

## CRPP for Extension Type III Supracondylar Fracture of Humerus by Lateral versus Crossed K Wires – a Comparative Hospital Based Study

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### Abstract

**Background:** SCFH accounts for sixty percent of all fractures around elbow. Type III SCFH is unstable. CRPP is treatment of choice. Both the crossed-k wires and lateral-entry k wires have been used successfully; however, superiority has not been established. This study compares stability, functional outcomes, radiological outcomes and complications of these two methods.

**Methods:** This is a hospital based prospective comparative study undertaken at GMCTH from June 2019 to November 2020. Fifty-six children of three to thirteen years with extension type III SCFH were included after taking informed consent. Ethical clearance was taken from NHRC, Kathmandu. Patients were followed up for three months. Statistical analysis was done using SPSS 25 and p value <0.05 was considered significant.

**Results:** The average age of participants was 7.70 years. There were 15 girls (26.7%) and 41 boys (73.3%). Right sided injuries occurred in 32.1% of children with 78.6% sustaining injury on the non-dominant side. Mean duration of fracture healing was 4.75 weeks. Average Baumann's angle at three completed months in lateral-entry group was 75.04 degrees and crossed-K wires was 74.50 degrees (p=0.374). The average carrying angle in lateral-entry group was 7.79 and crossed-K wires was 7.29 degrees (p=0.303). Average loss of flexion in lateral-entry group was 2.71 degrees and 2.25 degrees in crossed-K wires (p=0.479). Average loss of extension in lateral-entry group was 3.39 degrees and crossed-K wires was 2.82 degrees (p=0.37). Skaggs et al Criteria for grading loss of reduction showed no loss of reduction in all fifty-six cases.

**Conclusion:** Both the lateral and cross pinning techniques are equally efficient in maintaining reduction in management of supracondylar fracture of humerus. The ulnar nerve injury can be avoided while using the medial K wire by pinning in a semi-flexed elbow with ulnar nerve rolled back.

**Keywords:** Supracondylar fracture, crossed-K wires, Lateral-K wires

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### INTRODUCTION

Supracondylar fracture of Humerus (SCFH) is also called Malgaigne's fracture.<sup>1-4</sup> It accounts for 3-18% of all the childhood fractures and 60% of childhood fractures around the elbow joint.<sup>5-8</sup> It is more common in the age group of 5-8 years.<sup>5-8</sup> According to Modified Gartland's classification, Type III fractures are completely displaced with intact posterior periosteal

hinge. Type III A fractures demonstrate posteromedial displacement while III B fractures demonstrate posterolateral displacement.<sup>3,4,6-8</sup> These fractures are dreaded due to high rate of complications including neurovascular injuries, compartment syndrome, malunion, elbow stiffness and myositis ossificans.<sup>9-12</sup> The modality of treatment has shifted from conservative management with cast application with

elbow in hyperflexion to early closed reduction and pinning.<sup>6, 13</sup> At present, the configuration of the transfixing pins has been a matter of debate among Orthopaedic surgeons. Some prefer the use of lateral k-wires while others prefer to use cross k-wires. Invitro studies have shown that the cross pinning method, in which two wires are inserted each from lateral and medial epicondyle, is mechanically superior.<sup>14</sup> However, this technique has been attributed to ulnar nerve injury, which can occur in up to 5% of patients.<sup>7, 11</sup> Studies have also depicted good outcomes by using ulnar nerve preserving maneuvers before inserting the medial pin, for example making a small incision at the entry point to retract the ulnar nerve and pinning in semiflexed position of elbow with or without rolling back the ulnar through the skin.<sup>15</sup> More research adopting the nerve preserving methods needs to be conducted before the real picture of incidence of such complication can be ascertained with accuracy.<sup>11, 12</sup> Although fixation with lateral entry K wires has been proven to be inferior in terms of the stability offered, a well-placed divergent lateral wires provide excellent fixation of these fracture patterns while avoiding the much dreaded ulnar nerve injury.<sup>11, 12, 14, 16-19</sup> The aim of this study is to evaluate the results of fixation of SCFH using these two modalities of treatment and to compare the outcomes.

## MATERIALS AND METHODS

This is a hospital based prospective comparative study undertaken at Gandaki Medical College and Teaching Hospital (GMCTH), Pokhara, Kaski from June 2019 to November 2020. Children aged between 3 and 13 years with closed Gartland's extension type III SCFH presenting within 7 days of injury with normal neurovascular status of affected limb were taken up for study after taking informed consent from parents. Similarly, patients with flexion type injury, extension Type I & II SCFH, compound fracture, previous ipsilateral fracture to elbow, floating elbow injury and medical contraindication to surgery were excluded from study. Ethical clearance was obtained from Nepal Health Research Council, Kathmandu, Nepal on 30<sup>th</sup> June 2019 (Ref No: 3355). The study variables are epidemiological parameters such as age and sex; fracture parameters like type of fracture and side of injury; pre & post operative complications, radiological union time and functional outcomes of the procedures.

## Sample size

A total of 56 (28 in each group) patients included in this study. Sample size was calculated using the formula  $n = Z^2 * p * (1-p) / d^2$ . Non- Probability Convenience Sampling method was used and for purpose of division into groups, odd numbered patients were assigned into Group A which consisted of all patients undergoing lateral pinning, and even numbered patients were assigned into Group B which consisted of all patients undergoing cross pinning.

## Surgical Technique

Both of the procedures were done under Intra-venous anaesthesia. Surgical techniques were standardized in terms of pin location, pin size (weight < 20 kg size 1.5 mm and weight > 20 kg size 1.8 mm) and the position of the elbow for pin placement.<sup>19</sup> All the procedures were done by the authors. Closed reduction of the fracture was performed by following steps:

- Longitudinal traction for 2 minutes with elbow in extension and forearm in supination.
- Reduction of the medial or lateral shift/ tilt by applying valgus or varus force at fracture site.
- Hyperflexion of the elbow with anterior directed pressure over the distal fragment or olecranon at around 90 degrees of flexion.
- Pronation of the forearm in posteromedial displacement of distal fragment and supination of forearm in posterolateral displacement of distal fragment.
- Indications of successful reduction
  - Baumann's angle <80° in AP view (jones view)
  - Reappearance of the AHL and the hourglass in lateral view
  - Congruous lateral and medial columns in 10 degrees internal and external oblique views.

For the lateral fixation technique, two divergent K wires were inserted from the lateral condyle of elbow, under fluoroscopic guidance, along the lateral column to engage the medial cortex keeping the elbow in hyperflexion. Pins were placed in divergent configuration with adequate separation (>2mm) at the fracture site. For cross k- wire technique, first the lateral pin was inserted from lateral condyle to engage the medial cortex keeping the elbow in hyperflexion. The elbow was then kept in semiflexed position and the

ulnar nerve rolled back with the opposite thumb.<sup>7</sup> The medial pin was placed directly through the apex of the medial epicondyle such that it engaged the lateral cortex. The adequacy and stability of the reduction was checked under image intensification. Additional k wire was inserted in case of doubt of stability in lateral entry K wire. The pins were bent and cut outside the skin to prevent migration and to allow removal in the outpatient clinic. Follow up was done on first week, fourth week, eighth weeks and twelfth weeks. Pins were removed at 4<sup>th</sup> week.

**Outcome assessment tools:**

Clinical evaluation was graded based on carrying angle and elbow range of motion using the modified Flynn et al. criteria for reduction assessment.

**Table 1:** Modified Flynn et al. criteria for Reduction assessment<sup>20-22</sup>

Result/Ratings	Carrying angle loss (degrees)	Loss of flexion	Loss of extension
<b>Excellent</b>	0-5	0-5	0-5
Satisfactory			
<b>Good</b>	6-10	6-10	6-10
<b>Fair</b>	11-15	11-15	11-15
Unsatisfactory			
<b>Poor</b>	>15	>15	>15

Radiographic evaluation was performed based on anteroposterior (AP) and true lateral view at all follow ups and evaluation was done by measuring change in Baumann’s Angle using Skaggs et al. Criteria for Grading loss of reduction.<sup>18</sup> They co-related change in Baumann angle with loss of reduction using post-operative radiograph. Change in Baumann angle less than 6, 6 to 12 and greater than 12 degrees were graded as no loss of reduction, mild and major loss or reduction respectively.<sup>18</sup> The normal value of Baumann’s angle is less than 80 degrees (average 75 degrees).<sup>8</sup>

Data was collected in a predesigned case report form and analyzed using SPSS 16.0. The student t test was used to determine the significance of the measurements in two groups. A p-value of 0.05 was considered significant.

**RESULTS**

A total of 56 patients were included in this study out of which, 44 (78.6%) patients sustained SCFH on the

non-dominant side, including thirty-five out of thirty-eight right-handed and nine out of eighteen left-handed participants. The commonest cause was fall on the level ground attributing to 84% of the cases, followed by fall from height comprising of 8.9% and Road Traffic Accident 7.1%. Most of the injuries were sustained around home followed by school and road. At presentation, all the participants had a palpable and euvoletic radial artery with well perfused limb. Three patients (5.4%) had nerve injury with one radial (1.9%) and two AIN nerve injury (3.5%). None of the participants developed compartment syndrome ([Table 2](#)).

None of the patients developed any peri-operative complications like inadvertent nerve or vascular injuries. All the participants were discharged within a mean of 1.14 days of inpatient stay, with minimum of one day and maximum of four days of inpatient stay. Mean stay in group A 1.46 (± 0.693) days and group B 1.36 (0.82) days (p=0.60). Post-operatively 3 (5.4%) patients developed superficial pin tract infection, which was managed with dressing and oral antibiotics and observation. Two of them were in the lateral entry group. Total of 94.6% participants had no complication at one week follow up ([Table 2](#)). No significant change was seen between the intra-operative and twelve weeks Baumann’s angle signifying no significant loss of reduction in both the groups (p=0.103) ([Table 3](#)).

The average loss of Baumann’s angle from the standardized seventy-five degrees was 1.91 (± 1.14) degrees with minimum loss being zero and maximum being four degrees. The mean loss of 2.04 (± 0.99) degrees in Group A and 1.79 (± 1.28) degrees in Group B (p=0.420). According to Skaggs et al Criteria for grading loss of Reduction all 56 cases showed no loss of reduction. The average carrying angle at three completed months was 7.54 (± 1.79) degrees with the minimum being four and maximum being 12 degrees. The average carrying angle on the normal side was 8.02 (± 2.08) degrees, with the maximum and minimum being four degrees and thirteen degrees respectively. The average carrying angle in female was nine (± 2.23) degrees and male was 7.66 (± 1.93) degrees. The average loss of carrying angle was 0.48 degrees, with the minimum loss being zero and maximum being two degrees. Clinical evaluation based on loss of carrying

angle using the Modified Flynn Criteria for Reduction Assessment showed excellent results in all the participants. (Table 3).

The average extension was 3.11 (± 2.39) degrees with the maximum being zero and minimum being seven degrees. The average extension in group A was 3.39(±2.42) degrees and Group B was 2.82(±2.37) degrees (p=0.37). A total of 19.64 percent of participants obtained good results and 80.36% obtained excellent result based on the Modified Flynn Criteria for Reduction Assessment using extension loss as a parameter. A total of 21 participants (75%) obtained excellent result while seven (25%) obtained good result based on the Modified Flynn Criteria for Reduction Assessment using extension loss as a parameter in Group A. In group B twenty four (14.28%) of participants obtained good results and four participants (85.72%) obtained Excellent results. The average flexion was 137.52 (± 2.42) degrees with the minimum being 132 degrees and maximum being 140 degrees.

The average of flexion in Group A was 137.29 (±2.50) degrees and Group B was 137.75 (±2.36) degrees (p=0.479). The average loss of flexion is 2.48 (±2.48) degrees with minimum being zero degree and maximum of eight degrees, with loss of 2.71 (± 2.5) degrees in Group A and 2.25 (± 2.3) degrees in Group B (p=0.479). Of all the participants forty-eight (85.7%) had excellent results and eight (14.3%) had good results in Clinical evaluation according to loss of flexion using Modified Flynn Criteria for Reduction Assessment Of the twenty-eight participants in Group A, twenty-four (85.7%) showed excellent and four (14.3%) showed a good result. Similarly, of the twenty-eight participants in Group B twenty-four (85.7%) showed excellent and four (14.3%) showed a good result as graded by Clinical evaluation according to Loss of flexion using the Modified Flynn Criteria for Reduction Assessment (Table 3).

**Table 2:** Demographic and clinical data comparing Group A and Group B

Parameter	Overall sample (N=56)	Group A (n = 28)	Group B (n = 28)	P-value (Group A vs. Group B)
Age (mean ± SD) (years)	7.70 ± 2.86	8.29 ± 2.90	7.11 ± 2.74	0.124.
Gender (male: female) (cases)	41:15	23:5	18:10	0.131
Side of Injury (right: left) (cases)	18:38	7:21	11:17	0.25
Mechanism of injury: RTA (cases)	3	2	1	0.76
Mechanism of injury: fall from height (cases)	5	2	3	
Mechanism of injury: fall on level ground (cases)	48	24	24	
Nerve status: Intact (cases)	53	27	26	
Nerve status: Radial Nerve Injury (cases)	1	0	1	
Nerve status: AIN injury (cases)	2	1	1	
Type of fracture: IIIA	45	26	19	
Type of fracture: IIIB	11	2	9	
Hospital stays time (mean ± SD) (days)	1.41±0.76	1.46±0.69	1.36±0.83	0.60
Peri-operative complications	0	0	0	-
Post-operative complications	3	2	1	0.49



**Figure 1:** Immediate post operative and 4-week X rays



**Figure 2:** Range of motion at three months



**Figure 3:** X-ray at 1 month and Range of motion at three months

*Table 3. Clinical- radiological outcome comparison between two groups*

Parameters	Baumann's angle intraoperative (degrees)	Baumann's angle 12 weeks (degrees)	Carrying angle (degrees)	Extension (degrees)	Flexion (degrees)	Fracture union (weeks)
Crossed k wires	74.46	74.50±2.16	7.29±1.82	2.82±2.37	137.75±2.36	4.5 ± 0.88
Lateral k wires	74.89	75.64±2.30	7.79±1.77	3.39±2.42	137.29±2.50	5 ± 1.49
P value	0.46	0.37	0.30	0.37	0.47	0.132

## DISCUSSION

Extension Type SCFH is a common injury around elbow in children. Gartland's extension type III SCFH is a completely displaced fracture pattern. Failure to properly manage these fractures can lead to devastating complications such as elbow stiffness, cubitus varus, nerve injury and Volkmann's ischemic contracture. The aim of treatment is to obtain a functional limb without deformity and neurovascular compromise.

In this study, a total of fifty-six children with type III SCFH were managed with CRPP. The average age of the participants was 7.70 ( $\pm$  2.86) years with mean age in group A being 8.29 ( $\pm$  2.90) years and Group B 7.11 ( $\pm$  2.74) years. ( $p=0.963$ ) These findings were similar to study conducted by Houshian et al. where the average age was 7.9 years ( 7.2 years for boys and 8.5 years for girls). He studied 355 injuries around elbow of which 209 were supracondylar fractures.<sup>10</sup> SCFH occurs due to fall on outstretched hand with elbow extended. This anatomical region is inherently weak due to presence of olecranon fossa posteriorly and coronoid fossa anteriorly, with only thin intervening bone present between them. It is further weakened by the fact that the metaphyseal region of distal humerus undergoes remodeling resulting in fewer trabeculae, at the later part of the first decade of life. Besides this, the supporting ligamentous structures are underdeveloped resulting in increased laxity. Thus, when a child falls in an outstretched hand there is locking of the elbow in hyperextension with maximum concentration of force at the supracondylar region, leading to fracture.<sup>7</sup> The similarity in age in male and female participates is explained by similar anatomical and physiological processes going on in the age group. There were fifteen girls (26.7%) and forty-one boys (73.7%) participating in the study. In a study conducted by Kang et al. involving 230 children who underwent CRPP for Gartland type III SCFH between March 2003 and December 2012, 144 patients (62.6%) were male and eighty six patients (37.4%) were female.<sup>25</sup> This reflects the fact that boys are more active and engage more in outdoor activities. A total of 78.6% or forty-four patients sustained SCFH on the non-dominant side. These findings are similar to the study conducted by Kang et al. in which 146 (63.5%) out of 230 patients had left side involvement.<sup>25</sup> This shows that the child attempts to break the fall with their non dominant hand. It can also be assumed that the musculature in the non-dominant hand is comparatively weaker.

Three patients presented with nerve injuries with one radial nerve (1.9%) and two AIN (3.5%) i.e., 5.4% of participants sustained nerve injury. These findings were comparable with study done by Garg et al. including 1296 children, in which nerve palsy was identified in 105 children (12%). Of these, seventy-five (71%) had nerve palsy identified

preoperatively and thirty (29%) had nerve injury first identified postoperatively. The median nerve/anterior interosseus nerve (AIN) was the most frequently injured affecting ninety-four patients.<sup>26</sup> AIN is more vulnerable to get injured in SCFH. The median nerve is contused between the fragments affecting the dorsal component of the nerve where AIN fascicles are present. Besides this, first part of the AIN is more likely to sustain traction injuries than any other nerves during hyperextension injuries.<sup>27</sup>

In this study, none of the participants managed with crossed K wires developed iatrogenic ulnar nerve injury. This can be attributed to cautious pin insertion. Prior to medial pin insertion, the elbow was semiflexed and with the help of free hand the ulnar nerve was rolled back at all times.<sup>7, 21</sup> In his study Kocher et al. carried out a study involving fifty two children with SCFH. Twenty-eight children underwent lateral k wire fixation and twenty-four underwent crossed k wire fixation. None of the patients in both groups developed ulnar nerve palsy.<sup>15</sup> The risk of ulnar nerve injury rises by 5.04 times higher in cross pin configuration than lateral entry pins as discovered by Brauer et al.<sup>28</sup> They studied a total of 2054 children managed with crossed k wires and lateral entry k wires retrospectively. They also found that probability of iatrogenic nerve injury was 1.84 times higher with medial/lateral entry pins than with isolated lateral pins.<sup>28</sup> The ulnar nerve lies behind the medial epicondyle in the cubital tunnel. When the elbow is in flexion, the aponeurosis overlying the ulnar nerve (cubital tunnel retinaculum) is stretched, thereby decreasing the capacity of the cubital tunnel. Placing a medial K wire through the retinaculum in this position constricts the nerve in the tunnel and causes nerve palsy.<sup>29</sup> The ulnar nerve subluxes over the medial epicondyle in as many as 30% of patients; this subluxation occurs most commonly with hyperflexion of the elbow and, therefore, nerve injury is most likely when a medial pin is inserted with the elbow in this position.<sup>7, 8, 29</sup>

In this study none of the fifty-six patients had loss of reduction or pin migration. This finding is comparable to Skagges et al. who retrospectively viewed the results of reduction and Kirschner wire fixation of 345 extension-type supracondylar fractures in children. They found no difference with regard to maintenance of fracture reduction, between the crossed pins and the lateral pins.<sup>13</sup> However, Kallio et al. found a loss of reduction in 14% (eleven) of the eighty cases in which two lateral pins had been used.<sup>30</sup> The lack of loss of reduction with lateral entry K wires which are considered biomechanically less stable than the crossed k wires can be attributed to the fact that proper principles of K wiring were followed in both the groups. In the lateral entry group, divergent K wires were

used with adequate separation at the fracture site making sure that the medial cortex had good purchase. Following pinning, all the patients were checked for stability and a low threshold was kept for addition of third K wire in cases of doubt.

The mean duration of fracture healing was 4.75 ( $\pm$  1.24) weeks. In Group A the mean duration was five ( $\pm$  1.49) weeks and in Group B the mean duration of fracture healing was of 4.5 ( $\pm$  0.88) weeks. ( $p=0.132$ ) These findings were comparable with the study done by Onta et al. involving thirty-four participants comparing the outcome of management with crossed and lateral entry K wires. In their study all the fractures united by five weeks.<sup>31</sup> In a retrospective study conducted by Chen et al. involving 203 SCFH using different modalities of treatment like closed reduction and plastering, open or closed reduction with K wires. The average duration of fracture union was four to eight weeks.<sup>32</sup>

The average Baumann's angle at three completed months was 74.77 ( $\pm$  2.23) degrees, and the average loss of Baumann's angle from the standardized seventy-five degrees was 1.91 ( $\pm$  1.14) degrees. There was no significant change between intra-operative and twelve weeks' Baumann's angle. Using the Skaggs et al. Criteria for grading loss of reduction, all fifty-six cases showed no loss of reduction. The finding was comparable with Kocher et al. The mean Baumann's angle in their study was 75.7 degrees in lateral entry group and 75.8 degrees in cross pinning group. In a study conducted by Anwar et al. involving fifty children with SCFH, the loss of Baumann's angle was 5.56( $\pm$ 1.80) degrees in the crossed K wires group. Similarly the loss of Baumann's angle in lateral k wires group was 5.16( $\pm$ 2.64) degrees.<sup>22</sup>

In this study, the average carrying angle at three completed months was 7.54 ( $\pm$  1.79) degrees. The average loss of carrying angle was 0.48 degrees. Clinical evaluation based on loss of carrying angle using the Modified Flynn Criteria for reduction assessment showed excellent results in all the participants. This finding was comparable with Kocher et al.<sup>15</sup> In his study the mean carrying angle in the lateral entry group was 7.3 $\pm$ 1.7 degrees and 7.2  $\pm$ 1.9 degrees in crossed pinning group. Similar finding was published by Skaggs et al involving 355 children, where he found no difference with regard to maintenance of fracture reduction, between the crossed pins and the lateral pins.<sup>13</sup> In a study conducted by Anwar et al. involving fifty children with SCFH, the

loss of carrying angle was 4.32( $\pm$ 1.24) degrees in the crossed K wires group. Similarly the loss of carrying angle in lateral k wires group was 4.32( $\pm$ 1.81) degrees.<sup>22</sup>

In this study, the average flexion at three completed months was 137.52 ( $\pm$  2.42) degrees and the average loss of flexion is 2.48 ( $\pm$ 2.48) degrees. Of the Fifty-six patients, forty-eight (85.7%) had excellent results and eight (14.3%) had good results in clinical evaluation using the Modified Flynn Criteria for reduction assessment. In this study, the average loss of extension was 3.11( $\pm$ 2.39) degrees. A total of 19.64% participants obtained good results and 80.36% obtained excellent result based on the Modified Flynn Criteria for reduction assessment using extension loss as a parameter. All the above findings are comparable with Kocher et al.<sup>15</sup> In a study conducted by Anwar et al. involving fifty children with displaced SCFH the average loss of flexion was 8.38( $\pm$ 3.10) degrees with loss of 8.36( $\pm$ 3.13) degrees in group undergoing crossed K wires and 8.40( $\pm$ 3.14 degrees) in Lateral entry group. Similarly, the average loss of extension was 7.26( $\pm$ 3.22) degrees with loss of 7.08( $\pm$ 3.27) degrees in the crossed K wires group and 7.44( $\pm$ 3.22) in lateral entry group.<sup>22</sup> In another study, conducted by Foad et al. involving fifty five children with displaced SCFH the loss of flexion was 7.14( $\pm$ 9.10) degrees in group undergoing crossed K wires and 7.11( $\pm$ 10.8) in Lateral entry group. Similarly, the loss of extension was 8.68( $\pm$ 8.64) degrees in the crossed K wires group and 11.28( $\pm$ 10.4) in lateral entry group.<sup>16</sup>

The major limitation of this study is that, it is a non-randomized study with a small sample size and a short duration of study. Due to the short study periods the patients were followed up for only three months post procedure. Weaknesses of this study include the lack of blinding of the clinical and radiographic observers to the pinning technique. Additionally, measurement of Baumann's angle is x-ray dependent, so there is chance of measurement error.

## CONCLUSIONS

Both the lateral and cross pinning techniques are equally efficient in maintaining reduction in management of supracondylar fracture of humerus. They yield similar functional and radiological outcomes. The ulnar nerve injury can be avoided while using the medial K wire by pinning in a semi-flexed elbow with ulnar nerve rolled back.

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