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Study of clinical and radiological outcomes in paediatric supracondylar humerus fractures treated with 3 lateral pins versus crossed pins

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Abstract
Paediatric supracondylar fractures can be challenging to treat and are the most common elbow fractures in children. The most common method of treatment of displaced supracondylar humerus fractures is closed reduction and fixation with Kirschner wires. However, debate still persists regarding the configuration of pin placement for fracture stabilisation. This study compares clinical and radiological outcomes in paediatric supracondylar humerus fractures treated with three lateral pin fixation and crossed pin fixation.
It is a prospective study with 60 patients conducted between March 2015 and September 2016. In this study, it was found that there is no significant difference between crossed medial and lateral pin fixation and lateral entry three pin fixation in terms of stability. Lateral pinning is a considerably safer procedure to avoid iatrogenic ulnar nerve palsy. Results show that the Baumann's Angle was well maintained with significantly lesser chances of varus collapse following cross pinning as against lateral pinning.

Keywords: Supracondylar humerus, Kirschner wire, Baumann's angle

Introduction
Paediatric supracondylar fractures can be challenging to treat and are the most common elbow fractures in children, accounting for 75% of all paediatric elbow injuries. There are well-known complications associated with supracondylar fractures and their treatment-neurovascular injury, compartment syndrome, and malunion leading to cubitus varus. The amount of neurological complication has ranged between 10% and 20%, with the most common nerve palsy being the anterior interosseous nerve. The rate of compartment syndrome is estimated to be between 0.1% and 0.3% and in the presence of an ipsilateral forearm fracture can increase to 9%. The occurrence of deformity from malunion varies in the literature; it has been estimated to be 4.2% using data pooled from 1455 patients.
Debate persists in methods of treating displaced supracondylar fractures. The current recommended practice for displaced supracondylar fractures is closed reduction and pin fixation. In practice this varies using two main techniques: two lateral entry wires alone, using a closed pinning technique or a medial and lateral crossed wire technique. On placing medial wires, surgeons may choose to use a closed, miniopen, or open technique depending on their level of experience and current practice. Although two crossed pins were biomechanically more stable but the risk of iatrogenic ulnar nerve palsy was more with medial pin placement. This study was performed to compare the efficacy and complication of the two fixation method - medial and lateral cross pinning verses 3 divergent lateral pinning.

Materials and methods
An approval from the ethics committee was sought and the study was conducted in patients who were admitted between March 2015 and September 2016. The patients selected were aged between 5 to 12 years, attending the outpatient department or emergency department of Medical College and Hospital, Kolkata with supracondylar fracture of the humerus. The study was conducted on 60 patients who had a traumatic aetiology leading to the fracture, fractures

less than 5 days old, fractures without distal neurovascular deficit, without signs of impending compartment syndrome and Gartland type II and III fractures. Patients with co-morbid conditions unfit for surgery, fractures more than 5 days old, patients unwilling to undergo surgery and those with Gartland type I fractures were excluded from the study.

Parents and relatives of the patients were briefed about the operative procedure; patients who presented on or after the 5th day after fracture were counselled about failure of closed reduction and conversion of the procedure to open reduction and internal fixation. The possibility of development of cubitus varus in the future was also explained especially for Gartland III fractures.

Crossed pin fixation of supracondylar humerus fracture

Each child was subjected to a trial of closed manipulation and check X-Rays were done. Long arm plaster immobilisation was continued in those wherein reduction was acceptable while the rest were posted for closed reduction and percutaneous pinning.

Among 60 patients included in the study, 30 patients underwent crossed pinning with medial and lateral Kirschner wires while the remaining 30 underwent lateral 3 wire fixation. Adequacy of fixation in both cases was assessed with the help of image intensifier. The upper limb was immobilised in a long arm plaster with elbow in 90 degrees flexion and forearm supinated and limb elevation was given. Post-operative anteroposterior and true lateral views of the elbow were obtained and the results of the procedure were evaluated clinically in subsequent follow ups using Flynn's Criteria,[8] time of return to normal activities, pin tract infection, iatrogenic nerve injury and radiologically using Baumann's angle, Anterior Humeral Line and Humerotrochlear angle.

Flynn's Criteria

Result	Flynn's Rating	Cosmetic Factor-loss of carrying angle (degrees)	Functional Factor-loss of movement (degrees)
Satisfactory	Excellent	0–5	0–5
Satisfactory	Good	6–10	6–10
Satisfactory	Fair	11–15	11–15
Unsatisfactory	Poor	>15	>15

The data obtained was analysed using appropriate tests for significance.

Lateral three wire fixation of supracondylar humerus fracture

Results

The mean age of the sample of 60 children selected from the population was 8.115. Males constituted 68.34% of the study population while females constituted 31.66% of the study. 63.33% of the supracondylar humerus fractures were on the left side while the remaining 36.67% belonged to the right side. In the study, most of the patients with supracondylar humerus fractures belonged to the 8 year old group with 15 cases (25%). Next in line were 9 year olds with 10 cases (16.67%), followed by 10 year olds with 8 cases (13.33%). The cases were classified by Gartland Classification and Type III (88.33%) was found to be most abundant followed by type II (11.67%). Each of the patients from the study sample was selected randomly for crossed medial and lateral pin fixation and lateral entry three divergent wires. Results from each group will now be analysed separately.

1. Crossed medial and lateral pin fixation:

The mean range of movement at the elbow joint was 145.5 degrees. The minimum net range of movement was 125 degrees and the maximum was 150 degrees. 2 patients out of these had developed 10 degrees fixed flexion deformity while another had developed 15 degrees fixed flexion deformity. Only a single case with carrying angle 3 degrees was found in the study. Clinically the child regained complete movement at the elbow. In the remaining 29 cases, carrying angle was found to be between 5 to 10 degrees, the most common value being 7 degrees. The mean carrying angle at the elbow was 6.43 degrees with the minimum value being 3 degrees and the maximum being 9 degrees. The mean Baumann's Angle for this sample of 30 was 10.8 degrees. Most of the post op cases had an angle of 10 degrees. The minimum value was 6 degrees and the maximum value was 15 degrees.

The mean Humero-trochlear angle in this sample was 37.06 degrees. The minimum value was 28 degrees and the maximum value was 45 degrees. The anterior humeral line in 30 patients who underwent crossed medial and lateral pinning had the following results - the line passed through middle third of the capitellum in 21 cases, through anterior third in 4 cases, through posterior third in 5 cases. There were no clinically detectable varus deformities in all cases treated by crossed pin fixation. In the 30 patients treated by crossed pin fixation, 87% had excellent results, 10% had good results and 3% had fair results. All 30 out of 30 patients treated by crossed pin fixation had satisfactory clinical outcomes. 26 patients returned to their daily activities in the first 4 to 8 weeks, while 3 patients took 8 to 12 weeks. One patient took 16 weeks since this patient had developed ulnar nerve neuropraxia post operatively and requires that much time to recover, and hence was not included in the calculations. The mean time of return to activity was 6.5 weeks, the minimum being 4.7 weeks and the maximum being 8 weeks.

There was only one case of pin tract infection recorded.

One case of post-operative ulnar nerve palsy was noted in one child. This nerve affection was actually a neuropraxia as the child had motor paralysis, but intact sensations. The palsy completely recovered over a period of 14 weeks.

2. Lateral entry three divergent pin fixation:

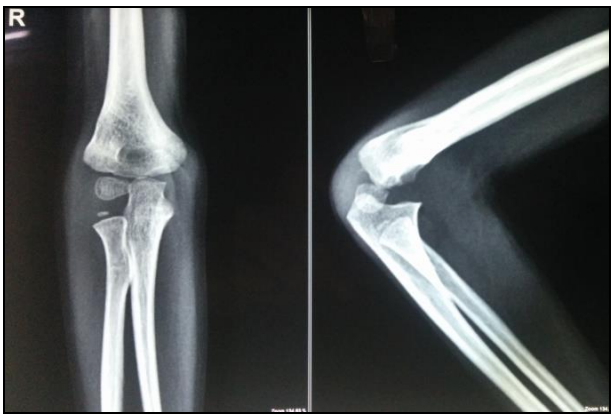
The mean range of movement at the elbow joint was 145.9 degrees. The minimum net range of movement was 125 degrees and the maximum was 154 degrees. One patient out of these had developed 10 degrees fixed flexion deformity, one had developed 20 degrees fixed flexion deformity and one had developed 30 degrees fixed flexion deformity while another had developed 10 degrees hyperextension. 17 patients had 150 degree or more range of motion.

The mean carrying angle was 6.14 degrees, the minimum value being 2 degrees and the maximum value being 9 degrees. The mean Baumann's Angle in this study sample was 9.38 degrees, the minimum value being 2 degrees and the maximum value being 15 degrees. Most of the post-operative cases had Baumann's angle 10 degrees. The mean humero-trochlear angle in this sample population was in this sample population was 36 degrees, the minimum value being 25 degrees and the maximum value being 46 degrees. Most number of cases had humero-trochlear angle of 40 degrees. The anterior humeral line in 29 patients who underwent lateral entry three wire divergent pinning passed through the middle third of the capitellum in 18 cases, through the anterior third in 8 and the posterior third in 3 cases. Of the 29 patients that underwent lateral pinning with 3 pins, 3 cases had clinically detectable varus, 26 cases did not and 1 child who underwent lateral pinning had persistent rotation deformity and varus collapse for which he underwent open reduction and internal fixation with crossed Kirschner wires. Among the 29 patients studied, 23 had excellent result, 4 had good and 2 had poor result. 2 had unsatisfactory outcome, while the remaining 27 had satisfactory outcome. 1 patient who underwent lateral pin fixation had to undergo open reduction and internal fixation with crossed Kirschner wires as there was rotation deformity with varus collapse. The mean time of return to daily activities is 7 weeks, the minimum time required being 5 weeks and the maximum time required being 10 weeks. 1 patient was reposted for surgery due to failed reduction (persistent rotation and varus collapse) wherein the child underwent open reduction and internal fixation with crossed 1 medial and 1 lateral Kirschner wire each. This patient has been excluded from follow up and the study.

Parameters	Mean (crossed pin)	Mean (lateral pin)	P value
Range of movement at the elbow (degrees)	145.5	145.9	0.88
Carrying angle (degrees)	6.43	6.14	0.48
Baumann's angle (degrees)	10.8	9.38	0.03
Humero-trochlear angle (degrees)	37.06	36	0.44
Anterior humeral line	-	-	0.96
Clinical varus	-	-	0.97
Clinical Result	-	-	0.97
Time of return to activity (weeks)	6.5	7	0.12

The above table shows the means of different parameters, each measured in the crossed pinning group and the lateral pinning group, along with their respective P values. Only the difference between the Baumann's angles at the end of 6 months was found to be statistically significant.

Fracture union after crossed pinning



Fracture union after three lateral divergent wires

Discussion

The supracondylar humerus fractures in the study were all of extension type. They are the most common fractures around the elbow in children and adolescents, in the non-dominant hand. Gartland type I fractures, being undisplaced are treated in an above elbow plaster slab. Gartland type II and type III fractures are the ones that are displaced and the preferred treatment is controversial. Five methods of treatment of extension type supracondylar fractures have been described in literature. These are closed reduction and above elbow casting, Blount's procedure (reduction is maintained in a flexed elbow in a collar and cuff sling), skeletal traction, primary closed reduction and percutaneous fixation (using medial and lateral crossed wires or only lateral wires) and open reduction and internal fixation.

The present study was conducted in Medical College and Hospital, Kolkata, over a period of 18 months in the Department of Orthopaedics. Sixty cases of paediatric supracondylar humerus fractures were divided into two groups-one group of thirty treated with crossed medial and lateral Kirschner wires and the other thirty treated with three lateral divergent Kirschner wires. Each patient was followed up over a period of 6 months for studying their radiological and clinical parameters in order to compare the outcomes of both surgeries.

The study conducted by Gordon *et al*. included 89 type III fractures and 49 type II fractures which proposed fixation of type II fractures with 2 lateral pins and 2 lateral with 1 medial pin in type III fractures after testing stability of fixation [1]. Skaggs *et al*. retrospectively reviewed 345 children amongst whom there were 141 type II fractures and 204 type III fractures and inferred that routine crossed pin fixation is to be avoided [2]. The study conducted by Lee Y.H. included 37 type III fractures and 24 type II fractures and found three lateral pin fixation to be safest and most stable.[3,12] Foead *et al*. found no difference between stability and restoration of radiographic parameters between crossed pin and lateral pin placement [4].

Most of the studies done to evaluate effectiveness of lateral pinning against crossed pinning found no statistically significant difference between lateral and crossed pin fixation [4, 5, 6, 9, 14, 15, 21, 23]. Some advocate routine use of lateral pins and reserve crossed pin configuration for unstable type III fractures [1, 2, 24]. Some have found excellent results with lateral pin fixations in unstable fractures thereby avoiding iatrogenic nerve injury [13, 16, 17, 19, 20, 22, 25]. Eidelman, M. *et al*. enumerates passing of medial pin with elbow in full extension to avoid ulnar nerve injury [7]. Green, D.W. *et al*. describes a mini open technique to avoid ulnar nerve injury while placing the medial pin [10]. Hamdi, A. *et al*. measured the biomechanical stability of the lateral pin construct and found that maximum divergence provided maximum stability.[11] Sangkomkamhang, T. *et al*. found higher incidence of loss of fixation in fractures fixed with only lateral pins, BMI>25 and poor surgical technique [18].

In this study, both the groups of patients were evaluated post operatively as per Flynn's criteria. In the crossed pinning group, 26 patients (87%) had excellent outcome, 3 patients (10%) had good outcome and 1 (3%) had fair outcome. In the lateral pinning group, 24 patients (80%) had excellent outcome, 4 patients (13%) had good outcome and 2 patients (7%) had poor outcome.

Mazda *et al*. conducted a study on 116 displaced paediatric supracondylar fractures and found that closed reduction and pinning with 2 lateral pins was a safe and effective procedure producing good or excellent results in 96% patients.

Lee YH. in his study concluded that lateral three divergent Kirschner wires were a safe procedure providing adequate stabilisation in Gartland Type III fractures achieving excellent results in 91.8% patients and good results in 8.2% patients.

In Krusche-Mandl's study on 78 patients treated with closed reduction and percutaneous pinning with crossed pins yielded satisfactory results in 93.5% patients while 6.4% had unsatisfactory results when graded by Flynn's criteria.

Only one incident of pin tract infection was noted in crossed pinning group. No cases of pin tract infection were noted in the lateral pinning group.

Also one patient who underwent lateral entry three pin fixation, was reoperated upon due to a persistent rotation deformity and varus collapse, with open reduction in internal fixation with crossed medial and lateral Kirschner wire. The patient was allowed to return to his daily activities 8 weeks after surgery.

One child in the crossed medial and lateral pinning group developed ulnar nerve neuropraxia post operatively which recovered under observation over the next 14 weeks and the child was allowed to resume her daily activites over the next 2 weeks. No cases of nerve palsies were recorded from the lateral three wire divergent pinning group.

The limitations of this study lie in its small sample size and short duration of follow up. For better evaluation of surgical techniques, larger sample size with longer follow up duration in a higher study protocol like a randomized controlled trial is needed.

Conclusion

There is no significant difference between crossed medial and lateral pin fixation and lateral entry three pin fixation in terms of stability.

However, the lateral pinning is a considerably safer procedure to avoid iatrogenic ulnar nerve palsy due to crossed pinning. One may consider crossed pinning in Modified Gartland type IV fractures and in fractures with medial column comminution.

But overall, both the methods of fracture fixation are safe and effective statistically for providing a biomechanically stable construct.

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