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Comparison of Outcomes of Gartland Type III Supracondylar Humerus Fractures Treated with Closed Reduction and Percutaneous Pinning with Lateral versus Crossed K-Wires in Children

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Abstract

Background

Supracondylar fractures of the humerus account for nearly 60% of elbow injuries in children. Closed reduction and percutaneous pinning is the preferred treatment modality. However, controversy persists regarding the optimal pin configuration lateral only versus crossed K-wire fixation. This study aims to compare the functional and cosmetic outcomes of Gartland type III supracondylar fractures in children treated with closed reduction and percutaneous lateral pinning versus crossed pinning using Flynn's criteria.

Methods

This hospital-based comparative study was conducted at Pokhara Academy of Health Sciences from May 2021 to April 2022. Ethical approval was obtained from the Institutional Review Board with reference number 05/078. A total of 44 children aged 4 to 12 years with closed Gartland type III supracondylar fractures were included in the study. Patients were randomly allocated into two groups: group A (n=22) underwent lateral pin fixation, and group B (n=22) underwent crossed pin fixation. Radiological parameters, loss of carrying angle, range of motion were assessed at 12 weeks postoperatively using Flynn's criteria.

Results

There was no statistically significant difference between the two groups in terms of Baumann's angle, loss of carrying angle, or loss of ROM at 12 weeks. According to Flynn's criteria, all patients achieved satisfactory functional outcomes. Excellent functional results were observed in 59.09% of patients in the lateral pinning group and 63.64% in the crossed pinning group.

Conclusions

Lateral and crossed K-wire pin configurations yield comparable functional and cosmetic outcomes in children with Gartland type III supracondylar fractures.

Keywords: Fracture Fixation; Humeral Fractures; Kirschner Wires; Treatment Outcome.

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Introduction

Supracondylar fractures of the humerus are the most common elbow injuries in children, accounting for approximately 60% of all pediatric elbow fractures, with a predilection for the non-dominant extremity [1,2]. These fractures are classified as either extension or flexion types, with extension-type injuries comprising nearly 98% of cases [3]. The pediatric distal humerus is particularly vulnerable due to its thin cortical bone and characteristic ossification pattern, making it prone to displacement following trauma [4]. Mechanically, extension-type fractures typically result from a fall onto an outstretched hand, causing posterior displacement of the distal fragment under the traction of the triceps [5].

The Gartland classification is widely used to categorize supracondylar fractures based on displacement and stability. Type III fractures are completely displaced and highly unstable, often necessitating accurate reduction and stable fixation to prevent long-term deformities [6,7]. Complications such as neurovascular injury, Volkmann's ischemic contracture, malunion, and elbow stiffness are notable concerns in the management of these fractures [8].

Closed reduction with percutaneous pinning remains the standard treatment for displaced type III supracondylar fractures. Two common pinning techniques are employed: lateral-only pinning and crossed medial-lateral pinning. While crossed pinning provides superior biomechanical stability, lateral pinning is associated with a lower risk of iatrogenic ulnar nerve injury. Special care must be taken to avoid injury to the ulnar nerve during insertion of the medial pin [9,10].

This study aims to compare the functional and cosmetic outcomes of Gartland type III supracondylar fractures treated with lateral versus crossed K-wire pinning in children, using Flynn's criteria [11]. The findings will help guide surgeons in selecting the optimal pinning technique that balances fracture stability and patient safety in the pediatric population.

Methods

This prospective comparative study was conducted in the Department of Orthopedics at Western Regional Hospital (WRH), Pokhara Academy of Health Sciences (PoAHS) over a period of 12 months from May 2021 to April 2022. Ethical approval was obtained from the Institutional Review Board of the Pokhara Academy of Health Sciences (PoAHS) with ref no. 05/078. All the patients aged 4 to12 years with isolated closed Gartland type III supracondylar humerus fractures, presenting within ≤ 4 days of injury and without distal neurovascular deficit, were included in the study. Patients with flexion-type fractures, previous fractures around the elbow, medical contraindications to surgery, failed closed reduction, loss to follow-up, or refusal to participate were excluded from the study. Eligible patients were randomized into two groups using Microsoft Excel random number generation: group A: Closed reduction and percutaneous lateral-entry pinning group B: Closed reduction and percutaneous crossed pinning. All procedures were performed under anesthesia in the supine position. A single prophylactic dose of intravenous ceftriaxone was administered preoperatively. Closed reduction was achieved under fluoroscopic guidance using traction-countertraction, correction of coronal and sagittal deformities, and rotational alignment based on displacement pattern. Adequacy of reduction was confirmed by assessing Baumann's angle and the anterior humeral line intraoperatively. Under all aseptic conditions, In group A, 2–3 lateral-entry K-wires (1.8 mm or 2 mm) were inserted through the lateral condyle. In group B, 2–3 K-wires (1.8 mm or 2 mm) were inserted in crossed configuration via lateral and medial entry points. The medial pin was inserted with the elbow flexed less than 80°, starting anteriorly at the medial epicondyle to minimize ulnar nerve injury. Pin sites were dressed, and an above-elbow posterior plaster slab was applied. Operative details and immediate postoperative neurovascular status were documented. Radiological assessment of reduction, including measurement of Baumann's angle, was performed prior to discharge. Patients

were discharged after inspection of the wound and pin sites, with advice to maintain limb splintage and to perform active and passive finger movements. Patients were followed up at 2, 3, 6, and 12 weeks postoperatively. At 2 weeks, pin tract infection and neurovascular status were assessed.

At 3 weeks, the slab and K-wires were removed if radiological evidence of union was present. If union was not evident, removal was performed the following week. Elbow mobilization under the supervision of a physiotherapist was initiated after slab and K-wire removal. Baumann's angle was measured. At 6 weeks, elbow flexion and extension were assessed bilaterally, and Baumann's angle was measured. At 12 weeks, loss of carrying angle and total loss of elbow range of motion were evaluated according to Flynn's criteria. Final Baumann's angle was measured. The incidence of nerve injury, recovery pattern (if applicable), and time to clinical and radiological union were documented. Functional outcomes were graded using Flynn's criteria based on loss of carrying angle and loss of total elbow range of motion and compared between the two groups [11]. Data were entered into Microsoft Excel and analyzed using SPSS version 23. For descriptive statistics, frequency, percentage, proportion, mean, and standard deviation were calculated. For inferential statistics, chi-square test was applied. P-value of <0.05 was taken as statistically significant at confidence interval of 95%.

Results

In this study period, 64 patients with supracondylar humerus fractures presented to our center. Out of which, 2 patients had open fractures, 8 patients had associated neurovascular compromise, 1 patient presented late, and 6 patients required open reduction, which were then excluded from the study. A total of 47 patients underwent closed reduction and percutaneous pinning. Three patients were lost to follow-up. Therefore, 44 patients completed the study with 22 patients in each group. Out of 44 patients, 30 were males (68.2%) and 14 were females (31.8%), with a male-to-female ratio of 2.14:1. The mean age of patients was 7.59 ± 2.23 years, with the majority 29(65.9%) in the age group of 4–8 years. The left elbow was involved in 23 patients (52.3%) and the right in 21 (47.7%). Fractures occurred more commonly in the non-dominant limb (59.1%). Posteromedial displacement was observed in 54.5% of cases, and posterolateral displacement in 45.5%. The most common mechanism of injury was fall while playing (54.5%), followed by fall from height (45.5%) (Table 1).

Table 1. Baseline Demographic and Injury Characteristics.

Variables	Lateral Pinning (n=22)	Crossed Pinning (n=22)
Age (years)		
4-8	14 (63.6%)	15 (68.2%)
9-12	8 (36.4%)	7 (31.8%)
Sex		
Male	14 (63.6%)	16 (72.7%)
Female	8 (36.4%)	6 (27.3%)
Side involved		
Left	10 (45.5%)	13 (59.1%)
Right	12 (54.5%)	9 (40.9%)
Dominance		
Dominant	11 (50.0%)	7 (31.8%)
Non-dominant	11 (50.0%)	15 (68.2%)
Fracture displacement		
Posteromedial	12 (54.5%)	12 (54.5%)
Posterolateral	10 (45.5%)	10 (45.5%)
Mode of injury		
Fall from height	15 (68.2%)	5 (22.7%)
Fall while playing	7 (31.8%)	17 (77.3%)

The mean intraoperative time was 30.68 ± 3.87 minutes in the lateral pinning group and 31.14 ± 6.71 minutes in the crossed pinning group (p = 0.785). At 12 weeks, the mean Baumann's angle was 72.64 ± 3.49° in the lateral group and 72.59 ± 3.41° in the crossed group (p = 0.965). The mean loss of carrying angle at 12 weeks was 5.14 ± 2.46° in the lateral group and 4.95 ± 2.38° in the crossed group (p = 0.630). Similarly, mean loss of range of motion (ROM) was 5.73 ± 2.64° and 5.32 ± 3.32°

in the lateral and crossed groups, respectively (p = 0.379). All fractures achieved radiological union by 6 weeks in both groups (p = 1.00). There was no statistically significant difference between the two groups in operative time, radiological alignment, or functional parameters at 12 weeks (Table 2).

Table 2. Operative and Radiological Outcomes Between Groups

Parameters	Lateral Pinning	Crossed Pinning	p-value
Intraoperative time (minutes)	30.68 ± 3.87	31.14 ± 6.71	0.785
Baumann's angle at 12 weeks (°)	72.64 ± 3.49	72.59 ± 3.41	0.965
Loss of carrying angle at 12 weeks (°)	5.14 ± 2.46	4.95 ± 2.38	0.63
Loss of ROM at 12 weeks (°)	5.73 ± 2.64	5.32 ± 3.32	0.379
Radiological union by 6 weeks	22 (100%)	22 (100%)	1
Iatrogenic ulnar nerve palsy	0	1 (4.5%)	–

One patient (4.5%) in the crossed pinning group developed iatrogenic ulnar nerve palsy, which completely recovered by 12 weeks. No cases of ulnar nerve palsy were observed in the lateral pinning group. Based on loss of ROM, excellent outcomes were observed in 59.1% of patients in the lateral group and 63.6% in the crossed group. No patient in either group had a poor outcome. Based on loss of carrying angle, excellent results were achieved in 63.6% of patients in both groups. Overall, all patients achieved excellent outcomes according to Flynn's criteria, with no statistically significant difference (Table 3).

Table 3. Functional Outcomes According to Flynn's Criteria

Outcome (Flynn's criteria)	Lateral Pinning	Crossed Pinning
Based on ROM		
Excellent	13 (59.1%)	14 (63.6%)
Good	7 (31.8%)	5 (22.7%)
Fair	2 (9.1%)	3 (13.6%)
Poor	-	-
Based on loss of carrying angle		
Excellent	14 (63.6%)	14 (63.6%)
Good	6 (27.3%)	7 (31.8%)
Fair	2 (9.1%)	1 (4.5%)
Poor	-	-

No cases of pin tract infection, pin back-out, residual pain, deformity, or stiffness were noted at final follow-up.

Discussion

Closed reduction and percutaneous pinning is the standard treatment for displaced extension-type supracondylar fractures of the humerus in children. However, controversy persists regarding the optimal configuration of percutaneous pin fixation. Crossed medial-lateral pinning provides superior biomechanical stability but carries an increased risk of iatrogenic ulnar nerve injury due to medial pin placement [6, 9]. Conversely, lateral-only pinning reduces the risk of ulnar nerve injury but may offer comparatively less biomechanical stability [10,12].

In our study, the mean age of children with type III supracondylar fractures was 7.59 ± 2.23 years, comparable to *Patel N et al.,* with mean age of 7.4 years13, *Afaque SF et la.,* with mean age of 7.2 years14, *Sapkota K et al* with mean age of 7.56 years [15], and *Devkota P et al* with mean age of 7 years 16. The most affected age group was 4–8 years, which aligns with prior studies [16,17]. This age group is more susceptible to supracondylar fractures due to the thin metaphyseal bone between the coronoid and olecranon fossae, and the relatively weaker metaphyseal sclerotin of the distal humerus [3]. At this stage, the supracondylar area is remodeling and has a slender cortex, making it fracture-prone [4] Furthermore, the tensile strength of the collateral ligaments and joint capsule exceeds that of the bone, so most energy during trauma is absorbed by bone rather than soft tissues 18In this

study, 68.2% of fractures occurred in males in our study which is comparable with other studies [13,16,17]. The higher incidence in boys may be due to greater participation in outdoor activities. Laterality analysis showed 52.3% of fractures involved the left side, similar to study be *Nepali et al* [17], *Shtarker H et al* [19]. The non-dominant limb was affected in 59.1% of cases, consistent with *Nepali et al,* A*faque SF et al* [14]. The higher involvement of the non-dominant limb may reflect the protective use of the dominant hand during falls [20]. In our study, posteromedial displacement was the most common in 54.5% of cases. P*atel N et al* found 75%of cases with posteromedial displacement,[13] Afaque SF et al found 67.5% of cases with posteromedial displacement 14 and *Lal K et al* found 65%of cases with posteromedial displacemen [21]. Given the natural valgus carrying angle of the elbow, postero-medial periosteum is most commonly injured. Falls during play were the most common mechanism of injury in our study (54.5%), similar to by *Prashant k et al Lal K et al* [21,22] while *Afaque SF et al* reported falls from height in 50.6%of cases as the leading cause [14] *Nepali et al* found fall on outstretched hand on ground to be the most common mechanism of injury [17] Overall, both modes are common in pediatric supracondylar fractures. The mean intraoperative time was 30.68 ± 3.87 minutes for lateral pinning and 31.14 ± 6.71 minutes for crossed pinning, with no significant difference (p = 0.785). Final Baumann's angle at 12 weeks was 72.64 ± 3.49° in the lateral group and 72.59 ± 3.41° in the crossed group (p = 0.965), consistent with *Afaque SF et al, Kocher MS et al , and Maity A et al*.[14,23,24] Both techniques were found to maintained effective reduction. In this study the mean loss of carrying angle at 12 weeks was 5.14 ± 2.46° for lateral group and 4.95 ± 2.38° for crossed pinning group (p = 0.630), comparable to the study done by *Afaque SF et al* who reported loss of 4.4±0.8 degrees in lateral group and 4.6±0.9 degrees in crossed pinning group (p- value=0.3) [14]. *Maity A et al* also reported 3.86 ± 3.33 degrees loss in lateral group and 3.58 ± 3.08 degrees in crossed pinning group (p-valu-0.63) [24]. Both the series did not show any significant difference in loss of carrying angle at 12 weeks. In our study the mean loss of ROM at 12 weeks was 5.73 ± 2.640 degrees in lateral group and 5.32 ± 3.315 degrees in crossed pinning group (p-value=0.379). This was similar to the study done by *Maity A et al* who reported 3.8 ± 3.21 degrees loss of ROM in lateral pinning group and 3.4 ± 2.9 degrees in crossed pinning group (p-value=0.45) [24]. In our study based on loss of ROM according to Flynn criteria, 13(59.1%) had excellent outcomes, 7(31.8%) had good, and 2(9.1%) had fair with lateral pinning whereas crossed pinning showed 14(63.6%) excellent, 5(22.7%) good, and 3(13.6%) fair outcomes; no poor outcomes were observed. The study done by *Sapkota K et al* showed 12(70.59%) excellent, 4(23.53%) good and 1(5.88%) fair results in lateral pinning group and 11(64.71%) excellent, 5(29.41%) good and 1(5.88%) fair results in crossed pinning based on loss of ROM [15]. Similarly, *Othman MK et al* reported 10(66.67%) excellent, 1(6.67%) good and 4(26.66%) fair results in lateral pinning group and 9(60%) excellent, 2(13.34%) good and 4(26.66%) fair results in crossed pinning group [25]. Both the studies reported no poor results which was similar to this study. Similarly, based on loss of carrying angle 14(63.64 %) had excellent outcomes, 6(27.27 %) had good outcomes and 2(9.09%) had fair outcomes in the lateral pinning group whereas 14(63.64 %) had excellent outcomes, 7(31.82 %) had good outcomes and 1(4.54 %) had fair results at the end of 12 weeks in crossed pinning group. None of the group had poor outcomes. Othman MK et al reported 14(93.33%) excellent and 1(6.67%) good results in lateral pinning group and 15(100%) excellent results in crossed pinning group based on loss of carrying angle [25]. Similarly, *Sapkota K et al* reported 14(82.35%) excellent results and 3(17.65%) good results in both lateral and crossed pinning groups based on loss of carrying angle [15]. Both the studies did not have any poor results according to Flynn's criteria based on loss of carrying angle which was similar to this study. In our study, all the cases were found to be united by 6 weeks in both the groups. There was no difference in time of union by

two methods similar to study by Patil [33] where the fracture united by mean 5.2 weeks in both groups [25]. Iatrogenic ulnar nerve injury is a known risk in crossed pinning (reported 0–6%) [6]. In our study, one patient (4.5%) in the crossed pinning group experienced transient ulnar nerve palsy, which fully recovered by the final follow-up, consistent with findings by *Afaque SF and Sapkota K.et al.* Afaque SF found 2 (5%) cases iatrogenic ulnar nerve palsy, Sapkota k et al found 1(5.88%) cases of ulnar nerve injury with cross pinning Group with full recovery [14,15]. The study had a relatively small sample size and short follow-up period, which may limit the generalizability of the results. Long-term outcomes and rare complications could not be fully assessed. Future multicenter studies with larger sample sizes and longer follow-up durations are recommended to better evaluate long-term functional outcomes and detect rare complications.

Conclusions

Lateral-only and crossed K-wire pinning provide comparable functional and cosmetic outcomes in children with Gartland type III supracondylar fractures. Lateral pinning offers the added advantage of a lower risk of iatrogenic ulnar nerve injury, and either technique can be used effectively used for displaced fractures in the pediatric population.

Recommendation

On the basis of findings, generalize the study to different settings.

Conflicts of Interest: The authors declare that they have no conflict of interest.

Availability of Data and Materials: All data analyzed during this study will be available from the corresponding author upon reasonable request.

Authors' Contributions

Conceptualization: AKS, JP, SCD, BBK, KT
Data curation: AKS, JP, SCD, BBK, KT
Formal Analysis: AKS, JP, SCD, BBK, KT
Investigation: AKS, JP, SCD, BBK, KT
Methodology: AKS, JP, SCD, BBK, KT
Writing-Original Draft: AKS, JP, SCD, BBK, KT
Writing-review & editing: AKS, JP, SCD, KT

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