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Do parallel pinning offer advantage over crossed pinning for displaced supracondylar humerus fractures in children: a randomized trial

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ABSTRACT

Background: To compare outcomes between cross pinning with lateral pinning for fixation of displaced supracondylar fracture of humerus in children.
Methods: Children (<12 years) with displaced supracondylar fractures of the humerus were randomized to receive either cross pinning (Group 1) or lateral pinning Group 2). Follow-ups were conducted at 3 weeks, 6 weeks, and 3 months. Clinic-radiological union, Baumann angle, loss of reduction, stability of fracture fixation, incidence of complications, and Flynn's score were compared.
Results: The mean age of children in group 1 was 7.2±2.1 and in group 2 was 6.7±2.3, respectively (independent t-test, p=0.259). The mean follow up was 6.4±2.3 and 6.54±2.1 months, respectively (p=0.356). There were no significant differences observed in Baumann's angle, change in Baumann angle, loss of reduction, carrying angle, loss of carrying angle, range of motion in flexion and extension of the elbow, or total loss of range of motion between the two groups. One patient (2.4%) in group 1 had ulnar nerve injury. Based on Flynn's grading, 32 patients (85.7%) in group I and 27 patients (67.5%) in group II achieved excellent results (Figure 2b &c). In group I, 9 patients (31.4%) and in group II, 10 patients (25%) had good results. group I had 1 patient (2.4%) with fair results, while group II had 2 patients (5%) with fair results. One patient (2.5%) in group II had poor results.
Conclusions: Both techniques ensure stable fixation, union, and good functional outcomes, except for iatrogenic ulnar nerve injury with cross pinning.

Keywords: Supracondylar fracture, Crossed pin, Lateral pin, Closed reduction

INTRODUCTION

Supracondylar fractures are a frequent bone injury in children, accounting for about 60% of pediatric elbow fractures.[1] After age 7, they become the second most common fracture type. Epidemiological studies indicate these fractures are more prevalent in males.[2-3] Most supracondylar humerus fractures (97-100%) occur from falling on an extended elbow on the non-dominant side.[4-5]

Gartland originally classified supracondylar fractures of the humerus into three subtypes based on displacement in coronal plane radiographs. Type I refers to displaced or minimally displaced fractures with an intact anterior humeral line. Type II indicates small deviations with fragments in contact and an intact posterior cortex. Type III describes complete displacement of fracture fragments with a breach in the posterior cortex.[6] Leitch et al, later introduced a Type IV Gartland fracture with

multidirectional instability.[7] Closed reduction and stabilization with percutaneous pins is a frequently used surgical technique for treating displaced supracondylar fractures in children.[8] Medial and lateral crossed pinning, as well as parallel pinning, are widely used pinning configurations.[9] The selection of pinning technique remains a topic of debate and is largely contingent upon the surgeon's discretion. When comparing these two pinning configurations, mechanical stability and the risk of iatrogenic ulnar nerve injury are important considerations. Cross pinning provides greater stability but has a higher risk of ulnar nerve injury due to medial pin insertion.[10] Lateral pinning has minimal risk of nerve injury but is biomechanically less stable and may lead to loss of reduction.[11] The objective of this randomized study was to evaluate and compare the outcomes and safety of two pinning techniques, namely crossed pinning and lateral pinning, in terms of radiological and functional results, as well as any associated complications, for the fixation of displaced supracondylar fractures (Gartland types II and III) in pediatric patients.

METHODS

A prospective, interventional, randomized, double-blind study was conducted in the Orthopedics departments of Safdarjung Hospital and Dr. Ram Manohar Lohia Hospital, New Delhi, from April 2023 to May 2024. The institutional review boards and the local ethics committee approved the trial. Written informed consent was obtained from all patients in accordance with the Helsinki protocol.

Inclusion criteria

Children less than 12 years of age with displaced supracondylar fractures (Gartland types II and III) participated in the study.

Exclusion criteria

Children with compound and comminuted fractures, those who had previous attempt of manipulations, neurovascular deficit and those presenting after 3 weeks of injury were excluded from the study.

Sample size

The sample size calculation was premised on the principle of 'inference for means, comparing means of two independent samples.' This calculation was performed using a web-based calculator provided by the University of British Columbia (UBC), accessible through the link (https://www.stat.ubc.ca/~rollin/stats/ssize/n2.html).

Additionally, the sample size can be determined manually using the formula mentioned below.

$$N = \frac{(Z_{\alpha/2} + Z_{\beta})^2 \times 2(SD)^2}{(\mu 1 - \mu 2)^2}$$

In this formula,

N=Sample size in each group
μ1=mean change in group 1or mean score at baseline
μ2=mean change in group 2 or mean score after intervention
μ1-μ2=clinically significant difference
SD=standard deviation
Zα/2=This depends on the level of significance (for 5%=1.96)
Zβ =This depends on power (for 90%=0.94).

To determine the sample size and compare the mean difference in carrying angle loss between patients receiving crossed pins (group 1) and parallel pins (group 2), a pilot study was conducted with 6 subjects. The mean carrying angle loss in group 1 was 4 degrees, while in group 2 it was 3.6 degrees, with a standard deviation of 0.6. Considering an 80% power (alpha = 0.05) and a precision error of 5% to detect a difference of 20% or more in carrying angle loss, the estimated sample size for each group was calculated to be 36.

Two experienced surgeons performed the procedures. Allocation codes were computer-generated by the Community Ophthalmology department and concealed in numbered green envelopes opened by non-care staff. Patients were unaware of their assigned procedure type. Independent evaluators, not involved in the surgery, were blinded to both the surgeon's identity and the procedure type.

Preoperative evaluation

An independent investigator performed a thorough preoperative evaluation. Clinical examinations covered pain, deformity, instability, and distal neurovascular status before surgery.

Anteroposterior and lateral elbow radiographs were taken to assess displacement and fracture type. Demographic details like age, sex, hand dominance, injury mechanism, fracture displacement direction, time from injury to surgery, and neurovascular status were recorded and compared between cohorts.

Surgical technique

Anaesthesia was administered with patients in a supine position and their injured limb on the table's side. Closed reduction was confirmed using an image intensifier. First, longitudinal traction was applied with the elbow in hyperextension and the forearm in supination. While maintaining traction, medial or lateral displacement was corrected using a valgus or Varus force. The posterior displacement of the distal fragment was corrected by applying force to the posterior aspect while gently hyper flexing the elbow. The elbow was then secured in hyperflexion, with the reduction confirmed by an image intensifier.

After acceptable closed reduction under image intensifier guidance, reduction was maintained by pinning according to group allocation. Patients assigned to the crossed pin (Figure 1) technique group (Group 1) received one medially placed, and one laterally placed bi-cortical pin. The first pin was inserted from the lateral side. Following the placement of the lateral pin, the medial pin was inserted percutaneously without visualizing the ulnar nerve.

To avoid ulnar nerve injury, the elbow was kept at less than 45–60° of extension, and the wire was positioned over the epicondyle, anterior to the ulnar groove. If the epicondyle was not palpable due to swelling, a stab incision was made to visualize it. In group 2, patients undergoing the parallel pin (Figure 2a& b) technique had two or three pins inserted from the lateral side into the elbow, which engaged the medial cortex while the elbow was in hyperflexion. Pins were cut and bent. A plaster of Paris slab was applied above the elbow after reduction and fixation.

Postoperative care and rehabilitation

The duration of surgery, and the size and number of K-wires were recorded. Neurovascular deficits were assessed immediately postoperatively. Reduction was evaluated with Baumann's angle on a lateral radiograph before discharge. Patients were discharged on the 2nd postoperative day after checking wound dressing/pin sites, with instructions to keep the limb splinted and perform joint/finger movements. They were advised to report to the emergency room in case of excessive pain, swelling, tingling, numbness, or bluish discoloration of fingers.

A repeat radiograph was done after 3 weeks, and slab and pins were removed based on clinical-radiological evidence of union. The patients were evaluated on an outpatient basis at three weeks, six weeks, and twelve weeks post-surgery. Follow-up assessments for each patient were consistently conducted by the same investigator throughout the trial. Relevant clinical and radiological data were meticulously recorded as per the established proforma at every visit.

Outcome measures

Postoperatively (at three weeks), the slab was removed on an outpatient basis, and the K wires were removed upon radiological evidence of union. Elbow mobilization was conducted by a physiotherapist. Clinically, the fracture site was assessed for tenderness and inflammatory features. Radiologically, evidence of callus formation was observed, and Baumann's angle was measured. At 6 weeks follow-up, Elbow ROM and Baumann's angle were assessed clinically and radiologically. At 12 weeks follow-up, the outcome measures recorded were loss of carrying angle and total range of elbow motion using Flynn's criteria, and grading of loss of reduction based on the change in Baumann angle (degrees) between immediate post-operative radiographs and those at the 12-week follow-up. The method described by Skaggs et al, was followed for grading loss of reduction.[12] According to this method, the following classifications are used, no displacement (loss smaller than 6°), moderate displacement (6–12°), and large displacement (more than 12°).

The final Baumann angle (degree) was calculated on the radiograph of the anteroposterior view of the elbow. Additionally, the incidence of nerve injury and recovery pattern (if applicable) was noted, as well as the time to union (radiological).

Statistical analysis

Statistical analysis was performed on an intent-to-treat basis using IBM, SPSS Statistics version 29 (IBM Inc.). Independent t tests were performed to ensure group similarities at baseline, the assumptions of performing t tests were met. Chi-square tests were used for proportions. A one-way repeated-measures analysis of variance (ANOVA) was conducted to determine whether there were significant differences in mean test values.

There were no outliers, and data were normally distributed. as assessed by a box plot and Shapiro–Wilk test (P.0.05), respectively. The assumption of sphericity was violated, as assessed by the Mauchly test of sphericity. Therefore, a Greenhouse–Geisser correction was applied. A post hoc (Tukey) test was performed using the Bonferroni correction, to determine where differences occurred; A P value less than 0.005 was considered statistically significant.

RESULTS

During the study, 102 children had supracondylar humerus fractures. Of these, 8 came after 3 weeks, 6 had open injuries, and 4 declined to participate. Eighty patients met the criteria and underwent closed reduction with percutaneous pinning. Forty-two were assigned crossed pins (Group 1) and forty-two to parallel pins (Group 2).

Figure 1: Supracondylar fracture of humerus fixed with cross pins.

Figure 2: (a and b) Supracondylar fracture of humerus fixed with lateral pins (AP & Lateral view). (c and d) Supracondylar fracture of humerus fixed with lateral pins after union.

One patient in Group 2 was lost to follow-up, and another required open reduction. Statistical analysis included 42 patients from Group 1 and 40 from Group 2.

The mean age of children in group 1 was 7.2±2.1 (range, 4-12 years) and in group 2 was 6.7±2.3 (range, 3-12 years), respectively (independent t-test, p=0.259). Group 1 consisted of 27 males with a male-to-female ratio of 1.8:1, while group 2 included 22 males with a male-to-female ratio of 1.2:1 (Fischer exact test, p=0.498).

The most common mode of injury in both groups was falling from height. The predominant type of fracture observed in both groups was Gartland type III. Detailed demographic and clinical information of patients is provided in Table 1.

Clinical and radiological outcomes

Table 2 presents a comparison of clinical and radiological outcomes between the two groups. There were no significant differences observed in Baumann's angle, change in Baumann angle, loss of reduction, carrying angle, loss of carrying angle, range of motion in flexion and extension of the elbow, or total loss of range of motion between the two groups (Figure 1).

Based on Flynn's grading, 32 patients (85.7%) in group I and 27 patients (67.5%) in group II achieved excellent results (Figure 2 (a, b, c, d). In group I, 9 patients (31.4%) and in group II, 10 patients (25%) had good results. Group I had 1 patient (2.4%) with fair results, while group II had 2 patients (5%) with fair results. One patient (2.5%) in group II had poor results.

Complications

Table 3 compares complications between the two study groups. Pin track infections occurred in 2 patients (4.7%) in group 1 and 4 patients (10%) in group 2.

One patient (2.4%) in group 1 and 2 patients (5%) in group 2 had pin loosening. Group 1 also had one patient (2.4%) with ulnar nerve injury. Both groups had one patient each with loss of reduction. Superficial pin track infections were treated with pin removal, oral antibiotics, and local wound care. Wound debridement was done for pin tract loosening and revision surgery was planned in one patient in group 2. Patient with ulnar nerve injury was put under observation.

Table 1: Demographic and clinical details.

Parameter	Group 1 (n=42)	Group 2 (n=40)	P value
Age (in years)	7.2±2.1	6.7±2.3	0.259
Gender			
Male	27 (64.3)	22 (55)	0.498
Female	15 (35.7)	18 (45)	
Injury to presentation time (days)	7.7±5.1	6.9±4.8	0.482
Mode of injury			
Playing	18 (42.9)	15 (37.5)	0.658
Fall from height	24 (57.1)	25 (62.5)	
Type of displacement			
Posteromedial	30 (71.4)	25 (62.5)	0.482
Posterolateral	12 (28.6)	15 (37.5)	
Fracture type			
Gartland type III	26 (61.9)	30 (75)	0.240
Gartland type II	16 (38.1)	10 (25)	
Follow-up (months)	6.4±2.3	6.54±2.1	0.356

Table 2: Clinical and radiological outcomes.

Parameter	Group 1 (n=42)	Group 2 (n=40)	P value
Carrying angle	8.6±2.3	7.9±3	0.256
Carrying angle loss	3.8±1.1	3.5±1.5	0.260
Baumann's angle	78±3.4	77.7±3.3	0.574
Change in Baumann's angle	1.7±0.1	1.8±0.2	0.145
Range of motion	133±2.7	132±2.5	0.665
Loss of reduction	2.9±0.1	3.0±0.1	0.142
Flynn's grading			
Excellent	32 (85.7%)	27 (67.5)	0.551
Good	9 (31.4)	10 (25)	
Fair	1 (2.4)	2 (5)	
Poor	0	1 (2.5)	

Table 3: Complications.

Complication	Group 1 (n=42)	Group 2(n=40)	P value
Pin track infection	2 (4.7)	4 (10)	0.124
Loosening	1 (2.4)	2 (5)	0.256
Ulnar nerve injury	1 (2.4)	0	0.076
Loss of reduction	1 (2.4)	1 (2.5)	0.876
Vascular injury	0	0	-

DISCUSSION

This study compared the postoperative outcomes of two percutaneous fixation techniques, lateral pinning and cross pinning, for managing displaced supracondylar humerus fractures. Our results indicate that postoperative and intraoperative outcomes for both pinning techniques are comparable. However, the cross-pinning technique may be associated with the risk of iatrogenic ulnar nerve injury.

Effective management of pediatric fractures requires the maintenance of proper alignment until the healing process is complete. The management of displaced supracondylar fractures of the humerus is typically conservative. However, in cases of displaced fractures, the preferred treatment is either open or closed reduction with Kirschner wire fixation; the treatment options are either medial and lateral pinning in a cross fashion or two parallel pins. The optimal pinning technique remains debated.

Medial pinning in a crossed configuration has been reported to have risk of ulnar nerve injury.[13] On the other hand, lateral pinning, while biomechanically less stable, risks reduction loss. A meta-analysis of randomized controlled trials (n=11) indicated that loss of reduction was more frequent with lateral pinning (relative risk 1.44, 95% confidence interval 1.04-2.00, p=0.027). Iatrogenic ulnar nerve injury was less frequent in lateral pinning when analyzed based on treatment (relative risk 0.36, 95% confidence interval 0.14-0.92, p=0.032). 14 Our study aligned with these findings. A study conducted in Iran examining the epidemiology of elbow fractures in children (n=300) reported that supracondylar fractures were more prevalent in boys, with an average age of 8.1±2.3 years at presentation.[15] The current study carried out in the subcontinent has an average age of 6.8±2.7 years at presentation, also showing a higher occurrence in boys. In our study, 68.3% of children had Gartland type III fractures and 31.7% had type IIb. The Baumann's angle change was similar between crossed and parallel pinning techniques after 12 weeks, both offering comparable stability.

While Otsuka et al, found cross pinning more stable than lateral pinning, other studies suggest both methods provide equal stability.[16-18] Hasan et al, meta-analysis of 22 RCTs compared two pinning techniques for ulnar nerve injury. Twenty studies reported an odds ratio of 3.76, indicating a lower risk with the lateral pin technique. No significant differences were found in other clinical outcomes between the two techniques.[19]

Another meta-analysis by Queiroz et al, recommends percutaneous pinning with lateral wires for type II supracondylar humerus fractures and crossed wires with a mini-open technique for type III and IV fractures. The study found a higher risk of iatrogenic ulnar nerve injury without the mini-open technique.[20] One patient with crossed pins sustained ulnar nerve injury in our study; difficulty identifying the medial epicondyle led to medial pin slipping into the ulnar groove, causing nerve damage.

Earlier, ulnar nerve injuries after pinning for supracondylar fractures were considered temporary with spontaneous recovery. Recent studies suggest surgical exploration is needed in about one-third of cases.[21] In our study, there was no ischemia, increasing pain, or

deterioration of perfusion at last follow up. Therefore, surgical exploration was not planned. Over 90% of patients in both groups achieved excellent to good outcomes based on Flynn's criteria, consistent with other studies reporting similar results.[22]

Authors acknowledge some limitations and strengths in this study. The small sample size may cause type II errors and overestimation. However, the randomized study design reduces bias from the surgeon's pinning preference.

CONCLUSION

In conclusion, lateral pinning and crossed pinning showed no significant differences in functional outcomes, stability, union, or surgical complications. Both techniques offer stable fixation, union, and good functional results without causing ulnar nerve injury if a small incision is made to identify the medial epicondyle before inserting the medial pin.

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Ethical approval: The study was approved by the Institutional Ethics Committee

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