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A PROSPECTIVE STUDY ON CLINICAL AND FUNCTIONAL OUTCOME OF SURGICAL MANAGEMENT OF SUPRACONDYLAR FRACTURE OF HUMERUS IN CHILDREN WITH CROSS K - WIRE FIXATION

SYED PARVEEZ AHMED[1], KARTHIK SAGAR .S[2], PRAKHYATH MAHADEV GOWDA[3], LIKHITH KUMAR L[4]

[1]Fellow in Arthroplasty, Department of Orthopedics, Bangalore Medical College and Research Institute, Bengaluru
[2]senior Resident, Department of Orthopedics, Bangalore Medical College and Research Institute, Bengaluru.
[3]Senior Resident, Department Of Orthopedics, Bangalore Medical College And Research Institute, Bengaluru.
[4]Fellow in Arthroplasty, Department Of Orthopedics, Bangalore Medical College and Research Institute, Bangalore

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ABSTRACT

Background: Displaced supracondylar humeral fractures are common paediatric elbow injuries and may cause malunion, neurovascular complications, stiffness, and functional impairment. This study evaluated the clinical, radiological, and functional outcomes and complications of crossed percutaneous K-wire fixation following closed reduction.

Methods: A prospective study was conducted in 50 children younger than 12 years with displaced supracondylar humeral fractures. Patients with open fractures, vascular injury, malunion, or age >12 years were excluded. Fractures were classified using the modified Gartland classification. Clinical and radiological outcomes were assessed using elbow range of motion, carrying angle, Baumann's angle, fracture alignment, and complications. Functional outcomes were graded using Flynn's criteria at 4, 12, and 24 weeks.

Results: The study included 39 males (78%) and 11 females (22%), with a mean age of 7.12 ± 2.30 years. The left elbow was involved in 66%, and extension-type fractures accounted for 96%. Posteromedial displacement was most common (48%). Two K-wires were used in 56% and three in 44%. At follow-up, 74% had ≤5° loss of elbow motion, with a mean loss of 3.62 ± 3.68°. Loss of carrying angle was ≤5° in 86%, with a mean loss of 3.04 ± 2.96°. Flynn grading showed excellent outcomes in 86%, good in 10%, fair in 2%, and poor in 2%, giving 96% satisfactory results. Superficial pin-tract infection and movement restriction occurred in 14% each, while iatrogenic ulnar nerve palsy occurred in 4% and K-wire migration in 2%.

Conclusion: Crossed percutaneous K-wire fixation following closed reduction provides stable fixation and favourable clinical, cosmetic, and functional outcomes in appropriately selected children, although careful medial pin placement is essential to minimize ulnar nerve injury.

Keywords: *Supracondylar fracture; humerus; children; paediatric orthopaedics; crossed K-wire fixation; percutaneous pinning; closed reduction; Flynn criteria; elbow; functional outcome.*

***Corresponding Author**
Dr. Likhith Kumar L

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INTRODUCTION

Supracondylar fractures account for 60% of all paediatric elbow fractures and 3% of all paediatric fractures [1]. The rate of occurrence rises steadily in the first five years of life before peaking at 5-7 years [2]. Falling on an outstretched hand and sustaining indirect elbow injury are the main causes of this fracture. Even for the most experienced surgeon, a paediatric supracondylar humerus fracture frequently causes anxiety [3]. Immobilization in the safer right-angle position will frequently allow the fragments to slip, producing various deformities causing supracondylar dilemma[4,5]. Closed reduction and fixation with percutaneous Kirschner (K) wire was first described by Swenson [5,6]. The current treatment of displaced supracondylar fractures consists of closed reduction and percutaneous pin fixation using Kirschner wires, while some controversies still exist regarding the placement of the pins [7,8,9]. Percutaneous pinning has proven to be the least invasive and safest techniques for bone healing. It is characterized by a low incidence of complications (2%–8%) and mainly consisting of pin migration under the skin, pin infections and loss of fracture reduction [10,11]. Closed reduction and percutaneous pinning appear to be the best method at present, although in irreducible situations, open reduction becomes mandatory. Only in cases of open fractures, irreducible fractures by interposition of soft tissues or in cases of possible neurovascular complications, should open surgery interventions be performed as soon as possible [10-14].

Controversy still exists about the optimal placement of the pins. A crossed-pin technique is thought to be mechanically more stable than lateral pin alone even if with the use of the last one, the ulnar nerve could be more easily injured. Slobogean et al [14] suggest that there is a greater risk of iatrogenic ulnar nerve injury with crossed pinning versus lateral pinning in children with supracondylar humerus fracture.

AIM & OBJECTIVES

1. To restore the anatomy of distal end of humerus with percutaneous cross kirschner's wire [k -wire] fixation.
2. To evaluate the result of surgery with reference to pain, restoration of function and complications.
3. To find out final range of movements of elbow joint in terms of flexion and extension and comparison of carrying angle of both elbow.

MATERIALS AND METHODS

This study was conducted in Bangalore Medical College & Research Institute between June 2024 and June 2025. During this period 50 cases of supracondylar fractures of humerus in children meeting the requirements of inclusion criteria were treated with cross pinning with Kirschner wires. The total study population comprised of 50 children.

Inclusion Criteria

All displaced supracondylar fractures
Age under 12 years
All patients with or without neuro complications.

Exclusion Criteria

Old Malunited fractures.
Age more than 12 years.
Open fractures Supracondylar fractures associated with vascular injury.

A detailed history of mode of injury and initial treatment was obtained from parents and children. The distal neurovascular status was thoroughly examined. Fractures were classified by modified gartland classification. After receiving approval from the institutional ethical committee, all paediatric patients satisfying the inclusion criteria were included in the study. Before a child could participate in the study, his or her parents or legal guardians had to provide a documented valid informed consent.

Surgical Technique

Anesthesia and position:
Brachial block was given in all cases.
Supine position with their arms supported by a radiolucent arm support, allowing the elbow to be seen under the c arm
Operative procedure:

The operated arm was scrubbed, painted and draped. All fractures were initially reduced using the close method. First traction was applied to the affected forearm, which is supplemented by counter traction from an assistant in the opposite site. This corrects the fracture's proximal shift and aids in length regaining. The surgeon then corrected the deformity in the coronal plane (i.e. posteromedial or posterolateral displacement) by applying forces in the opposite direction. In case of posteromedial displacement pronation closes the hinge and corrects the malalignment, in case of posterolateral displacement supination corrects the malalignment. Finally, the extension component was corrected by hyper pronating and flexing the elbow while simultaneously pushing the olecranon tip in a volar direction with the thumb. The pin size used was 1.6 mm in younger children and 2mm in older children.

A fluoroscopic image is taken in AP and lateral views to confirm the reduction . In case of cross pinning lateral pin was first done in flexion. Precautions were taken to protect ulnar nerve and then medial pinning was done in extension. To avoid further ulnar nerve injury, the entrance point for the medial wire was chosen in a slightly anterior plane. The wires were put in such a way that the two wires intersected proximal to the fracture site. Postoperatively the extremity was placed in well-padded posterior splint with elbow flexed to 90° and patient was shifted to the ward after recovery from anaesthesia.

The following were noted in the postoperative X-Rays for adequacy of reduction.

1. Anterior humeral line
2. Crescent sign
3. Baumann's angle was measured in immediate post op x ray, and the x ray before k wire removal at three to four weeks. Loss of reduction is determined by change in baumann's angle. The displacement is graded by Skaggs.

Follow up:

- Patients were called for follow up after 4 weeks the POP slab was removed.
- The K-Wires were removed after 4 weeks.
- Active range of motion exercises were encouraged,
- A special mention and warning was given after the removal of splint about
- avoiding massage and passive stretching of elbow joint.
- Further follow ups were done at 12 weeks and 24 weeks.
- The patients were examined clinically and radiologically, assessed for range of motion and carrying angle.

➢ The functional results were graded based on Flynn et al grading

Statistical Analysis

The data obtained from the present study were tabulated and the percentage calculated accordingly. All characteristics were summarized descriptively. For continuous variables, the summary statistics of mean ± standard deviation (SD) were used. For categorical data, the number and percentage were used in the data summaries and diagrammatic presentation. Data were analysed using SPSS software v.23 (IBM Statistics, Chicago, USA) and Microsoft office 2021.

RESULTS

A total of 50 patients with supracondylar fractures of the humerus were included in the study. There was a male predominance, with 39 males (78%) and 11 females (22%) (Table 01). The mean age of the study population was 7.12 ± 2.30 years. The largest proportion of patients belonged to the 6–9-year age group (28 patients, 56%), followed by children

younger than 6 years (14 patients, 28%) and those aged 10–12 years (8 patients, 16%) 9 Table 02).With respect to the mechanism of injury, fall while playing was the most frequently reported mode of trauma, involving 32 patients. Twelve patients sustained the injury following a fall from a bicycle, while 6 patients sustained a fall from a height. The corresponding percentages reported in the table were 64%, 24%, and 12%, respectively (Table 03). The fracture involved the left upper limb in 33 patients (66%) and the right upper limb in 17 patients (34%), as reported in Table 4. Regarding fracture morphology, the majority of fractures were of the extension type, accounting for 48 patients (96%), whereas flexion-type fractures were observed in 2 patients (4%) (Table 05) .The fracture distribution according to Gartland classification was reported as 12 type II and 36 type III fractures. Among the type III, 24 patients (48%) had posteromedial displacement, while 12 patients (24%) had posterolateral displacement (Table 6). An associated fracture of the distal radius was documented in 4 patients (8%) (Table 07). The mean interval between admission and surgery was 2.84 ± 0.99 days (Table 08). Surgery was performed on the second day in 25 patients (50%), on the third day in 12 patients (24%), on the fourth day in 9 patients (18%), and on the fifth day in 4 patients (8%).The duration of hospital stay ranged from 3 to 5 days, with a mean hospital stay of 4.04 ± 0.78 days. Fourteen patients (28%) remained hospitalized for 3 days, 20 patients (40%) for 4 days, and 16 patients (32%) for 5 days (Table 09)

The most frequently reported complications were superficial pin-tract infection and restriction of elbow movements, occurring in 7 patients (14%) each. Iatrogenic ulnar nerve palsy occurred in 2 patients (4%), while K-wire migration was observed in 1 patient (2%). No patient developed traumatic median nerve palsy or cubitus varus deformity (Table 10)

The postoperative loss of range of motion was ≤5° in 37 patients (74%). Eight patients (16%) had a loss of 6–10°, 3 patients (6%) had a loss of 11–15°, and 2 patients (4%) had a loss exceeding 15°. The mean loss of range of motion was 3.62 ± 3.68° (Table 11).

Assessment of the carrying angle demonstrated an excellent result, defined as a loss of 0–5°, in 43 patients (86%). Five patients (10%) had a loss of 6–10°, while one patient each was classified as having a loss of 11–15° and more than 15°. The mean loss of carrying angle was 3.04 ± 2.96° (Table 12)

Functional outcome was assessed using Flynn's grading system. Forty-three patients (86%) achieved an excellent result, while 5 patients (10%) achieved a good result. One patient was graded as fair and one as poor. The study therefore reported 48 satisfactory outcomes and 2 unsatisfactory outcomes according to the overall Flynn grading classification (Table 13).

The distribution of fracture configuration is presented in Table 16. In the present study, extension-type fractures constituted the predominant fracture pattern, accounting for 48 cases (96%), whereas flexion-type fractures accounted for 2 cases (4%). The predominance of extension-type injuries was also observed across the comparative series, with reported proportions ranging from 90.29% to 100%. The present study therefore demonstrated a fracture pattern broadly comparable with that reported in previous series.

The average duration of hospital stay is shown in Table 17. The mean hospital stay in the present study was 4.04 days, compared with 4.20 days in the series reported by Nacht et al. and 3.45 days in the series of Aronson and Prager. Thus, the duration of hospitalization in the present series was within the range reported in the comparative literature.

As shown in Table 18, posteromedial displacement was the most frequently observed displacement pattern in the present series, occurring in 24 cases (48%). Posterolateral displacement was observed in 12 cases (24%), while 12 cases (24%) had an extension-type fracture with no displacement and an intact posterior hinge. Flexion-type fractures with anterior displacement accounted for 2 cases (4%). Overall, the findings demonstrate that posteromedial displacement represented the predominant displaced fracture configuration in the study population.

Comparison with previous studies is presented in Table 19. The proportion of posteromedial displacement ranged from 75% to 90% in the cited comparative series, while the corresponding proportion reported for the present study was 48%. Posterolateral displacement ranged from 10% to 25% in the comparative studies and was reported as 24% in the present study. These findings demonstrate variation in the distribution of displacement patterns among published series.

The pre-operative complications are summarized in Table 20. Severe oedema was the most frequently documented pre-operative complication, occurring in 15 patients (30%). Puncture wounds were present in 6 patients (12%), whereas no pre-operative nerve injury was recorded. Thus, among the complications evaluated, soft-tissue swelling represented the predominant pre-operative finding.

The comparative distribution of pre-operative neurological complications is shown in Table 21. In the present study, no cases of complete median nerve palsy, radial nerve palsy, ulnar nerve palsy, or anterior interosseous nerve palsy were recorded. In comparison, Bhans et al. reported radial palsy in 4.5% of cases, while Fowles et al. reported complete median palsy and radial palsy in 2.7% of cases each. No ulnar or anterior interosseous nerve palsy was reported in the comparative data presented.

The distribution of the number of K-wires used for fixation is presented in Table 22. Two K-wires were used in 28 patients (56%), whereas three K-wires were used in 22 patients (44%). Thus, fixation with two K-wires was more frequently employed in the present series.

The occurrence of Volkmann's ischemic contracture is shown in Table 23. The present study reported no cases (0%) of Volkmann's ischemic contracture, which was comparable with the 0% rate reported by Krishna Kumar. Ottoleghni et al. reported an incidence of less than 1%.

Similarly, no cases of myositis ossificans were reported in the present study (0%), as shown in Table 24. This was comparable with the 0% incidence reported in both of the cited comparative series.

Pin-track infection is presented in Table 25. The present study recorded a pin-track infection rate of 14%, compared with 2.7% in the series reported by Fowles et al. and 1% in the

series of Krishna Kumar. The incidence observed in the present study wastherefore higher than that reported in the two comparative series included in the analysis.

Table 01: Sex distribution

Sex	No. of patients	Percentage
Male	39	78%
Female	11	22%

Table 02: Age distribution

Age group	No. of patients	Percentage
<6 years	14	28%
6–9 years	28	56%
10–12 years	8	16%

Note: Mean ± SD age: 7.12 ± 2.30 years.

Table 03: Mode of injury

Nature of trauma	No. of patients	Percentage
Fall from bicycle	12	24%
Fall while playing	32	64%
Fall from height	6	12%

Table 04: Laterality of fracture

Side	No. of patients	Percentage
Left	33	66%
Right	17	34%

Table 05: Classification of fracture pattern

Fracture pattern	No. of patients	Percentage
Gartland type III – posteromedial	24	48%
Gartland type III – posterolateral	12	24%

Table 06: Type of fracture

Fracture type	No. of patients	Percentage
Extension type	48	96%
Flexion type	2	4%

Table 07: Associated injuries

Associated injury	No. of patients	Percentage
Ipsilateral distal radius fracture	4	8%

Table 08: Time to surgery

Time of surgery	No. of patients	Percentage
2nd day	25	50%
3rd day	12	24%
4th day	9	18%
5th day	4	8%

Note: Mean ± SD time to surgery: 2.84 ± 0.99 days.

Table 09: Duration of hospital stay

Hospital stay (days)	No. of patients	Percentage
3	14	28%
4	20	40%
5	16	32%

Note: Mean ± SD hospital stay: 4.04 ± 0.78 days.

Table 10: Postoperative complications

Complication	No. of patients	Percentage
Traumatic median nerve palsy	0	0%
Superficial pin-tract infection	7	14%
Iatrogenic ulnar nerve palsy	2	4%
K-wire migration	1	2%
Restriction of movements	7	14%
Cubitus varus	0	0%

Table 11: Loss of range of motion

Loss of ROM	No. of patients	Percentage
0–5°	37	74%
6–10°	8	16%
11–15°	3	6%
>15°	2	4%

Note: Mean ± SD loss of ROM: 3.62 ± 3.68°.

Table 12: Loss of carrying angle

Result	Loss of carrying angle	No. of cases	Percentage
Excellent	0–5°	43	86%
Good	6–10°	5	10%
Fair	11–15°	1	2%
Poor	>15°	1	2%

Note: Mean ± SD loss of carrying angle: 3.04 ± 2.96°. Percentages for 1/50 were recalculated as 2%.

Table 13: Functional outcome based on Flynn grading system

Overall result	Flynn rating	No. of patients	Percentage
Satisfactory	Excellent	43	86%
Satisfactory	Good	5	10%
Satisfactory	Fair	1	2%
Unsatisfactory	Poor	1	2%

Table 14" Side incidence in comparative series

Series	Year	Right humerus	Left humerus
Nikhil et al. [15]	2019	12	18
Akhtar et al. [16]	2021	28	52
Rahat et al. [17]	2019	22	61
Fowles et al. [18]	1974	97	63
Edwards et al. [19]	1978	42	58
Present study	2022	17	33

Table 15: Mean age in comparative series

Series	Year	Mean age (years)
Pirone et al. [20]	1988	7.4
Wilkins et al. [21	1993	6.7
Fowles et al. [18]	1974	6.5
Nikhil et al. [15]	2019	6.52
Rahat et al. [17]	2019	7.036
Surendra et al. [22]	2021	6.7
Present study	2022	7.12

Table 16: Comparison of fracture type

Series	Year	Extension type	Flexion type
Nikhil et al [15]	2019	100%	0
Fowles et al [18]	1974	158 (90.29%)	17 (9.71%)

Pirone et al [20]	1988	321 (98.77%)	4 (1.23%)
Davis et al [23]	2000	86 (98.9%)	1 (1.1%)
Saad et al [24]	2000	50 (100%)	0 (-)
Present study	2022	48 (96%)	2 (4%)

Table 17: Average hospital stay

Study	Year	Average hospital stay (days)
Nacht et al [25]	1983	4.2
Aronson & Prager [26]	1987	3.45
Present study	2022	4.04

Table 18: Fracture type

Type	Displacement	No. of cases	Percentage
Extension type 3	Posteromedial	24	48%
Extension type 3	Posterolateral	12	24%
Extension type 2	No displacemt-Intact posterior hinge	12	24%
Flexion	Anterior	2	4%

Table 19: Comparison of displacement types

Series	Year	Posteromedial	Posterolateral
Aronson & Prager [26]	1987	15 (75%)	5 (25%)
Pirone et al [20]	1988	94 (81%)	22 (19%)
Wilkins et al [21]	1993	75%	25%
Saad et al [24]	2000	45 (90%)	5 (10%)
Present study	2022	26 (48%)	12 (24%)

Table 20: Pre-operative complications

Complication	No. of cases	Percentage
Severe oedema	15	30%
Nerve injury	0	0%
Puncture wound	6	12%

Table 21: Comparison of pre-operative complications

Series	Complete median palsy	Radial palsy	Ulnar palsy	Anterior interosseous (branch) palsy
Bhans et al [27]	0%	4.5%	0%	0%
Fowel's J et al [18]	2.7%	2.7%	0%	0%
Present study	0%	0%	0%	0%

Table 22: Number of K-wires used in each case

K-wires	No. of cases	Percentage of cases
2 K-wires	28	56%
3 K-wires	22	44%

Table 23: Volkmann's ischemic contracture

Series	Percentage
Ottoleghni CE [28]	<1%
Krishna Kumar [3]	0%
Present study	0%

Table 24: Myositis ossificans

Series	Percentage
Fowels' J et al [18]	0%
Krishna Kumar [3]	0%
Present study	0%

Table 25: Pin track infection

Series	Percentage
Fowels J et al [18]	2.7%
Krishna Kumar [3]	1%
Our study	14%

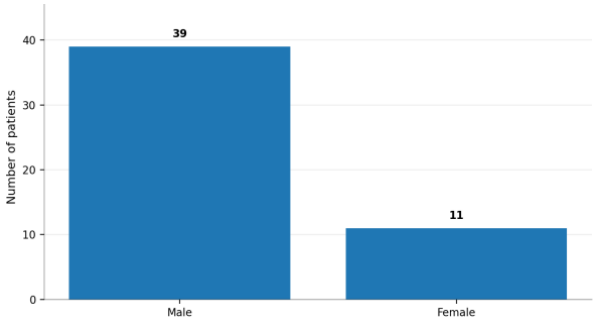

Figure 01: Sex Distribution

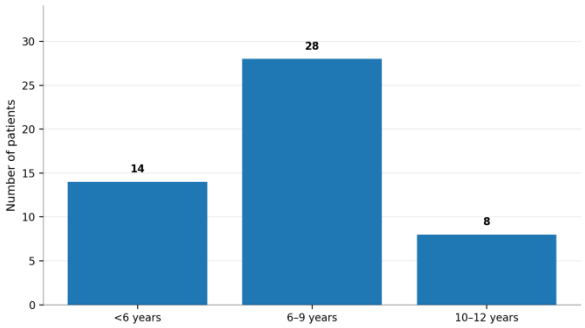

Figure 02: Age Distribution

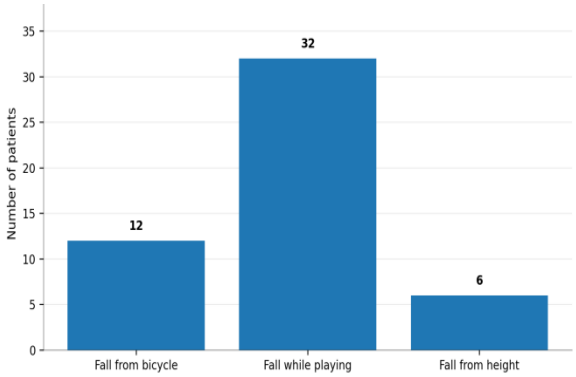

Figure 03: Mode of Injury

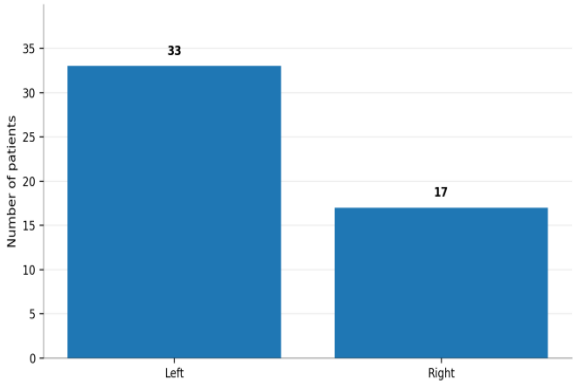

Figure 04: Sex Laterality of Fracture

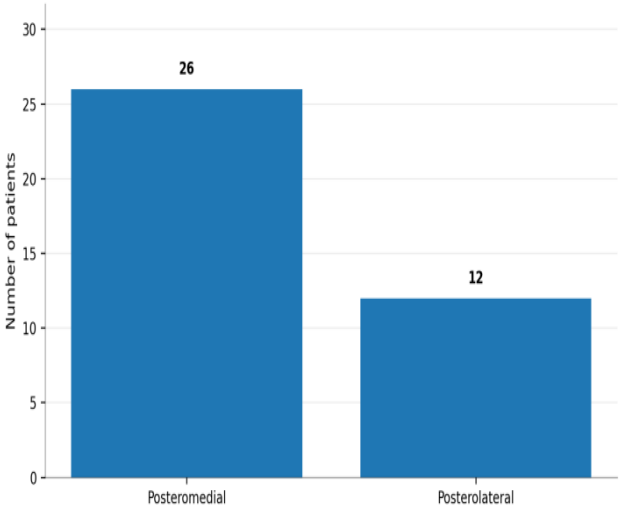

Figure 05: Type-III Displacement Pattern

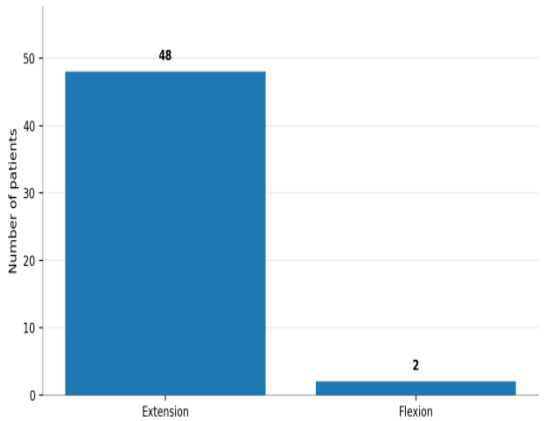

Figure 06: Fracture Type

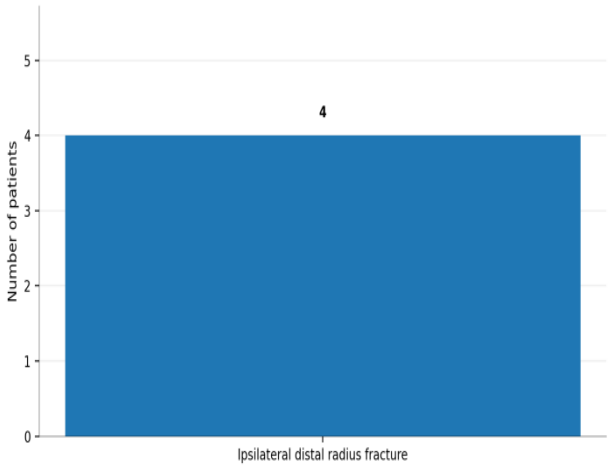

Figure 07: Associated Injuries

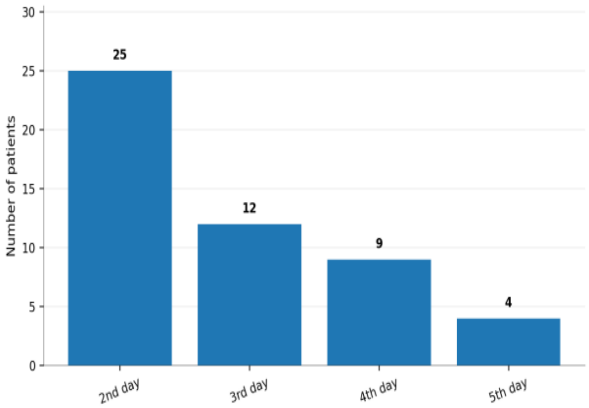

Figure 08: Time to Surgery

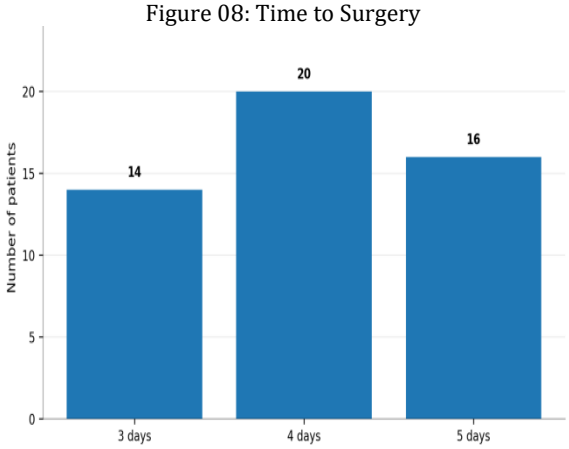

Figure 09: Hospital Stay

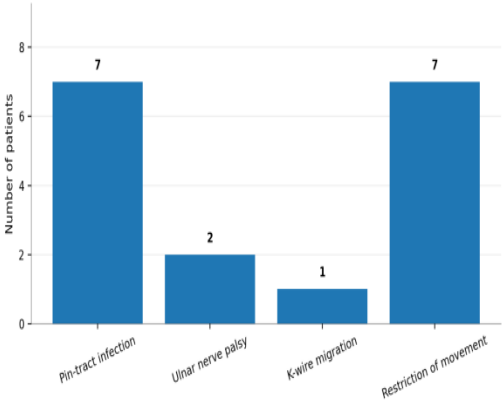

Figure 10: Prospective Complications

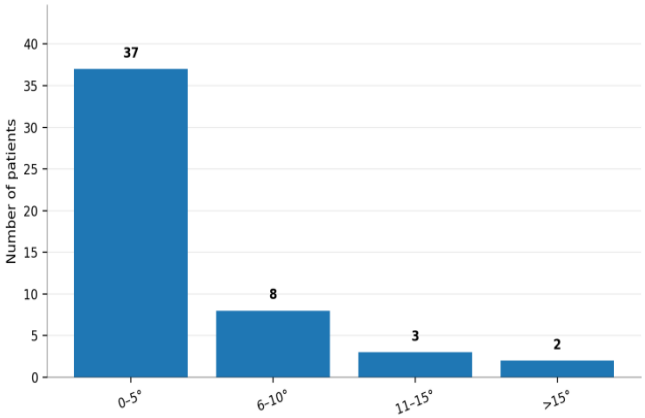

Figure 11: Loss of Range of Motion

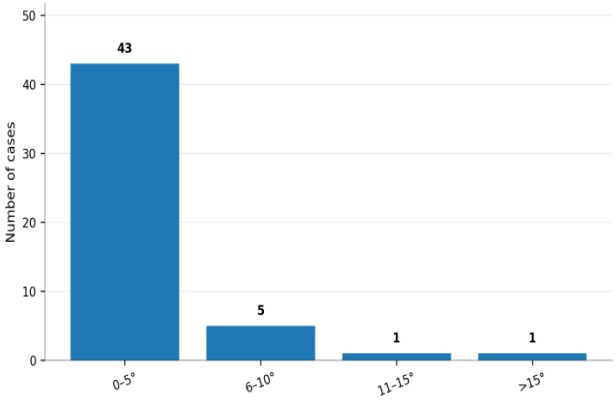

Figure 12: Loss of carrying angle

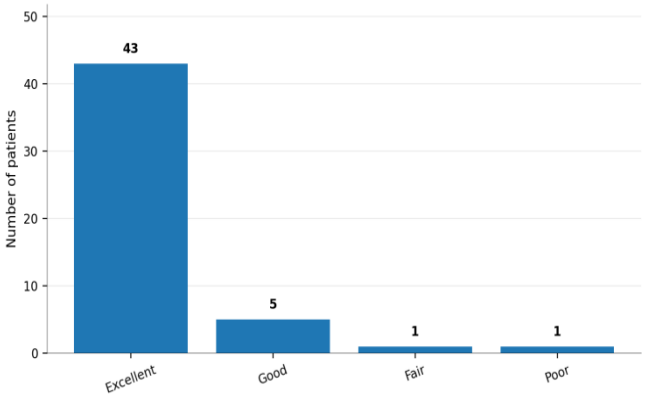

Figure 13: Functional Outcome (Flynn)

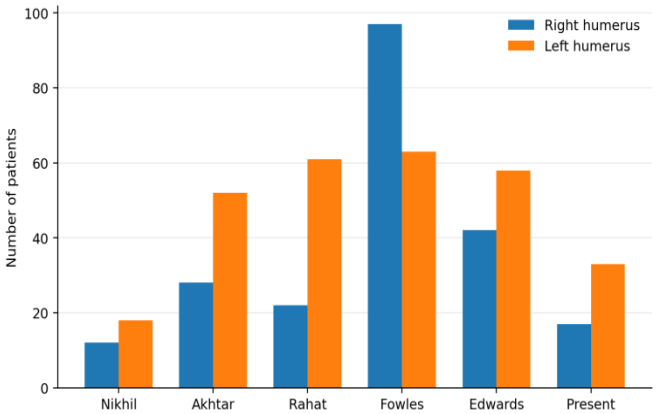

Figure 14: Side Incidence across comparative series

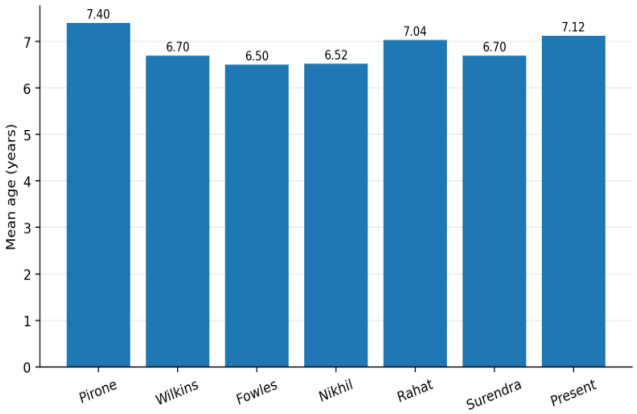

Figure 15: Mean age across comparative series

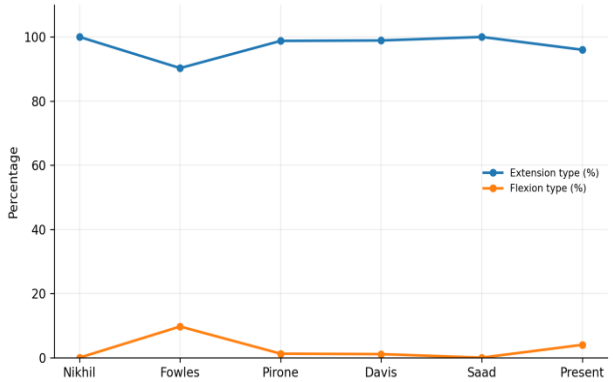

Figure 16: Comparison of fracture type

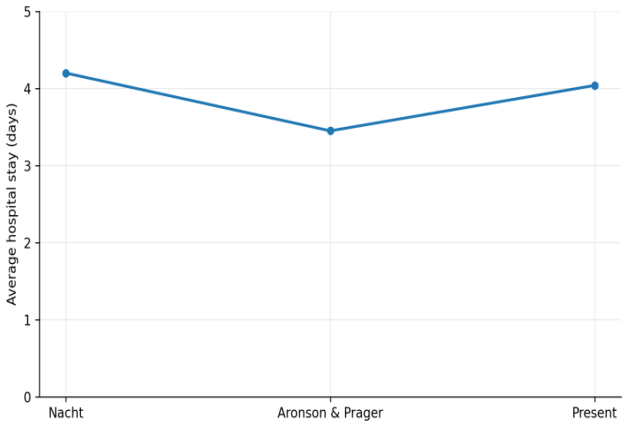

Figure 17: Average hospital stay

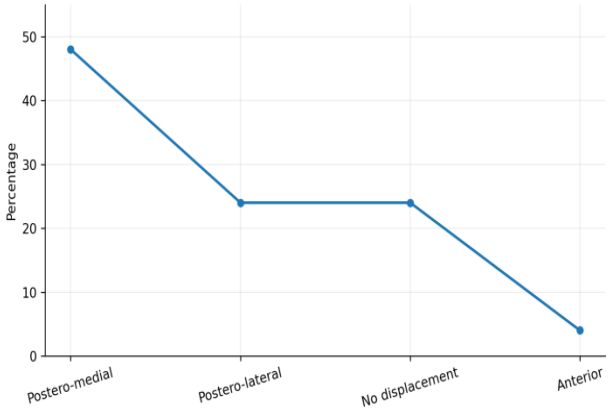

Figure 18: Fracture type and Displacement

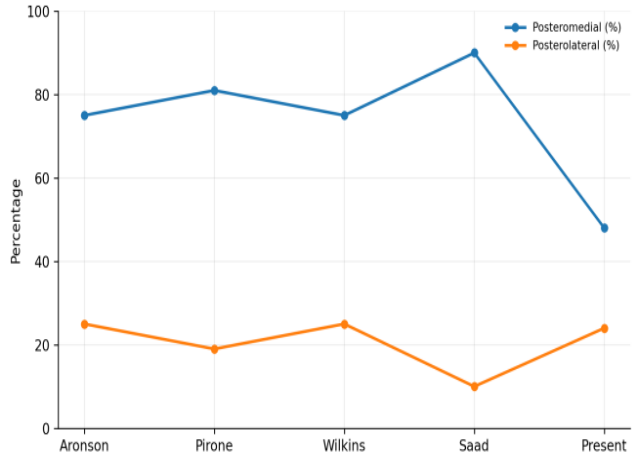

Figure 19: Comparison of displacement type

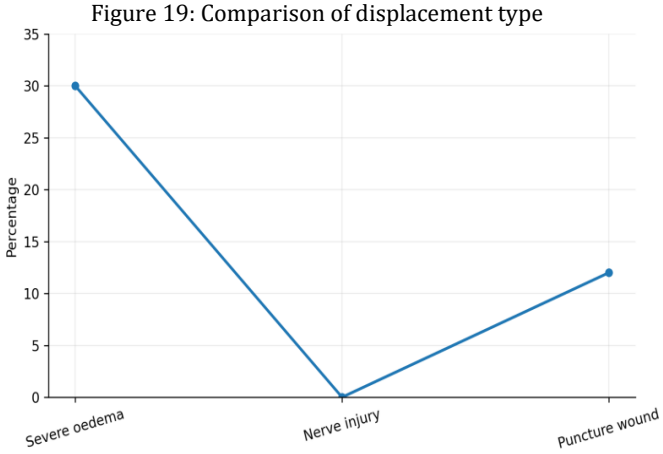

Table 20: Pre-operative complications

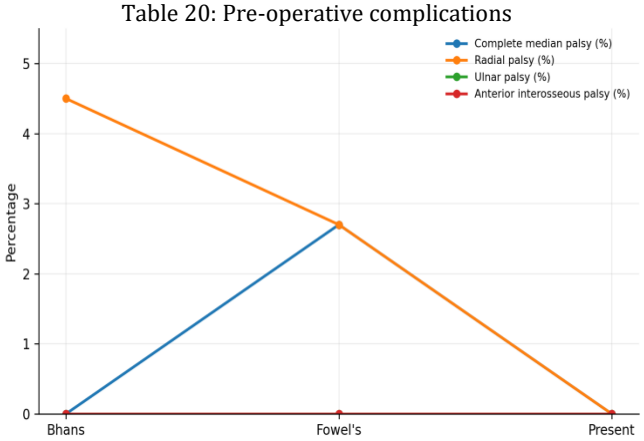

Table 21: Comparison of Pre-operative complications

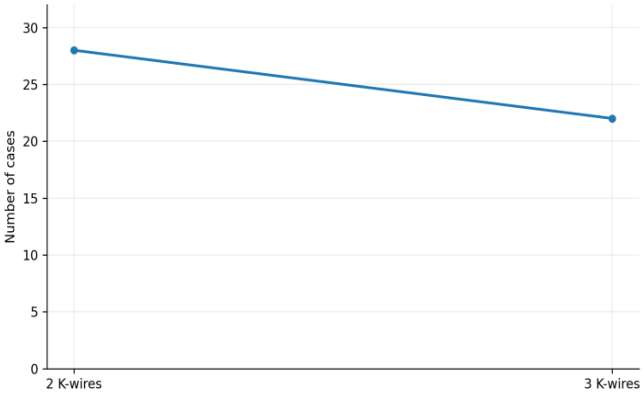

Table 22: Number of K-wires used

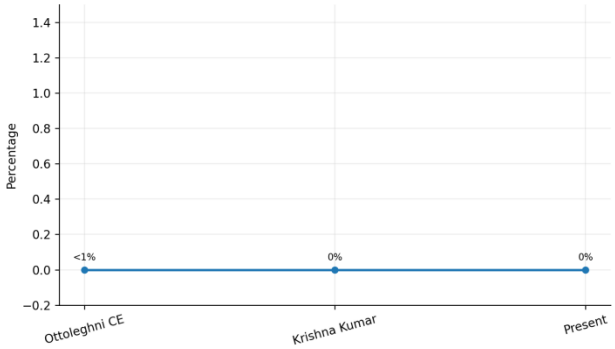

Table 23: Number of K-wires used

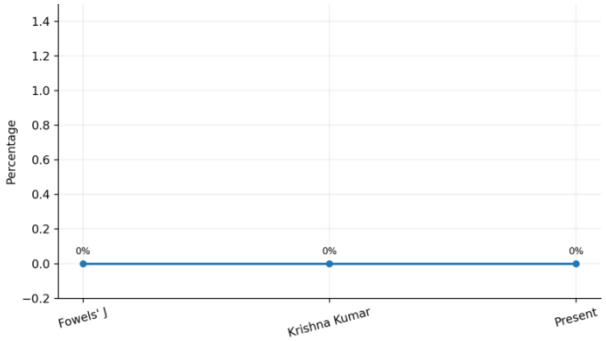

Table 24: Myositis ossificans

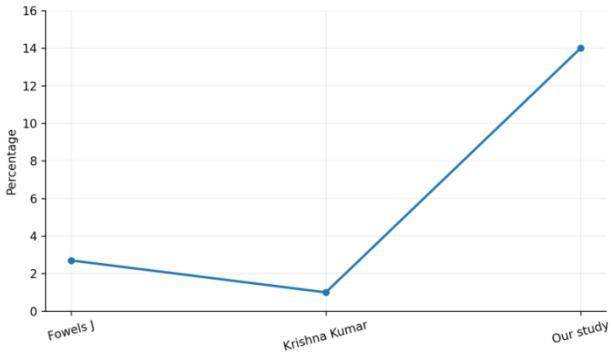

Table 25: Pin Track infection

DISCUSSION

Displaced supracondylar fracture of humerus in children when accompanied by marked swelling, presents a formidable challenge. Some displaced fractures are stable after reduction and may be managed by satisfactorily after closed reduction by collar and cuff or by plaster slab immobilization. However, many of these fractures are unstable after reduction except in acutely flexed position. If considerable swelling is present this acutely flexed position may compromise circulation and predisposes to Volkmann's ischemic contractures. Immobilization in safer right angle position will frequently allow the fragment to slip producing varus deformity. Mac Laughlin called this "The Supracondylar fracture is a dilemma". Displaced supracondylar fractures are managed with various methods; closed reduction with plaster, traction, closed reduction and percutaneous pinning, open reduction and k wire fixation, lateral divergent pins or crossed pins. Management of displaced supracondylar fracture of humerus in children may present problems in management including limb threatening Volkmann's ischemia, neurovascular complications and deformity. It demands considerable skill and experience. Complications can occur due to injury itself or may

follow treatment. It is essential to minimize additional trauma to already traumatized joint and periarticular tissues. As the collected hematoma may organize into post-traumatic calcification thus leading to myositis ossificans, it needs to be evacuated from the joint by open reduction and internal fixation, having advantage over the percutaneous closed pinning. But, the main complication of ORIF are infection and stiffness of elbow can be prevented by strict aseptic precautions during pre-op and post-op period. Supracondylar fracture should be reduced accurately and stabilized. Acceptance of poor reduction in a displaced position leads to imperfect results like limited movement of elbow joint like limited extension, varus & valgus deformities. So perfect anatomic reduction is key factor in management of displaced supracondylar fracture of humerus. In this series our aim was to avoidance of complications and achievement of excellent functional and cosmetic results, which should be goal in the treatment of all fractures. After reviewing the advantages of closed reduction and internal fixation by cross k-wire fixation over other types of management of displaced supracondylar fractures of humerus, it can be considered as one of the choices of treatment for these fractures

Overall, the study demonstrated predominantly satisfactory functional outcomes following operative fixation of paediatric supracondylar humeral fractures, with most patients achieving excellent functional results and minimal loss of elbow range of motion and carrying angle. The principal postoperative complications were superficial pin-tract infection and temporary restriction of movements, while no cases of traumatic median nerve palsy or cubitus varus were reported.The present series demonstrated a predominance of extension-type fractures (96%), with posteromedial displacement being the most frequently documented displacement pattern (48%). The mean hospital stay was 4.04 days. Severe pre-operative oedema was observed in 30% of patients, while no pre-operative neurological deficit was documented in the present series. Two K-wires were used in the majority of patients (56%). No cases of Volkmann's ischemic contracture or myositis ossificans were observed, whereas pin-track infection occurred in 14% of patients.

CONCLUSION

Cross pinning technique is theoretically more stable biomechanical construct, but it adds to the risk of ulnar nerve injury. The risk of ulnar nerve palsy in cross k wire fixation can be reduced by preventing hyperflexion and retracting the nerve carefully during insertion of medial wire. Rigid fixation is achieved by cross k-wire fixation put through medial epicondyle and lateral epicondyle. The method is simple, safe and effective. The period of hospital stay is short, which makes this method very economical. With this technique, consistently satisfactory results can be obtained both cosmetically and functionally. By this method, we have achieved early stabilization of the elbow with good range of elbow movement and fewer complications. Hence the cross k-wire fixation remains fixation of choice for supracondylar fracture of humerus in children.

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INFORM CONSENT AND ETHICAL STATEMENT

Not Declared

AUTHOR CONTRIBUTION

All authors are contributed equally.

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CONFLICT OF INTREST

Authors are declared that no conflict of interest

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