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An observational study on radiological and functional outcome of cross-pinning versus parallel pinning in supracondylar humerus fracture

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Abstract

Introduction Supracondylar humerus fractures are the most common elbow fractures in children, often resulting from falls on an outstretched hand. The standard treatment for displaced fractures involves closed reduction and percutaneous pinning. However, the optimal pin configuration — cross-pinning (medial-lateral) versus parallel pinning (lateral-lateral) — remains a topic of debate due to concerns regarding stability and risk of iatrogenic ulnar nerve injury.

Aims This study aims to compare the clinical and radiological outcomes of cross-pinning versus parallel pinning in the management of displaced supracondylar humerus fractures in children.

Methods A prospective observational study was conducted over 18 months at Kalpana Chawla Govt. Medical College, Karnal, Haryana. A total of 54 children aged 3–12 years with Gartland type III supracondylar humerus fractures were enrolled. Patients were divided into two groups based on the surgical technique: cross-pinning (n = 27) and parallel pinning (n = 27). Both groups were comparable in terms of demographics, mechanism of injury, and pre-operative neurovascular status. Functional and radiographic outcomes were evaluated using Flynn's criteria, Baumann's angle, carrying angle, and range of motion at follow-up intervals (3, 6, 10, 14, and 24 weeks).

Results Mean Baumann's angle, Carrying angle and range of motion showed no statistically significant differences between the two groups. At the final follow-up, 92.6 % of patients in the parallel pinning group had excellent outcomes per Flynn's criteria, compared to 51.9 % in the cross-pinning group ($p < 0.01$). One patient in the cross-pinning group developed ulnar nerve neuropraxia, whereas no cases of nerve injury were reported in the parallel pinning group.

Conclusion Parallel pinning demonstrated superior radiological and functional outcomes, with a lower risk of ulnar nerve injury compared to cross pinning. These findings suggest that parallel pinning should be the preferred method for stabilizing displaced supracondylar humerus fractures in children.

Keywords: supracondylar humerus fracture, cross-pinning, parallel pinning, Baumann's

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INTRODUCTION

Supracondylar fractures of the humerus accounts for 18 % of paediatric fractures and 60 % of elbow fractures [1]. In 1959 Dr. J.J. Gartland [2] described that even expert trauma surgeons are anxious and apprehensive while managing supracondylar humerus fractures. Despite evolutions in the evaluation and treatment over the years, these fractures still pose considerable challenges to orthopaedic surgeons. They most frequently occur in children aged 5 to 7 years. The median age is approximately six years, and the incidence gradually decreases with age [3]. Extension-type fractures are much more common than flexion-type fractures and occur as a result of a fall on an outstretched hand [4]. Flexion-type fractures are more prevalent in older children [4].

Lateral pins and crossed-pins bicortical constructs can be used to treat supracondylar humerus fractures. Lateral pin configurations are frequently used and they reduce the risk of iatrogenic ulnar nerve injury.

The use of crossed-pins increases the risk of iatrogenic ulnar nerve injury; however, they improve the torsional rigidity of the construct as compared to the use of two lateral pins. A medial incision should be made of an adequate size that will allow the protection of the ulnar nerve before inserting a medial pin. A further way to reduce the risk of iatrogenic ulnar nerve injury is to extend the elbow while inserting the medial pin [5].

There is a debate about the best management approach to treat supracondylar fractures of humerus in children. Therefore, the present study was done to compare the outcome of the cross-pinning vs parallel pinning in displaced supracondylar humerus fracture in children.

The **aim** of this study is to compare the outcome of the cross-pinning versus parallel pinning for displaced supracondylar humeral fracture in children.

MATERIAL AND METHODS

This prospective observational clinical study was conducted at the Department of Orthopedics of Kalpana Chawla Government Medical College, Karnal, India from June 2023 to April 2025 after approval of institutional ethical committee. Informed written consent was taken from all the parents of children.

Sample size was calculated by taking values from previous studies at 80 % confidence interval and 70 % power using Kelsey Formula:

$n = 2\ (Z\alpha/2 + Z\beta)^2\ P(1–P)\ /\ 1\ (P_1 – P_2)^2$;

$P = P_1 + P_2\ /\ 2 = 2 + 33.3\ /\ 2 = 17.65\ \%$,

P_2 = prevalence in cross-pinning, P_2 = prevalence in parallel pinning.

In the study by R.K. Rupesh et al. [6], prevalence in cross-pinning = 2 % and prevalence in parallel pinning = 33.3 %. $Z\alpha/2$ = standard normal variate at 95 % confidence interval and 5 % level of significance = 1.96. $Z\beta$ = standard normal variate at 80 % power = 0.84. So, $n = 2\ [(1.96 + 0.84)^2\ (0.18)\ (0.82)]/(0.31)^2 = 24$ in each group. Taking drop-out rate of 10 % sample size in each group will be = 27. Group A (cross-pinning) had 27 patients. Group B (parallel pinning) had 27 patients. The decision to undergo cross or parallel pinning was made by the operating surgeon.

Children aged between 3–12 years with Gartland type III supracondylar humeral fracture were included in the study. While children with open fractures, fractures that require open reduction, fractures with vascular injuries, previous ipsilateral elbow fracture and those presenting after three days of injury were excluded from the study. The patients underwent anteroposterior and lateral radiographs. All displaced humerus supracondylar fractures were admitted and immobilized with an above-elbow splint and limb elevation. Surgical technique was standardized in terms of pin location, pin size (for weight 20 kg size 1.5-mm K-wire and for weight > 20 kg 2-mm K-wire was used), stability on the operation table, and elbow placement position.

A senior orthopedic surgeon performed the operation. In a supine position with the injured upper limb resting on the table edge, an anesthesia was administered to all patients. A closed reduction

was performed. First, traction was applied longitudinally with the elbow in hyperextension and the forearm in supination. While maintaining traction, the medial or lateral displacement was corrected at the fracture site by administering a valgus or varus force. The posterior displacement of the distal fragment was then corrected by applying force to the posterior aspect of the fragment while the elbow was gently flexed and secured in hyperflexion and the reduction was confirmed by the image intensifier. For parallel pin fixation technique, two or three pins were inserted from the lateral aspect of the elbow across the lateral cortex in order to engage the medial cortex while maintaining hyperflexion of the elbow. At the fracture site, pins were positioned either in parallel or divergent configurations with adequate separation. For cross-pinning (medial-lateral) fixation technique, the lateral pin was inserted from the lateral cortex into the medial cortex while maintaining hyperflexion of the forearm. The medial pin was inserted with the elbow in extension. Under image intensification, the reduction was evaluated for sufficiency and fracture stability. The pins were bent to prevent migration and cut outside of the epidermis to facilitate removal in an outpatient clinic. A single parenteral dose of antibiotic was administered preoperatively 30 minutes before induction and postoperatively, according to child's weight. The extremity was immobilized postoperatively in a well-cushioned posterior splint with the elbow flexed to 90 degrees. Postoperative radiographs were taken to ascertain the stability of the reduction. All the children with supracondylar fractures of the humerus were assessed for vascular and neurological status at every follow-up visit. At the end of third postoperative week, K-wires were removed. Functional and radiographic outcomes were evaluated using Flynn's criteria, Baumann's angle, carrying angle, and range of motion at follow-up intervals (3, 6, 10, 14, and 24 weeks). Using the Flynn's criteria, the results were graded as excellent, good, fair, or poor based on the loss of range of motion and loss of carrying angle [7] (Table 1).

Table 1

Flynn's criteria for grading of functional and cosmetic results

Rating		Cosmetic factor: Carrying angle loss (°)	Functional factor: Movement loss (°)
Satisfactory	Excellent	0–5	0–5
	Good	5–10	5–10
	Fair	10–15	10–15
Unsatisfactory	Poor	> 15	> 15

Statistical Analysis

The analysis included profiling of patients on different demographic, radiological and clinical parameters. Descriptive analysis of quantitative parameters was expressed as means and standard deviation. Ordinal data were expressed as absolute number and percentage. Chi-square test was applied to compare carrying angle and range of motion between patients undergoing cross-pinning and parallel pinning. The normality of variables was checked by Kolmogorov – Smirnov test. Baumann's angle was compared between cross-pinning and parallel pinning using unpaired Student t-test. A p-value < 0.05 was considered statistically significant. All analysis was done using SPSS software, version 24.0.

RESULTS

In the present study, mean age of patients in cross-pinning group and parallel pinning group was 6.8 years and 7.3 years respectively, with no significant difference between them (p value = 0.82). It was observed that supracondylar fractures were most common between 6 to 10 years (Table 2)

In terms of gender distribution, 68.5 % of the children were males (n = 37) and rest were females (31.5 %, n = 17). The two study groups were similar with respect to gender distribution of patients (p-value = 0.76) (Table 3).

The mechanism of injury was fall from height in 13 % of children, 20.4 % had road traffic accident and 66.7 % had sports related injuries. Both study groups were similar with respect to mechanism of injury (p-value = 0.89) (Table 4).

It was observed that one child in the parallel pinning group had associated distal radial fracture. No other children had any other associated injury (Table 5).

Table 2

Comparison of age groups distribution between cross-pinning and parallel pinning group

Age groups (years)		Group Cross-pinning	Group Parallel pinning	Total patients
Less than 5	*n*	5	3	8
	%	18.50	11.10	14.80
6 to 10	*n*	20	22	42
	%	74.10	81.50	77.80
11 to 12	*n*	2	2	4
	%	7.40	7.40	7.40
Total	*n*	27	27	54
	%	100.00	100.00	100.00
p-value		0.88		
Mean age (years)		6.8 ± 1.7	7.3 ± 1.7	
p-value		0.82		

p-value analyzed using independent t-test.

Table 3

Comparison of gender distribution between cross-pinning and parallel pinning group

Gender		Group Cross-pinning	Group Parallel pinning	Total patients
Female	*n*	8	9	17
	%	29.60	33.30	31.50
Male	*n*	19	18	37
	%	70.40	66.70	68.50
Total	*n*	27	27	54
	%	100.00	100.00	100.00
p-value		0.88		

p-value analyzed using independent t-test.

Table 4

Comparison of mechanism of injury between cross-pinning and parallel pinning group

Mechanism of injury		Group Cross-pinning	Group Parallel pinning	Total patients
Fall from height	*n*	4	3	7
	%	14.80	11.10	13.00
Road traffic accident	*n*	5	6	11
	%	18.50	22.20	20.40
Sports	*n*	18	18	36
	%	66.70	66.70	66.70
Total	*n*	27	27	54
	%	100.00	100.00	100.00
p-value		0.88		

p-value analyzed using Fisher's exact test.

Table 5

Comparison of associated injury between cross-pinning and parallel pinning group

Associated injury		Group Cross-pinning	Group Parallel pinning	Total patients
Distal radial fracture	*n*	0	1	1
	%	0.00	3.70	1.90
None	*n*	27	26	53
	%	100.00	96.30	98.10
Total	*n*	27	27	54
	%	100.00	100.00	100.00
p-value		0.5		

p-value analyzed using Fisher's exact test.

Pre-operatively, in the cross-pinning group, 11.1 % had cubital region paresthesia and 18.5 % had ulnar nerve neuropraxia, while in the parallel pinning group 18.5 % had cubital paresthesia and 11.1 % had ulnar nerve neuropraxia. Both the groups were similar with respect to pre-operative neurovascular status (*p*-value = 0.64) (Table 6).

Mean operative time was 34.2 ± 3.05 min in the cross-pinning group, while it was 34.8 ± 0.5 min in the parallel pinning group, with no significant difference between them (*p*-value = 0.51) (Table 7).

Table 6

Comparison of pre-operative neurovascular status between cross-pinning and parallel pinning group

Mechanism of injury		Group Cross-pinning	Group Parallel pinning	Total patients
Fall from height	*n*	4	3	7
	%	14.80	11.10	13.00
Road traffic accident	*n*	5	6	11
	%	18.50	22.20	20.40
Sports	*n*	18	18	36
	%	66.70	66.70	66.70
Total	*n*	27	27	54
	%	100.00	100.00	100.00
p-value		0.88		

p-value analyzed using Fisher's exact test.

Table 7

Comparison of mean operative time between cross-pinning and parallel pinning group

Operative time (mins)				
Group Cross pinning		Group Parallel pinning		*p*-value
Mean	SD	Mean	SD	
34.26	3.058	34.85	3.416	0.51

p-value analyzed using independent t-test.

At 3-weeks post-operatively, mean carrying angle was found to be 9 ± 0.8 and 9 ± 0.9 degrees (*p*-value = 0.9) in the cross-pinning and parallel pinning group, respectively. Further on, the mean carrying angle was 9.6 and 9.5 degrees at post-operative week 6, 10.4 and 10.6 degrees at week 10, 11.6 and 11.4 degrees at week 14 and 10.1 and 10.3 degrees at post-operative week 24 in cross-pinning and parallel pinning group, respectively. The mean carrying angle was found to be statistically insignificant at different follow-up examination (Table 8).

The mean Baumann's angle was found to be statistically insignificant at different follow-up examinations (Table 9).

Table 8

Comparison of mean carrying angle between cross-pinning and parallel pinning group at different follow up

Postoperative carrying angle	Group Cross-pinning		Group Parallel pinning		*p*-value
	Mean	SD	Mean	SD	
3rd week	9.0	0.8	9.0	0.9	0.9
6th week	9.6	1.2	9.5	1.1	0.8
10th week	10.4	1.1	10.6	1.1	0.4
14th week	11.6	1.1	11.4	1.1	0.4
24th week	10.1	0.9	10.3	1.1	0.4

p-value analyzed using independent t-test.

Table 9

Comparison of mean Baumann's angle between cross-pinning and parallel pinning group at different follow up

Baumann's angle	Group Cross-pinning		Group Parallel pinning		*p*-value
	Mean	SD	Mean	SD	
3rd week	66.3	2.2	68.8	2.2	0.407
6th week	68.3	1.8	67.4	1.9	0.693
10th week	70.4	1.8	71.5	1.8	0.312
14th week	71.3	1.9	73.8	2.2	0.158
24th week	72.0	1.5	74.9	2.5	0.377

p-value analyzed using independent t-test.

It was observed that range of motion (ROM) was reduced in 18.5 % of cross-pinning patients and in 7.4 % of parallel pinning group at week 3. At 6th week, ROM was reduced in 11.1 % of cross-pinning and in 3.7 % of parallel pinning group patients. At subsequent follow ups, ROM was normal in all patients in both study groups (Table 10).

Table 10

Comparison of range of motion between cross-pinning and parallel pinning group at different follow-ups

Range of motion			Group Cross pinning	Group Parallel pinning	Total patients	*p*-value
3rd week	Normal	*n*	22	25	47	0.42
		%	81.50	92.60	87.00	
	Reduced	*n*	5	2	7	
		%	18.50	7.40	13.00	
6th week	Normal	*n*	24	26	50	0.61
		%	88.90	96.30	92.60	
	Reduced	*n*	3	1	4	
		%	11.10	3.70	7.40	
10th week	Normal	*n*	27	27	54	NA
		%	100.00	100.00	100.00	
14th week	Normal	*n*	27	27	54	NA
		%	100.00	100.00	100.00	
24th week	Normal	*n*	27	27	54	NA
		%	100.00	100.00	100.00	
Total		*n*	27	27	54	
		%	100.00	100.00	100.00	

p-value analyzed using Fisher's exact test.

Post-operatively, there was one patient in the cross-pinning group who had ulnar nerve injury. Other than that, none of the patients had pin loosening, superficial infection or any other complications (Table 11).

Post-operative neurovascular examination revealed ulnar nerve neuropraxia in only one patient from cross-pinning group which was not statically significant (Table 12).

Table 11

Comparison of post-operative complications between cross-pinning and parallel pinning group

Post-op complications		Group Cross pinning	Group Parallel pinning	Total patients	*p*-value
Ulnar nerve injury	*n*	1	0	1	0.31
	%	3.70	0.00	1.80	
Pin loosening	*n*	0	0	0	NA
	%	0.00	0.00	0.00	
Superficial infection	*n*	0	0	0	NA
	%	0.00	0.00	0.00	
None	*n*	26	27	53	0.31
	%	96.30	100.00	98.20	
Total	*n*	27	27	54	
	%	100.00	100.00	100.00	

p-value analyzed using Fisher's exact test.

Table 12

Comparison of post-operative neurovascular status between cross-pinning and parallel pinning groups

Post-op complications		Group Cross pinning	Group Parallel pinning	Total patients	*p*-value
Ulnar nerve neuropraxia	*n*	1	0	1	0.75
	%	3.70	0	1.8	
Normal	*n*	26	27	53	
	%	96.30	100	98.2	
Total	*n*	27	27	54	
	%	100.00	100.00	100.00	

p-value analyzed using Fisher's exact test.

Based on Flynn's criteria, at last follow-up, significantly higher proportion of patients in the parallel pinning group had an excellent outcome as compared to cross-pinning group (92.6 % vs 51.9 %, *p*-value < 0.01) which was statically significant. In the cross-pinning group, the outcome was good in 37 % and fair in 11.1 %, while in the parallel pinning group, the outcome was good in 3.7 % and fair in 3.7 % (Table 13).

Table 13

Comparison of post-operative outcomes based on Flynn`s criteria between cross-pinning and parallel pinning groups at final follow-up

Flynn criteria		Group Cross pinning	Group Parallel pinning	Total patients	*p*-value
Excellent	*n*	14	25	39	< 0.01
	%	51.90	92.60	72.20	
Good	*n*	10	1	11	
	%	37.00	3.70	20.40	
Fair	*n*	3	1	4	
	%	11.10	3.70	7.40	
Total	*n*	27	27	54	
	%	100.00	100.00	100.00	

p-value analyzed using Fisher's exact test.

DISCUSSION

The goal of surgery in any fracture should be secure fixation, early rehabilitation, early functional recovery and minimal/no complications. This prospective observational study was done to compare the outcome of the cross-pinning versus parallel pinning in displaced supracondylar humeral fracture in children. In the present study, mean age of children in cross-pinning group and parallel pinning group was 6.8 years and 7.3 years respectively, with no significant difference between them (*p*-value = 0.82). 68.5 % of the patients were males (*n* = 37) and rest were females (31.5 %, *n* = 17) which was similar to the study done by Afaque et al. [8]; in that study the mean age of the patient at the time of presentation was 6.8 ± 0.9 years in the lateral pinning group and 7.2 ± 0.8 years in the cross-pinning group. In study by Mandal et al. [9], males constituted 68.34 % of the study population while females constituted 31.66 % of the study population which showed similar gender distribution as in the present study. Whereas in a study by Rupesh et al. [6], the mean age of patients in cross-pinning and parallel pinning groups was 7.5 years and 7.7 years, respectively.

Out of 64 subjects, 34 subjects were males (53 %) and 30 were females (46 %). In another study done by Singh et al. [10], the mean age in the lateral pinning group was 8.26 years, whereas it was 8.54 years in the cross-pinning group. In the study done by Khan et al. [11], there were 50 (59.5 %) males and 34 (40.5 %) were females. Mean age of the patients in the cross-pinning group was 5.14 ± 9.88 years and in the parallel pinning group it was 6.14 ± 8.35 years.

In the present study, 13 % had a fall from height, 20.4 % had road traffic accidents and 66.7 % had sports related injuries. Study done by Khan et al. [11] showed similar findings in terms of mechanism of injuries which showed sports was the most common cause of fracture in 71.43 % of children followed by road traffic accident in 20.24 % and the rest were 8.3 % due to fall from the height. Whereas in the study done by Rupesh et al. [6], mechanism of injuries in majority of children (53 %) was slip and fall, 45.3 % had fall from height and 1.6 % had fall from height while playing. In the study by Singh et al. [10], the most common cause of injury was fall from height in 63.9 % of children followed by fall during playing in 29.5 % of children and by road traffic accidents in 6.5 % children. Afaque et al. [8] reported fall from height was the commonest mode of injury. In the present study, the mean operative time was 34.2 ± 3.05 minutes in the cross-pinning group, while it was 34.8 ± 0.5 min in the parallel pinning group, with no significant difference between them (p-value = 0.51) whereas the study done by Khan et al. [11] showed the mean surgical time in cross-pinning group was 30.42 ± 6.09 minutes while in the lateral pinning group it was 34.24 ± 2.16 minutes. In the present study, at 3-weeks post-operatively, the mean carrying angle was 9 ± 0.8 and 9 ± 0.9 degrees (p-value = 0.9) in the cross-pinning and parallel pinning groups, respectively. Furthermore, the mean carrying angle was 9.6 and 9.5 degrees at post-op 6th week, 10.4 and 10.6 degrees at post-op 10th week, 11.6 and 11.4 degrees at post-op 14th week and 10.1 and 10.3 degrees at post-op 24th week in cross-pinning and parallel pinning groups, respectively. The mean carrying angles were similar between cross-pinning and parallel pinning groups at all post-operative follow-ups. The mean Baumann's angle was found to be statistically insignificant at different follow-up examination. Also, the range of motion was reduced in 18.5 % of cross-pinning children and in 7.4 % of parallel pinning group at 3rd week post-operative. At 6th week, ROM was reduced in 11.1 % of cross-pinning and in 3.7 % of parallel pinning group patients. At subsequent follow-ups, ROM was normal in all patients in both study groups. Study done by Rupesh et al. [6] showed similar results. It showed that the carrying angle in the cross pinning group vs parallel pinning group was 11.18 ± 1.99 vs 11.96 ± 1.92 degrees. The Baumann's angle in the cross pinning group vs parallel pinning group was 71.59 ± 3.10 vs 71.65 ± 2.23 degrees. Also, in the study done by Singh et al. [10], there was no significant difference ($p > 0.05$) regarding the change in Baumann`s angle, carrying angle and elbow range of motion. Similar findings were observed in the study done by Eguia et al. [12] which showed that there was no significant difference in Baumann`s angle with p-value > 0.05 between groups.

Similar to our findings, Afaque et al. [8] also reported that the change in Baumann angle, change in carrying angle, range of motion in flexion and extension of the elbow were not significantly different at any point of time between two groups. In the study Younus et al. [13], the final clinical outcome at 6 months follow-up was assessed by examining range of motion at the affected elbow. 99 children achieved full range of motion at 6 months. The remaining 11 patients (5 of them had lateral pinning and 6 had crossed wiring) were advised to continue physiotherapy. The difference in this parameter was statistically insignificant among the two groups (p-value = 0.12). In a similar study, Sapkota et al. [14] observed that there was no statistical significance in comparing Baumann's angle after the intervention and at the last follow-up examination. By comparing the mean, there was no significant change in Baumann's angle.

In the present study, post-operatively there was one child in the cross-pinning group who had ulnar nerve neurapraxia. Other than that, none of the patients had pin loosening, superficial infection or any other complications. In a systematic review study, Brauer et al. [15] reported that the rate of iatrogenic injury of the ulnar nerve from cross-entry pin fixation was 3.3 % and cross-entry pin fixation method has 4.86 times higher risk for developing iatrogenic nerve injury than the lateral pinning fixation method. In the study done by Shim et al. [16], it was observed that the risk of iatrogenic nerve injury can be minimized with small incision over the medial aspect of the elbow and putting the elbow in extension at the time of medial pin. The majority of iatrogenic injury of the ulnar nerve due to placement of medial pin resolves spontaneously [17]. In the study done by Singh et al. [10], postoperative complication such as superficial pin-tract infection was present in 2 cases (6.67 %) of the lateral pinning group and one case (3.22 %) in the cross-pinning group.

All the infections subsided during follow-up. Iatrogenic ulnar nerve neuropraxia was present in 6.4 % of cases of the cross-pinning group, and it recovered fully within 3 weeks. Khan et al. [11] observed that the most common complication in the cross-pinning group was superficial infection in 5 cases (11.9 %) followed by pin loosening in 3 cases (7.14 %) and ulnar nerve neuropraxia in one case (2.4 %) but in the lateral pinning group the most common complication found in 4 cases (9.5 %) was superficial infection followed by pin loosening in 2 cases (4.8 %). In the study by Eguia et al. [12], 5 participants (3.5 %) experienced superficial pin-site infection (4 in the crossed pinning group and one in the lateral pinning group) (p-value = 0.05). Two participants in the lateral pinning group had postoperative neurological complications compared with none in the crossed pinning group (p-value = 1.0). Neurological complications were seen in one case due to radial nerve palsy. In the study by SAfaque et al. [8], two patients in the cross-pinning group developed tingling sensation and numbness in ulnar nerve distribution with intact motor function which was seen after two days of surgery. On subsequent follow-up, all three patients recovered. In the study done Younus et al. [13], three patients (2.7 %) had ulnar nerve injury which all eventually recovered. The difference in this important complication was statistically insignificant (p = 0.082). Four patients had superficial pin-site infection during the follow-up which was treated with oral antibiotics. Sapkota et al. [14] observed that there were 4 cases (11.76 %) with nerve palsy associated with supracondylar fractures. Three patients had radial nerve palsy and one had median nerve palsy. One patient had iatrogenic ulnar nerve injury following fixation with cross K-wires. All of them recovered completely by 3 months. Superficial pin-tract infection was detected in five cases at the time of pin removal.

In the present study, based on Flynn's criteria, at the final follow-up, a significantly higher proportion of patients in the parallel pinning group had an excellent outcome as compared to the cross-pinning group, 25 patients (92.6 %) versus 15 patients (51.9 %), with p-value < 0.01. In the studies done by Rupesh et al. [6] and Flynn et al. [18], 100 % of the patients in the parallel group had excellent scores whereas in the cross-pinning group, 94 % had excellent results. Singh et al. [10] also observed that the final result was excellent in 49 cases (80.32 %) and was good in 12 cases (19.67 %). Excellent outcome was found in 23 cases (76.67 %) of the lateral pinning group and 26 cases (83.87 %) of the cross pinning group. The outcome of 7 cases (23.33 %) in the lateral pinning group and 5 cases (16.12 %) in the cross-pinning group was found good. Khan et al. [11] observed that according to Flynn's criteria, excellent results in the cross-pinning group were found in 25 cases (59.5 %), good results in 12 cases (28.6 %) and fair results found in 5 cases (11.9 %) while in the lateral pinning group excellent results were found in 23 cases (54.8 %), good results in 15 cases (35.7 %) and fair results in 4 cases (9.5 %). Eguia et al. [12] found no significant differences between crossed versus lateral pinning groups in any patient reported outcomes (PROs). Mean QuickDASH scores were 1.6 in the crossed pinning group and 3.0 in the lateral pinning group (p-value = 0.14). Mean PROMIS (Patient-Reported Outcomes Measurement Information system) scores in the crossed pinning versus lateral pinning groups were 57 versus 56 for the upper extremity domain; 54 versus 53 for strength impact; and 12 in both groups for pain interference (all, p-value > 0.05). Afaque et al. [8] observed that according to Flynn's grading, 26 patients in the lateral pinning group and 24 patients in the cross-pinning group had excellent results, 7 patients in the lateral pinning group and 15 in the cross-pinning group had good result, 4 patients in the lateral pinning group and one in the cross-pinning group had fair results, respectively. None of the patients in either group had poor results on the basis of Flynn's criteria. Sapkota et al. [14] observed that according to Flynn's criteria in both groups more than 95 percent of cases had good to excellent results.

Limitation A large sample size is needed to determine which approach is better (cross-pinning vs lateral pinning) to treat displaced supracondylar fracture of humerus.

CONCLUSION

Parallel pinning demonstrated superior radiological and functional outcomes with a lower risk of ulnar nerve injury compared to cross pinning. These findings suggest that parallel pinning should be the preferred method for stabilizing displaced supracondylar humerus fractures in children.

Future multicentric studies with larger sample size are required to support our finding.

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