

Study of type-III supracondylar humerus fractures in children treated by closed reduction with percutaneous crossed pin fixation

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Abstract: *Aims & Objective:* To achieve anatomical reduction, stable fixation and to restore optimum functions of the elbow. *Introduction:* Supracondylar fractures of the humerus in children are the most common serious elbow injuries in childhood among which, Gartland's extension type III is the commonest. Type III fractures and its treatment are fraught with many complications. Closed reduction and percutaneous crossed pin fixation of these fractures has shown improved results. *Methods:* Twenty eight cases of Gartland's Type III supracondylar humeral fractures were treated with closed reduction and percutaneous crossed Kirschner wire fixation under image intensifier. The cases were followed up for an average period of 6 months. *Results:* All fractures healed without loss of reduction. Flynn's criteria were used to assess the outcome. 21 cases showed excellent, 6 cases showed good and 1 case showed fair results. The average duration of pin fixation was 25 days (range, 21-30 days). There were no treatment related neurovascular complications. *Conclusion:* Closed reduction with percutaneous crossed pin fixation is a safe and effective treatment for Type III supracondylar humeral fractures with several advantages.

Keywords: Type III supracondylar fractures, Closed reduction, Percutaneous crossed pin fixation.

Introduction

Fractures around elbow joint represent approximately 10% of all pediatric orthopaedic injuries. Supracondylar fracture of humerus is the second most common fracture in children accounting for about 75% of all injuries around the elbow [1-2]. These fractures are most common serious elbow injuries and commonest upper extremity fracture in children associated with complications [3-4]. Extension type of supracondylar fracture is the most common occurring in 98% of cases [1], about one third show little or no displacement and in these treatment is simple. The remainder is associated with varying degrees of major displacement which is difficult to treat [5-7].

There is no controversy about the management of undisplaced fractures but variety of methods of treatment for displaced supracondylar fractures has been recommended; such as closed reduction and cast application, skin traction, overhead skeletal traction, Blount's technique, open reduction, closed reduction with percutaneous pin fixation:crossed medial and lateral and two lateral. Completely displaced type III fractures

may be associated with nerve injuries, vascular injuries and treatment may be complicated by malunion, elbow stiffness, iatrogenic neurovascular injury and compartment syndrome, Volkmann's ischemic contracture [8], skin slough. The standard treatment for completely displaced type III extension supracondylar fractures of humerus in children is closed reduction and percutaneous pin fixation. However controversy exists regarding whether lateral or crossed medial and lateral pin fixation is optimal technique.

When a supracondylar fracture of humerus in a child is being treated with percutaneous pinning it is important to achieve stable fixation to prevent rotational displacement which may lead to a cubitus varus deformity, while some authors [2, 9-10], obtained a good results using crossed pins placed from medial and lateral condyles and other authors [2, 11], have suggested use of pins placed from lateral condyle in either parallel or a crossed configuration to minimize the risk of injury to ulnar nerve. Injury to the ulnar nerve from medial placement of pin is a potentially

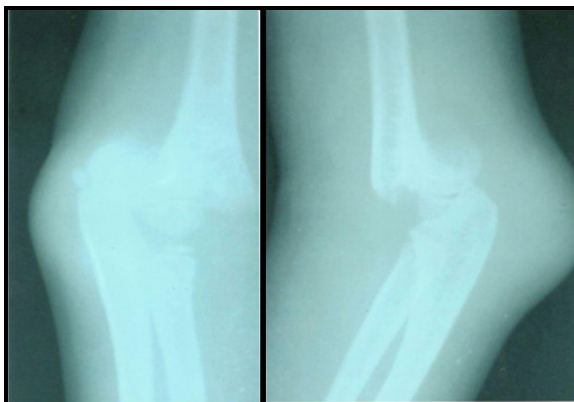
serious although uncommon complication that is most likely to occur when medial epicondyle cannot be palpated because of swelling of elbow. Only lateral pinning is associated with increased rotational instability. Moreover in younger children with comminution in medial cortex does not provide good stability.

The goal of management of supracondylar fractures of humerus in children is to gain functional, anatomical and cosmetically acceptable upper limb with normal range of movement and to return the patient to their pre injury level as quickly as possible, while minimizing the complications. Ideally this should be achieved by one of the definitive procedure. The purpose of this study is to evaluate the role of closed reduction and percutaneous crossed medial and lateral pin fixation of extension type III supracondylar humerus fractures in children.

Material and Methods

This study is a prospective observational randomized and open study on patients admitted to department of orthopaedics in Al-Ameen medical college and district hospital Bijapur with extension type III supracondylar humerus fractures in children are part of this study (Fig-1). The complete data is collected from patient's attendants in a specially designed case record form by history of illness and by doing detailed clinical examination and relevant investigations. Finally after diagnosis the patient are selected for the study depending on the inclusion and exclusion criteria. Post procedure all cases were followed for an average period of 6 months.

Fig-1: Pre operative



Inclusion Criteria:

1. Children with closed extension type III supracondylar humerus fractures.
2. Patients who are aged below 10 years.

Exclusion Criteria:

1. Open supracondylar humerus fractures.
2. Those cases that are treated non-surgically
3. Aged above 10years.
4. A fracture requiring open reduction.

Procedure:

Reduction technique

Positioning: Patient is lying in supine position and arm is placed over the fluoroscopy platform. Traction is applied by the surgeon and counter traction is given by assistant. First restore length then realignment of distal fragment to humeral shaft, traction is applied to the arm to free the proximal fracture site from the brachialis muscle, then longitudinal traction is applied with elbow in extension and supination in an attempt to appose edges of both fragments, counter traction is provided by the assistant.

Medial and lateral translation and transrotation: While traction is being maintained next the medial or lateral displacement of distal fragment is corrected, reduction is facilitated either by pronation or supination depending on whether there is medial or lateral fracture displacement.

Medial displacement of distal fragment: Medial displacement is more common than lateral displacement, and this implies that the medial hinge is intact this fragment needs to be laterally translated for reduction, forearm is pronated to tighten the medial periosteal hinge along with application of valgus force and translation with one hand traction must be maintained during this maneuver, full pronation is required to reduce varus tilt.

Lateral displacement of distal fragment: Forearm is supinated to tighten the lateral periosteal hinge along with application of varus force and translation with one hand, traction must be maintained during this maneuver, at this point fracture is out to length and rotation has been restored.

Fracture angulation and posterior displacement:

We have to address fracture angulation and posterior displacement; elbow is flexed to 120° while pushing distal fragment anterior by placing thumb over olecranon to reduce it by pronating the forearm as the elbow is being flexed similarly the posterior directed force is applied to the proximal fragment with anatomic reduction. Full flexion should be achieved incomplete flexion implies interposed soft tissue. Brachialis may become interposed at fracture site or by proximal humeral fracture fragment button hole through brachialis if this occurs closed reduction with longitudinal traction may worsen tightening of muscle around protruding fragment, in this case the muscle can be milked off from the spike by grasping the proximal arm and squeezing sequentially from proximal to distal avoiding excessive medial squeezing to avoid neurovascular injury.

Pinning technique pin size: Pins need to be smooth with trochar point. With children younger than 5-6yrs 1.5mm smooth k wire and in older children 2mm k wire were used. We always used smaller K wire on medial side than that used for lateral side.

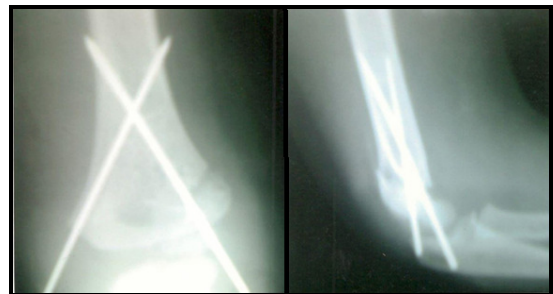
Lateral pin: insertion point is in the centre of lateral condyle (capitellum). The pin is aimed 35° upwards and 10° posterior, should avoid the olecranon fossa and should just pierce the far cortex, because the centre of capitellum is in line with anterior aspect of humeral shaft the wire is inserted through the capitellum, and then the distal humeral physis. The lateral pin is inserted first always.

Medial pin: Passed obliquely through medial epicondyle, entry point is at anterior aspect of epicondyle, to protect ulnar nerve; with flexion; the ulnar nerve can sublux over the medial epicondyle placing it at risk with medial pin insertion. We always placed the lateral pin first with elbow hyper flexed which confers stability once the lateral pin has been inserted then elbow is brought out to 80-90 degree flexion which decreases the ulnar nerve subluxation and then the medial pin is inserted as medial epicondyle is slightly as posterior to the shaft we have to direct the medial pin slightly anterior also ensuring that the medial pin enters straight into the epicondyle rather than distal to the epicondyle. With the

thumb ulnar nerve is milked back into its posterior position and held it there before insertion. After pin placement carrying angle and bauman's angle are assessed. Finally the radial pulse and the quality of the pulse rechecked, pin should cross 1-2 cm proximal to the fracture at an angle of about 30 degrees to the humeral shaft. Pins are cut outside the skin for easier removal in the opd without anaesthesia later.

Post operative management: Posterior slab applied with elbow in less than 90°, the operated limb was elevated. Careful observation for any neurovascular deficit was observed at regular intervals. Appropriate antibiotics and analgesics were used. Patients were discharged on advice to come for regular follow up. Immediate post operative radiographs were taken to determine the quality of reduction (Fig-2).

Fig-2: Immediate Postoperative



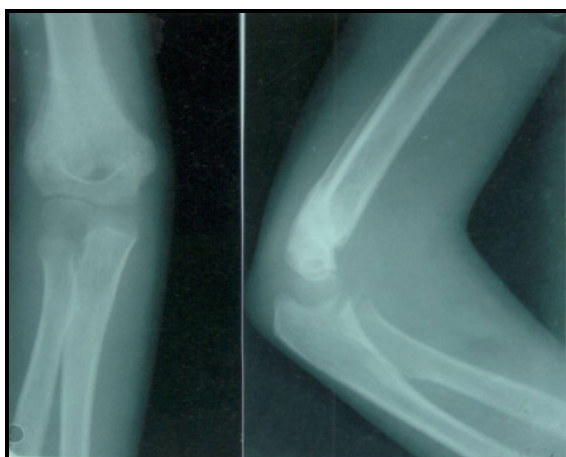
Follow up: All patients returned for both clinical and radiographic evaluations at 1 week, 3-4 weeks, 3 months and 6 months. Carrying angle, Bauman's angle and Movements of the elbow were assessed at each follow up, the slab and pins are removed at outpatient department at 3-4 week follow up appointment.

Active range of motion exercises were encouraged. Radiographs were taken immediate post operatively; 3-4 weeks and 3-month follow up visits. Functional outcome was assessed in subsequent follow up. No formal physiotherapy was required (Fig-3 & 4).

Fig-3: Four weeks post operative



Fig-4: Final follow up



Statistical Analysis: The final results were evaluated by Flynn's criteria. The results were graded as excellent, good, fair and poor according to loss of range of motion and loss of carrying angle.

Table-1: Flynn's criteria

Results	Rating	Cosmetic factor: carrying angle loss	Functional factor: motion loss
Satisfactory	Excellent	0-5	0-5
	Good	6-10	6-10
	Fair	11-15	11-15
Unsatisfactory	Poor	>15	>15

Results

A total of 31 cases of type III supracondylar fractures of humerus were part of the study group 3 patients lost to follow up and hence a total of 28 patients included in this study. The minimum

follow up period was 3 months in all patients and followed for an average period of 6 months ranging from 3-9 months. The final results were evaluated by Flynn's criteria. In our study all of the patients had satisfactory results.

Demographic characteristics: The overall study showed mean age of patients forming the study group was 5.96 years, majority of patients were in the range of 4-8 years, youngest was 2 years and the oldest was 10 years, majority of patients were male accounting for 18 cases i.e 64.3%, the leading cause of injury was fall accounting for 78.21% of cases whereas road traffic accident accounts 21.26%. 11 cases occurred on right side and 17 occurred on left which is non dominant limb, there were 20 cases (71.42%) belonging to posteromedial (type III a) and 8 cases (28.58%) belonging posteriolateral (type III b) variety.

All cases included in this study group were fresh fractures that underwent surgery at earliest possible time after admission to hospital with average duration between injury and surgery 1.7 days. K-wire were used which were smooth with trochar point. In children younger than 5- 6years 1.5mm smooth K-wire and in older children 2mm K-wire were used. We always used smaller size K wire on medial side than that used on lateral side. The average hospital stay in our study was 2.29 days. Mobilization of elbow started on 3rd week and active movements were advised.

Union: evidence of bridging callus was seen at an average of 21 days ranging from 14 -28 days, pins and plaster removed at 3-4 week follow up. The average time taken for union was 6 weeks, all fractures united. No formal physiotherapy was required. One case of pin tract infection which recovered after pin removal and oral antibiotics. There were no cases of iatrogenic ulnar nerve injury in our study. Two cases of median nerve palsies which were present preoperatively associated with the fracture resolved spontaneously. We had absent radial pulses in 4 cases, in which pulse returned in all four cases after closed reduction and percutaneous crossed pin fixation.

Discussion

Supracondylar fractures are most common serious elbow injuries in children because the bony architecture at supracondylar region is weak and vulnerable because in this region:

- (a) Bone is remodeling.
- (b) It is flattened anteroposteriorly.
- (c) Three fossae makes cortex thin.
- (d) Anterior cortex has defect in area of coronoid fossa.
- (e) Laxity of the ligaments permits hyperextension at the elbow.
- (f) High sportive activity in children.

Extension type are the most common type of supracondylar fractures accounting for about 98%, the most common mechanism of injury is fall on outstretched hand with hyperextension at the elbow. Supracondylar fracture of humerus is a condition that epitomizes the most important skill that the orthopaedic surgeon must develop, namely, the ability to choose from a number of treatment modalities the best treatment for a given condition. To achieve functionally and cosmetically satisfactory results and to avoid complication, assuring a low cost and decreasing the hospitalization period are very important for both surgeons and patient's parents. Closed reduction and immobilization require 120° of elbow flexion to maintain stable reduction [9], there are two disadvantages of this method as the "supracondylar dilemma", i.e.- further flexion to 120° in a swollen elbow may compromises the circulation but less flexion predisposes to loss of reduction. This method has a high incidence of poor results when used for all types of fracture [6], while Mitchell and Adams reported an incidence of 60% of cubitus varus deformity using this method [12].

Extremity with even brachial artery injury (itself is rare) can survive by the rich collaterals provided the extremity is kept in less flexion and also an intact artery can be occluded by excessive flexion or cast [13]. Skin traction [10] and skeletal traction are still effective method and have been recommended particularly in complicated fracture and when there is concern regarding swelling of soft tissues. But it has many drawbacks. First, it is expensive second, when the extremity is swollen it is very risky to attempt skin traction. Third, hospital stay is likely to be

longer with increased costs and does not provide any advantage over immediate reduction. The incidence of cubitus varus however will be high (0-57%). Volkmann ischemic contracture is a rare event, with a prevalence of 0.5% or less. In our study, we found no cases of compartment syndrome. Historically this has been one of the most feared complications of supracondylar fracture and probably is the reason why the fracture is treated as an emergency by many surgeons.

Movements at the elbow nearly always recover after supracondylar fracture [14-16], because it is an extra-articular injury. Supervised physiotherapy is unnecessary and could produce problems of myositis ossificans. Cubitusvarus is one of the most common complications of supracondylar fracture of the humerus in children treated with non-operative management without reduction and fixation. Its reported incidence varies from 4% to 58%. It is the most frequent problem with a mean incidence of 30% in the series reviewed by Smith. This deformity is due to medial tilting of the distal fragment, associated with rotation [17]. It does not remodel with growth is not progressive and is not due to physeal injury [16].

Primary open reduction and internal fixation is an alternative method of treatment. There are several different surgical approaches to the fracture site. The most heavily criticized has been posterior approach which is claimed to be the method most likely to cause loss of elbow movement, infection and 0-35% of cubitus varus deformity. It is not easy even in patients who present soon after their fractures occur because of the anatomy of distal end of humerus [5]. It certainly is difficult when the elbow is swollen various authors have cautioned regarding the risk of stiffness and myositis ossificans after repeated manipulations or open reduction of swollen elbow. Hence closed reduction and percutaneous medial and lateral pinning is best treatment modality for type III supracondylar humeral fracture.

Primary closed reduction and percutaneous pinning is the preferred treatment for the displaced fractures and gives the lowest rate

of residual deformity and lowest rate of compartment syndromes of the forearm [18]. Closed reduction and percutaneous pinning are now widely recommended. Wilkins has advocated stabilization by K-wires for all displaced fractures. The inpatient stay is reduced and the elbow can be immobilized in a more extended position reducing concern about limb perfusion in injuries with major swelling of soft tissues [19]. Now the choice has been between:

- (a) Using the lateral two wires and
- (b) Medial and lateral cross pinning, the choice is based upon two basic points
 - (i) Stability of the construct and
 - (ii) The avoidance of injury to the ulnar nerve.

The advantage of lateral entry pin fixation is avoidance of iatrogenic ulnar nerve injury, although the construct may be less, stable bio mechanically [20]. Conversely, the advantage of medial and lateral entry pin fixation is probably increased biomechanical stability, intra operatively can extend the elbow to measure the carrying angle and Baumann's angle although iatrogenic ulnar nerve injury may result from placement of the medial pin [21].

Using an adult human cadaver model, Zionts et al measured the resistance to rotation of the distal fragment of simulated supracondylar fractures fixed with four different pin configurations. They found that the crossed-wire configuration, placed from the medial and lateral condyles, was the most stable arrangement. The torque required to produce 10° of rotation averaged 37% less with two parallel pin 80% less with two crossed lateral pins. Re-displacement of the fracture has been reported to be significant after the use of lateral K-wires [20, 22]. A lateral K-wire configuration may not allow full extension of the elbow thus preventing examination of the carrying angle at operation [23].

When the elbow is in extension, both the extensor and the flexor muscles are mechanically neutralized and the carrying angle can be judged accurately, clinically and radiologically [24]. The incidence of reported iatrogenic ulnar injury ranges from 2-8% (58). Iatrogenic injury to the ulnar nerve [24], may occur even when the medial epicondyle is palpable [23]. We think that differences in fracture severity, adequacy of pretreatment evaluation, experience of the

surgeon, and pin configuration may lead to observed differences in the rates of iatrogenic nerve injury. There was no case of iatrogenic ulnar nerve injury in our study.

We followed the following methods to prevent ulnar nerve injury.

- Lateral pin was passed first and elbow extended till 90° before passing the medial pin.
- Palpation of the nerve and rolling it backwards.
- Entry point was made in the anterior aspect of the medial epicondyle.
- Sliding the pin to the epicondyle.
- Preoperative evaluation for ulnar nerve instability
- Avoiding the cubital tunnel.

Percutaneous crossed medial and lateral K-wire fixation of type III supracondylar fracture in children has the following advantages.

- Most stable construct.
- Resolves the "supracondylar dilemma"
- Low cost.
- Short hospital stay.
- Decreasing the incidence of cubitus varus deformity.
- Preventing compartment syndrome.
- Minimal or no risk of ulnar nerve injury.
- Intra operative measurement of carrying angle and Baumann's angle.

Conclusion

- Closed reduction with percutaneous crossed medial and lateral pin fixation is a safe, reliable and effective treatment modality for type III supracondylar humerus fractures with several advantages such as low cost, decreased hospital stay, preventing complications like compartment syndrome, decreasing the incidence of cubitus varus deformity and is the most stable construct not associated with an increased risk of ulnar nerve injury.
- The technique resolves the "supracondylar dilemma"

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