

EVALUATING CLOSED VS. OPEN REDUCTION TECHNIQUES FOR SUPRACONDYLAR HUMERUS FRACTURES IN CHILDREN

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Abstract

This study aimed to evaluate the outcomes of two surgical methods—closed reduction with percutaneous pinning (CRPP) and open reduction with internal fixation (ORIF)—in the treatment of supracondylar fractures of the humerus in children. A total of 40 pediatric patients with Gartland Type 3 supracondylar fractures were treated at Al-Hussein Teaching Hospital, Samawa city, between 1st September 2022 and 1st May 2023. The study sample included 26 male and 14 female patients, with an average age of (mean age to be filled). The fractures were classified into 35 cases of extension type and 5 cases of flexion type. Patients were treated with either CRPP (20 cases) or ORIF (20 cases), with the procedures performed under general anesthesia and imaging guidance.

The primary aim was to compare the effectiveness of CRPP and ORIF in terms of anatomical outcomes, including Baumann's angle, carrying angle, and loss of mobility. Follow-up assessments were performed weekly for the first month and biweekly for the next two months, with radiological evaluations using anteroposterior (AP) and lateral elbow views.

The findings indicated that CRPP provided superior results when compared to ORIF in terms of preservation of anatomical alignment and functional outcomes. The CRPP group showed minimal deviations in Baumann's angle and carrying angle, as well as better maintenance of elbow mobility. Moreover, the incidence of complications was lower in the CRPP group. The study also examined variables such as sex, fracture mechanism, and limb side, all of which were consistent with typical patterns of supracondylar fractures in children.

In conclusion, the CRPP technique was found to be more effective than ORIF in treating supracondylar fractures in children, offering better functional outcomes and fewer complications. These results suggest that CRPP should be considered as the preferred method for managing these fractures in pediatric patients.

Keywords: Supracondylar fracture, Children, CRPP, ORIF, Baumann's angle

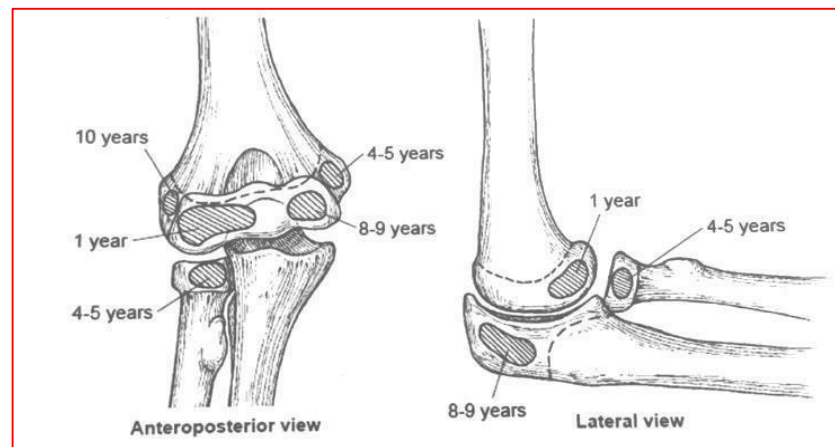
Introduction Definition

One sixteenth of all paediatric fractures and two-thirds of all paediatric elbow injuries requiring hospitalisation are supracondylar fractures, making them the most prevalent kind of elbow injury in children. Supracondylar fractures are most common in children aged 6–7.

Anatomy

One synovial joint in the upper limb connects the arm to the forearm; this joint is called the elbow joint. The three bones that make up the forearm—the ulna, the radius, and the humerus—articulate at this position. According to its structural makeup, the elbow joint is a synovial joint. At one year of age, the capitellum is the first to emerge. After the radial head and medial epicondyle start to ossify around four to five years old, the trochlea and olecranon epiphysis start to ossify about eight or nine years old. In most cases, the lateral condyle does not develop until about the age of 10. The supracondylar region is more prone to fractures because it goes through remodelling between the ages of 6 and 7, becoming thinner and having a more slender cortex. Due to its arrangement in two columns joined by thin bone, the distal humerus anatomy is particularly vulnerable to damage.

Understanding the general order and timing of the different ossification centers within elbow provides landmarks for the physician to define anatomy on radiographs and to treatment.

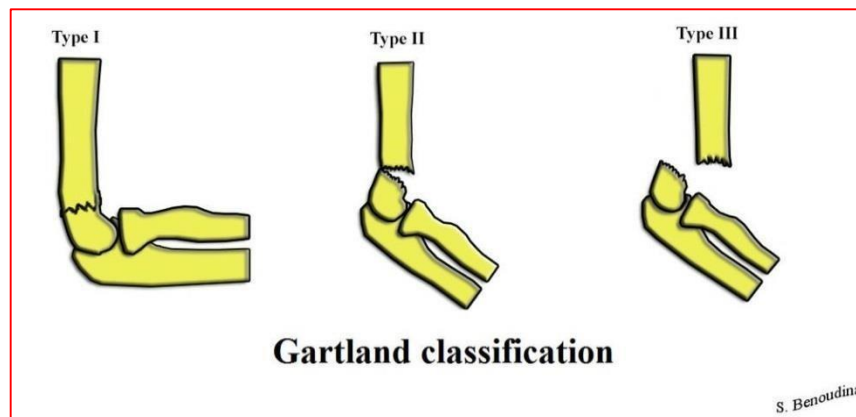


Mechanism of fracture

The most common cause is a fall onto an extended hand, which causes the arm to hyperextend. In almost all instances, the distal piece moves backward. The distal humerus fractures because the olecranon acts as a fulcrum and directs the force onto it when the elbow is hyperextended. A fall onto a flexed elbow is a common cause of the uncommon flexion-type supracondylar fracture. The supracondylar region becomes thin and more susceptible to fractures during remodelling that occurs between the ages of 6 and 7.

Classification (Gartland classification)

Type	Description
1	Non-displaced
11	Angulated with intact posterior cortex
11A	Angulation
11B	Angulation with rotation
111	Complete displacement but have periosteal (medial/lateral) contact
111A	Medial periosteal hinge intact. Distal fragment goes posteromedially
111B	Lateral periosteal hinge intact. Distal fragment goes posterolaterally
1V	Periosteal disruption with instability in both flexion and extension

**Clinical Presentation**

A painful, swelling elbow that the patient is reluctant to move is the clinical manifestation of a supracondylar humerus fracture. Angulated elbow and shorter upper limbs are possible symptoms. Open wounds are seen in up to 30% of these fractures, according to certain data.

Radiological Finding

Radiographs taken of the hurt limb should show the elbow and any other painful or abnormal areas in a lateral and anteroposterior (AP) orientation. As it provides an estimate of the carrying angle—the varus or valgus attitude of the distal humerus and elbow—on the AP view, Baumann's angle is often used for fracture evaluation. The intersection of two lines drawn along the growth plate of the lateral condyle of the elbow and the axis of the

humeral shaft creates what is known as Baumann's angle, which typically ranges from 9 to 26 degrees. When the varus deviates from the proximal humerus, the angle widens. In case further comparison is necessary, radiographs of the opposite elbow should be taken. Every person's Baumann angle is different.



- a) Baumann's angle is obtained on the anteroposterior radiograph by measuring the angle(between a line perpendicular to the longitudinal axis of the humerus and a line parallel to the growth plate of the capitellum.
 (b) The anterior humeral line is a vertical line drawn directly on the anterior aspect of the distal humeral shaft that should pass through the mid- portion of the capitellum.

Patients and Methods

In this study (40) patients were collected with the supracondylar fracture of humerus with class (3) according to Gartland classification. They sent for anteroposterior and lateral X-ray. The patient assessed radiologically with the Baumann's angle and clinically with carrying angle and loss of motion. Twenty patients underwent closed reduction and fixation with two K-wires under general anesthesia and imaging control. Twelve of these patients treated with the lateral pin fixation and the other eight patients treated with medial – lateral pin fixation. The remaining twenty patients underwent open reduction and internal fixation with two K-wires through posterior approach. We evaluate the age, the sex, the side affected, the type of fracture and mechanism of injury. We followed up the patients at first week then at every two weeks for three months through the assessment of Baumann's angle, carrying angle and loss of motion.



Reduction Maneuver

After the image intensifier verified closed reduction, it was executed. At the outset, hyperextension of the elbow and supination of the forearm were used to provide longitudinal traction. A valgus or varus force was applied to the fracture site to rectify the medial or lateral displacement while the traction was maintained. After that, the distal fragment's posterior displacement was fixed by applying a force to its posterior aspect while the elbow was safely hyperflexed and softly hyperflexed; the image intensifier subsequently verified the reduction. An incision was made at the very top of the medial epicondyle to insert the medial pin. The lateral epicondyle served as the site for the insertion of the lateral pin. The lateral fixation method included inserting two or three pins from the outside of the elbow, going through the lateral cortex, and then engaging the medial cortex while the elbow was hyperflexed. The pins were positioned at the fracture site in either a parallel or divergent pattern, making sure there was enough space between them. Prior to engaging the medial cortex while maintaining hyperflexion of the elbow, the lateral pin was introduced from the lateral cortex for the medial–lateral fixation procedure. The procedure included extending the elbow to $\sim 90^\circ$, using the opposite thumb to roll back the ulnar nerve, and inserting the medial pin to engage the lateral cortex while the arm was flexed at $\sim 90^\circ$. Those who suffer from varus can try pronating their forearms with a 90-degree bend.



Results

Table (1): Distribution of age and sex groups according to type of fixation

Mean	CRPP	ORIF	P Value
Age Mean $\pm$ SD	6.8 $\pm$ 2.37	6.70 $\pm$ 2.36	0.895
1-3 years old	2 (10)	2 (10)	0.942
3-6 years old	6 (30)	7 (35)	
>7 years old	12 (60)	11 (55)	
Sex: Male	12 (60)	14 (70)	0.507
Female	8 (40)	6 (30)	

* represent a significant difference at P <0.05.

Table (2): Comparison of mechanism and Type of Fixation

Groups		Fall		FWP		RTA	
		Yes	No	Yes	No	Yes	No
CRPP	Count	7	13	10	10	7	13
	%	30.4%	76.5%	76.9%	37.0%	87.5%	40.6%
ORIF	Count	16	4	3	17	1	19
	%	69.6%	23.5%	23.1%	63.0%	12.5%	59.4%
Total	Count	23	17	13	27	8	32
	%	57.5%	42.5%	32.5%	67.5%	20.0%	80.0%

P value	0.004*	0.018*	0.018*
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* represent a significant difference at $P < 0.05$.

Table (3): Outcome according to side groups and type of fixation

Groups		Right		Left	
		Yes	No	Yes	No
CRPP	Count	13	7	7	13
	%	46.4%	58.3%	58.3%	46.4%
ORIF	Count	15	5	5	15
	%	53.6%	41.7%	41.7%	53.6%
Total	Count	28	12	12	28
	%	70.0%	30.0%	30.0%	70.0%
P value		0.490		0.490	

* represent a significant difference at $P < 0.05$.

Table (4): Outcome according to Loss of carrying angle criteria and type of fixation

Groups		Loss of carrying angle			
		Exc.	Good	Fair	Poor
CRPP	Count	17	2	0	1
	%	65.4%	25.0%	0.0%	50.0%
ORIF	Count	9	6	4	1
	%	34.6%	75.0%	100.0%	50.0%
Total	Count	26	8	4	2
	%	65.0%	20.0%	10.0%	5.0%
P value		0.037*			

* represent a significant difference at $P < 0.05$.

Table (5): Outcome according to Loss of motion criteria and type of fixation

Groups		Loss of motion			
		Exc.	Good	Fair	Poor
CRPP	Count	16	2	1	1
	%	55.2%	28.6%	33.3%	100.0%
ORIF	Count	13	5	2	0
	%	44.8%	71.4%	66.7%	0.0%
Total	Count	29	7	3	1
	%	72.5%	17.5%	7.5%	2.5%
P value		0.403			

* represent a significant difference at $P < 0.05$.

Table (6): Outcome according to Baumann's angle criteria and type of fixation

Groups		Baumann's angle			
		Exc.	Good	Fair	Poor
CRPP	Count	17	2	0	1
	%	65.4%	22.2%	0.0%	100.0%
ORIF	Count	9	7	4	0
	%	34.6%	77.8%	100.0%	0.0%
Total	Count	26	9	4	1
	%	65.0%	22.5%	10.0%	2.5%
P value		0.017*			

* represent a significant difference at $P < 0.05$.

No.	Age (Yrs.)	Sex	Mechanism			Side		Type of fracture	Type of surgery	Loss of carrying angle				Loss of motion			Baumann's angle				P-Value	
			Fall	F.W.P	R.T.A	Right	Left			Exc.	Good	Fair	Poor	Exc.	Good	Fair	Poor	Exc.	Good	Fair	Poor	
1	8	M	Yes				Yes	Extension	CRPP													
2	10	F	Yes				Yes	Extension														
3	6	F		Yes		Yes		Extension														
4	7	M	Yes				Yes	Flexion														
5	9	F	Yes			Yes		Extension														
6	8	M	Yes			Yes		Extension														
7	5	F	Yes				Yes	Extension														
8	5	M		Yes		Yes		Extension			17	2	0	1	16	2	1	1	17	2	0	1
9	8	M	Yes			Yes		Flexion														
10	4	F	Yes			Yes		Extension														
11	7	M	Yes				Yes	Extension														
12	10	M		Yes		Yes		Extension														
13	3	F	Yes			Yes		Extension														
14	6	F	Yes				Yes	Extension														

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15	9	M	Yes			Yes		Extension
16	4	F	Yes			Yes		Flexion
17	2	M	Yes			Yes		Extension
18	10	M			Yes	Yes		Extension
19	7	M	Yes			Yes		Extension
20	8	M	Yes				Yes	Extension
21	6	F	Yes			Yes		Extension
22	9	M		Yes			Yes	Extension

ORIF

9	6	4	1	13	5	2	0	9	7	4	0
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24	8	F	Yes			Yes		Extension
25	7	M	Yes			Yes		Flexion
26	8	M	Yes			Yes		Extension
27	10	M		Yes		Yes		Extension
28	5	M	Yes			Yes		Extension
29	4	F	Yes				Yes	Flexion
30	7	M	Yes			Yes		Extension
31	6	M	Yes			Yes		Extension
32	2	M			Yes		Yes	Extension
33	4	F	Yes			Yes		Extension
34	3	M	Yes			Yes		Extension
35	8	M	Yes			Yes		Extension
36	7	F	Yes				Yes	Extension
37	10	M	Yes			Yes		Extension
38	6	M		Yes		Yes		Extension

39	9	M	Yes			Yes	Extension												
40	10	F	Yes			Yes	Extension												

Table (7): comparison between (CRPP) and (ORIF) methods.

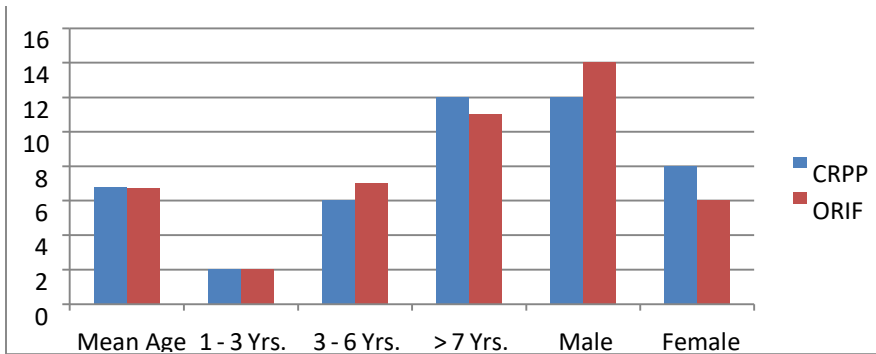


Figure (1): Distribution of age and sex groups according to type of fixation

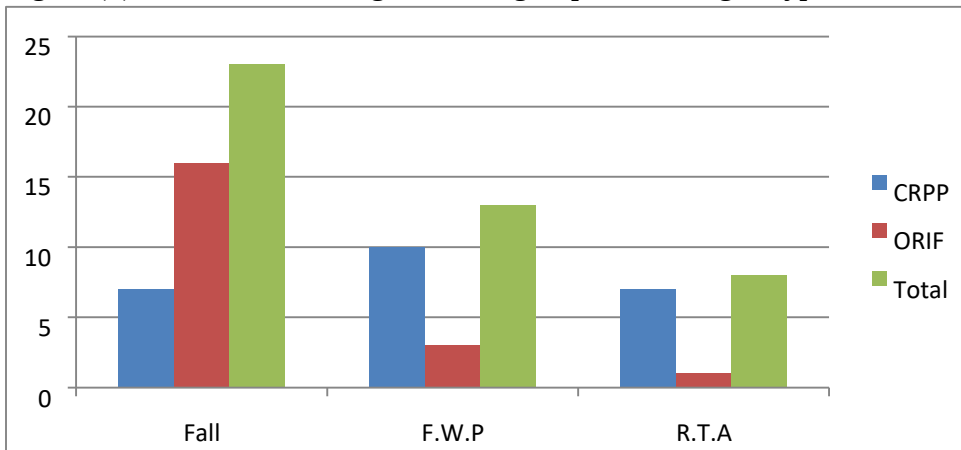


Figure (2): Comparison of mechanism and Type of Fixation

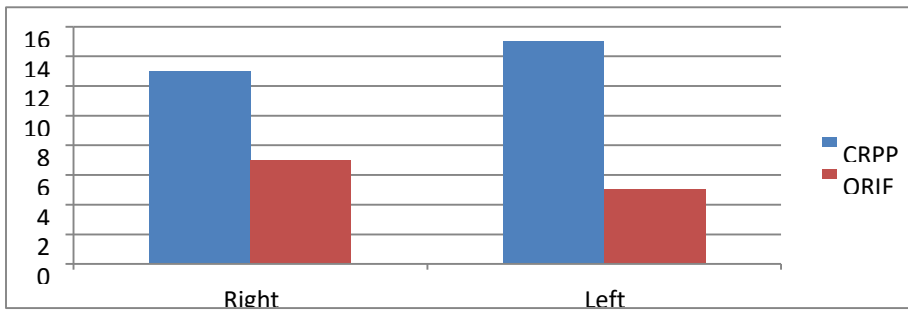


Figure (3): Outcome according to side groups and type of fixation

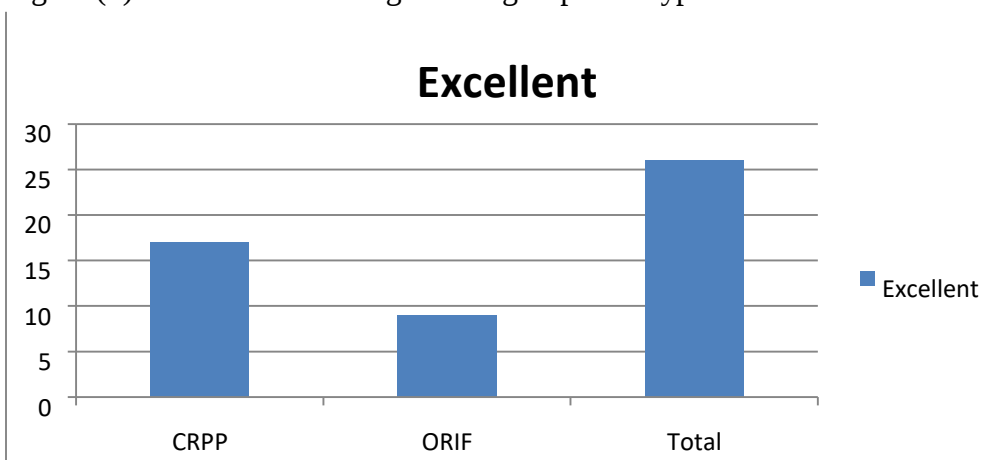


Figure (4): Outcome according to Loss of carrying angle criteria and type of fixation

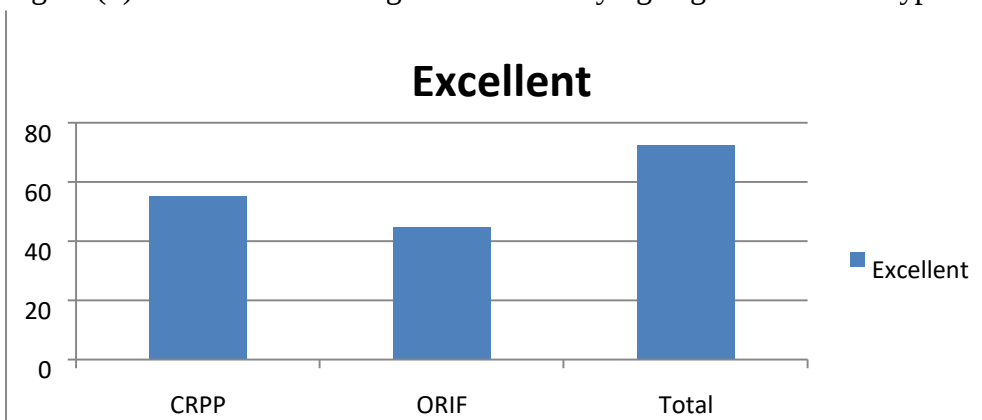


Figure (5): Outcome according to Loss of motion criteria and type of fixation

Discussion

According to Chi-square test we find the following information :

- Regarding the loss of carrying angle and Baumann's angle criteria about 65.4 % were excellent result with the CRPP method, while 34.6 % with the ORIF method, which mean there is a significant result of CRPP better than ORIF method as shown in tables (4) and (6).

- Regarding the loss of motion criteria there is a 55.2 % are excellent results with the CRPP method while 44.8 % with the ORIF method, this indicate also the CRPP method better than ORIF method, so we conclude that the CRPP method is a gold stand method in treatment of supracondylar fracture of humerus in children of class (3) Gartland, due to :-

- 1- Less trauma and safe .
- 2- Least time consuming .
- 3- Cost efficient method .
- 4- Provide stable fixation .
- 5- Short hospital stay .
- 6- Reduce post-operative stiffness.
- 7- Faster recovery .
- 8- Excellent results .

But the disadvantage of CRPP method is iatrogenic ulnar nerve injury, which is the most common complication in this method (4) cases in our study in the medial-lateral fixation, while there is only one case with the ORIF method. Most cases like neuropraxia recovered within three months, if persist so we apply electromyographic measurement and treated accordingly.

- There is a significant association between mechanism of injury and result of technique, which means one the trauma is severe leads to more injury to the bone and tissue which ends in poor prognosis, as shown in table (2).

- There is no significant association between age, sex and side of the injury and the result of method of fixation.

- Cubitus varus deformity (Gunstock deformity) this is because coronal rotation or tilting of the distal fragment. The residual medial tilt after reduction is the most important in the varus angulation. In our study there are two cases with CRPP method and one case with ORIF method.

- Pin tract infections : they are superficial and healed after removing pins and administration of oral antibiotics. In our study we find (4) cases with the CRPP method and two cases with the ORIF method.

- Stiffness : it should be start physiotherapy once removing of the pins. In our study there are two cases with the CRPP method and (5) cases with the ORIF method.

- Myositis ossificans : also it should be start physiotherapy at the early time. In our study there are (3) cases with the ORIF method, while no case recorded with the CRPP method. **Conclusions**

In contrast to the open procedure, the percutaneous approach is a successful surgical treatment modality due to a large list of benefits, even if the outcomes are approximate. Children with displaced supracondylar fractures may benefit from closed reduction with percutaneous pinning because it shortens their recovery time, decreases the need for physical therapy, and decreases the likelihood of complications. Providing outstanding outcomes. Compared to medial lateral fixation, lateral pin fixation spared the ulnar nerve damage.

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