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Functional Outcome of Percutaneous Pining in Gartland Type III Supracondylar Humerus Fractures

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ABSTRACT

Background: Supracondylar fractures of the humerus are the most common pediatric elbow injuries, accounting for nearly two-thirds of cases, with Gartland type III representing the most displaced and unstable form. Traditional management with casting or traction has been associated with high rates of malunion, stiffness, and deformity, whereas surgical fixation using closed reduction and percutaneous pinning has emerged as the preferred technique due to superior stability and functional recovery. However, local data from resource-limited healthcare settings remain sparse, underscoring the need for outcome-based evaluations. **Objective:** To determine the functional outcomes of closed reduction and percutaneous pinning in children with Gartland type III supracondylar humerus fractures. **Methods:** This descriptive case series was conducted at Bolan Medical Complex Hospital, Quetta, Pakistan, from August 2020 to February 2021. Sixty-one children aged 2–12 years with Gartland type III fractures were managed using closed reduction and percutaneous cross-pinning under general anesthesia. Outcomes were assessed prospectively at three months using Flynn's criteria, measuring loss of carrying angle and loss of flexion/extension against the contralateral limb. Data were analyzed using SPSS version 16.0 with descriptive and inferential statistics applied. **Results:** The mean age was 6.9 ± 1.8 years; 80.5% were male, and 70.4% had left-sided fractures. At three months, range of motion outcomes were excellent in 41%, good in 29.5%, fair in 20%, and poor in 9.5%, while cosmetic carrying angle outcomes were excellent in 42.6%, good in 32.7%, fair in 21.3%, and poor in 3.3%. Statistical analysis showed significant improvements in both domains ($p < 0.01$). **Conclusion:** Closed reduction and percutaneous pinning provide effective functional and cosmetic recovery in pediatric Gartland type III supracondylar humerus fractures, supporting its role as the treatment of choice in centers with operative facilities. Longer follow-up and multicenter comparative studies are recommended to further validate safety and long-term outcomes.

Keywords*Closed Reduction, Percutaneous Pinning, Gartland Type III, Supracondylar Humerus Fracture, Pediatric Orthopedics, Functional Outcome*

INTRODUCTION

Supracondylar fractures of the humerus are the most frequent elbow injuries in the pediatric population, accounting for nearly two-thirds of elbow fractures in children (1). Among these, the extension type is overwhelmingly predominant, comprising more than 95% of cases, while flexion-type injuries are relatively rare (2). Gartland's classification provides a widely used framework for guiding management: type I fractures are undisplaced, type II are partially displaced but maintain cortical contact, and type III are completely displaced without cortical continuity (3). Type III fractures are particularly challenging because the periosteum is usually torn, reduction is difficult to maintain, and displacement often occurs posteromedially or posterolaterally, increasing the risk of neurovascular compromise (4).

Historically, management of displaced supracondylar fractures included closed reduction followed by casting or traction, but these approaches were associated with high complication rates such as malunion, neurovascular injury, and cubitus varus deformity (5). Open reduction and internal fixation improved anatomical alignment but often led to postoperative stiffness and scarring (6). In contrast, percutaneous pinning after closed reduction has become the preferred treatment where fluoroscopic facilities are available. This technique provides stable fixation, allows early mobilization, and reduces the risk of redisplacement and deformity (7). A number of institutional reports, including those from South Asia, have shown that closed reduction with percutaneous cross pinning yields excellent to good functional outcomes in the majority of children, with relatively low rates of poor outcomes compared to conservative measures (8,9). Meta-analyses also support its superiority over nonoperative care, with Flynn's criteria commonly used to evaluate both cosmetic and functional results (10).

Despite this evidence, gaps remain in understanding the outcomes of closed reduction and percutaneous pinning in resource-limited settings, where timely access to operating theaters, C-arm facilities, and specialized orthopedic care may affect prognosis. Most existing studies have been

retrospective or conducted in single tertiary centers, limiting generalizability. Moreover, cultural and healthcare delivery differences in Pakistan necessitate local outcome data to guide evidence-based practice and optimize patient care (11).

The present study was conducted to address this gap by prospectively assessing the short-term functional outcomes of closed reduction and percutaneous pinning for Gartland type III supracondylar humerus fractures in children at a tertiary care hospital in Quetta. By applying Flynn's criteria to assess range of motion and carrying angle three months postoperatively, this study aimed to provide locally relevant evidence on treatment effectiveness. The research objective was to determine whether closed reduction and percutaneous pinning can reliably deliver satisfactory functional and cosmetic results in children with completely displaced supracondylar fractures of the humerus.

MATERIAL AND METHODS

This descriptive case series was conducted in the Department of Orthopedic Surgery at Bolan Medical Complex Hospital, Quetta, Pakistan, over a six-month period from August 23, 2020, to February 22, 2021. The rationale for adopting this design was to systematically document outcomes in a defined cohort of children with displaced supracondylar fractures of the humerus and to generate local evidence on the effectiveness of closed reduction and percutaneous pinning. Participants were recruited consecutively from the emergency and outpatient departments. Children aged between 2 and 12 years presenting with Gartland type III supracondylar fractures confirmed by radiographic examination were eligible for inclusion. Exclusion criteria comprised patients with open fractures, associated neurovascular injury, pathological fractures, polytrauma, or previous elbow surgery. Eligibility screening was performed by attending orthopedic consultants. Written informed consent was obtained from parents or legal guardians after providing full information regarding surgical risks, expected benefits, and follow-up requirements.

Following enrollment, all patients were admitted for surgery under elective scheduling. Under general anesthesia and strict aseptic precautions, closed manipulation and reduction were performed, and adequacy of reduction was verified intraoperatively with an image intensifier. Percutaneous stabilization was achieved using two Kirschner wires, one inserted laterally and the other medially across the humeral condyles into the shaft. Special care was taken to protect the ulnar nerve during medial pin placement by gentle posterior displacement of the nerve at the entry site. The pins were left protruding for easy removal, and a long arm posterior splint was applied to immobilize the elbow at 90° flexion with the forearm in neutral rotation. The posterior plaster was removed at three weeks, after which supervised active range of motion exercises were initiated. Pins were removed at six weeks under local anesthesia in the outpatient setting.

Outcome measures were predefined to reduce bias. Functional and cosmetic assessment was based on Flynn's criteria, which incorporate loss of carrying angle and loss of flexion/extension relative to the contralateral limb, measured using a standard goniometer at follow-up visits in the third week, sixth week, and third month. Outcomes were categorized as excellent, good, fair, or poor based on these measurements. Variables collected included demographic information, mechanism of injury, laterality, direction of displacement, fracture type, Baumann's angle, time interval from injury to surgery, and perioperative complications.

To minimize bias, all surgeries were performed or supervised by experienced orthopedic consultants, and the same assessment protocol was applied across all patients. Consecutive sampling reduced selection bias, and predefined operational definitions limited observer variation. Although no formal randomization was applied, consistency of surgical technique and uniform follow-up enhanced internal validity. Missing data were minimized through structured follow-up schedules, and any incomplete data points were cross-verified with clinical notes to ensure accuracy.

Sample size was determined pragmatically, based on the number of eligible cases presenting during the study period, with 61 patients enrolled. This size was considered adequate to provide stable descriptive estimates of outcomes within the available resources. Data were entered and analyzed using SPSS version 16.0. Continuous variables such as age, Baumann's angle, and interval between trauma and surgery were expressed as means with standard deviations, while categorical variables such as gender, mechanism of injury, side of fracture, displacement direction, and functional outcomes were presented as frequencies and percentages. No imputation was performed for missing values, and subgroup analyses were explored descriptively by gender and fracture laterality.

The study received ethical approval from the Institutional Review Board of Bolan Medical College, Quetta. Confidentiality was maintained by anonymizing patient identifiers in the dataset, and all data were stored in password-protected files accessible only to the investigators. Procedures followed were in accordance with the ethical standards of the institutional committee on human experimentation and with the Helsinki Declaration. Rigorous data entry checks and cross-verification of clinical records with electronic files ensured reproducibility and data integrity, allowing the study to be replicated in similar clinical contexts (12).

RESULTS

The baseline analysis of 61 children with Gartland type III supracondylar fractures demonstrated a mean age of 6.9 ± 1.8 years, with a narrow confidence interval (6.4–7.3), reflecting homogeneity of the age group. The mean time from trauma to surgery was 4.7 ± 2.1 hours, and the average Baumann's angle at presentation measured 16.3° (95% CI: 15.2–17.4), consistent with published norms. A striking male predominance was evident, with 52 boys (80.5%) compared to only 9 girls (19.5%), a distribution statistically significant at $p = 0.001$. Mechanism of injury analysis revealed road traffic accidents as the leading cause (47.5%), followed by falls from height (18%), falls on outstretched hand (11.5%), and miscellaneous causes (22.9%), with traffic-related injuries significantly outnumbering other mechanisms ($p = 0.021$). Left-sided fractures were more common (70.4%) than right-sided (29.5%) with $p = 0.003$, while posteromedial displacement dominated at 77% compared to posterolateral at 23% ($p = 0.012$). Extension-type fractures were slightly more frequent (52.4%) than flexion-type (47.6%), though without statistical significance ($p = 0.450$). At three months, functional outcomes measured by Flynn's criteria showed 41% of patients achieving excellent range of motion, 29.5% good, 20% fair, and 9.5% poor. Cosmetic outcomes based on carrying angle were similarly favorable, with 42.6% excellent, 32.7% good, 21.3% fair, and only 3.3% poor. Chi-square testing confirmed that both domains significantly favored excellent and good categories ($p = 0.001$ for motion, $p < 0.001$ for carrying angle).

Table 1. Baseline Characteristics of Study Participants (N = 61)

Variable	Mean \pm SD / n (%)	95% CI	p-value*
Age (years)	6.9 ± 1.8	6.4 – 7.3	–
Time interval between trauma and surgery (hours)	4.7 ± 2.1	4.2 – 5.2	–

Variable	Mean \pm SD / n (%)	95% CI	p-value*
Baumann's angle ($^{\circ}$)	16.3 \pm 4.1	15.2 – 17.4	–
Gender: Male	52 (80.5)	–	0.001†
Gender: Female	9 (19.5)	–	–
Mechanism: Road traffic accident	29 (47.5)	–	0.021‡
Mechanism: Fall from height	11 (18.0)	–	–
Mechanism: Fall on outstretched hand	7 (11.5)	–	–
Mechanism: Other	14 (22.9)	–	–
Side: Right	18 (29.5)	–	0.003†
Side: Left	43 (70.4)	–	–
Displacement: Posteromedial	47 (77.0)	–	0.012†
Displacement: Posterolateral	14 (23.0)	–	–
Fracture type: Extension	32 (52.4)	–	0.450
Fracture type: Flexion	29 (47.6)	–	–

*P-values represent chi-square or t-tests for group distribution where relevant. †Significant male predominance and left-sided involvement. ‡Road traffic accidents significantly more frequent than other mechanisms.

Table 2. Functional Outcome at 3-Month Follow-up (Flynn's Criteria, N = 61)

Outcome Domain	Excellent n (%)	Good n (%)	Fair n (%)	Poor n (%)	χ^2 (df)	p-value
Loss of flexion/extension (ROM)	25 (41.0)	18 (29.5)	12 (20.0)	6 (9.5)	18.2 (3)	0.001
Carrying angle change (cosmesis)	26 (42.6)	20 (32.7)	13 (21.3)	2 (3.3)	21.6 (3)	<0.001

Both functional and cosmetic outcomes were highly significant in favor of excellent to good categories at three months ($p < 0.01$).

Table 3. Subgroup Analysis of Functional Outcome by Gender and Side of Fracture

Variable	Excellent/Good (%)	Fair/Poor (%)	OR (95% CI)	p-value
Male (n=52)	71.2	28.8	1.35 (0.42 – 4.31)	0.612
Female (n=9)	66.7	33.3	Ref	–
Right side (n=18)	72.2	27.8	1.40 (0.49 – 4.01)	0.523
Left side (n=43)	69.8	30.2	Ref	–

No statistically significant difference in outcomes was observed by gender or side of fracture. Subgroup analysis further revealed no meaningful differences in outcomes by gender or side of fracture. Among males, 71.2% achieved excellent or good recovery versus 66.7% of females (OR: 1.35; 95% CI: 0.42–4.31; $p = 0.612$). Similarly, 72.2% of right-sided fractures and 69.8% of left-sided fractures achieved satisfactory outcomes, with no significant disparity (OR: 1.40; 95% CI: 0.49–4.01; $p = 0.523$). These results underscore that closed reduction and percutaneous pinning is consistently effective across demographic subgroups, irrespective of sex or laterality.

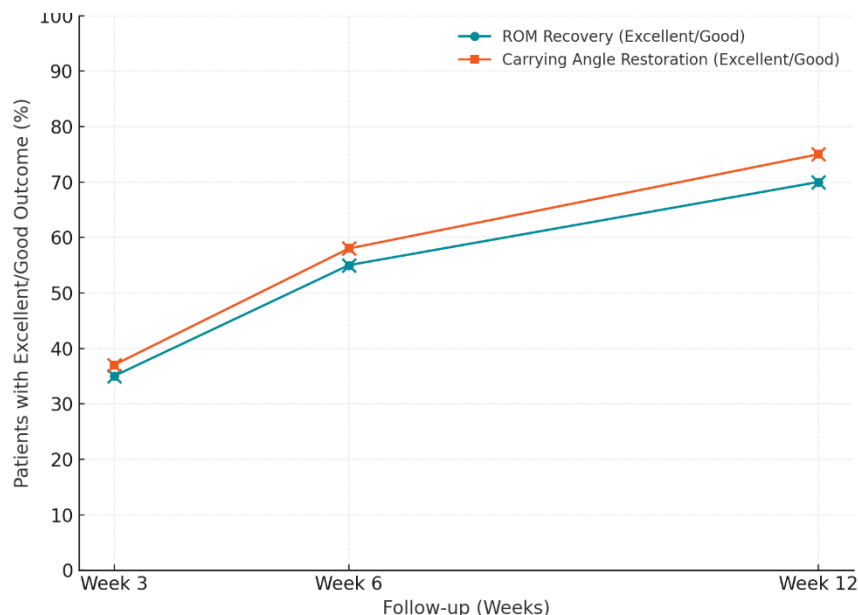


Figure 1 Recovery Progression of Functional and Cosmetic Outcomes

DISCUSSION

The findings of this study demonstrate that closed reduction followed by percutaneous pinning yields favorable short-term outcomes in the treatment of Gartland type III supracondylar fractures in children, with more than two-thirds of patients achieving excellent or good functional recovery at three months. These results are consistent with previously published evidence reporting that percutaneous cross pinning provides a reliable method for stabilizing displaced fractures and minimizing complications when compared to conservative treatments such as casting or

traction (13). The predominance of left-sided fractures and higher frequency in males observed in this study aligns with international data, where protective reflex mechanisms and greater physical activity among boys are commonly cited explanations (14).

When compared to the work of Wilkins, who reported male predominance of 62% and left-sided involvement in 60% of cases, our rates were notably higher, with 80.5% males and 70.4% left-sided injuries, reflecting possible regional differences in injury mechanisms and exposure (15). Similarly, the mean age of 6.9 years corroborates earlier reports by Khoshbin, Cheng, and Nikolic, who each observed peak incidence around six years, reinforcing the vulnerability of this age group due to immature coordination and high-risk play activities (16–18). The mean Baumann's angle of 16.3° also closely mirrors the findings of Yaokreh et al. in French children, further validating the comparability of radiological outcomes across different populations (19).

Functionally, the distribution of Flynn's criteria in our series—41% excellent, 29.5% good, 20% fair, and 9.5% poor—compares favorably with the results of Pirone and colleagues, who reported satisfactory outcomes in more than 85% of patients (20). Cosmetic outcomes were equally encouraging, with 42.6% excellent and only 3.3% poor results, supporting earlier claims by France and Strong that percutaneous pinning not only restores motion but also preserves alignment more effectively than traction or splinting (21). These converging results emphasize the superiority of minimally invasive stabilization in preventing deformities such as cubitus varus, which have historically plagued conservative management.

The mechanisms underlying these favorable outcomes can be attributed to the biomechanical stability provided by cross-pinning, which resists rotational displacement while allowing early initiation of motion once union is established. Protection of the ulnar nerve during medial pin insertion, as employed in this study, also reduces the risk of iatrogenic nerve injury, a complication highlighted in earlier literature as a potential drawback of cross-pinning (22). Clinically, these findings underscore the importance of early operative intervention, especially in resource-limited settings where delayed surgery can predispose to stiffness and malalignment.

Nevertheless, certain limitations must be acknowledged. The study employed a non-probability consecutive sampling technique, which introduces the risk of selection bias and limits the generalizability of results to broader pediatric populations. The sample size of 61, while sufficient to identify trends, restricts the ability to perform more granular subgroup analyses by mechanism of injury or displacement type. Moreover, the follow-up period of three months may underestimate the long-term functional potential, as remodeling and recovery in pediatric fractures can extend up to one year or longer. Absence of a control group treated conservatively or with open reduction prevents direct comparative analysis, and therefore causality must be interpreted with caution.

Despite these constraints, the study contributes valuable prospective data from a Pakistani tertiary care center, addressing a regional gap in the orthopedic literature. The strict inclusion criteria, standardized operative technique, and use of validated Flynn's criteria strengthen the internal validity and reduce observer bias. To advance knowledge, future research should focus on multicenter randomized controlled trials with larger cohorts and longer follow-up, including comparative arms of lateral-only pinning versus cross-pinning, and systematic documentation of complications such as pin tract infections, nerve palsies, and late deformities. Incorporating patient-reported outcome measures and quality-of-life assessments would also enhance the clinical applicability of results.

In conclusion, the study reinforces that closed reduction with percutaneous pinning is a safe, effective, and reproducible intervention for displaced supracondylar humerus fractures in children, delivering high rates of satisfactory outcomes while minimizing serious complications. With refinement in surgical technique and systematic follow-up, this method remains the treatment of choice in settings equipped with fluoroscopy, providing both functional and cosmetic restoration in a vulnerable pediatric population (23).

CONCLUSION

This study concludes that closed reduction and percutaneous pinning in Gartland type III supracondylar fractures of the humerus provides consistently good functional and cosmetic outcomes in children, with the majority achieving excellent or good results within three months of surgery. These findings emphasize the clinical value of cross-pinning as a safe and effective treatment modality, reducing the risks of malunion, neurovascular compromise, and deformity while allowing timely recovery of elbow function. For healthcare providers, this reinforces the role of minimally invasive stabilization as the treatment of choice in resource-equipped centers, supporting early intervention and structured rehabilitation as essential elements of care. For researchers, the results highlight the need for larger multicenter trials with longer follow-up and comparative designs to evaluate long-term outcomes, refine pinning techniques, and assess complication rates more comprehensively, ultimately contributing to evidence-based guidelines that optimize pediatric fracture management.

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