Functional and Radiological Outcome of Type III Supracondylar Fracture of Humerus Treated by Crossed Versus Lateral Pinning a Prospective Cohort Study Conducted in a Tertiary Health Care Centre in Thiruvananthapuram, Kerala

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ABSTRACT

BACKGROUND

Supracondylar fracture of humerus is a common fracture in children. Closed manipulative reduction and percutaneous K-wire fixation is the most widely recognized treatment method for displaced supracondylar humerus fracture in children but controversy persists regarding the ideal pin fixation technique. The purpose of this study was to compare the radiological and functional outcome of lateral entry pinning with that of crossed pinning fixation for Gartland type III supracondylar humerus fractures in children.

METHODS

This prospective cohort study was conducted in Govt. Medical College Hospital, Thiruvananthapuram from February, 2015 to September, 2016. A total of 54 patients who satisfied the inclusion and exclusion criteria were enrolled in the study. They were allocated to Group A (crossed pin fixation) and Group B (lateral pin) fixation with 27 patients in each. All the cases of percutaneous pinning were done according to a uniform standardized technique. The patients were re-evaluated at post-operative day, three weeks, and three months after the surgery. Following information were recorded as outcome measures: (i) carrying angle (ii) range of motion (iii) modified Flynn's criteria. (v) Baumann's angle (vi) neurovascular injury.

RESULTS

There was no statistically significant difference between crossed and lateral pinning with regard to mean Baumann's angle, carrying angle, complication rate, stability and functional outcome, but there was evidence of iatrogenic ulnar nerve injury (3.7 %) in crossed pinning group. There was one case of pin tract infection.

CONCLUSIONS

There is no statistically significant difference between the radiological and functional outcome provided by crossed pin fixation method and lateral pin fixation methods. Closed reduction and percutaneous pin fixation are safe and efficient methods for fixation of displaced supracondylar fractures of the humerus. Closed reduction and percutaneous pin fixation for displaced supracondylar factures of the humerus in children gives good functional and cosmetic results.

KEYWORDS

Humerus, Percutaneous Pinning, Supracondylar Fracture

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BACKGROUND

Supracondylar fracture of humerus is one of the commonest fractures in the first decade of life.[1] The management of paediatric supracondylar humerus fractures has advanced from a purely conservative approach to a more aggressive approach in recent years. Supracondylar fractures require a meticulous treatment to obtain a good outcome because of low bone remodelling associated with these injuries. If mismanaged, it may give rise to complications like Volkmann's ischaemic contracture, myositis ossificans, neurovascular injury, stiff elbow and malunion.[2] Supracondylar fractures are usually initially classified as flexion or extension type. They are then classified according to the amount of radiographic displacement. The three-part classification by Gartland in 1959 has been shown to be more reliable than any other classification systems.[3] Gartland Classification : Type I- Undisplaced or minimally displaced Type II - Fractures having angulation of distal fragment with one cortex remaining intact a) With distal fragment merely angulated b) With distal fragment both angulated and malrotated Type III - Completely displaced with both cortices fractured.

There are numerous methods of treatment for the management of type III supracondylar fracture of humerus. Presently closed manipulative reduction and percutaneous pinning is most widely accepted treatment method for displaced supracondylar humerus fracture but dispute persists regarding the optimal pinning technique. The intention of this study is to compare the functional and radiological outcome of percutaneous crossed pinning versus lateral pinning alone in type III supracondylar fracture humerus.

Objectives

Primary

To compare the outcome of Type III supracondylar fractures of humerus in children aged 3 - 12 years managed by two different approaches - crossed pinning and lateral pinning.

Secondary

To compare the complications of Type III supracondylar fractures of humerus in children aged 3 - 12 years managed by two different approaches - crossed pinning and lateral pinning.

METHODS

This prospective cohort study was conducted in Orthopaedic wards of Govt. Medical College and Hospital, Thiruvananthapuram from February 2015 to September 2016 after getting approval from the ethics committee of our institution. Children admitted in Orthopaedic wards with supracondylar fracture humerus were included in the study if they had the following inclusion criteria.

(i) Age between 3 - 12 years (ii) Extension type Gartland type III fractures (iii) No previous fracture in the same elbow. Patients were excluded if they fulfilled the following exclusion criteria : (i) Bilateral fracture (ii) Associated injury in the same limb (iii) Developmental deformity of ipsilateral or bilateral limb (iv) Open fracture (v) Unsatisfactory closed reduction requiring open reduction (vi) Associated neurovascular injury.

Sample size was calculated based on the reference study.

A prospective randomised, controlled clinical trial comparing medial and lateral entry pinning with lateral entry pinning for percutaneous fixation of displaced extension type supracondylar fractures of the humerus in children. Abhijan Maity1,3*, Debasish Saha2 and Debasis Sinha Roy1

Outcome Variable - Baumann Angle		
Baumann angle (degree)	Crossed medial-lateral pin entry group † (N = 64)	Two-lateral pin entry group * (N = 66)
	77.2 ± 4.35	76.2 ± 3.51
Based on the Results from the Above Study		

Sample Size

$$N = \frac{2\left(z_{1-\alpha/2} + z_{1-\beta}\right)^2 \sigma^2}{\delta^2}$$

Using the formulae

Where, SR +

$\sigma^2 = \frac{\sigma_1^2+\sigma_2^2}{2}$

$\delta = m_1 - m_2$

Type I error (α) = 5 %

Type II error (β) = 20 %

Power = 1- β = 80%

$\left(z_{1-\alpha/2} + z_{1-\beta}\right)^2 = 7.849$

$\sigma_1 = 4.35$

$\sigma_2 = 3.51$

Expected difference $\delta = m_1 - m_2 = 3$

Sample size N = 27 (in each group)

Sample size was calculated to be 27 in each group based on the reference study by Abhijan Maity et al.[4] using the formulae to detect a minimum significant difference of Baumann's angle which is a continuous variable. Non randomized sampling method was used to allocate patients to group. Children who underwent crossed pinning were included in group A and those who underwent lateral pinning were included in group B.

Patients were examined during pre-operative period, clinical history data was collected, clinical examination including a detailed neurological examination was done. Surgery was done under general anaesthesia. Immediate clinical and radiological outcome was assessed post-operatively. Patients were followed up regularly at 3 weeks & 3-months post-operatively. Slab and K-wires were removed at 3 weeks post-operatively and active assisted mobilization was started. Each time it was assessed radiologically for reduction and union, and clinically for range of motion, neurovascular damage, carrying angle & other complications. The carrying angle and Baumann's angle

were assessed immediately after which pinning was compared with that at 3 months follow up visit.

Statistical Analysis

Data was entered in excel sheets & analysed using statistical package for social sciences (SPSS) version 17.0 software. Quantitative variables were expressed as mean & standard deviation (SD). Qualitative variables was expressed as proportions. Between groups, comparison of quantitative variables was analysed using independent sample (t) test or Mann Whitney test according to the nature of the data. Qualitative variables were compared using chi-square test or Fisher's exact test, whichever is applicable. A P - value of 0.05 was taken as the level of significance.

Operative Procedure

Closed Reduction and Percutaneous 'K' Wire Fixation[5]

Closed manipulative reduction was done under general anaesthesia with C-arm guidance. With elbow hyperextended, and forearm supinated, longitudinal traction is applied. Maintaining the traction, a varus or valgus force is applied at the fracture site to correct displacement in the coronal plane. The posterior displacement of the distal fragment is then corrected by applying an anterior pressure to olecranon while the elbow is gently hyper flexed. The elbow is placed in the lateral position directly under C-arm. The fractures are stabilized with 1.2 mm to 2.0 mm K-wires based upon the age of the patients. For the lateral fixation technique two K-wires were inserted from lateral aspect of elbow across the lateral cortex to engage the medial cortex keeping the elbow in hyperflexion. K-wires were placed either in parallel or divergent configuration with the adequate separation at fracture site. For the crossed pin technique, first the lateral K-wire was inserted from lateral cortex to engage the medial cortex keeping the elbow in hyperflexion. Then the elbow was extended and a small medial incision was made over the medial epicondyle. Blunt dissection was done to locate the medial epicondyle and ulnar nerve rolled back with thumb and the medial K-wire was inserted from the medial cortex to engage the lateral cortex. The pin configuration was considered to be acceptable if one pin was placed in lateral column and another pin in central or medial column. Elbow is extended after placing the K-wires and the carrying angle and Baumann angle is measured and compared to that on the non-affected side. The adequacy and stability of the reduction is checked under image intensification. The K-wires are bent to prevent migration and cut off outside the skin to so that it can be removed in the outpatient clinic without anaesthesia. Post-operatively, the extremity is placed in a long arm slab with the elbow flexed to 90°.

RESULTS

Group A & B are similar with respect to pre-fracture characteristics, fracture patterns, post reduction radiographic & clinical measurements. 54 patients were treated for Type III supracondylar humerus fracture during the study period and study was done with these 54 patients. Group A (cross entry) comprised of 27 patients and Group B (lateral entry) comprised of 27 patients of the 54 patients included in the study, most of the patients were between 7 – 9 years (37.03 %). 33.3 % of patients were between 3 - 6 years & 29.6 % were between 10 - 12 years. The mean age group in group A (cross pinning) was 7.37 (SD 2.57) & Group B (lateral pinning) was 7.96 (SD 2.56). Majority of the patients in study group were males (74.1). Majority of the patients (96.3 %) sustained injury following fall, while 3.7 % patients had injury following road traffic accidents. 70.4 % of the patients sustained their injuries in the right upper limb and 29.6 % on left. In group A 74 % and in group B 66 % patients had injuries in the right upper limb. The difference between the two groups based on side of injury was not found to be statistically significant. The P value as per chi square test was 0.55. Displacements in Type 3 supracondylar fractures can be either posteromedial based on the shift of distal fragment. According to western literature posteromedial displacement is more common (75 %). In this study, 74.1 % patients had posteromedial displacement and 25.9 % patients had posterolateral displacement.

Post-operatively all the patients were examined for ulnar nerve injuries. Since the chance for ulnar nerve injury is more in case of cross pinning, all patients in group A were specifically checked for any ulnar nerve injury. A patient in group A had numbness in ulnar nerve area of hand and there was clawing. A patient in group B had numbness in median nerve area of hand and pointing index sign was present. Both patients were managed conservatively with observation and the patients recovered completely by 3 months. According to this study the difference in the incidence of post-operative nerve injury between these two procedures was not statistically significant. (P value = .368).

There was a single case of pin tract infection, which was treated by pus culture and sensitivity and appropriate antibiotics. This occurred in group B and the difference was not a significant one (P value = .313.).

There was pin loosening for one patient in each group at 3 weeks follow-up. The result was not statistically significant between the two groups (P value = 1).

During the follow up one patient from group B had loss of reduction compared to the initial radiograph. No further interventions were taken and the patient had a poor outcome. But the result was not significant between the two groups (P value = .313). The Baumann's angle was measured in all patients at 3 months follow up. Baumann's angle is most commonly used method for assessing fracture reduction and has been revealed to correspond well with the final carrying angle. In the study group, mean Baumann's angle was 71.05 degree.

The mean Baumann's angle in group A was 70.85 degree and in group B was 71.26 degree. There was no statistically significant difference between two groups based on Baumann's angle measurements as per Pearson chi square tests. The carrying angle is the angle between the long axis of the arm and long axis of the forearm at central point of

extended elbow axis. It is measured in the extended and supinated position of the forearm. It varies from 10 - 15 degree. The exaggeration of this angle is called cubitus valgus. Reversal of this angle is called cubitus varus.

In the study group the mean carrying angle was 10.03 degree. It was 9.74 degree in group A and 10.33 degree in group B. The carrying angle in those extremities with extension lag was measured at the maximum possible extension. There was no significant difference between the two groups based on carrying angle measurement (P value =.616).

All patients at 3 months follow up were clinically assessed for the flexion, extension and total range of movements. As evidenced from previous studies, flexion, extension and range of movements of the elbow are important indicators for the functional outcome of supracondylar fractures of the humerus. Normal range of elbow movement is 0 to 140 - 160 degrees. In this study the mean elbow flexion was 125.52^{o} in crossed pin group and 125.04^{0} in lateral pin group at 3 months. The mean extension was - 2^{o} in crossed pin group and -1.93^{o} in lateral pin group at 3 months. The mean total range of movement was 123.52^{o} in crossed pin group and 123. 11^{o} at 3 months. No statistically significant difference was found between the two groups based on flexion at 3 months (P value = 0.772), extension at 3 months (P value = 0.882) and total range of movements at 3 months (P value = 0.832), based on chi square tests.

Loss of carrying angle is a component in grading the functional aspect of elbow as per modified Flynn's criteria. This was calculated at the final follow up at 3 months by comparing the difference in carrying angle with contralateral elbow. The degrees of carrying angle lost were put in final grading system and the grades were determined. No statistically significant difference was there between the two groups in terms of loss of carrying angle as per chi square test (P – value = 0.525).

Loss of flexion and extension are independent components of modified Flynn's criteria determined the final functional outcome. The degrees of flexion and extension loss were determined by comparing with the contralateral elbow at 3 months. The values were put in the final grading system. The P - value determined as per chi square test was 0.697 for loss of flexion and 0.873 for loss of extension and both values were statistically insignificant between the two groups.

Modified Flynn's criteria is an accepted scoring system for the assessment of functional outcome following injuries about the elbow. According to this criterion, the disability due to elbow injury is assessed and the functional outcome is graded as excellent (0 - 4.9 degree), good (5 - 9.9 degree), fair (10 - 14.9 degree) and poor (> 15 degree). The components of this criteria are the loss of carrying angle, loss of flexion and extension of the affected elbow. Each component is independent and has an equal magnitude in scoring. The lowest score among the three components was taken for determining the final grade. The values were assessed at 3 months in each patient.

In this study, in group A, 3 patients had excellent, 7 patients had good, 17 patients had fair and none had poor results. In Group B, 5 patients had excellent, 9 patients had good, 17 patients had fair and 1 patient had poor outcomes. The difference between the two groups were not statistically significant.

Nerve Injury	Procedure: Cross Pinning N	Cross Pinning %	Lateral Pinning N	Lateral Pinning %	Total N	Total %	χ^2	df	P
Absent	26	96.3	26	96.3	52	96.3	2.000	2	0.368
Ulnar	1	3.7	0	0	1	1.9			
Median	0	0	1	3.7	1	1.9			
Total	**27**	**100**	**27**	**100**	**54**	**100**			

Table 1. Post-Operative Nerve Injury in the Two Groups

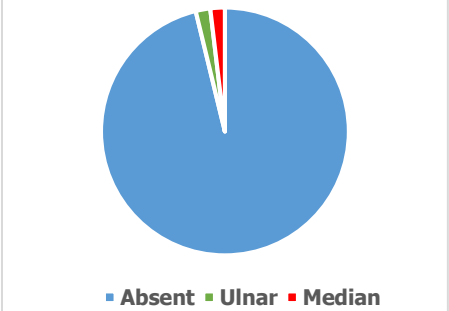
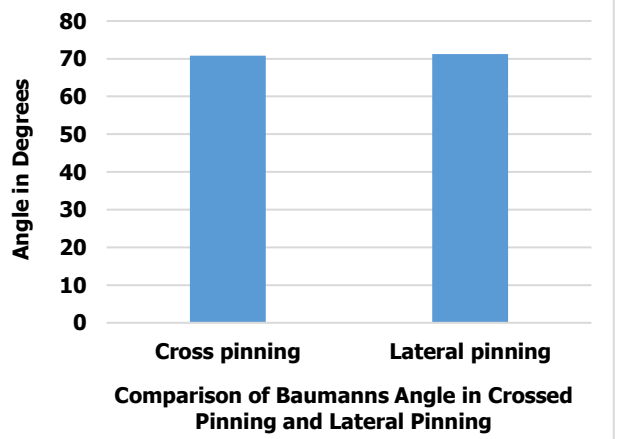


Figure 1. Distribution of Post-Operative Nerve Injury

Procedure	BAU ANGLE N	Mean	SD	t	P
Cross pinning	27	70.85	4.87	-.294	.770
Lateral pinning	27	71.26	5.30		

Table 2. Baumann's Angle in the Study Groups



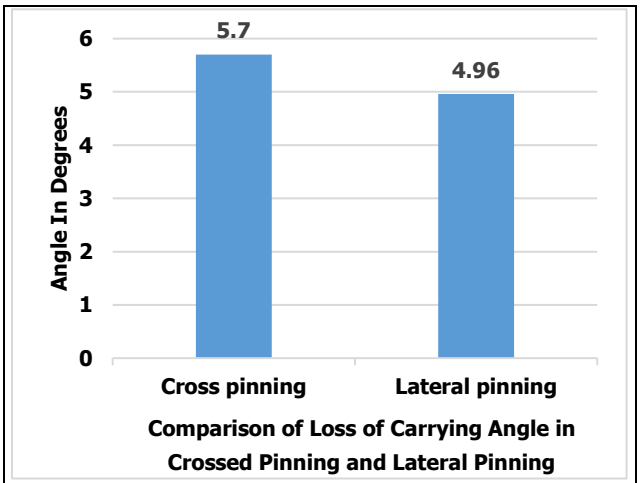
Graph 1. Baumann's Angle in the Study Groups

Procedure	CR AN LOS N	Mean	SD	t	P
Cross pinning	27	5.70	4.04	.640	.525
Lateral pinning	27	4.96	4.46		

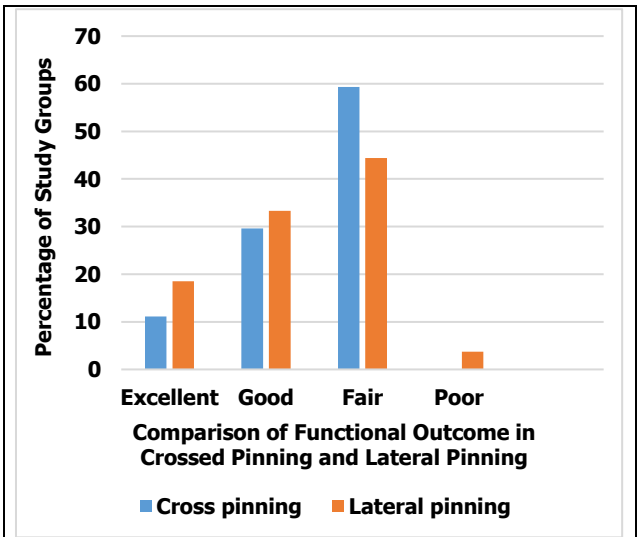
Table 3. Loss of Carrying Angle in the Two Study Groups

Modified Flynn Criteria Functional Outcome	Procedure: Cross Pinning N	Cross Pinning %	Lateral Pinning N	Lateral Pinning %	Total N	Total %	χ^2	df	P
Excellent	3	11.1	5	18.5	8	14.8	2.130	3	.546
Good	8	29.6	9	33.3	17	31.5			
Fair	16	59.3	12	44.4	28	51.9			
Poor	0	0.0	1	3.7	1	1.9			
Total	**27**	**100.0**	**27**	**100.0**	**54**	**100.0**			

Table 4. Modified Flynn Criteria



Graph 2. Loss of Carrying Angle in the Two Study Groups



Graph 3. Modified Flynn Criteria

DISCUSSION

The follow up duration of 54 patients was 3 months. Of the 54 patients, majority (37.03 %) were between 7 - 9 years, which is also the common age group in which supracondylar fracture of humerus occurs.[6] The age range and the mean age of peak incidence are in concordance with the current literature. Supracondylar humerus fractures of childhood are more common in boys.[6,7] Majority of the patients in our study group were males (40) and this predilection may be due to more agile nature of boys. Left sided elbow fractures were more common in previous studies.[7,8] It is probably because left arm does the protective duty during a fall. But 70.4 % of the patients in our study sustained their injury in the right upper limb, which may be due to the prominent right-handed dominance in the community. According to literature, posteromedial displacement is more common (75 %). Posterolateral type although less common is associated with more neurovascular complications. In this study, 74.1 % patients had posteromedial displacement and 25.9 % patients had posterolateral displacement.

The most common nerve injured in extension type fractures is anterior interosseous nerve. Iatrogenic ulnar nerve injury is the most common type of nerve injury in flexion-type injuries.[9] Iatrogenic ulnar nerve injury incidence is 3.7 % in crossed pinning group in this study. According to this study the difference in the incidence of post-operative nerve injury between the two procedures was not statistically significant. But there is always a risk of ulnar nerve injury with crossed pinning procedure. Thus, the obvious conclusion is that if medial K-wire is used, the lateral K-wire should be put first followed by medial K-wire fixation with elbow in extension. But the best way to avoid ulnar nerve injury is not to place medial K-wire.

There was a single case of pin tract infection, which was treated by pus culture and sensitivity and appropriate antibiotics. This occurred in lateral pinning group and the difference was not a statistically significant one. There was pin loosening for one patient in each group at 3 weeks, follow-up result was not statistically significant between the two groups.

Yousri et al.[8] has described in the current systematic review article: No significant difference was found between crossed and lateral pinning in terms of loss reduction. Both methods have similar stability. During the follow-up one patient from lateral pinning group had loss of reduction compared to the initial radiograph. No further interventions were taken and the patient had a poor outcome. But the result was not significant between the two groups.

Williamson et al.[10] found that an average of 72 degrees (64 - 81 degrees) could be considered as normal Baumann's angle and as long as the angle did not exceed 81° cubitus varus could not occur. In the study group, mean Baumann's angle was 71.05 degree. The mean Baumann's angle in group A was 70.85 degree and in group B was 71.26 degree. There was no statistically significant difference between two groups based on Baumann's angle measurements as per Pearson chi square tests. In the study group, the mean carrying angle was 10.03 degree. It was 9.74 degree in group A and 10.33 degrees in group B. The difference between the two groups based on carrying angle measurement was not statistically significant. There was no statistically significant difference between groups A and B in terms of loss of carrying angle as per chi square test. There was no statistically significant difference between the two groups based on flexion at 3 months (P value = 0.772), extension at 3 months (P value = 0.882) and total range of movements at 3 months (P vale =.832), based on chi square tests. There was no statistically significant loss of flexion and extension between the two study groups.

Modified Flynn's criteria is an accepted scoring system for the assessment of functional outcome following injuries about the elbow. According to this criterion, the disability due to elbow injury is assessed and the functional outcome is graded as excellent, good, fair and poor. In this study, in group A (crossed pinning), 3 patients had excellent, 7 patients had good, 17 patients had fair and none had poor results. In group B (lateral pinning), 5 patients had excellent, 9 patients had good, 17 patients had fair and 1 patient had poor outcome. The difference between the two groups was not statistically significant. The result of this study was comparable to a similar study done by Foead A et al.[11]

CONCLUSIONS

There is no statistically significant difference between the stability and functional outcome provided by crossed and lateral pinning methods. Closed manipulative reduction and percutaneous pinning is a safe and efficient method for fixation of displaced supracondylar humerus fractures in children which yields excellent functional and cosmetic results.

Limitations

Follow up period was only 3 months which may not be enough to assess the long-term complications of supracondylar fracture.

Data sharing statement provided by the authors is available with the full text of this article at jebmh.com.
Financial or other competing interests: None.
Disclosure forms provided by the authors are available with the full text of this article at jebmh.com.

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