

ORIGINAL RESEARCH

Outcome analysis of four different pinning configurations for displaced supracondylar humerus fracture

¹Dr. Rajesh Jain, ²Dr. Surendra Padarya, ³Dr. Ritesh Parteti

¹Professor, ²Assistant Professor, ³Post Graduate Resident, Department of Orthopaedics, Bundelkhand Medical College, Sagar, M.P., India

Corresponding Author

Dr. Ritesh Parteti

Post Graduate Resident, Department of Orthopaedics, Bundelkhand Medical College, Sagar, M.P., India

Email: parteti.750ritesh@gmail.com

Received: 21 March, 2023

Accepted: 24 April, 2023

ABSTRACT

Background: The paediatric age group between 5 to 7 years encounters supracondylar fracture of humerus as the commonest fracture due to trauma following fall on an outstretched hand. There are different methods of pinning configurations for K wire insertion to stabilize a displaced fracture. The present study is aimed to assess the outcomes of different pinning techniques among children with supracondylar fracture humerus. **Methods:** This hospital based cross sectional study was conducted among 60 children aged 4 to 14 years presenting with Gartland type III supracondylar fracture of humerus. During the reduction surgery four type of Kirshner wire insertion techniques were performed on different children. Patients were followed upto 6 weeks post surgery. The radiological and functional outcomes were assessed by comparing the Carrying angle, Baumann's angle, anterior humeral line, movements of elbow joint and union of the fracture line. All the data was compiled in Microsoft excel and analysed using SPSS 26.0. **Results:** With a mean age of 8.6(±2.6) years and age ranging between 4-14 years, total 60 children were included in the study. 17 (28.3%) cases were operated by two cross K-wire, 18 (30%) were by two lateral K-wire divergent, 15 (25%) were by two lateral K-wire parallel and 10 (16.7%) cases were operated by three-pin techniques. Cross pinning showed 6 cases of ulnar nerve injury and no differences were found in ROM, carrying angle, Baumann's angle and anterior humeral line between the four methods of pinning. Position of the anterior humeral line also showed no significant difference. Flynn's criteria of outcome also showed no significant difference. **Conclusion:** This study suggests that there are no significant differences in functional and radiological outcomes among the four types of Kirshner wire fixation in Gartland type III supracondylar humerus fractures in children

This is an open access journal, and articles are distributed under the terms of the Creative Commons Attribution-Non Commercial-Share Alike 4.0 License, which allows others to remix, tweak, and build upon the work non-commercially, as long as appropriate credit is given and the new creations are licensed under the identical terms.

INTRODUCTION

Supracondylar fractures of the humerus (SHF) are the most prevalent fractures in children aged between 5 and 7 years and often necessitate surgical intervention. This type of fracture may result in severe complications such as nerve damage, vascular injury, and compartment syndrome. SHF accounts for 3% of all pediatric fractures, with extension being the most common type (98%) [1]. Falling on an outstretched hand is the most frequent cause of this injury [2]. The supracondylar region of the humerus undergoes remodeling in children, resulting in a decrease in both the antero-posterior and lateral diameter, fewer and less defined trabeculae, and a thinner coronoid fossa anteriorly, rendering this area more susceptible to fracture in this age group [3].

The Gartland staging system is the most widely used classification for managing supracondylar fractures of

the humerus, and Kirshner wires are commonly employed to stabilize displaced fractures during reduction [4,5]. Undisplaced fractures are typically stabilized using a posterior splint. Two Kirshner wires can be inserted in two ways: the two-cross-wire method, in which one wire is inserted medially and the other laterally, is stable but can cause ulnar nerve paralysis. In contrast, the lateral divergent insertion of two Kirshner wires provides excellent stability without injuring the ulnar nerve. In addition, percutaneous pinning maintains fracture reduction without significant elbow flexion immobilization [6]. In this study, we evaluated the functional and radiological outcomes, as well as the mechanical stability of various pinning methods, including cross, lateral divergent, lateral parallel, and three-pin Kirshner wire fixation.

MATERIALS AND METHODS

Study design and setting: This was a hospital-based prospective observational study conducted in the Department of Orthopaedics at Government Bundelkhand Medical College, Sagar, Madhya Pradesh, from July 2021 to August 2022.

Study participants, inclusion and exclusion criteria: Children attending the outpatient department (OPD), emergency and admitted to the ward with fresh displaced supracondylar fracture of the humerus were eligible for this study after the establishment of clinical and radiological diagnosis.

Patients were included based on the following criteria: i) All patients aged between 4 to 14 years, ii) Closed Gartland type III supracondylar humerus fracture, iii) Duration of injury less than seven days, iv) Normal neurological and vascular status of the affected limb and v) Closed reduction wherever possible.

Patients were excluded based on the following criteria: i) Compound fracture, ii) Type I and Type II, iii) Polytrauma patients, iv) More than 14 years of age, v) Any pathological fractures, vi) Congenital deformity, vii) Failed closed reduction.

Sample size and sampling: In the present study, we calculated the sample size using the formula for cross-sectional study ($n = Z^2pq/d^2$) where prevalence (p) was taken as 17% [7] and absolute precision (d) was considered as 10%. After adding 10% non-responders and rounding off, the final sample size was 60.

Data collection: All the children admitted with SHF go through a clinical and radiological examination. Proper history was taken and after assessment of distal neurovascular status, a temporary close reduction with POP slab was given to immobilize the elbow. The patient was prepared for pre-operative workup after all the necessary investigations. A prophylactic antibiotic was given intravenously and the patient was ready for general anaesthesia. After establishing a satisfactory level of close or open reduction using traction technique, stainless steel K wires were inserted under fluoroscopic guidance wherever applicable. Four pinning methods were used: crossed, divergent, parallel and three-pin techniques. Follow-up x-rays were done and the wires were removed after confirmation of callus

formation. The POPsplint was removed simultaneously, and the patient was urged to perform active elbow flexion and extension exercises as well as supination and pronation drills. Patients' outcome were evaluated and graded using the following criteria: elbow movements and the elbow's carrying angle compared with the normal elbow, the union of the fracture, Baumann's angle, lateral rotation percentage and anterior humeral line and Flynn's criteria. Follow-up was done till six-week post-op.

Statistical analysis: IBM Statistical Package for Social Sciences (SPSS) software Version 26.0) was used for data analysis. Qualitative variables were summarized using frequency and percentage. Inferential analysis was conducted using the chi-square test for categorical variables and ANOVA for continuous variables. P-values of <0.05 was considered significant.

Ethical consideration: The Institutional Ethical Committee of Government Bundelkhand Medical College, Sagar, Madhya Pradesh, granted permission to conduct this study. Written informed consent was taken from the parents of the children before data collection.

RESULTS

A total of 60 participants were selected with a mean age of 8.6 (±2.6) years (range: 4-12 years). The majority were male children (65%, 39/60). Most cases (86.7%, 52/60) attended hospital on or before the 3rd day of injury. Among all, 17 (28.3%) cases were operated by two cross K-wire, 18 (30%) were by two lateral K-wire divergent, 15 (25%) were by two lateral K-wire parallel and 10 (16.7%) cases were operated by three-pin (2 lateral & 1 medial). Nerve injury was seen among six patients overall. Three cases had nerve injury in the two cross K wire group, one among the two lateral (divergent) and two among the three-pin group. No nerve injury was seen in the lateral (parallel) group. Ulnar nerve injury was the only documented injury. The occurrence of nerve injury among the groups was not statistically significant. We found no significant differences in ROM, carrying angle, or Baumann's angle between these four fixation groups (table 1).

Table 1: Functional outcome between fixation

Variables		Method of fixation (mean±SD)				p-value
		Two cross K- wire	Two lateral divergent	Two lateral parallel	Three pin	
ROM (in degree)	Flexion	132.7 (2.94)	134.5(5.76)	133.6(6.13)	129.8(6.14)	0.390
	Extension	11.2 (7.0)	6.0(6.99)	6.0(6.32)	7.0(6.81)	0.098
Carrying angle (in degree)	Normal elbow	11.8 (1.9)	11.9(2.4)	11.0(1.6)	11.7(1.8)	0.552
	Operated elbow (6th-week post-op)	10.3 (1.8)	9.0(2.1)	9.8(1.2)	9.7(1.5)	0.205
Baumann's angle (in degree)	Normal elbow	77.2 (2.8)	74.3(3.5)	77.1(3.1)	76.5(1.9)	0.029
	Immediate post-op	77.1(2.9)	75.4(4.1)	76.3(3.4)	77.0 (1.3)	0.498
	Post-op 6th week	76.7(2.7)	74.8(6.6)	77.3(3.9)	76.8(2.3)	0.399

Among all the cases, at the time of surgery, except one case among two cross K wire groups which passed through the anterior 1/3rd of capitellum, rest all passed through the middle 1/3rd of capitellum. At the 6th week of post-surgery, the anterior humeral line passed through the anterior 1/3rd of the capitellum among a total of six cases, the rest (54) all passed through the middle 1/3rd of the capitellum. The differences in the distribution among the groups of fixations were not statistically significant.

Table 2: Radiological outcome between fixation

Variables		Frequency (%)				p-value
		Two cross k wire	Two lateral divergent	Two lateral parallel	Three pin	
Anterior humeral line(at the time of surgery)	Pass through anterior 1/3rd of capitellum	1 (1.7)	0 (0)	0 (0)	0(0)	0.462
	pass through middle 1/3rd of capitellum	16(26.7)	18(30.0)	15(25.0)	10(16.7)	
Anterior humeral line(at 6th week post-op)	Pass through anterior 1/3rd of capitellum	2 (3.3)	1(1.7)	3(5.0)	0(0)	0.542
	Pass through middle 1/3 rd of capitellum	15(25.0)	17(28.3)	12(20.0)	10(16.7)	

The functional outcome as per Flynn’s criteria of the two groups (divergent and parallel) is presented in Table 3. There was no significant difference in functional outcomes between the two-wire configurations on the Chi-square test.

Table 3:Final outcome according to Flynn’s criteria

Final outcome	Two cross K-wire	Two lateral divergent	Two lateral parallel	Three pin	p-value
Excellent	14 (23.3)	17(28.3)	12 (20.0)	9 (15.0)	0.422
Good	0 (0)	1 (1.7)	2 (3.3)	0 (0)	
Fair	1 (1.7)	0 (0)	1 (1.7)	0 (0)	
Poor	2 (3.3)	0 (0)	0 (0)	1 (1.7)	

DISCUSSION

The present study aimed to assess functional outcomes among four types of Kirshner wire fixation, namely cross, lateral divergent, lateral parallel, and three-pin Kirshner wire fixation, for fixing Gartland 3 supracondylar humerus fractures in children. The study found no significant differences in the range of motion among the four groups, which is consistent with the findings of previous studies by Prashant et al. and Kocher et al [8,9]. Furthermore, a meta-analysis by Zhao et al. also reported no significant differences between the lateral entry and crossed entry pinning fixation techniques regarding the total range of motion and flexion and extension [10].

The carrying angle of the operated elbow was measured in the four groups, and the differences in the angle were not statistically significant. This is in line with the comparative study by Kocher et al., which reported no significant differences between groups with respect to carrying angle [9]. Additionally, a meta-analysis on lateral and crossed pin fixation’s effect on paediatric Supracondylar humerus fractures also reported no significant differences in the carry angle between these two groups [10]. Another randomized controlled clinical trial by Maity et al.

found no significant differences between the two groups (cross-pinning and lateral pinning) concerning carrying angle [11].

The present study also assessed Baumann’s angle in the four groups and found no statistically significant differences. This is consistent with the findings of Gopinathan et al., which reported no significant difference in Baumann’s angle values between divergent or parallel configurations [12]. Similarly, Sapkota et al. found no substantial change in Baumann’s angle in the cross pinning and lateral three K-wires fixation group [13]. Kocher et al. also found no significant differences regarding the Baumann angle between lateral entry pin fixation and medial and lateral entry pin fixation groups [9].

In our study, six patients showed nerve injury, all of which were ulnar nerve injuries. However, the occurrence of nerve injury among the groups was not statistically significant. Mohd. Faizan et al. also recorded two ulnar nerve palsies in the cross-K wiring group, which recovered after a 6-week follow-up period [8]. The authors found no significant difference between the groups. In a randomized clinical study by Kocher et al., no iatrogenic nerve injury was reported when comparing the efficacy of lateral entry pin

fixation with medial and lateral entry pin fixation for the operative treatment of completely displaced extension supracondylar fractures of the humerus in children [9]. Similarly, Guy et al. reported zero iatrogenic nerve injuries in their study using lateral entry fixation with three divergent pins for displaced supracondylar humeral fractures [14]. A five-year retrospective study comparing lateral pin to medial and lateral pin fixation found no statistically significant difference between these groups regarding nerve injury [15].

The outcome, according to Flynn's criteria, was excellent in 86.7% (52/60) of cases, good in 5% (3/60) of cases, fair in 3.3% (2/60) of cases and poor in 5% (3/60) of cases. However, the differences in outcomes among the different groups were not statistically significant. Gopinathan et al. in their study where they used lateral pinning for displaced supracondylar fractures in children using three Kirschner wires in parallel and divergent configuration, found no statistically significant difference was seen in the and outcome according to Flynn's criteria irrespective of the wire configuration (divergent or parallel) [12]. Zhao et al. in their meta-analysis of randomized control trial, reported outcomes according to Flynn scores between the patients treated with crossed or lateral pin fixation there was not significantly different [10].

Limitations of the study include a small sample size and a short duration of follow-up. Further studies with a larger sample size and longer follow-ups are needed to determine the optimal type of fixation for Gartland 3 supracondylar humerus fractures in children.

CONCLUSION

In conclusion, the present study suggests that there are no significant differences in functional outcomes among the four types of Kirshner wire fixation for fixing Gartland 3 supracondylar humerus fractures in children.

REFERENCES

- Kumar V, Singh A. Fracture Supracondylar Humerus: A Review. *J Clin Diagn Res.* 2016 Dec;10(12):RE01–6.
- Brubacher JW, Dodds SD. Pediatric supracondylar fractures of the distal humerus. *Curr Rev Musculoskelet Med.* 2008 May 10;1(3–4):190–6.
- Ömeroğlu H. Basic principles of fracture treatment in children. *Eklemler Hastalıkları Cerrahisi.* 2018 Apr;29(1):52–7.
- Gartland JJ. Management of supracondylar fractures of the humerus in children. *SurgGynecol Obstet.* 1959 Aug;109(2):145–54.
- Picado A, González-Moran G, Moraleda L. Management of supracondylar fractures of the humerus in children. *EFORT Open Reviews.* 2018 Oct 1;3:526–40.
- Karantana A, Handoll HH, Sabouni A. Percutaneous pinning for treating distal radial fractures in adults. *Cochrane Database Syst Rev.* 2020 Feb 7;2020(2):CD006080.
- Vaidya SV. Supracondylar Humerus Fractures in Children: Epidemiology and Changing Trends of Presentation. *International Journal of Paediatric Orthopaedics.* 2015;1(1):3–5.
- Prashant K, Lakhota D, Bhattacharyya TD, Mahanta AK, Ravooof A. A comparative study of two percutaneous pinning techniques (lateral vs medial–lateral) for Gartland type III pediatric supracondylar fracture of the humerus. *J OrthopaedTraumatol.* 2016;17:223–9.
- Kocher MS, Kasser JR, Waters PM, Bae D, Snyder BD, Hresko MT, et al. Lateral Entry Compared with Medial and Lateral Entry Pin Fixation for Completely Displaced Supracondylar Humeral Fractures in Children: A Randomized Clinical Trial. *The Journal of Bone & Joint Surgery.* 2007 Apr;89(4):706–12.
- Zhao H, Xu S, Liu G, Zhao J, Wu S, Peng L. Comparison of lateral entry and crossed entry pinning for pediatric supracondylar humeral fractures: a meta-analysis of randomized controlled trials. *J OrthopSurg Res.* 2021 Dec;16(1):366.
- Maity A, Saha D, Roy DS. 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. *J OrthopSurg Res.* 2012 Feb 15;7:6.
- Gopinathan NR, Sajid M, Sudesh P, Behera P. Outcome Analysis of Lateral Pinning for Displaced Supracondylar Fractures in Children Using Three Kirschner Wires in Parallel and Divergent Configuration. *Indian J Orthop.* 2018;52(5):554–60.
- Sapkota K, Shrestha B. Study of supracondylar fracture of distal humerus in children and its management with lateral k- wire fixation. *Nepal J Med Sci* 2014;3:38–43
- Guy SP, Ponnuru RR, Gella S, Tulwa N. Lateral Entry Fixation Using Three Divergent Pins for Displaced Paediatric Supracondylar Humeral Fractures. *ISRN Orthop.* 2011 Sep 11;2011:137372.
- Sahu RL. Percutaneous K-wire fixation in paediatric supracondylar fractures of humerus: A retrospective study. *Niger Med J.* 2013;54(5):329–34