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Evaluate Functional and Radiological Outcome of Displaced Supracondylar Fracture Type 2 and 3 in Children Treated with Lateral and Transolacranon Pinning

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ABSTRACT

Supracondylar fractures of the humerus (SCFH) are a common and challenging pediatric injury, accounting for approximately 60% of all elbow fractures in children. Optimal management of displaced SCFH remains a topic of debate, particularly concerning the choice between lateral-only pinning and cross pinning techniques. This study evaluates the functional and radiological outcomes of a modified surgical approach involving lateral and transolecranon pinning in pediatric patients with displaced SCFH. A prospective analysis was conducted on [230] pediatric patients, aged 4-12 years, presenting with Gartland Type II and III SCFH. Following closed reduction under general anesthesia, percutaneous pinning was performed using a combination of lateral and transolecranon pins. Postoperative outcomes were assessed through Flynn's criteria for functional results and radiographic analysis for fracture healing. The study demonstrated that the modified technique provided stable fixation, with all fractures achieving union by 3-6 weeks duration. The mean duration of fracture union was [3.3] weeks. Functional outcomes were rated as excellent 24 patients (80%) and good 6 patients (20%) with minimal complications. The incidence of ulnar nerve palsy was zero, suggesting that this approach mitigates the risk of neurovascular injury commonly associated with cross pinning. In conclusion, the modified lateral and transolecranon pinning technique is a safe and effective method for managing displaced SCFH in children, offering a balance between stability and safety. These findings support the use of this technique, particularly in cases with high risk of complications associated with other methods. Further research through randomized controlled trials is recommended to validate these results.

INTRODUCTION

Supracondylar fractures of the humerus (SCFH) represent a significant proportion of pediatric fractures, particularly in the elbow region, with an estimated incidencAugust 20, 2024e of 60% among all elbow fractures in children[1-2]. These fractures are most commonly seen in children between the ages of 5 and 7, often resulting from falls on an outstretched hand[3-4]. The management of SCFH is challenging due to the risk of complications such as neurovascular injury, malunion and joint stiffness. Historically, various treatment modalities have been employed, ranging from conservative methods like skin traction to more invasive surgical techniques[5]. The goal of this study is to evaluate the functional and radiological outcomes of a modified surgical approach involving lateral and transolecranon pinning for the treatment of displaced SCFH[6-8].

Recent advances in surgical techniques and a better understanding of the anatomical and biomechanical factors involved in SCFH have led to improved outcomes[9-10]. However, the optimal method for managing these fractures remains a topic of debate, particularly concerning the choice between lateral-only pinning and cross pinning[11-12-13]. This study seeks to contribute to this ongoing discussion by presenting the results of a modified pinning technique that aims to balance stability and safety[14].

MATERIALS AND METHODS

The treatment of SCFH has evolved significantly over the past few decades. Initially, non-operative management, including various forms of traction, was the standard approach[15]. However, these methods often resulted in suboptimal outcomes, with a high incidence of malunion and prolonged immobilization periods leading to joint stiffness and functional impairment[16].

Closed reduction followed by percutaneous pinning has become the preferred method of treatment for displaced SCFH. Among the various pinning techniques, the choice between lateral-only pinning and cross pinning has been widely debated. Cross pinning, which involves the insertion of pins from both the medial and lateral sides of the elbow, offers superior biomechanical stability, particularly in cases of severely displaced fractures. However, the risk of iatrogenic ulnar nerve injury associated with medial pin placement is a significant drawback. Lateral-only pinning, on the other hand, avoids this risk but may provide less stable fixation, especially in cases with comminution or rotational instability[17].

Several studies have compared the outcomes of these two pinning techniques. For example, Lee *et al.* (2012) demonstrated that cross pinning provided better rotational stability, but at the cost of a higher incidence of ulnar nerve injury[18]. Conversely, Skaggs *et al.* (2001) showed that lateral pinning could achieve comparable functional outcomes with a significantly lower risk of nerve injury, particularly when two or more lateral pins were used[19].

In response to the limitations of both techniques, various modifications have been proposed. One such modification is the addition of a transolecranon pin, which provides additional stability without increasing the risk of nerve injury. This technique, which has been less extensively studied, is the focus of the current investigation[20].

Applied Anatomy: A thorough understanding of the anatomy of the distal humerus is essential for the effective management of SCFH. The distal humerus is composed of two condyles (medial and lateral) and the olecranon fossa, which is centrally located on the posterior aspect. The supracondylar region, where these fractures typically occur, is a transitional zone between the broad metaphysis and the narrower diaphysis, making it particularly vulnerable to fractures under stress[21].

The primary neurovascular structures at risk during SCFH and its treatment include the brachial artery, the median nerve, and the ulnar nerve. The brachial artery and median nerve are most commonly injured in extension-type fractures due to their proximity to the anterior aspect of the humerus. The ulnar nerve, located posterior to the medial epicondyle, is at risk during medial pin placement in cross pinning techniques. Careful consideration of these anatomical relationships is critical during surgical intervention to minimize the risk of complications[22].

Mechanism of Injury: SCFH typically result from a fall on an outstretched hand with the elbow in hyperextension, which generates a significant axial load that is transmitted through the forearm to the distal humerus. The olecranon process acts as a fulcrum, leading to the failure of the humeral metaphysis, usually resulting in a posterior displacement of the distal fragment[23].

The direction of displacement is influenced by the mechanism of injury. For instance, a fall on an outstretched hand with the forearm in pronation often results in a posteromedial displacement, while a fall with the forearm in supination typically leads to a posterolateral displacement. These patterns of displacement have implications for the treatment approach, as they affect the stability of the fracture and the likelihood of neurovascular injury[24].

Classification: The Gartland classification system is widely used to categorize SCFH based on the degree of displacement and the integrity of the cortex:

- **Type I:** Non-displaced fractures with an intact cortex. These fractures are typically stable and can

often be managed conservatively.

- **Type II:** Displaced fractures with an intact posterior cortex. These fractures are less stable and often require surgical intervention to achieve and maintain reduction.
- **Type III:** Completely displaced fractures with no cortical contact. These fractures are inherently unstable and almost always require operative management.

This classification system is not only useful for determining the appropriate treatment strategy but also serves as a predictor of potential complications[25-26]. For example, Type III fractures are associated with a higher risk of neurovascular injury and may require more complex surgical techniques to achieve stable fixation[27].

The study population consisted of 230 children who met the inclusion and exclusion criteria, Out of 230 patients 30 were treated operatevely.

Inclusion Criteria:

- Displaced supracondylar fractures (Type II, Type III).
- Age group 4-15 years.

Exclusion Criteria:

- Undisplaced fractures (Type I)
- Open fractures
- Fractures with compartment syndromes

A detailed history of the injury and initial treatment was obtained. Distal neurovascular status was thoroughly examined and fractures were classified using the modified Gartland classification. Cases were managed as emergency or elective procedures.

Operative Technique: Under appropriate anesthesia, closed reduction was performed. Manual traction with the elbow at 120° flexion was applied to correct medio-lateral displacement and rotation. The posterior displacement was corrected by “milking” the distal fragment with the surgeon's thumbs on the flexed elbow. Reduction was confirmed under an image intensifier, ensuring no step on medial and lateral columns, normal olecranon fossa orientation in the AP view, tear drop restoration and 40° anterior tilt of the capitellum in the lateral view. The forearm was strapped to the arm with maximum flexion and pronation to maintain reductionv[28].

The elbow was then painted and draped. The first K-wire was inserted from the tip of the lateral epicondyle at a 45°-55° angle, advancing to the medial cortex after confirming the central position in the lateral view. The second K-wire was introduced parallel to the first, passing through the lateral cortex, two walls of the olecranon fossa and the medial cortex in the proximal fragment, termed the Transolecranon Fossa Four Cortex Purchase (TOF-FCP) technique. A third wire was added if needed, using the same technique. Throughout the procedure, the image intensifier was rotated, not the child's arm, to obtain AP and lateral views. After adequate fixation with two to three pins, the elbow's stability was confirmed, the wires were bent and cut outside the skin and a well-padded posterior splint was applied with the elbow in 60°-90° flexion as tolerated[29].

Postoperatively, neurovascular status was assessed immediately after recovery from anesthesia. Radiographs were taken before discharge to evaluate the reduction quality using Baumann's and humero-capitellar angles. Patients were discharged on the same or following day and followed up weekly for one month to assess pin tract condition and plaster care. Radiographs were taken after three weeks to assess fracture healing, and wires were removed as an outpatient procedure. Gradual mobilization exercises and physiotherapy were encouraged until full elbow range of motion was regained. The carrying angle was measured with a goniometer after achieving full elbow extension, and Baumann's angle was measured from radiographs taken at that time. The adequacy of reduction was assessed using the anterior humeral line in postoperative X-rays[30-31].

RESULTS AND DISCUSSIONS

A prospective study was conducted on 30 children with displaced supracondylar humerus fractures, treated with lateral and trans-olecranon pinning. The mean follow-up duration was 3 months and radiological healing was observed at 3 weeks in 3 patients, at 4 weeks in 24 patients and at 6 weeks in 3 patients.

The study population consisted of 20 males (66.66%) and 10 females (33.33%), with ages ranging from 5 to 15 years and a mean age of 8.7 years. Sixteen fractures were on the left side (53.3%), and fourteen were on the right side (46.7%). All patients sustained their injuries from falls: 15 children (50%) fell from a height, 12 (40%) while playing and 3 (10%) from a bicycle. All injuries were classified as extension type, with 17 Type II and 13 Type III fractures according to the Gartland classification.

Radiographic evaluation post-surgery and at follow-up indicated minimal functional loss. Compared with the uninjured elbows, the injured elbows showed a mean loss of flexion of 3.06°±3.25° ($p<0.001$), a mean loss of extension of 1.97°±4.16° ($p=0.015$), and a mean change in carrying angle of 0.833°±2.036° ($p=0.033$). Additionally, the mean difference in Baumann’s Angle between the injured and uninjured limbs was 1.067° ± 1.639° ($p=0.001$). The mean difference in the humero-trochlear angle was 1.567°±1.357° ($p<0.001$),

and the mean difference in the humero-ulnar angle was 4.067°±2.75° ($p=0.036$). In 24 cases, the anterior humeral line passed through the middle third of the

capitellum, in 2 cases through the anterior third and in 4 cases through the posterior third. Notably, no clinically detectable varus deformities were observed. All fractures united within 3-6 weeks, with a mean union time of 3.3 weeks. Out of the 30 cases, 11 (36.66%) were operated on within one day of injury, while 19 (63.33%) were operated on between 24 hours and 4 days due to delayed presentation. The mean duration between injury and surgery was 1.24 days.

Postoperatively, 18 patients (60%) had some limitation of terminal flexion compared to the normal contralateral side, with 12 of these cases having a limitation of 5 degrees or less. Out of these 18 cases, only 6 had a flexion loss between 5-10 degrees. Regarding the carrying angle, 14 cases showed no loss,

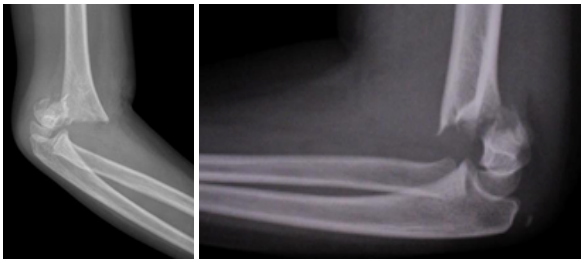

Fig.1:Pre-Op X-rays

Fig.2: Immediate Post-Op X-rays X-ray 8 Weeks Later

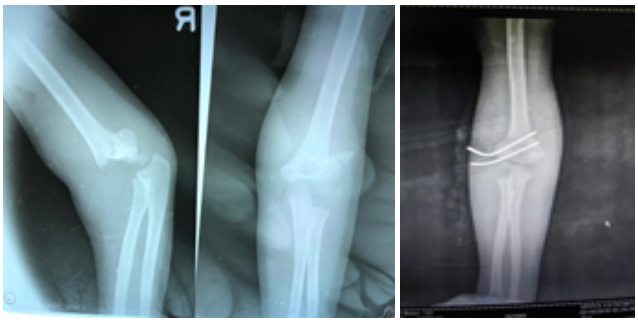

Fig.3: Pre-Op X-ray Immediate Post-Op X-ray

Table 1: Distribution of study subjects according to their age group (n = 30)

Age (in years)	No.	Percent
1-5	3	10.0
6-10	19	63.3
>10	8	26.7
Mean (SD)	8.60(2.32)	
Range	5-13	

Table 2: Distribution of study subjects according to the gender (n=30)

Gender	No.	Percent
Male	20	66.7
Female	10	33.3

Table 3: Distribution of study subjects according to the side (n=30)

Side	No.	Percent
Left	16	53.3
Right	14	46.7

Table 4: Distribution of study subjects according to the type of fracture (gartland classification) (n=30)

Type of Fracture	No.	Percent
II	17	56.7
III	13	43.3

Table 5: Distribution of study subjects according to the boumann s angle (n=30)

Boumanns Angle	Uninjured Limb	Injured Limb At 3 months
67	1(3.3)	
68	1(3.3)	
70	2(6.7)	2(6.7)
71		1(3.3)
72	3(10.0)	2(6.7)
73	6(20.0)	2(6.7)
74	3(10.0)	2(6.7)
75	2(6.7)	3(10.0)
76	5(16.7)	9(30.0)
77	3(10.0)	5(16.7)
78	2(6.7)	2(6.7)
80	1(3.3)	
81		1(3.3)
82	1(3.3)	1(3.3)

Table 6: Distribution of study subjects according to the humero-ulnar angle (n=30)

Humero-Ulnar Angle	Uninjured Limb	Injured Limb At 3 months
≤165	3(10.0)	5(16.7)
166	4(13.3)	1.(3.3)
167		1.(3.3)
168	6(20.0)	3(10.0)
170	6(20.0)	2(6.7)
171		3(10.0)
172	5(16.7)	4(13.3)
173		3(10.0)
174	6(20.0)	2(6.7)
≥175		6(20.0)

Table 7: Distribution of study subjects according to the humero-trochlear angle (n=30)

Humero-Trochlear Angle	Uninjured Limb	Injured Limb At 3 months
34		1(3.3)
36	2(6.7)	4(13.3)
37		1(3.3)
38	3(10.0)	5(16.7)
39	2(6.7)	3(10.0)
40	8(26.7)	8(26.7)
41	5(16.7)	6(20.0)
42	3(10.0)	2(6.7)
43	5(16.7)	
44	1(3.3)	
A45	1(3.3)	

Table 8: Distribution of study subjects according to the grading based on flynns criteria(n=30)

Flynns Grading	No	Percent
Excellent	24	80.0
Good	6	20.0

Table 9: Distribution of study subjects according to the complications (n =30)

Complications	No	Percent
Nerovascular Dificit Pre-op	0	0.0
Compartmental Syndrome Pre-op	0	0.0
Neurovascular Defict Post-op	0	0.0
Compartmental Syndrome post-op	0	0.0
Pintrack Infection	2	6.7
Pin Loosening	0	0.0

15 cases showed less than a 5-degree loss and 1 case had a loss of <10 degrees. Importantly, no loss of reduction was detected in either the initial postoperative radiograph or the radiograph taken at the time of Kirschner wire removal.

The study reported no instances of post-operative ulnar nerve injury, vascular injury, compartment syndrome, myositis ossificans, or non-union. Two patients developed pin site infections, which resolved with pin removal and oral antibiotics. Ultimately, all 30 patients experienced satisfactory results: 24 had excellent outcomes and 6 had good outcomes, according to the Flynn grading system. The study demonstrates that lateral and trans-olecranon pinning provides reliable fixation and satisfactory functional and cosmetic outcomes for treating displaced supracondylar humerus fractures in children.

The primary aim in managing displaced supracondylar fractures is to achieve reduction and immobilization, minimizing morbidity. Closed reduction and percutaneous pin fixation have consistently yielded good outcomes, though controversy exists between cross pinning (medial and lateral) and lateral-only pinning (LOP). Studies by Lee *et al.* and Zionts *et al.* showed greater torsional rigidity with cross pinning but highlighted the risk of iatrogenic ulnar nerve injury, which is significantly higher in cross pinning compared to LOP. This injury can result from direct trauma, contusion, or nerve stretching[32].

A meta-analysis of 1,615 cases revealed that cross pinning carries a 4.3 times higher risk of ulnar nerve injury. Given that ulnar nerve damage may be irreversible while malunion is correctable, LOP has been recommended for supracondylar fractures of the humerus (SCFH). Modified LOP techniques, including the use of two or more lateral wires passing through the olecranon fossa for four cortical purchases, offer stable fixation without the risk of ulnar nerve injury. This method was first described by Judet in 1947[33].

The study by Skaggs *et al.* demonstrated that lateral pinning alone is effective even for unstable fractures, with no nerve injuries or loss of reduction reported. Gottschalk *et al.* supported the efficacy of lateral pinning with at least one pin starting at the capitellum for improved stability. However, Balakumar *et al.* found that LOP fixation is associated with a higher risk of loss of reduction, attributed to technical errors such as insufficient pin purchase or inadequate pin spread[34-35].

In contrast, our study of 30 children treated with transolecranon and lateral pinning showed no loss of reduction postoperatively, despite minor malreductions at surgery. The technique provided stable fixation throughout healing. The learning curve is modest, requiring careful central pin positioning in the lateral epicondyle to avoid missing the olecranon fossa.

Our study reported 80% excellent and 20% good outcomes, comparable to Mazda *et al*.'s study, but without poor results or the need for open reduction, making it superior in these aspects. The large sample size and adequate follow-up were strengths, though the lack of comparison with other pinning methods was a limitation.

CONCLUSION

In conclusion, the modified lateral and transolecranon pinning technique is a safe and effective method for the treatment of displaced SCFH in children. This approach provides the advantages of stable fixation and reduced risk of neurovascular complications, making it a viable option for pediatric orthopedic surgeons. The positive outcomes observed in this study support the use of this technique, particularly in cases where traditional methods may pose a higher risk of complication.

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