Functional Outcome in the Treatment of Supracondylar Humerus Fracture in Children: A Prospective Observational Study at a Tertiary Care Hospital

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ABSTRACT

Background
Supracondylar humerus fracture is the commonest fracture around the elbow in children and displaced fractures need accurate reduction to prevent stiffness, malunion and carrying-angle deformity. Closed reduction and percutaneous K-wire fixation is widely used, but the relative functional recovery across fracture severity and fixation patterns remains clinically relevant in tertiary-care settings.

Aim
To evaluate functional and radiological outcomes of children with Gartland type II, III and IV supracondylar humerus fractures treated with closed reduction and percutaneous K-wire fixation.

Methods
This prospective observational study included 35 children aged 4-12 years with closed Gartland type II-IV supracondylar humerus fractures. Patients underwent closed reduction and percutaneous pinning using either lateral-entry or crossed K-wire configuration. Functional outcome was assessed at six months using Flynn's criteria. Range of motion, Baumann's angle, anterior humeral line, radiocapitellar line, time to union, return to activity and complications were analysed. Categorical variables were compared using Chi-square/Fisher's exact test and continuous variables using t-test, paired t-test, ANOVA or repeated measures ANOVA as appropriate.

Results
Mean age was 7.0±2.1 years, with male predominance 23 (65.7%). Gartland type III fractures were most common 23 (65.7%). Lateral-entry K-wire fixation was used in 18 (51.4%) and crossed K-wire fixation in 17 (48.6%) children. At six months, Flynn outcomes were excellent in 26 (74.3%), good in 6 (17.1%), fair in 2 (5.7%) and poor in 1 (2.9%), giving a

satisfactory outcome rate of 91.4%. Mean flexion improved from 98.3±12.4° at six weeks to 138.2±5.1° at six months, and extension deficit reduced from 24.1±8.7° to 2.3±3.1° ($p<0.001$ for range-of-motion improvement). Baumann's angle improved from 32.6±8.4° pre-operatively to 20.8±4.2° post-operatively ($p<0.001$), with a final mean of 21.2±3.8°. No significant difference was observed between lateral and crossed pinning for Flynn excellent outcome ($p=0.71$), satisfactory outcome ($p=0.60$), Baumann's loss ($p=0.43$) or nerve palsy ($p=0.22$).

Conclusion

Closed reduction and percutaneous K-wire fixation provided satisfactory functional recovery in most paediatric supracondylar humerus fractures. Outcomes were more favourable in lower Gartland grades, while crossed pinning showed a small, non-significant concentration of transient ulnar nerve neurapraxia.

Keywords: Baumann Angle; Closed Reduction; Elbow Fracture; Flynn Criteria; Gartland Classification; Kirschner Wire.

INTRODUCTION

Supracondylar fracture of the humerus is a familiar injury in paediatric orthopaedic practice, but its routine appearance should not obscure its seriousness. It accounts for a large share of elbow fractures in children, usually after a fall on the outstretched hand, and it tends to cluster in the school-going age group where play-related falls are common. The distal humeral anatomy, the relatively thin metaphyseal region and the hyperextension mechanism together explain why displacement can be abrupt even after a seemingly ordinary household or playground fall.[1]

Classification still shapes the first real decision. The Gartland system separates undisplaced fractures from progressively displaced fractures, while later refinements improved its reliability and allowed recognition of multidirectionally unstable type IV injuries.[2] Yet classification is not a mechanical label alone. Interobserver variation remains possible, and the treating surgeon often has to combine radiographic appearance with intra-operative stability before finalising fixation strategy.[3]

Type IV supracondylar fractures deserve particular attention because they are unstable in both flexion and extension. These injuries usually imply circumferential periosteal disruption, and they can lose alignment if fixation is not sufficiently stable. Leitch et al. described this modified Gartland type as a separate unstable subset, reinforcing the need for careful intra-operative assessment rather than relying only on static radiographs.[4]

Closed reduction and percutaneous pin fixation is now the accepted standard for most displaced extension-type supracondylar fractures, particularly Gartland type II and III injuries, and is commonly extended to type IV fractures when satisfactory closed reduction is achieved.[5] The attraction of this approach is straightforward: it preserves soft tissue, allows early stabilisation, reduces the chance of malunion and avoids the additional morbidity of open reduction in many children.

Pin configuration, however, remains debated. Crossed medial-lateral K-wires are mechanically intuitive because they engage both columns, but the medial pin introduces a risk of iatrogenic ulnar nerve injury. Lateral-entry pins avoid that nerve trajectory but require adequate pin spread, bicortical purchase and careful stress testing to prevent rotational instability. Skaggs et al. helped define this practical concern by showing that pin placement itself can influence both stability and nerve safety.[6]

Outcome assessment has also become more standardised. Flynn's criteria remain widely used because they combine functional loss of elbow motion with cosmetic loss of carrying angle, translating clinical recovery into a simple grading system of excellent, good, fair or poor.[7] Radiological follow-up complements this through Baumann's angle, the anterior humeral line and the radiocapitellar line, which help identify residual coronal or sagittal malalignment before it becomes a late deformity.

The debate between lateral-only and crossed pinning is not purely academic in Indian tertiary-care hospitals. Children may reach the hospital after swelling has already developed; parents may be anxious about repeated visits; and rehabilitation can be uneven when families travel from rural catchment areas. In such a setting, a stable reduction that remains safe for the ulnar nerve is not a small technical issue. It determines whether the child returns to school and play with a straight, mobile elbow.[8]

The present study evaluated functional and radiological outcomes after closed reduction and percutaneous K-wire fixation in children with Gartland type II, III and IV supracondylar humerus fractures. The working hypothesis was that satisfactory functional recovery would be achieved in most children at six months, with outcome influenced more by fracture severity than by pin configuration.

AIM & OBJECTIVES

Aim

To assess functional outcome at six months in children with supracondylar humerus fractures treated with closed reduction and percutaneous K-wire fixation using Flynn's criteria.

Objectives

- To evaluate elbow range of motion at six weeks, three months and six months after surgery.
- To assess carrying angle loss and final cosmetic outcome.
- To analyse radiological alignment using Baumann's angle, anterior humeral line and radiocapitellar line.
- To document complications including pin-tract infection, iatrogenic nerve palsy, deformity, stiffness, vascular injury, myositis ossificans, avascular necrosis and loss of reduction.
- To compare outcomes between lateral-entry and crossed K-wire fixation, and across Gartland fracture types.

MATERIALS AND METHODS

Study design and setting

A prospective observational study was conducted in the Department of Orthopaedics, Mandya Institute of Medical Sciences, Mandya, Karnataka. Children with displaced closed supracondylar humerus fractures who satisfied the eligibility criteria were enrolled consecutively.

Study Population

The study included 35 children aged 4-12 years with closed supracondylar humerus fractures classified as Gartland type II, type III or type IV on anteroposterior and lateral radiographs.

Inclusion Criteria
Children aged 14 years or below, either sex, with closed supracondylar humerus fractures confirmed radiologically, Gartland type II-IV injuries, presentation within 72 hours of trauma, and parent/guardian consent for surgery and follow-up were included.

Exclusion Criteria
Open fractures, Gartland type I fractures treated conservatively, fractures with established vascular compromise requiring vascular reconstruction, injuries requiring formal nerve exploration, pathological fractures, ipsilateral upper-limb fractures interfering with assessment, pre-existing neuromuscular disorders affecting elbow function and cases without six-month follow-up assessment were excluded.

Surgical Procedure
All operations were performed under general anaesthesia. The child was positioned supine with the affected arm on a radiolucent support. Closed reduction was performed using longitudinal traction, correction of medial or lateral translation, and elbow flexion with forearm positioning according to the displacement pattern. Reduction was checked under biplanar C-arm fluoroscopy. Fixation was performed with 1.5-2.0 mm K-wires using either two or three lateral-entry wires or crossed medial-lateral wires. A posterior above-elbow slab was applied with the elbow flexed approximately 70-90°. Wire removal was performed at 4-6 weeks after radiological evidence of callus formation.

Post-Operative Protocol
Clinical and radiological review was performed at six weeks, three months and six months. Active elbow range-of-motion exercises were started after splint and wire removal. Return to school and routine daily activity was permitted according to pain, stability and radiological union.

Outcome Measures
The primary outcome was Flynn's functional grade at six months. Secondary outcomes included elbow flexion, extension, pronation and supination; carrying angle loss compared with the contralateral side; Baumann's angle; anterior humeral line; radiocapitellar line; time to radiological union; time to return to daily activity; and complications.

Statistical Analysis
Data were analysed using SPSS version 25.0. Continuous variables were expressed as mean±standard deviation and categorical variables as frequency and percentage. Inter-group comparisons used independent t-test or Mann-Whitney U test for continuous variables and Chi-square/Fisher's exact test for categorical variables. Paired t-test was used for pre-operative and post-operative radiological comparison. Repeated measures ANOVA assessed serial range-of-motion changes. A p-value <0.05 was considered statistically significant.

RESULTS

A total of 35 children were analysed. The mean age was 7.0±2.1 years, with an age range of 4-12 years. Children aged 5-8 years formed the peak age group, accounting for 24 (68.6%) cases. Male predominance was observed with 23 (65.7%) boys and 12 (34.3%) girls. The left side was involved in 21 (60.0%) children, while 22 (62.9%) injuries affected the non-dominant limb. Baseline characteristics are summarised in Table 1 and illustrated in Figure 1.

Variable	n (%) / Mean±SD
Sample size	35 patients
Age	7.0±2.1 years; range 4-12 years
Peak age group	5-8 years: 24 (68.6%)
Male	23 (65.7%)
Female	12 (34.3%)
Left side involvement	21 (60.0%)
Right side involvement	14 (40.0%)
Non-dominant limb	22 (62.9%)
Dominant limb	13 (37.1%)

Table 1. Demographic and baseline clinical characteristics of children with supracondylar humerus fracture (n=35)

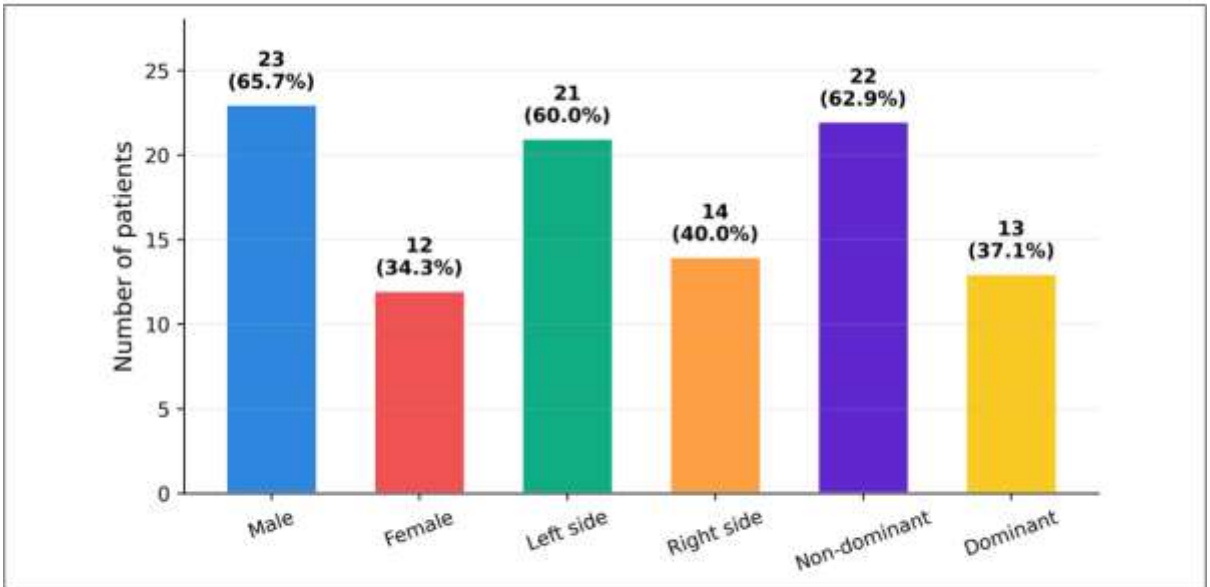

Figure 1. Baseline demographic and limb-side distribution

Bars show patient counts; percentages are displayed above each bar

Gartland type III fracture was the predominant pattern, noted in 23 (65.7%) children, followed by type II in 8 (22.9%) and type IV in 4 (11.4%). Lateral-entry K-wire fixation was performed in 18 (51.4%) children and crossed K-wire fixation in 17 (48.6%). Radiological parameters showed satisfactory restoration of alignment after reduction and fixation. These findings are shown in Table 2 and Figure 2.

Parameter	Result
Gartland type II	8 (22.9%)
Gartland type III	23 (65.7%)
Gartland type IV	4 (11.4%)

Lateral-entry K-wire fixation	18 (51.4%)
Crossed K-wire fixation	17 (48.6%)
Anterior humeral line normal	31 (88.6%)
Anterior humeral line abnormal	4 (11.4%)
Radiocapitellar line normal	35 (100.0%)

Table 2. Fracture pattern, fixation method and radiological alignment parameters (n=35)

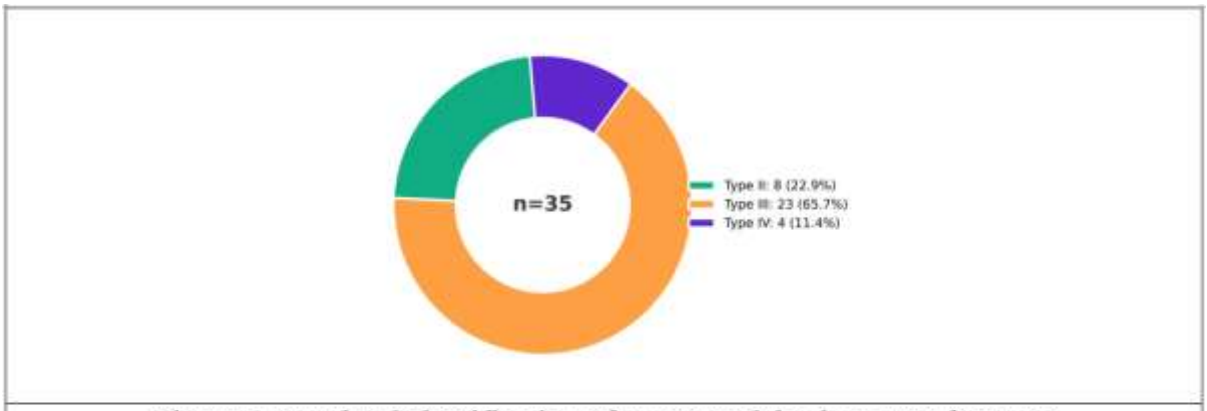

Figure 2. Gartland classification of supracondylar humerus fractures

Donut chart shows fracture-type distribution among the 35 children

Elbow movement improved progressively across follow-up visits. Mean flexion increased from 98.3±12.4° at six weeks to 138.2±5.1° at six months. Extension deficit reduced from 24.1±8.7° to 2.3±3.1°, while pronation and supination also improved steadily. Repeated measures ANOVA demonstrated significant improvement in all planes of motion ($p<0.001$). Baumann's angle improved significantly from 32.6±8.4° pre-operatively to 20.8±4.2° immediately after fixation ($p<0.001$) and was maintained at 21.2±3.8° at six months. Details are given in Table 3.

Parameter	6 Weeks	3 Months	6 Months	p-value
Flexion (°), mean±SD	98.3±12.4	124.6±8.2	138.2±5.1	<0.001
Extension deficit (°), mean±SD	24.1±8.7	8.9±5.3	2.3±3.1	<0.001
Pronation (°), mean±SD	68.5±11.2	78.3±6.9	84.6±4.2	<0.001
Supination (°), mean±SD	63.7±10.8	74.1±7.5	81.3±5.4	<0.001
Baumann's angle (°), mean±SD	Pre-op: 32.6±8.4	Post-op: 20.8±4.2	Follow-up: 21.2±3.8	<0.001†
Time to radiological union	6.3±1.4 weeks	Range 4-10 weeks	-	-
Return to daily activities	9.1±2.6 weeks	Range 6-16 weeks	-	-

Table 3. Functional range of motion and radiological parameters during follow-up

†Paired t-test for pre-operative versus immediate post-operative Baumann's angle; ROM p-values by repeated measures ANOVA

and poor in 1 (2.9%) child. The satisfactory outcome rate, combining excellent and good grades, was therefore 32 (91.4%). By fracture type, satisfactory outcome was achieved in all type II fractures, 21 (91.3%) type III fractures and 3 (75.0%) type IV fractures, showing a significant severity-related trend ($p=0.04$). The distribution of Flynn outcome across Gartland types is presented in Figure 3.

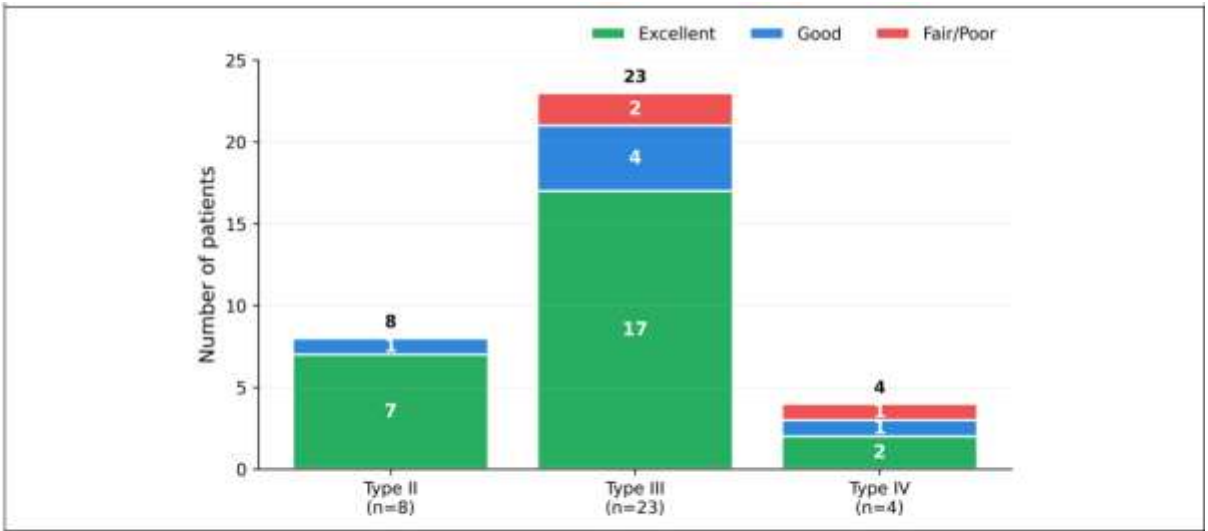

Figure 3. Flynn outcome pattern across Gartland fracture types

Stacked bars show excellent, good and fair/poor outcome groups within each Gartland type

Complications were documented in 11 (31.4%) children, while 24 (68.6%) had no complication. Pin-tract infection was the commonest event, occurring in 4 (11.4%) children; all were superficial and resolved with dressings and oral antibiotics. Iatrogenic nerve palsy occurred in 2 (5.7%) children, both being ulnar nerve neurapraxia in the crossed-pin group, and both recovered spontaneously. There were no vascular injuries, myositis ossificans or avascular necrosis. The overall complication status is shown in Figure 4, while detailed complications and inter-group comparisons are given in Table 4.

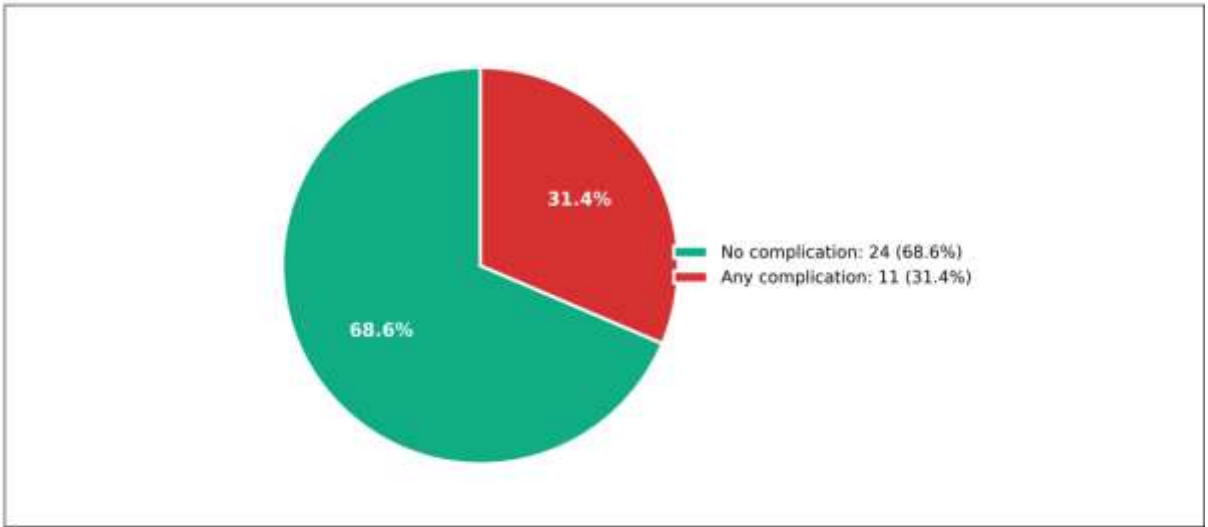

Figure 4. Overall complication status after K-wire fixation

Pie chart shows the proportion of children with and without any documented complication

Variable	Overall / Group comparison	p-value
Flynn excellent	26 (74.3%)	-
Flynn good	6 (17.1%)	-

Flynn fair	2 (5.7%)	-
Flynn poor	1 (2.9%)	-
Flynn satisfactory	32 (91.4%)	-
Pin-tract infection	4 (11.4%)	-
Iatrogenic nerve palsy	2 (5.7%); both crossed-pin ulnar neurapraxia	0.22
Cubitus varus	2 (5.7%); mild <10°	-
Cubitus valgus	1 (2.9%)	-
Elbow stiffness	1 (2.9%); resolved with physiotherapy	-
Loss of reduction	1 (2.9%); required re-operation	-
Vascular injury	0 (0%)	-
Myositis ossificans	0 (0%)	-
Avascular necrosis	0 (0%)	-
Lateral vs crossed: Flynn excellent	14/18 (77.8%) vs 12/17 (70.6%)	0.71
Lateral vs crossed: Flynn satisfactory	17/18 (94.4%) vs 15/17 (88.2%)	0.60
Lateral vs crossed: Baumann's loss	1.9±2.1° vs 1.4±1.7°	0.43
Gartland trend for satisfactory outcome	Type II 100.0%, Type III 91.3%, Type IV 75.0%	0.04

Table 4. Functional outcome, complications and comparative analysis

DISCUSSION

The present study shows that closed reduction and percutaneous K-wire fixation produced satisfactory six-month functional outcome in 91.4% of children with Gartland type II-IV supracondylar humerus fractures. This is a clinically reassuring finding because the cohort contained a high proportion of type III injuries and a smaller, but important, group of type IV fractures. The outcome profile broadly agrees with Kocher et al., who reported comparable effectiveness of lateral and medial-lateral pinning in completely displaced fractures when reduction and pin placement were technically sound.[9]

The absence of a statistically significant difference between lateral-entry and crossed K-wire fixation in Flynn excellent outcome, satisfactory outcome and Baumann's loss is also in keeping with Maity et al. In their randomised clinical trial, the two configurations did not differ meaningfully in carrying angle, elbow motion, Flynn grading or loss of reduction when a standardised technique was followed.[10] The practical message is not that configuration is irrelevant, but that execution matters. Lateral pins need adequate divergence and column purchase. Crossed pins demand deliberate protection of the ulnar nerve.

The current findings sit comfortably within recent pooled evidence as well. Rehm et al. noted that lateral and crossed pinning have broadly similar effectiveness in many functional and radiographic endpoints, although nerve risk continues to shape the choice of technique.[11] In our series, both ulnar neurapraxias occurred after crossed pinning. The difference was not statistically significant, probably because of the modest sample size, but the direction of the finding is clinically recognisable and should not be ignored during medial pin placement.

Fracture severity influenced outcome more visibly than fixation method. All type II fractures achieved satisfactory results, whereas satisfactory outcome fell to 91.3% in type III and 75.0% in type IV injuries. This gradient is expected. Type IV fractures are unstable in more than one plane, and even after a good reduction, minor rotation or coronal drift can leave some restriction or cosmetic change. El-Adl et al. also reported favourable results with

percutaneous fixation, but their work underscores the importance of stable multi-column fixation in displaced injuries.[12]

The range-of-motion recovery was steady rather than abrupt. Flexion rose from a mean of 98.3° at six weeks to 138.2° at six months, while the extension deficit reduced from 24.1° to only 2.3°. This pattern fits everyday clinical experience in children after immobilisation: early stiffness is common, parents often notice it first during feeding, dressing or writing, and most children regain function with reassurance and active use. Lee et al. showed that even among surgeons there are different perspectives on immobilisation and elbow-motion exercises after fixation, reflecting the lack of a single universal rehabilitation rhythm.[13]

Radiological alignment was restored well. Mean Baumann's angle improved significantly from 32.6° pre-operatively to 20.8° immediately after surgery, and was maintained at 21.2° at final follow-up. The small mean change of 0.4° between post-operative and final values suggests that fixation was generally stable. This point is important because loss of pin fixation is rarely a random event. Sankar et al. described technical causes such as inadequate pin separation, poor bicortical purchase and unstable fracture geometry, all of which are preventable only through disciplined intra-operative assessment.[14]

Pin-tract infection was the most frequent complication, affecting 11.4% of children, and all cases resolved with local care and oral antibiotics. Bashyal et al. reported that percutaneous pinning generally has a low complication rate when standard aseptic measures and follow-up are maintained.[15] In a resource-sensitive Indian hospital, the practical burden of pin-site care is real. Families must understand dressing hygiene, warning signs and the need to return before the scheduled visit if discharge, fever or loosening occurs.

Cubitus varus occurred in two children and was mild. No child had vascular injury, myositis ossificans or avascular necrosis. The low deformity burden is relevant because cubitus varus remains the late complication most visible to families, even when function is acceptable. Pirone et al. emphasised early accurate management of displaced extension-type fractures to avoid malunion and poor cosmetic outcomes, a principle that remains unchanged despite advances in imaging and implants.[16]

This study has limitations. The sample size was modest, especially for type IV fractures, so subgroup comparisons must be interpreted cautiously. The study was observational rather than randomised; therefore, pin configuration may have been influenced by surgeon preference, fracture stability or swelling. Follow-up was limited to six months, which is adequate for early functional recovery but not for all late cosmetic concerns. Still, the study reflects a real tertiary-care orthopaedic workflow where children present with variable swelling, family logistics influence follow-up, and surgical decisions are made within routine service constraints.

The findings support a balanced surgical approach. Lateral-entry pinning appears attractive where ulnar nerve safety is a concern, provided stability is confirmed under fluoroscopy. Crossed pinning remains useful in unstable patterns, but the medial pin should be inserted with meticulous attention to elbow position, palpation or mini-open protection when needed. In either method, the endpoint is the same: a stable anatomical reduction, maintained Baumann's angle, and a child who regains a painless functional elbow.

CONCLUSION

Closed reduction and percutaneous K-wire fixation achieved satisfactory functional outcome in 91.4% of children with Gartland type II-IV supracondylar humerus fractures at six months.

Radiological alignment improved significantly after surgery and remained stable at follow-up. Lateral-entry and crossed K-wire fixation showed no statistically significant difference in functional or radiological outcomes, although transient ulnar nerve neurapraxia occurred only in the crossed-pin group. Fracture severity showed a clearer relationship with final recovery, with type IV fractures carrying a higher risk of suboptimal outcome. Careful reduction, stable pin placement, radiological surveillance and supervised mobilisation remain central to restoring elbow function in paediatric supracondylar humerus fractures.

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Nil.
Conflict of Interest
Nil.

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