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ORIGINAL ARTICLE

Early Results of Supracondylar Humeral Fractures in Pediatrics treated with Dorgan's Technique

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ABSTRACT

Background: fixation of supracondylar fractures in children with Kirschner wires (two lateral and one medial wire) increases the risk of ulnar nerve damage. Dorgan's Technique (lateral crossed pin fixation) lowers the risk of ulnar nerve injury. This study was conducted for the first time at Zagazig University Hospitals. Our goal was to assess Dorgan's Technique's clinical and radiological results in fixing supracondylar fractures. Methods: This clinical trial was conducted at the Trauma unit in the Orthopedic Surgery Department, Zagazig University Hospitals on 30 children; graded according to Garteland's classification as follow: extension type fracture: in the 28 cases (93%) and flexion type fracture: in the 2 cases (7%). Results: There was intact ulnar nerve and vascular examination pre and post-operative for studied patients. Early Postoperative complications were; radial nerve neuropraxia in 10% of patients, pin tract infection was seen in six patients (20%). Late Complications distributed as following; rotated, Malunion, Deformity "cubitus varus" were found in in three patients (10%), for each of them. Conclusion: In order to achieve excellent functional, esthetic, and radiological results, the lateral cross-pinning approach offers a biomechanically stable fixation that permits early and safe active elbow movements. Without putting the radial nerve in jeopardy, a correctly executed Dorgan's approach totally eliminates the possibility of iatrogenic ulnar nerve damage.

Keywords: Supracondylar Humeral Fractures, Pediatrics, Dorgan's Technique.

INTRODUCTION

Supracondylar fractures of the distal humerus account for 15% of all pediatric fractures. The incidence progressively declines with age until the age of 15, with the median age of presentation being 6 years old [1].The mechanism of damage is usually a fall onto an outstretched hand with axial transmission of body weight through the maximally extended elbow. This results in an extension type, which may be exacerbated by ligamentous laxity and is responsible for 97–99% of injuries. Open fractures are also uncommon, occurring in 1% or more of older children, while flexion-type injuries are far less prevalent, occurring in 1–3% of cases [2].In the coronal plane, the distal humerus is roughly triangular, with the transverse condylar masses (lateral epicondyle, capitellum, trochlear, and medial epicondyle) constituting the base and the medial and lateral supracondylar ridges creating the sides. This triangle is centered

on the olecranon and coronoid fossae, with a narrow strip of bone between the supracondylar pillars and close to the condylar masses. In the axial plane, this creates a dumbbell form, and the thin bone plate functions as a stress riser that breaks with high axial force [3].The arm could be swollen, and bruised. Any elbow bleeding should be evaluated as it may indicate an open fracture [4]. It is essential to carefully evaluate the distal pulsation and the functioning of the radial, median, and ulnar nerves [5].

Plain elbow radiographs are needed to confirm the diagnosis. Verification of the fracture type (flexion versus extension), degree of displacement, malrotation, and comminution requires anteroposterior and lateral views [6]. Nonoperative immobilization in an above-elbow cast with the elbow at a 90-degree angle is suitable for nondisplaced Gartland I and minimally displaced Gartland IIA fractures. Surgical intervention is advised for displaced Gartland II and III fractures. When the closed approach is unable to achieve reduction, open reduction is required [7].

Dorgan technique (lateral cross k wires fixation): An alternative fastening technique to avoid ulnar nerve damage is to mount two parallel K-wires via the lateral cortex. By placing the medial K-wire, the ulnar nerve is protected. However, compared to the crosswire system, this structure is believed to be less biomechanically robust [8]. Crossed lateral pin fixation with ascending and descending K-wires (Dorgan's side cross wiring) is a modified version of the cross-wire technique used to achieve stability and avoid ulnar nerve damage. Cross-wire fixing is only to be accomplished on the lateral side .[9]Since 1994, Dorgan's lateral cross k wire fixation method has been in use. Not only does it prevent damage to the ulnar nerve, but it also reduces rotation torque by 37% biomechanically when compared to medial and lateral cross k wire fixation [10].

The working hypothesis is that Dorgan's Technique in fixing supracondylar fracture in pediatrics will decrease the risk of ulnar nerve injury and reduce the risk of rotational torque. The aim of this work is to evaluate clinical and radiological results using Dorgan's Technique in fixation of supracondylar fractures.

METHODS

30 children had SCHF in this clinical, 28 cases (93%) had an extension type fracture, and 2 cases (7%), a flexion type fracture which was rated using Garteland's categorization system and carried out in the Trauma unit of the Orthopedic Surgery Department of Zagazig University Hospitals. (from February 2024 to July 2024). The study was approved by Ethical committee of faculty of Medicine, Zagazig University (IRB number 11428-14-1-2024). An informed written consent was obtained from all patients. Children with transverse fractures, extension and flexion types, recent fractures, and an acceptable closed reduction of SCHF who were below skeletal maturity met the inclusion criteria.

Failure of closed reduction, refusal of operation, infection, untreated fractures, and articular fractures were among the exclusion criteria. Prior to intervention, all patients underwent a thorough clinical picture capturing, a thorough clinical examination, a neurovascular examination that included distal pulsation and the functioning of the ulnar, median, and radial nerves, a standard laboratory workup, X-ray films, and an AP/LAT image.

Operative procedure: Under general anesthesia, the patient was laid supine on the operating table with the injured limb outside the table and without a tourniquet. The limb

was then scrubbed, draped, and fluoroscopy was used. For approximately two minutes, the surgeon and an assistant performed longitudinal traction/counter-traction while keeping the elbow slightly flexed. Once the fragments are out to length, any lateral or medial movement can be carefully adjusted. The posterior dislocation was corrected by pushing the olecranon anteriorly after palpating it. To fix the prevalent internal rotation defect, the elbow was externally rotated after being flexed to roughly 40 degrees. The elbow was fully flexed while the olecranon was kept under pressure.

The posterior soft tissue hinge was utilized to support the fracture, and after it was fully reduced, there was typically no obstruction to full flexion. An incomplete reduction is suggested by a notable barrier to flexion. It is challenging to evaluate the quality of the reduction since the proximal forearm bones are invariably stacked over the elbow joint in this view. Fluoroscopic images of the shoulder taken in both internal and external rotation provide oblique views that clearly show the shorter lateral and medial columns. Because applying internal or external rotation at this stage could cause rotation at the fracture site and loss of reduction in unstable fractures, it was better to rotate the C-arm into the horizontal position around the hand table to provide a good lateral view.

Whether or whether the distal fragment was rotated is the most important thing to observe on the lateral radiograph. The proximal and distal fragments at the fracture site will have the same width if the rotational distortion has been completely rectified. The assistant secured the arm in full flexion to maintain the lowered position after the fracture reduction was verified in both views. Making sure the wire that will contact the medial column's most distal side is not too close to the fracture site was especially crucial.

Each postero-antero (PA) and lateral X-ray's quality was evaluated. To guarantee accuracy on PA X-rays, the humeral axis and capitellar physis were assessed. The contour of the posterior supracondylar ridges on lateral X-rays was used to calculate the actual lateral position. In order to provide an AP view in the event of two lateral divergent wire fixations, a Kirschner wire was inserted through an entry site lateral to the olecranon selected using the image intensifier. It was crucial to maintain the humerus parallel to the arm board and to keep in mind that, in the sagittal plane, the epicondyles are located just in front of the humerus' anatomical axis. The wires should therefore be oriented a little backward. A second diverging wire should be able to pass through the entry site **(Figure 1)**. Both wires were pushed in until the medial cortex's resistance disappeared, signifying that they had just passed through. Keep in mind that the pins will typically cross outside the skin when divergent wires are inserted. They put in a reverse lateral pin. A third pin was placed when needed. We made sure the reverse lateral pin did not pierce the medial condyle's distal cortex in order to prevent damage to the ulnar nerve. The more proximal wire could theoretically cause damage to the radial nerve during insertion. However, the radial nerve, which is situated anterior to the lateral intermuscular septum at this level, can be avoided by entering the skin somewhat posterior to the mid-coronal plane. In our study for children under six, it is safe to estimate the patient's age in years multiplied by one centimeter to determine the distance between the radial nerve proximally and the distal humeral physis. The radial nerve's distance reaches the adult range (>6 cm) at the age of six. [11].

AP and oblique views were used to verify the wire positions and fracture reduction. if the cables were positioned correctly (in both planes). The arm could then be externally rotated to obtain the lateral view because the fracture was typically stable enough **(figure 2).** The picture intensifier should be turned over the top instead of the child's arm if there was any question. The elbow is extended to offer an AP view and measure the carrying angle, which can subsequently be compared with the other arm if the fracture is stable. The wires are left percutaneous after being bent over and severed. A gauze dressing or sponge soaked in iodine was used to dress the wires, A plaster back slab was then set on the long arm, and the elbow was bent at a straight angle. At the conclusion of the

process, the radial pulse should be examined and recorded. Use a lengthy arm splint after that.

Post-operative management: The operated limb was kept elevated for three days. Finger motions were encouraged, and the neurovascular condition of the limb was carefully evaluated on a regular basis due to the possibility of compartment syndrome. After receiving first-generation cephalosporin antibiotics for seven days and a broad-arm sling for support, patients were typically released the next day. Weekly follow-up at the orthopedic outpatient clinic. Follow-up radiography at 1, 2, 4, and 6 weeks. The duration of complete immobilization is four weeks. 4-6 weeks, based on the union rate as seen by the follow-up X-ray. At six weeks, physiotherapy and active elbow joint activities started **(figure 3). Follow up:** Clinical examination uses Flynn criteria to grade elbow range of motion and carrying angle. At 1, 2, 4, and 6, radiographic examination is done using AP and true Lat views.

Figure (1): Entry of proximal k wire.

Figure (2): pre and post AP and lateral view of SCHF fixed by Dorgan's technique(healing after 6m).

Figure(3) : full extension and flexion

STATISTICAL ANALYSIS

The IBM SPSS Statistics for Windows, Version 23.0, was used to gather, tabulate, and statistically analyze all of the data (IBM Corp., Armonk, NY). The Mcnemar test, Mann Whitnney u-test, and t-test were employed

RESULTS

The follow up was 6 months. The mean age of children in the study was 8.6±3years (range 2–14 years) ,. Of the thirty patients in the study there were 10 females (33.3%) and 20 males (66.7%), with ratio 1:2.

Associated medical history; one child (3.3%) has diabetic type 1 **(Table 1S).**

Table 1S: Demographic characters of studied children (n. 30)			
Age per years	Mean ± SD (range)	8.6±32-14	
Gender		n.	%
	Females	10	33.3
	Males	20	66.7
Comorbidity			
Yes		1	3.3
No		29	96.7
Type of Comorbidity			
diabetic type 1		1	3.3

Site of Supracondylar Humeral Fractures in Pediatrics was similar Right side: 15 (50%), Left side: 15 (50%). Supracondylar Humeral Fractures in studied children; mainly extension type in 28 patients (93.3%), while in the other two patients (6.7%) it was Flexion type. The percentage of associated fractures was 6.7%, one fracture in distal radius fracture, another fracture was green stick radius, Fixation of supracondylar humeral fracture was done in 4 patients (13.3%) via two K wires, while in 26 patients (86.7%) was done via three K wires **(Table 1).**

Table 1: Site, types of Supracondylar Humeral Fractures and associated fractures in studied children (n 30)

Item		n.	%
Affected side	Right	15	50.0
	Left	15	50.0
Variable		n.	%
types of fracture			
Extension		28	93.3
Flexion		2	6.7
Associated fractures	Yes	2	6.7
	No	28	93.3
Associated fracture Types	Distal radius	1	3.3
	Green stick radius	1	3.3
Number of K wires	Two	4	13.3
	three	26	86.7

The mean ± SD of healing time in proper union of supracondylar humeral fractures was (5.4±0.8), with (range 4-6weeks) ,while in mal-union fracture was 5.7±0.58 ,with range(5-6 weeks), p>0.05 . Allover mean time of bone union in the current study was 5.5±0.77weeks ,(range 4–6 weeks) **(Table 2).**

Table 2: Time of bone union (weeks)

	Proper union n.27	Mal union n.3	total	t	p
Time of healing (week) Mean ± SD (range)	5.4±0.8 4-6	5.7±0.58 5-6	5.5±0.77 4-6	0.464	0.646
t: student's t test, p>0.05=no- significant					

Early Postoperative complications were; Radial nerve Neuropraxia in 10% of patients, pin tract infection was seen in six patients (20%),. Late Complications distributed as following *;* rotated, Malunion, Deformity "cubitus varus" were found in in three patients (10%), for each of them **(Table 3).** There was a significant higher Baumann angle in cases with rotate supra condylar humeral fractures (87.33±2.08) with (range 85-89), compared to 74.3±4.5 (range 65–80)in the proper anatomical position fracture, p<0.001.

Table 3: Incidence of postoperative complications

Postoperative complications		n.(%)
Postoperative complications		
Early complications	Radial nerve Neuropraxia	3(10.0%)
	pin tract infection	6(20.0%)
Late complications	Reduction(rotated)	3(10.0%)
	Mal union	3(10.0%)
	Deformity "cubitus varus"	3(10.0%)

While Allover Baumann angle mean was 75.6±5.9,with range (65-89). There was a significant higher ROM flexion in cases with rotate supracondylar humeral fractures (133.9±4.9) with (range 125-140), compared to 115±5 (range 110–120)in the proper anatomical position fracture, p<0.001.While Allover ROM flexion mean was 132±7.5,with range (110-140). There was no difference of ROM extension in cases with rotate supracondylar humeral fractures (5±5) with (range 0-15), compared to 3.3±2.9 (range 5-5)in the proper anatomical position fracture, p>0.05.While Allover ROM extension mean was 4.8±4.8,with range (0-15) **(Table 4).**

Table 4: Comparison of Baumann angle, ROM flexion, ROM extension in Proper anatomical site cases and rotated cases (n. 30):

	Rotated n.3	Proper anatomical n.27	total	t	p
Baumann angle(N64:81) Mean ± SD (range)	87.33±2.08 85-89	74.3±4.5 65-80	75.6±5.9 65-89	4.8	<0.001*
ROM flexion(N:130:140) Mean ± SD (range)	133.9±4.9 125-140	115±5 110-120	132±7.5 110-140	6.4	<0.001*
ROM extension(N: 0:10) Mean ± SD (range)	5±5 0-15	3.3±2.9 0-5	4.8±4.8 0-15	0.48u	0.63
t: student's t test, *p<0.05= significant , p>0.05=no- significant					

DISCUSSION

Children between the ages of three and ten are most commonly affected by supracondylar fractures of the humerus, which make up 50–70% of all elbow fractures in children and adolescents. The best course of action for treating displaced supracondylar fractures has not been universally agreed upon. A number of therapeutic approaches have been suggested, such as traction, open reduction and internal fixation, closed reduction and percutaneous pinning, and closed reduction and plaster immobilization. [12].

The current study's objective is to assess Dorgan's Technique's clinical and radiological results in fixing supracondylar fractures. Thirty children with supracondylar humeral fractures repaired with Dorgan's Technique were the subjects of this prospective investigation. Between February 2024 and July 2024, the Orthopedic department of Zagazig University Hospitals used a variety of suggested pinning procedures. Swenson et al. [13], Flynn et al. et al. [14], and Nacht et al. et al. [15], across the medial and lateral epicondyles, with two pins placed medially and laterally. With a documented incidence of 2–8%, the possibility of iatrogenic ulnar nerve injury is always a worry while inserting the medial pin. Arino et al et al., [16] suggested that in order to prevent damage to the ulnar nerve, the two wires be inserted through the lateral epicondyles. Biomechanically, the two lateral pins' fixation is less secure because it can permit the fracture to rotate, causing the medial column to rotate posteriorly. It was discovered that using two lateral parallel pins instead of medial and lateral pins reduced the force needed to generate 10° of rotation by 37%.

Dorgan's side cross wiring, also known as crossed lateral pin fixation with ascending and descending K-wires, is a modified cross-wire technique used to prevent injury to the ulnar nerve and achieve stability. Only the lateral side is intended to have cross-wire fixation. [17].

Ziont et al., [18] showed that using a cross-pinning configuration greatly increased stability, while parallel pinning was thought to be less effective. Lee et al., [19] using a saw bone model, it was discovered that in axial rotational testing, the cross-pinning model was more stable than the parallel pinning model. Memisoglua et al., [20] determined that the biomechanical characteristics of all lateral crossing pins (Dorgan's approach) were superior to those of the two laterally parallel and laterally divergent pins, and they were biomechanically equivalent to the crossed medio-lateral.

The number and diameter of pins required to treat displaced pediatric SCHF fractures were the subject of numerous biomechanical research. Pradhan et al., [21] showed that setups with a medial pin were more stable than those without at both 15 and 25 degrees of rotation. The most stable design overall in their samples was two lateral pins and one medial pin, which was followed by three lateral pins, two lateral pins, and one lateral and one medial pin. Whether comparing small or large pin models, this result held true. With larger diameter pins, more torque was needed to generate 15 and 25° of rotation. Additionally, the crossed pin designs with small pins were stronger than both lateral pin arrangements with large pins when comparing the torque needed to generate 15 and 25° of rotation. They came to the conclusion that pins with a bigger diameter offer more resistance to torsional stress. The fracture stability is affected by the pin's diameter. The pin size in our study was determined by the child's body weight (1.5 mm for children under 20 kg and 2 mm for those over 20 kg). Other than the fact that the more wires used in fixation, the earlier ROM could be begun, there was no difference in the results between utilizing two, three, or four wires.

In this work, we examined Dorgan's percutaneous lateral cross-wiring method for lateral side supracondylar humeral fractures. The crossed-wire arrangement produced by inserting both wires from the lateral side is the same as that produced by the conventional medial and lateral approach, despite the lack of supporting biomechanical data. Unless the proximally implanted wire is forced through the medial condyle, the ulnar nerve is not in danger. The more proximal wire could theoretically cause damage to the radial nerve during insertion. However, by entering the skin slightly posterior to the mid-coronal plane, one can bypass the

radial nerve, which is located anterior to the lateral intermuscular septum at this level.

El-Adl et al., [12] Percutaneous lateral cross-wiring was used to treat 70 children with displaced type II and III supracondylar fractures of the humerus between January 2006 and January 2007. The average age of the 16 females and 54 boys was 6.1 ± 3.07 years. The Dorgans percutaneous lateral cross-wiring approach was used to operate on all patients within twenty-four hours of the trauma. The average duration of patient follow-up was 6.1 ± 2.6 months.

In our research In cases of adequate union of supracondylar humeral fractures, the mean healing time was 5.4±0.8 weeks, with a range of 4-6 weeks. In cases of mal-union, the mean healing time was 5.7±0.58, with a range of 5-6 weeks. The current study's overall mean bone union time was 5.5±0.77 weeks, with a range of 4–6 weeks. In terms of clinical outcome, the mean Baumann angle for all cases was 75.6±5.9, with a range of 65–89, while the mean Baumann angle for cases with rotate supra condylar humeral fractures was 87.33±2.08, with a range of 85–89, compared to 74.3±4.5, with a range of 65–80, in the proper anatomical position fracture. Compared to 115±5 (range 110–120) in the normal anatomical position fracture, cases with rotate supracondylar humeral fractures had a significantly larger range of motion (ROM) flexion (133.9±4.9; range 125–140). The range of the Allover ROM flexion mean was 110-140, with a mean of 132±7.5. There was no difference in range of motion extension between instances of rotated supracondylar humeral fractures (5±5) with (range 0-15) and those with normal anatomical position fractures (3.3±2.9; range 5-5). The Allover ROM extension ranged from 0 to 15, with a mean of 4.8±4.8. Three patients showed an increase in carrying angle (cubitus varus).

Phan et al., [22] revealed that range of motion functional outcomes evaluated using Flynn's criteria were 87.5% excellent, 10.5% good, 2% fair, and 0% bad. 75% of cosmetic effects were great, 19% were good, 2% were fair, and 4% were poor, as determined by changes in the carrying angle. The final result was taken into account for the combined evaluation, thus if the functional results were outstanding but the cosmetic results were mediocre, the total result would be mediocre. The study's overall findings, which included two cases of elbow deformity, were 96% satisfactory and 4% poor. According to Flynn's criteria, our study's functional outcomes for range of motion were 93.3% outstanding, 3.3% good, 3.3% fair, and 0% bad. As determined by variations in the carrying angle, the cosmetic results were 90% superb, 6.6% acceptable, 3.4% fair, and 0% poor. In three instances, the cubitus varus (carrying angle) increased.

Ducic et al., [24] found that patients treated with Dorgan's approach had an outstanding outcome in 90 cases, whereas those treated with a typical pin design had an excellent outcome in 89.5% of cases. Patients treated with Dorgan's approach experienced a longer procedure time and a much higher radiation exposure. Early postoperative problems in our study included radial nerve neuropraxia in 10% of patients, pin tract infection in 6% of patients, and late sequelae, which were twisted, malunion, and deformity "cubitus varus" in 3% of each patient.

Queally et al., [23] revealed that three individuals experienced pin-site infections as a result of postoperative difficulties; these were managed with an oral antibiotic course. None of the patients needed the wire to be removed too soon. Topical silver nitrate was used to treat six patients who developed significant granulation tissue at the pin sites. Six patients (20%) in our study had an early postoperative pin tract infection after taking oral antibiotics.

Ducic et al., [24] found that 71 patients treated using normal techniques had 9.9% iatrogenic ulnar nerve injury, while individuals treated using Dorgan's method did not experience any neurological issues. Four patients experienced sensory loss, which resolved on its own after three months, whereas two patients experienced motor function loss, which returned between two and five months later. In every instance, nerve function was fully restored.In 10% of the patients in our study who had radial nerve neuropraxia healed after two months, we observed that the proximal K wire should be inserted into the skin somewhat posterior to the mid-coronal plane..

Sadek et al, [25] found that, in terms of postoperative clinical and radiological outcomes, there was no discernible difference between the

lateral cross-wiring procedure and conventional lateral pinning. Although lateral cross wiring may be more stable, there is no discernible difference in the final clinical outcomes, and cross lateral method is a little more challenging and may theoretically result in iatrogenic radial nerve damage. In terms of fracture stability,early results of the lateral cross-pinning technique for pediatric supracondylar humeral fractures is comparable to the traditional cross-wire technique; however, it is superior in terms of ulnar nerve safety. Although it is better at establishing fracture stability, it is comparable to other lateral entrance procedures in preventing damage to the ulnar nerve. It might be a good choice for treating children's misplaced supracondylar fractures and for future study with a large sample size and long term follow up would provide a better evaluation for percutaneous fixation by cross-pinning techniques

CONCLUSION

In order to achieve excellent functional, esthetic, and radiological results, the lateral cross-pinning approach offers a biomechanically stable fixation that permits early and safe active elbow movements. Without putting the radial nerve in jeopardy, a correctly executed Dorgan's approach totally eliminates the possibility of iatrogenic ulnar nerve damage.

Disclosure of Conflict of interests: there is no conflict of interests

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