

Percutaneous Lateral Pinning of Type Three Supracondylar Humeral Fracture in Children

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Abstract: Background: Supracondylar fractures of the humerus are the most common fracture of the elbow in children. The majority of these fractures (96–98 %) are extension-type fractures. **Aim of the Work:** The study was targeting at the evaluation of radiographic and functional outcome after closed reduction and lateral percutaneous pinning fixation for fractures of the supra condylar humerus by three k-wires in children. **Patients and Methods:** This prospective randomized-controlled trial included 20 children with Gartland type III supracondylar humeral fractures. They were all treated by closed reduction and lateral percutaneous pinning in Mabret Misr El-Kadema orthopedic department from March 2018 to October 2018. **Results:** In our prospective randomized controlled study, lateral fixation of supracondylar fracture of humerus type three by three k-wires is effective in obtaining stability with good alignment and range of motion at all cases in our study. **Conclusion:** Lateral fixation of supracondylar fracture of humerus type three by three k-wires can avoid ulnar nerve injury and obtain the fracture stability.

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1. Introduction

Supracondylar fractures of the humerus are the most common fracture of the elbow in children. The majority of these fractures (96–98 %) are extension-type fractures⁽¹⁻⁴⁾. Gartland originally described a classification for extension-type supracondylar humerus fractures, dividing them into three types: type I is non-displaced, type II is displaced with an intact posterior cortex, and type III is displaced without cortical contact^(2, 5). The current preferred treatment for Gartland type III fractures consists of attempted closed reduction and percutaneous pinning^(3, 6-8).

The focus of many recent research studies on the treatment of these fractures has been pin configuration. Biomechanical testing has demonstrated a theoretical advantage of both medial and lateral cross pinning; however, these initial findings have not translated into clinical results⁽⁹⁻¹¹⁾. The concern for iatrogenic ulnar nerve injury during the placement of a medial pin discourages this configuration. Slobogean et al. pointed out that there is a greater risk of iatrogenic ulnar nerve injury with crossed pinning versus lateral pinning in children with supracondylar fracture⁽¹²⁾.

Until the late 1990s, it was believed that displaced pediatric supracondylar humerus fractures required emergent surgical intervention or skeletal traction. The theoretical advantage proposed that this would lead to a decrease in perioperative complications, including iatrogenic nerve injury,

compartment syndrome, and conversion to an open reduction^(6, 8, 13, 14). In recent years, many adult trauma hospitals have decreased night-time on-call orthopedic surgery without affecting patient outcomes by allowing dedicated trauma operative time during the day^(15, 16).

In 1999, **Iyengar et al.** published a retrospective review comparing early versus delayed (greater than 8 h following fracture) treatment of 58 patients with type III fractures and showed no difference in terms of clinical results or perioperative complications, including conversion to open reduction⁽⁸⁾. Multiple studies followed showing similar results^(6, 14, 17). Conversely, studies by **Walmsley et al. and Yildirim et al.** showed that delayed intervention resulted in an increase in open reduction but no other perioperative complications^(7, 13). With regards to operative delay leading to open reduction, there is literature supporting both arguments, resulting in a lack of conclusive agreement.

Supracondylar fractures represent 55% to 75% of all elbow fractures. Male to female ratio is 3:2. Most occur in patients 5 to 8 years of age⁽¹⁸⁾.

Aim of the work

The study was targeting at the evaluation of radiographic and functional outcome after closed reduction and lateral percutaneous pinning fixation for fractures of the supra condylar humerus by three k-wires in children.

Patients and Methods

This prospective randomized-controlled trial included 20 children with Gartland type III supracondylar humeral fractures. They were all treated by closed reduction and lateral percutaneous pinning in Mabret Misr El-Kadema orthopedic department from March 2018 to October 2018.

Children with fractures were usually first seen in the emergency section. They were examined, the vascular and neurological statuses were assessed and x-rays of the elbow were done.

Displaced supracondylar fractures requiring a reduction should be initially splinted with the elbow in a comfortable position of approximately 20 to 40 degrees of flexion, while avoiding tight bandaging or splinting. Excessive flexion or extension may compromise the limb's vascularity and increase compartment pressure. The elbow and hand should then be gently elevated above the heart. A careful examination of the neurologic and vascular status is vital in all patients with a supracondylar fracture as well as an assessment of the potential for compartment syndrome. The remainder of the limb should be assessed for other injuries and radiographs should include any area which is tender, swollen, or lacks motion.⁽¹⁹⁾

The inclusion criteria:

- Patients scheduled for closed reduction and lateral fixation of supracondylar fractures of the humerus by three k-wires under general anaesthesia.
- Type III Supracondylar fractures of the humerus
- Patients below 15 years.
- Consent was necessary to participate in the study.

The exclusion criteria:

- Open fractures.
- Gartland type I or type II.
- Fractures with vascular injury.
- Fractures with compartmental syndrome.
- Fractures with pre-operative ulnar nerve injury.
- Refusal to provide an informed consent.

The mean age at presentation was about 7years (range: 2–12 years).

There were 6 girls and 14 boys.

The left elbow was involved in 9 patients and the right in 11 patients.

The mode of trauma was fall to the ground in 9 patients, fall downstairs in 8 patients and fall from height in 3 patients.

There were associated fractures in three patients; One of them had a fracture of the ipsilateral distal radius and was managed by closed reduction and percutaneous pinning in the same sitting. The second patient had a greenstick fracture of the proximal phalanx of the contralateral thumb and was managed

by thumb spica, the third patient had both bones of forearm fractures and were fixed by k-wires in the same sitting.

Surgical Technique:

Positioning

The patient is positioned supine on the operating room table. The fractured elbow is placed on a radiolucent armboard after generally anesthetizing the patient. The arm should be far enough onto the armboard to allow for complete visualization of the elbow and distal humerus. In smaller children, the child's shoulder and head may need to rest on the armboard as well. The wide end of a fluoroscopy unit is sometimes used as a table. The fluoroscopy monitor is placed opposite to the surgeon for ease of viewing.⁽²⁰⁾

Closed Reduction

Traction is applied with the elbow in 20 to 30 degrees of flexion to prevent tethering of the neurovascular structures over the anteriorly displaced proximal fragment. For severely displaced fractures, where the proximal fragment is entrapped in the brachialis muscle, the "milking maneuver" is performed.⁽²⁰⁾

The soft tissue overlying the fracture is manipulated in a proximal to distal direction. Once length is restored, the medial and lateral columns are realigned on the AP image. Varus and valgus angular alignment is restored. Medial and lateral translation is also corrected. For the majority of fractures (ie, extension type), the flexion reduction maneuver is performed next. The elbow is gradually flexed while applying anterior pressure on the olecranon (and distal condyles of the humerus) with the thumbs.⁽²⁰⁾

The elbow is held in hyperflexion as the reduction is assessed by fluoroscopy. Reduction is adequate if the following criteria are fulfilled: The anterior humeral line crosses the capitellum. The Baumann angle is 10 degrees or comparable to the contralateral side. Oblique views show intact medial and lateral columns. The forearm is held in pronation for posteromedial fractures. The forearm is held in supination for posterolateral fractures. For unstable fractures, the fluoroscopy machine instead of the arm is rotated to obtain lateral views of the elbow.⁽²⁰⁾

Once satisfactory reduction is obtained, K-wires can be inserted percutaneously for fracture stabilization. 0.062-inch smooth K-wires are commonly used. Smaller or larger sizes may be used depending on the size of the child. The goals of the lateral-entry pin technique are to maximally separate the pins at the fracture site and to engage both the medial and lateral columns. The pins can be divergent or parallel. Sufficient bone must be engaged in the proximal and distal fragments. Pins may cross the olecranon fossa. As a general rule, two pins are

adequate for type II fractures; three pins are recommended for type III fractures.⁽²⁰⁾

The K-wire is positioned against the lateral condyle without piercing the skin. The starting point is assessed under AP fluoroscopic guidance. The K-wire is held freehand to allow maximum control. Once a satisfactory starting point and trajectory are confirmed, the K-wire is pushed through the skin and into the cartilage.⁽²⁰⁾

The cartilage of the distal lateral condyle functions as a pincushion. The starting point and trajectory are assessed by AP and lateral fluoroscopic guidance. When satisfactory starting point and trajectory are confirmed, the pin is advanced with a drill until at least two cortices are engaged. At this point, the reduction is again assessed. The reduction must appear satisfactory on AP, lateral, and two

oblique views. The elbow is rotated to allow for oblique views of the medial and lateral columns. Additional pins are inserted. The elbow is stressed under live fluoroscopy in both the AP and lateral planes. Once satisfactory reduction and stability are confirmed, the vascular status is again assessed. Upon completion, the pins can be bent and cut approximately 1 to 2 cm off the skin.⁽²⁰⁾

Postoperative Care

The arm is immobilized, preferably in a cast (sometimes a splint), with the elbow in 45 to 60 degrees of flexion. Flexing the elbow to 90 degrees, as is used for most other casting, will increase the risk of compartment syndrome because the fracture reduction is stabilized by the pins, not the cast. Sterile foam may be directly applied to the skin before cast application to allow for postoperative swelling.⁽²⁰⁾

Table (1): Duration of various stages of treatment

Duration	Minimum	Maximum	Mean
Injury to Admission (hours)	2	72	12.75
Injury to Surgery (hours)	8	80	20.37
Hospitalization (days)	1	3	1.13

Table (2): Duration from injury to surgery

Injury to Surgery (hours)	Number of Patients
8-23.9	9
24-47.9	5
48-71.9	4
>72	2

Follow up:

The child was seen 1 week after surgery in the outpatient clinic. X-ray was obtained in both anteroposterior and lateral planes.

If it was acceptable, the child was seen again three weeks postoperatively. The cast (or slab) was removed, the elbow was inspected for pin tract infection and another elbow x-ray was obtained to see the degree of bone healing.

The child was seen again six weeks postoperatively. Elbow x-ray was obtained and the k-wires were removed.⁽²⁰⁾

Follow-up continued until full range of motion was regained.

Some children had prolonged follow-up because of a postoperative complication.

Cases with complications would undergo a different follow-up protocol depending on the nature of the complication.

The average follow-up period was 4.1 (4–6) months.

The clinical and radiological assessments were reviewed at the final visit.

Clinical assessment included pain, range of motion, stability and daily function according to Mayo Elbow Performance Index.⁽²¹⁾

The Mayo Elbow Performance score (MEPS) or Mayo Elbow Performance Index (MEPI) is an instrument used to test the limitations, caused by pathology, of the elbow during activities of daily living (ADL). This specific test uses 4 subscales:

1. Pain
2. Range of Motion
3. Stability
4. Daily Function.⁽²¹⁾

Technique

MEPS is a 4 part test where clinical information is rated based on a 100 points scale.

- <60 - poor
- 60-74 – fair
- 75-89 - good
- 90-100 – excellent.⁽²¹⁾

Part 1: Pain

The doctor asks the patient how severe the pain is and in how frequent the pain appears.

- 45 points are for patients who do not have pain,
- 30 points are given to patients who have mild pain,
- Moderate pain results in 15 points,
- Patients with severe pain get 0 points.⁽²¹⁾

Part 2: Range of motion

The patient starts with his elbow fully extended and then tries to flex the elbow.

- 20 points are given when the arm reaches more than 100° flexion.

- 15 points If the angle is between 100°-50°.

- 5 Points when the elbow bends 50° or less.

(21)

Part 3: Stability

- When the elbow is considered stable 10 points are given.

- A mildly unstable elbow results in 5 points.

- An unstable elbow does not receive points (0).⁽²¹⁾

Part 4: ADL

Based on 5 ADL's who are each given 5 points an image is sketched how well the patient is able to participate in the daily life. The activities are:

- Combing your hair

- Performing personal hygiene

- Eating

- Putting on shirt and shoes.

The results are graded with a maximum of 100 points and categorised into 4 groups:

- 91- 100: excellent

- 90 – 81: good

- 80 – 71: fair

- <70: poor.⁽²¹⁾

Statistical Analysis

Data were collected, revised, coded and entered to the Statistical Package for Social Science (IBM SPSS) version 23. Qualitative variables were presented as number and percentages.

The comparison between groups regarding qualitative data was done by using **Chi-square test**.

The confidence interval was set to 95% and the margin of error accepted was set to 5%. So, the p-value was considered significant as the following:

- P-value > 0.05: Non significant (NS)

- P-value < 0.05: Significant (S)

- P-value < 0.01: Highly significant (H)

Results

Twenty children were treated for displaced supracondylar fracture of the humerus during the study period. The mean age was 7 years (range: 2–12 years).

The duration from injury to admission to the hospital ranged from 2 to 72 hours, with a mean of 12.75 hours (Table 3).

We followed up all the patients for postoperative stability, range of motions and pin tract infection.

Concerning stability, the lateral method by three k-wires was stable in all patients.

Table (3): Postoperative Stability

Stability	Lateral
Stable	20
Unstable	0
Total	20

The range of motions was restored in 2 months after removal of the wires except five children who required an extended period of intensive physiotherapy because of persistent elbow stiffness.

All regained full range of motion after physiotherapy.

Table (4): Postoperative Range of Motion (ROM)

ROM	Lateral
Full Range	15
Postoperative Stiffness	5
Total	20

Pin tract infection was noticed in two patients on the third week, all were resolved by dressing.

Table (5): Pin Tract Infection (PTI)

	Lateral
PTI	2
No PTI	18
Total	20

Table (6): Postoperative Complications

Method	Instability	↓ ROM	PTI
Lateral	0	5	2

4. Discussion

A supracondylar fracture of the humerus is the most common fracture of the elbow in children. Unfortunately, it can also be one of the most difficult fractures to treat. While some authors have relied on a child's remodeling capability to compensate for inadequate reduction, most authors agree that accurate reduction with minimum joint and soft tissue trauma is required to achieve the best possible functional result.^(22, 23)

The pin fixation technique is always controversial. It involves the use of two lateral pins which are placed in a parallel pattern but by addition of one another k-wire to be three k-wires, the fracture will be more stable.

In our prospective randomized controlled trial, from a total number of 20 cases. The mode of injury was fall to the ground in 9 patients, fall downstairs in 8 patients and fall from height in 3 patients.

We will compare our results to other series using the same treatment as well as other methods of treatment available in the literature.

Stability:

Devkota et al. ⁽²⁴⁾ reviewed 102 supracondylar fractures treated by pinning, of which 79 were treated with crossed pinning and 23 were treated with lateral pinning. Loss of reduction was seen in two patients (1.96%) of the lateral pinning group which was not significant and did not require re-reduction or re-pinning.

Chakraborty ⁽²⁵⁾ reviewed in his prospective study 92 patients, 56 were treated by crossed pinning and 36 were treated by lateral pinning. Instability of the fracture was seen in 16 patients, ten of them were from the lateral pin configuration group and the remaining six patients were from the crossed pin configuration group. He considered the crossed pinning was recommended in the Gartland's type III fractures because it was more stable. In case of severe swelling, a medial incision to see the entry point of

the medial pin was required to prevent the iatrogenic ulnar nerve injury. Two lateral pin fixations was suitable only for the type II fractures, where the rotational stability was better because of the intact bone and the periosteum posteriorly.

Zamzam et al. ⁽²⁶⁾ reviewed 108 supracondylar fractures treated by pinning, 71 were treated with crossed pinning and 37 were treated with lateral pinning. Significant instability due to inadequate fixation, and early loss of reduction of different degrees and indifferent planes, were observed in postoperative radiographs of nine children who underwent fixation by two lateral pins (eight had type III fractures and one had a type II fracture).

In our study, Postoperative instability of the fracture didn't occur in any case from the 20 cases of the lateral pin configuration group; Rotation and posterior displacement didn't occur in any case.

Table (7): A Comparison of instability between the published studies and our study

Authors	Lateral		
	Number of cases	Instability	Lateral Instability Perc%
Devkota et al (102 cases)	23	2	8.70%
Chakraborty (92 cases)	36	10	27.78%
Zamzam et al (108 cases)	37	9	24.32%
Our Study (20 cases)	20	0	0.00%

Ulnar Nerve Injury:

Devkota et al. ⁽²⁴⁾:

Seven patients of the 79 patients in the crossed pinning group (6.86%) got ulnar nerve injury.

While no ulnar nerve injury occurred to all the 23 patients of the lateral pinning group.

He concluded that there was a risk of injuring the ulnar nerve in crossed pinning and that could be avoided by pinning only two lateral pins.

Chakraborty ⁽²⁵⁾:

Four patients of the 56 patients in the crossed pinning group (7.14%) got ulnar nerve injury.

While no ulnar nerve injury occurred to all the 36 patients of the lateral pinning group.

He concluded that there was a risk of ulnar nerve injury in crossed pinning and that could be avoided if

adequate care was taken by proper medial pin fixation. 10% of the cases of ulnar nerve irritability resolved spontaneously. In case of severe swelling, a medial incision to see the entry point of the medial pin was required to prevent the iatrogenic ulnar nerve injury.

Zamzam et al. ⁽²⁶⁾:

Two patients of the 71 patients in the crossed pinning group (2.81%) got ulnar nerve injury. They recovered spontaneously during the follow up period.

While no ulnar nerve injury occurred to all the 37 patients of the lateral pinning group.

He concluded that in doubtful cases with a massively swollen elbow, a small incision could save the ulnar nerve from injury.

Table (8): A Comparison of ulnar nerve injury between the published studies

Authors	Lateral			Crossed		
	Number of cases	Ulnar N. Injury	Lateral Ulnar N. Injury. Perc%	Number of cases	Ulnar N. Injury	Crossed Ulnar N. Injury Perc%
Devkota et al. (102 cases)	23	0	0.00%	79	7	8.86%
Chakraborty (92 cases)	36	0	0.00%	56	4	7.14%
Zamzam et al. (108 cases)	37	0	0.00%	71	2	2.82%
In our study (20 cases)	20	0	0.00%			

Postoperative Range of Motion (ROM):
Devkota et al. (24):

Three patients of the 79 patients in the crossed pinning group (3.79%) and one patient of the 23 patients in the lateral pinning group (4.34%) got poor range of motion.

Zamzam et al. (26):

All regained full range of motion, except for one boy who lost approximately 20° of elbow flexion and

had an extension lag of <10°, and one girl who also had an extension lag of <10°.

In our study, the range of motions was restored in 2 months after removal of the wires except five children who required an extended period of intensive physiotherapy because of persistent elbow stiffness with lateral pin configuration.

Table (9): A Comparison of the decreased range of motion between the published studies and our study

Authors	Lateral			Crossed		
	Number of cases	Range of Motion	Lateral Range of Motion Perc%	Number of cases	Range of Motion	Crossed Range of Motion Perc%
Devkota et al. (102 cases)	23	1	4.35%	79	3	3.80%
Zamzam et al. (108 cases)	37	0	0.00%	71	2	2.82%
Our Study (20 cases)	20	5	25%			

Postoperative Pin Tract Infection (PTI):**Devkota et al. (24):**

Eight patients from a total of 102 patients (7.84%) got pin tract infection, which was superficial and healed after removing the pins and oral antibiotic administration.

Chakraborty (25):

There were 12 cases (33.33%) of pin tract infection in lateral pinning and 40 cases (71.42%) in crossed pinning which were resolved with antibiotics. The pin tract infection was superficial, may be

because of poor hygiene and scratching due to postoperative irritability, which was treated adequately with oral antibiotics and it was resolved completely. He considered it was not a problem.

Zamzam et al. (26):

Only one child from a total of 108 patients developed a pin-track infection which resolved completely with local wound care.

In our study, Pin tract infection was noticed in two patients on the third week with lateral pin configuration. All were resolved by dressing.

Table (10): A Comparison of the pin tract infection between the published studies and our study

Authors	Lateral		
	Number of cases	PTI	PTI Perc%
Devkota et al (102 cases)	102	8	7.84%
Chakraborty (92 cases)	92	52	56.52%
Zamzam et al (108 cases)	108	1	0.93%
Our Study (20 cases)	20	2	10%

Table (11): A Comparison of the complications between the published studies and our study

Authors	Total Number of cases	Instability		Ulnar N. Injury		↓ROM		PTI	
		No. of cases	Inst. Perc. %	No. of cases	Ulnra N. Injury Perc. %	No. of cases	↓ROM Perc. %	No. of cases	PTI Perc. %
Devkota et al. (102 cases)	102	2	1.96%	7	6.86%	4	3.92%	8	7.84%
Chakraborty (92 cases)	92	16	17.39%	4	4.35%	0	0.00%	52	56.52%
Zamzam et al. (108 cases)	108	9	8.33%	2	1.85%	2	1.85%	1	0.93%
Our Study (20 cases)	20	0	0.00%	0	0.00%	5	25%	2	10%
Chi-square test	X ²	73.667							
	P-value	< 0.001 (HS)							

Conclusion

Closed reduction and percutaneous lateral pinning by three k-wires in the management of supracondylar fractures of the humerus in children is safe as regards avoidance of neurovascular complications, effective in obtaining good results, and relatively economic regarding hospitalization.

The disadvantage is the need for technical proficiency and the availability of C-arm fluoroscopy. Closed method of treatment is generally preferred to the open method, unless the fracture is complicated by vascular or nerve injury that requires exploration.

Current interest is mainly focused on the configuration of pin for fixation that provides adequate stability with the lowest risk of iatrogenic nerve injury.

In our prospective randomized controlled study, lateral fixation of supracondylar fracture of humerus type three by three k-wires is effective in obtaining stability with good alignment and range of motion at all cases in our study.

So, According to our results, lateral fixation of supracondylar fracture of humerus type three by three k-wires can avoid ulnar nerve injury and obtain the fracture stability.

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