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A Randomized Control Trial Comparing Effectiveness of Cross K-Wire and Lateral K-Wire Fixation Techniques in Reducing Gartland Type 3 Supracondylar Fractures of Children

Muhammad Junaid Khan, Shahid Mahmood, Muhammad Naeem Malik, Irfan Ali Shujah, Zahid Iqbal, Muhammad Arslan Ghori

Abstract

Objective: To compare the effectiveness of cross K-wire fixation versus lateral entry K-wire fixation in maintaining postoperative reduction of Gartland type III supracondylar humerus fractures in children.

Study Design and Settings: A randomized control trial was conducted at Orthopaedics Department, Bahawal Victoria Hospital, Bahawalpur, from 25th June 2025 to 10th December 2025.

Methodology: Ninety children aged 2–13 years with closed Gartland type III supracondylar fractures were randomly allocated into two groups: cross K-wire fixation (n = 45) and lateral entry K-wire fixation (n = 45). All patients underwent closed reduction and percutaneous pinning under general anesthesia. Standardized 1.5 mm K-wires were used in both groups.

Results: Loss of reduction occurred in 20% of patients in the cross-pin group compared to 71.1% in the lateral entry group ($p < 0.01$). Baumann's angle remained more stable in the cross-pin group ($p = 0.01$), and anterior humeral line integrity was preserved 73.3% patients of Cross K-Wire group as compared to 55.5% of Lateral Entry K-Wire group. No permanent ulnar nerve injuries were reported in either group, although transient postoperative concerns were slightly higher in the cross-pin group.

Conclusion: Cross K-wire fixation was more effective than lateral entry K-wire fixation in maintaining postoperative reduction in Gartland type III supracondylar fractures in children.

Keywords: Humeral fractures, Postoperative complications, Treatment outcomes

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INTRODUCTION

Supracondylar fractures just above elbow joints are one of the most prevalent injuries of distal humerus, affecting substantial proportion of all elbow fractures in children. Occurrence of these injuries have been increased dramatically during last decades accounting for 3 to 15% of all fracture types particularly among children aged between 5 and 7 years.[1] These injuries underscore immediate requirement of surgical intervention among affected population.

A consistent pattern of these injuries has been observed across different population around the globe. A Brazilian study of 197 children, having mean age 5.4 years, reported humeral supracondylar fractures in 56.9% male children with left sided fracture in 51.8%.[2] Similarly, A south African study of 266 children having mean age 6.3 years, documented supracondylar fractures in 71.8% male children with 64.3% injuries on left side. Extension type humeral supracondylar fractures were predominant ones.[3] Moreover, in New Zealand, a 10-year retrospective data-based research of 1563 pediatric patients documented 73.7% per 100,000 incident rate with substantial number of 5 to 9 years old children.[4]

Distal humerus elbow fractures account 85% and among these 55-75% comprises of supracondylar injuries, making 3.5% of all pediatric fractures [4]. Supracondylar fractures of the humerus cause high rates of neurovascular injury due to falls on non-dominant limbs, often resulting from falls during play or stairs.[5] Achieving and maintaining reduction are one of the major challenges faced while managing supracondylar fracture as they usually present to emergency department with variations in soft tissue swelling.[6]

Rates of nerve injury and vascular injury on presentation range from 5% to 19% and 5% to 17%, respectively.[7] These injuries can be difficult to treat due to immediate complications like compartment syndrome, neurovascular damage, and late complications like Volkman's ischemic contracture and malunion. Supracondylar humerus fractures are most often classified according to Gartland and his colleagues, who classified the fracture using the degree of displacement. Type I fractures are non-displaced, Type II fractures are displaced, but have a preserved posterior cortex, and Type III fractures are completely displaced without any contact of the posterior cortex. Type III fractures, especially, are more difficult and may require surgery because of their inherent instability and potential for neurovascular compromise.[8] Traditionally these fractures have been treated with either closed reduction and casting or open reduction with the use of fixation. Closed reduction and percutaneous pinning with Kirschner wires (K-wires) have become the standard of care, however, because of the evolution of pediatric orthopedic practice and the increased emphasis on minimally invasive techniques for displaced fractures.[9] In orthopedics, especially in the paediatric field, minimally invasive surgery is increasingly being used, as it is associated with quick recovery times, minimal scarring and better cosmesis, which are especially significant in young people. Lateral pinning and crossed pinning are two commonly employed fixation techniques for pediatric supracondylar humerus injuries. The lateral K wire configuration is superior over crossed K wire configuration in terms of avoiding iatrogenic ulnar nerve injury but comparatively less stable biochemically.[10] Balakumar B, et al. conducted a study including 29 children with lateral entry pins. Among these 10 (34.5%) revealed postoperative loss of reduction. Configurations with at least one medial pin were (c) crossed pins in 28 cases and (d) two lateral pins and one medial pin in 20 cases. In the groups which included at least one medial pin, 4 (8.3%) out of 48 cases lost reduction.[11] Another previous study conducted by Abubeih H, at final follow-up, there were no statistically significant differences (P>0.05) between group A and group B with respect to the average Baumann's angle (P=0.081), change in the Baumann angle (P=0.121), range of elbow motion (P=0.795), Flynn's grade (P=0.541), or Skaggs criteria (P=0.548).[12]

METHODOLOGY

This randomized control trial was carried out in the Orthopedics Department of Bahawal Victoria Hospital, Bahawalpur. The study was registered at ClinicalTrials.gov under the identifier NCT07266038. The study duration extended from 25 June 2025 to 10 December 2025, following ethical approval and synopsis clearance. Rules of Declaration of Helsinki and CONSORT guidelines were followed while conducting intended research. A total 90 patients (45 each group) were included in this study. Sample size was calculated using OpenEpi software at a 5% significance level and 95% power. The calculation was based on previously published findings reporting postoperative loss of reduction of 34.5% in lateral-entry pin configurations compared with 8.3% in configurations involving at least one medial pin. Patient enrollment was by a non-probability consecutive sampling technique. In order to achieve target sample, all patients visiting emergency department who met the eligibility criteria were approached. Patients of both genders having age less than 13 years with closed Gartland type III supracondylar humerus fractures no older than 7 days were included in this research. Those with open fractures, neurovascular injuries, medial column comminution, fractures older than 7 days, ipsilateral fractures of the radius, ulna or humeral shaft, and/or pathological fractures due to abnormal bone density, previous surgery on same elbow and allergic to metal implants were excluded. Parents/legal guardians signed informed consent before enrolling the child. Informed consent contained information about randomization process, both surgical procedures, associated risk factors (infection or nerve injury) and follow-up details. Those who met the criteria were placed under and initially treated with splinting, elevation, and appropriate analgesia. Ethical approval was obtained and eligible patients were put under and initially treated as follows: splintage, elevation and appropriate analgesia. Basic demographic and clinical parameters, including age, sex, side involved, and neurovascular assessment (radial pulse and motor function of median, radial, and ulnar nerves) were noted on a proforma. Patients were randomly allocated to either study group by lottery method. A research assistant having no involvement in clinical trial performed random sequence via computer based random number table. Allocation concealment was ensured by a closed opaque envelop which was opened by surgeon revealing group allocation. Blinding of the surgeon was not possible in view of the type of surgeries performed.

All surgery was performed under general anesthesia, with fluoroscopic guidance for reduction and pin placement by experienced orthopedic surgeons. All patients had standardized 1.5 mm K-wires and uniform pin-spread distance. A group of 45 patients received cross-K-wire fixation (Group A), and another group of 45 patients received lateral-entry K-wire fixation (Group B). Postoperative care consisted of pain management, instructions for immobilization and advice on the hygiene of pin sites. Patients were discharged on the 2nd day after operation.

Follow up visits were performed at 1st, 3rd and 6th postoperative weeks to evaluate the maintenance of reduction using Baumann angle and anterior humeral line. SPSS version 20 or later was used for data analysis. The quantitative data such as age, Baumann's angle, pin spread distance and ratio of pin spread were analyzed by the mean and standard deviation. Qualitative data (gender, side of fracture, integrity of anterior humeral line) were coded and the frequencies and percentages calculated. Loss of reduction was defined as a substantial change in the angle of Baumann and/or misalignment of the anterior humeral line. Age, gender, side, Baumann's angle, pin spread distance and pin spread ratio were stratified as effect modifiers. Paired-samples t-test was used for quantitative variables and chi-square test was used for categorical variables in the post-stratification analyses. The p-value < 0.05 was regarded as statistically significant.

RESULTS

Data were collected from 90 patients, with a mean age of 7.52 ± 3.44 years. Females were slightly more represented (52.2%) than males (47.8%). The distribution of fracture laterality was even, as 45 patients (50%) presented with right-sided injuries and 45 (50%) with left-sided injuries. Most patients (74.4%) had intact neurovascular status at presentation, while a smaller proportion demonstrated median nerve deficits (8.9%), radial nerve deficits (7.8%), or ulnar nerve deficits (8.9%). Preoperative measurements averaged 72.94 ± 1 °; immediate postoperative measurements were 73.5 ± 4.3 °, and a gradual decline to 72.4 ± 4.8 ° by week 6 was observed radiologically. After surgery, the alignment of the anterior humeral line significantly improved, rising from 42.2% preoperatively to 72.2% immediately postoperatively and remaining aligned in 64.4% by week 6. Postoperative outcomes showed that reduction was maintained in 49 patients (54.4%), whereas 41 patients (45.6%) experienced postoperative loss of reduction. Complications were not uncommon, with swelling reported in 23.3% of children, pin tract infections in 21.1%, postoperative stiffness in 20%, and cubitus varus in 18.9%. Alignment of the anterior humeral line immediately after surgery was higher in the cross-pin group (80.0% vs. 64.4%), and the trend persisted at week 6 (73.3% vs. 55.6%), although these differences were not statistically significant. The lateral-entry group experienced significantly more loss of reduction (71.1%) than the cross-pin group (20.0%), which is a significant difference. Swelling, infections of the pin tract, stiffness, and cubitus varus all occurred at similar rates in both groups. However, the lateral-entry group had a significantly higher overall complication rate (66.7% vs. 37.8%).

Table 1. Demographic and Clinical Characteristics of Patients (n = 90)

Variable	Category / Statistic	Value (n = 90)
Age (years)	Mean ± SD	7.52 ± 3.44
Gender	Male	43 (47.8%)
	Female	47 (52.2%)
Side Involved	Right	45 (50.0%)
	Left	45 (50.0%)
Fracture Age (days)	Mean ± SD	3.9 ± 1.8
Randomization Group	Cross K-wire (Group A)	45 (50.0%)
	Lateral-entry K-wire (Group B)	45 (50.0%)
Neurovascular Status at Presentation	Overall intact	67 (74.4%)
	Median nerve deficit	8 (8.9%)
	Radial nerve deficit	7 (7.8%)
	Ulnar nerve deficit	8 (8.9%)

Table 2. Radiological Characteristics of Patients (n = 90)

Variable	Statistic / Category	Value (n = 90)
Baumann's Angle	Preoperative (mean ± SD)	72.9 ± 4.1
	Immediate postoperative	73.5 ± 4.3
	Week 1	73.1 ± 4.5
	Week 3	72.8 ± 4.6
	Week 6	72.4 ± 4.8
Anterior Humeral Line Alignment	Pre-op aligned	38 (42.2%)
	Immediate post-op aligned	65 (72.2%)
	Week 6 aligned	58 (64.4%)
Pin Spread Distance (mm)	Mean ± SD	12.7 ± 3.4
Pin Spread Ratio	Mean ± SD	0.47 ± 0.11

Table 3. Postoperative Outcomes and Complications (n = 90)

Variable	Category / Statistic	Value (n = 90)
Maintenance of Reduction	Maintained	49 (54.4%)
	Loss of reduction	41 (45.6%)
Postoperative Complications	Swelling	21 (23.3%)
	Pin tract infection	19 (21.1%)
	Stiffness	18 (20.0%)
	Cubitus varus	17 (18.9%)
Neurovascular Complications	Any postoperative nerve injury	0 (0%)
Overall Complication Rate	Any complication	47 (52.2%)
	No complication	43 (47.8%)

DISCUSSION

Main objective of this research as to compare the efficacy of two different fixation techniques in the maintenance of reduction in children with Gartland type III supracondylar humerus fractures, the cross K-wire fixation and the lateral entry K-wire fixation. The result clearly demonstrated that postoperative alignment was significantly better with cross wire fixation (20.0%) than with lateral entry fixation (71.1%) with a significantly lower loss of reduction and rate of overall

Table 4. Comparison of Radiological Outcomes between Cross K-Wire and Lateral Entry K-Wire Groups (n = 90)

Radiological Parameter	Group A: Cross K-wire (n = 45)	Group B: Lateral Entry K-wire (n = 45)	p-value
Baumann's Angle (°)			
Immediate postoperative (mean ± SD)	73.8 ± 4.4	73.1 ± 4.2	0.42
Week 1	73.3 ± 4.6	72.9 ± 4.5	0.58
Week 3	72.9 ± 4.7	72.6 ± 4.6	0.70
Week 6	72.6 ± 4.9	72.2 ± 4.7	0.64
Anterior Humeral Line Alignment			
Immediate postoperative aligned, n (%)	36 (80.0%)	29 (64.4%)	0.11
Week 6 aligned, n (%)	33 (73.3%)	25 (55.6%)	0.07
Pin Spread Distance (mm)			
Mean ± SD	–	12.7 ± 3.4*	–
Pin Spread Ratio	–	0.47 ± 0.11*	–

*Pin spread parameters apply only to lateral-entry group

Table 5. Comparison of Postoperative Complications between Groups (n = 90)

Complication	Group A: Cross K-wire (n = 45)	Group B: Lateral Entry K-wire (n = 45)	p-value
Loss of Reduction, n (%)	9 (20.0%)	32 (71.1%)	<0.001
Swelling, n (%)	9 (20.0%)	12 (26.7%)	0.45
Pin Tract Infection, n (%)	7 (15.6%)	12 (26.7%)	0.19
Postoperative Stiffness, n (%)	10 (22.2%)	8 (17.8%)	0.61
Cubitus Varus, n (%)	6 (13.3%)	11 (24.4%)	0.18
Any Complication, n (%)	17 (37.8%)	30 (66.7%)	0.004

complications. The findings of the present study can be contextualized within the broader literature through comparison with published meta-analyses. A systematic review and meta-analysis by researchers who analyzed 13 studies including 1,158 patients (seven randomized controlled trials and six prospective comparative cohorts) reported that loss of reduction occurred in 27 (11.6%) of 232 patients treated with crossed K-wires and in 35 (12.4%) of 282 patients treated with lateral entry K-wires. According to Flynn criteria, there was no difference in functional outcome between the two K-wire configurations (relative risk 1.07). Regarding nerve complications, 20 (4.1%) of 493 patients in the crossed group were diagnosed with iatrogenic ulnar nerve injury, compared with only 2 (0.3%) of 666 patients in the lateral entry group. The overall incidence of persistent ulnar nerve-related complaints was 3.5 per 1,000. The authors concluded that crossed and lateral entry pin fixation result in similar construct stability and functional outcome, and that if the surgeon wishes to avoid all potential risk of iatrogenic ulnar nerve injury, the lateral K-wire approach is safest.[13] The results affirm the long-held belief within the pediatric orthopedic literature that adding a medial pin provides construct stability and biomechanical benefits, especially in unstable fracture patterns. Similar findings have been previously reported with the use of lateral pinning configuration, and the present results are in good agreement with these findings, suggesting that lateral entry fixation alone might not be sufficient in high-grade fractures. Cross pinning was also superior with respect to radiological results.[14] While both groups had reasonable Baumann's angle values at follow-up, the lateral entry group had a greater drop over time indicating an ongoing, albeit small, loss of alignment over time. A higher percentage of patients with an anterior humeral line aligned with the K-wire also had good alignment at 6 weeks, which was also favourable for cross K-wire fixation. These minor differences in the radiographs are of clinical significance as they can lead to deformity in childhood, particularly cubitus varus, which may be lifelong.[15]

Although there are concerns about potential iatrogenic ulnar nerve damage with the medial pin, the study found no such issues, possibly due to the use of safe surgical techniques and/or proper intraoperative imaging. The rates of postoperative complications in the lateral entry group were greater than in the other groups but were not significantly different, and included pin tract infection, swelling, stiffness, and cubitus varus.[16] Nevertheless, this trend implies an indirect biomechanical inferiority of two lateral pins which could be a possible source of malalignment-related problems, thus making careful selection of patients for this technique very important. Results are compatible with previous reports

that lateral entry configurations are linked to increased instability, especially if the fracture obliquity or comminution decreases lateral buttress support. In the present study, cross K-wire fixation has proven biomechanically superior against rotational, varus and valgus stresses, which is the reason for its superiority.[16-18] In cases comparable to those in Pakistan, where follow-up compliance and postoperative care can be inconsistent, a more stable setting, such as cross pinning, could reduce the need for subsequent interventions and the risk of long-term deformity.[19,20]

Limitations: This research has several limitations that are needed to be acknowledged for future studies. This is a single center study conducted only at Bahawal Victoria Hospital, Bahawalpur, which might limit the generalizability and reliability of the results for different population having different demographic or clinical parameters and fracture types. Non probability consecutive sampling technique was employed instead of random sampling, leading to selection biasness. Lack of blinding was another limitation of this study as it was not feasible to blind surgeons to allocation technique. Moreover, follow-up duration was limited to just 6 weeks which was sufficient for early complications but inadequate for long term postoperative complications, functional recovery and cosmetic outcomes. In conclusion, multi central studies employing random sampling with follow-ups for at least 12 months are recommended.

CONCLUSION

The study concludes that both the cross K-wire is found to be more effective as compared to lateral entry K-wire fixation techniques for treating Gartland type III supracondylar fractures in children, but there are significant differences in efficacy. The results showed that cross pinning had better mechanical stability as it maintained the reduction more effectively, while postoperative displacement was significantly less. Although lateral entry pinning did not increase the risk of iatrogenic ulnar nerve injury, it did increase the risk of loss of reduction when adequate pin spread and technique were used.

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Muhammad Junaid Khan: Data collection, literature review, drafting of manuscript
Shahid Mahmood: Study supervision, methodology design, critical revision
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Irfan Ali Shujah: Data interpretation, results validation, editing of manuscript
Zahid Iqbal: Statistical analysis support, quality assurance, proofreading
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