

# Evaluation of Percutaneous Pinning Techniques in Management of Pediatric Supracondylar Humeral Fractures

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## Abstract

**Background:** Supracondylar fracture institute 60-65% of the fractures nearby the elbow joint classified according to modified Gartland's criteria. The closed reduction and percutaneous pinning fixation are the best broadly recognized way of management, but disagreement stays about the pin fixation techniques.

**Aim of the study:** To the evaluation of percutaneous pinning techniques in the management of displaced supracondylar humeral fractures Gartland type II, III.

**Materials and method:** A prospective analysis of 30 patients admitted in the Orthopedic Department of Zagazig university hospital in the period between Jan 2019 and Jul 2019. Type II was affected in 24 patients and type III was 6 patients, were randomized into two groups-lateral pin fixation (n=22) and medial-lateral pin fixation (n=8). Everyone in the patient's primary assessment was achieved for the loss of reduction, vascular, and iatrogenic ulnar nerve injury. The patients were assessed clinically by Flynn criteria post-operatively.

**Results:** Regarding Flynn's criteria, satisfactory was 86.7%, which is excellent, and Unsatisfactory was 13.3%, which is fair and poor. Regarding complications, there is no case of vascular injury or Cubits Varus, and the Pin tract infection was 13.3%, and Ulnar nerve injury was 3.3%. The unsatisfactory group was significantly associated with associated injuries and significantly associated with loss of reduction, pin tract infection, and ulnar nerve injury.

**Conclusions:** The closed reduction and percutaneous K-wire fixation are reliable, minimally invasive, rapid, and a consistent method for treatment of unstable type II, III Gartland supracondylar fractures in pediatrics with small or minimal complication.

**Keywords:** Pediatric Supracondylar humerus; Humeral fractures in children; Percutaneous pinning

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## Introduction

Supracondylar fracture of the humerus is the second frequent types of bone injury in children; Supracondylar fractures institute 60–65% of the fractures nearby the elbow joint, with a greatest incidence between 4-7 years of age in children [1,2].

The fracture is classified, according Gartland's criteria as the Gartland type I, II and III type I fracture is in place and not displaced, type II and III are unstable with present displacement and angulation in the fracturesite, children are prone to this fracture by the bending structure and the weak metaphyseal sclerosis in the distal humerus in addition to the thin ridge of bone in metaphyseal area between the coronoid fossa and the olecranon fossa [3].

The impact transmitted to the outstretched hand causes the elbow to hyperextend when falls lead the olecranon to gather most of the impact at the humeral supracondylar and the axial force is converted to a bending force at this region, resulting in the extension-type

supracondylar humeral fracture which is most common type 95-98%. And a fall on the olecranon with elbow flexed leads to the flexion-type supracondylar humeral fractures rare type <5% [4].

The main complications related to supracondylar humeral fractures are neurovascular damage, malunion and ischemic contracture. The management of Gartland type I supracondylar fractures fixation with cast is a main way to prevent the displacement of fracture segments and according to same classification Gartland type II, III displaced fractures fixation with closed reduction and percutaneous transphyseal Kirschner wires is the best widely accepted technique of treatment. The implants are inert, cheap to manufacture and provide adequate fixation. They are most employed in a percutaneous fashion with the ends left protruding from the skin to facilitate subsequent removal, but controversy continues regarding the techniques of pin fixation [5,6].

In this study, the effectiveness in terms of stability, iatrogenic ulnar nerve and functional outcome in medial-lateral entry pin and lateral entry pin fixation of displaced supracondylar humeral fractures of the



pediatric will be discussed [7].

The aim of this work is to evaluation of percutaneous pinning techniques in the management of displaced supracondylar humeral fractures Gartland type II, III from 3 to 12 years age of pediatric.

## Patients and Methods

### Study design and settings

In the Orthopedic Surgery Department, Zagazig University Hospitals, after taking an informed consent from child's fathers or near relatives and approval from the institute ethical committee, since January 01, 2019 through July 01, 2019 a prospective cohort single blinded randomized control study was conducted on 30 children with supracondylar humeral fractures.

### Inclusion criteria

- Aged Between 3 and 12 years.
- Closed supracondylar humeral fracture Gartland types II and III.
- Duration of injury <14 days.

### Exclusion criteria

- Compound fracture.
- Duration of injury more than 14 days.
- Inability to take portion in postoperative rehabilitation.
- Medical problem contraindications to surgery.
- Fracture requiring open reduction.
- Previous ipsilateral elbow fracture.

### Patients

30 patients that included in this study, graded according to Gartland's classification as Extension type II fracture in the 20 cases (66.6%), Extension type III fracture in the 10 cases (33.3%). the age incidence ranged from 3 to 12 years, and mean age was distributed as  $6.36 \pm 2.26$  of patients, regard sex distribution male represent majority with 70% and female 30%.

### Mechanism of injury

All studied group were caused by fall down (FD).

### Associated injuries

Only 10.0% from the patients had associated injuries 6.7% neurological and 3.3% vascular.

### Methods

#### Complete clinical picture taking before intervention:

- The personal history (name, age and sex) of the patient.
- Complaint of the patient.
- Present history.
- Past history.

**Careful clinical examination:** It was achieved to assess the neurovascular state, skin condition and to detect any associated fractures in the affected limb or elsewhere in the body. Routine laboratory works up.

**Imaging:** All patients need X-ray films; AP/LAT view.

**Assessment:** Radiographic evaluation is performing by AP and true Lat views at 1, 3, and 6 weeks and at 3 months, Clinical evaluation is grading according to carrying angle and elbow range of motion using Flynn criteria, excellent and good results are considered satisfactory while fair and poor results are considered unsatisfactory.

**Surgical Technique:** The patient was placed in supine position on the operating table under general anesthesia with the affected limb on a hand table, without a tourniquet, followed by draping of the limb.

Longitudinal traction and counter traction should be applied by the surgeon and an assistant with the slightly flexed elbow for about 2 min. Any displacement can be corrected by careful handling when the fragments are out to length. The olecranon was palpated and then pushed anteriorly to correct the posterior displacement. The elbow was flexed to about 45°C then externally rotated to correct the internal rotation deformity commonly present. With pressure continued the olecranon the elbow was flexed maximally, clinical assist point of elbow.

Once the fracture was reduced completely there was usually no block to full flexion, used the posterior soft tissue hinge to stabilize the fracture. Incomplete flexion suggests an incomplete reduction. The proximal forearm bones are inevitably overlaid the elbow joint on this view making it difficult to assess the quality of the reduction. Fluoroscopic images taken with the shoulder in both internal and external rotation yield oblique views which give good views of the reduced lateral and medial columns. As applying internal or external rotation at this stage to obtain the lateral view may cause in rotation at the fracture site and loss of reduction in unstable fractures, it was better to switch the C-arm into the horizontal position around the hand table to obtain a good lateral view.

The key point to see on the lateral radiograph is the distal part was rotated or not. If the rotational deformity was corrected completely, the thickness of the proximal and distal part at the fracture site should be the same. Once the fracture reduction has been confirmed in both views, the arm was fixed in full flexion by the assistant to maintain the reduced position. It was principally important to make sure that the wire which will appoint the most distal aspect of the medial column is not too close to the fracture site.

In case of two lateral divergent wires fixation, a Kirshner wire was inserted through an entry point lateral to the olecranon selected using the image intensifier to provide an AP view. It was significant to preserve the humerus parallel with the arm board, and to remember that the epicondyles lie slightly anterior in the sagittal plane of the anatomical axis in the humerus. Later, the wires should be slightly backwards in direction. The entry point should let a second divergent wire to be passed. the wires were pushed up to the cortex resistance is absent indicating they are just across the cortex. Note that when introducing divergent wires, the wire will usually cross outside the skin.

The position of the k-wires and reduction of the fracture weremaking sure on AP and lateral views. If the wires were in a good position in both views, the fracture was usually satisfactorily stable to allow the arm to be externally rotated to plan the lateral view. If there was any hesitation, then the image intensifier should be rotated over the top rather than rotating the child's arm. If the fracture is stable, the elbow extended to get an AP view and to inspection the carrying angle, which can be compared with the other arm. The wires are bending over and cut, being left percutaneous.



In cases of two crossed wires, after checking the position by means of radiographic controls, K-wire is inserted just above the Sulcus Ulnaris (check by palpation). The diameter of the wires according to the age did not exceed 1.2 to 1.8 mm.

The K-wire was inserted until it hits the bone and then drilled in. By this method, the chances of torsion of the ulnar nerve around the K-wire are as small as possible. The K-wire crosses and was cut off just above the skin so that they can be easily removed later. In cases of sever edema that we could not feel the medial epicondyle, stab wound above the medial epicondyle was done and the medial wire was inserted under vision to avoid ulnar nerve damage.

Finally, the wires were dressed with an iodine-soaked sponge or gauze dressing and a long arm plaster back slab applied with the elbow flexed at a right angle. At the end of the procedure the radial pulse should be examined and documented.

## Results

Among the 30 studied patients, Time of union was distributed as  $3.36 \pm 0.61$  with minimum 3 and maximum 5, 80% were Anatomical reduction regarding radiological assessment and only 6.7% had medial displacement and 13.3% had posterior displacement, regarding Flynn 86.7% had satisfactory (excellent and good) and 13.3% had Unsatisfactory (fair and poor) (Table 1). No case of vascular or Cubitus Varus, superficial Pin tract infection were 13.3% and Ulnar nerve injury 3.3% (Table 2).

Unsatisfactory group significant associated with associated injuries and significantly associated with displacement and pin tract infection also with ulnar nerve injury (Table3).

## Captions of patients cases

Female patient 3 years old admitted to the hospital with history of fall down with displaced fracture right supracondylar humerus Garlands

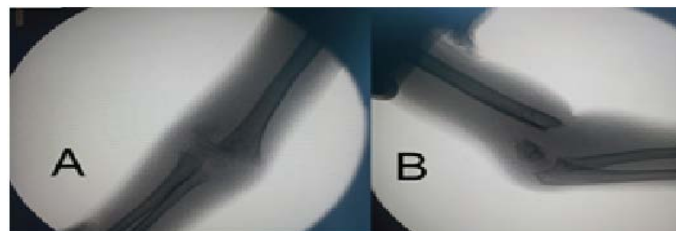
**Table 1:** Outcome characters distribution among studied group.

		Time of union	
Mean±SD		3.36±0.61	
Median (Range)		3.0 (3-5)	
		No	%
Flynn cosmetic	Poor	1	3.3
	Fair	3	10.0
	Good	14	46.7
	Excellent	12	40.0
Flynn function	Poor	1	3.3
	Fair	3	10.0
	Good	14	46.7
	Excellent	12	40.0
Radiological	Anatomical reduction	24	80.0
	Medial displacement	2	6.7
	posterior displacement	4	13.3
Flynn	Satisfactory	26	86.7
	Unsatisfactory	4	13.3
	Total	30	100.0

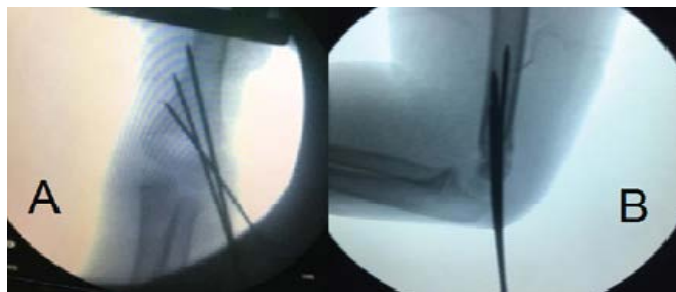
**Table 2:** Complication distribution among studied group.

Complication	No	%
Vascular	0/30	0.0%
Pin tract infection	4/30	13.3 %
Ulnar nerve injury	1/30	3.3%
Cubitus Varus	0/30	0.0%

type III, Procedure done by using closed reduction, percutaneous pinning technique with three lat pins. time for union was 4 weeks. Time of full range of motion was 6 weeks and clinical evaluation by Flynn criteria was excellent. No Postoperative complication (Figures 1 and 2).



**Figure 1:** Lt Supracondylar humeral fracture Gartland type III, pre CRPP intraoperative C-arm x-ray anteroposterior(A) and lateral views(B).



**Figure 2:** Lt Supracondylar humeral fracture post CRPP with three lateral pins, intraoperative C-arm x-ray anteroposterior(A), and lateral views(B).

## Discussion

Fractures around the elbow joint about 10% of all pediatric orthopedic trauma, and supracondylar humeral fractures account for 60-70% of all elbow fractures. There are numerous treatment modalities for the supracondylar fractures of the humerus in children including closed reduction and casting, percutaneous pinning or open reduction and wire fixation. Closed reduction pinning percutaneous is widely accepted, has become the treatment of choice for displaced fractures and gives the lowest rate of lasting deformity and lowest rate of compartment syndromes of forearm [8].

Debate exists about the best K-wire pattern in the fixation of supracondylar fractures. Two principal configurations have presented in the literature: crossed pins (medial and lateral) and two lateral pins [9].

The classic medial-lateral cross-wire technique included the placement of two ascending K-wires, one of them inserted through the lateral condyle and the other through the medial condyle. With this technique, the ulnar nerve could be injured by the medial wire as it is passed through the medial condyle. Ulnar nerve injury rates of up to 6-8% have been reported [10].

To prevent ulnar nerve injury, two parallel K-wires may be placed through the lateral cortex as an alternative method of fixation and avoiding placement of K-wire medially. However, this technique is believed to be biomechanically less stable than the cross-wire configuration [11]. To reach stability and avoid ulnar nerve injury, a modified version of the cross-wire technique, lateral crossed pin fixation with ascending and descending K-wires Dorgan's lateral cross-wiring, has been suggested, where cross-wire fixation is achieved just from the lateral side [12].



**Table 3:** Relation with outcome.

			Satisfactory	Unsatisfactory	t/Mann Whitney / X <sup>2</sup>	P
Age			6.3±2.21	6.75±1.7	-0.358	0.723
Time before surgery			1.61±0.84	2.0±1.5	Z=-0.584	0.564
Time union			3.30±0.54	3.75±0.95	-1.359	0.185
Sex	Male	N	19	2	-	
		%	73.1%	50.0%	-	
	Female	N	7	2	0.87	0.34
		%	26.9%	50.0%	-	
Side	Left	N	12	3	-	
		%	46.2%	75.0%	-	
	Right	N	14	1	1.15	0.28
		%	53.8%	25.0%	-	
Associated injury	-	N	25	2	-	
		%	96.2%	50.0%	-	
	Neurological	N	1	1	9.64	0.008*
		%	3.8%	25.0%	-	
	Vascular	N	0	1	-	
		%	0.0%	25.0%	-	
Gartland	II	N	18	2	-	
		%	60%	50.0%	-	
	III	N	8	2	2.59	0.107
		%	26.7%	50.0%	-	
Technique	Lateral	N	19	3	-	
		%	84.6%	75.0%	-	
	Medial lateral	N	7	1	0.23	0.63
		%	15.4%	25.0%	-	
Radiological	Anatomical reduction	N	24	0	-	
		%	92.3%	0.0%	-	
	Medial displacement	N	0	2	21.34	0.00**
		%	0.0%	50.0%	-	
	Posterior displacement	N	2	2	-	
		%	7.7%	50.0%	-	
Pintract infection	No	N	26	0	-	
		%	100.0%	0.0%	-	
	Yes	N	0	4	30.0	0.00**
		%	0.0%	100.0%	-	
Ulnar nerve injury	No	N	26	3	-	
		%	100.0%	75.0%	-	
	Yes	N	0	1	21.66	0.00**
		%	0.0%	25.0%	-	
Total	N	26	4	-		
	%	100.0%	100.0%	-		

In our study, time of union was distributed as 3.36±0.61 with minimum 3 weeks and maximum 5 weeks, 80%.

Regarding complications, no case of vascular or Cubitus Varus, Pin tract infection were 13.3% and Ulnar nerve injury 3.3%. Unsatisfactory group was significantly associated with associated injuries and significantly associated with displacement and pin tract infection also with ulnar nerve injury.

In the 20 cases of Shannon FJ, et al. (2004) all children had a full range of elbow motion correlated with their normal side, and the mean carrying angle of the injured elbow was 15° (Range:10°-20°). There were no intraoperative complications, involving ulnar nerve injuries. All complications were related to K-wires [13].

Ozturkmen Y, et al. (2005) have evaluated closed reduction and lateral pin fixation in 39 children with displaced supracondylar fractures of the humerus. They noticed that complications such as pin

tract infections, myositis ossificans, compartment syndrome or nerve injuries did not occur, and the functional and radiographic results were satisfactory in all children (100%) [14].

Sibinski M, et al. (2006) reviewed the clinical and radiological notes of 131 children fixation by lateral wires fixation 66 children and crossed wires 65 children. They see no change in outcome between the two groups either clinically or radiologically in value of outcome. However, 6% of children treated with crossed fixation postoperatively suffered from ulnar nerve injuries, while none occur of the group with laterally inserted wires, so they advise management of supracondylar humeral fractures with two or three lateral wires put in parallel or in a divergent fashion [15].

In a similar series from Wael A, et al. (2008) Cubitus Varus deformity was noted in six patients (8.6%). They related it to unsatisfactory reduction of the fracture before pinning [16].





Osman M, et al. (2014) found that 8 patients (25%) developed mild pin-site infections, which were treated with a course of oral antibiotics without early removal of the wire in any patient [17]. 13 patients about (40.6%) developed excessive granulation tissue at the pin sites, especially around the proximal wire, which was treated with topical silver nitrate. Mild Cubitus Varus deformity occurred in 2 patients (6.3%), in whom the reduction quality was unsatisfactory. Regarding neurological examination, the three patients who had arrived with anterior interosseous nerve deficit at the time of injury had recovered from this deficit within 3 months of their injuries. There was no case of iatrogenic ulnar or radial nerve injury. No iatrogenic vascular injury was noted. They established that the lateral cross-pinning technique offers fracture stability and ulnar nerve safety.

Bhuyan BK, et al. (2012) evaluated the role of fixation of the displaced supracondylar humeral fracture in children by closed reduction and K-wire fixation percutaneous. They established that closed reduction and percutaneous pinning is a sound and effective modality for the treatment of displaced supracondylar fractures even in the presence of swelling. With the advantages of decreased duration of hospital stay, stable fixation and early mobilization resulting satisfactory functional outcome and cosmetics [18].

Scaglione M, et al. (2012) managed 125 patients' emergency or within 12-hour, reduction and two percutaneous pin fixations at the lateral entry. The mean age was 7.5 years. The mean follow up was 8.2 years. They used the Wilkins-modified ranking of Gartland. Using the Flynn criteria, they assessed 125 patients: 100 percent of patients had no elbow joint mobility impairment. They had seven deviations from the valgus, one of which was over 10°. They also had 17 variations of Varus, 11 of which were not above 8° and only two were 15°. Baumann angle normal value was calculated as high as 16°. The findings acquired were categorized as very good 80%, good 11%, sufficiently enough good 6%, and bad 3%. All Gartland's Type II and III fractures must be operated within 12 h with a closed reduction and stability method with K-wire lateral entry. Only in type I fracture is suggested the conservative cast therapy. Trans-olecranon treatment is not feasible owing because leading to the stiffness, the danger of iatrogenic ulnar lesion, and long-term hospitalization. The open reduction continues the therapy of first option for non-reducible fractures and in vascular injury cases [19].

Clinically and radiographically, Pavone V, et al. (2016) compared the effectiveness of SCHF fixation and the complications with the two already the most common percutaneous K-wire pinning: cross-and lateral configurations [20]. Between May 2005 and December 2012, they studied 35 kids registered. 2 different pin modules were used in patients, crossed (Group1) and lateral (Group 2). Evaluation Clinical and radiographic was carried out after the surgery. Postoperatively, the clinical evaluation demonstrated restoration of the elbow's joint function. Two patients of brief paresthesia were recorded in group 1, one patient of slight Varus, mild asymmetry, and decrease of humerus extension, two patients of local infection and one patient of a slight hyperextension in group 2. They indicated that there was no important distinction between using the cross and lateral K-wire techniques; both groups had satisfactory results, Both techniques were similar, both clinically and radiographically, although in the cross-wired configuration there is a higher chance for neurovascular injuries than the lateral K-wire.

Stability studies had established that crossed pins supported the best stability. Using an adult human cadaver model, Zions LE, et al. (1994) fixed with four different wires patterns and measured the distal

fragment resistance to rotation in supracondylar humeral fractures of model [21]. They create that the crossed-wire pattern, placed from the medial and the lateral condyles, was most stable procedure. They supported the use of the crossed-pin pattern, but mentioned that with significant swelling, the two lateral parallel pins could be considered as an inferior but acceptable option.

However, the weakness of this study is the smaller numbers of the patients and the duration was shorter than other studies, but the result came as an approach to the results of the similar previous studies.

## Conclusion

Closed reduction and K-wire fixation percutaneous is a rapid, slightly invasive, safe, and a reliable method for treatment of unstable supracondylar fractures in pediatrics with less or minimal complication. Fixation of the pediatrics supracondylar humeral fractures by using lateral entry pinning or medial-lateral entry pinning is without difference in prevention of complications and gets the best outcome of the patient.

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