ORIGINAL ARTICLE

ANNALS OF PUNJAB MEDICAL COLLEGE

Treatment of Pediatric Supracondylar Fractures - A Comparison of Conventional Cross K-Wiring Versus Dorgan's Technique

Khair Ul Inam[1], Farhan Sarwar[2], Mumtaz Salik Naqshband[3], Syed Maisum Raza Naqvi[4], Zuhair Zubair[5], Ahmad Humayun Sarfraz[6], Muhammad Kashif Naseer[7], Faisal Masood[8]

1 *Medical Officer, District Head Quarter Hospital Alpurai, Shangla Khyber Pakhtunkhwa, Pakistan*
Abstract writing & Analysis

2 *Assistant Professor, Department of Orthopedic Surgery, University Medical & Dental College, Faisalabad Pakistan*
Writing introduction

3 *Associate Professor, Department of Orthopedic Unit-2, Mayo Hospital, Lahore Pakistan*
Analysis & Abstract writing

4 *Senior Registrar, Department of Orthopedic Unit-2, Mayo Hospital, Lahore Pakistan*
Writing methods

5 *Consultant Orthopedic Surgeon, 60 bedded Government Hospital Khurrianwala, Faisalabad Pakistan*
Discussion writing

6 *Assistant Professor, Department of Orthopedic Surgery, Mayo Hospital, Lahore Pakistan*
Writing Material and Methods section

7 *Assistant Professor, Department of Orthopedic, King Edward Medical University/ Mayo Hospital, Lahore Pakistan*
Discussion writing & Analysis

8 *Professor & Head, Department of Orthopedic Surgery Unit-2, Mayo Hospital, Lahore Pakistan*
Conclusion writing

CORRESPONDING AUTHOR
Dr. Khair Ul Inam
Medical Officer, District Head Quarter Hospital Alpurai, Shangla Khyber Pakhtunkhwa, Pakistan
Email: drmkanam92@gmail.com

Submitted for Publication: 04-05-2025
Accepted for Publication 04-09-2025

How to Cite: Inam KU, Sarwar F, Naqshband MS, Naqvi SMR, Zubair Z, Sarfraz AH, Naseer MK, Masood F. Treatment of Pediatric Supracondylar Fractures - A Comparison of Conventional Cross K-Wiring Versus Dorgan's Technique. APMC 2025;19(3):220-226. **DOI: 10.29054/APMC/2025.1767**

ABSTRACT

Background: Pediatric supracondylar fractures are commonly managed with closed reduction and internal fixation (CRIF) with Kirchner's wires (K-wires), in different configurations, while the main objective remains stable fixation. **Objective:** This study aimed to compare functional and radiological outcomes, rate of iatrogenic ulnar nerve injury, operative time, and radiation exposure between conventional cross K wiring and Dorgan's Technique. **Study Design:** Prospective study. **Settings:** Department of orthopedic surgery, Mayo hospital (King Edward Medical University), Lahore, Pakistan. **Duration:** From April 2024 to December 2024. **Methods:** Patients were divided into the standard group (group S) and Dorgan's technique group (group D), each with 36 patients. Results were compared, and statistical tests were applied with significance at $p < 0.05$. **Results:** Of 72 children, 48 were boys and 24 were girls. The mean age was around 7 years in both groups. Differences in mean surgical duration and radiation exposure were not significant between the two techniques. ($p = 0.359$ and 0.897, respectively). Post-operative iatrogenic ulnar nerve injury occurred in 3 cases (8.5%) in group S and none in group D. The Difference in Flynn's criteria results for both groups was not significant. ($p = 0.190$). The difference in post-operative radiological outcome was also statistically not significant between the two groups. ($p=0.309$ for Bowman's angle and $p = 0.55$ for Anterior humeral line). **Conclusion:** Dorgan's technique has comparable results to standard cross-K wiring and is better regarding the safety of the ulnar nerve in the surgical management of supracondylar fractures.

Keywords: *Supracondylar Fracture, Closed reduction, K-wires, Dorgan's technique, Iatrogenic ulnar nerve injury.*

INTRODUCTION

Supracondylar fracture accounts for over 70% of elbow fractures observed in the pediatric population.[1] The incidence of such fractures is most pronounced in children aged between 5 and 7 years, with equal distribution in girls and boys.[2] Its annual incidence is 177.3 per 100000.[3] More than 95 % of supracondylar fractures are extension type.[4] There are different treatment options for the treatment of these fractures depending upon their type, open or closed and availability of equipment and expertise.[5]

Extension type supracondylar fractures in the pediatric population are most commonly managed with closed reduction and internal fixation (CRIF) with Kirchner's wires (K wires), also known as closed reduction and percutaneous pinning (CRPP). However, the optimal technique out of many is a matter of debate.

The most widely accepted method of fixation is closed reduction and internal fixation with K-wires.[6] There are various configurations for K-wire fixation of supracondylar fractures.[7] Cross K wires (one each from medial and lateral condyles in retrograde fashion is considered as standard and the most stable fixation method for supracondylar fractures,[8] but it has significantly higher chances of iatrogenic Ulnar nerve injury (about 4%), which may be reduced to 0.4 to 1.8 % if a stab incision is given for medial wire.[9] However, in Dorgan's technique (passing both wires from the lateral side- one in retrograde while the other in antegrade fashion), the chances of such injury are decreased, but at the cost of some degree of compromise on the stability.[10]

A study conducted by Sinisa Ducica *et al* concluded that Dorgan's technique gives adequate stability and good functional and cosmetic recovery for extension-type supracondylar fractures (Gartland type II and III) without iatrogenic ulnar nerve injury.[11] Jairam *et al* also observed that lateral wiring is equally stable as cross pinning, but in the former technique, no injuries to the ulnar nerve were reported.[12] Nevertheless, the construct of K-wires in managing supracondylar fractures remains a topic of debate. The conventional cross retrograde wiring technique is straightforward but carries the risk of ulnar nerve damage. On the other hand, lateral wiring eliminates the chance of causing iatrogenic injury to the ulnar nerve, yet it presents challenges such as a less stable structure, procedural complexity, increased surgical duration, and consequently, higher radiation exposure.[13]

The purpose of this study was to evaluate the differences between traditional cross K wiring and Dorgan's method regarding the functional results and safety of the ulnar nerve. Additionally, we assessed surgical duration and radiation exposure as secondary outcomes.

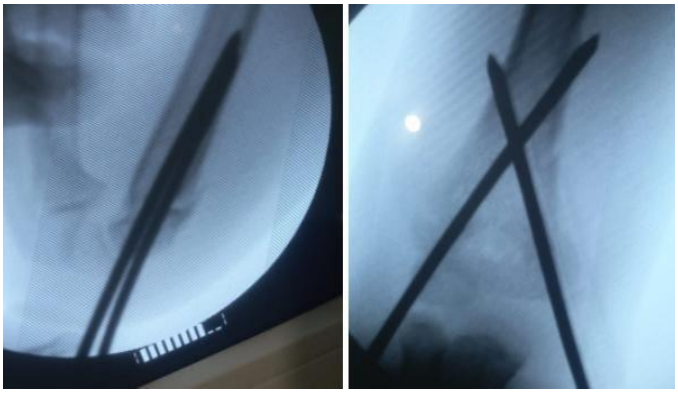
METHODS

This prospective study was carried out at the Department of Orthopedic Surgery, Mayo Hospital, King Edward's Medical University, Lahore, Pakistan, from April to December 2024. Approval from the institutional review board was taken vide notification number 185/RC/KEMU dated 20-03-2024. Children below 12 years, both boys and girls, having type II and III fractures (based on Gartland classification), which were reduced closely and presented within a week of the injury, were included in the study. Patients having open fractures, floating elbows, fractures demanding open reduction or conservative management, those with neurovascular injury, and patients with a previous history of fractures around the ipsilateral or contralateral elbow were excluded from the study.

A total of 72 patients (36 in each group) meeting the inclusion criteria were evaluated in the study by taking reference of the previous study[14] using the World Health Organization (WHO) calculator 7.4b (Hypothesis testing for two population means (two-sided test)) while setting level of significance at 5% and the power of the test at 90%. A convenient sampling technique was used. After taking informed consent from the parents, fractures in both groups were reduced closely under image intensifier in general anesthesia, and when all the reduction parameters like Baumann's angle, humerocapitellar line, and olecranon fossa were maintained, K-wires were passed either in the standard way or from the lateral side according to Dorgan's technique.

Standard Cross K-Wiring: In group S, two K-wires (one from the lateral condyle and the other from the medial one) were passed in retrograde fashion. Both wires were crossing each other in the anteroposterior (AP) view just above the olecranon fossa. A wire from the lateral condyle engaging the lateral part of the distal fragment was passed through the lateral column, sparing the Olecranon fossa, and then crossed into the medial cortex above the fracture line in the AP view. In the lateral view, this wire appeared intramedullary. The second wire was introduced from the medial condyle, engaging the medial parts of the distal fragment, then the medial column, crossed the lateral wire just above the fossa, and finally penetrated through the lateral cortex. This wire when checked on C-arm in the lateral view, also appeared intramedullary. The K-wires were bent and cut outside the skin, and above the elbow backslab was applied. Reduction and position of wires were once again checked under fluoroscopy, as depicted in Figure 1.

Figure 1: Standard (medial, lateral) cross K-wires



Dorgan's Technique: In group D, both K-wires were introduced from the lateral side. The first K wire was introduced in a retrograde manner from the lateral condyle into the lateral part of the distal fragment, then into the lateral column and crossed through the medial cortex as in the standard technique. However, the second K-wire was also passed from the lateral side in an antegrade fashion. This wire was engaged in the lateral

cortex of the distal humerus at the level where the first retrograde wire was exiting the medial cortex. Then, under C-arm guidance, this wire was crossed through the first wire just above the Olecranon fossa, passed through the medial column, and finally exited the medial condyle. Special attention was given that the tip of this antegrade wire lies subperiosteally and is not lying too long outside the medial condyle to pierce or impinge the ulnar nerve. Intramedullary position of both the wires was confirmed under fluoroscopy on the lateral view. Wires were bent and cut outside the skin, and above the elbow backslab was applied. Figure 2 shows K-wiring using Dorgan's Technique.

Figure 2: K-wiring using Dorgan's technique

Surgical time after reduction and the number of image-intensifier shots were recorded, and stability was also checked after passing both wires in both groups.

Postoperatively, patients in both the groups were shifted to the ward and were evaluated for iatrogenic ulnar nerve injury immediately after recovery from general anesthesia and recorded in a proforma if present. Patients were discharged the subsequent day and assessed in the outdoor patient department at 2nd, 6th and 12th post-operative weeks. At all follow-up visits, digital X-rays were done and checked for fracture union and position of wires (before their removal). The ulnar nerve was also checked on all the visits. Backslab was removed in all patients of both groups after two weeks, and passive range of motion was allowed under supervision. Polysling was applied after the removal of the back slab. After 6 weeks, wires were removed in all the patients of both groups and full range of motion exercises were allowed. Final follow-up was done at 12th weeks and range of motion (ROM) were evaluated using modified Flynn's criteria.

Modified Flynn's criteria:[15] It is calculated from measuring the carrying angle and elbow range-of-motion (ROM), that is, flexion and extension of the operated side, and then comparing these values with the contralateral normal elbow.

The outcome is excellent if the loss in carrying angle and elbow ROM is 0 to 4.9 degrees, good if the loss is between 5 and 9.9 degrees, fair if it is from 10 to 14.9 degrees and poor if it is 15 degrees or more as compared to the contralateral normal elbow. The outcomes are satisfactory if it is less than 15 degrees and unsatisfactory if the loss is more.

The statistical package for social sciences (SPSS) version 25.0 was employed to gather, arrange and examine the data. Frequencies and percentages were utilized to represent qualitative variables such as age, limb-side and gender. For quantitative variables like age, time since injury, operative time and angle measurements, mean ± standard deviation was used if the data followed a normal distribution, and parametric tests including Pearson's correlation and independent t test were applied. In cases of non-normally distributed data, the median with interquartile range (IQR) was presented, and non-parametric tests such as Spearman's correlation and Mann-Whitney U tests were utilized. Statistical significance was determined at a p-value below 0.05.

RESULTS

72 children were evaluated in the study, comprising 48 (66.7%) males and 24 (33.3%) females (26 boys and 10 girls in group S and 22 boys and 14 girls in group D). In group S, the right elbow was involved in 21 (58.3%) cases, while the left elbow was involved in 14 (41.7%). Similarly, in group D, right and left elbows were involved in 20 (55.6%) and 16 (44.4%) cases, respectively. According to the Gartland classification, Group S had 19 (52.7%) type-II and 17 (47.3%) type-III fractures. In group D, there were 22 (61.1%) type II fractures and 14 (38.9%) type III fractures (Table 1).

Among the individuals of the standard group, the mean age was 7.06 ± 2.11 years, while in Dorgan's group, it was 7.63 ± 2.2 years. The median time from injury to presentation was 6 hours (IQR = 6.5) in group S and 5 hours (IQR = 3.0) in group D. The mean surgical duration in group S (Cross K-wires group) was 41.19 ± 12.27 minutes (range: 19 - 72) compared to group D (Dorgan's technique group), which was 38.77 ± 9.79 minutes (range: 25 - 114). This disparity did not exhibit statistical significance. (p=0.359) as determined by an independent sample t-test. The mean number of C-arm fluoroscopic images taken during surgery in group S was 62.6 ± 26.32, compared to 63.3 ± 20.53 in group D. However, variation did not attain statistical significance (p = 0.897) applying an independent sample t-test (Tables 2 and 3).

Table 1: Basic demographic data and comparison of frequencies of different variables in both groups

Variables		Frequency	Percent	Valid Percent	Cumulative Percent
Gender in Group S (Cross K wires)	Male	26	72.2	72.2	72.2
	Female	10	27.8	27.8	100.0
	Total	36	100.0	100.0	
Gender in Group D (Dorgan's Technique)	Male	22	61.1	61.1	61.1
	Female	14	38.9	38.9	100.0
	Total	36	100.0	100.0	
Side involved in group S (Cross K wires)	Right	21	58.3	58.3	58.3
	Left	15	41.7	41.7	100.0
	Total	36	100.0	100.0	
Side involved in group D (Dorgan's Technique)	Right	20	55.6	55.6	55.6
	Left	16	44.4	44.4	100.0
	Total	36	100.0	100.0	
Gartland type in group S (Cross K wires)	Type II	19	52.7	52.7	52.7
	Type II	17	47.3	47.3	100.0
	Total	36	100.0	100.0	
Gartland type in group D (Dorgan's Technique)	Type II	22	61.1	61.1	61.1
	Type III	14	38.9	38.9	100.0
	Total	36	100.0	100.0	
Iatrogenic UN injury in group S (Cross K wires)	Yes	3	8.3	8.3	8.3
	No	33	91.7	91.7	100.0
	Total	36	100.0	100.0	
Iatrogenic UN injury in group D (Dorgan's Technique)	Yes	0	0	0	0
	No	36	100.0	100.0	100.0
	Total	36	100.0	100.0	
Anterior Humeral line touching capitellum in group S at 12 weeks post op (Cross K wires)	Yes	35	97.2	97.2	97.2
	No	1	2.8	2.8	100.0
	Total	36	100.0	100.0	
Anterior Humeral line touching the capitellum in group D at 12 weeks post op (Dorgan's Technique)	Yes	34	94.4	94.4	94.4
	No	2	5.6	5.6	100.0
	Total	36	100.0	100.0	

Table 2: Comparison between means of different variables in both groups

Variables		Statistic	Std. Error
Age in years (Cross K wires)	Mean	7.0625	.35262
	Std. Deviation	2.11574	
Age in years (Dorgan's Technique)	Mean	7.6389	.36683
	Std. Deviation	2.20101	
Time since injury in hours (Cross K wires)	Mean	11.6389	2.93018
	Median	6.0000	
	Range	95.00	
	Interquartile Range	6.50	
Time since injury in hours (Dorgan's Technique)	Mean	12.5694	4.63764
	Median	5.0000	
	Range	141.00	
	Interquartile Range	3.00	
Operative time in minutes (Cross K wires)	Mean	41.1944	2.04544
	Std. Deviation	12.27266	
Operative time in minutes (Dorgan's Technique)	Mean	38.7778	1.63207
	Std. Deviation	9.79245	
No of C arm Shots in group S (Cross K wires)	Mean	62.6667	4.38667
	Std. Deviation	26.32001	
No of C arm Shots in group D (Dorgan's Technique)	Mean	63.3889	3.42314
	Std. Deviation	20.53885	
Bauman's angle in degrees (12 weeks post op) (Cross K wires)	Mean	72.9444	.80074
	Std. Deviation	4.80443	
Bauman's angle in degrees (12 weeks post op) (Dorgan's Technique)	Mean	71.8611	.69024
	Std. Deviation	4.14145	

Group Statistics	Group	N	Mean	Std. Deviation	Std. Error Mean
Operative time	Cross K wires	36	41.1944	12.27266	2.04544
	Dorgan's Tech	36	38.7778	9.79245	1.63207
No of C arm shots	Cross K wires	36	62.6667	26.32001	4.38667
	Dorgan's Tech	36	63.3889	20.53885	3.42314
Bauman's Angle at 12-week post op	Cross K wires	36	72.9444	4.80443	.80074
	Dorgan's Tech	36	71.8611	4.14145	.69024

Table 3: Independent sample t-tests of different variables in both groups

Variables		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Operative time	Equal variances assumed	1.882	.174	.924	70	.359	2.416	2.616	-2.802	7.635
	Equal variances not assumed			.924	66.712	.359	2.416	2.616	-2.806	7.640
No of C arm shots	Equal variances assumed	1.779	.187	-.130	70	.897	-.722	5.564	-11.819	10.375
	Equal variances not assumed			-.130	66.096	.897	-.722	5.564	-11.831	10.386
Baumann's Angle at 12 weeks post op	Equal variances assumed	.773	.382	1.025	70	.309	1.083	1.057	-1.025	3.191
	Equal variances not assumed			1.025	68.511	.309	1.083	1.057	-1.025	3.192

Post-operative iatrogenic ulnar nerve injury was noted in 3 cases out of 36 (8.5%) in the standard technique group. Conversely, no iatrogenic injury to the ulnar nerve was reported in Dorgan's technique group.

At final follow-up of 12 weeks while applying Flynn's criteria, excellent results were found in 23 patients (63.9%), good in 8 (22.2%), fair in 4 (11.1%) and poor in 1 (2.8%) in standard group as compared to Dorgan's group in which these results were excellent in 18 (50.0%), good in 9 (25.0%), fair in 7 (19.4%) and poor in 2 (5.6%) patients. Overall, loss in both carrying and ROM was more prominent in Dorgan's technique group, but statistically not significant by applying the Mann-Whitney U test (p = 0.190) (Tables 4 and 5).

Table 4: Comparison of functional outcome between the two groups according to Flynn's criteria at 12 weeks after surgery

Variables		Frequency	Percent	Valid Percent	Cumulative Percent
Group S (Cross K wires)	Excellent	23	63.9	63.9	63.9
	Good	8	22.2	22.2	86.1
	Fair	4	11.1	11.1	97.2
	Poor	1	2.8	2.8	100.0
	Total	36	100.0	100.0	
Group D (Dorgan's technique)	Excellent	18	50.0	50.0	50.0
	Good	9	25.0	25.0	75.0
	Fair	7	19.4	19.4	94.4
	Poor	2	5.6	5.6	100.0
	Total	36	100.0	100.0	

Ranks	Group	N	Mean Rank	Sum of Ranks
Flynn's Criteria	Cross K wires	36	33.61	1210.00
	Dorgan's Tech	36	39.39	1418.00
	Total	72		

Table 5: Mann-Whitney U test for Functional outcome between the two groups using Flynn's criteria

Test Statistics[a]	Flynn's Criteria
Mann-Whitney U	544.000
Wilcoxon W	1210.000
Z	-1.311
Asymp. Sig. (2-tailed)	.190
a. Grouping Variable: Group	

Similarly at 12 weeks follow-up, the mean Bowman's angle was 72.9 ± 4.8° (67-81) in cross K wires group as compared to lateral K-wires group which was 71.8 ± 4.1° (69 -77) but no statistical disparity was revealed between the two cohorts by applying independent sample t-test (p=0.309). Anterior humeral line was touching the capitellum in 35 (97.2%) patients in group S and 34 (94.4%) patients in group D (Table 1), and this did not demonstrate statistical significance between the two groups of patients by applying the Pearson's Chi-square test (p = 0.55).

DISCUSSION

Our results showed that two-thirds of the included patients were male, while one-third were female. Challa *et al*[16] also reported male predominance. This may be attributed to the more intractable nature of boys. The average age is around seven years, which lies within the peak age interval between five and seven years. Nearly two in three patients had a fracture of the right elbow, which may be because of the more common right-hand dominancy. Easwar *et al*[17] also reported a higher frequency in the right hand. Hardera *et al*[18] found that 99% of supracondylar fractures occur in the dominant hand.

The average time of presentation to the hospital was 7 hours and 20 minutes. Of the 72 patients, 63 (87.5%) reached within 24 hours of the injury, 6 patients (8.3%) within 3 days, and 3(4.1%) patients within a week. These 9 cases initially visited bone setters who negatively counselled them to visit the hospital. A reasonable number of patients who presented within 24 hours (26 of 63) also visited bone setters initially, but when the pain of child was not relieved, they were brought to the hospital. The majority of parents of the patients who were initially treated by bone setters were either illiterate or were educated up to the college level. So, this relatively late presentation was due to multiple factors, including quackery, financial issues of parents, nonavailability of image intensifier at district headquarters hospitals (DHQs) near Lahore or even some tertiary care hospitals within Lahore city, nonavailability of orthopedic surgeons in peripheral areas and in some cases, parents were not satisfied from other hospitals. Strong actions should be taken against quackery, and provision of orthopedic surgeons and operative facilities should be ensured to overcome these difficulties.

Regarding operative time and radiation exposure, we did not notice any statistical difference between the two groups. These findings are contrary to the results reported by Ducica *et al*[11] in which the Dorgan's technique required more time and longer radiation exposure.

We noted post-operative injury to the ulnar nerve in 3 patients of the cross K-wire group and no such injury in Dorgan's technique. Queally *et al*[19] also reported few cases of iatrogenic ulnar nerve injury in the cross K-wires group, but no such complication in the lateral-wires group.

After 12 weeks follow up, applying modified Flynn's criteria, we observed excellent results in 23 individuals (63.9%), good in 8 (22.2%), fair in 4 (11.1%) and poor in 1 (2.8%) in standard group while 18 (50.0%) excellent, 9 (25.0%) good, 7 (19.4%) fair and 2 (5.6%) poor in patients treated with Dorgan's Technique. However, this disparity in both groups did not show significance. Ducica *et al*[11] in their study also reported a non-significant difference in functional outcomes between these categories.

The study revealed no statistically significant disparity between the two groups regarding post-operative radiological evaluation, specifically Baumann's angle and the anterior humeral line's passage through the capitellum. Weal *et al*[20] similarly concluded in their research that post-operative radiological assessment showed no substantial difference between the groups. Phan *et al*[21] reported comparable results, noting no statistical variance between lateral cross pinning and medial and lateral cross pinning.

CONCLUSION

For the treatment of supracondylar fractures, Dorgan's technique proves as efficacious as standard cross K-wiring, without the associated risk of post-operative iatrogenic ulnar nerve injury. This method could serve as a viable alternative to conventional (medial and lateral) cross-K wiring, which carries a notable risk of iatrogenic ulnar nerve damage.

LIMITATIONS

The primary constraints of this research were the limited sample size and brief follow-up duration.

SUGGESTIONS / RECOMMENDATIONS

Further studies with larger cohorts and extended follow-up periods are recommended to thoroughly assess the safety and efficacy of this procedure.

CONFLICT OF INTEREST / DISCLOSURE

All the authors declare no conflicts of interest.

ACKNOWLEDGEMENTS

This research was facilitated by Orthopedic Department of Mayo Hospital / King Edward Medical University Lahore, Pakistan.

FUNDING SOURCE:

This research was not funded by anybody or organization.

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