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A prospective comparative study of functional and radiological outcome in percutaneous trans-olecranon fossa four cortex purchase lateral pinning versus cross-pinning in displaced supracondylar fractures of humerus in children

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Abstract

Traditional treatment with closed reduction and application of plaster slab or cast is inappropriate in the case of displaced supracondylar fractures of humerus as this method may potentially lead to malunion & subsequent elbow deformity, as it is difficult to obtain satisfactory reduction and to maintain the reduction due to distraction forces acting at the elbow. Our study involved 40 children who had sustained displaced supracondylar fractures (Gartland-Type III) who were treated in the Department of Orthopaedic at a Tertiary care trauma center, between November 2018 to May 2020. 55% of our cases were in the age group 5-10 years, 60% were male & 40% female.
80% (n=32) of the cases had history of fall on outstretched hand, followed by 3% with fall on flexed hand which is in concordance with the most common mode of injury established by many studies. 70% of the cases had fracture of left supracondylar humerus as compared to 30% on the right side. 30 out 40 cases had postero-medial displacement of distal fragment & remaining 10 cases had postero-lateral displacement.

Keywords: Supracondylar, percutaneous pinning, pediatric, humerus

Introduction

Supracondylar fracture of humerus is a common elbow injury among children and constitutes

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50-70% of all fractures around the elbow [1].
The most common mode of injury is fall on an outstretched hand and subsequent indirect injury to the elbow. It involves a fracture of the lower end of the humerus which is through the thin portion of the coronoid or olecranon fossae or just above the fossae or through the metaphysis of the lower end of the humerus. Proper management of supracondylar fractures of humerus is important because of high rates of neurovascular complications and malunion resulting in like cubitus varus deformity, stiffness of or loss of elbow functionn.

These complications are especially more common, if initial injuries are displaced fractures and are not managed adequately in time.
Traditional treatment with closed reduction and application of plaster slab or cast is inappropriate in the case of displaced supracondylar fractures of humerus as this method may potentially lead to malunion & subsequent elbow deformity, as it is difficult to obtain satisfactory reduction and to maintain the reduction due to distraction forces acting at the elbow.
Hence, surgical management in the form of percutaneous pinning after closed reduction or internal fixation with K-wires plays an important role in this type of fractures [2]. Among these, a continuous debate persists between cross pinning (lateral and medial K-wires) and Lateral Only Pinning (LOP). Medial pinning carries the risk of iatrogenic ulnar nerve injury whereas LOP can result in an unstable fixation [3, 4, 5, 6].
The purpose of this study is to assess the functional and radiological outcomes of percutaneous fixation of displaced SCFH with TOF-FCP pinning and compare them with those of cross-pinning. The results are graded with cosmetic and functional factors using Flynn's criteria.

Materials and Methods

Our study involved 40 children who had sustained displaced supracondylar fractures (Gartland-Type III) who were treated in the Department of Orthopaedic at a Tertiary care trauma centre, between November 2018 to May 2020. The children of the age group between 3 to 14 years were included in the study. Institutional eethical clearance was obtained before the study was undertaken.

Exclusion criteria

Crush injury of elbow, pathological fractures, fractures associated with other injuries around elbow, Garland Type I and II fractures.

Management

Information regarding mode of injury, first aid, treatment before presentation was obtained from the parents as well as from the patients. Then, general and local examination of the affected elbow was carried out to know the extent of injury and neurovascular status of the limb. The affected limb was immobilized in a temporary splint and sling and radiographs (standard antero-posterior and lateral views) were obtained. Based on the fracture type, the patients were either included into or excluded from the study. Those included were posted for surgery within 24 hours of presentation and were randomly assigned to either of the two modes of surgical fixation.

Operative technique

All patients underwent surgery under general anesthesia in lateral decubitus position with

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adequate padded supports. The elbow was supported over a padded bolster and forearm was left hanging free over the side of the table. Manual traction was given to the limb in line with the longitudinal axis of the shaft of humerus with the elbow at 20° of flexion to correct medio-lateral displacement and rotation. The distal fragment was milked with both thumbs of the operating surgeon on the flexed elbow of the patient leading to correction of the posterior displacement. Reduction was checked under image intensifier and was deemed "acceptable" if the following criteria were fulfilled: no step of the medial and lateral columns, normal Orientation of olecranon fossa in the AP view, tear drop restoration and 40° anterior tilt of capitellum in the lateral view. Once satisfactory reduction was achieved, the forearm was strapped to the arm at maximum flexion and pronation to secure the reduction. Two K-wires (1.6 mm or 2 mm in older children) were used. The first K-wire was passed from the tip of the lateral epicondyle at an angle of 45–55° directed superiorly and medially, advanced above the olecranon fossa up to medial cortex. The second K-wire was introduced one cm inferior to and parallel to the first (roughly at the capitellum). It was confirmed that this wire passes through the lateral cortex, two walls of olecranon fossa, and medial cortex in the proximal fragment, thus piercing four cortices in total. We call this the Trans-Olecranon Four Cortex Purchase (TOF-FCP) technique. Range of movements and reduction is checked before immobilized in an above elbow plaster slab.

Fig 1: Schematic representation of placement of pins in the TOF-FCP technique.

The limb was kept elevated for 2 to 3 days to facilitate resolution of edema. Antibiotics and analgesics are administered for 3 to 5 days. Wound condition was assessed at 10 days and sutures removed. The above elbow plaster slab was continued for a period of 3 weeks. At 3 weeks follow up, standard radiographs were obtained, and K-wires removed under mild sedation. The elbow was then immobilized in a sling and cuff for 2 weeks, following which active movements except those involving lifting weights were initiated. Serial radiographs were taken at the end of 3, 6 and 12 weeks. The patients were followed up till 6 months, and changes in the range of movements, carrying angle and Baumann's angle were measured and compared with the normal contra-lateral elbow. Patients were also assessed for signs of deformity and restriction of range of movements.

Results

Study groups were named as Group A and Group B for statistical analysis. Cross pinning technique group is named Group A and TOF-FCP group is named Group B.

Table 1: Age Incidence

Age Category	Operative Technique		Total
	Cross-pinning	TOF-FCP	
1 (3-6 years)	8 (40%)	3 (15%)	11 (27.5%)
2 (7-10 years)	9 (45%)	13 (65%)	22 (55%)
3 (11-14 years)	3 (15%)	4 (20%)	7 (17.5%)
Total	20 (100%)	20 (100%)	40 (100%)

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Table 2: Sex Incidence

Sex	Operative Technique		Total
	Cross-pinning	TOF-FCP	
Female	10 (50%)	6 (30%)	16 (40%)
Male	10 (50%)	14 (70%)	24 (60%)
Total	20 (100%)	20 (100%)	40 (100%)

Table 3: Mode of Injury Incidence

Mode of injury	Operative Technique		Total
	Cross-pinning	TOF-FCP	
FFH*	2 (10%)	1 (5%)	3 (7.5%)
FOOSH^	16 (80%)	16 (80%)	32 (80%)
Not Known	2 (10%)	3 (15%)	5 (12.5%)
Total	20 (100%)	20 (100%)	40 (100%)

*FFH-fall from height, ^FOOSH-fall onto an outstretched hand.

Table 4: Side Affected

Side affected	Operative Technique		Total
	Cross-pinning	TOF-FCP	
Left	14 (70%)	14 (70%)	28 (70%)
Right	6 (30%)	6 (30%)	12 (30%)
Total	20 (100%)	20 (100%)	40 (100%)

Table 5: Post-Operative Pin Tract Infection Incidence

Post-op pin tract infection	Operative Technique		Total
	Cross-pinning	TOF-FCP	
No	18 (90%)	18 (90%)	36 (90%)
Yes	2 (10%)	2 (10%)	4 (10%)
Total	20 (100%)	20 (100%)	40 (100%)

Functional outcome was measured according to Flynn's criteria which included loss in carrying angle and loss in elbow range of motion compared to the contralateral side.
Radiological assessment was done with Baumann's angle measurement.

Table 6: Flynn's criteria

Rating	Loss in carrying angle	Loss in elbow movements
Excellent	$0^o - 5^o$	$0^o - 5^o$
Good	$6^o - 10^o$	$6^o - 10^o$
Fair	$11^o - 15^o$	$11^o - 15^o$
Poor	$>15^o$	$>15^o$

Table 7: Carrying Angle Assessment

Rating	Operative Technique		Total	p value
	Cross-pinning	TOF-FCP		
Excellent	17 (85%)	18 (90%)	35 (87.5%)	0.63
Good	3 (15%)	2 (10%)	5 (12.5%)	
Total	20 (100%)	20 (100%)	40 (100%)	

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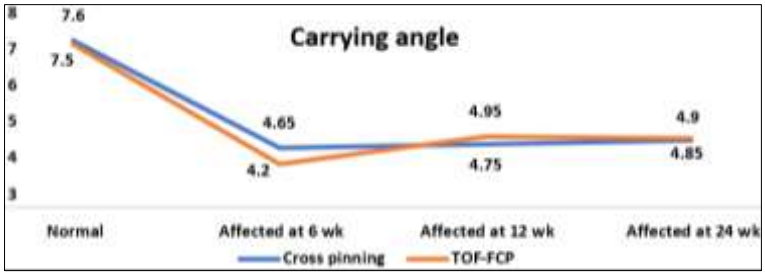

Fig 2: Line diagram depicting the change in carrying angle during follow up

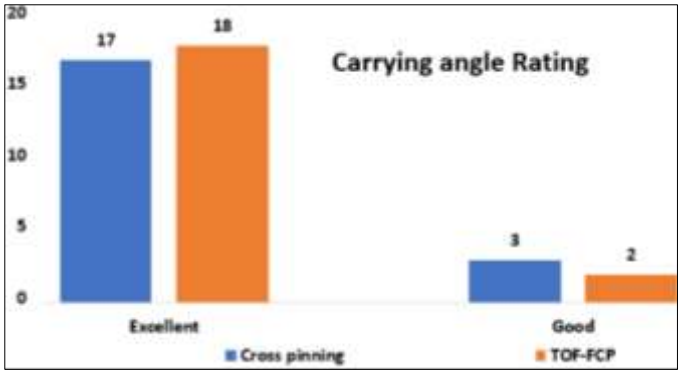

Fig 3: Bar chart showing Carrying angle changes in two groups.

Table 8: ROM assessment at 24 weeks

Rating	Operative Technique		Total	p value
	Cross-pinning	TOF-FCP		
Excellent	12 (60%)	13(65%)	25(62.5%)	0.74
Good	8 (40%)	7(35%)	15(37.5%)	
Total	20 (100%)	20(100%)	40(100%)	

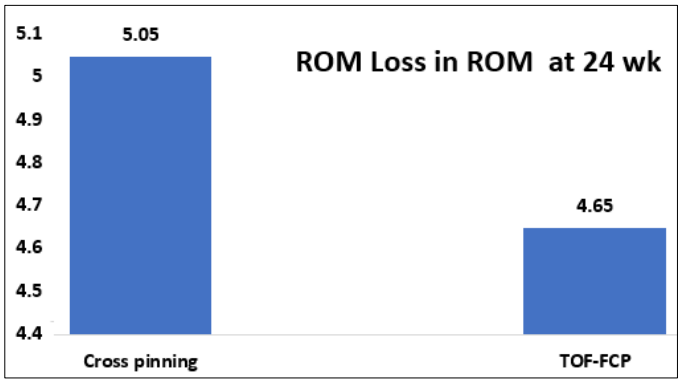

Fig 4: Bar chart depicting ROM loss among the two groups

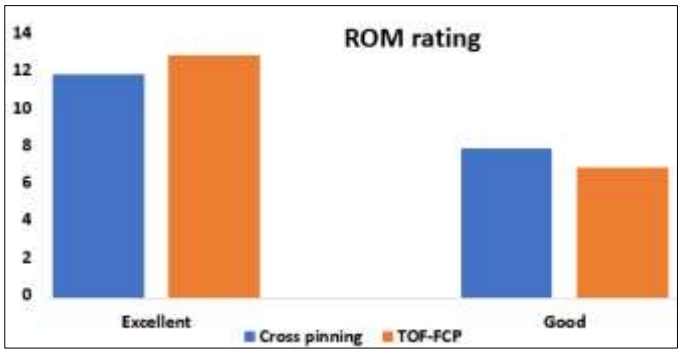

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Fig 5: Bar diagram showing the outcome ratings based on Loss of ROM

Table 9: Baumann's angle assessment

Rating	Operative Technique		Total
	Cross-pinning	TOF-FCP	
Excellent	18 (90%)	18 (90%)	36 (90%)
Good	2 (10%)	2 (10%)	4 (10%)
Total	20 (100%)	20 (100%)	40 (100%)

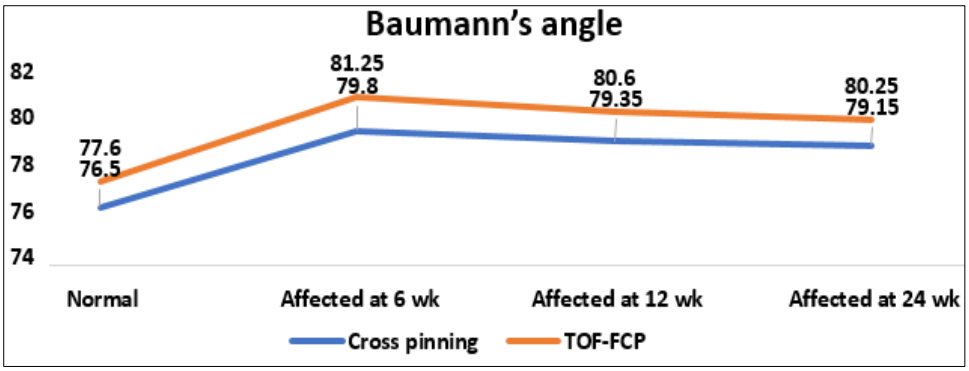

Fig 6: Line diagram showing post-operative change in Baumann's angle.

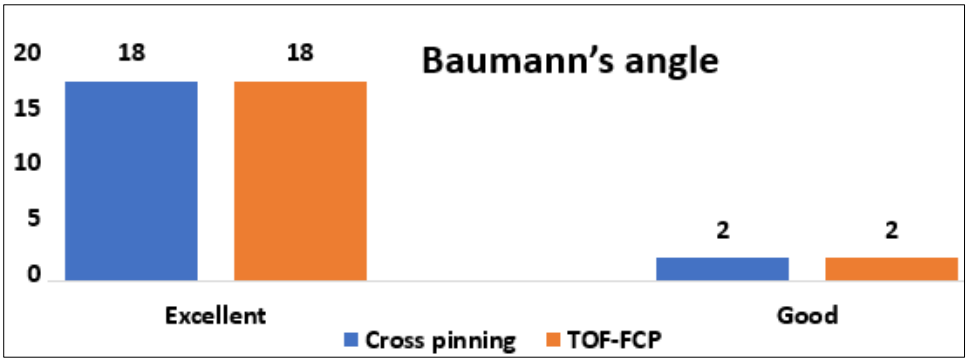

Fig 7: Bar diagram comparing the radiological outcomes among the 2 groups.

Baumann's Angle Assessment

18 children in cross-pinning technique and 18 children in TOF-FCP technique had a loss in angle of -5 to +5 degrees. And 2 children in each technique had a loss of 5-10 degree of Baumann's angle at the end of 24 weeks. No child had Poor outcome.

Table 10: Overall Rating of Outcome (Flynn Criteria)

Operative Technique	Carrying angle rating		Loss in ROM rating		Overall rating		Total
	Excellent	Good	Excellent	Good	Excellent	Good	
TOF-FCP	18	2	13	7	14	6	20
Cross-pinning	17	3	12	8	13	7	20
Total	35	5	25	15	27	13	40

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Fig 8: Case 1-Pre-operative (left) and post-operative radiographs.

Fig 9: Case 1-Post-operative assessment at 6 months

Fig 10: Case 2-Pre-operative (left-AP and lateral), and post-operative radiographs (right-AP and lateral at 6 weeks).

Fig 11: Case 2 - Post-operative assessment at 6 months.

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Time interval to surgery

16 children were operated on the same day; 23 children were operated upon within 24 hrs. and 1 child was operated on the second day after admission

Fracture classification

Only TYPE III in Gartland classification of supracondylar fracture of humerus were included in our study.

Nerve injury

There were no incidence of post-operative neurological deficits in across the groups during the entire 6 months of follow up.

Vascular injury

All children had swelling around the elbow pre-operatively but had normal radial pulse on presentation and peripheral circulation was adequate. They were treated with immediate closed reduction and internal fixation with K wires.

Grading of results

The results were graded based on Flynn *et al*., criteria clinically and based on Baumann's angle radiologically, compared with normal elbow.

Discussion

The main aim in the management of displaced SCFH is to achieve good reduction, maintain it till fracture union with stable fixation and initiate early movements. These fractures are prone for varus collapse, leading to "gun-stock deformity" of elbow and elbow stiffness if immobilized for too long. Displaced supracondylar fractures are usually managed by closed reduction and percutaneous pin fixation with various pin configurations and have been found to be very effective. There are continuing debates over the best pin configuration. Medial and lateral entry has greater torsional rigidity than the LOP fixation [7, 8]. Cross-pinning technique has the disadvantage of iatrogenic ulnar nerve injury caused by the medial pin either by direct injury, contusion or stretching of the nerve [9]. The ultimate aim of the SCFH fixation is to get a stable fixation without the risk of iatrogenic ulnar nerve injury.

Saravanan Kasirajan *et al*., [8] from their comparative study of functional and radiological outcome of supracondylar humerus fracture fixation by cross-pinning versus TOF-FCP lateral pinning, reported that stable fixation could be achieved using a modified LOP technique where two or more lateral wires are passed through the olecranon fossa to get four cortex purchase.

From their study of 124 cases of lateral pinning, Skaggs *et al*., [10] observed that lateral entry pin alone was effective for even the most unstable supracondylar fractures. There were no incidence of iatrogenic ulnar nerve injury and no loss of reduction. They emphasized the technical points for LOP fixation as follows:

a) Maximize separation of pins at fracture site.
b) Engage medial and lateral column proximal to fracture.
c) Engage sufficient bone in both proximal and distal fragment.
d) Maintain a low threshold for use of a third lateral entry pin if there is concern about.

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Fracture stability. This can be accomplished by dividing the fracture into three columns in AP view and confirming fixation of both medial and lateral columns.

The high rate of loss of reduction in LOP technique is attributable to technical errors like insufficient purchase by the pins or reduced spread of the pins [8].

55% of our cases were in the age group 5-10 years, 60% were male & 40% female.

80% (n=32) of the cases had history of fall on outstretched hand, followed by 3% with fall on flexed hand which is in concordance with the most common mode of injury established by many studies. 70% of the cases had fracture of left supracondylar humerus as compared to 30% on the right side. 30 out 40 cases had postero-medial displacement of distal fragment & remaining 10 cases had postero-lateral displacement.

10% of the cases had post-operative pin tract infection. All infections resolved after treatment with appropriate antibiotics and wound debridement if indicated.

Out of 20 cases operated with Cross-pinning (Group A) & TOF-FCP (Group B) techniques each, 13 children in Group A & 14 in Group B had excellent functional and cosmetic outcome assessed by Flynn criteria & graded by Flynn scoring system. 7 cases in Group A & 6 in Group B had good outcome. Out of 20 cases operated with Cross-pinning (Group A) & TOF-FCP (Group B) techniques each, 18 cases in each group had excellent & 2 in each group had good radiological outcome measured by serial change in Baumann angle during follow up (3w to 6m). None of the cases in either group had iatrogenic ulnar injury.

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