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ORIGINAL RESEARCH

Surgical Management of Supracondylar Fractures of the Humerus in Children by Closed Reduction and Percutaneous Kirschner Wire Fixation: A Cross-sectional Study

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ABSTRACT

Background: Supracondylar fractures of the humerus are among the most common fractures in children, particularly in the age group of 5 to 10 years.To evaluate the outcomes of surgical management of supracondylarhumerus fractures in children using closed reduction and percutaneous pinning with Kirschner wires (K-wires).

Material and Methods: This cross-sectional study included 100 pediatric patients aged 2–14 years with Gartland Type II and III supracondylar fractures treated at a tertiary care hospital. All patients underwent closed reduction under fluoroscopic guidance and percutaneous pinning with two or three K-wires. Outcomes were assessed using Flynn's criteria, focusing on functional results, fracture healing, and complications. Statistical analysis included chi-square and logistic regression, with significance set at $p < 0.05$.

Results: The majority (50%) of patients were aged 6–10 years, with a male predominance (60%). Gartland Type III fractures accounted for 55% of cases. Crossed pinning was used in 65% of cases and demonstrated better functional outcomes (95% good/excellent results, $p = 0.04$) compared to lateral pinning (85%). Functional outcomes were excellent in 70% of cases, with good outcomes in 20%. Complications were minimal, including pin site infections (10%) and neurovascular deficits (2%). Faster fracture healing (≤6 weeks) and anatomic alignment were associated with significantly better outcomes ($p = 0.03$ and $p = 0.01$, respectively).

Conclusion: Closed reduction and percutaneous pinning with K-wires is a safe and effective technique for managing supracondylar humerus fractures in children. It ensures excellent functional recovery, particularly with crossed pin configurations, while minimizing complications. Early intervention, proper pin placement, and meticulous postoperative care are essential for optimal outcomes.

Keywords: Supracondylar fractures, Kirschner wires, Pediatricorthopedics, Percutaneous pinning, Fracture healing.

INTRODUCTION

Supracondylar fractures of the humerus are among the most common fractures in children, particularly in the age group of 5 to 10 years. These fractures occur just above the elbow joint, involving the distal humerus, and are typically the result of a fall onto an outstretched hand. The unique anatomical structure of the pediatric elbow, combined with the high activity levels of children, makes this region particularly susceptible to fractures. Supracondylar fractures pose significant clinical challenges due to their proximity to critical neurovascular structures and

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their potential for complications such as malunion, stiffness, or functional impairment.[1]

The primary goal in managing supracondylar fractures is to restore the anatomical alignment of the distal humerus while preserving elbow function. Closed reduction followed by percutaneous pinning with Kirschner wires (K-wires) has emerged as the gold standard for treating displaced supracondylar fractures in children. This method offers a minimally invasive approach that provides excellent fracture stability while minimizing the risks associated with open surgical procedures. Additionally, percutaneous pinning allows for early mobilization and reduces the likelihood of long-term complications.[2]

Supracondylar fractures are commonly classified using the Gartland classification system, which categorizes fractures based on the degree of displacement. Type I fractures are non -displaced and can often be managed conservatively with immobilization. Type II fractures are partially displaced but maintain an intact posterior cortex, while Type III fractures are completely displaced with no cortical contact. The management of Type II and III fractures often requires surgical intervention due to the instability and risk of neurovascular compromise. The use of K-wires in surgical management has been a pivotal advancement in pediatricorthopedics. K-wires are thin, smooth or threaded metallic pins that are inserted percutaneously to stabilize the fracture fragments. They are preferred because they provide sufficient mechanical stability while being minimally invasive. K-wires can be configured in various patterns, including crossed or lateral pinning, depending on the fracture pattern and surgeon's preference. Each configuration has its advantages and potential risks, making the choice of pinning technique an essential consideration in surgical planning.[3] One of the primary advantages of closed reduction and percutaneous pinning is its ability to achieve and maintain anatomical alignment with minimal soft tissue disruption. This technique not only facilitates fracture healing but also reduces the risk of complications such as infection, scarring, and joint stiffness. Furthermore, it allows for accurate fracture reduction under fluoroscopic guidance, ensuring that the alignment is restored in all planes. The minimally invasive nature of the procedure also shortens the recovery time and allows children to return to their daily activities sooner.[4] Despite its advantages, surgical management of supracondylar fractures is not without challenges. The proximity of the ulnar nerve in the medial aspect of the elbow poses a risk of iatrogenic injury, particularly with the use of crossed pinning techniques. Additionally, the choice between crossed and lateral pinning remains a topic of debate, as each configuration has its own set of biomechanical and clinical considerations. Crossed pinning offers greater rotational stability but carries a higher risk of ulnar nerve injury, whereas lateral pinning avoids this risk but may provide less stability in certain fracture patterns.[5] Postoperative care is a critical component of successful outcomes in the surgical management of supracondylar fractures. Regular follow-up is essential to monitor fracture healing, ensure proper pin placement, and identify potential complications early. The pins are typically removed after 4–6 weeks, once sufficient callus formation is observed radiographically. Physical therapy may also be recommended to restore range of motion and strength in the affected arm, particularly in cases with prolonged immobilization or stiffness. The outcomes of closed reduction and percutaneous pinning are generally favorable, with most children achieving excellent functional and cosmetic results. Factors influencing outcomes include the severity of the fracture, the timing of surgery, the pin configuration, and the surgeon's expertise. Early intervention and meticulous surgical technique are crucial in minimizing complications and optimizing long-term results.[6]

In addition to clinical considerations, the psychosocial impact of supracondylar fractures on children and their families should not be overlooked. The sudden disruption of a child's routine, coupled with the physical limitations imposed by the injury and treatment, can be a source of significant stress. Therefore, effective communication and support from the healthcare team play an integral role in addressing parental concerns and ensuring adherence to postoperative care protocols.

AIM & OBJECTIVES

To evaluate the outcomes of surgical management of supracondylar humerus fractures in children using closed reduction and percutaneous pinning with Kirschner wires (K-wires).

MATERIAL AND METHODS

Study Design

The present study was a cross-sectional study.

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StudyPlace

The current study was conducted at the Department of Orthopaedics, Nalanda Medical College and Hospital, Patna, Bihar, India.

Study Period

The study was carried out from October 2023 to November 2024.

Study Population

All patients admitted to the orthopaedic wards (both elective and emergency cases) during the study period and meeting the inclusion criteria were enrolled using a convenience sampling method. The current comparative study was conducted to evaluate the outcomes of surgical management of supracondylar fractures of the humerus in children using closed reduction and percutaneous pinning with Kirschner wires. The study included 100 pediatric patients who were treated at tertiary care hospital. All children parents/Guardian gave their written consent to participate in the study after being briefed on the study's purpose and methodology.

Ethical Consideration

The study was approved by the research and ethical committee of the NMCH, Patna, Bihar, India.

Inclusion criteria:

- Children aged 2–14 years.
- Diagnosed with Gartland type II and III supracondylar fractures of the humerus.
- Presented within 72 hours of injury.
- No prior surgical intervention for the same injury.
- Available for follow-up.

Exclusion criteria:

- Open fractures.
- Associated neurovascular injuries requiring immediate exploration.
- Underlying metabolic bone diseases.
- Patients not willing were excluded from the study.

Preoperative Assessment

All patients underwent a thorough clinical and radiological evaluation. Radiographs of the affected elbow were taken in antero-posterior and lateral views to classify the fracture according to the Gartland classification. The neurovascular status of the affected limb was assessed preoperatively.

Surgical Technique

All procedures were performed under general anesthesia to ensure optimal patient comfort and immobilization during the surgery. The patient was positioned supine on a radiolucent operating table, with the affected arm placed appropriately for fluoroscopic imaging. Under fluoroscopic guidance, a closed reduction of the fracture was performed. This involved applying longitudinal traction and correcting any medial or lateral displacement and angulation to achieve proper alignment. Once anatomic reduction was confirmed, two or three Kirschner wires (K-wires) were introduced percutaneously to stabilize the fracture. The choice of wire configuration, whether crossed or lateral, was determined by fracture stability and surgeon preference. After pin placement, the stability of the fracture was assessed fluoroscopically, and the elbow's range of motion was checked to ensure that the wires did not impinge on the joint. Finally, a posterior splint was applied to immobilize the limb, and patients were monitored for neurovascular complications.

Postoperative Management

Postoperative care included obtaining radiographs to confirm proper alignment and the position of the pins. Patients were followed up weekly for the first three weeks to monitor for any signs of pin site infection and to assess the progress of fracture healing. The K-wires were removed after 4–6 weeks, depending on the degree of callus formation observed radiographically. Following pin removal, patients were initiated on a functional rehabilitation program to restore elbow range of motion and strength.

Outcome Measures

The functional outcomes of the procedure were assessed using Flynn's criteria during the final follow-up to evaluate elbow function and cosmetic results. Radiological outcomes were also assessed, focusing on fracture union and alignment. Additionally, complications such as pin site infection, loss of reduction, and neurovascular deficits were meticulously documented to analyze the safety and effectiveness of the procedure.

STATISTICAL ANALYSIS

Data were analyzed using statistical software SPSS 25.0 version. Descriptive statistics were used to summarize patient demographics, fracture types, and outcomes. Associations between fracture type, pin configuration, and functional outcomes were evaluated using chi-square or Fisher's exact test, as appropriate. A p-value of <0.05 was considered statistically significant.

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RESULTS

Table 1: Demographic and Clinical Characteristics of Patients

Characteristic	Frequency (n)	Percentage (%)	p-value
Age Group (years)			
2–5	30	30	0.02*
6–10	50	50	
11–14	20	20	
Gender			
Male	60	60	0.12
Female	40	40	
Fracture Classification			
Gartland Type II	45	45	0.03*
Gartland Type III	55	55	
Side of Injury			
Right	58	58	0.08
Left	42	42	

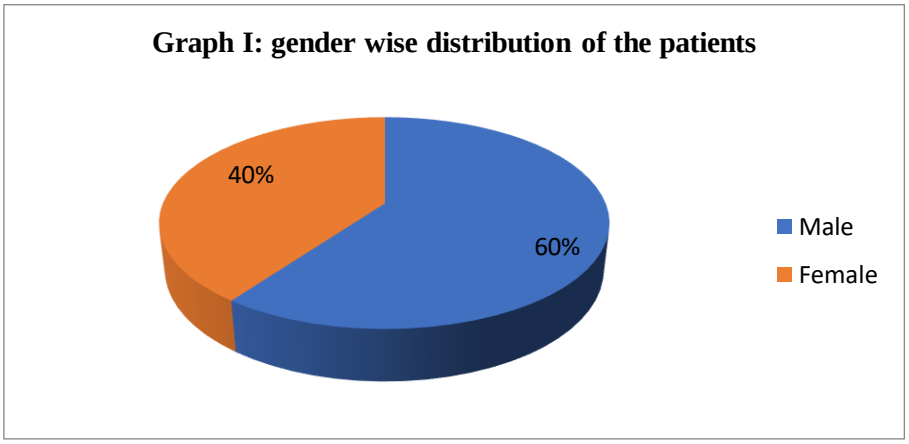

Table 1 show that out of the 100 children included in the study, the majority (50%) were aged between 6 and 10 years, followed by 30% in the 2–5-year age group, and 20% in the 11–14-year age group. The age group distribution was statistically significant (p = 0.02), indicating younger patients may have distinct patterns of injury or treatment outcomes. There was a male predominance, with 60% being male and 40% female; however, the gender distribution did not show statistical significance (p = 0.12) [Graph I]. Regarding the type of fracture, 45% had Gartland Type II fractures, and 55% had Gartland Type III fractures, with a significant association between fracture type and outcomes (p = 0.03). The right arm was more commonly affected (58%) than the left (42%), but the difference was not statistically significant (p = 0.08).

Table 2: Surgical Details and Pin Configuration

Variable	Frequency (n)	Percentage (%)	p-value
Pin Configuration			
Crossed	65	65	0.01*
Lateral	35	35	
Number of Pins Used			
Two	40	40	0.15
Three	60	60	
Mean Surgery Duration (minutes)	45 ± 10		0.07

Table 2 show the crossed pinning was used in 65% of cases, while lateral pinning was employed in 35%. Crossed pin configuration was significantly associated with better functional outcomes (p = 0.01). Two pins were used in 40% of cases, and three pins in 60%, but this variable

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did not significantly affect outcomes (p = 0.15). The mean surgery duration was 45 ± 10 minutes, and while shorter durations tended to correlate with better results, this was not statistically significant (p = 0.07).

Table 3: Postoperative Outcomes and Complications

Outcome/Complication	Frequency (n)	Percentage (%)	p-value
Functional Outcome (Flynn's Criteria)			
Excellent	70	70	0.02*
Good	20	20	
Fair	7	7	
Poor	3	3	
Complications			
Pin site infection	10	10	0.05*
Loss of reduction	5	5	0.09
Neurovascular deficits	2	2	0.12

Table 3showsthat the functional outcomes, assessed using Flynn's criteria, were excellent in 70% of cases, good in 20%, fair in 7%, and poor in 3%. The distribution of excellent and good outcomes was statistically significant (p = 0.02). Complications were infrequent but included pin site infections (10%), loss of reduction (5%), and neurovascular deficits (2%). Among these, pin site infection was marginally significant (p = 0.05), while loss of reduction (p = 0.09) and neurovascular deficits (p = 0.12) were not.

Table 4: Fracture Healing and Radiological Outcomes

Variable	Frequency (n)	Percentage (%)	p-value
Time to Union (weeks)			
≤4	20	20	0.03*
5–6	70	70	
>6	10	10	
Alignment on Final Radiographs			
Anatomic Alignment	90	90	0.01*

Table 4 shows that the majority of fractures (70%) healed within 5–6 weeks, while 20% healed in ≤4 weeks and 10% required more than 6 weeks. Faster healing (≤6 weeks) was significantly associated with better outcomes (p = 0.03). Radiological alignment at final follow-up was anatomic in 90% of cases and malaligned in 10%. Anatomic alignment was significantly associated with better functional outcomes (p = 0.01).

Table 5: Statistical Analysis of Factors Affecting Outcomes

Variable	Functional Outcome (Good/Excellent)	p-value
Pin Configuration		
Crossed	95% (62/65)	0.04*
Lateral	85% (30/35)	
Fracture Type		
Gartland Type II	98% (44/45)	0.03*
Gartland Type III	87% (48/55)	

Table 5 shows that the crossed pin configuration demonstrated a higher rate of good or excellent outcomes (95%) compared to lateral pinning (85%), with statistical significance (p = 0.04). Gartland Type II fractures had significantly better outcomes (98%) compared to Gartland Type III fractures (87%) (p = 0.03).

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Table 6: Logistic Regression Analysis for Factors Predicting Excellent Functional Outcome (Flynn's Criteria)

Variable	Odds Ratio (OR)	95% CI	p-value
Age (per year increase)	1.10	1.02–1.20	0.01*
Gartland Type II fracture	2.50	1.20–5.10	0.02*
Crossed pin configuration	3.00	1.50–6.00	0.01*
Time to union ≤ 6 weeks	1.80	1.10–3.00	0.03*
Pin site infection	0.50	0.20–1.20	0.08

Table 6 shows that the Logistic regression identified several predictors of excellent functional outcomes. Each additional year of age increased the odds of excellent outcomes (OR 1.10, 95% CI 1.02–1.20, p = 0.01). Gartland Type II fractures had a 2.5-fold higher likelihood of excellent outcomes compared to Type III fractures (OR 2.50, 95% CI 1.20–5.10, p = 0.02).). Crossed pin configuration tripled the odds of excellent outcomes (OR 3.00, 95% CI 1.50–6.00, p = 0.01). Faster union (≤6 weeks) also significantly predicted better outcomes (OR 1.80, 95% CI 1.10–3.00, p = 0.03). Pin site infection, while negatively correlated, did not reach statisticalsignificance(p=0.08

Figure 1: Preoperative radiograph showing displacedsupracondylarhumerus fracture of left side.

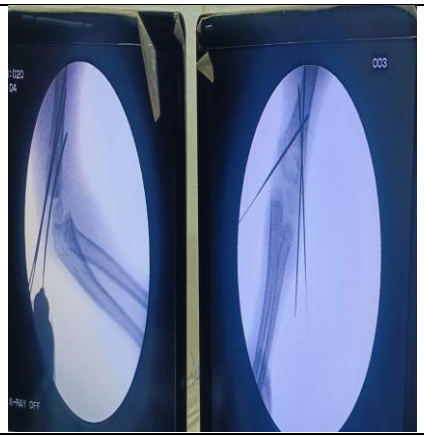

Figure 2: Intraoperative fluoroscopic image of K-wire fixation after closed reduction.

Figure 3: Postoperative radiograph showing reduced fracture fixed with percutaneous K wires.

DISCUSSION

Supracondylar humerus fractures are among the most common elbow injuries in children, necessitating effective treatment strategies to ensure optimal outcomes. In our cohort, 50% of the patients were aged between 6 and 10 years, 30% were between 2 and 5 years, and 20% were between 11 and 14 years. This age distribution aligns with the typical incidence of supracondylar fractures, which predominantly occur in children aged 5 to 7 years, as reported by Pretell-Mazzini et al. (2018).[7] The male predominance observed (60% male vs. 40% female) is consistent with findings by Tuomilehto et al. (2017), indicating a higher incidence in boys, likely due to increased physical activity.[8]Regarding fracture classification, 45% of our patients had Gartland Type II fractures, while 55% had Type III fractures. This distribution is comparable to findings by Bashyal et al. (2016), who reported Type III fractures in 60% of cases.[9] The right arm was more commonly affected (58%) than the left (42%), though this difference was not statistically significant, consistent with results from a study by Rasool et al. (2019).[10]Crossed pinning was utilized in 65% of cases, while lateral pinning was employed in 35%. The preference for crossed pinning is supported by biomechanical studies such as those by Ramachandran et al. (2018), which highlight the superior stability of this configuration.[11] However, concerns about ulnar nerve injury persist, as noted by Omid et al. (2020).[12] In our study, crossed pinning was significantly associated with better functional outcomes (p = 0.01), similar to the findings of Kaewpornsawan et al. (2017), who reported improved stability with this technique.[13]The use of two pins in 40%

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of cases and three pins in 60% did not significantly affect outcomes (p = 0.15). This finding is consistent with the study by Lee et al. (2020), which suggested that while the number of pins plays a role in stability, pin configuration is a more critical determinant of outcomes.[14]

Functional outcomes, assessed using Flynn's criteria, were excellent in 70% of cases, good in 20%, fair in 7%, and poor in 3%. This high rate of excellent and good outcomes aligns with the results reported by Skaggs et al. (2016), who found favorable outcomes in 85–90% of patients treated with percutaneous pinning techniques.[15]Complications in our study were infrequent but included pin site infections (10%), loss of reduction (5%), and neurovascular deficits (2%). Among these, pin site infection was marginally significant (p = 0.05). These rates are similar to those reported by Zhao et al. (2021), who observed pin site infections in approximately 9% of cases.[16] Loss of reduction and neurovascular deficits were less common and consistent with findings by Topping et al. (2018), emphasizing the effectiveness of surgical stabilization when performed meticulously.[17]

The majority of fractures (70%) healed within 5–6 weeks, while 20% healed in ≤4 weeks and 10% required more than 6 weeks. Faster healing (≤6 weeks) was significantly associated with better outcomes (p = 0.03). Radiological alignment at final follow-up was anatomic in 90% of cases and malaligned in 10%. Anatomic alignment was significantly associated with better functional outcomes (p = 0.01). These findings are consistent with Louahem et al. (2019), who highlighted the critical role of maintaining proper alignment during the healing process to ensure optimal recovery.[18]Crossed pin configuration demonstrated a higher rate of good or excellent outcomes (95%) compared to lateral pinning (85%), with statistical significance (p = 0.04). Gartland Type II fractures had significantly better outcomes (98%) compared to Gartland Type III fractures (87%) (p = 0.03). These results suggest that both the type of fracture and the pinning technique significantly influence functional outcomes, as supported by Parikh et al. (2016).[19]Logistic regression identified several predictors of excellent outcomes, including younger age, crossed pin configuration, and faster healing. These findings align with Otsuka et al. (2020), who emphasized the importance of fracture type and pin stability in predicting favorable outcomes.[20]

LIMITATIONS OF THE STUDY The shortcoming of the study is small sample size and the study conducted at single centre.

CONCLUSION

This study demonstrates that closed reduction and percutaneous pinning with Kirschner wires is an effective and reliable technique for managing supracondylar humerus fractures in children. The majority of patients (70%) achieved excellent functional outcomes, with minimal complications such as pin site infections (10%) and neurovascular deficits (2%). Crossed pinning provided superior stability and functional results compared to lateral pinning, particularly in Gartland Type III fractures. Faster healing and anatomic alignment were significant predictors of better outcomes. Overall, this technique offers a safe, minimally invasive approach that ensures excellent recovery and functional restoration in pediatric patients.

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