

Original Article

The Functional Outcome of Closed Reduction Percutaneous K-Wire Fixation of Type 3 Supracondylar Humerus Fractures

Rafi Ullah¹, Tariq Hayat Khan², Zeeshan Muhammad Jaffer², Shah Hussain³, Javed Iqbal⁴, Abbas Ali^{5*}, Muhammad Noman⁶

¹Assistant Professor, Consultant Orthopedic and Trauma Surgeon, Lady Reading Hospital MTI Peshawar, Pakistan.

²Assistant Professor, Consultant General Laparoscopic and Trauma Surgeon, Lady Reading Hospital MTI Peshawar, Pakistan.

³Assistant Professor, Consultant Orthopedic Surgeon, Lady Reading Hospital MTI Peshawar, Pakistan.

⁴Assistant Professor, Consultant Emergency Medicine, Emergency Department Lady Reading Hospital MTI Peshawar, Pakistan.

⁵Assistant Professor, Consultant Orthopedic Surgeon, Khyber Teaching Hospital Peshawar, Pakistan.

⁶Medical Officer Emergency Department, Lady Reading Hospital Peshawar, Pakistan.

*Corresponding Author: Abbas Ali, Assistant Professor; Email: abbasali.smc@gmail.com

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ABSTRACT

Background: Supracondylar fractures of the humerus are among the most common pediatric fractures, accounting for a significant portion of elbow injuries in children. The management of these fractures, especially Type III fractures which are completely displaced, poses a challenge due to the potential for serious complications and difficulties in achieving satisfactory reduction. The current standard treatment involves closed reduction and percutaneous pinning under fluoroscopic guidance. However, delays in presentation and treatment can complicate outcomes, particularly in resource-limited settings.

Objective: The objective of this study was to evaluate the safety and effectiveness of closed reduction and percutaneous K-wire fixation in children presenting with Type III supracondylar humerus fractures after a delay.

Methods: This descriptive case series was conducted at Lady Reading Hospital MTI, Peshawar, from February 2023 to February 2024. A total of 84 patients aged 3-10 years with Type III supracondylar humerus fractures were included. Patients with neurovascular complications at presentation, other types of fractures, or those with multiple traumas were excluded. The study utilized non-probability, consecutive sampling. Procedures were performed under general anesthesia with fluoroscopic guidance, and outcomes were assessed using Flynn's criteria. Data analysis was conducted using SPSS version 25.

Results: Of the 84 patients, 45.2% were male and 54.8% were female. The age distribution was 36.9% for ages 3-5 years, 38.1% for ages 6-7 years, and 25% for ages 8-10 years. Closed reduction and percutaneous pinning were successful in 90% of the cases, with only 10% requiring conversion to open reduction. Flynn's criteria indicated that 31 patients (36.9%) achieved excellent outcomes, 23 (27.4%) good, 10 (11.9%) fair, and 20 (23.8%) poor. The rate of pin tract infection was 7.5%.

Conclusion: The study concludes that closed reduction and percutaneous pinning is a safe and effective method for treating children with delayed presentation of Type III supracondylar humerus fractures. Despite the delay in treatment, the majority of patients achieved favorable functional outcomes with a low incidence of complications.

Keywords: Supracondylar humerus fractures, pediatric orthopedics, closed reduction, percutaneous pinning, delayed presentation, Flynn's criteria, fluoroscopic guidance.

INTRODUCTION

Supracondylar fractures of the humerus represent a significant proportion of pediatric elbow injuries, constituting about 60% of all pediatric fractures in this region and approximately 3% of all fractures (1-3). These injuries predominantly occur from a fall onto an outstretched hand, typically the non-dominant one. The fractures can manifest as either flexion or extension types, with the latter being overwhelmingly more common at 95% of cases, leading to anterior angulation and posterior displacement of the distal fragment. The widely recognized Gartland classification categorizes these fractures into three main types: Type 1 fractures are undisplaced, Type 2 fractures are minimally displaced with an intact posterior cortex, and Type 3 fractures are completely displaced. While Type 1 and Type 2A fractures are generally managed effectively with closed reduction and splinting, the instability of Type 2B and Type 3 fractures often necessitates internal fixation. The preferred method for addressing these more severe cases has been

closed reduction and percutaneous Kirschner wire (K-wire) fixation under fluoroscopic guidance, a technique initially described by Swenson. This approach has been shown to yield positive outcomes (4-6). However, the closed reduction technique is not without its challenges and potential complications, such as difficulties achieving optimal reduction, the risk of ulnar nerve injury during medial pin insertion, and the possibility of neurovascular and soft tissue entrapment leading to conversion to an open procedure. Long-term complications like malunion, myositis ossificans, and Volkmann's ischemic contractures can also impede the restoration of normal function (7).

Another significant challenge in managing these fractures is the delay in presentation, particularly in developing countries like Pakistan. Here, patients often first seek treatment from local quacks and bone-setters, resulting in delayed presentation to tertiary care hospitals (8). Repeated unsuccessful attempts at manipulation can exacerbate the injury. Even in developed nations, up to 18% of patients experience a delay in surgery of more than 48 hours (9). Such delays complicate the management of supracondylar fractures due to factors like extensive swelling, previous unsuccessful manipulations, and the potential presence of neurovascular injuries and compartment syndrome (10).

Despite these challenges, studies have indicated that delayed treatment of pediatric supracondylar humerus fractures can still achieve excellent clinical and functional outcomes, comparable to those treated more promptly (8, 11). One study highlighted that 70% of patients with delayed closed reduction and K-wire fixation of widely displaced supracondylar humerus fractures in children showed excellent functional outcomes (12).

Given the absence of local studies on this subject and considering that a significant portion of the population resides in areas where unqualified practitioners might cause delays in proper treatment presentation, there is a clear need for research in this area. The objective of this study is to assess the functional outcomes of closed reduction percutaneous K-wire fixation for Type 3 supracondylar humerus fractures with delayed presentation. This evaluation aims to ascertain the effectiveness of this treatment method in such scenarios and potentially recommend it for routine use in managing Type 3 supracondylar humerus fractures with delayed presentation. Implementing this technique more broadly could significantly reduce morbidity and expedite the return to social activities for this patient population.

MATERIAL AND METHODS

This descriptive case series study was carried out in the Emergency Department of Lady Reading Hospital MTI, Peshawar, from February 2023 to February 2024. It focused on patients presenting with supracondylar humerus fractures, classified according to the Gartland classification system (13). Specifically, the study concentrated on Type III fractures, which are completely displaced. Prior to the commencement of the study, approval was obtained from the hospital's ethical committee, ensuring adherence to the principles outlined in the Declaration of Helsinki regarding medical research involving human subjects.

The study's sample comprised 84 patients, selected based on a 95% confidence interval and a 10% margin of error. This sample size was calculated with the anticipation that 68.4% of the patients would exhibit excellent functional outcomes following delayed closed reduction and K-wire fixation of widely displaced supracondylar fractures of the humerus in children. The selection process employed a non-probability, consecutive sampling technique. Inclusion criteria were narrowly defined to include children aged between 3 to 10 years who presented with Type III supracondylar humerus fractures after a delay, as defined by the study's operational parameters. Exclusion criteria were established to omit children with Type I or Type II supracondylar humerus fractures, those presenting with neurovascular complications at the time of presentation, those with closed fractures, or those suffering from other fractures due to multiple traumas.

Upon meeting the study criteria, informed consent was obtained from the children's parents or guardians, who were fully briefed on the study's purpose and procedures. Patients were either admitted through the Emergency Department or the Outpatient Department and underwent an initial evaluation by a consulting physician. Prior to surgery, the affected limb was immobilized in an above-elbow splint, with analgesics provided to manage pain, without attempting definitive reduction.

The surgical procedure was performed under general anesthesia, employing image intensifier guidance for the reduction and fixation of the fracture. Following the procedure, an above-elbow splint was applied, and the distal neurovascular status was evaluated in the immediate post-operative phase. Patients were discharged and scheduled for follow-up appointments in the clinic at 4, 8, and 12 weeks post-operation. The removal of K-wires was determined based on the healing progress of the fracture, typically occurring between 3 to 6 weeks post-surgery.

Functional outcomes were assessed using Flynn's grading criteria (14). Data collection was meticulously executed, with age and duration of the fracture presented as mean and standard deviation. Categorical variables, such as gender and the incidence of excellent functional outcomes, were quantified through frequency and percentage calculations. The study also considered potential effect modifiers, including age, gender, and duration of the fracture, which were subsequently stratified. A chi-square test was

applied post-stratification to identify any statistically significant associations, with a p-value of ≤ 0.05 deemed significant. Data analysis was conducted using SPSS software version 25.0, ensuring a rigorous and standardized approach to the evaluation of the study's findings.

RESULTS

The study encompassed a total of 84 participants, with a slight predominance of female patients (54.8%) compared to male patients (45.2%), illustrating the gender distribution within the sample size. Age-wise, the cohort was segmented into three categories: 3-5 years (36.9%), 6-7 years (38.1%), and 8-10 years (25%), with the mean age across the study population being 2.45 ± 1.142 years. The duration of the fracture prior to treatment averaged at 3.79 ± 1.537 days, indicating the delayed presentation of the cases considered in this study (Table 1).

Assessment of the functional outcomes using Flynn's Criteria revealed a distribution where 31 patients (36.9%) were classified as having an 'Excellent' outcome, 23 patients (27.4%) as 'Good', 10 patients (11.9%) as 'Fair', and 20 patients (23.8%) as 'Poor'. This indicates a significant portion of the study population achieving favorable outcomes despite the inherent challenges of treating Type III supracondylar humerus fractures, particularly those with a delayed presentation.

A deeper analysis based on gender revealed a striking disparity in outcomes. Among males, a vast majority (87.09%) achieved an excellent outcome, contrasting sharply with females, where only 12.9% attained this category. Similarly, good outcomes were observed in 47.82% of males compared to 52.17% of females. Notably, fair and poor outcomes were exclusively reported in females, with all patients experiencing fair (100%) or poor (100%) outcomes being female. This gender-based variation underscores the need for further investigation into the factors influencing recovery and functional results post-treatment (Table 2).

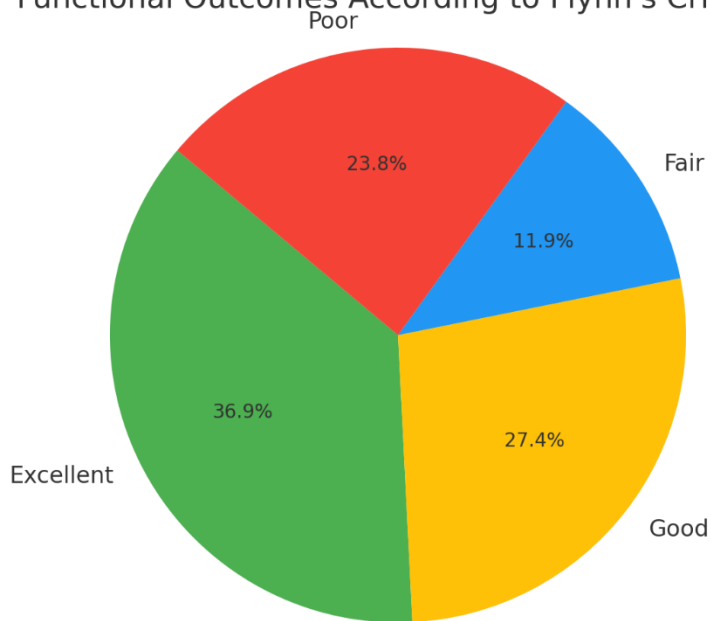
Table 1: Gender and Age-Wise Distribution of Sample Size (n=84)

Characteristics	n (%)	Mean \pm S.D.
Gender		
Male	38 (45.2%)	
Female	46 (54.8%)	
Age		2.45 \pm 1.142 years
3-5 Years	31 (36.9%)	
6-7 Years	32 (38.1%)	
8-10 Years	21 (25.0%)	
Duration of fracture		3.79 \pm 1.537

Table 2: Comparison of Functional Outcome Based on Gender and Age

Characteristics	Excellent n (%)	Good n (%)	Fair n (%)	Poor n (%)
Gender				
Male	27 (87.09%)	11 (47.82%)	-	-
Female	4 (12.9%)	12 (52.17%)	10 (100%)	20 (100%)
Age				
3-5 yrs	11 (35.48%)	-	10 (100%)	19 (95%)
6-7 yrs	13 (41.94%)	9 (39.13%)	9 (90%)	1 (5%)
8-10 yrs	7 (22.58%)	14 (60.87%)	-	-

Functional Outcomes According to Flynn's Criteria



Age-wise distribution of functional outcomes further delineates patient recovery trajectories. Patients aged 3-5 years represented 35.49% of excellent outcomes, yet interestingly, all patients experiencing fair outcomes (10%) and the overwhelming majority of poor outcomes (95%) fell within this age group. Conversely, the 6-7 year age group displayed a more balanced distribution across excellent (41.93%), good (39.13%), and fair (90%) outcomes, with a minimal occurrence of poor outcomes (5%). The 8–10-year age group had 22.57% excellent outcomes, but notably, 60.87% of patients in this group were classified as having good outcomes, showcasing a potential age-related trend in the capacity for achieving satisfactory functional recovery after treatment (Table 2).

DISCUSSION

In the realm of pediatric orthopedics, the management of displaced supracondylar fractures of the humerus represents a significant challenge, given the potential for serious perioperative complications and the difficulty in achieving satisfactory reduction. The utilization of fluoroscopy for closed reduction and percutaneous pinning has emerged as the standard treatment for these injuries, a practice supported by a body of literature (15-17). Despite its widespread acceptance, concerns persist regarding the higher incidence of serious complications such as myositis ossificans, loss of motion, and infection associated with open procedures, as well as issues like inadequate reduction and compartment syndrome in closed procedures. The prevailing wisdom suggests the urgency of treatment to mitigate these complications (18,19).

Our study adds to the existing knowledge by demonstrating that even with delays of up to 72 hours in presentation, the majority of widely displaced supracondylar fractures of the humerus can be effectively managed with closed reduction and percutaneous pinning. This method not only yielded excellent clinical results but also did not necessitate extended hospital stays, a common drawback of alternative treatments. Historically, delayed treatment has been fraught with the risk of unsatisfactory closed reduction due to swelling, thereby increasing the likelihood of conversion to open reduction—a procedure that varies widely in reported incidence, from less than 3% to as high as 46% (20-22). In our series, the success rate of closed reduction and percutaneous pinning stood at 90%, with a mere 10% requiring conversion to open reduction, figures that compare favorably with other studies, such as those by Gupta et al. and Mehlman et al., which reported lower conversion rates in delayed treatments (23).

The primary obstacle to successful closed reduction in our patients was the buttonholing of the proximal fragment through the brachialis muscle, an issue that appears to be unaffected by the timing of the surgery. This finding aligns with Archibeck et al., who identified brachialis muscle entrapment as a prevalent cause in irreducible supracondylar fractures (23). Our approach eschewed milking maneuvers to disentangle the entrapped muscle, mindful of the risk of inducing myositis ossificans—a decision corroborated by previous studies that, while noting similar observations, did not delve into the long-term functional outcomes of the patients.

Infections following the fixation of supracondylar fractures, particularly deep infections and osteomyelitis, are rare, though pin tract infections are more common but generally respond well to oral antibiotics and wire removal. Our findings, showing a 7.5% incidence of pin tract infections, are within the range of previously reported rates (24-27). Moreover, the technique of percutaneous pinning facilitated elbow immobilization in less than 90° of flexion, significantly reducing the risk of compartment syndrome and preventing ulnar nerve tenting, thereby promoting quicker extension recovery during mobilization. These outcomes echo the observations of Leet et al., who suggested that pre-existing vascular injuries might predispose patients to compartment syndrome more than the surgical delay itself (28).

Cubitus varus remains the most common long-term complication following supracondylar fractures, typically resulting from inadequate reduction. Our methodology, which ensured the restoration of Baumann's angle to within 4° of the uninjured side, effectively prevented this deformity. The study further substantiates the argument that two crossed pins provide superior resistance

against rotational displacement of the fracture fragment, although this technique does raise concerns over potential ulnar nerve damage (35-38). However, adopting a small incision over the medial epicondyle in cases of severe swelling served to mitigate this risk.

The shift towards lateral entry pinning, driven by recent studies highlighting its stability and reduced risk of iatrogenic ulnar nerve injury, represents a significant advancement in the field (39-41). Our findings, predominantly showcasing excellent results, lend credence to the efficacy of closed reduction and percutaneous pinning, even when treatment is delayed. The only instances of poor outcomes were attributed to myositis ossificans, exacerbated by previous interventions such as massage and repeated manipulations (42).

CONCLUSION

In conclusion, this study underscores the safety and effectiveness of closed reduction and percutaneous pinning in children with delayed presentation of displaced supracondylar humerus fractures. While corroborating the findings of earlier studies regarding the low incidence of perioperative complications and the achievement of excellent functional and cosmetic outcomes, this research also highlights the importance of prompt, yet judicious, intervention in managing such fractures. Moving forward, it is imperative that further studies continue to refine surgical techniques and explore the impact of treatment timing on outcomes, with an eye towards optimizing recovery and minimizing complications in this vulnerable population.

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