

# Controversial Issues in Closed Reduction and percutaneous pinning of Supracondylar Fractures of Humerus in children

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## Abstract

Closed reduction and percutaneous pinning is the mainstay in treatment of supracondylar humerus fractures in children. Although most of the issues are quite straight forward, but in certain situations, there exists difference in opinion in literature. Individual/ group of researchers will always find data to favor one approach over other, but the metaanalysis of the entire literature on the topics fails to show any advantage of one over other. We have tried to touch upon few such questions like Pin Configurations, emergency vs delayed fixation, radiation exposure etc. The pattern of the article is quite unique in terms of referencing the references in details and one after the other. The results are then compiled and guidelines are suggested according to current literature.

Keywords: closed reduction, supracondylar humerus fracture, percutaneous pinning.

### Introduction

Percutaneous pinning of supracondylar fracture is one of the commonest procedures in paediatric orthopaedics, yet there remain certain areas of controversy or lack of consensus. This article is prepared in separate dialectic sections each dealing with a unique question. Relevant literature is then reviewed to reach a logical answer.

#### A] Pin configurations: Lateral v/s Cross

Closed reduction and pinning is a gold standard in the management of displaced supracondylar fractures of humerus in children [1]. It allows the elbow to be maintained in a position of relative extension thus minimizing chances of compartment syndrome and vascular compromise yet providing stability and avoiding malunion associated with the fracture. There is an ongoing debate on choice of the the pin configuration while fixing SCFH [2]. In laboratory settings, cross pinning appears to have better stability but in clinical setting both seem to do equally well with additional risk of iatrogenic ulnar nerve palsy with medial

pinning. We examined some of recent papers which can guide an orthopedic surgeon solve the dilemma.

### Literature

#### 1. Medial and Lateral Crossed Pinning Versus Lateral Pinning for Supracondylar Fractures of the Humerus in Children: Decision Analysis [1].

#### Salient Features

-A decision analysis model was designed containing the probability of iatrogenic ulnar nerve palsy and malunion caused by unstable fixation for each of lateral pinning and medial and lateral crossed pinning techniques. The final outcome was function adjusted life year and used as a utility in the decision tree, where function was evaluated using the McBride disability evaluation.  
-Medial and lateral crossed pinning and lateral pinning have opposite aspects to each other in terms of mechanical stability and iatrogenic ulnar nerve injury.  
-Iatrogenic ulnar nerve injury after percutaneous pinning of a supracondylar

correctable. Therefore, the authors recommend the lateral pinning technique for supracondylar fracture of the humerus in children.

-If the minimal medial incision technique could reduce the iatrogenic ulnar nerve injury rate down to 0.7% or a surgeon used a crossed pinning technique with an iatrogenic ulnar nerve injury rate of <0.7%, then the medial and lateral crossed pinning technique could be a better choice than the lateral pinning technique.

#### 2. Is lateral pin fixation for displaced supracondylar fractures of the humerus better than crossed pins in children? [2]

#### Salient features

-A meta-analysis of the data from pubmed, embase and Cochrane library of RCTs.  
-Using various statistical analytic tools, it was found out that iatrogenic ulnar nerve palsy rate was higher in patients who underwent cross pinning.  
-There were no statistical differences in radiographic outcomes, function, and other surgical complications. No significant heterogeneity was found in these pooled results.  
-Authors recommended 2 lateral k wires.

#### 3. Meta-Analysis of Pinning in Supracondylar Fracture of the Humerus in Children [3]

#### Salient Features

-All randomized controlled trials and cohort studies comparing outcomes (ie, loss of fixation, iatrogenic ulnar nerve injury, and Flynn criteria) between crossed and lateral

fracture of the humerus can be devastating and irreversible, whereas malunion is

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pinning were identified.

-The risk of iatrogenic ulnar nerve injury was 4.3 times higher in cross pinning compared with lateral pinning.

-There was no significant difference for loss of fixation, late deformity, or Flynn criteria between the two types of pinning.

-The study concluded that lateral pinning is preferable to cross pinning for fixation of pediatric supracondylar humerus fractures as a result of decreased risk of ulnar nerve injury.

#### **4. Treatment of displaced supracondylar humeral fractures among children: Crossed versus lateral pinning. [4]**

##### **Salient features**

-108 children were treated by closed reduction and percutaneous pinning: 37 with crossed pins, 37 with two lateral pins and 34 with two lateral and one medial pin  
-Fractures fixed by two lateral pins were found significantly prone to postoperative instability, late complications and need for medial pin fixation.

-Of the 48 type III fractures fixed primarily with two lateral pins, 31 showed intraoperative instability that warranted an additional medial pin. Of the 17 fractures fixed by lateral pins alone, 8 demonstrated significant postoperative instability and 4 of these developed cubitus varus deformity.

-There was a significant relation between either delay to surgery or postoperative instability and occurrence of complications.

-Fixation by two lateral pins only is not recommended for treating type III supracondylar humeral fractures, but could be used initially to fix severely unstable fractures to allow extension of the elbow before inserting a medial pin. Every effort should be made to avoid iatrogenic ulnar nerve injury while inserting the medial pin.

-Measures taken to avoid iatrogenic ulnar nerve damage while inserting a medial pin include relative extension of the elbow with a maximum of 60° flexion, after inserting the lateral pin. This should reduce possible ulnar nerve subluxation before inserting the medial pin. In very unstable fractures, a second lateral pin may be needed to provide more stability before partially extending the elbow for safe medial pin placement. If the ulnar nerve and groove can not be identified with confidence, a small incision should be made over the pin insertion site and blunt dissection should be performed down to the

bone, to place the pin under direct vision.

Dorgan's technique of inserting crossed pins from the lateral side of the arm, as described by Shannon et al. offers the biomechanical advantages of cross-pinning while avoiding the risk of iatrogenic ulnar nerve injury.

#### **5. Crossed pinning in paediatric supracondylar humerus fractures: a retrospective cohort analysis. [5]**

##### **Salient features**

-Clinical and radiological results of 78 paediatric patients treated with closed reduction and percutaneous pinning

-No iatrogenic ulnar nerve palsy but one iatrogenic radial palsy which recovered in 13 weeks

-All patients were operated within 6 hours of injury

-Authors concluded that In cases where the ulnar nerve is palpable in the ulnar groove, blind percutaneous crossed pin placement is safe. If closed reduction fails or ulnar nerve subluxation cannot be excluded, a medial mini-open approach to visualise the nerve is certainly safer and should be preferred.

#### **6. Biomechanical Analysis of Pin Placement for Pediatric Supracondylar Humerus Fractures: Does Starting Point, Pin Size, and Number Matter? [6]**

##### **Salient features**

-20 synthetic humeri were sectioned in mid-olecranon fossa, and were directly reduced and fixed with 2 lateral k wires. There were 2 groups, one where both wires had a lateral entry and one group where one wire was put through capitellum and other through more lateral entry. Capitellar group provided greater stiffness in internal and external rotation. Capitellar entry provides for better stiffness of the construct compared to direct lateral entry by engaging sufficient bone and providing enough separation between the wires.

-Authors concluded that a capitellar entry should be used for one of the k wires.

#### **7. Radial nerve safety in Dorgan's lateral cross-pinning of the supracondylar humeral fracture in children: a case report and cadaveric study [7].**

##### **Salient Features**

-Authors encountered a radial nerve palsy while using a lateral proximal pin entry for

the cross K wire fixation for supra-condylar fracture of humerus.

-They did a cadaveric study in a pediatric humeri and noted that radial nerve is farthest from the wire in the postero lateral plane.

-Authors concluded that direction of the pin should be posterolateral within 2 cm of the lateral epicondyle.

#### **8. Safe Zone for Superolateral Entry Pin Into the Distal Humerus in Children: An MRI Analysis [8]**

##### **Salient features**

To determine the course of the radial nerve at the lateral distal humerus, authors reviewed 23 elbow radiographs and MRIs of 22 children and mapped radial nerve course.

-They concluded that Percutaneous direct lateral entry Kirschner wires and half-pins can be safely inserted in the distal humerus in children along the transepicondylar axis, either at or slightly posterior to the lateral supracondylar ridge, when placed caudal to the point located where the lateral supracondylar ridge line diverges from the proximal extent of the supracondylar ridge on AP elbow radiograph.

#### **9. A retrospective analysis of loss of reduction in operated supracondylar humerus fractures [9].**

##### **Salient features**

-18% patients had loss of reduction. Technical errors were noted to be higher in those patients where reduction was lost.

#### **10. Management of Pediatric Type III Supracondylar Humerus Fractures in the United States: Results of a National Survey of Pediatric Orthopaedic Surgeons [10].**

##### **Salient features**

-A short survey was sent to Pediatric Orthopaedic Society of North America (POSNA) members using an online survey and questionnaire service. The purpose of the survey was to establish an overview of current practices in the United States concerning treatment of type III supracondylar humerus fractures and the influence of the recent literature on the management of these injuries. -- A total of 309 members, representing a wide range of locations and years in practice, responded to

the survey

They reported 3 lateral pins (37%), 2 lateral pins (33%), and cross pins (30%) as the preferred method of fixation among respondents. This does show that two thirds of survey participants were using lateral pins primarily.

-However, many of those responding noted that they will add a medial pin to a lateral pin construct if they feel like more stability is needed intraoperatively. Some said that medial cortex comminution is one instance where a medial pin may be needed.

-The respondents that do place a medial pin regularly, advise placement of the lateral pin first for stability, followed by extension of the elbow for placement of the medial pin. This plus opening the medial side and exposing the medial epicondyle has been shown as a reliable technique to assist in protecting the ulnar nerve during medial pin placement. Overall, the sense was that ulnar nerve injury is not a common occurrence if proper precautions are taken.

#### Authors Comments and recommendations

1. The battle between lateral pinning and cross pinning is a battle between safety and stability
2. The supracondylar fractures are of different configurations and hence pin configurations have to be customized to the specific fracture geometry
3. Most cases of transverse and lateral oblique variety can be well treated by two or three lateral parallel or divergent pins. The stability of lateral pins can be improved in these cases by following measures
  - a. Capitellar entry point for one of the pins
  - b. Divergent pin configuration
  - c. Using wires more than 2 mm diameters
  - d. Pass pins from anterior to posterior direction at 15-30° to shaft of humerus to have maximum purchase in the distal humerus which is inclined 45 to shaft of humerus
  - e. Avoid multiple attempts. Multiple attempts weaken the pin bone interface and weakens the hold of the K wire
4. In some situations medial pin may be added in addition to lateral pins These indications are
  - a. Intraoperative instability after passing lateral pins
  - b. Medial comminution
  - c. Medial oblique fracture

- d. Adolescent supracondylar fracture
- e. Low supracondylar fractures
- f. Obliquity in coronal plane which signifies instability
5. Some medial oblique fractures may need only medial pinning
6. The safety of medial pinning can be improved in these cases by
  - a. Pinning in relative extension The elbow should not be flexed more than 60°
  - b. Pinning from anterior to epicondyle to posterior
  - c. Feeling the medial epicondyle and pushing ulnar nerve manually with a thumb pressure
  - d. In doubt or whenever there is a swelling using a mini opening on medial side to make sure the pin is well away from the nerve and does not entangle it
  - e. Use of a K wire protecting sleeve to prevent entanglement of ulnar nerve sheath.

#### B] Timing of surgery Emergency v/s Elective

Traditionally supracondylar fractures have been treated as emergency cases. The delay in management of supracondylar fracture may be because of delay in presentation of patient to the hospital or delay after the patient presents to the hospital. If the patient presents in the morning hours the emergency management is not an issue but when the patient presents to hospital the emergency management poses issues of availability of senior consultant, anaesthesia risk, support staff and cost. The main concerns associated with delayed treatment are as follows:

1. the failure of closed reduction due to swelling
  2. the need to convert to open reduction
  3. the complications of neurovascular compromise and compartment syndrome.
- One study found that children who underwent later surgery after injury (more than 8 h) were more likely to require an open reduction as compared with those who underwent earlier surgery after injury (8 h or less)[3], whereas other studies found no such statistically significant association [4,5]. One of the issues in the management of displaced supracondylar fracture is to manage the patient as emergency or do the surgery the next morning on a routine list. We have again explored recent literature to show some guidelines for treating orthopedic surgeons on this issue.

#### 1. A systematic review of early versus delayed treatment for type III supracondylar humeral fractures in children [11].

##### Salient features

-Using medline and Cochrane database 156 publications were scrutinized. Only 7 studies were identified where the effect of early versus delayed treatment were studied. Treatment given in all of them was closed reduction and percutaneous pinning. All the studies were non-randomized and retrospective.

-The authors concluded that chances of failure of closed reduction and conversion to open reduction were significantly high if surgery was delayed beyond 12 hours.

#### 2. Delayed surgery in displaced paediatric supracondylar fractures: a safe approach? Results from a large UK tertiary paediatric trauma centre [12].

##### Salient features

-Authors reviewed charts of patients :115 children into those treated before 12 h (early surgery) and after 12 h (delayed surgery) .

-The results indicate that delayed surgery appears to offer a safe management approach in the treatment of displaced supracondylar fractures, but it is important that cases are carefully evaluated on an individual basis

#### 3. Operative Treatment of Type II Supracondylar Humerus Fractures: Does Time to Surgery Affect Complications? [13]

##### Salient Features

-Retrospective review of a consecutive series of 399 modified Gartland type II supracondylar fractures treated operatively at a tertiary referral center over 4 years. A total of 48% were pinned within 24 hours, 52% pinned >24 hours after the injury.

-Delay in surgery did not result in an increased rate of major complications following closed reduction and percutaneous pinning of type II supracondylar humerus fractures in children.

#### 4. Management of Pediatric Type III Supracondylar Humerus Fractures in the

## United States: Results of a National Survey of Pediatric Orthopaedic Surgeons [10].

### Salient features

-An overwhelming majority of respondent to the survey (81%) noted that they do not treat type III supracondylar humerus fractures on an emergent basis if they present after normal work hours, assuming the patient has no obvious reason for emergent intervention, such as, impending compartment syndrome, open injury, vascular injury, or skin compromise

-NPO status and aspiration risk is a concern during emergency surgery. This is a complication that can potentially be avoided with delayed treatment.

- Some respondents treated these on an emergent basis if the fracture is severely displaced or that reduction has seemed more difficult as swelling increases. Other participants cite the lack of OR time the following morning as a reason to fix some of these fractures after normal work hours.

-However, the majority of respondents felt like delayed surgical fixation in this setting was appropriate.

### Authors Comments and recommendations

1. We feel that every displaced supracondylar fracture is different and need to have different strategy
2. A displaced supracondylar fracture should be splinted in 60 flexion in an above elbow slab and note be made of neurovascular status, swelling, compartment syndrome, open injury, pucker sign, medial spike
3. Most who present in routine hours get fixed in routine list
4. Those who present in after routine hours are classified into two types
  - a. Those who can wait till next day
    1. Those not fitting into emergency fixation check list
    2. Those Presenting after 48 hours where delay of few hours will not make a difference
  - b. Those who need to be fixed immediately
    1. Open injury
    2. Compartment syndrome or impending compartment syndrome or even suspicion of compartment syndrome
    3. Nerve palsy
    4. Pulseless hand pink or pale

5. Difficult reductions due to swelling medial spike puckering etc as the difficulty will increase with increasing time
5. In borderline cases or when doubt exists the case is operated as emergency in presence of senior consultant
6. Even in emergency situation make sure that facilities for open reduction if required are available.

### C] Radiation Exposure - What is the risk?

The use of fluoroscopy facilitates the accurate placement of K wires while fixing supracondylar fractures. One negative side effect of fluoroscopic imaging, however, is ionizing radiation. It is a practice to use image intensifier in inverted fashion while doing CRPP for SCFH in children. The issue is what are the factors affecting direct beam and scattered radiation exposure and how to minimize this.

### 1. The Effect of C-Arm Position on Radiation Exposure During Fixation of Pediatric Supracondylar Fractures of the Humerus [14].

#### Salient features

-There is a concern that using image intensifier as operating table during surgery may lead to increased radiation exposure to the patient and to the surgeon. This study was done to determine radiation exposure from c-arm configurations.

-It was noted that there was 16% less scatter at waist level but 54% more scatter at the neck level when using c arm as operating table as compared to using an arm board.

-Although the statistical difference was significant between the 2, yet neither of the 2 was safe.

### 2. Direct Beam Radiation Exposure to Surgeons During Pinning of Supracondylar Humerus Fractures: Does C-Arm Position and the Attending Surgeon Matter?

3842 fluoroscopic still images from 78 closed reduction and percutaneous pinning surgeries for supracondylar humerus fractures performed or supervised by 6 attending surgeons. The percentage of images containing a surgeon's body was calculated as an indicator of direct beam

radiation exposure. Total fluoroscopy time, C-arm position (standard or inverted), and whether the primary surgeon was an attending, resident, or both were recorded.

-They noted that fluoroscopy was significantly longer and surgeon's exposure to direct beam radiation higher when the C-arm position was inverted when compared with the standard position.

### Authors Comments and recommendations

1. Direct exposure delivers approximately 100 times more ionizing radiation to the surgeon compared with scatter radiation.
2. Standard radiation dosimeter badges are worn on the neck and waist of surgeons, which measure only scatter radiation unless the fluoroscopy beam directly hits the badge.
3. The surgeons' hands are the most exposed part of the body during surgery, with the fingertips and the dominant index finger being at greatest risk.
4. Suggestions for minimizing the radiation exposure to both the patient and the surgeon.
  - a. Use of protective lead aprons, thyroid seals, leadlined eyeglasses, and lead-lined gloves.
  - b. Lead-lined gloves, however, may produce a false sense of security by providing little additional protection.
  - c. Being close to the radiation source side of the platform and reducing the fluoroscopy time is shorter.
  - d. Using a laser light guidance beam with the conventional C-arm.

### Other issues

#### 1. Can CRPP for supracondylar fractures be considered as being a day care procedure?

**Answer :** Yes. Provided fracture is not open or associated with a neuro-vascular injury [16].

#### 2. Does the Pin Size influence the stability of supracondylar fixation

**Answer -** Large pin sizes improved radiographic sagittal alignment at final follow-up without an increased rate of infection or ulnar nerve palsy. The commonly used 1.6-mm K-wire may be considered a "large" pin if used in a young or small patient, but also could be

considered a “small” pin if used in an older or larger individual. The pin diameter should be similar to the thickness of the midshaft cortex. At the time of fracture reduction, the ratio of the diameter of the pin to the patient’s humeral midshaft cortical thickness can quickly and easily be

determined by placing the pin over the arm during fluoroscopy. For a “large” pin, the ratio should be at least one [17,18]

### 3. How long does it take for children supracondylar fractures to regain full range of motion after closed pinning?

**Answer:** By 6 weeks children gain 72% of elbow ROM of contralateral elbow and by 52 weeks 98% of elbow ROM of contralateral elbow [19].

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