenic ulnar nerve injury but it is less stable biomechanically *(7,8,9,22)*. While the crossed K wire configuration is biomechanically more stable but is fraught with the risk of ulnar nerve injury

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(10,15,19). So in order to compare the efficacy of the two methods for fixation of displaced type 3 supracondylar humerus fracture in children this study was performed.

MATERIAL AND METHODS

This was a prospective randomized clinical study in design. It included patients between the age of 3 to 12 years presenting to our OPD and/or Casualty between January 2012 to November 2016. It included the patients presenting to four different units. All patients were operated by senior surgeon in the team of respective units.

The patients between 3-12 years of age with completely displaced type 3 supracondylar fractures (extension type) presenting to us within 72 hours post injury were included in the study. The exclusion criteria were an age of less than three years old or greater than twelve years old, those with compromised neurovascular status, those with concomitant ipsilateral wrist or forearm injury , bilateral supracondylar humeral fracture, compound fractures, fractures which required open reduction, a prior fracture of the same elbow were excluded from the study.

The fixation was carried alternately that is one patient with cross K wire and the next patient presenting to us with lateral 2 K wires irrespective of fracture comminution pattern. A major loss of reduction was defined as a change in the Baumann angle of >12° between the initial postoperative and three-month follow up radiographs *(11)*.

Surgical techniques were standardized in terms of the pin location, the pin size, the incision and position of the elbow used for medial pin placement, and the postoperative course *(11)*. All patients were operated in either general or brachial block anaesthesia. Two millimetre K wires were used in all patients for fracture fixation. For the pin construct to be considered acceptable, in lateral K wire construct one wire must pass through the lateral column of the distal humerus and the other wire should go in the central column that is through the olecranon fossa of the humerus. For the cross K wire configuration, the K wire placed from lateral side of the elbow across the lateral cortex to engage the medial cortex with the elbow being in hyperflexion. With elbow then being extended to a position of less than 90° flexion so as to avoid injury to the ulnar nerve which comes to lie anteriorly in hyperflexed position of elbow. In case of gross swelling a small incision of 1.5 to 3.0 cm was made over the medial epicondyle. Superficial dissection was performed so that the K wires were put directly over the medial epicondyle. The medial K wire was put over the medial epicondyle and proceeded to engage the lateral cortex with the elbow in a flexion of less than 90 degrees with retraction of soft tissue from the medial epicondyle. The acceptable K wire configuration was if one wire was placed in the lateral column and the other in medial or central column of the distal humerus. The K wires were bent outside skin and limb was immobilized in above elbow slab in full supination.

After surgery, neurovascular status was checked again in the ward by the operating surgeon. All the patients were followed in the respective OPD were reviewed by one of the authors. The above elbow slab was removed after 3 weeks when the clinical and radiological evidence of union was evident. The patient was called for follow up after 6 weeks and then 3 months for repeat check X- ray. Standardized AP view of the distal humerus was taken with the posterior aspect of whole arm touching the cassette. The X-ray tube was focussed over distal humerus and perpendicular to the cassette. For the lateral view, the elbow was positioned in 90 degrees of flexion and the cassette placed on the medial side of elbow joint. The X-ray tube was focussed at the elbow perpendicular to the cassette. Subsequent follow-up would be done 6-weekly. All the clinical parameters were based on the last evaluation when full range of elbow motion was achieved. We considered deviation in all these parameters at this stage due to loss of reduction. The clinical results were graded according to the criteria of Flynn et al. *(4)* which are based on the carrying angle and elbow motion. Radiographs were made post operatively after fracture fixation then at the three -week and three-month follow-up visits. The Baumann angle was calculated on the anteroposterior radiograph with the method of Williamson et al. *(20)* at the three-month follow-up examination, and any change in the Baumann angle between the post operative radiograph taken after fixation and at three-month follow up visit was recorded. Loss of reduction was determined on the basis of the change in the Baumann angle. Iatrogenic ulnar nerve injury was determined by clinical evaluation and was defined as a postoperative ulnar nerve deficit in a patient who had a normal result on the preoperative ulnar nerve examination.

Flynn's criteria for grading involved the evaluation of carrying angle loss and total range of motion loss *(4)* (Table I). In our study in place of total range of motion loss we measured loss of flexion and extension separately. We measured the change in carrying angle, loss of elbow flexion and elbow extension, decrease in Baumann angle by comparing it with the normal or uninjured side. Then we compared these values between the two fixation groups and level of significance was determined by student's t test. As the incidence of ulnar nerve injury was less in number we applied Fisher's exact test to compare the two methods of fixation.

RESULTS

Sixty six children were included in the study 34 in cross K wire group and 32 in lateral k wire entry group. Two patients from cross K wire group were lost for follow up after 1 week due their residence being in different state. Two patients from lateral K wire entry group were also lost for follow up due to unknown reasons. So we hereby give our results based on sixty two patients, 32 in cross K wire group and 30 in lateral K wire entry group. The time of presentation to the hospital following injury ranged from 45 minutes to 72 hours, with a mean duration of 6.3 hours. The mean duration of follow up of the patients was 26.45± 0.75 months.

Out of 62 patients operated 50 patients had a carrying loss ranging between 0-4.9° (Table II) which fell in excellent group. Out of these 50 patients who were in excellent group 26 were in cross K wiring group and 24 were from lateral K wiring group. Seven patients (4 cross K wire and

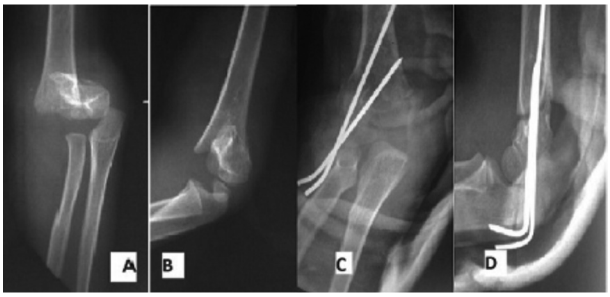

Fig. 1. — (A) and (B). Lateral and antero-posterior radiograph of 6 year old patient showing displaced supracondylar fracture with rotation; (C) and (D). Showing post operative radiograph of the patient in figure A and B showing lateral entry of the k wires which are divergent and pass through lateral and central columnof distal humerus

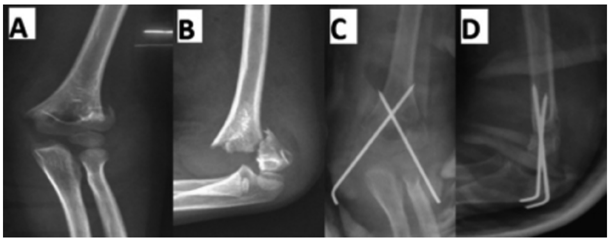

Fig. 2. — A) and (B) Show lateral and AP radiograph of another patient with displaced supracondylar fracture humerus; (C) and(D). Show post operative radiograph showing crossed entry of the k wires, in lateral and medial column

Table I. — Modified Flynn's criteria for evaluating the treatment outcome of the study.(originally it comprises of total loss of range of motion but here we divide it in between flexion and extension loss)

Result	Rating	Carrying angle loss (in degrees)	Flexion loss (in degrees)	Extension loss (in degrees)
Satisfactory	Excel-lent	0-4.9	0-4.9	0-4.9
	Good	5-9.9	5-9.9	5-9.9
	Fair	10-14.9	10-14.9	10-14.9
Unsatisfactory	Poor	≥15	≥15	≥15

Table II. — Shows comparison of loss in carrying angle between the two groups

Carrying angle loss (in degrees)	No. of patients in respective fixation groups		Total no. of patients
	Cross k wire group	Lateral k-wire group	
0-4.9	26	24	50
5-9.9	4	3	7
10-14.9	2	3	5
≥15	0	0	0
Total number of patients	32	30	62

Table III. — Shows extension loss between the two groups

Extension loss (in degrees)	No. of patients in respective fixation groups		Total no. of patients
	Cross k wire group	Lateral k-wire group	
0-4.9	16	12	28
5-9.9	10	9	19
10-14.9	5	7	12
≥15	1	2	3
Total number of patients	32	30	62

Table IV. — Flexion loss compared between the two groups

Flexion loss (in degrees)	No. of patients in respective fixation groups		Total no. of patients
	Cross k wire group	Lateral k-wire group	
0-4.9	8	6	14
5-9.9	12	10	22
10-14.9	8	11	19
≥15	4	3	7
Total number of patients	32	30	62

Table V. — Comparision of the carrying angle loss, elbow flexion and extension loss and Baumann's angle loss, and humerocapitellar angle change between the two intervention group using student's t test

Change in parameter	Cross k wire entry group (mean±SD)	2 Lateral k wire entry group (mean±SD)	P value (student t test)
Carrying angle loss (in degrees)	4.3± 2.8	4.4±2.9	0.907
Elbow flexion loss(in degrees)	8.9±4.2	9.0±4.1	0.911
Elbow extension loss(in degrees)	8.8±4.5	9.0±4.6	0.932
Decrease in Baumann's angle (in degrees)	5.2±3.2	5.6±3.8	0.695
Decrease in Humero-capitellar angle (in degrees)	5.4±4.2	5.9±4.5	0.311

3 lateral K wire entry group) had a carrying angle loss ranging between 5-9.9° that is good result. Five patients (2 in cross K wiring group and 3 in lateral K wire entry group) had a carrying angle loss in range of 10-14.9° that is fair result. No patient had poor result that is >15° loss of carrying angle.

The mean loss of elbow flexion in cross K wire entry group was 8.98±4.21° (Table III) while that in lateral K wire fixation group was 9.02±4.12°, mean loss of extension was 8.76±4.45° and 8.96±4.56° in cross K wire entry group and lateral K wire entry group respectively (Table IV). The Baumann's angle decreased by 5.2±3.2° in cross K wiring group and by 5.6±3.8° in 2 lateral K wire entry group. The humero capitellar angle decreased by 5.36±4.2° in cross K wire group and by 5.86±4.5° in 2 lateral K wire entry group. It was found that there was no significant difference between the two groups in terms of carrying angle loss, flexion – extension loss, decrease in Baumann's angle, decrease in humero-capitellar angle on applying Student's t test. (Table V).

Two ulnar nerve palsies were recorded in the cross K wiring group both of which recovered after 6 weeks follow up. However Fisher exact test was applied and it came to be insignificant (p value= 0.336)

DISCUSSION

Taking the above clinical and radiological parameters into account, there was no significant difference found between the changes in alignment at distal humerus by the employment of the two fixation methods. Intraoperatively image intensifier was used to assess the reduction and only those reduction were accepted which had normal or near normal Baumann's angle on AP and humerocapitellar angle on lateral projections. As the patients were randomized between the groups no selection bias was there to interfere with the results as well as the fixation method was also standardised and all operating surgeons followed the same operative protocol, so any change in alignment at the follow up was ascribed to the loss of reduction postoperatively. This in other terms can be accounted for as the stability of the fixation construct of the techniques. So we inferred from the study that there was no advantage of either of the fixation methods over the other in terms of stability at the fracture site.

We had a mean follow up 26.45±0.75 months and all patients achieved full range of movement at the time of final recording of the data which showed that no residual stiffness was left. So whatever loss of range of movement was present was due to the malunion at the fracture site. The malunion was measured clinically by carrying angle change and radiologically by decreased Baumann's angle in coronal plane and humero-capitellar angle in the sagittal plane. Out of 62 patients 5 patients had a decrease in carrying angle >10° (2 in cross K wire entry group and 3 in lateral K wire entry group. This either led to decrease in carrying angle or cubitus varus deformity. This would require surgical correction in order to avoid postero-lateral rotary instability in future *(13).* This instability pattern is secondary to deficiency of the ulnar part of the lateral collateral ligament. 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 *(7)*. 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 *(18)*. 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 *(8,18)*.

Various cadaveric studies and artificial paediatric bone model studies have shown that biomechanically cross K wire fixation is torsionally more rigid than the 2 lateral k wire entry group *(9,22)*. Zionts et al. *(22)* in their cadaveric simulation study of supracondylar fractures noted the torsional strengths of different pin configurations in adult human cadaver. They found that crossed pins had 25% more rigid torsional strength than three lateral pins but this difference was not significant. They also showed 37% more resistance to torsional forces in crossed pins configuration than the two parallel lateralpins these differences were significant ($p < 0.05$). So the overall strength of construct not only depends on the side of entry of k wires but also the divergence of wires and number of K wires. Divergent lateral k wires in lateral and central column provide similar stability as compared to the cross K wire construct.

There is 4.86 times higher relative risk of the ulnar nerve injury in cross k wire fixation than the lateral K wire fixation method. But this risk of iatrogenic ulnar nerve injury can be minimized by giving a small medial incision over the medial epicondyle and keeping the elbow in < 90° flexion while inserting the medial K wire1,6,17. According to Zaltz et al. *(21)* on flexing elbow to more than 90° the ulnar nerve migrated anterior to the medial epicondyle in 18% of children less than five years of age and over the epicondyle in 43%. In children ranging from six to ten years of age these rates decreased to 8% and 21% respectively decreasing further to 6% and 20% in children eleven to eighteen years age range. According to them the lateral pin needs to be inserted first so that elbow can be brought to lesser degrees of flexion while inserting the medial pin. This decreases the tractional pull on the nerve and keeps it posterior. Once the ulnar nerve has been found to be affected replacing medial K wire to other site suffices as most of the ulnar nerve injuries are neuropraxias which resolve when the tension over the nerve is relieved *(3,16)*.

The strength of our study was that it was a randomized clinical study in design. The operative techniques were standardized in terms of K wire size, location, use of medial incision, and elbow position for medial k wire placement. The weakness of our study is lack of blinding of observer while calculating the parameters considered in the study.

To conclude both the cross K wire entry and 2 lateral K wire entry method for fixing the displaced supracondylar humerus fracture appear to be effective. Ulnar nerve injury can be avoided by keeping elbow in <90° flexion while inserting medial k wire and giving a small incision over the medial epicondyle. While lateral K wire fixation care should be taken to divergently place the wires and lateral and central column should be purchased. Even after fixing with lateral or cross K wires if instability persists then addition of third K wire is advised but not incorporated in this study.

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