



CLOSED REDUCTION AND PERCUTANEOUS K-WIRE FIXATION FOR DISPLACED SUPRACONDYLAR HUMERUS FRACTURES IN CHILDREN: A PROSPECTIVE STUDY OF CLINICAL AND FUNCTIONAL OUTCOMES

Orthopaedics

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ABSTRACT

Background: Supracondylar fracture of the humerus is the commonest paediatric elbow injury. Closed reduction and percutaneous K-wire fixation (CRPP) is the accepted treatment for displaced (Gartland type II/III) fractures, but the comparative merits of cross versus lateral pin configurations remain debated. **Objectives:** To evaluate the clinical and functional outcomes of CRPP in children with displaced supracondylar humerus fractures and to compare cross and lateral K-wire configurations. **Methods:** A prospective study of 52 children aged 3–12 years with Gartland type II or III fractures, treated with fluoroscopy-guided CRPP at a tertiary-care centre over one year, was conducted. Functional outcome was graded by Flynn's criteria; union time, pin-tract infection, ulnar nerve injury, loss of reduction and cubitus varus were recorded. Categorical variables were compared using the chi-square test and union time using the independent t-test (SPSS; $p < 0.05$ significant). **Results:** Gartland type III fractures accounted for 65.38% of cases; cross K-wire fixation was used in 59.62% and lateral pinning in 40.38%. Excellent or good functional outcomes were achieved in 94.23% of children. Pin-tract infection occurred in 5.77%, ulnar nerve injury in 7.69%, loss of reduction in 3.85%, and cubitus varus in 7.69%. Mean union time was 4.19 ± 0.91 weeks with cross pinning versus 4.57 ± 0.87 weeks with lateral pinning ($p = 0.18$). No significant association was found between functional outcome and age ($p = 0.78$), pin configuration ($p = 0.608$), or Gartland type ($p = 0.15$), nor between pin configuration and complication rate ($p = 0.87$). **Conclusion:** CRPP provides safe, reliable union and excellent functional recovery in displaced paediatric supracondylar humerus fractures. Both cross and lateral pin configurations yield comparable functional outcomes, union times and complication rates; pin selection should be individualised to fracture stability and surgeon expertise, with anatomical reduction and stable fixation remaining the key determinants of a favourable outcome.

KEYWORDS

Supracondylar Humerus Fracture; Percutaneous Pinning; Kirschner Wire; Children; Gartland Classification; Flynn's Criteria

INTRODUCTION

Supracondylar fractures of the humerus are the most common elbow injury of childhood, accounting for 13–17% of all paediatric fractures and up to 60% of paediatric elbow fractures, with peak incidence between five and seven years of age.¹ The classical mechanism is a fall onto an outstretched hand with the elbow in extension, generating a hyperextension force across the distal humeral metaphysis; extension-type injuries constitute more than 95% of cases, while flexion-type fractures, caused by a direct blow to a flexed elbow, are uncommon.¹ Because the brachial artery and the median, radial and ulnar nerves lie in close proximity to the fracture site, a thorough neurovascular examination is mandatory at presentation, and progressive signs of ischaemia warrant emergency intervention.²

Radiographic assessment with standard anteroposterior and lateral elbow views is usually sufficient for diagnosis, and severity is graded using the Gartland classification: type I fractures are non-displaced, type II show displacement with an intact posterior cortex, and type III fractures are completely displaced with no cortical contact; a later type IV, described by Leitch and colleagues, denotes multidirectional instability from disruption of both periosteal hinges.³ Non-operative management with above-elbow casting suffices for type I injuries, whereas displaced type II–IV fractures generally require surgical stabilisation.⁴

Closed reduction and percutaneous K-wire fixation (CRPP) has emerged as the treatment of choice for displaced paediatric supracondylar fractures, providing anatomical realignment while preserving the periosteal soft-tissue envelope.⁵ Two pinning strategies are in common use: lateral-entry pinning, which avoids instrumentation of the medial column and therefore carries a lower risk of iatrogenic ulnar nerve injury, and crossed medial–lateral pinning, which is biomechanically more rigid but exposes the ulnar nerve to injury during medial pin placement.⁴ The comparative safety and efficacy of these two configurations remain a subject of ongoing debate, with some authors favouring lateral pinning for its neurological safety and others advocating crossed pinning for markedly unstable fracture patterns.⁴

When treatment is delayed or inadequate, complications such as

malunion, cubitus varus (gunstock) deformity, elbow stiffness, pin-tract infection and, rarely, compartment syndrome or Volkmann ischaemic contracture may compromise the functional and cosmetic outcome.⁵ Given the persisting controversy regarding optimal pin configuration and the relative paucity of prospective data from Indian tertiary-care settings, this study was undertaken to evaluate the clinical and functional outcomes of CRPP in children with displaced supracondylar humerus fractures and to compare the efficacy and complication profile of cross versus lateral K-wire fixation.⁶

MATERIALS AND METHODS

Study Design and Setting

This hospital-based prospective observational study, reported in accordance with the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) guidelines for cohort studies, was conducted in the Department of Orthopaedics, Dr KNS Memorial Institute of Medical Sciences (formerly Mayo Institute of Medical Sciences), Barabanki, Uttar Pradesh, India, over a period of one year. The protocol was approved by the Institutional Ethics Committee, and written informed consent was obtained from a parent or legal guardian of every child, with additional assent obtained from older children. The study was conducted in accordance with the World Medical Association Declaration of Helsinki.

Participants

Children presenting to the orthopaedic emergency and outpatient department with a radiologically confirmed supracondylar fracture of the humerus were screened consecutively for eligibility, and eligible children were enrolled by simple random sampling. Children aged 3–12 years with Gartland type II or type III displaced fractures, who were medically fit for surgery, whose parents consented, and who presented within three weeks of injury were included. Children unwilling to undergo surgery and those with open fractures, old malunited fractures, pathological fractures, undisplaced (type I) fractures, associated head injury, or presentation beyond three weeks were excluded.

Sample Size

The sample size was calculated for comparison of two proportions

using the standard chi-square formula $n = (Z\alpha/2 + Z\beta)^2 \times [p_1(1-p_1) + p_2(1-p_2)] / (p_1 - p_2)^2$, assuming a two-sided α of 0.05, power of 80%, and expected excellent-outcome proportions of 91% and 70% for the two pinning groups based on prior literature. This yielded a minimum requirement of 52 patients, which formed the final study sample. A pilot study on five additional patients, excluded from the final analysis, was used to standardise the data-collection proforma and radiographic measurement technique.

Surgical Technique

All patients underwent closed reduction under general anaesthesia with continuous C-arm fluoroscopic guidance. Satisfactory reduction was confirmed on orthogonal (anteroposterior and lateral) fluoroscopic images before fixation. Percutaneous fixation was performed with 1.5-mm or 2-mm Kirschner wires, inserted either as two or three divergent lateral-entry pins or as crossed medial-lateral pins, at the operating surgeon's discretion based on fracture stability and pattern. When crossed pins were used, meticulous care was taken during medial pin insertion, with a small skin incision and direct palpation of the medial epicondyle, to avoid ulnar nerve injury. Construct stability was confirmed intraoperatively by assessing the full range of elbow motion under fluoroscopy. An above-elbow posterior slab of plaster of Paris was applied with the elbow flexed, and the limb was elevated postoperatively; radial pulse, capillary refill, and finger sensation and movement were monitored closely during the first 12 postoperative hours.

Follow-up and Outcome Assessment

Patients were followed up at 2 and 3 weeks (with radiographs to assess callus formation) and at 6 weeks and 3 months. The plaster slab and K-wires were removed at 3 weeks, after which supervised physiotherapy for elbow range of motion was initiated. At each visit, patients were assessed clinically and radiologically for fracture union, carrying angle, range of motion, and complications, including pin-tract infection, ulnar nerve injury, loss of reduction, and cubitus varus deformity. Final functional and cosmetic outcome was graded at the last follow-up using Flynn's criteria, which classifies results as excellent, good, fair, or poor on the basis of combined loss of carrying angle and loss of elbow motion relative to the contralateral side.

Statistical Analysis

Data were entered in Microsoft Excel and analysed using SPSS software. Categorical variables were summarised as frequencies and percentages and compared using the chi-square test; continuous variables (union time) were expressed as mean $\pm$ standard deviation and compared between pin-configuration groups using the independent-samples Student's t-test. A two-sided p-value <0.05 was considered statistically significant.

RESULTS

Fifty-two children fulfilling the eligibility criteria were enrolled and completed follow-up. Thirty-two children (61.54%) were aged 8–12 years and 20 (38.46%) were aged 3–7 years. The left elbow was involved in 34 patients (65.38%) and the right in 18 (34.62%). On Gartland classification, 34 fractures (65.38%) were type III and 18 (34.62%) were type II (Table 1).

Table 1. Demographic and Fracture Characteristics of the Study Population (n=52)

Variable	Category	n	%
Age group	3–7 years	20	38.46
	8–12 years	32	61.54
Side	Left	34	65.38
	Right	18	34.62
Gartland type	Type II	18	34.62
	Type III	34	65.38

Cross K-wire fixation was performed in 31 patients (59.62%) and lateral-entry pinning in 21 (40.38%). Pin-tract infection occurred in 3 patients (5.77%); the remaining 49 (94.23%) had no infection. Ulnar nerve injury occurred in 4 patients (7.69%). Loss of reduction occurred in 2 patients (3.85%), and cubitus varus deformity developed in 4 patients (7.69%) (Table 2).

Table 2. Pin Configuration and Postoperative Complication Profile (n=52)

Variable	Category	n	%
Pin configuration	Cross K-wire	31	59.62

	Lateral K-wire	21	40.38
Pin-tract infection	Present	3	5.77
Ulnar nerve injury	Present	4	7.69
Loss of reduction	Present	2	3.85
Cubitus varus	Present	4	7.69

Using Flynn's criteria, 45 patients (86.54%) achieved an excellent outcome, 4 (7.69%) good, 2 (3.85%) fair, and 1 (1.92%) poor, giving a combined excellent-to-good outcome in 94.23% of children (Table 3).

Table 3. Functional Outcome by Flynn's Criteria (n=52)

Outcome grade	n	%
Excellent	45	86.54
Good	4	7.69
Fair	2	3.85
Poor	1	1.92
Total	52	100.00

Among children aged 3–7 years, 18/20 (90%) had excellent outcomes, compared with 27/32 (84.4%) in the 8–12-year group; this association was not statistically significant ($\chi^2=1.09$, $p=0.78$). Excellent results were obtained in 28/31 (90.3%) of the cross-pinned group and 17/21 (81.0%) of the laterally pinned group, again without a significant association between pin configuration and Flynn grade ($\chi^2=1.834$, $p=0.608$). Excellent outcomes were achieved in 17/18 (94.4%) of Gartland type II and 28/34 (82.4%) of type III fractures; this difference also did not reach statistical significance ($\chi^2=5.264$, $p=0.15$) (Table 4).

Table 4. Association Between Clinical Variables and Flynn's Functional Outcome

Variable	Excellent outcome, n/N (%)	χ^2	p-value
Age 3–7 y vs 8–12 y	18/20 (90.0) vs 27/32 (84.4)	1.09	0.78
Cross vs lateral pinning	28/31 (90.3) vs 17/21 (81.0)	1.834	0.608
Gartland type II vs III	17/18 (94.4) vs 28/34 (82.4)	5.264	0.15

A complication of any type occurred in 7/31 (22.6%) of the cross-pinned group compared with 6/21 (28.6%) of the laterally pinned group; this difference was not statistically significant ($\chi^2=0.027$, $p=0.87$). The mean time to radiographic union was 4.19 ± 0.91 weeks in the cross-pinned group and 4.57 ± 0.87 weeks in the laterally pinned group, a difference that was also not statistically significant (independent t-test, $t=1.58$, $p=0.18$) (Table 5).

Table 5. Pin Configuration Versus Overall Complication Rate and Mean Union Time

Pin configuration	n (%)	Complication, n (%)	Union time, weeks (mean $\pm$ SD)
Cross K-wire	31 (59.62)	7 (22.6)	4.19 ± 0.91
Lateral K-wire	21 (40.38)	6 (28.6)	4.57 ± 0.87

χ^2 (complications) = 0.027, $p=0.87$; independent t-test (union time) $t=1.58$, $p=0.18$.

DISCUSSION

In this prospective study of 52 children with displaced supracondylar humerus fractures treated by CRPP, excellent-to-good functional outcomes were achieved in 94.23% of cases, with low rates of pin-tract infection (5.77%), ulnar nerve injury (7.69%), loss of reduction (3.85%) and cubitus varus (7.69%), confirming CRPP as a safe and reliable technique consistent with its established role as the gold-standard treatment for displaced paediatric supracondylar fractures.

The predominance of older children (61.54% aged 8–12 years) in our cohort mirrors the findings of Sahu, who reported a similar age distribution among 170 children with displaced fractures and attributed the higher incidence in older, more active children to greater participation in outdoor play.⁷ The left-sided predominance observed in our series (65.38%) is consistent with the report of He et al., who found comparable left-sided involvement (60%) in a cohort of children with supracondylar fractures, a pattern generally attributed to protective use of the dominant limb during a fall.⁸ The majority of our patients (65.38%) had Gartland type III fractures, similar to the 83% reported by He et al.,⁸ reflecting referral bias toward more severely displaced injuries at tertiary centres and supporting the applicability of CRPP even in completely displaced fracture patterns.

Cross K-wire fixation was used more frequently than lateral pinning in our cohort (59.62% versus 40.38%). Sahu similarly reported comparable use of both configurations with no significant difference in functional outcome between groups at multiple follow-up intervals,⁷ a

finding corroborated by the systematic review and meta-analysis of Dekker et al., who found no significant difference in functional outcome between crossed and lateral pinning across 13 studies (1158 patients; relative risk 1.07), although the incidence of iatrogenic ulnar nerve injury was higher with crossed pinning (4.1%) than with lateral pinning (0.3%).⁶ Our results similarly demonstrated no significant difference in Flynn outcome ($p=0.608$) or overall complication rate ($p=0.87$) between the two configurations, although the numerically higher rate of ulnar nerve injury with crossed pinning in our series is consistent with this broader literature and reinforces the importance of meticulous medial pin technique whenever a crossed configuration is chosen.

Our pin-tract infection rate of 5.77% is comparable with the 4.3% reported by Shahid et al. in a large retrospective series of 490 children, in which most infections were superficial and resolved with local care.⁹ The 7.69% incidence of ulnar nerve injury observed in the present study, although higher than the near-zero rate reported by Zhou et al. using a modified K-Hammer technique for medial pin insertion, remains within the range reported in most large series and underscores that refinements in surgical technique for medial pin placement may further reduce this risk.¹⁰

The low rate of loss of reduction (3.85%) in our study is consistent with the meta-analysis of Carrazzone et al., who found that crossed-wire fixation conferred a modestly lower risk of loss of reduction than lateral-wire fixation, while lateral fixation carried a lower risk of iatrogenic nerve injury — a trade-off that should guide individualised pin selection rather than a uniform approach.¹¹ The cubitus varus rate of 7.69% observed here is comparable to the 10% reported in the lateral-pinning group by Hussein et al.,¹² and reflects the overall adequacy of reduction and fixation achieved in our cohort.

Functional outcomes in our series (86.54% excellent) compare favourably with the 68% excellent outcome reported by Kumar in a similarly designed prospective study of 50 children, in which poorer results were significantly associated with Gartland type III fractures.¹³ In contrast, we did not find a significant association between fracture severity and functional outcome ($p=0.15$), suggesting that with meticulous reduction and stable fixation even completely displaced fractures can achieve results comparable to less severe injuries, a conclusion also supported by Bhakta et al. in a cohort of 30 children with type III fractures treated with cross-pinning,¹⁴ and by the systematic review of Yousri et al., which found no significant difference in stability or loss of reduction between crossed and lateral configurations specifically in Gartland type III fractures.¹⁵

Mean union time in our study (4.19–4.57 weeks) closely parallels the roughly 4-week mean union time reported by Sahu⁷ and is consistent with the observation of Akçaalan et al. that union time in supracondylar fractures is largely independent of coronal-plane pin configuration,¹⁶ reaffirming that anatomical reduction, rather than the specific pin arrangement, is the principal determinant of timely healing.

Limitations of this study include the relatively modest single-centre sample, non-randomised allocation of pin configuration (determined by surgeon preference rather than randomisation), and a follow-up period of three months, which may not capture late complications such as growth disturbance. Larger multicentric randomised trials with longer follow-up are needed to definitively establish the superiority, if any, of crossed versus lateral pinning constructs.

CONCLUSION

Closed reduction and percutaneous K-wire fixation is a safe and effective treatment for displaced (Gartland type II and III) supracondylar humerus fractures in children, achieving excellent-to-good functional outcomes by Flynn's criteria in over 94% of patients, with low rates of infection, nerve injury, loss of reduction and cubitus varus deformity. Neither patient age nor fracture severity significantly influenced the final functional outcome, and both crossed and lateral pin configurations achieved comparable functional results, union times and overall complication rates, although lateral pinning may confer a lower risk of iatrogenic ulnar nerve injury. Pin configuration should therefore be individualised according to fracture stability and surgeon expertise, with anatomical reduction and stable fixation remaining the principal determinants of a favourable outcome.

REFERENCES

1. Kumar V, Singh A. Fracture supracondylar humerus: a review. *J Clin Diagn Res.*

2016;10(12):RE01-6.

2. Vaquero-Picado A, González-Morán G, Moraleda LM. Management of supracondylar fractures of the humerus in children. *EFORT Open Rev.* 2018;3(10):526-40.
3. Alton TB, Werner SE, Gee AO. Classifications in brief: the Gartland classification of supracondylar humerus fractures. *Clin Orthop Relat Res.* 2015;473(2):738-41.
4. Micheloni GM, Novi M, Leighab M, Giorgini A, Porcellini G, Tarallo L. Supracondylar fractures in children: management and treatment. *Acta Biomed.* 2021;92(Suppl 3):e2021015.
5. Hoffman B, Lee A, DiGiacomo D, Maag S, Liu J, Skie M. A systematic review of the operative techniques for treating cubitus varus deformity in children. *J Pediatr Orthop B.* 2024;33(6):590-9.
6. Dekker A, Krijnen P, Schipper I. Results of crossed versus lateral entry K-wire fixation of displaced pediatric supracondylar humeral fractures: a systematic review and meta-analysis. *Injury.* 2016;47(11):2391-8.
7. Sahu RL. Percutaneous K-wire fixation in paediatric supracondylar fractures of humerus: a retrospective study. *Niger Med J.* 2013;54(5):329-34.
8. He X, Zou K, Wang S, Li J, Hong P. Lateral external fixation plus K-wire for pediatric supracondylar humeral fracture with medial comminution: a retrospective study of 53 cases in a tertiary medical center. *Transl Pediatr.* 2025;14(8):1952-60.
9. Shahid GF, Abubakar M, Sanobar M, Hashmi MU. Rate of pin tract infection among children with supracondylar fracture of humerus: buried versus percutaneous K-wires. *Med Forum Mon.* 2019;30(10):1-4.
10. Zhou Y, Bai X, Li C, Zhou M, Bai F, Chen J, Sun G. K-Hammer percutaneous fixation: a novel technique for preventing iatrogenic ulnar nerve injury in pediatric supracondylar humeral fractures. *Front Pediatr.* 2025;13:1718195.
11. Carrazzone OL, Barbachan Mansur NS, Matsunaga FT, Matsumoto MH, Faloppa F, Belloti JC, et al. Crossed versus lateral K-wire fixation of supracondylar fractures of the humerus in children: a meta-analysis of randomized controlled trials. *J Shoulder Elbow Surg.* 2021;30(2):439-48.
12. Hussein MT. Comparative study between two patterns of percutaneous K-wire fixation of supracondylar fracture of the humerus in children. *Mustansiriyah Med J.* 2016;15(2):14-9.
13. Kumar S. A prospective study of percutaneous K-wire fixation in supracondylar fracture humerus in children. *Int J Life Sci Biotechnol Pharma Res.* 2025;14(3):1332-6.
14. Bhakta AK, Rahman MZ, Mobarok H, Kumar SA, Kabir MH, Sadi SM, et al. Closed reduction and percutaneous cross K-wire fixation: management of displaced supracondylar fracture of the humerus (Gartland type III) in children. *Saudi J Med Pharm Sci.* 2024;10(7):447-54.
15. Yousri T, Tarassoli P, Whitehouse M, Monsell F, Khan WS. Systematic review of randomized controlled trials comparing efficacy of crossed versus lateral K-wire fixation in extension type Gartland type III supracondylar fractures of the humerus in children. *Ortop Traumatol Rehabil.* 2012;14(5):397-405.
16. Akçaalan S, Çağlar C, Kengil MC, Akkaya M, Kapıcıoğlu M, Doğan M. Does the configuration of the K-wires in the coronal plane affect the time to union in supracondylar humerus fractures? *Ege J Med.* 2025;64(1):1-7.