

Evaluation of Functional Results in the Management of Supracondylar Fracture of Humerus in Children by Various Methods

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Abstract

Introduction: Supracondylar fractures of Humerus are one of the most common fractures in pediatric age group. The aim of the study was to evaluate the functional results in the management of supracondylar fracture of humerus in children by various methods.

Materials and Methods: This study was conducted at the Orthopaedics department of Mahatma Gandhi Memorial Hospital, Warangal. This was a 2 years prospective, longitudinal, hospital based, observational study and its outcomes. Participants were a total of 30 children aged 0 to 14 years (21 males, 9 females) diagnosed with supracondylar fracture of humerus.

Results: Patients were assessed by Flynn's criteria. Results were excellent in 70%, good in 20%, fair in 6.66%, and poor in 3.33%.

Conclusion: Closed reduction and external immobilization are reserved for Gartland's type 1 and select type 2 fractures. In unstable type 2 and type 3, closed or open reduction and K-wire fixation give better results.

Key words: Flynn's criteria, Open reduction and internal fixation, Percutaneous pinning, Supracondylar fracture of humerus, Traction

INTRODUCTION

At the end of 19th century, Sir Robert Jones echoed the opinion of that era about elbow injuries. "The difficulties experienced by surgeons in making an accurate diagnosis; the facility with which serious blunders can be made in treatment and prognosis; and fear shared by so many, of subsequent limitations of function, serve to render injuries in the neighborhood of elbow less attractive than might otherwise prove.^[1] These concerns are applicable even today.

Supracondylar fractures of humerus account for 50–70% of fractures around the elbow in children^[2] and 12–17% of all pediatric fractures. Peak incidence is from 5 to 8 years of age.^[3]

The medial and lateral columns of the distal humerus are connected by a thin segment of bone between the olecranon fossa posteriorly and coronoid fossa anteriorly, resulting in high risk of fractures of this area. The metaphysis is thinned both anteriorly by coronoid fossa and posteriorly by olecranon fossa to accommodate the upper end of the ulna during flexion and extension, respectively. The metaphyseal flare of the distal humerus connects the diaphysis of the humerus to the epiphysis.

The most common mechanism of injury is when a patient falls on the outstretched hand with the elbow fully extended. The olecranon engages with the olecranon fossa and acts as a fulcrum, while anterior capsule simultaneously provides a tensile force on distal humerus at its insertion. The flexion

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injury results from direct trauma to the posterior aspect of the distal humerus or falling onto the point of flexed elbow.

Supracondylar fractures are known for its complications because of the inherent fracture instability, close vicinity of the brachial artery and major nerves of extremity, poor radiographs, and poor interpretations of reduction.

The following are treatment modalities available in the management of supracondylar fracture of humerus

1. Closed reduction and immobilization in an above elbow plaster cast
2. Closed reduction and percutaneous pinning (CRPP) under image intensifier
3. Open reduction and internal fixation (ORIF) with k wires (2 lateral pins, one medial pin and one lateral pin [cross pinning], two lateral, and one medial pin)
4. Lateral external fixator
5. Overhead olecranon wingnut traction
6. Straight arm skeletal traction.

We conducted a study with the purpose of assessing the results and functional outcomes of management of supracondylar fracture of humerus by various methods in our institution.

METHODOLOGY

This study comprises 30 patients who are diagnosed to have a supracondylar fracture of humerus admitted in Mahatma Gandhi Memorial Hospital (Tertiary care institution at Warangal, Telangana state) from December 2016 to November 2018.

All patients and their parents were informed about the study, and their consent was obtained about their inclusion in this study. Ethical approval was taken from the Institutional Ethics Committee.

Inclusion Criteria

Age of patient 1–14 years was included in the study.

All types of supracondylar fracture of the humerus.

Exclusion Criteria

The following criteria were excluded from the study:

- Age of patient above 14 years.
- Patient with supracondylar fracture having an intercondylar extension.
- Floating elbow injuries.
- Patient presenting with infection at the site of fracture.
- Patient not seeking treatment according to our protocol.

Data Recording (Clinical and Radiological)

As soon as, the child is admitted in hospital with elbow injuries, a detailed careful history is elicited from patients and from their parents in young children, with regard to mode of injury and time since injury. A physical examination was conducted and evaluation of patients was done in terms of swelling at elbow, deformity, painful range of motion (ROM), closed or open fracture, and puckering of the skin. Presence or absence of radial pulse, nail bed capillary refill time and signs of compartment syndrome, neurological status in radial, median, and ulnar nerve territories and other associated musculoskeletal injuries.

An initial radiological evaluation was done by obtaining anteroposterior and lateral views of affected elbow [Figure 1a], and after manipulation with or without pinning, jones view was evaluated.

In this study, supracondylar fractures of the humerus were classified according to Gartland's classification.^[4] There are two types of fractures, extension type (96–98%)^[5] and flexion type (2–4%) depending on the sagittal tilt of the distal fragment.

- Type 1 – Undisplaced
- Type 2 – Displaced with intact posterior cortex, may be angulated or rotated
- Type 3 – Displaced with no cortical contact
- 3a – posteromedial
- 3b – posterolateral.

In the meantime, analgesics were given and fracture part was splinted temporarily [Figure 1b]. Before surgery, the necessary laboratory investigations were done.

Management Protocol

The protocol was drawn according to the type of fracture.

Type 1 fractures – The affected limb was immobilized in above elbow posterior splint with elbow in $\leq 90^\circ$ flexion and forearm in neutral rotation. Cuff and collar were applied. The patient was reviewed after 3 days and if any loosening of splint was seen, it was corrected with instructions to review after 3 weeks. At the end of 3 weeks, splint was removed, and X-rays were repeated to assess the fracture healing. The patient was advised to do active ROM exercises at the elbow.

Type 2 fractures – under general anesthesia, closed reduction was carried out by giving longitudinal traction to the forearm by the surgeon and counter traction to the proximal arm by the assistant. The elbow is flexed up to 90° and the distal fragment is pushed anteriorly. The further elbow was flexed up to 120° and forearm was fully pronated and distal vascular status was assessed. After reduction has

been confirmed by fluoroscopy, it can be maintained by two methods.

- a. To apply an above elbow plaster splint at 120° of flexion and patient was given cuff and collar for 3 weeks.
- b. If the fracture is unstable (if there is medial column comminution), or if the reduction cannot be maintained without excessive flexion, which may place vascular structures at risk; the fracture was fixed with percutaneous K wires (cross pins or two lateral pins)^[6,7] and an above elbow plaster splint was applied for 3 weeks. The patient was discharged at 24 h and advised to review after 3–4 weeks. X-ray was repeated and if healing was satisfactory, slab was removed and ROM exercises of elbow encouraged.

Advantages of Percutaneous Pinning

1. It is done without opening the fracture
2. Less chances of infection
3. Provides strong fixation and stability in any position of elbow
4. Elbow can be mobilized early.

Technique of CRPP. Under general anesthesia, the patient was placed in supine position on the operation table after which closed reduction was done by giving longitudinal traction applied to forearm with an elbow in extension and forearm in supination. Counter-traction to the proximal arm was provided by the assistant. With the traction being maintained, the medial or lateral displacement was corrected by applying a varus or valgus force at the fracture site. The displacement and angulation of the distal fragment were corrected by flexing the elbow, at the same time a posteriorly directed force was applied to anterior portion of arm over the proximal fragment and then anteriorly directed force was applied over the distal fragment with thumb on the olecranon and elbow is hyper flexed and forearm is pronated to maintain reduction. Reduction is checked under fluoroscope by taking an anteroposterior view and lateral view of elbow. Maintenance of reduction was achieved by passing one lateral pin with elbow in flexion and one medial pin with an elbow in extension (to avoid ulnar nerve injury). Once the pins were in place, the fixation was checked under fluoroscope [Figure 1c]. After leaving about 1 cm of pins outside the skin, the pins were bent and cut off and a well-padded posterior above elbow slab was applied with elbow flexed to $\leq 90^\circ$ flexion, ensuring distal vascularity.

In the post-operative period, the limb was kept elevated. Antibiotics and analgesics were given for 3–5 days. Dressing was changed usually on 2nd, 5th, and 7th day. The posterior slab was reapplied and the patient was asked to review after 3–4 weeks. X-ray was taken and if evidence of union is

present, K-wires were removed, and ROM exercises of elbow encouraged.

Type 3 fractures – Under general anesthesia, closed reduction of fracture was done and fracture was fixed with percutaneous K-wires, similar to the technique described for type 2 fractures.

Indications for ORIF were:

1. 2–3 attempts of failed closed reduction
2. When closed reduction is unsatisfactory
3. If the swelling of elbow is grotesque, that closed reduction cannot be maintained
4. Type 3 fractures with puckering of the skin
5. Open fractures that require irrigation and debridement
6. Fractures complicated by vascular injury.

Technique of ORIF

After administration of general anesthesia, the patient was placed in lateral decubitus position with the extremity supported on a sandbag. No tourniquet was used. Intravenous antibiotic (ceftriaxone) was administered before the start of the procedure. The extremity was prepared from axilla to the wrist and painted with betadine solution. A standard posterior approach was used in all patients. The fracture was exposed and the hematoma and debris were cleared, the fracture was reduced and fixed with 2–3 Kirschner's wire of diameter 1.5–2.5 mm. The lateral wire was inserted through the anterior side of the lateral condyle and was directed posteriorly into the posteromedial side of the opposite cortex. The medial wire was started through the posteromedial side of medial condyle (great care is taken to avoid the ulnar nerve) and engaged into the anterolateral side of opposite cortex. The stability of the fracture fixation was checked and wire fixation was checked under image intensifier. K-wires were bent and cut outside the skin. Hemostasis was secured and wound was closed in layers and sterile dressing was applied. A posterior long arm splint was applied with an elbow in 90° flexion and forearm in mid-prone position.

In the post-operative period, the limb was kept elevated. Antibiotics and analgesics were given for 3–5 days. Dressing was changed usually on 2nd, 5th, and 7th days. Sutures were removed on the 10th day. Posterior slab was reapplied and the patient was asked to review after 3–4 weeks. X-ray was taken and if evidence of union is present, K-wires were removed and ROM exercises of elbow encouraged.

Follow-Up Protocol

The patients were advised to attend outpatient department at regular intervals (3 weeks, 6 weeks, 3 months, 6 months,

and 1 year), for checkup and to note the progress of union (radiological) [Figures 1d,e] and movements at elbow, onset of any deformity (clinical). ROM [Figure 1f] and carrying angle [Figure 1g] were measure by goniometer.

OBSERVATIONS AND RESULTS

In the present study, the results were evaluated according to Flynn’s criteria^[8] which is based on change in carrying angle and loss of movement after treatment.

Flynn’s criteria			
Result	Rating	Cosmetic factor (loss of carrying angle in degrees)	Functional factor (motion loss in degrees)
Satisfactory	Excellent	0–5	0–5
	Good	6–10	6–10
	Fair	11–15	11–15
Unsatisfactory	Poor	>15	>15

Franke *et al.*^[9] in study of 106 patient with displaced supracondylar fracture of humerus treated with CRPP showed 85.7% with very good to good results, 10.7% with satisfactory results, and 3.6% with unsatisfactory results.

Ababneh *et al.*^[10] in his retrospective study of 135 patients with displaced supracondylar fracture humerus treated with three different methods, the results of CRPP were superior with excellent and good results in 87% patients and poor results in 8% patients.

Boparai *et al.*^[11] studied 50 cases of supracondylar fracture and found 80% had good results and 20% had unsatisfactory results in ORIF group compared to 44% unsatisfactory results in the closed reduction and percutaneous pinning group.

In the present study, out of 30 patients, 90% were good to excellent results and 10% proved fair and poor results, according to Flynn’s criteria.

DISCUSSION

Age Distribution

Musa *et al.*^[12] conducted a prospective study based on 30 cases with Gartland type 3 supracondylar fracture of humerus managed with crossed percutaneous pinning over a period of 2 years. Age group was 2–13 years with a mean age of 7.06 years. In our study, the average age is 7 years and the most common age group affected was between 5 and 8 years [Table 1].

Sex Distribution

Pirone *et al.*^[13] in their study of 230 patient with a supracondylar fracture of humerus showed that boys (119) were affected more than girls (111)

D’Ambrosia in his series found the incidence of supracondylar fracture in males is 63% and females are 37%.

In the present study, the incidence is 70% in males and 30% in females [Table 2].

Incidence of Fracture type: (Gartland’s Classification)

Pirone *et al.* studied that 230 cases of supracondylar fracture and observed 137 were type three fractures and 93 were type 2 fractures.

In type 3 fractures, 94 cases were posteromedial displacement and 22 were with posterolateral displacement and 21 with direct posterior displacement.

Mehlman *et al.*^[14] during the study of operative management of supracondylar fracture of humerus in children found that 77.4% were type three fractures and 18.3% were type 2 fractures.

In the present study, 10% were type 1 and type 2 is 26.66% and type 3 is 63.33% [Table 3].

Side Involvement

D’Ambrosia^[15] found that the involvement of left elbow was 64% and the right elbow was 36%. Ahmed *et al.*^[16] in their series showed a predominance of the left elbow.

Table 1: Distribution based on age

Age in years	Number of patients	Percentage
0–4	3	10
5–8	13	43.33
9–12	11	36.66
13	3	10

Table 2: Distribution based on sex

Sex	Number of patients	Percentage
Male	21	70
Female	9	30

Table 3: Distribution based on the type of fracture

Type of fracture	Number of patients	Percentage
Type 1	3	10
Type 2	8	26.66
Type 3	19	63.33

In our study, the left side was involved in 73.33% and the right side was 26.66% [Table 4].

The incidence in the present study is consistent with the above series.

Treatment Modality Employed [Table 5]

Traction was not used in the management of patients in our study, as its popularity has decreased due to concerns of cubitus varus, pin complications, compartment syndrome and prolonged stay in the hospital though Maffulli *et al.*^[17] and Piggot *et al.*^[18], reported excellent results in their case series of cases managed by traction.

Table 4: Distribution based on the side affected

Side	Number of patients	Percentage
Right	8	26.66
Left	22	73.33

Table 5: Distribution based on treatment modality

Treatment modality	Number of patients	Percentage
Traction	0	0
Closed reduction and cast application	6	20
Closed reduction and percutaneous pinning	17	56.66
Open reduction and k wire fixation	7	23.33

Table 6: Distribution based on pin construct

Type of construct	Number of patients	Percentage
2 lateral pins	2	8.33
1 lateral pin and 1 medial pin	19	79.16
2 lateral and 1 medial pin	3	12.50

Table 7: Distribution of incidence of post-operative complications

Complication	Number of patients	Percentage
Cubitus varus deformity	1	4.16
Pin tract infection	1	4.16
Nerve injury	0	0
Proximal migration of pin	0	0
Restriction of movements	2	8.33

Table 8: Final results

Result	According to loss of motion in degrees		According to loss of carrying angle in degrees		Average percentage
	Number of patients	Percentage	Number of patients	Percentage	
Excellent	21	70	21	70	70
Good	6	20	6	20	20
Fair	2	6.66	2	6.66	6.66
Poor	1	3.33	1	3.33	3.33

6 cases were treated by closed reduction and cast application. 17 cases were treated by closed reduction and percutaneous pinning. 7 cases were treated by open reduction and K-wire fixation.

Pin Construct

The optimal method of pin fixation varies among the authors and convincing evidence regarding pin construct is lacking in literature.

Swenson, Casiano and Flynn used two pins: one medial and one lateral. Arino used two lateral pins.

Fracture geometry, stability of fixation and surgeons preference come into consideration with regards to pin configuration. In present study of 30 cases, we fixed 24 cases of supra condylar fracture of humerus and our preferred construct was cross pinning as it provides biomechanically stable construct.^[19]

We did 1 lateral and 1 medial pin fixation in 19 cases, 2 lateral pins in 2 cases and 2 lateral and 1 medial pin in 3 cases [Table 6].

Pin Tract Infection

Pirone *et al.* studied 230 cases of displaced supracondylar fracture of the humerus and observed that in 78 cases treated with CRPP, 2 cases had pin tract infection.

Cramer *et al.*^[20] in his retrospective study of 29 children with supracondylar fracture of humerus; treated with CRPP in 15 children and open reduction and pinning in 14 children, only one patient in CRPP showed superficial infection.

Lejman *et al.*^[21] showed no case of pin tract infection in 20 cases of supracondylar fracture of humerus treated with CRPP.

In the present study, one patient had evidence of pin tract infection in 7 cases treated with open reduction and pinning [Table 7]. Infection was treated by antibiotics and regular dressings.

Cubitus Varus

Topping *et al.*^[22] showed the incidence of cubitus varus in one patient out of 47 cases treated with CRPP.

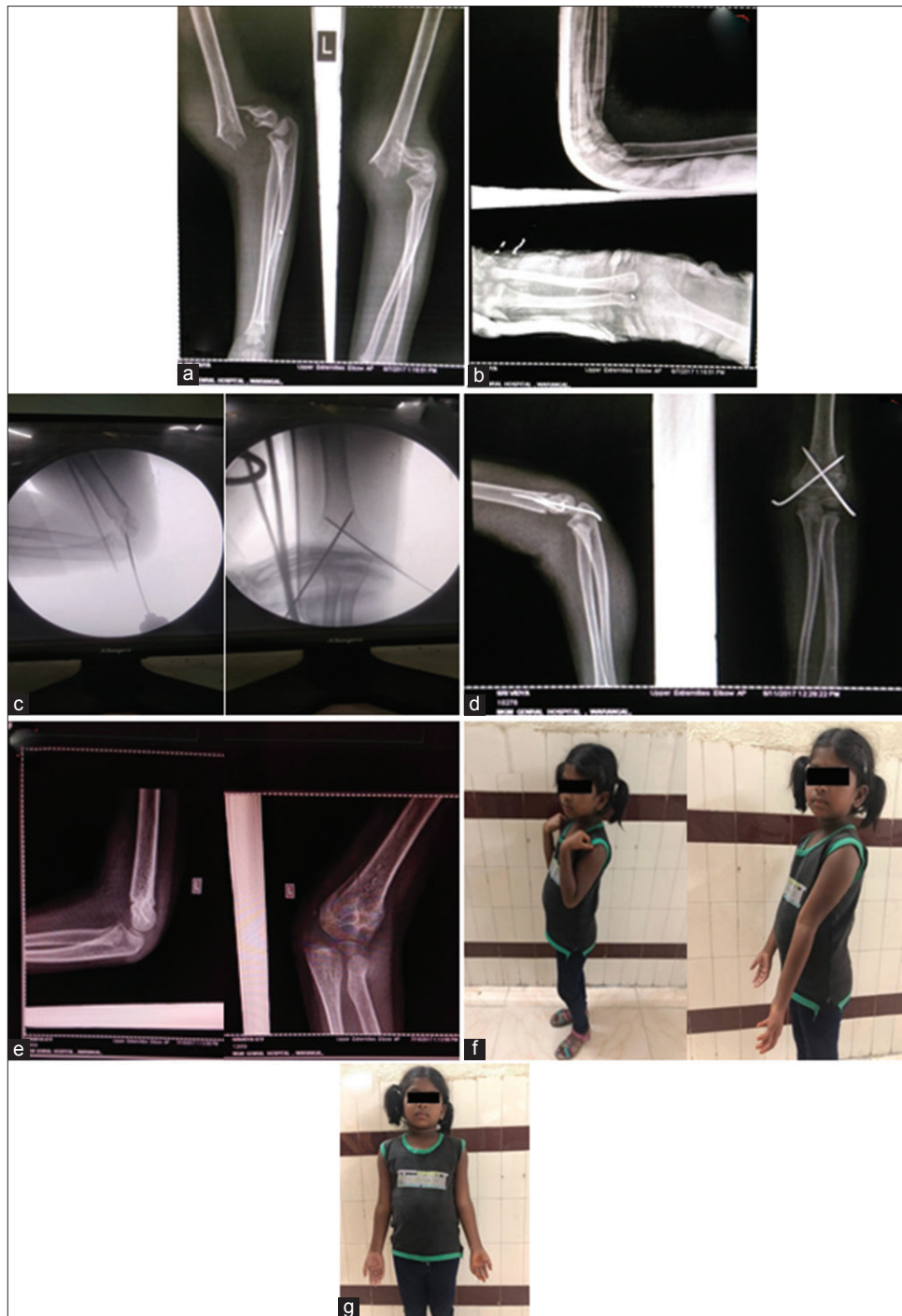


Figure 1: (a) X-ray of the elbow anteroposterior and lateral view showing supra condylar fracture of humerus. (b) X-ray showing immediate splinting of supracondylar fracture of humerus. (c) Intraoperative fluoroscopic images showing fracture fixation with K-wires. (d) Post-operative X-ray showing fracture fixation with K-wires. (e) Late post-operative follow-up X-rays showing evidence of fracture union. (f) Clinical pictures showing functional results during follow-up period: Flexion and extension movements at elbow, respectively. (g) Clinical picture showing carrying angle at elbow during follow-up

Kennedy *et al.*^[23] observed two cases of cubitus varus among 40 cases of displaced supracondylar fracture in children. In our study, two patients developed cubitus varus. This deformity is seen with one patient in open reduction and pinning group [Table 7].

Proximal Migration of K Wire

Pirone *et al.* observed the migration of one lateral pin, out of 96 cases treated with CRPP. In the present study, we did not see this complication [Table 7].

RESULTS

Patients were assessed by Flynn's criteria. Results were excellent in 70%, good in 20%, fair in 6.66% and poor in 3.33% [Table 8].

CONCLUSION

The outcomes of treatment of the supracondylar fracture of humerus in children depend on perfect anatomical reduction and stable immobilization.

In type 1 undisplaced fractures, treatment is immobilization in an above elbow plaster splint for 3–4 weeks.

In type 2 fractures

- Closed reduction and immobilization in above elbow plaster splint is done provided no gross angulation at the fracture site and if the reduction is stable
- Closed reduction and fixation with percutaneous k wire fixation (CRPP), if fracture shows the great collapse of the weakened medial column and if the fracture is unstable.

In Type 2 and 3 fractures, where closed reduction is not satisfactory and also in open fracture, treatment is by open reduction and fixation with K wires, one from medial and one from the lateral side of lower end of the humerus (cross pins) or 2 lateral pins.

In the present study, the above protocol of treatment of supracondylar fractures of the humerus has given good cosmetic and functionally satisfactory results.

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