



# Management of Grossly Displaced Paediatric Supracondylar Humeral Fractures with Delayed Presentation by Closed Reduction and Percutaneous Pinning

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## Authors' contributions

This work was carried out in collaboration between all authors. Authors KRK and SSB designed the study, wrote the protocol, and wrote the first draft of the manuscript. Authors TVSB and KD managed the statistical analyses of the study, data sorting and literature searches. All authors read and approved the final manuscript.

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## ABSTRACT

**Background:** Management guidelines are not yet clear for these patients who present late with displaced supracondylar fracture. The aim of this prospective study was to evaluate the clinical, radiological and functional outcome following closed reduction and percutaneous pinning of widely displaced supracondylar fractures of the humerus presenting 24 hours or more after injury.

**Patients and Methods:** This prospective study was conducted at the Orthopaedic and Trauma Department of Dr Pinnamaneni Siddartha Institute of Medical Sciences and Research Foundation, Chinnoutpalli from January 2010 to July 2011. A total of 44 children were included in this study who had displaced supracondylar fracture of humerus presenting late ie, after 24 hours after injury and within a week. They were treated with closed reduction of the fracture and percutaneous pinning.

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Follow-up was done up to 12 months.

**Results:** Patients were assessed on the basis of Flynn's criteria, there were 37 excellent, 6 good results and fair results in 1 case. There were 25 boys and 19 girls. The average age of the patients was 7.5 years (range: 4 to 12 years). Fall on the outstretched hand was the mechanism of injury in 36 patients, and the other 8 patients were pedestrians struck by a motor vehicle. Non-dominant extremity was more commonly involved (30 patients). In 24 patients the fracture was displaced posteromedially (54.54%), in 18 patients posterolaterally (40.90%), and 2 patients had isolated posterior displacement (2.54%). The average delay in presentation was 57.56 hours (range: 1 day to 6 days). The mean time to surgery after presentation was 9.83 hours (range: 4 hours to 13 hours) and the mean time to surgery after trauma was 67.39 hours. Sixteen patients had one or more attempts of reduction by massaging by a quack and in 2 patients it was attempted by a qualified surgeon before they presented to us. 26 patients (59.09) visited a quack prior to presentation to us. There was a direct relation between duration of delayed presentation and the times of manoeuvre. Sixteen patients (36.36%) had neurologic complications at presentation to the emergency room of which three had median nerve palsy (6.81%) where as seven (15.90%) had isolated anterior interosseous nerve palsy and six (13.6%) had radial nerve palsy all patients showed total neurological recovery at 12 weeks follow-up. Six patients (13.63%) had vascular compromise at initial presentation of which five patients had feeble radial pulse and one had absent radial pulse, but capillary filling was adequate in all. The pulse was restored within 24 hours in all patients following reduction.

**Conclusion:** Our preliminary results support our recommendation ie, closed reduction and percutaneous pin fixation as an effective treatment option for grossly displaced supracondylar fractures presenting late but requires good and careful judgment and also technique by the surgeon to avoid complications. Our results also support the chances of spontaneous recovery of peripheral nerve palsy and brachial artery spasm post reduction over a period of time in majority of cases though they present late.

*Keywords: Displaced supracondylar fracture; closed reduction; percutaneous pinning; delayed presentation.*

## 1. INTRODUCTION

Supracondylar fractures are the most common fractures occurring in the first decade of life accounting for about 60% to 75% of all the fractures around the pediatric elbow and represents approximately 3% of all fractures in children [1]. Modern day healthcare has greatly evolved following advances in technology and medical research but despite the availability of these services, traditional bonesetting has continued as an 'alternative' health service. In developing countries, especially in the Indian subcontinent quacks treat 60% of all trauma [2], this mainly leads to delay in presentation to orthopaedician.

Displaced supracondylar fractures are difficult to treat, much more is the difficulty with fractures which present late. The difficulty is due to excessive swelling, earlier attempted and failed manipulations and sometimes presence of associated complications, such as neurovascular injury and compartment syndrome [3]. The management guidelines are not clear for these

patients presenting late but there are various treatment options for these fractures.

The importance of our study is to draw the attention of orthopedic surgeons to percutaneous pinning (PCP) for the treatment of displaced pediatric supracondylar fracture of humerus presenting late after injury with which the chances of redisplacement, loss of elbow motion, and cubitus varus deformity are minimal. However it is important to consider the options of treatment very carefully and tailor the treatment to the personality of each fracture.

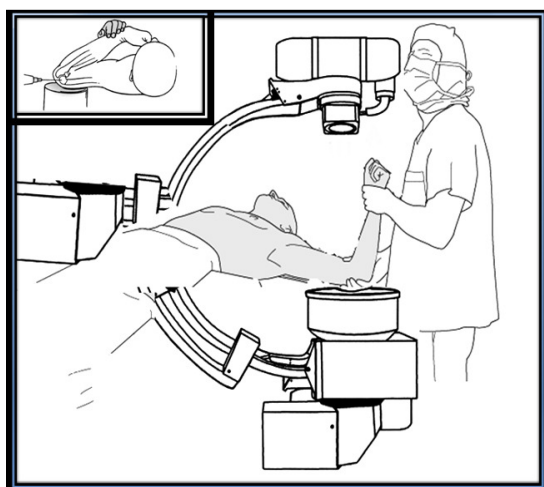
## 2. MATERIALS AND METHODS

Between January 2011 to July 2012, 64 patients with grossly displaced supracondylar fractures of the humerus were treated at our institute, which is a tertiary referral center. Children presenting with a compound fracture or vascular injury or extensive swelling with blisters were excluded, as were those with other fractures of the ipsilateral limb or head injury and patients aged above 12 years. Patients with no pulse or a feeble pulse were taken for Colour Doppler

immediately. Those of whom had a vascular injury were excluded from the study ie, those with vessel wall tear but those with spasm were included in our study. This left 59 patients available for inclusion in the study out of which 2 patients were lost to follow-up and 4 children presented to us more than 1 week after injury and 9 children presented within 24 hours of trauma, these children were excluded from the study. The remaining 44 patients were followed up for a minimum period of 12 months and formed the basis of this study. All the patients' attendants gave the informed consent prior to being included into the study and the study was authorized by our local ethical committee in accordance with the Ethical standards declaration in 2000.

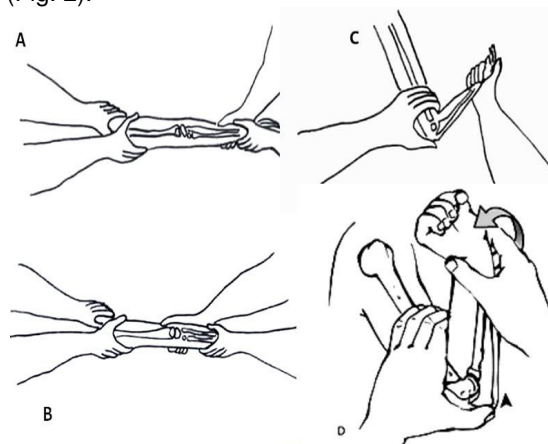
On presentation, age, gender, injured side, dominant side, exact delay between injury and presentation and Baumann's angle of the normal upper limb were recorded for each patient. Clinical evaluation was done with particular emphasis on compartment syndrome and neurovascular status of the limb. All fractures were splinted in 30° of flexion. Extremity was kept elevated to promote venous outflow and to reduce swelling.

All operations were done under general anesthesia. Fracture reduction was achieved in all cases by the method described by us, in cases where reduction was not achieved in the first attempt the manoeuvre was repeated in our series for as many as six times. For reduction the child was brought to the edge of the table with the elbow over the image intensifier after reversing the image intensifier (Fig. 1).



**Fig. 1. Patient positioning**

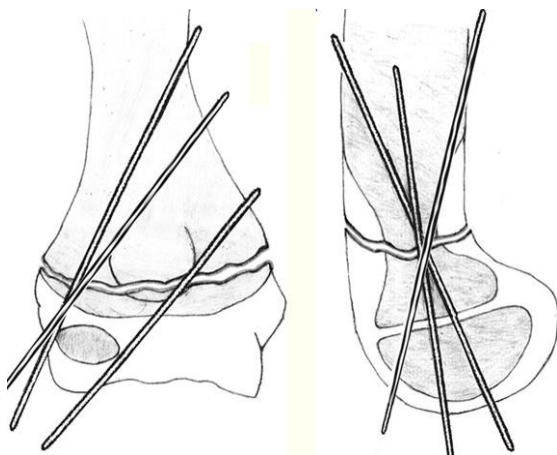
Firm and sustained traction is given for 3 to 5 minutes with the elbow in full extension and forearm supinated, this helps to disimpact the fracture, medio-lateral translation pressure is applied to the distal fragment to achieve reduction in the coronal plane. Once the reduction in coronal plane is confirmed under image intensifier counter traction is applied to the proximal fragment, using four fingers of the surgeon to maintain the distal fragments position by placing them anteriorly just proximal to the elbow crease, the thumb is used to push the patient's olecranon anteriorly, concurrently the other hand is used to flex the elbow to 120° to stabilize the reduction, finally pronation of the forearm is important in the prevention of a varus deformity by locking and securing the reduction (Fig. 2).



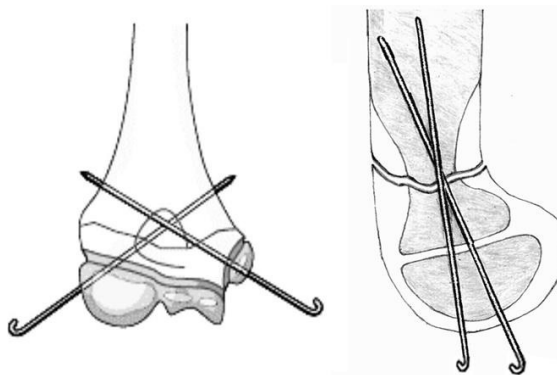
**Fig. 2. Reduction technique**

After confirming the reduction in both planes under image intensifier first a lateral pin is passed later based on fracture geometry and fracture comminution decision on passing a medial pin and number of lateral pins to be used is made. Lateral pinning (Fig. 3) as described by Flynn was done in 24 cases and in the remaining 20 cases cross pins (Fig. 4) as described by Swenson et al were used to secure the fracture. When gross swelling made palpation of medial epicondyle difficult, a mini open technique as described by Green et al was used for placement of medial wire in 4 cases. Once K-wires were passed, the elbow was extended to maintain 80° elbow flexion and forearm was supinated, radial pulse palpated and stability of reduction was assessed under image intensifier. The K-wires were left outside the skin after being bent at right angles and above elbow posterior plaster slab was given. K-wires were removed at 4 to 5 weeks and slab was discontinued after 5 to 6

weeks ie, 1 to 2 weeks further after pin removal, no patient was immobilized beyond 8<sup>th</sup> week. At each follow-up after pin removal, the carrying angle, range of motion of the elbow and neurovascular status of operated limb were recorded. Each patient was followed up for at least one year and results were graded using the Flynn's criteria.



**Fig. 3. Ideal pin placement for lateral pinning technique**



**Fig. 4. Ideal pin placement for cross pinning technique**

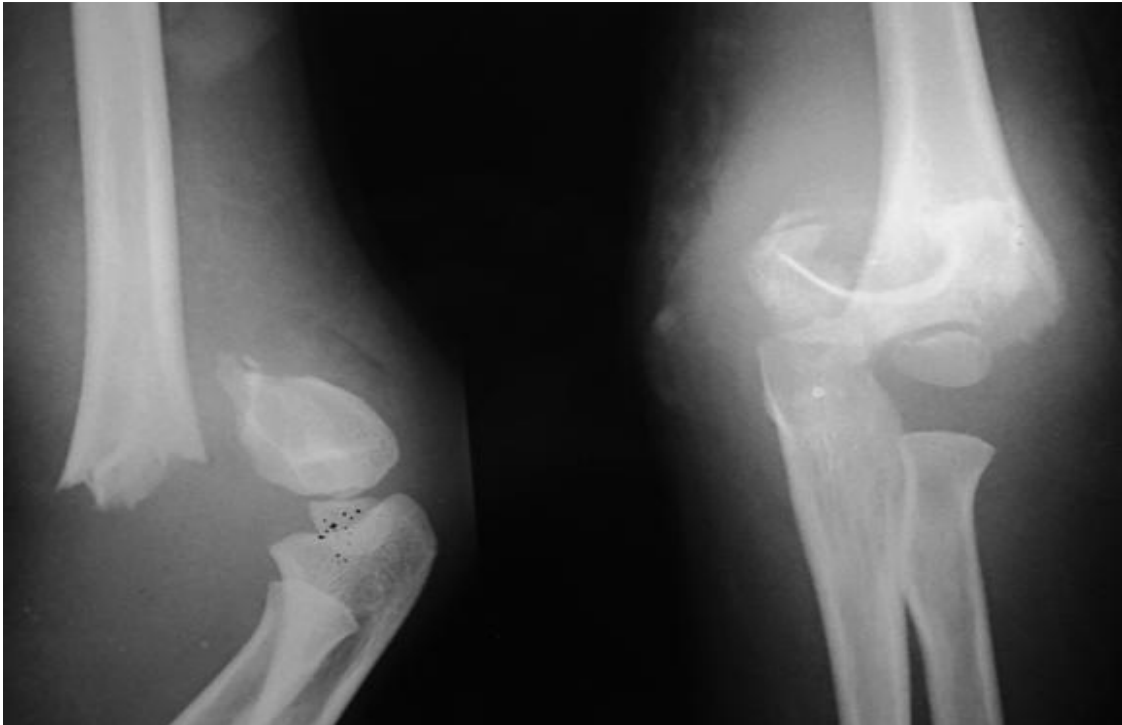
### 3. RESULTS

The age of patients ranged from 4 - 12 years with a mean age of 7.5 years. There were 25 males and 19 females. All the patients had pain, gross swelling and restricted elbow movement at presentation. The left elbow was involved in 34 cases and right in 10 cases. The usual cause was a fall on the outstretched hand. The minimum delay in presentation from injury was 24 hours and maximum was 6 days. The exact

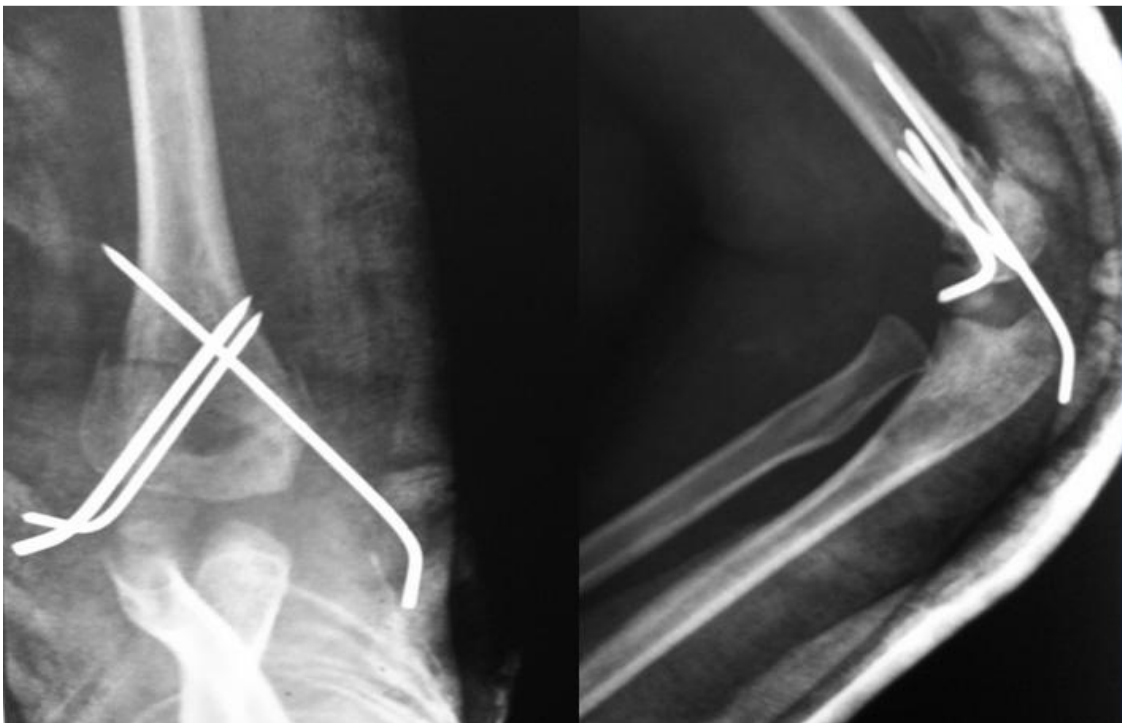
cause of delay in each case was not documented but we observed that 26 of our patients underwent primary treatment from an unqualified person in the form of manipulation, massaging, splinting or just medication before presentation to us. The mean time to surgery after presentation was 9.83 hours (range: 4 hours to 13 hours) and the mean time to surgery after trauma was 67.39 hours. 18 patients had undergone attempted reduction or massaging prior to presentation to us of which 2 were performed by a qualified doctor without anaesthesia and the remaining were performed by quacks. The non-dominant upper extremity was involved in 30 cases. Of the 44 patients, 24 had posteromedial type of displacement (Fig. 5a, b, c, d), 18 had posterolateral displacement (Fig. 6a, b, c, d) and 2 had isolated posterior displacement (Fig. 7a, b, c, d). Sixteen had nerve injuries at the time of presentation out of which 6 had radial nerve injury, 7 had anterior interosseous nerve injury and 3 had median nerve injury. All these cases recovered completely within 12 weeks. Five patients presented with a feeble radial pulse and in one the radial pulse was totally absent but all had adequate capillary filling at presentation. Colour Doppler studies were done as a routine in all these patients which revealed spasm of brachial artery in the adjacent area of fracture. Adequate blood flow was restored in all cases within 24 hours after reduction which was confirmed by a repeat Doppler and no exploration was required (Table 1).

The time required for clinicoradiological union ranged from 4 - 6 weeks with an average of 5 weeks. The carrying angles on follow up were measured and compared with that of the normal. The average carrying angle was 10.65° (range 4° - 15°) on the affected side and 12.62° (range 8° - 18°) on the normal side. Six patients had pin tract infection which regressed after pin removal and one week of oral antibiotics. Thirty five patients had a loss of range of flexion within 5° of the normal side and six had a loss of range of flexion within 5 - 10° of the normal side, only one patient had loss of flexion of 20° and extension loss of 10° probable due to myositis (Fig. 8a, b, c). Rest of the patients had no complications (Table 2).

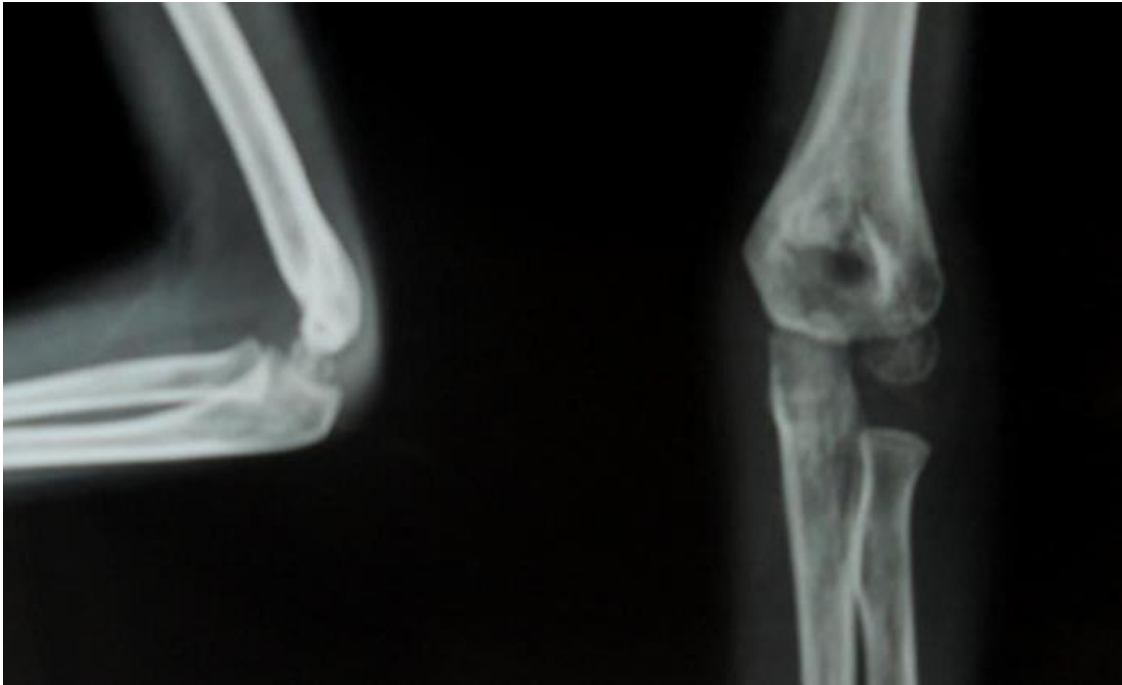
Each patient was followed up for at least one year and results were graded using the Flynn's criteria. We had 37 excellent results (84.09%), 6 good results (13.63%) and fair results in 1 case (2.27%) at the final follow up (Table 3).



**Fig. 5a. Pre-op radiograph of posteromedially displaced supracondylar fracture**



**Fig. 5b. Post-op radiograph of posteromedially displaced supracondylar fracture**



**Fig. 5c. Radiograph showing united post operative posteromedially displaced supracondylar fracture after pin removal**



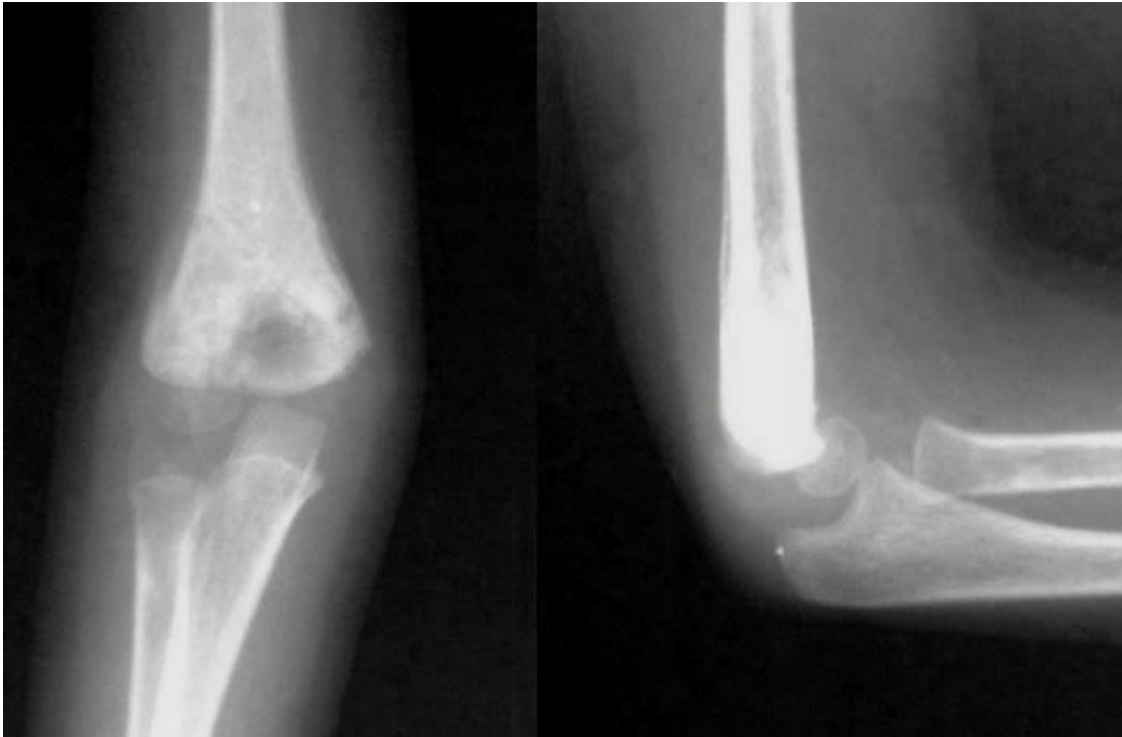
**Fig. 5d. Clinical photograph of post-op case of postero-medially displaced supracondylar fracture after fracture union showing elbow movements**



**Fig. 6a.** Pre-op radiograph of postero-laterally displaced supracondylar fracture



**Fig. 6b.** Post-op radiograph of postero-laterally displaced supracondylar fracture



**Fig. 6c. Post-op radiograph of postero-laterlly displaced supracondylar fracture after pin removal showing fracture union**



**Fig. 6d. Clinical photograph of post-op case of postero-laterlly displaced supracondylar fracture after fracture union showing elbow movements**





**Fig. 7a. Pre-op radiograph of isolated posteriorly displaced supracondylar fracture**



**Fig. 7b. Post-op radiograph of posteriorly displaced supracondylar fracture**



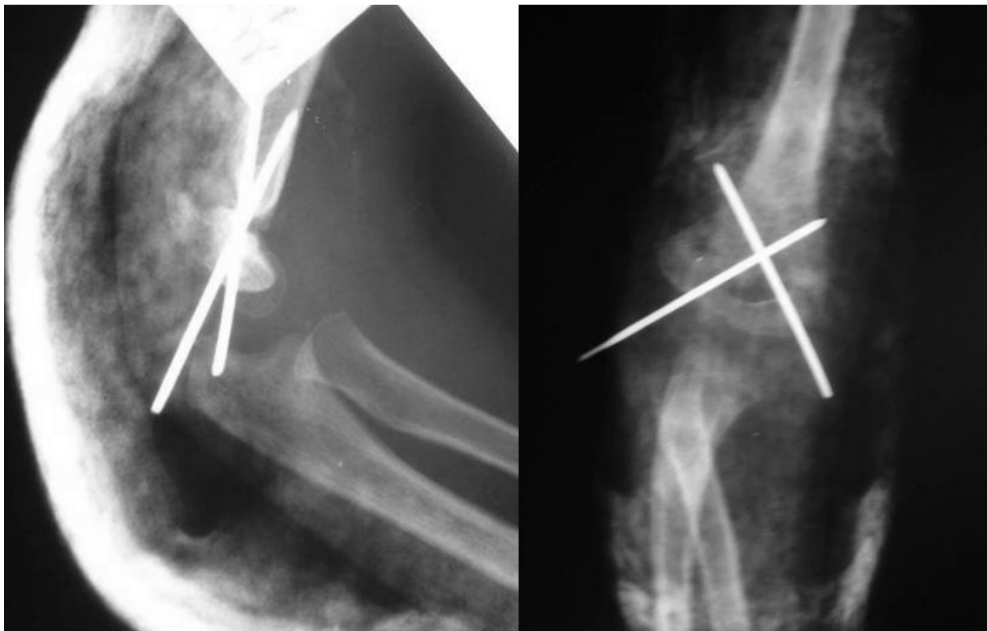
**Fig. 7c. Post-op radiograph of posteriorly displaced supracondylar fracture after pin removal showing fracture union**



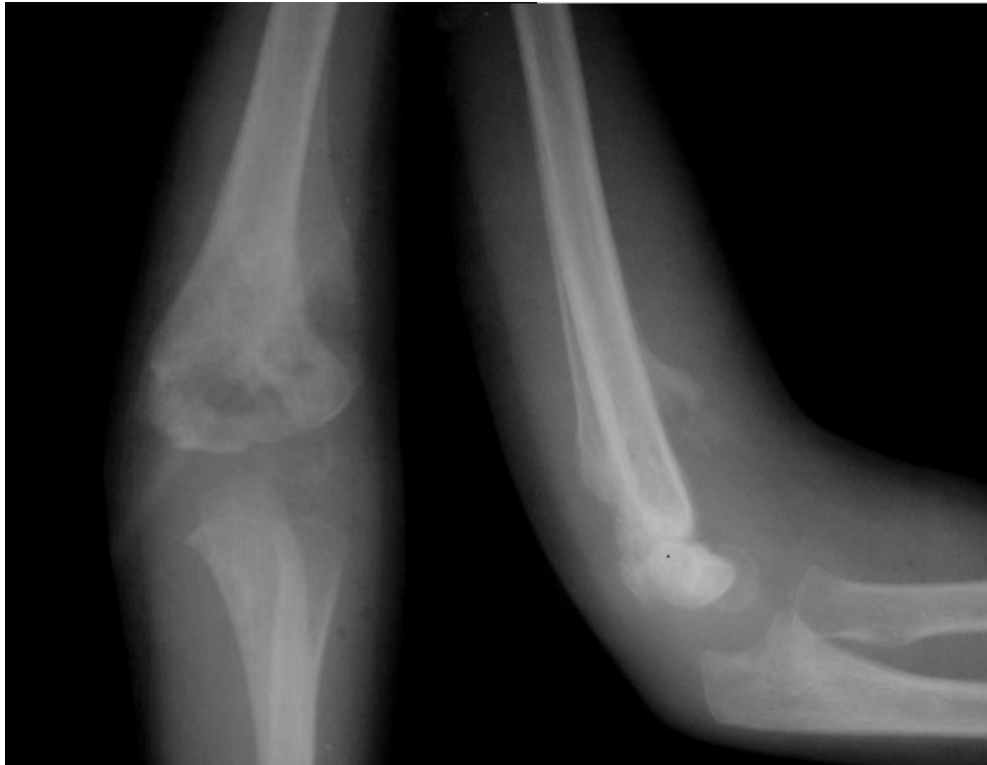
**Fig. 7d. Clinical photograph of post-op case of posteriorly displaced supracondylar fracture after fracture union showing elbow movements**



**Fig. 8a. Pre-op radiograph of posteriorly displaced supracondylar fracture with fair clinical result**



**Fig. 8b. Post-op radiograph of posteriorly displaced supracondylar fracture with fair clinical result**



**Fig. 8c. Post-op radiograph of posteriorly displaced supracondylar fracture showing union of fracture and myositis with fair clinical result**

**Table 1. Clinical details in our series**

<b>Sex distribution</b>	<b>Boys - 25</b>	<b>Girls - 19</b>	
Mechanism of injury	Fall on outstretched hand - 36	Pedestrian stuck by ongoing vehicle - 8	
Displacement	Posteriomedial - 24	Posteriolateral - 18	Posterior - 2
Side involved	Right - 10 Dominant - 14	Left - 34 Nondominant - 30	
Manipulations prior to presentation	Quack - 16	Qualified doctor - 2	
Nerve palsy	Radial - 6	Anterior interosseous - 7	Median - 3
Radial pulsations at presentation	Absent - 1	Feeble - 5	
Cause for delayed presentation	Treatment with a quack - 26	Socioeconomic problems - 14	Unknown - 4
Pinning method (to secure reduction)	Lateral pinning - 24	Cross pinning - 20	
Result (Flynn's criteria)	Excellent - 37	Good - 6	Fair - 1

**Table 2. Complications encountered in our series**

Complications	No. of patients
Stiffness (range of movement loss >15°)	1
Cubitus varus (carrying angle loss >15°)	0
Nerve palsies (preoperative – all recovered at 12wks follow up)	Median nerve - 3 Anterior interosseous nerve - 7 Radial nerve - 6
Vascular problems(all recovered after reduction)	Feeble radial pulse - 5 Absent radial pulse - 1
Pin tract infection	6
Myositis ossificans	1
Avascular necrosis of trochlea	0
Compartment syndrome	0
Osteomyelitis	0

**Table 3. Overall grading of patients according to the Flynn's criteria\***

Results	Cosmetic factor Loss of carrying angle (degrees)	Functional factor Loss of elbow movements (degrees)	Results in our series (total patients / percentile)
Excellent	0-5	0-5	37 / 84.09%
Good	6-10	6-10	6 / 13.63%
Fair	11-15	11-15	1 / 2.27%
Poor	> 15	> 15	-----

\* The lower of the 2 grading was taken as the overall grading

#### 4. DISCUSSION

Delayed presentation of fractures in a child is common in developing countries [2]. Ours being a tertiary referral center with patients being referred from as far as 100 km late presentation is much more common. Modern day healthcare has greatly evolved following advances in technology and medical research but despite the availability of these services, traditional bone setting has continued as an 'alternative' health service [2]. In developing countries - especially in the Indian subcontinent quacks treat 60% of all trauma, this mainly leads to delay in presentation to an orthopaedician [2]. Even in developed countries 18% of trauma patients undergo surgery 48 hours or longer following presentation in the hospital after injury [4]. The management guidelines are not clear for these patients who present late and there is a fear of high incidence of perioperative and late postoperative complications in these patients.

Fractures which present late are difficult to treat because of excessive swelling, earlier attempted and failed manipulations and sometimes presence of associated neurovascular complications [3]. There are concerns about higher incidence of serious perioperative complications and inability to achieve satisfactory

reduction while treating these patients, potential complications include higher risk of elbow stiffness, myositis ossificans, loss of motion, infection, higher incidence of inadequate reduction and compartment syndrome [5]. The relative incidence of nerve injuries has been reported as being 12–20% and they mainly (86–100%) consist of neurapraxias, which usually resolve spontaneously [6]. In our series the incidence of nerve palsy was higher (18.18%, probably because we accounted only patients with delayed presentations and type 3 fractures) but all our patients recovered spontaneously requiring no definitive treatment. The management of patients with a pulseless but otherwise well perfused hand still remains controversial. Post-traumatic arterial spasm is a transient phenomenon with no permanent injurious sequelae unless it is prolonged, in such cases status of collaterals play an important role [7]. Pre-operative evaluation based on a thorough clinical examination with the aid of Doppler sonography is considered to be sufficient in evaluating the patency and status of the brachial artery [7]. If the hand remains pulseless due to arterial spasm but well perfused after stabilization, vascular injury need not be treated as it is a transient phenomenon and instead rely on collateral circulation, a time window ranging from 12 hours to 24 hours post

reduction is usually given beyond which brachial artery is unlikely to recover its patency [8]. At 24 hour post reduction re-evaluation all our patients who earlier showed signs of brachial artery spasm showed good patency both clinically and by Doppler study. There was a direct relation between duration of delayed presentation and the times of manoeuvre. Greater was the delay to presentation more was the difficulty in satisfactory reduction and more was the number of times we had to repeat the manoeuvre before pinning.

The results of our study indicate that the majority of widely displaced supracondylar fractures of the humerus even with a delay in presentation of up to 6 days can be safely treated with the technique of closed reduction and percutaneous pinning described by us. The healing of a metaphysis in children is fast, presence of soft tissue callus by the end of the first week renders the fracture irreducible [9] so we didn't attempt this method in children presenting to us on the seventh day or more after injury.

France and Strong [10] compared the various modalities of treatment of these fractures and found closed reduction and percutaneous pinning to be superior. Cheng et al [11] and Topping et al [12] compared lateral and cross k- wiring and found equivalent excellent results in both groups.

The results of our study indicate that the majority of widely displaced supracondylar fractures of the humerus even with a delay in presentation of up to 6 days can be safely treated with our technique of closed reduction and percutaneous pinning with excellent clinical results. In our series, closed reduction and percutaneous pinning was possible in all our patients. The rate of conversion to open reduction in delayed presentations of these fractures has been reported in literature as ranging from less than 10% up to 36% [4, 13]. Archibeck et al [14] reported entrapment of brachialis muscle as a cause in 90% of irreducible supracondylar fractures. We did not encounter any such problems in our series.

Deep infections and osteomyelitis following fixation of supracondylar fracture are rare, while pin tract infections are common, which usually heal well with oral antibiotics and removal of wires, Infection rates of 2% - 6.6% have been reported with percutaneous fixations [11, 15]. In the present series, 6 out of 44 patients (13.64%) developed pin tract infection. All the infections

healed after removal of K-wires and administration of a short course of oral antibiotics. Greater incidence of pin tract infections in our series was probably due to excessive swelling (due to various reasons) at presentation.

Percutaneous pinning enabled us to immobilize the elbow in less than 90° flexion in postoperative period, facilitating venous outflow and significantly reducing the risk of compartment syndrome [4]. In addition, it prevents tenting of ulnar nerve [16] and allows healing of the brachialis in a slightly elongated state which hastens regaining of extension during mobilization [17]. None of our patients developed compartment syndrome, Leet et al [18] reported similar observation and suggested that vascular injury at the time of trauma is a bigger predisposing factor for development of compartment syndrome than delay in surgical intervention.

Although modern pinning techniques have reduced the incidence of complications the most common complication in these fractures continues to be an alteration of the carrying angle, nearly always in varus [18, 19]. The cause of deformity is coronal rotation or tilting or a combination of both of the distal fragment due to faulty reduction or the inability to maintain good reduction till union [19]; it is not an epiphyseal growth disturbance as earlier believed [19]. The most important factor correlating with the final varus deformity following closed reduction and percutaneous pinning is the difference in Baumann's angle between the operated and normal side [11]. In all our patients, Baumann's angle was restored to within 4° of the uninjured side. None of our patients had cubitus varus deformity at a minimum follow up of 1 year. Our study results agree with other studies, which have reported that cubitus varus is caused by inadequate reduction [19].

None of our patients had loss of reduction during follow-up. We used lateral pinning technique in majority of our cases and reserved the cross pinning technique for cases where comminution of medial supracondylar ridge was present or in cases where lateral pins alone did not appear to give satisfactory stability intraoperatively. The use of a small medial incision over medial epicondyle as described by Green et al [20] for medial pinning in cases with severe elbow swelling helped to prevent ulnar nerve injury.

In our series, we had excellent results in 37 (84.09%), good results in 6 (13.63%) and fair results in 1 case (2.27%) at the final follow up. The fair result due to loss of flexion of 20° and loss of extension of 10° in our case was probably due to myositis ossificans. Patient presented to us on the 5<sup>th</sup> day after trauma and had a history of massage and repeated manipulations by a quack which probably added to the initial soft tissue injury and may have contributed to the unsatisfactory result in our patient.

## 5. CONCLUSION

In developing countries even today quacks and traditional bone setters are the first to attend to trauma patients in major cases. Fall on outstretched hand is the most common cause of supracondylar fractures with the non-dominant extremity being commonly involved. Most common displacement of the distal fragment is postero-medial.

Our preliminary results support our recommendation ie, closed reduction and percutaneous pin fixation as an effective treatment option for grossly displaced supracondylar fractures presenting late but requires good and careful judgment and also technique by the surgeon to avoid complications. Our results also support the chances of spontaneous recovery of peripheral nerve palsy and brachial artery spasm post reduction over a period of time in majority of cases though they present late.

## CONSENT

All authors declare that written informed consent was obtained from the patient (or other approved parties) for publication of this case report and accompanying images.

## ETHICAL APPROVAL

All authors hereby declare that all experiments have been examined and approved by the appropriate ethics committee and have therefore been performed in accordance with the ethical standards declaration.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

## REFERENCES

1. Kasser JR, Beaty JH. Supracondylar fractures of the distal humerus. In: Beaty JH, Kasser JR, eds. *Rockwood and Wilkins' Fractures in Children*. 6<sup>th</sup> ed. Philadelphia, PA: Lippincott Williams & Wilkins. 2006;543-589.
2. Agarwal A, Agarwal R. The Practice and Tradition of Bonesetting. *Education for Health*. 2010;23(1):1-8.
3. Ismatullah, Liaqat Ali Khan. Results of conservative treatment of displaced extension type supracondylar fractures of humerus in children. *JPMI* 2009; 23(1):95-98
4. Aman D, Krishna Kiran E, Rajesh M, Lalit Sharma, Mallinath G. Closed reduction and percutaneous pinning of displaced supracondylar fractures of humerus in children with delayed presentation. *Chinese Journal of Traumatology*. 2011;14(1):14-19.
5. Sadiq MZ, Syed T, Travlos J. Management of grade-III supracondylar fracture of the humerus by straight-arm lateral traction. *Intern Orthop (Sicot)* 2007;31:155–158.
6. Campbell CC, Waters PM, Emans JB, Kasser JR, Millis MB. Neurovascular injury and displacement in type III supracondylar humerus fractures. *J Pediatr Orthop*. 1995;15:47–52.
7. Sabharwal S, Tredwell SJ, Beauchamp RD, Mackenzie WG, Jakubec DM, Cairns R, LeBlanc JG. Management of pulseless pink hand in pediatric supracondylar fractures of humerus. *J Pediatr Orthop*. 1997;17:303-310.
8. Erasmus JFP. Post-traumatic arterial spasm – A report of 17 cases. *S Afr Medical Journal*. 1947;21(21):806-20.
9. Ating'a JE. Conservative management of supracondylar fractures of the humerus in Eastern Provincial General Hospital, Machakos. *East Afr Med J* 1984; 61:557–560.
10. France J, Strong M. Deformity and function in supracondylar fractures of the humerus in children variously treated by closed reduction and splinting, traction and percutaneous pinning. *J Pediatr Orthop* 1992;12:494-498.
11. Cheng JC, Lam TP, Shen WY. Closed reduction and percutaneous pinning for type III displaced supracondylar fractures of the humerus in children. *J Orthop Trauma*. 1995;9:511–515.

12. Topping RE, Blanco JS, Davis TJ: Clinical evaluation of crossed pin versus lateral pin fixation of the displaced supracondylar humeral fracture. *J Pediatr Orthop.* 1995;15:435-439
13. Tiwari A, Kanojia RK, Kapoor SK. Surgical management for late presentation of supracondylar humeral fracture in children. *Journal of Orthopaedic Surgery.* 2007;15(2):177-182.
14. Archibeck MJ, Scott SM, Peters CL. Brachialis muscle entrapment in displaced supracondylar humerus fractures: a technique of closed reduction and report of initial results. *J Pediatr Orthop.* 1997;17(3):298-302.
15. Boyd DW, Aronson DD. Supracondylar fractures of the humerus: a prospective study of percutaneous pinning. *J Pediatr Orthop.* 1992;12(6):789-794.
16. Rasool MN. Ulnar nerve injury after K-wire fixation of supracondylar humerus fractures in children. *J Pediatr Orthop* 1998;18(5):686-690.
17. Jones KG. Percutaneous pin fixation of fractures of the lower end of the humerus. *Clin Orthop Relat Res.* 1967;50:53-69.
18. Leet AI, Frisancho J, Ebramzadeh E. Delayed treatment of type 3 supracondylar humerus fractures in children. *J Pediatr Orthop.* 2002;22(2):203-207.
19. Flynn JC, Matthews JG, Benoit RL. Blind pinning of displaced supracondylar fractures of the humerus in children: sixteen years' experience with long-term follow-up. *J Bone Joint Surg Am.* 1974;56(2):263-272.
20. Green DW, Widmann RF, Frank JS, et al. Low incidence of ulnar nerve injury with crossed pin placement for pediatric supracondylar humerus fractures using a mini-open technique. *J Orthop Trauma.* 2005;19(3):158-163.

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