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Original Article

Evaluating the Effectiveness of Divergent Versus Crossed Kirschner Wire Techniques in Managing Pediatric Misaligned Fractures Above the Elbow (Supracondylar) in the Humerus

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ABSTRACT

Objectives: To compare the effectiveness of lateral and crossed K-wire techniques in treating misaligned supracondylar humerus fractures in children, focusing on functional outcomes and complications.
Study Design: Quasi-experimental study.
Place and Duration of Study: Combined Military Hospital (CMH), Peshawar, Pakistan, from Dec 2019 to Mar 2024.
Methodology: We randomized the participants into Group A, using lateral K-wire fixation (n=58) and Group B, using crossed K-wire fixation (n=65), to compare the efficacy of the two fixation techniques in managing Type III fractures, with outcomes evaluated based on Flynn's Criteria, carrying angle, Baumann's Angle, and time to radiological union. All data was collected systematically and analysed using SPSS version 23.0 to ensure robust statistical evaluation and integrity of the results.
Results: Loss of carrying angle showed no statistically significant difference between the groups while mean loss of Baumann Angle was highest in Group B (3.99±1.01) as compared to Group A (2.48±1.73) with statistically significant difference (p-value < 0.001).
Conclusion: Both lateral and crossed K-wire techniques effectively treat displaced supracondylar humerus fractures in children, showing similar outcomes and low complication rates.

Keywords: Crossed fixation, Kirschner wire, Lateral fixation, Paediatric orthopaedics, Supracondylar humerus fractures.

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INTRODUCTION

Fractures of the humerus above the elbow (supracondylar) are a frequent type of orthopaedic injury in children, constituting about 15-20% of all fractures in this age group,[1] which commonly happen due to a fall on a stretched-out arm,[2] with timely management essential to avoid permanent issues with function and shape.[3] Various techniques can correct these fractures.[4] with the most commonly employed method being Kirschner wire (K-wire) fixation, favoured for its simplicity and effectiveness,[5] however, there is still some debate on which arrangement of wires yields the best results, these being divergent (lateral) and convergent (crossed) K-wire configurations.[6] In crossed K-wire fixation, the wires are inserted from both the medial and lateral sides and converge in the middle, providing stable fixation by creating a cross pattern that helps to resist various forces acting on the fracture site.[7] In contrast, lateral entry K-wire fixation involves inserting wires only from the lateral side, with these wires being divergent, meaning they spread out as they penetrate deeper into the bone, which helps enhance stability and reduces rotational movement of the fractured segments.[8] This study aimed to assess the efficacy of both Kirschner wire methods in addressing misaligned injuries above the elbow (supracondylar) in the humerus of paediatric patients. By comparing the results of lateral and crossed Kirschner wire methods, this research seeks to determine the optimal strategy for securing fracture stability, enhancing healing, and reducing complications, ultimately resulting in improved functional outcomes and quality of life for children.

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METHODOLOGY

This quasi-experimental study was conducted from July 2019 to March 2024, at Combined Military Hospital (CMH), Peshawar, Pakistan. The sample size, of 123 patients, was calculated using the Power and Sample Size Calculator, based on outcome prevalence from studies done on paediatric fractures, to ensure adequate power for detecting significant differences between groups.[4,5,8] After obtaining permission from Ethics Review Committee, via letter number 0070/24, participants were enrolled and informed consent was taken from all parents and guardian. The researchers

randomly assigned patients into two groups using a chit-drawing mechanism. A nursing staff member, who was not part of the study, selected a chit from a hidden bowl labelled "A" or "B," representing the two treatment groups. This method ensured an unbiased allocation of patients to either Group A or Group B.

Inclusion Criteria: Patients aged 12 years or younger, who presented with closed, extension-oriented classification 2 and 3 fractures of the supracondylar region of the humerus.

Exclusion Criteria: Patients with flexion category trauma, Gartland Classification I fractures, open wounds, ipsilateral elbow trauma, or aged more than 13 years.

Preoperative assessments included clinical examination, neurovascular function assessment, and ruling out compartment syndrome with radiographs taken to confirm the type and displacement of the fracture and Baumann's angle9 assessed for coronal plane alignment, with a standard range of 64–81. All surgeries were performed under general anaesthesia with C-arm guidance. Closed reduction was achieved, followed by pinning, according to the assigned group. Postoperatively, patients were provided with above-elbow splints and anti-inflammatory medications. Follow-up visits were scheduled at four weeks, three months, and six months. Outcomes were evaluated using functional and cosmetic criteria, as defined by Flynn's criteria.[10] at the six-month follow-up visit to determine the success of the treatment. All data was analysed using version 23.0 of the IBM Statistical Package for the Social Sciences Statistics (SPSS) software. Descriptive statistics were employed, independent sample t-tests, and Chi-square tests were used for comparative analysis. The p value ≤ 0.05 was consideres as significant.

RESULTS

The study evaluated 123 children with supracondylar humerus fractures, categorized into Group A (lateral Kirschner wire, n=58) and Group B (cross Kirschner wire, n=65), consisting of 69(56.1%) males and 54(43.9%) females. Fractures were more common on the dexter side 67(54.5%,) than on the sinister side 56(45.5%). The mean age was 6.52±2.32 years for Group A and 7.41±3.13 years for Group B, with no significant difference among demographic characteristics, as shown in Table-I.

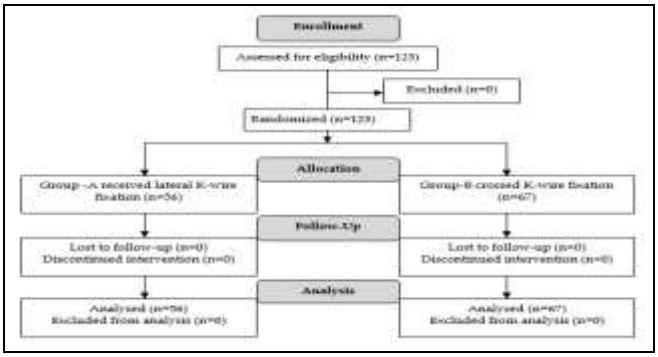

Figure: Patient Flow Diagram (n=123)

Table-I: Demographic Characteristics of Both Groups (n=123)

	Group A (n=56)	Group B (n=67)	p-value
Mean Age (Years)	6.71±2.70	7.34±2.99	0.228
Gender			
Male	33(58.9%)	36(53.7%)	0.563
Female	23(41.1%)	31(46.3%)	
Side			
Left	31(55.4%)	36(53.7%)	0.857
Right	25(44.6%)	31(46.3%)	
Neurovascular Injury			
Yes	1(1.8%)	2(3.0%)	-
No	55(98.2%)	65(97.0%)	

Loss of carrying angle showed no statistically significant difference between groups while mean loss of Baumann Angle was highest in Groups B (3.99±1.01) as compared to Group A (2.48±1.73) with statistically significant difference noted with *p*-value<0.001. The follow up time and time of radiological union for both showed no statistical difference as *p*-value > 0.05, which can be seen in Table-II.

Table-II: Comparison of Loss of Carrying Angle and Loss of Baumann Angle Among Groups (n=123)

	Group A (n=56)	Group B (n=67)	p-value
Loss of Carrying Angle	3.96±1.14	4.12±1.09	0.680
Loss of Baumann Angle	2.48±1.73	3.99±1.01	< 0.001
Follow up Time	6.41±2.28	6.07±2.00	0.387
Time to Radiological union (weeks)	6.32±2.42	6.01±1.96	0.307

We assessed all outcomes using Flynn's criteria, where, in Group B, 48(82.7%) patients demonstrated excellent results, 7(12.1%) showed good results, and 3(5.2%) achieved fair results, while in Group A, 58(89.2%) patients showed excellent outcomes, 5(7.7%) had good outcomes, and 2(3.1%) reached fair outcomes. The treatment group showed significant affect on the odds of achieving excellent outcomes

(p=0.03), indicating comparable efficacy between the two fixation methods, these have been summarized in Table-III.

Table-III: Comparative Analysis of Therapeutic Results According to Flynn's Criteria Between Study Groups for Paediatric Cases of Supracondylar Humerus Fractures (n=123)

Flynn's Criteria Outcome	Group A (n=56)	Group B (n=67)
Excellent	48(82.7%)	58(89.2%)
Good	7(12.1%)	5(7.7%)
Fair	3(5.2%)	2(3.1%)

DISCUSSION

Supracondylar humerus fractures in paediatric patients necessitate careful management due to the risk of serious complications with Grade III fractures, in particular, posing a threat of leading to conditions such as cubitus varus/valgus deformities, neurovascular damage, compartment syndrome, and Volkmann ischemic contracture (VIC).[11] due to which surgeons must ensure precise reduction of these fractures to prevent adverse outcomes.[12] Although cross-pin fixation offers superior biomechanical stability in terms of bending and torsion,[13] it is associated with a potential risk of causing ulnar nerve damage but lateral pin fixation is considered to be somewhat less stable against torsional forces, however, it does not carry the same risk of ulnar nerve injury yet the concern for iatrogenic ulnar nerve injury with a medial pin.[14] has led to the preference for a construct of three lateral pins. Similar to another study, this study noted a higher incidence of fractures in males and a predominance of left-side involvement.[15] Functionally, this study found no significant difference between the two approaches, mirroring the findings in literature.[15,16] which indicates that surgeons can choose either technique based on their preference, the fracture pattern, and surgical expertise. The findings of this analysis revealed no significant statistical difference in the loss of carrying and Baumann angles between the two groups, similar to those reported by another study.[15], which observed no difference in functional outcome, loss of carrying angle, or Baumann's angle between the two procedures, with other studies also reporting similar findings.[17,18] This study showed that the duration for radiological consolidation was similar for both cohorts, suggesting that each method is equally effective in stabilizing these fractures and enabling early movement and functional recovery, similar to another study.[19] which reported no notable disparity between the two treatment approaches in terms of fixation stability and functional results, however, they noted a higher risk of ulnar nerve damage with transverse K-wire fixation, unlike these findings. The recognized risk of ulnar nerve impairment.[20] associated with putting in the medial Kirschner pin in transverse K-wire fixation can be minimized by adopting measures such as placing the lateral pin first, straightening the elbow during medial wire insertion, creating a small incision, and safeguarding the nerve while threading the wire. Research conducted in Singapore.[21] revealed that the sliding method is an innovative approach to safeguard the ulnar nerve during closed reduction percutaneous pinning of supracondylar humerus fractures, however, the nerve palsies observed in our study were neurapraxias, which resolved spontaneously within month and a half.

LIMITATIONS OF STUDY

This study had limitations owing to small sample size, as more extensive, multi-center trials would provide a more comprehensive comparison of both fixation methods and contribute to developing definitive guidelines for treating supracondylar humerus fractures in pediatric patients.

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CONCLUSION

Both methods showed similar functional outcomes and anatomical restoration, with no significant differences in the reduction of carrying angle, change in Baumann's angle, or time to radiological union.

Conflict of Interest: None.

Funding Source: None.

Authors' Contribution

Following authors have made substantial contributions to the manuscript as under:

AH & EAM: Data acquisition, data analysis, critical review, approval of the final version to be published.

AEM & NA: Study design, data interpretation, drafting the manuscript, critical review, approval of the final version to be published.

Authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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