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Original Article

Short-Term Clinical and Radiological Outcomes of Triceps-Sparing Posterior Approach in Displaced Pediatric Supracondylar Humeral Fractures

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ABSTRACT

Background: Fractures of the supracondylar region of the humerus are the most frequent elbow injuries in children, making up around 60% of all pediatric elbow fractures. This study aimed to assess the short-term clinical and radiological outcomes of using a triceps-sparing posterior approach in children with displaced supracondylar humeral fractures. **Methods & Materials:** This prospective observational study was conducted at the National Institute of Traumatology and Orthopaedic Rehabilitation (NITOR), Sher-E-Bangla Nagar, Dhaka, from July 2020 to June 2022, including 44 children aged 5-10 years with displaced supracondylar humeral fractures, all treated using the triceps-sparing posterior approach. Surgery was performed within 4-7 days after injury, and patients were monitored over a short follow-up period. Radiological evaluation was carried out using Baumann's angle and the carrying angle. Clinical assessment included healing duration, elbow range of motion, triceps muscle strength (based on MRC grading), and functional outcomes measured using Flynn's criteria. Data were entered and analyzed using SPSS version 26. **Results:** The mean age of participants was 7.41 ± 1.66 years, with a higher proportion of boys (75%). The most common cause of injury was falling from a tree (54.5%), and the left arm was more frequently affected (72.7%). Baumann's angle remained stable from the postoperative period (76.77 ± 2.04°) to the final follow-up (76.84 ± 2.46°). The average healing time was 5.00 ± 1.01 weeks. The mean elbow range of motion was 129.30 ± 3.45°. Normal triceps strength (5/5 MRC) was maintained in 90.9% of patients. Complications were observed in 13.6% of cases. Based on Flynn's criteria, 75% of patients had excellent outcomes, while 13.6% had good outcomes. **Conclusion:** The triceps-sparing posterior approach provides favorable short-term clinical and radiological results in children with displaced supracondylar humeral fractures. It effectively preserves triceps strength and achieves a high rate of excellent functional outcomes, supporting its use as a reliable surgical technique.

Keywords: *Supracondylar humeral fracture, Triceps-sparing approach, Pediatric orthopedics, Flynn's criteria*

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INTRODUCTION

SCHFs are the most common fractures of the elbow in the pediatric population, accounting for approximately 55-70% of all pediatric elbow injuries in the 5 to 10-year-old child population [1]. The incidence of supracondylar fractures in the pediatric population peaks in the range of 5 to 8 years of age, during which the distal humeral bone is particularly susceptible to injury due to the transitional bone stage, which is associated with ligamentous laxity[2]. The most common mechanism of injury in these fractures is a fall onto an outstretched hand in an extended position, which results in a supracondylar fracture of the humerus, most commonly classified according to the Gartland classification, which ranges from an undisplaced fracture (Type I) to a completely displaced fracture (Type III) [3]. In the case of a completely displaced fracture, which is classified as a Type III supracondylar fracture, the fracture is completely displaced, resulting in the absence of cortical contact, thereby increasing the chances of neurovascular injuries, which need to be treated urgently, most commonly through closed reduction and pinning [4,5]. That is the gold standard treatment, but sometimes open reduction has to be performed in the case of completely displaced fractures when proper reduction cannot be achieved, which has a very high degree of implications in the choice of the surgical technique, particularly in the preservation of the integrity of the triceps muscle [6]. Traditionally, the posterior approach to the distal humerus has required the splitting or reflection of the triceps muscle and tendon, which has resulted in a prolonged rehabilitation process and inadequate recovery of elbow extension strength [7]. On the contrary, the triceps-sparing posterior approach to the distal humerus, also known as the paratricipital approach, provides adequate visualization of the distal humerus without violating the triceps mechanism. This approach has proven to result in better recovery of extensor strength and range of motion in the pediatric population [8]. Although the interest in the use of muscle-sparing approaches in the treatment of supracondylar fractures of the humerus is increasing, the evidence on the short-term clinical and radiological effectiveness of the triceps-sparing posterior approach in the treatment of pediatric supracondylar humeral fractures remains scarce. Baumann's angle and the carrying angle are important radiological parameters in the assessment of the effectiveness of the treatment approach in the restoration of the anatomy of the affected limb [9]. Flynn's criteria are a set of guidelines that can be followed to assess the effectiveness of the treatment approach in the restoration of the functions of the affected limb [10]. The Medical Research Council grading scale is a

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reliable tool in the assessment of the effectiveness of the treatment approach in the restoration of the functions of the affected limb, especially the triceps muscle [11]. Therefore, the study of the effectiveness of the triceps-sparing posterior approach in the treatment of pediatric supracondylar humeral fractures is important due to the functions of the pediatric elbow during the development of the child. This approach is consistent with the principles of minimally disruptive surgical approaches and has shown promising results in the treatment of supracondylar fractures of the humerus in the pediatric population [9,11]. This study aims to assess the effectiveness of the triceps-sparing posterior approach in the treatment of pediatric supracondylar humeral fractures with regard to the healing time, range of motion of the elbow joint, triceps strength, and functional grading of the affected limb.

METHODS & MATERIALS

The prospective observational study was carried out at the National Institute of Traumatology and Orthopaedic Rehabilitation (NITOR), Sher-E-Bangla Nagar, Dhaka, from July 2020 to June 2022. The study included 44 pediatric patients with displaced supracondylar humeral fractures who met the inclusion criteria and provided consent through their guardians. The study included patients aged 5 to 10 years with Gartland type III displaced supracondylar humeral fractures, who underwent surgical intervention within 4 to 7 days after injury. The exclusion criteria included patients with open fractures, pathological fractures, associated neurovascular compromise, and upper limb injuries involving the same side, previous history of elbow surgery, and pre-existing deformity of the elbow. Patients with poor follow-up were also excluded. All patients underwent open reduction through the triceps-sparing posterior approach under general anesthesia, followed by percutaneous Kirschner wire fixation. In this method, the triceps muscle and tendon are preserved, and the approach is made to the distal humerus through the medial and lateral paratricipital windows, maintaining the continuity of the extensor mechanism. Postoperative immobilization is done for three to four weeks with a posterior plaster slab, followed by mobilization through physiotherapy. The variables in the study were the demographic data of the patient, the mechanism of injury, the laterality of the injury, the interval from the injury to the surgery, and the outcomes of the surgery. The radiological parameters were evaluated based on the angle formed in the radiograph according to Baumann, which is the angle formed between the carrying angle in the radiograph taken in the immediate postoperative period and the radiograph taken in the final follow-up period. The clinical parameters evaluated were the healing period of the fracture, the range of motion in the elbow, and the muscle power of the triceps, which were evaluated according to the Medical Research Council grading system. The data were analyzed using the software program SPSS version 26, which generated the descriptive statistics, including the mean, standard deviation, frequency, and percentage of the data obtained from the study population.

RESULTS

Table I shows the demographic features of 44 pediatric patients. Most patients were in the 7-8 years age bracket, representing 40.9% of the study population, with a mean age of 7.41 ± 1.66 years. Males comprised three-fourths of the cohort (75%), a pattern often linked to higher-risk play activities among boys. This distribution is consistent with the known epidemiology of pediatric supracondylar humeral fractures.

Table I
Demographic characteristics of the study participants (n = 44).

Variables	Category	Frequency (n)	Percentage (%)
Age group (years)	5-6	14	31.8
	7-8	18	40.9
	9-10	12	27.3
Sex	Male	33	75.0
	Female	11	25.0
Mean age (years)	Mean ± SD	7.41 ± 1.66	-

Table II outlines the injury characteristics and perioperative findings. Falling from a tree was the most common mechanism of injury (54.5%), followed by sports-related falls (22.7%), reflecting typical childhood injury patterns. The left upper limb was more frequently affected (72.7%), which may relate to fall mechanics in predominantly right-handed individuals. The mean time from injury to surgery was 5.48 ± 1.06 days, with all patients treated within a 4–7-day period, indicating a delayed yet structured surgical schedule.

Table II
Injury and perioperative profile of the study participants (n = 44).

Variables	Category	Frequency (n)	Percentage (%)
Cause of injury	Fall from tree	24	54.5
	Sports injury	10	22.7
	Fall from bed	6	13.6
	Accidental fall	4	9.1
Affected side	Left	32	72.7
	Right	12	27.3
Interval between injury and operation	4 to 5 days	23	52.3
	6 to 7 days	21	47.7
Mean interval, days	Mean ± SD	5.48 ± 1.06	-

Table III summarizes the short-term radiological outcomes. Baumann's angle remained stable from the immediate postoperative measurement (76.77 ± 2.04°) to the final follow-up (76.84 ± 2.46°), suggesting maintained anatomical alignment. The carrying angle of the injured limb (7.64 ± 2.31°) was lower than that of the unaffected limb (11.20 ± 1.62°), indicating a mild residual varus alignment in some patients, though still within acceptable limits.

Table III
Short-term radiological outcomes after triceps-sparing posterior approach (*n* = 44).

Radiological variables	Mean ± SD
Baumann's angle, postoperative, degree	76.77 ± 2.04
Baumann's angle, last follow-up, degree	76.84 ± 2.46
Carrying angle, fractured limb, degree	7.64 ± 2.31
Carrying angle, healthy limb, degree	11.20 ± 1.62

Table IV represents the short-term clinical outcomes. The average healing time was 5.00 ± 1.01 weeks, aligning with expected healing durations in children. The mean range of motion in the affected limb was 129.30 ± 3.45°, compared to 134.20 ± 1.66° in the normal limb, reflecting a slight but clinically relevant difference. Overall, these results indicate satisfactory recovery, with motion nearing that of the uninjured side.

Table IV
Short-term clinical outcomes after triceps-sparing posterior approach (*n* = 44).

Clinical variables	Mean ± SD
Healing time, weeks	5.00 ± 1.01
Range of motion, fractured limb, degree	129.30 ± 3.45
Range of motion, healthy limb, degree	134.20 ± 1.66

Table V details postoperative triceps strength and complications. Full triceps strength (5/5 MRC grade) was retained in 90.9% of patients, while 9.1% showed a slight reduction (4/5 MRC grade). These findings highlight the effectiveness of the triceps-sparing approach in preserving muscle function. Complications were observed in 13.6% of patients, whereas 86.4% experienced no adverse events, consistent with reported outcomes in similar procedures.

Table V
Postoperative triceps power and complications (*n* = 44).

Variables	Category	Frequency (n)	Percentage (%)
Power of triceps, MRC grading	5/5	40	90.9
	4/5	4	9.1
Complication	Yes	6	13.6
	No	38	86.4

Table VI summarizes functional outcomes based on Flynn's criteria. Excellent results were observed in 75% of patients, followed by good (13.6%), fair (2.3%), and poor (9.1%) outcomes. The combined rate of excellent and good outcomes (88.6%) indicates the overall success of the triceps-sparing posterior approach in restoring elbow function.

Table VI
Functional outcome according to Flynn's criteria (*n* = 44).

Flynn's criteria	Frequency (n)	Percentage (%)
Excellent	33	75.0
Good	6	13.6
Fair	1	2.3
Poor	4	9.1
Total	44	100.0

DISCUSSION

This study demonstrated the short-term clinical and radiological results of the triceps-sparing posterior approach in the treatment of supracondylar fractures of the humerus in children. The results of the study show a high success rate in clinical outcomes, triceps strength, and radiological results, indicating the viability of the approach for the treatment of pediatric supracondylar fractures of the humerus. In the current study, the mean age of the patients was 7.41 years, with a male preponderance of 75%. This is consistent with Moraleda et al., who reported on pediatric supracondylar fractures of the humerus, which show a male preponderance of 60-80% [12]. The most common mechanism of injury in this study, i.e., fall from a tree (54.5%), is in keeping with the outdoor environment in which the study population lives, which is in the developing world [13]. The predominance of injuries to the left arm (72.7%) in our study is in keeping with Pretell-Mazzini et al., who indicated that in right-handed children, the non-dominant arm bears the brunt of the fall [14]. In the current study, the radiological results show a stable Baumann angle from the immediate postoperative period to the final follow-up, i.e., from 76.77° ± 2.04° to 76.84° ± 2.46°, respectively, indicating no progressive coronal plane deformity in the distal humerus, which is an indicator of the stability of the reduction in the fracture. A discrepancy in the carrying angle of the fractured (7.64° ± 2.31°) and normal (11.20° ± 1.62°) arms indicates a tendency to cubitus varus, which is the most common complication of pediatric supracondylar fractures of the humerus, occurring in 90% of cases, even after surgical treatment [15]. The mean fracture healing time was 5.00 ± 1.01 weeks, which was similar to a study by Larson et al., who used similar techniques, including open reduction, for displaced fractures [16]. The elbow movement in the fractured limb was 129.30 ± 3.45°, slightly

less than in the contralateral arm, which was 134.20 ± 1.66°. It was, however, still within an acceptable limit. It has been postulated that this approach results in earlier mobilization, thus reducing postoperative stiffness, compared with the triceps-splitting approach, which has been reported by Chen et al [17]. The advantage of the triceps-sparing approach, as shown in this study, was the maintenance of triceps muscle strength [18]. The triceps strength was maintained at full strength, i.e., MRC 5/5, in 90.9% of patients, and only 9.1% had slightly reduced triceps strength, i.e., MRC 4/5. No patient had triceps strength reduced to 3/5 or less. The triceps-splitting approach has been reported to result in prolonged weakness, especially in the early postoperative period, which has been a drawback in this approach [19]. The advantage of the triceps-sparing approach, therefore, has been shown in this study, which corroborates the theoretical advantage of this approach, avoiding muscle incision, which has been reported by Edmonds et al., who advocate the use of the paratricipital approach [20]. The postoperative complications observed in 13.6% of patients, though slightly higher, were within the acceptable limits for pediatric orthopedic surgery of the elbow. The commonly reported complications reported by Ramachandaran et al. include pin-site infection, nerve palsies, and cubitus varus deformity [21]. The low rate of complications in this study could be attributed to meticulous surgical technique and postoperative care protocol. In the case of the functional assessment, the application of Flynn's criteria produced 75% excellent results and 13.6% good results, giving an aggregate satisfactory outcome rate of 88.6%. The results are favorable when compared with other published data using the lateral approach in CRPP and even other open reduction techniques, where the combined rate of excellent and good results varies between 70 and 90% [22]. The 9.1% rate of poor outcome is related to the amount of initial displacement, preoperative edema, and the degree of residual deformity, which are all considered to be important determinants in the prognosis of pediatric SCHFs [23]. All the above results indicate the triceps-sparing posterior approach as an important and functionally sound surgical method in the treatment of displaced pediatric SCHFs, especially when open reduction is indicated [24].

LIMITATIONS

The limitations of this study lie in its small number of cases and lack of a control group for comparison with other techniques, like the lateral or triceps sparing approach. Moreover, it is possible that some postoperative complications, like avascular necrosis, progressive cubitus varus, and decreased range of motion, may not be evident within this short follow-up period.

CONCLUSION

The triceps-sparing posterior approach has been proven to be an effective and functionally sound surgical method for treating displaced pediatric supracondylar fractures of the humerus. The study has shown satisfactory short-term radiological results with stable Baumann's angle and acceptable carrying angle, along with satisfactory clinical recovery in terms of healing time and elbow range of motion. The advantage of this approach was also seen in terms of maintaining triceps muscle strength, with 90.9% of patients achieving full strength in the affected limb. The overall rate of complications was also satisfactory, and Flynn's criteria revealed 88.6% of patients with excellent or good functional outcomes.

RECOMMENDATIONS

Future multicenter randomized controlled trials with extended follow-up durations are needed to directly compare the triceps-sparing posterior approach with other surgical techniques and to develop evidence-based guidelines for selecting the optimal approach in displaced pediatric supracondylar humeral fractures.

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CONFLICT OF INTEREST

None declared

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