



Original Article

Comparative Study of Functional Outcome Between Two Crossed K-wire Fixation Versus Two Lateral Divergent K-wire Fixation in Management of Pediatric Supracondylar Humerus Fracture

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Received: 30-05-2026

Accepted: 13-07-2026

Available online: 17-07-2026

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Medical and Pharmaceutical Research

ABSTRACT

Background: The dislocated supracondylar fractures of the humerus in children are most commonly dealt with via closed reduction and percutaneous Kirschner (K)-wire fixation. The ideal pin configuration, however, crossed or lateral divergent, remains a subject of contention owing to the balance between mechanical stability and risk of iatrogenic ulnar nerve damage.

Methods: This comparative research work includes 30 children with “supracondylar humerus fracture” divided equally into 2 groups. Each group included 15 children. Both groups were treated with two crossed k-wires and two lateral divergent k-wires respectively. We recorded and compared the baseline fracture severity using the Gartland classification, the functional outcome with the Flynn criteria, the radiological outcome, and the postoperative complications between the groups.

Results: Within both groups as a whole, there were more Gartland type III fractures than type II fractures (21 Vs 9). Furthermore, there were no significant differences between groups with respect to fractures severity ($p>0.05$). In total, 86.67% of the patients achieved good-to-excellent functional results which was comparable between the crossed (93.3% good-excellent) and the lateral divergent (93.3% good-excellent) ($p>0.05$). Both outcomes, functional and radiological, were similar in both groups, with most patients showing excellent and good outcomes ($p>0.05$). Complications were rare (3/30 overall), and the single case of transient ulnar nerve injury occurred only in the crossed K-wire group, whereas pin tract infection was equally observed in both groups.

Conclusion: Both crossed and lateral divergent K-wire fixation techniques for the management of supracondylar humerus fractures in children produced equivalent functional and radiological outcomes. The crossed configuration poses a risk for iatrogenic ulnar nerve injury. When equally stable pinning can be accomplished, lateral divergent pinning is preferable.

Keywords: supracondylar humerus fracture, Kirschner wire, Flynn criteria, pediatric orthopedics.

INTRODUCTION

Humeral supracondylar fracture is the most common elbow fracture occurring in children. It accounts for a major portion of pediatric fractures presenting in a tertiary care centre.[1] Reported incidences are around 308 per 100000 children per year. Type II (displaced but with intact posterior cortex) and III (completely displaced) further types of extension-type fractures (according to the Gartland system) should be managed well and accurately.[2] Otherwise, malunion, cubitus varus, neurovascular injury, and permanent functional deficit could occur.[3].

Closed reduction and percutaneous K-wire fixation are currently the preferred treatments for displaced (Gartland type II and III) fractures. However, the optimal configuration of pins continues to engender debate in the orthopedic literature. Fixation using crossed K-wires (one lateral and one medial pin) is biomechanically advantageous as it provides better torsional and coronal plane stability. However, placing the medial pin carries a risk of iatrogenic ulnar nerve injury. The use of Lateral divergent (two laterally entry) K-wire fixation avoids this neurological risk by keeping both pins away from the medial epicondyle, although some studies suggest it might offer slightly less rotational stability.[1,2,4]

In light of this ongoing controversy, we planned this study to compare the functional outcome, radiological outcome and complication profile of crossed K-wire fixation versus lateral divergent K-wire fixation in the management of paediatric supracondylar humerus fractures. The study was conducted at a tertiary care centre with the aim of enabling evidence-based choice of pinning technique in everyday practice.

MATERIALS AND METHODS

Study Design

This was a prospective observational study designed to compare the functional and radiological outcomes of two crossed K-wire fixation versus two lateral divergent K-wire fixation in the management of pediatric supracondylar humerus fractures.

Study Setting

The study was conducted as a single-centre, hospital-based study.

Place of Study

The study was carried out at Sri Aurobindo Medical College and Post Graduate Institute, Indore.

Duration of the Study

The study spanned a total duration of 18 months, from 01.06.2024 to 30.09.2026.

Study Source

Patients admitted to Sri Aurobindo Medical College and Post Graduate Institute, Indore, with a diagnosis of supracondylar humerus fracture were considered for enrolment. Written informed consent was obtained from all patients (or their legal guardians, given the pediatric population) prior to inclusion. Following confirmation of diagnosis, patients were screened and selected for the study based on the predefined inclusion and exclusion criteria.

Inclusion criteria:

- Displaced supracondylar fractures (Gartland type II and type III)
- Age less than 15 years
- Fractures treated by closed or open reduction
- Duration of injury less than 1 week

Exclusion criteria:

- Undisplaced fractures (Gartland type I)
- Age more than 15 years
- Pathological fractures
- Patients unwilling to participate
- Patients with polytrauma
- Duration of injury more than 1 week

Sample Size

The sample size was calculated using the standard formula for estimating sample size in a prevalence-based study:

$$n = \frac{z^2 \times p(1 - p)}{e^2}$$

where z is the standard normal deviate corresponding to the desired confidence level, p is the expected proportion, and e is the margin of error (precision). For a 90% confidence level (z = 1.645), an expected proportion (p) of 0.1, and a margin of error (e) of 0.09, the calculation was as follows:

$$n = \frac{1.645^2 \times 0.1 \times (1 - 0.1)}{0.09^2} = \frac{0.2435}{0.0081} = 30.067 \approx 30$$

Accordingly, the final sample size was set at 30 patients, who were subsequently allocated into two equal groups of 15 patients each — one group treated with two crossed K-wires and the other with two lateral divergent K-wires.

Method of Data Collection

Data were collected using a pre-structured, study-specific proforma designed to capture demographic, clinical, radiological, and outcome-related variables. The sequential steps of data collection were as follows:

- History from the patient and accompanying attendants
- Clinical examination of the injured limb
- Radiological examination (anteroposterior and lateral elbow radiographs)
- Clinical and radiological diagnosis, including Gartland classification of fracture severity
- Relevant preoperative investigations
- Post-procedure evaluation using clinical examination and follow-up radiography

Anaesthesia and Patient Positioning

All patients received general anaesthesia prior to surgery. The patient was positioned supine with the shoulder placed at the edge of the operating table. The elbow was thoroughly cleaned, painted, and draped to expose the operative field.

Surgical Technique

Closed reduction: Longitudinal traction was applied to the forearm with counter-traction on the upper arm to achieve fracture reduction. Traction was maintained under fluoroscopic (radiographic) control for approximately five minutes. Residual varus or valgus displacement was corrected using digital pressure, and adequacy of alignment on the lateral view was assessed by gradual flexion of the elbow.

Open reduction: When repeated attempts at closed reduction failed to achieve satisfactory alignment, open reduction was performed via a posteromedial approach, with careful isolation and protection of the ulnar nerve prior to pin insertion. Two anatomical surface landmarks were used during pinning to minimize the risk of iatrogenic ulnar nerve injury.

K-wire insertion: Following satisfactory closed reduction, Kirschner wires (1.5–2.0 mm, stainless steel) were introduced percutaneously using a power drill under C-arm fluoroscopic guidance. In the crossed K-wire group, one wire was inserted from the medial epicondyle and one from the lateral condyle in a crossing configuration. In the lateral divergent K-wire group, two wires were introduced from the lateral condyle in a divergent (non-parallel) configuration.

Postoperative Management and Follow-up

- The operated limb was elevated on a stand postoperatively, and patients were encouraged to actively move their fingers.
- Wound dressing was inspected on postoperative day 2, along with assessment of the operative site; anteroposterior and lateral radiographs were obtained following dressing.
- Patients with no immediate complications were discharged on postoperative day 2.
- Patients were reviewed in the outpatient department on postoperative day 12 for a check dressing.
- Radiographs were repeated at 4 weeks postoperatively; upon confirmation of satisfactory callus formation, K-wires were removed and the immobilizing slab was discontinued, after which patients began active elbow range-of-motion exercises.
- Patients were advised to avoid weight-bearing activity with the operated limb until 12 weeks postoperatively.
- Follow-up was continued on an outpatient basis at 1, 2, and 3 months postoperatively.

Clinical and radiological evaluation at each follow-up visit assessed the following outcome parameters, per Flynn's criteria for supracondylar fracture outcomes:

1. Elbow range of motion
2. Carrying angle of the operated elbow compared with the contralateral (normal) elbow
3. Overall functional outcome graded according to Flynn's criteria (excellent, good, fair, poor)

RESULTS

Table 1 Baseline Fracture Severity

Gartland Type	Crossed K-wire Group	Lateral Divergent K-wire Group	Total
Type II	4	5	9
Type III	11	10	21
Total	15	15	30

The presence of type III Gartland fractures was more than that of Gartland type II fractures in the combined cohort (70%, 21 of 30). This distribution was comparable between the two groups ($p>0.05$), suggesting baseline fracture severity was similar for outcome comparison.

Table 2 Functional Outcome (Flynn Criteria)

Flynn Criteria	Crossed K-wire Group	Lateral Divergent K-wire Group	Total
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Excellent	10	9	19
Good	4	5	9
Fair	1	1	2
Poor	0	0	0
Total	15	15	30

A good to excellent functional outcome was seen in 26/30 (86.67%) patients overall, with 93.3% (14/15) patients in the crossed group and 93.3% (14/15) patients in lateral divergent group. The difference in outcome rates of fixation techniques was not statistically significant ($p>0.05$). None of the patients in both the groups had poor outcomes.

Table 3 Radiological Outcome

Radiological Outcome	Crossed K-wire Group	Lateral Divergent K-wire Group	Total
Excellent	10	9	19
Good	4	5	9
Fair	1	1	2
Total	15	15	30

The radiological outcomes were consistent with the functional results. 19/30 (63.3%) of patients had excellent alignment while 2/30 (6.7%) were classified as fair with no significant difference between groups $p>0.05$.

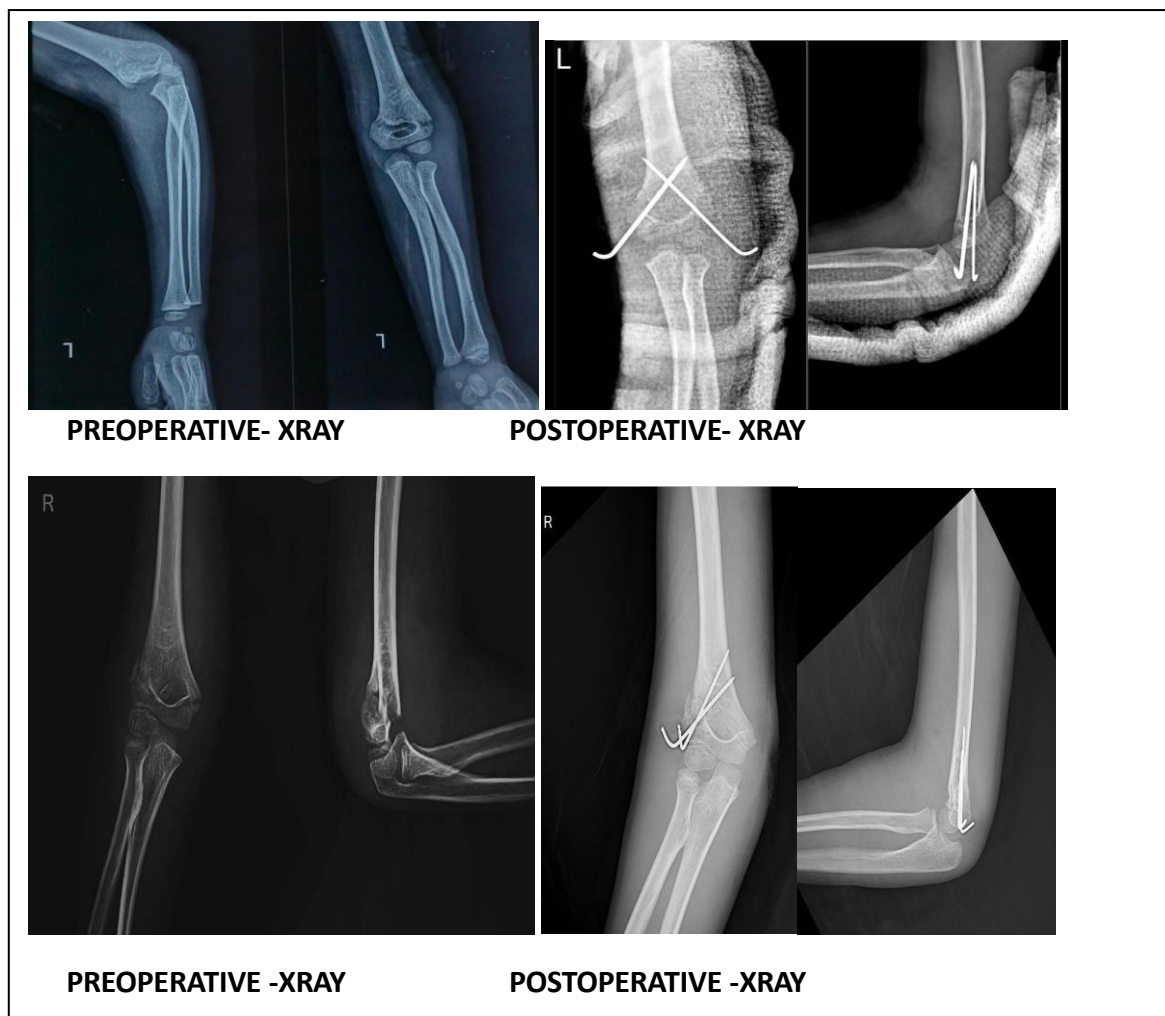
Table 4 Postoperative Complications

Complications	Crossed K-wire Group	Lateral Divergent K-wire Group	Total
Pin tract infection	1	1	2
Ulnar nerve injury	1	0	1
Cubitus varus	0	0	0
No complication	13	14	27
Total	15	15	30

Out of a total of 30 patients, 90% (27) were complication-free. There was one pin tract infection in both groups. Only one patient in the crossed K-wire group suffered from transient ulnar nerve injury. No patient in either group developed cubitus varus.

DISCUSSION

The study shows that in paediatric supracondylar humerus fractures, crossed K-wire fixation and lateral divergent K-wire fixation provide comparable functional and radiological outcomes in the same time period. Overall, 86.67 percent patients had good-to-excellent Flynn scores. This matches the current state of comparative literature well. A systematic review of a meta-analysis by Ramachandran et al [3] on 1158 patients reported that there is no difference in the Flynn functional outcomes between the crossed and lateral-entry pin. (relative risk 1.07) According to Gaddam et al. [1] and Alarcón et al. [2], randomized controlled trials evaluated fixation techniques and demonstrated satisfactory functional results with no statistical difference. Furthermore, the profile of complications noted in this study, with particular relevance to isolated ulnar nerve injury in the crossed K-wire group, is in keeping with the widely reported safety concern of medial pin insertion. According to a meta-analysis conducted by Alarcón et al. [2], iatrogenic ulnar nerve injury was seen in 4.1% of patients who were treated with crossed K-wires, but occurred in only 0.3% of the patients in the lateral-entry group. Crossed pinning carries a higher risk. In spite of the above, a meta-analysis of RCTs by Woratanarat et al. [6] confirmed the superiority of cross pinning in mechanical stability. Furthermore, iatrogenic ulnar nerve injuries are significantly less likely to occur with lateral pinning (relative risk of 0.36, $p=0.032$). The single ulnar nerve injury we observed in the crossed wire group is indicative of the fact that although crossed K-wire fixation affords better mechanical stability, it comes with a greater risk of nerve injury. Nevertheless, Green et al. [4] and Bahk et al. [5] had reported low rates of ulnar nerve injury (1.1–1.5%) with their mini-open or modified crossed-pinning techniques when the medial pin was inserted with direct vision. Moreover, Recent Literature by Lu et al. [7] are showing the success of ultrasound guidance in safely placing the medial pin with minimal iatrogenic harm. In other words, the surgical technique and the method of pin insertion greatly modulate this risk rather than the crossed configuration by itself. Thus, pin crossing configuration is not a risk factor. This finding is clinically relevant as it suggests that accurate placement of the medial pin, rather than avoidance of crossed pinning, may be the more important determinant of nerve safety in units where crossed fixation is preferred to improve stability in unstable or comminuted type III fractures.



CONCLUSION

Crossed and lateral divergent K-wire fixation techniques achieve similar functional and radiological outcomes in terms of good to excellent after pediatric supracondylar humeral fractures. Nonetheless, the fact that the one ulnar nerve injury occurred with crossed K-wire reinforces current evidence that lateral divergent pinning has a lower neurological risk profile, and should be the preferred option when similar fixation stability can be obtained. Crossed pinning may be reserved for specific unstable fracture patterns with careful surgical technique.

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