

Original Research Article

Functional outcome of displaced (gartland type III) supracondylar humerus fractures in children treated by closed reduction and percutaneous kirschner wire fixation: a prospective observational study

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ABSTRACT

Background: Displaced (Gartland type III) supracondylar humerus fractures in children risk malunion and neurovascular complications. Closed reduction and percutaneous K-wire fixation is widely regarded as standard treatment, however Indian tertiary-centre data are limited. We evaluated the functional and cosmetic outcomes and complications of this procedure.

Methods: This prospective observational study was conducted at a tertiary care centre, BMCRC Ballari, India; from June 2023 to December 2024, 50 children aged 3–13 years with closed, completely displaced supracondylar fractures underwent closed reduction and percutaneous K-wire fixation under C-arm guidance (crossed pins, n=40; two lateral pins, n=10), then an above-elbow slab application for three weeks. Outcome was graded by Flynn's criteria.

Results: Mean age was 8.0 ± 2.5 years; 68% were boys and 64% had left-sided injuries. Median time to surgery was 1 day and mean hospital stay 2.6 days. Outcome was excellent in 36 (72%), good in 9 (18%) and fair in 5 (10%); none was poor (satisfactory 100%, 95% CI 92.9–100). Mean loss of motion was 5.4° and of carrying angle 1.9° . Five patients (10%) had complications such as ulnar nerve palsy in 2 (both after crossed pinning; full recovery by two months), K-wire migration in 2 and superficial pin-tract infection in 1. No cubitus varus was recorded.

Conclusions: Closed reduction and percutaneous K-wire fixation gave satisfactory outcomes in all 50 children with few, mostly minor complications. Ulnar nerve injury occurred only after crossed pinning, supporting lateral-entry pinning when adequate stability can be achieved without a medial pin.

Keywords: Supracondylar humerus fracture, Children, Closed reduction, Percutaneous pinning, Kirschner wire, Flynn's criteria

INTRODUCTION

A supracondylar humerus fracture is a break in the distal humerus just above the elbow joint, occurring above the condyles of the humerus, accounting for 60% of the fractures around the elbow in children.¹ The rate of occurrence increases steadily in the first five years of life

to peak at 5-7 years of age.² The classical presentation is a fall on outstretched hand and consequent pain and swelling over the elbow. Urgent assessment should be done when there is absence of radial pulse, ischemia of hand, severe swelling, skin puckering, open fracture and neurological injury. Radiographs in antero-posterior (AP) and a lateral view of the elbow should be taken in case of pain and

tenderness after a trauma. Management of supracondylar fractures of the humerus depends on various factors including integrity of the skin, concurrent neurological or vascular injury, degree of displacement and the presence of compartment syndrome. The common methods of management include closed reduction and plaster of Paris slab application, skin traction, overhead skeletal traction, open reduction and internal fixation, and closed reduction and percutaneous K wire fixation.³ If the fracture is not treated properly, it may give rise to many complications like Volkmann's ischemic contracture, neurovascular injury, myositis ossificans, elbow stiffness and malunion.⁴

Closed reduction with plaster of Paris slab immobilization has traditionally been recommended for displaced supracondylar fractures, but loss of reduction and necessity of repeated manipulation is likely to go for malunion producing varus or valgus deformity of elbow and elbow stiffness. Traction (skin or skeletal), which has also been used for many years, has been shown to be safe and reliable, but it has the drawback of requiring a long stay in the hospital. The Gartland classification system is instrumental in guiding management strategies, categorizing fractures based on the degree of displacement and involvement of the posterior periosteum.⁵ While the overall agreement for type I and a few type II fractures has been closed reduction and cast application, Dunlop traction, or Olecranon traction.⁶ Type II and type III generally warrants closed reduction and pinning. Conservative treatment is related to complexities like loss of reduction and malunion.⁷

The most widely recognized decision of pinning is either a medial or lateral pin in a cross manner or two lateral pins. Open reduction and internal fixation have generally been reserved for specific indications mainly for an open fracture, a fracture requiring neurovascular exploration, or a reducible fracture.⁸ This study aims to analyse the functional and radiological outcome of displaced supra condylar humerus fractures in children with k-wire fixation in tertiary care centre with early mobilization of elbow, which can reduce the risk of malunion, elbow stiffness and other vascular complications.

METHODS

Study design and setting

This prospective observational study was carried out in the Department of Orthopaedics, Ballari Medical College & Research Centre, Ballari, Karnataka, India, from June 2023 to December 2024. The first 50 children who met the eligibility criteria and whose parents or guardians consented were enrolled. No formal sample size calculation was performed.

Participants

Children aged 3–14 years with a closed, completely displaced (Gartland type III) supracondylar fracture of the

humerus were eligible. Exclusion criteria were Gartland type I and II fractures, open or comminuted fractures, and fractures previously treated by traditional bone setters. Flexion-type fractures were included when completely displaced. At presentation, the elbow was examined for swelling, skin blebs and neurovascular status, the limb was protected in a sling and cuff, and anteroposterior and lateral radiographs were obtained. Data were recorded on a structured case record form.

Surgical technique and post-operative care

With the patient supine, longitudinal traction was applied to the forearm with the elbow extended and supinated, with counter-traction on the arm. Coronal deformity was corrected by valgus force for medial and varus force for lateral displacement. Sagittal alignment was restored by progressive elbow flexion while pushing the proximal fragment posteriorly and the distal fragment anteriorly. Reduction was confirmed with a C-arm in the anteroposterior (Jones) and true lateral views. Smooth K-wires of 1.2–2.0 mm diameter were inserted percutaneously, either as crossed wires (one lateral, one medial) or as two lateral-entry wires, according to fracture stability and surgeon preference.

The lateral wire entered at the centre of the lateral condyle and the medial wire at the tip of the medial epicondyle; wires were directed about 40° to the humeral shaft and about 10° posteriorly. Representative radiographs are shown in Figure 1.



Figure 1: Radiographs of one patient: anteroposterior (A–C) and lateral (D–F) views before surgery (A, D), immediately after closed reduction and percutaneous K-wire fixation (B, E) and at 3 months (C, F).

The limb was elevated for 2–3 days and one dose of intravenous antibiotic and analgesia given as required. An above-elbow posterior slab was applied for three weeks. At three weeks a check radiograph was taken, the K-wires were removed and gentle active mobilisation was started with a cuff and collar for two weeks. Patients were reviewed weekly until a good range of movement was regained, with radiographs at 3, 6 and 12 weeks and 6 months.

Outcome measures

Elbow range of motion (measured with a goniometer) and carrying angle of the injured and contralateral elbows were recorded, and the loss on the injured side was calculated. Outcome was graded with Flynn's criteria⁷: excellent (0–5° loss of carrying angle and of motion), good (6–10°), fair (11–15°) and poor (>15° loss), with excellent, good and fair regarded as satisfactory. The overall grade was the poorer of the cosmetic and functional grades. Complications (nerve injury, pin-tract infection, pin migration and cubitus varus) were recorded at follow-up.

Statistical analysis

Continuous variables are presented as mean $\pm$ standard deviation (SD) or median with interquartile range (IQR), and categorical variables as number (percentage). Exact (Clopper–Pearson) 95% confidence intervals (CI) were calculated for the main outcomes. Excellent versus less-than-excellent outcome was compared between subgroups with Fisher's exact test as an exploratory analysis (two-sided $p < 0.05$; no adjustment for multiple comparisons). Analyses were performed in Python (SciPy).

Ethical approval and consent

The protocol was reviewed by the Institutional Ethics Committee of BMCRC, Ballari. Written informed consent was obtained from the parent or legal guardian of every child.

RESULTS

Fifty children were included (34 boys, 16 girls; mean age 8.0 ± 2.5 years, range 3–13), and 33 (66%) were aged 6–10 years. The left side was affected in 32 (64%) and the right in 18 (36%). The injury followed a fall while playing in 38 (76%) and a fall from height in 12 (24%). All fractures were Gartland type III: 48 (96%) extension-type (35 posteromedial, 13 posterolateral) and 2 (4%) flexion-type (Table 1).

Crossed pins were used in 40 (80%) and two lateral pins in 10 (20%). The median interval from injury to surgery was 1-day (IQR 1–2; range 1–4), and 46 (92%) children were operated within 2 days. Mean hospital stay was 2.56 ± 0.61 days (range 2–4), and 47 (94%) were discharged within 3 days.

At final follow-up, mean loss of motion was $5.4 \pm 4.4^\circ$: 36 (72%) had a loss of 0–5°, 9 (18%) 6–10° and 5 (10%) 11–15°, and none exceeded 15°. Mean loss of carrying angle was $1.9 \pm 2.4^\circ$: 44 (88%) had a loss of 0–5° and 6 (12%) 6–10°, and none exceeded 10° (Table 2).

According to Flynn's criteria, the outcome was excellent in 36 (72%; 95% CI 57.5–83.8), good in 9 (18%) and fair in 5 (10%) patients; there were no poor results, so all 50 outcomes (100%; 95% CI 92.9–100) were satisfactory (Table 3 and Figure 2). All nine good results were determined by a 10° loss of motion, and all five fair results by a 12–15° loss of motion; four of the five fair cases also had a carrying-angle loss above 5°.

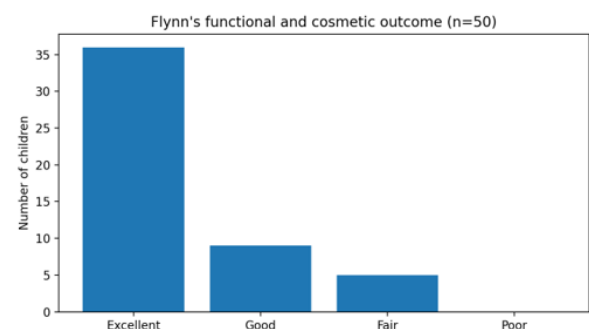


Figure 2: Distribution of final outcomes according to Flynn's criteria (n=50).

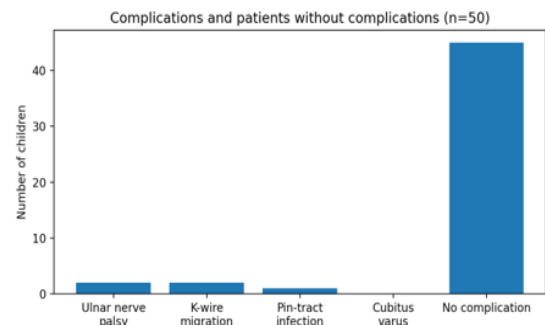


Figure 3: Complications recorded during follow-up (n=50).

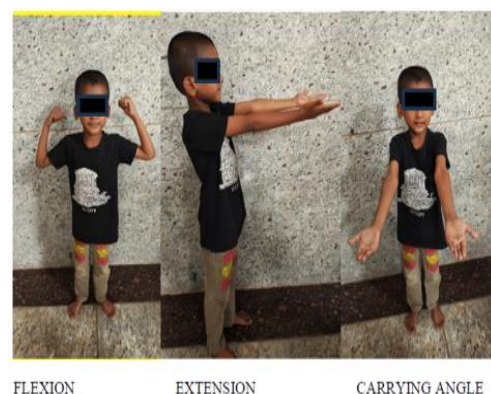


Figure 4: Clinical photographs.

Complications occurred in 5 patients (10%; Table 4 and Figure 3, 4). Two children (aged 7 and 11 years), both treated with crossed pins, developed iatrogenic ulnar nerve palsy (4%; 2/40 crossed vs 0/10 lateral pins, $p=1.00$), which recovered completely by two months. Two patients (4%) had K-wire migration and one (2%) a superficial pin-

tract infection that resolved with oral antibiotics. No cubitus varus was recorded. Notably, all three patients with pin migration or pin-tract infection had a fair result, whereas both patients with ulnar nerve palsy had an excellent result (fair result in 3/3 vs 2/47; $p<0.001$, exploratory).

Table 1: Baseline and treatment characteristics of the 50 children.

Characteristics	Value	N (%)
Demographics and injury		
Age (years), mean $\pm$ SD (range)	8.0 $\pm$ 2.5 (3–13)	
Age group: ≤ 5 / 6–10 / 11–13 years		7 (14) / 33 (66) / 10 (20)
Sex: boys / girls		34 (68) / 16 (32)
Side: left / right		32 (64) / 18 (36)
Mechanism: fall while playing / fall from height		38 (76) / 12 (24)
Displacement: posteromedial / posterolateral / flexion-type		35 (70) / 13 (26) / 2 (4)
Treatment		
Pin configuration: crossed / two lateral		40 (80) / 10 (20)
Injury-to-surgery interval (days), median (IQR)	1 (1–2)	
Injury-to-surgery interval (days), mean $\pm$ SD (range)	1.54 $\pm$ 0.71 (1–4)	
Surgery within 2 days / after 2 days		46 (92) / 4 (8)
Hospital stay (days), mean $\pm$ SD (range)	2.56 $\pm$ 0.61 (2–4)	
Hospital stay ≤ 3 days / 4 days		47 (94) / 3 (6)

SD, standard deviation; IQR, interquartile range. All fractures were completely displaced (Gartland type III).

Table 2: Loss of elbow motion and carrying angle at final follow-up (affected vs contralateral side).

Loss (degrees)	Loss of motion, N (%)	Loss of carrying angle, N (%)
0–5	36 (72)	44 (88)
6–10	9 (18)	6 (12)
11–15	5 (10)	0 (0)
>15	0 (0)	0 (0)
Mean $\pm$ SD (range)	5.4 $\pm$ 4.4 (0–15)	1.9 $\pm$ 2.4 (0–8)
Median (IQR)	5 (0–10)	1.5 (0–3)

Values are those recorded at the final follow-up visit. SD, standard deviation; IQR, interquartile range.

Table 3: Outcome according to Flynn's criteria.

Grade	Carrying-angle loss (°)	Loss of motion (°)	N	%	95% CI (%)
Excellent	0–5	0–5	36	72.0	57.5–83.8
Good	6–10	6–10	9	18.0	8.6–31.4
Fair	11–15	11–15	5	10.0	3.3–21.8
Poor	>15	>15	0	0.0	0.0–7.1
Satisfactory (excellent + good + fair)			50	100.0	92.9–100.0

The overall grade was the poorer of the cosmetic (carrying angle) and functional (motion) grades. CI, exact (Clopper–Pearson) confidence interval.

Table 4: Complications.

Complication	N	% of 50	Details
Iatrogenic ulnar nerve palsy	2	4.0	Both after crossed pinning; complete recovery by 2 months; both Flynn excellent
K-wire migration (backout)	2	4.0	Both Flynn fair
Superficial pin-tract infection	1	2.0	Resolved with oral antibiotics; Flynn fair
Cubitus varus	0	0.0	–
Any complication	5	10.0	
No complication	45	90.0	

Percentages are of the total cohort (n=50).

Table 5: Exploratory comparison of excellent outcome across subgroups

Sub-group	Excellent / N (%)	Comparator, excellent / N (%)	P value*
Crossed pins vs two lateral pins	28/40 (70.0)	8/10 (80.0)	0.70
Fall from height vs fall while playing	9/12 (75.0)	27/38 (71.1)	1.00
Posterolateral vs other displacement	8/13 (61.5)	28/37 (75.7)	0.47
Surgery after 2 days vs within 2 days	1/4 (25.0)	35/46 (76.1)	0.061
Age ≤5 vs >5 years	6/7 (85.7)	30/43 (69.8)	0.66
Boys' vs girls	23/34 (67.6)	13/16 (81.3)	0.50

*Two-sided Fisher's exact test (excellent vs less than excellent); no adjustment for multiple comparisons. Analyses are exploratory and the study was not powered for subgroup comparison. Ulnar nerve palsy: 2/40 with crossed pins vs 0/10 with lateral pins (p=1.00).

In exploratory subgroup analyses (Table 5), the proportion of excellent results did not differ significantly by pin configuration (70.0% vs 80.0%, p=0.70), mechanism, displacement pattern, age or sex. Of the four children operated on after 2 days, only one had an excellent result, compared with 35 of 46 operated on earlier (p=0.061).

DISCUSSION

In this prospective series of 50 children with completely displaced supracondylar humerus fractures, closed reduction and percutaneous K-wire fixation produced a satisfactory Flynn outcome in every child, with 72% excellent results, a mean hospital stay of 2.6 days and complications in 10%, none of them permanent.

The demographic profile was in consensus with published data. The peak incidence is reported at five to eight years, with a higher incidence in boys and more frequent involvement of the non-dominant arm,^{1,10} and our cohort was predominantly boys (68%) aged 6–10 years, with left-sided injuries in 64%.^{1,10} Hand dominance was not recorded, so we cannot comment on dominance. Sex ratios vary by region: a large United States series reported more girls, and falls from a height in 70% of injuries.¹¹ Our categories (fall while playing vs fall from height) are not directly comparable, but play-related falls predominated. Extension-type injuries accounted for 96%, close to the 97–99% reported and posteromedial displacement was the commonest pattern (70%).¹

All 50 outcomes were satisfactory. The proportion of excellent results (72%) is lower than the 78% reported for percutaneous pinning by Pirone et al.⁵ and the 91% and 86% reported by Devkota et al and Tran Trung et al (Table 6), although outcome definitions and follow-up differ.^{5,12,13} Two features of our approach may explain part of the difference. First, the overall grade was the poorer of the motion and carrying-angle grades, and a 10° motion loss alone downgraded nine children. Second, outcome was assessed at a relatively early time point; in the series of Devkota et al. the proportion of excellent results in the crossed-pin group rose from 71% at eight weeks to 91% at 14 weeks,¹² suggesting that motion continues to recover, and our figures may therefore underestimate the final result.

Iatrogenic ulnar nerve palsy occurred in 2 of 40 children (5%) with crossed pins and in none of the 10 with lateral pins. This agrees with meta-analytic and decision-analysis data showing a several-fold higher risk with crossed pins (relative risk 4.3; 3.4% vs 0.7%),^{8,9} and with the observation that a pin lying close to the nerve, without direct penetration, may be sufficient to injure it.¹⁴

Both of our cases recovered fully within two months, consistent with the usually neuropraxic nature of these injuries.¹ Lateral-entry pins can provide stable fixation even in unstable fractures when adequately spread and randomised and systematic-review evidence on pin configuration is available.^{1,15-17} Because pin configuration in our series was chosen by fracture stability and surgeon preference and only 10 children received lateral pins, no comparative inference can be drawn; nevertheless, our findings support using lateral-entry pins whenever adequate stability can be achieved.

Pin-tract infection occurred in one patient (2%), lower than the 1% to over 25% range reported¹ and then the 7.8% in the series of Devkota et al.¹² Early wire removal at three weeks and short hospitalisation may have contributed, although no comparison was made. Severe deep infection after pinning is uncommon.¹⁸ Two patients (4%) had K-wire migration.

Loss of pin fixation is most often related to technical factors such as inadequate pin spread or failure to engage both fragments, which we did not analyse.¹⁹ It is noteworthy that all three patients with pin migration or infection had fair results; this small-number association is hypothesis-generating only. No cubitus varus was recorded, although follow-up was too short to exclude late deformity. The median interval to surgery was one day. Most published series report no increase in complications with delayed surgery in the absence of neurovascular compromise, whereas one series found that delay increased the need for open reduction.^{1,20-22} Only one of four children operated on after 2 days had an excellent result (p=0.061); with such small numbers this cannot be interpreted, but timing merits examination in larger series.

This study has limitations. It is a single-centre, single-arm series without a comparison group and with a modest sample and no formal sample size calculation. Follow-up

was short, so late deformity and remodelling could not be assessed. Flynn's criteria capture only carrying angle and motion; patient-reported function and radiographic parameters such as Baumann's angle were not analysed.

Hand dominance, neurovascular status at presentation and pin spread were not recorded. Pin configuration was not randomised, and subgroup comparisons were exploratory and unadjusted. Finally, claims about cost or infection risk relative to other treatments cannot be made because costs were not measured and no alternative treatment was studied.

CONCLUSION

Closed reduction and percutaneous K-wire fixation under C-arm guidance gave satisfactory outcomes in all 50 children with displaced supracondylar humerus fractures (72% excellent), with a short hospital stay and few, mostly minor complications. Iatrogenic ulnar nerve palsy occurred only after crossed pinning and recovered fully; lateral-entry pinning should be preferred where stability allows. Larger comparative studies with longer follow-up are required.

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

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