"EVALUATION OF MANAGEMENT OF SUPRACONDYLAR FRACTURES OF THE HUMERUS IN CHILDREN TREATED BY CLOSED REDUCTION AND PERCUTANEOUS K-WIRE FIXATION."

Submitted By

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Dissertation submitted to

B.L.D.E UNIVERSITY, BIJAPUR, KARNATAKA.

In partial fulfilment of the requirements for the degree of

MS

ORTHOPAEDICS

Under the guidance of

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2012

DECLARATION BY THE CANDIDATE

I hereby declare that this dissertation entitled–**"EVALUATION OF MANAGEMENT OF SUPRACONDYLAR FRACTURES OF THE HUMERUS IN CHILDREN TREATED BY CLOSED REDUCTION AND PERCUTANEOUS K-WIRE FIXATION"** is a bonafide and genuine research work carried out by me under the guidance of **DR. ASHOK R NAYAK** **M.S (ORTHO)** professor of Orthopaedics.

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ACKNOWLEDGEMENT

On completion of this contribution of scientific document it gives me immense pleasure to acknowledge the guidance provided by my distinguished mentors.

With privilege and respect I like to express my gratitude and indebtedness to my guide. Dr.ASHOK R NAYAK MS (ORTHO), professor of orthopaedics, Shri B.M.Patil Medical College, Bijapur, for his constant inspiration, extensive encouragement and support, which he rendered in pursuit of my post graduate studies and in preparing this dissertation.

I am forever grateful to Dr.O.B.Pattanashetty prof. and HOD, Dr.Kiran S Patil Assoc prof, Dr S S Nandi Assoc prof,Dr M A Q Ansari Asst prof, Dr Dayanad Asst prof, Dr.Sheepad Kulkarni Asst prof, Dr.Hari Das Asst prof, Dr Avinash kulkarni Asst prof, Dr.Sudhir Hasareddy, for their valuable help and guidance during my study.

I am extremely thankful to Dr. M. S. Biradar, Principal, and Dr.Siva Kumar H Medical Superintendent of B.L.D.E.U'S Shri B .M. Patil Medical college Hospital and Research Centre, Bijapur for permitting me to utilize resources in completion of my work.

I would like to express my gratitude to the statistician, Mrs.Vijaya Sorganvi who helped me in my dissertation work.

My thanks to one and all staff of Library, Orthopaedic Dept and Hospital for their co-operation in my study.

I am thankful to my seniors Dr.Kiran Reddy, Dr.Prashanth Shah, Dr.Kirankumar, Dr.Ajaykumar.

I am thankful to my colleagues Dr.Harshavardhan Reddy, Dr.ShushruthBhavi. I extend my thanks to my juniors Dr.MounishBami, Dr.Preetish, Dr.Vinayak Santosh, Dr.Gireesh, Dr.Yogesh , Dr.Mithun, Dr.Rupali Gupta,Dr.Tejaswini R, Dr.Mahesh C for their suggestions and advice.

I am deeply indebted to my father late shri K.Prasada Rao, my mother Mrs.K.Ramakoteswari, my uncle B V .Ramana kumar and aunty B.Udayalakshmi and my sister Pratyusha Loya , whose constant inspiration, encouragement, patience and support helped me to complete this dissertation work.

Last but not the least I convey my heartfelt gratitude to all my patients without whose co-operation this study would be incomplete.

My special thanks to Mr.Kalyan Kumar and Asif of 'PREETI NET ZONE'

Bijapur for computerizing my dissertation work in a right format.

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LIST OF ABBREVATIONS

AO	Arbeitsgemeinschaft fur osteosynthesefragen
A-P	Anterior posterior
POP	Plaster of Paris
K wire	Kirschner’s wire
JBJS	The journal of bone and joint surgery
No. of patients	Number of patients
ORIF	Open reduction and internal fixation
CRIF	Closed reduction and internal fixation
#	Fracture

ABSTRACT

Background and objective: The supracondylar fracture of humerus in children is a very common condition, treating of which is involved with many complications including neurovascular injuries and mal-uninon resulting in loss of range of motion and other functional disabilities in the child. Even though there are many studies evaluating the operative treatment with closed reduction and open reduction, in this present study of ours, we evaluated the functional outcome in displaced fractures of the supracondylar region of the humerus without any neurovascular impairment, treated by closed reduction and percutaneous K-wire fixation without any neurovascular impairment.

Materials and Methods: In our study we evaluated a total of 54 patients of which 4 patients were lost to follow-up and the functional outcome is evaluated in the remaining 50 patients using the Flynn's criteria taking the loss of carrying angle as the criteria, who came to Shri B.M. Patil Medical College and Research centre during a time period of one and a half years i.e from October 2010 to April 2012. The patients who were above the age of 15yrs and patients with open fractures were excluded from the study. Institutional ethical committee clearance has been obtained for the study. Written informed consent is taken from all the patients involved in the study.

Results: Of the total number of cases studied, majority of them 35(70%) are males and the average age of the patients is 8.9 yrs. Most of them were injured while playing 28(56%), of which majority of them 36(72%) had posteromedial displacement and 9(18%) had some or the other complication. 49(98%) patients had satisfactory results and only 1(2%) had unsatisfactory outcome.

Conclusion: The fractures of the supracondylar region of the humerus in children without any neurovascular damage can be treated by close reduction and percutaneous K-wire fixation quite effectively with excellent functional outcome in majority of the patients.

Keywords: Supracondylar humerus fractures in children, closed reduction and percutaneous K-wire fixation, Flynn's criteria.

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INTRODUCTION

Supracondylar fracture is a common injury in children. It accounts for 60% of fractures about the elbow joint in children[1]. The rate of occurrence increases steadily in the first five years of life to peak at 5-7years of age[2].

If the fracture is not treated properly it may give rise to many complication slikeVolkmann's ischemic contracture, nerve injury, arterial injury, skin slough, myositis ossificans, and stiffness of elbow and malunion. The management of displaced supracondylar fracture of the elbow is one of the most difficult of the many fractures seen in children[3].

Pitfalls in the management occur frequently and continue to plague the doctor caring for these patients, especially with respect to displaced supracondylar fractures[4].

There is no controversy about management of the non-displaced fractures. But many methods have been proposed for the treatment of displaced supracondylar fractures of the humerus in children, such as closed reduction and plaster of paris slab application, skin traction, overhead skeletal traction, open reduction and internal fixation, and closed reduction and percutaneous pin fixation[5].

Closed reduction with splint or cast immobilisation has traditionally been recommended for displaced supracondylar fractures, but loss of reduction and necessity of repeated manipulation is likely to go for malunion producing varus or valgus deformity of elbow and elbow stiffness[6].

Traction (skin or skeletal), which has been used for many years, has been shown to be safe and reliable, but it has the drawback of requiring a long stay in the hospital[5].

Open reduction and internal fixation has generally been reserved for specific indication mainly for an open fracture, a fracture requiring vascular exploration, or an irreducible fracture[5].

Recent studies have shown good functional results with closed reduction and percutaneous fixation using ‘K’ wires. It is the most commonly accepted treatment of displaced supracondylar fractures of the humerus in children.

AIM OF THE STUDY

1. To study age, sex and side incidence of supracondylar fracture of humerus
2. To study anatomical and functional results of treatment of supracondylar fractures of humerus with closed reduction and percutaneous ‘K’ wire fixation.
3. To know the complications of the procedure.

REVIEW OF LITERATURE

Miller (1939) described “blind pinning” of intercondylar fractures of the distal humerus in adults[7.]

Swenson (1948) was the first to describe percutaneous pinning for displaced supracondylar humeral fractures in children[8].

Jones (1967) emphasised on the method of percutaneous pin fixation for displaced supracondylar humeral fractures as described by Swenson[3].

Haddad Ray J et al (1970) treated ten cases of displaced supracondylar fractures of the elbow by closed reduction and percutaneous pinning.All the ten cases showed no loss of reduction and no loss of carrying angle.There were no significant complications except for one broken pin tip[3].

Flynn J C et al (1974) while presenting the long term follow up of 52 fractures concluded that rotation of distal fragment per se does not result in varus deformity but it had predisposed to varus tilt or angulation of distal fragment and that produces varus deformity. Remodelling does not correct this varus deformity[7].

Nacht Jeffrey L et al ((1983) reports 38 children with displaced supracondylar fractures of the humerus treated by closed reduction and percutaneous pin fixation.25 of the 38 children were reviewed , 9 to 86 months after operation. According to Flynn’s criteria acceptable results were obtained in 19 of the 25 patients studied. Three results were unacceptable due to cubitusvarus and 3 to loss of flexion.There were no neurological or vascular complications from this treatment[9].

Aronson David D and Prager Bruce 1 (1987) treated 20 patients with closed reduction and percutaneous pinning. Intra operative AP radiograph were taken to check for the baumann's angle. They obtained 18 excellent and 2 good results by maintaining the baumann's angle within 4^0 of that on normal side. There was no cubitusvarus deformity.They also made a note that internal fixation with percutaneous pinning stabilizes the fracture and minimises the chance of any re-displacement and loss of reduction during the post -operative period[4].

Pirone A M et al (1988) undertook a retrospective study in 230 patients who had displaced extension type supracondylar fractures of the humerus to evaluate the results of treatment by 4 different methods. The mean length of follow up was 4.6 years.The highest percentage of excellent results were achieved by percutaneous 'K' wire fixation (78%) , skeletal traction (67%), open reduction with internal fixation (67%) and closed reduction and application of cast (51%). Hence percutaneous Kirschner wire fixation is advocated as the method of choice for majority of displaced fractures[5].

Kurer M H J and Regan M W (1990) reviewed 1708 comparable cases of completely displaced supracondylar fracture which were treated by several different techniques.The worst results occurred with manipulation and splint immobilisation alone.The best results occurred with traction techniques and well performed 'K' wire transfixation, either open or closed. So completely displaced supracondylar fracture in a child should not be treated by manipulation and splint immobilisation alone[10].

Sutton W R et al (1992) studied clinical outcome and treatment cost in 65 children treated by either percutaneous pinning or skeletal traction for displaced supracondylar humeral fractures. Results of treatment were basically equivalent in the two groups

and were satisfying in 90% or more, but cost of treatment was low in the group treated by percutaneous pinning[8].

Zionts L E et al (1994) studied on 37 human cadaver models and opined that two crossed pins provided maximum stability. However when marked swelling of elbow makes safe placement of a medial pin difficult, the alternative of two or three lateral parallel pins may be considered. Fixation with two lateral crossed pins should be avoided[11].

Campbell Crawford C et al (1995), studied 59 consecutive type III supracondylar fractures in children 29 patients (49%) had evidence of neurovascular compromise. The median nerve was involved in 15 (52%) of these patients and was associated with postero-lateral displacement in 87% of cases. The radial nerve was involved in 8 (28%) of these patients and was associated with posteromedial displacement in every case. Injuries to the brachial artery occurred in 11 (38%) of these patients and was associated with posterolateral displacement in 64% and posteromedial displacement in 36% of cases and it was concluded that posterolateral displacement in type III supracondylar humerus fractures is associated with median nerve injuries, posteromedial displacement is responsible for injuries to the radial nerve and brachial artery injuries may occur with either type of displacement[12].

Garbuz DS, Leitch K, Wright JG (1996) while discussing absent radial pulse in supracondylar fractures had opined that the initial treatment for children with displaced supracondylar fractures with an absent radial pulse should be close reduction, 'K' wire fixation and immobilisation in $< 90^0$ of fixation. Children who

have a well perfused hand but an absent radial pulse after satisfactory closed reduction do not necessarily require routine exploration of the brachial artery[13].

Mulhall K J et al (1998) recommended open reduction and internal fixation for these serious injuries after the experience with 16 patients who were treated with open reduction and internal fixation. Twelve patients had an excellent result, 2 had good results and 1 had a fair result based on Flynn's criteria. They also said that open reduction had a more consistent favourable result compared to other methods[14].

Bennet G C et al (1998) believed that open reduction and internal fixation is a safe method of management of supracondylar fractures. Predictable and satisfactory outcome can be expected in most cases. They also suggested that it is a preferable method of management than repeated attempts of closed reduction[15].

Canale S. Terry (1998) described three causes for residual cubitusvarus deformity, which included the inability to interpret poor x-rays resulting in accepting less than adequate reduction, other cause being inability to interpret good x-rays because of lack of knowledge of pathophysiology and third cause being the loss of reduction[6].

Robert E Lins et al (1999) opined the current major indications for open reduction are vascular insufficiency with a probable entrapped brachial artery in fracture site or an irreducible fracture[16].

Kennedy JG et al (1999) compared role of pin fixation with that of collar and cuff immobilization. They opined that pin fixation is beneficial in unstable injuries whereas cuff and collar continues to have an important role in the treatment of selected types of type II and type III stable supracondylar fractures[17].

Mostafavi Hamid R Charles Spero (2000) has retrospectively evaluated 42patients with displaced supracondylar humerus fractures treated with crossed pinfixation. All fractures healed without loss of reduction. No patients had iatrogenic ulnar nerve injury. Percutaneous pinning offered stable fixation preventing rotational displacement, reduced hospital time and better anatomical and functional results[1].

O'Hara LJ, Barlow JW, Clarke NMP (2000) reported an audit of 71 children with consecutive displaced, extension-type of supracondylar fractures of the humerus. They recommended few guidelines to minimise complications like experienced surgeon, stabilization with kirschner wires of closed or open reduction of type-IIB and type-III fractures and use of k-wires of adequate thickness (1.6 mm) in a crossed fixation. 11 of their patients had unsatisfactory result due to failure to institute treatment according to the guidelines[18].

Davis RT, John TG and Kevin Pugh (2000) revived 87 children treated operatively for supracondylar fractures and had one (4%) of 23 type-II supracondylar fractures which were displaced postoperatively. Four (7%) of the 60 Type III supracondylar humerus fractures were displaced postoperatively. They opined that proper K wire placement is essential to prevent postoperative fracture displacement. They also stressed that careful examination of radiographs obtained postoperatively was necessary to detect fracture displacement in the early postoperative period, when the displacement is easiest to correct[19].

Mazda K et al (2001) when reviewing supracondylar fracture humerus management using parallel K-wire fixation opined that K-wire be more than 1.6mm diameter and had to be separated by a minimum distance of 1 cms[20].

Skaggs DL et al (2001) retrospectively reviewed the results of closed reduction and Kirschner wire fixation of 345 extension-type supracondylar fractures in children. Maintenance of fracture reduction and evidence of ulnar nerve injury were evaluated in relation to pin configuration and fracture pattern. They opined that fixation with only lateral pins was safe and effective for both Gartland type-2 and Gartland type-3 (unstable) supracondylar fractures of the humerus in children. Lateral pins when used alone prevent iatrogenic injury to the ulnar nerve. They do not recommend the routine use of crossed pins in the treatment of supracondylar fractures of humerus in children. They also said that, if a medial pin is used, the elbow should not be hyperflexed during its insertion[21].

Shim Jong Sup and Yong SeukLee(2002) have investigated 63 consecutive patients who underwent cross-fixation with three kirschner wires after reduction of a completely displaced supracondylar fractures of the humerus. The clinical outcome of the surgery after an average of 17 months was investigated. 62 (98.4%) of the 63 patients studied, showed a "satisfactory" result[22].

Tabak A.Y. et al(2003) treated 22 children with supracondylar fracture of the humerus and an ipsilateral fracture of the forearm by closed reduction and percutaneous fixation. There were four Gartland Type-II and 18 Gartland Type-III supracondylar fracture of the humerus. There were fractures of both bones of the forearm in 16 and of the radius in six. Both the supracondylar and the distal forearm fractures were treated by closed reduction and percutaneous fixation. The mean follow-up time was 38.6 months. At the latest follow-up there were 21 excellent or good results and one fair result[23].

RS Ayengar, R singh, C M Badole, K R patond (2003) proved that even displaced supracondylar fractures are treated with closed reduction with k-wires and the outcome was excellent in 86% of the cases and good in 11% of cases and proposed that this method is safe even if swelling is present, with short hospital stay and consistently satisfactory results considering functional and cosmetic outcome[24].

U B Yadav, R singhal, G Tonk, T Aggarwal, A N Warma (2004) concluded that closed reduction with k-wires is a sound and effective treatment for displaced supracondylar fractures with several advantages[25] .

DevkotaP,KhanJA,Acharya BM (2008) opined that open reduction is more invasive and recovery is prolonged[26].

Antoine de Gheldere, Damien Bellan (2010) in a retrospective study of 74 patients with Gartland type II or III fractures treated by closed reduction and immobilisation (Blount's technique) showed that pure posterior displacement is more stable than posteromedial displacement which is more stable than posterolateral displacement. This study suggests that Gartland type II and pure posterior or posteromedial displaced Gartland type III fractures can be treated by closed reduction and immobilisation with success[27].

AbhijanMaity, DebasishSaha and DebasisSinhaRoy (2012) in a single center, prospective, randomized controlled clinical trial 160 patients who satisfy the inclusion and exclusion criteria were enrolled in the study, with 80 patients in each group of patients with 80 in lateral pinning group and 80 in medial pinning group found that, if a uniform standardized operative technique is followed in each method, then the result of both the percutaneous fixation methods will be same in terms of safety and efficacy[28].

ANATOMY

ANATOMY OF THE LOWER END OF THE HUMERUS AND ELBOW JOINT[29]:

The lower end of the humerus is wide, flattened antero-posteriorly and bent slightly forwards and presents articular and non-articular portions. The articular portion takes part with the radius and the ulna in the formation of elbow joint. It is divided by a faint groove into a lateral convex surface, termed the capitulum and medial pulley shaped surface termed the trochlea.

The capitulum is a rounded, convex projection, considerably less than half of a sphere, which covers the anterior and inferior surfaces of the lateral part of the condyle of the humerus but does not extend onto its posterior surface. It articulates with the disc like head of the radius, which lies in contact with its inferior surface in full extension of the elbow but moves onto its anterior surface when the joint is flexed.

The trochlea is a pulley shaped surface, which covers the anterior, inferior and posterior surfaces of the condyle of the humerus. On its lateral side it is separated from the capitulum by a faint groove, but its medial margin is salient and projects downwards beyond the rest of the bone. The trochlea articulates with the trochlear notch of the ulna. When the elbow is extended the posterior and inferior aspects of the trochlea are in contact with the ulna, but as the joint is flexed, the trochlear notch roles forward onto the anterior aspect and the posterior aspect is then left uncovered. The downward projection of the medial edge of the trochlea is the principal factor in determining the angulation which is present between the long axis of the humerus and long axis of the supinated forearm when the elbow is extended.

The non-articular part of the condyle of the humerus includes the medial and lateral epicondyles together with the Olecranon, Coronoid and Radial fossae.

The medial epicondyle forms a conspicuous, blunt projection on the medial side of the condyle. It is subcutaneous and can be easily identified through the skin, especially in passive flexion of the elbow. The posterior surface is smooth and is crossed by the ulnar nerve, which lies in a shallow sulcus, as it runs down into the forearm. In this situation the nerve can be felt and rolled against the bone. The lower part of the anterior surface of the medial epicondyle shows an impression which gives attachment to the superficial group of flexor muscles of the forearm.

The lateral epicondyle occupies the lateral part of the non-articular portion of the condyle, but does not project beyond the lateral supracondylar ridge. Its lateral and anterior surfaces show a well-marked impression, which gives origin to superficial group of extensor muscles of the forearm. Its posterior surface, which is very slightly convex, can be easily felt through the bottom of a well-marked impression, which gives origin to the superficial group of extensor muscles of forearm. Its posterior surface can be seen when the extended elbow is viewed from behind. The lateral border of the humerus terminates at the lateral epicondyle, and its lower portion is usually termed as the lateral supracondylar ridge. The medial border of the humerus terminates below at the medial epicondyle and its lower portion is termed as medial supracondylar ridge.

A deep hollow is situated on the posterior surface of the condyle, immediately above the trochlea. It is termed as the Olecranon fossa on account of the fact that it lodges the tip of the olecranon of the ulna when the elbow is extended. The floor of the fossa is always thin and may be partially deficient. A similar but smaller hollow

lies immediately above the trochlea on the anterior surface of the condyle and is termed the coronoid fossa. It provides room for the anterior margin of the coronoid process of the ulna during flexion of the elbow a very small depression lies above the capitulum on the lateral side of the coronoid fossa, it is termed as the radial fossa, since it is related to the margin of the head of the radius in full flexion of the elbow.

The articular portion of the condyle of the humerus is curved forwards, so that the anterior and posterior surfaces lie in front of the corresponding surfaces of the shaft. The groove of the trochlea winds backwards and laterally as it is traced from the anterior to the posterior surface of the bone and it is more wider, deeper and more symmetrical posteriorly. Anteriorly , the medial flange of the pulley is much longer than the lateral, and the surface adjoining its projecting medial margin is convex to accommodate itself to the medial part of the upper surface of the coronoid process of the ulna.

The capsular ligament of the elbow is attached anteriorly to the upper limits of the radial and coronoid fossae, so that both these bony depressions are intracapsular and therefore lined with synovial membrane. Medially it is attached to the medial non-articular aspect of the projecting tip of the trochlea and to the root of the medial epicondyle. Posteriorly it ascends to, or almost to, the upper margin of the olecranon fossa, which is therefore intracapsular and covered by synovial membrane. Laterally, it skirts the lateral borders of the trochlea and capitulum, lying medial to the lateral epicondyle.

ANATOMICAL CONSIDERATIONS OF THE ELBOW JOINT[29]:

The elbow joint is made up of three articulations contained within a single capsule. The ulno-humeral joint provides flexion and extension, which is stabilized in all positions by the collateral ligaments whose humeral attachments correspond to the pivot of this hinge motion. The radial head rests against the capitulum and lesser sigmoid notch of the ulna. The orbicular ligament which holds the upper end of the radius in position blends with the external collateral ligament, the capsule and the periosteum enveloping the radial shaft.

The anterior capsule of the joint is supported by a thin ligament to which the brachialis muscle is closely applied but loosely attached. The tendon of the biceps muscle crosses the joint superficial to the brachialis and at the level of the joint line gives off lacertus fibrosis, which swings medial ward to blend with the deep fascia of the forearm and forms an arc under which passes the brachial artery and vein and the median nerve as they enter the forearm. The radial nerve crosses the joint buried deep in the interval between brachialis and brachioradialis muscles on the lateral aspect of the extremity.

The medial side of the elbow is covered by the mass of forearm muscles diverging from their common origin at the medial epicondyle. Crossing the joint just behind this point is the ulnar nerve.

The triceps tendon and its aponeurosis attach to enclose olecranon region of ulna. The palpable prominences of the olecranon, lateral epicondyle and medial epicondyle form a triangle when the elbow is flexed to 90^0.

Capsule

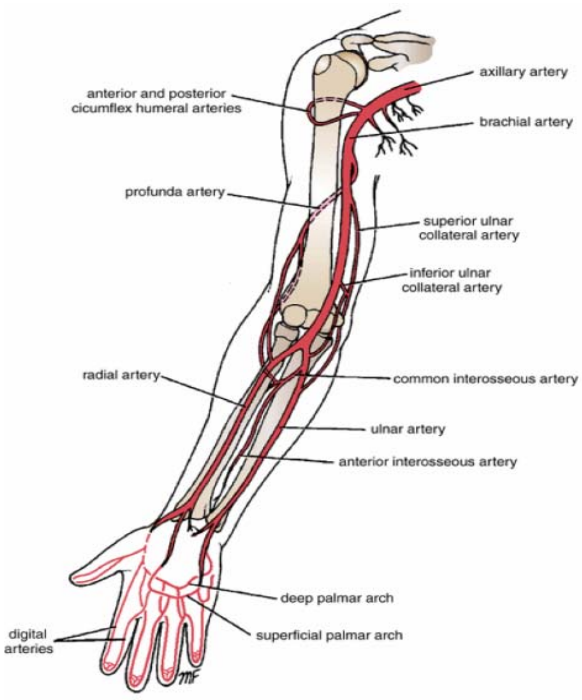
The capsule of the elbow joint is thick and strong anteriorly. These tight anterior bands force the ulna into firm contact with the humerus resulting in transmission of fulcrum of rotation from the tip of olecranon into the supracondylar area. This is an important mechanism in the supracondylar fractures.

The elbow joint or cubital articulation has only one synovial cavity, but has functionally two distinct movements and is composed of three different bones, articulating with each other in three different joints.

The flexion-extension movements takes place in humero-ulnar and humero-radial joints, the pronation-supination in proximal radio-ulnar joint[29,30].

Relationship of neurovascular structures[29,30]:

There is a rich arterial network around the elbow. The brachial artery, a continuation of the axillary artery, is the main arterial supply of the lower third humerus. It ends about a centimetre distal to the elbow joint(at the level of the neck of the radius) by dividing into radial and ulnar arteries. At first it is medial to the humerus, but gradually spirals anterior to it until it lies midway between the humeral epicondyles. It is very important to note that the brachial artery lies very close to the anterior aspect of the lower end of the humerus and thus, vulnerable to get injured by the proximal fragment of the supracondylar fractures.



Diagram, showing the vascular relations around the elbow joint

The median nerve arises from the brachial plexus with the root value of $C_{5,6,7,8}T_1$. The median nerve lies medial to the brachial artery and descends to the cubital fossa where it lies posterior to the bicipital aponeurosis and anterior to the brachialis muscle. It enters the forearm between the two heads of the pronator teres wherein it gives a branch called anterior interosseous nerve.

The ulnar nerve arises from the medial cord of brachial plexus with root value of C_8 T_1. After passing through the radial groove, it pierces the lateral intermuscular septum to enter the anterior compartment. It then descends deep in a furrow between the brachialis on one side and the brachioradialis above and the extensor carpi adialislongus below on the other side.

In front of the lateral epicondyle, it divides into its two terminal branches, the superficial and deep.

Nerve Supply of Elbow Joint[29]:

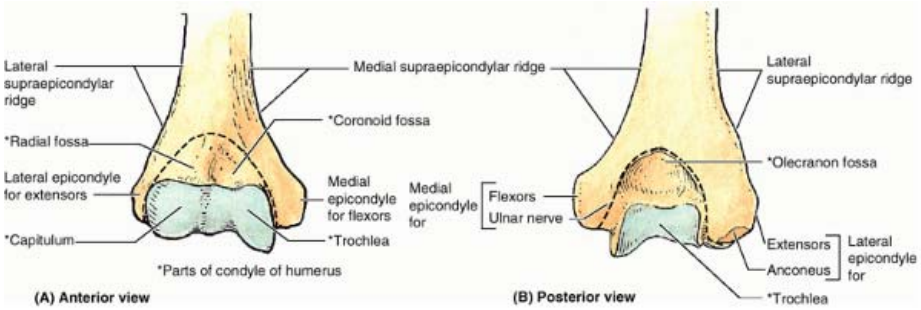
The joint is supplied by the musculocutaneous , median , ulnar and radial nerve(Hilton's Law). Nerve to anconeus sends a twig to the joint.

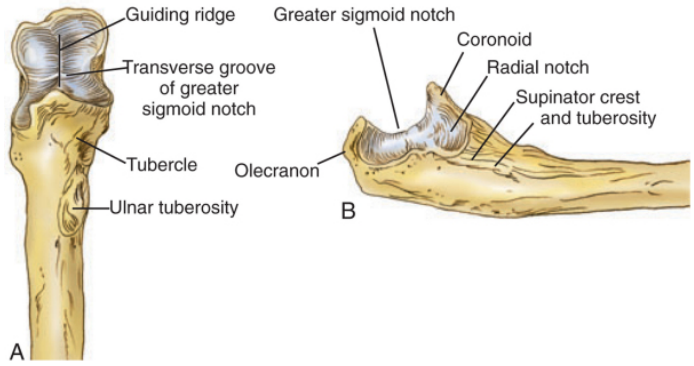
Movements of the Elbow Joint[29]:

The possible movement at the joint is the simple hinge movements of the flexion and extension.

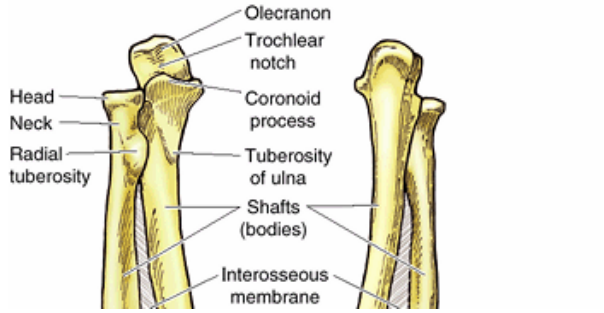
1. Flexion is bought about by
    a. Brachialis
    b. Biceps and
    c. The brachioradialis
2. Extension is produced by
    a. The triceps and
    b. The anconeus

BONES AT THE ELBOW JOINT

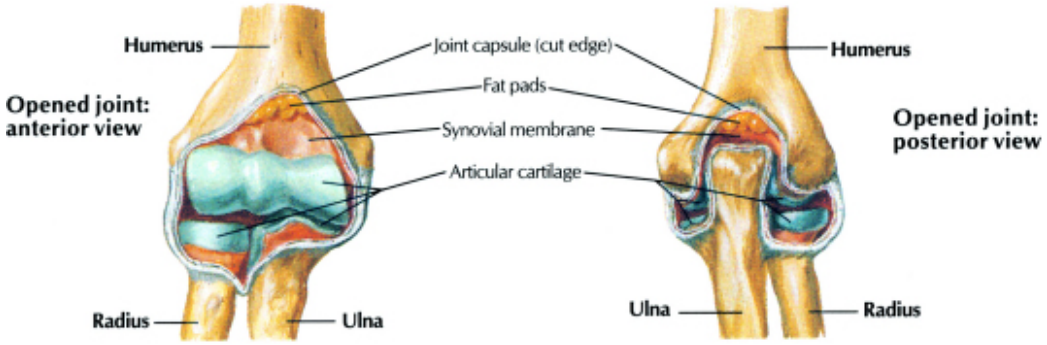




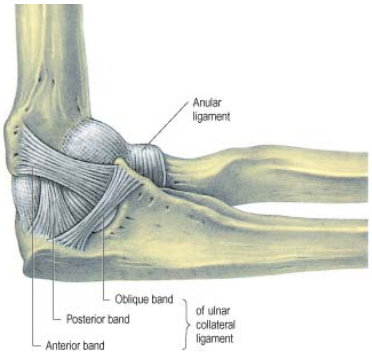
(A) anterior view (B) lateral view

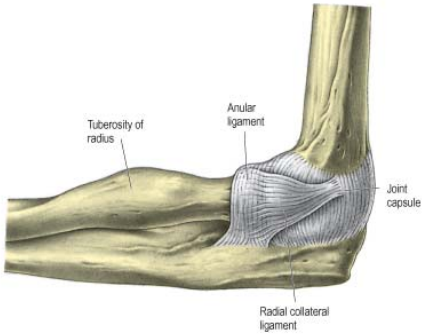


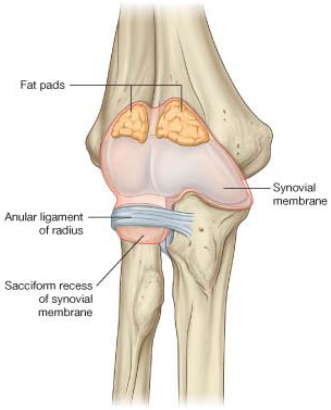
Proximal end of radius

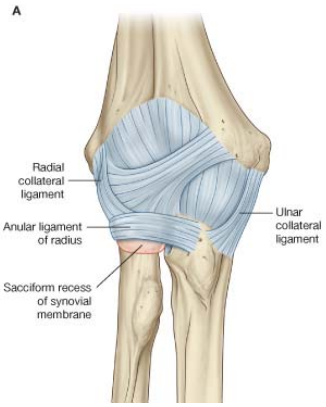


LIGAMENTS AROUND THE ELBOW JOINT





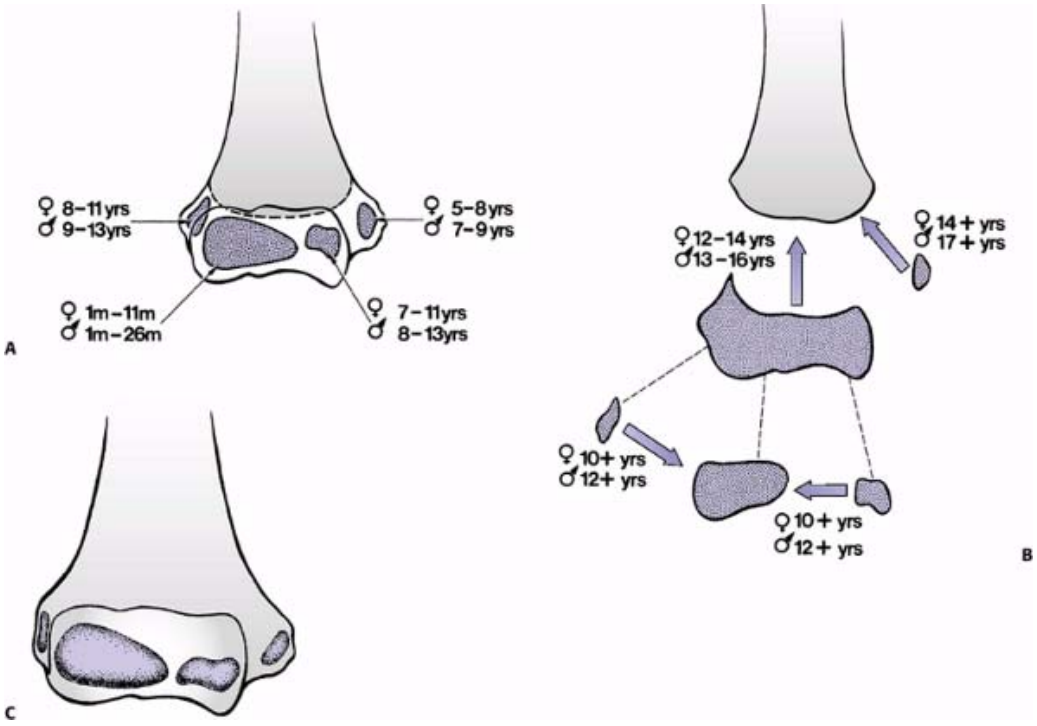




OSSIFICATION OF DISTAL HUMERUS[2,30]

The distal growth plate accounts for just 20% of the humeral growth. Distally there are four secondary ossification centres, two are epiphyseal and rest are apophyseal. None of these centres are visible on x-ray at birth. The lateral condyle is the first secondary centre to appear in distal humerus, appearing between 1-2 years of age. Medial epicondyle and trochlea appearing between 5-6 years and 9-10 years of age respectively follow it. Lateral epicondyle appears at the age of 10 years.

OSSIFICATION OF DISTAL HUMERUS



The capitulum, lateral epicondyle and trochlea fuse to form one epiphyseal centre and ultimately fuse with distal humeral metaphysis. The medial epicondyle fuses with the metaphysis separately at 14-17 years. In general, the rate of ossification in girls exceeds that of boys.

CARRYING ANGLE[2,30,31]

This is the anatomical valgus angulation of the elbow joint. The angle formed between the long axis of the arm with that of long axis of supinated forearm with elbow extended.

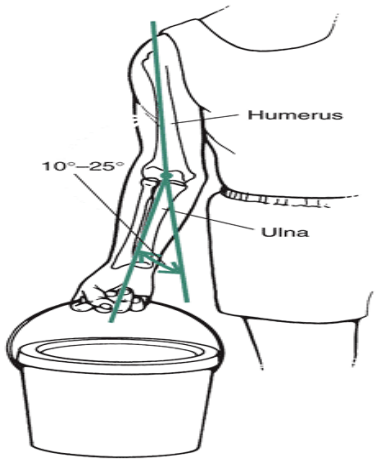


Diagram showing the carying angle

Normal carrying angle

The carrying angle is partly caused by the projection of medial trochlear edge about 6mm beyond its lateral edge and partly by the spiral orientation of the trochlea resulting in oblique transverse axis of the humero-ulnar joint. It is about 15^0 and slightly more in the females. This increased value in the females is due to increased ligament laxity, facilitating a greater degree of extension of elbow and thus a greater carrying angle. Moreover, the tilt of the humeral and ulnar articular surface is approximately equal; hence the carrying angle disappears on full flexion, the two bones reaching the same plane. The carrying angle also gets masked in pronation of extended forearm, which brings the upper arm, semi-pronated forearm and hand into line.

PATHOLOGY[2,30]

In order to properly evaluate and treat extension type of supra condylar fractures, one needs to have a clear understanding of the pathology of fractures and the associated soft tissue findings.

1. Bony pathology;

In a minimally displaced fracture, the fracture line can be well delineated on the antero-posterior x-rays. The fracture is transverse extending from just above the epicondyles and entering the thin area separating the coronoid and olecranon fossae. This fracture is just proximal to the widest antero-posterior diameter, but is still distal to the termination of cortex of the distal diaphysis.

The fracture line is some-what oblique, usually from distal medial to posterolateral on the antero-posterior x-ray. The fracture line in some cases may be just slightly above the weak area of fossae or it may in some cases be somewhat below the central position of the fossae. It is totally metaphyseal, lying at the anterior and posterior capsular origins. In some cases there are very sharp protruding spikes involving the cortical portion of the respective supracondylar ridges. These sharp spikes of bone can create considerable damage to the surrounding soft tissue.

In the classic sense, Kocher described the extension type of supracondylar fracture as in the sagittal plane, the fracture line starting proximal posterior and extending obliquely to anterior distal.

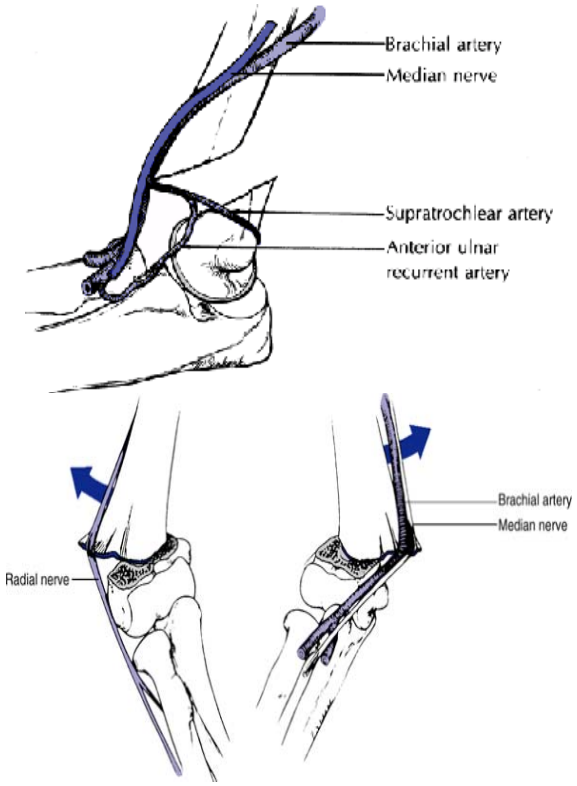
However, clinical studies by Holmberg and Nand have demonstrated that the fracture pattern is transverse on lateral radiographs in more than 80% of patients. The fracture line in the antero-posterior (AP) view extends transversely across both the medial and lateral columns of the distal humerus at the level of the middle of the olecranon fossa.

Posteromedial versus posterolateral displacement:

Generally, medial displacement of the fragment is more common than lateral displacement, occurring in approximately 75% of patients in most series. The biceps tendon insertion and axis of muscle pull lies medial to the shaft of the humerus and Holmberg suggested that this anatomic location of muscle pull created a force that tended to displace the humeral fragment medially.

The position of the hand and forearm at the time of injury plays a role in the direction of displacement of the distal humeral fragment. In a patient who falls onto an outstretched supinated arm, the forces applied tend to disrupt the posteromedial periosteum first and displace the fragment postero-laterally. Conversely if a patient falls with arm pronated, the distal fragment tends to become displaced postero-medially.

Fracture displacement and neurovascular injury[2,30,32,33,34,35]



The difference between these two fracture patterns is of clinical significance.

a) Medial displacement of the distal fragment places the radial nerve at risk, and lateral displacement of the distal fragment places the median nerve and brachial artery at risk.
b) Some authors used the position of the distal fragment to determine the position of forearm to lock against the periosteal hinge.
c) The displacement has a bearing on which pin has to be placed first if percutaneous pinning is planned.
d) Development of residual deformity is more likely with postero medial type.

Soft tissue pathology:[2,30]

Role of Periosteum:

As the supracondylar fracture displaces posteriorly, the anterior periosteum fails and tears away from the displaced distal fragment.

The anterior loss of periosteal integrity leads to frequent failure of anterior callus formation in early fracture healing, which is of little significance clinically. Further fracture displacement is accompanied by corresponding increased periosteal disruption with decreased fracture stability.

Intact medial or lateral periosteum, the periosteal hinge provides stability after fracture reduction. Pronation of the forearm after reduction of a postero-medially displaced supracondylar fracture is said to stabilize reduction by closing the fracture gap laterally, tensioning the medial periosteal hinge, and tightening the lateral ligaments of the elbow. Conversely, a lateral displaced supracondylar fracture is more stable in supination.

If the periosteum is intact medially and laterally in a supracondylar fracture with pure posterior displacement, it may yield a very stable reduction.

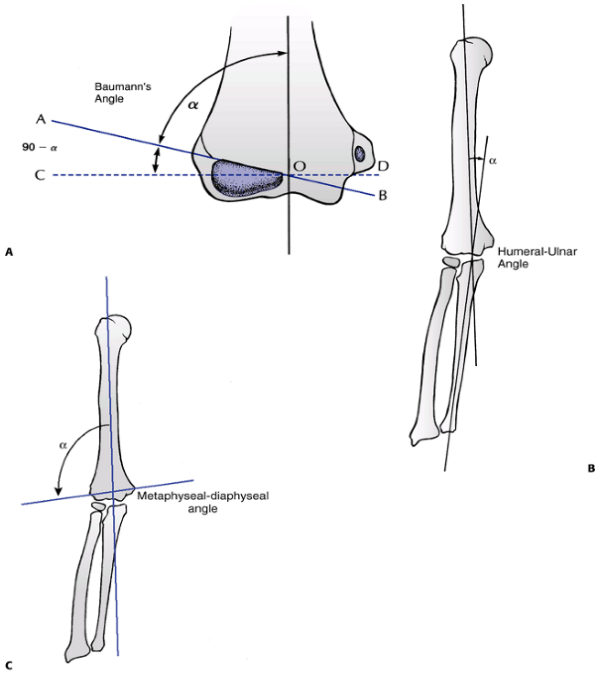
- **Muscle:** Brachialis protects anterior neurovascular structures. In severe displacement, the fracture spike may be impaled in the dermis to create a puckering of the underlying epidermis. Clinically, this puckering is significant since its presence may point to difficult reduction by closed measures.
- **Neurovascular:** With posteromedial displacement, lateral spike often may injure median nerve or brachial artery.

RADIOLOGICAL ANATOMY OF ELBOW JOINT[2,30]:

Anterposterior landmarks:

1. **Baumman's angle**: it is the angle formed between the physeal line of ossification centre of lateral condyle to that of long axis of humerus. The mean baumman's angle is 72 +/- 4^0(range= 64-81^0). Special care has to be taken to avoid angulation of the tube in the cephalad-caudal direction greater than $20^0$to prevent inaccurate baumman's angle. It is useful to study medial column collapse and also to evaluate the quality of reduction. Baumman's angle is a good measurement of any deviation of the angulation of the distal humerus.

Anteroposerior radiological angles.

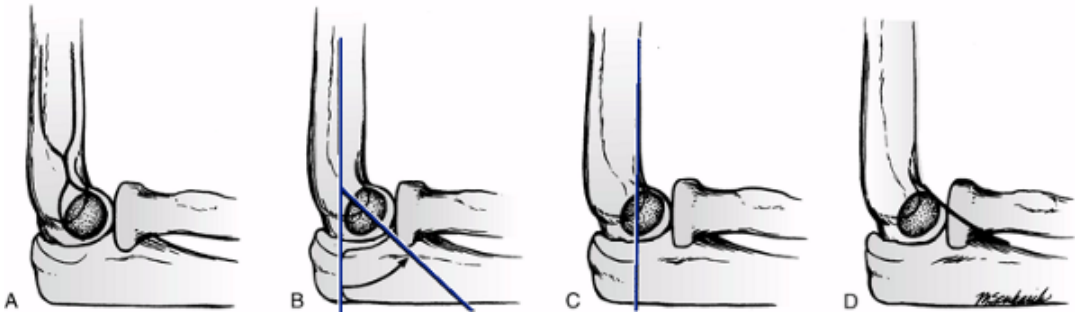


2. **Humero-ulnar angle:**It is the angle formed between the long axis of ulna to that of humerus. This is the most accurate of the above three angles in predicting the true carrying angle of elbow. Metaphyseal- diaphyseal angle is the least accurate.
3. **Metaphyseal-diaphyseal angle:** angle formed between the long axis of humerus to that of a line joining the two widest points of metaphyses of distal humerus.

Lateral landmarks:

a. Tear drop sign: posterior margin of coronoid fossa anteriorly, anterior margin of olecranon fossa posteriorly and the ossification centre of capitulum inferiorly forms a tear drop like shadow in a true lateral view.
b. Shaft condylar angle: angle between long axis of humerus and long axis of lateral condyle in a true lateral view is around 40^0

Lateral radiological findings



c. Anterior humeral line: a line drawn along the anterior border of the distal humeral shaft should normally pass through the middle third of

the ossification centre of capitulum. It is said that this line is most reliable factor in detecting the presence or absence of an occult fracture.

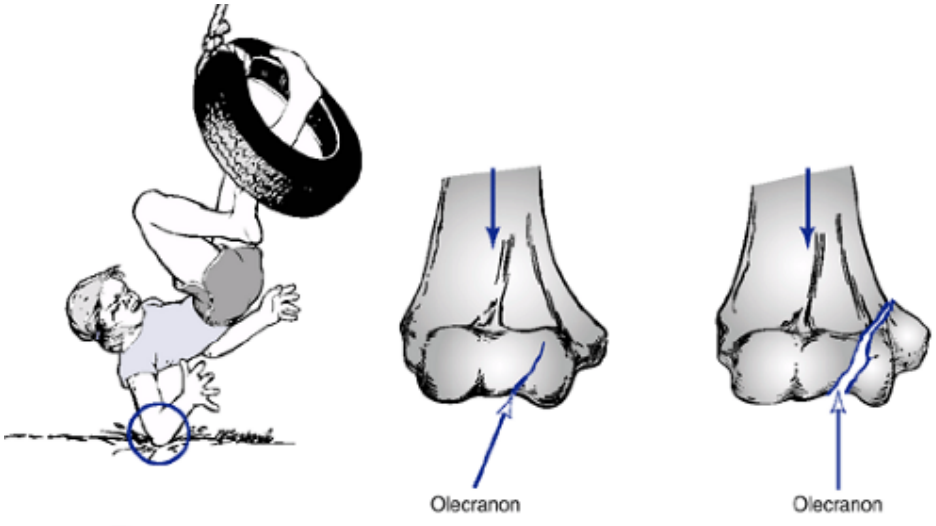
d. Coronoid line: A line directed proximally along the anterior border of coronoid process should barely touch the anterior portion of lateral condyle. Posterior displacement of lateral condyle projects the ossification centre posterior to the coronoid line.

MECHANISM OF INJURY[2,30,36]

1. **Flexion type of supracondylar fracture:**

Is due to fall directly onto the elbow in which the force is applied to the olecranon or posterior surface of ulna.

The distal fragment is displaced anteriorly and may migrate proximally in a totally displaced fracture. The ulnar nerve is vulnerable in this fracture pattern and it may be entrapped in the fracture on in the healing callus.

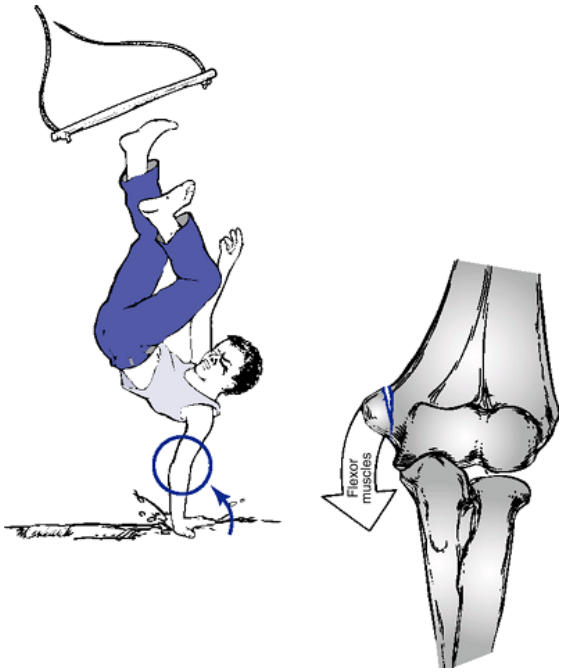


2. **Extension type of supracondylar fracture:**

Occur as a result of a fall onto the outstretched hand with the elbow in full extension.

Most children attempt to break their fall by extending the elbow. Because of ligamentous laxity, the elbow hyperextends and thus the linear force applied along the extended elbow is converted into an anterior tension force or bending force. This bending force is concentrated by the olecranon into the anatomically weak supracondylar area. As the bending force continues and exceeds the strength of the bone, a supracondylar fracture is produced.

Since supracondylar fracture has a peak of incidence in the later part of the first decade of life, there must be something unique about the anatomy of the elbow during this period that produces this type of fractures.



The three major factors that seem to contribute to the unique predisposition of the juvenile humerus to supracondylar fractures are:

1. Ligamentous laxity
2. The relationship of joint structures in hyper extension
3. The bony architecture of supracondylar area.

1. Ligamentous laxity:

During the peak age for supracondylar fracture, the child's ligaments are especially lax. This ligamentous laxity allows for a hyperextensibility of the major joints. As the child matures, the ligaments tighten, decreasing the amount of extension of the joint. This is especially true in the elbow.

Henrickson studied the ability to hyperextend the elbow in his patients who had sustained supracondylar fractures. He found that those with supracondylar fractures were more likely to have hyperextension of the normal elbow than those children who had sustained other types of elbow injuries.

2. The relationship of joint structures in hyperextension:

Children often extend their elbows to break the force of a fall. Because of the ligamentous laxity, the elbow hyperextends allowing the linear force applied along the extended elbow to be converted into a bending force. This bending force is then concentrated by the olecranon into the anatomically weak supracondylar area. The anterior capsule and the anterior portion of the collateral ligaments become taut in hyperextension and serve to reinforce the tension forces anteriorly. In addition, as extension of the elbow increases, the two portions of the elbow joint become more tightly interlocked by these ligamentous forces. This converts the articular forces to a simple lever distally.

3. Bony architecture of the supracondylar area:

There are considerable differences in the bony architecture of the supracondylar area between the child and the adult. At the age of peak incidence for supracondylar fractures, the bone in the supracondylar area is undergoing remodelling with a decrease in both the antero-posterior and lateral diameter. It is less cylindrical

than in the adult. The metaphysis of the child extends just distal to the two fossae. Since this is newly formed bone, the trabeculae are less well defined and thinner and the cortex is very slender. In the lateral projection, the anterior cortices of the medial and lateral supracondylar columns do not project as far anteriorly, thus producing an anterior defect in the area of the coronoid fossa. As the humerus matures and the osseous epiphyseal centres fuse, the structure of the distal humerus widens both medially and laterally and in the antero-posterior projection to provide more resistance to stresses in this area. The cortices in the distal humerus and supracondylar area are also thicker.

In addition, the large amount of elastic epiphyseal and articular cartilage in the distal portions can serve as a buffer to transfer the force of the hyperextension injury to the supracondylar area.

INCIDENCE AND GENERAL CONSIDERATIONS OF SUPRACONDYLAR FRACTURES[2,30]

Definition: it is the fracture which involves the lower end of the humerus usually involving the thin portion of the humerus through the coronoid and olecranon fossae, or just above the fossae or through the metaphysis of the humerus.

These fractures can be divided into extension type, which is common type occurring in 98%. It is also the type with the most serious complications and highest rate of residual cosmetic deformity. The rare flexion type accounting about 2%.

Like other fractures, supracondylar fractures can be classified into

1. Simple fractures
2. Compound fractures
3. Complicated fractures: this fracture is described as complicated if there is accompanying damage to major neighbouring structures, like neurovascular structures.

The peak age at which supracondylar fractures occur is between 5 and 7 years. The rate of occurrence increases steadily in the first 5 years of life, and traditionally boys have had a higher incidence of these fractures than girls. Combining 61 reports of supracondylar fractures treating 7,212 displaced fractures of the distal humerus yields a consistent pattern, as shown in table. Boys have outnumbered girls by about 3 to 2. The average age at fracture is 6.7 years. The left or non-dominant side predominates in almost all studies. Two thirds of children hospitalized with elbow injuries have supracondylar fracture. Nerve injury occurs in at least 7%. The radial nerve has been the most frequent nerve in older studies: however, the median nerve is

much more commonly injured, particularly the anterior interosseous nerve(AIN), in more recent studies. The ulnar nerve is most commonly injured iatrogenically during pinning or in a flexion type of supracondylar fracture.

Almost all supracondylar fractures are caused by accidental trauma. A fall from a height accounts for 70% of all supracondylar fractures. In children under 3 years of age, the fracture generally results from a fall from monkey bars, swings, or other playground equipment.

The most commonly associated fractures are distal radial fractures, but fractures of the scaphoid and proximal humerus do occur. Pulse is absent at presentation in 12% to 15% of patients, but vascular insufficiency requiring operative intervention is relatively rare(2%-4%). Volkmann’s ischemic contracture is rare,occurring in about 0.5% of patients.

Efficiency of supracondylar fractures[2]

Incidence	Percentage of total number of fractures (%)	Nerve involved	Percentage of total nerve injuries (%)[a]
Side involved		Radial	41.2
Right	39.2	Median	36.0
Left	60.8	Ulnar	22.8
Sex incidence			
Male	62.8		
Female	37.2		
Ipsilateralfractures	1.0		
Open fractures	1.0		
Volkmann contracture	0.5		
Flexion type	2.0		
Fractures with nerve injuries	7.7		

Data were compiled from 7,212 fractures occurring in 61 major series average age was 6.7 years.

CLASSIFICATION OF SUPRACONDYLAR FRACTURES[2,30,37]

They may be broadly classified as:

1. **Flexion type of supracondylar fractures:**

Where the distal fragment is flexed in relation to the proximal fragment and is less common.

2. **Extension type of supracondylar fracture:**

Here the distal fragment is extended in relation to the proximal fragment.

Numerous attempts have been made in the literature to classify the extension type of supracondylar fractures. These classifications have been based on the two factors

a. The degree of displacement
b. The type and location of fracture line

Simple classification of extension type of supracondylar fractures proposed by Gartland, based primarily on the degree of displacement. This classification is divided into three main categories. In the first type, the fracture is non-displaced and there is difficulty in visualizing the fracture line. The diagnosis may be made by taking oblique views, measuring the angulation of distal humeral condyles or assessing displacement of the fat pads. Second type there is obvious fracture line with displacement of distal fragment but there is still intact cortex posteriorly. The amount of displacement may be minimal or great. In addition, there may be rotatory component. Final type involves complete displacement where there is no contact between the fragments. It is useful to sub-

classify these into postero-medial and postero-lateral as this helps to dictate the modality of treatment and possible sequelae.

1. **Gartland's classification[30:]**

Type I	Undisplaced
Type II	Displaced(with intact posterior cortex)
Type III	Completely displaced(no cortical contact)

   a) Posteromedial

   b) Posterolateral

2. **Gruber and Hudson classification[38]:**

Type I	Undisplaced fracture
Type II	Displaced fracture with angulation
Type III	Displacement with rotation and shift
Type IV	Severely displaced or a comminuted fracture. No bone to bone contact.

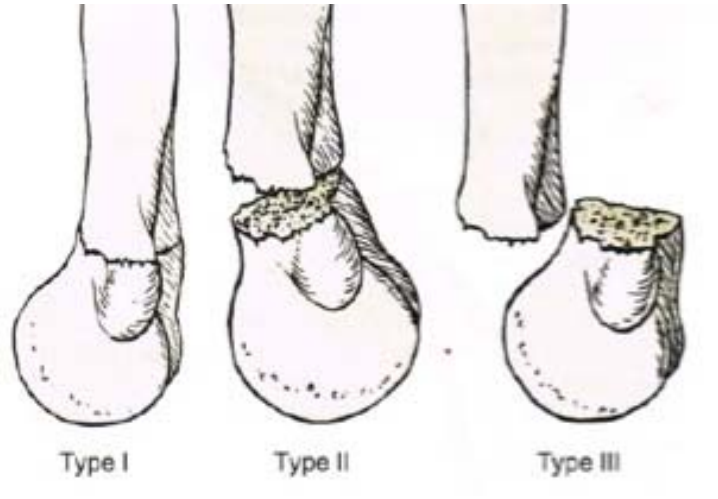
3. **Gartland and Wilkins classification[18:]**

Type I	Undisplaced fracture
Type IIA	Greenstick fracture with posterior angulation
Type IIB	Greenstick fracture with malrotation + posterior angulation
Type III	Completely displaced fracture

4. **Holmberg's classification[39:]**

Type I	Fracture without displacement
Type II	Fracture with sideways displacement
Type III	Fractures with displacement due to rotation
Type IV	Fractures with considerable displacement without contact between the fragments

GARTLAND'S CLASSIFICATION



Humerus in lateral view

Type III is further classified based on its appearance in antroposterior view. It is either medially displaced as in type IIIa or laterally displaced, as in type IIIb

CLINICAL FEATURES[2,30,36,37,40]

The patient complains of pain and swelling of elbow, when the fracture is complete (Type III), 'S' shaped deformity of the arm is obvious and there is a loss of both active and passive movements of the elbow. Careful examination of brachial artery and all the three nerves of the upper limb namely the radial nerve, the median nerve and ulnar nerves should be done.

The following are the characteristic clinical signs in supracondylar fracture of humerus.

- Arm is short, forearm is normal in length
- Gross swelling of elbow and tenderness
- Crepitus is present but should not be elicited for fear of increasing the pain and damaging the neighbouring neurovascular structures
- 'S' shaped deformity is created by the prominence of the spike of the proximal fragment, flexion of the distal fragment and the posterior prominence of the olecranon
- An anterior pucker sign due to one of the spikes of the proximal fragment penetrating the brachialis muscle and the anterior fascia of the elbow
- Relationship between three bony points is maintained
- Movements of elbow both active and passive are decreased

RADIOGRAPHS IN SUPRACONDYLAR FRACTURES[2,30]

The antero-posterior and lateral view should always be obtained. In some cases X-ray of the normal elbow may be needed for comparison. In a displaced supracondylar fracture, the location of the fracture line determines its differentiation from a fracture of the distal humerus or a fracture involving one of the physis.

The fracture line in a true supracondylar fracture may pass:

1. Through the coronoid and olecranon fossae
2. Proximal to the fossae
3. Involving the metaphysis

In some instances when a supracondylar fracture is suspected but not visualized on the routine antero-posterior and lateral views, an oblique view may be necessary to demonstrate the fracture line.

Often in the X-ray, the difficulty lies in the determination of the minimally displaced supracondylar fracture. Because there is an intra-articular effusion, the characteristic “fat pad sign” should be present on a true lateral view. The classic fat pad sign was first described by Norell in 1954. The olecranon fossa is deep and thus the fat pad here lies totally contained in the fossa. Distension of the capsule with an effusion can cause the dorsal olecranon fat pad to be visualized.

On the lateral view, if a line is drawn along the anterior border of the distal humerus shaft, it should pass through the middle third of the ossification centre of the capitulum. This is commonly referred to as the “anterior humeral line”. Posterior displacement of the ossificationcentre of the capitulum in relation to the “anterior

humeral line" is another very valuable sign of minimal hyperextension of the distal fragment.

In several displaced supracondylar fractures, the presence of a large medial spike into the subcutaneous fat layer may indicate that the distal fragment has "button holed" through the brachialis muscle and closed reduction may be very difficult to accomplish.

TREATMENT

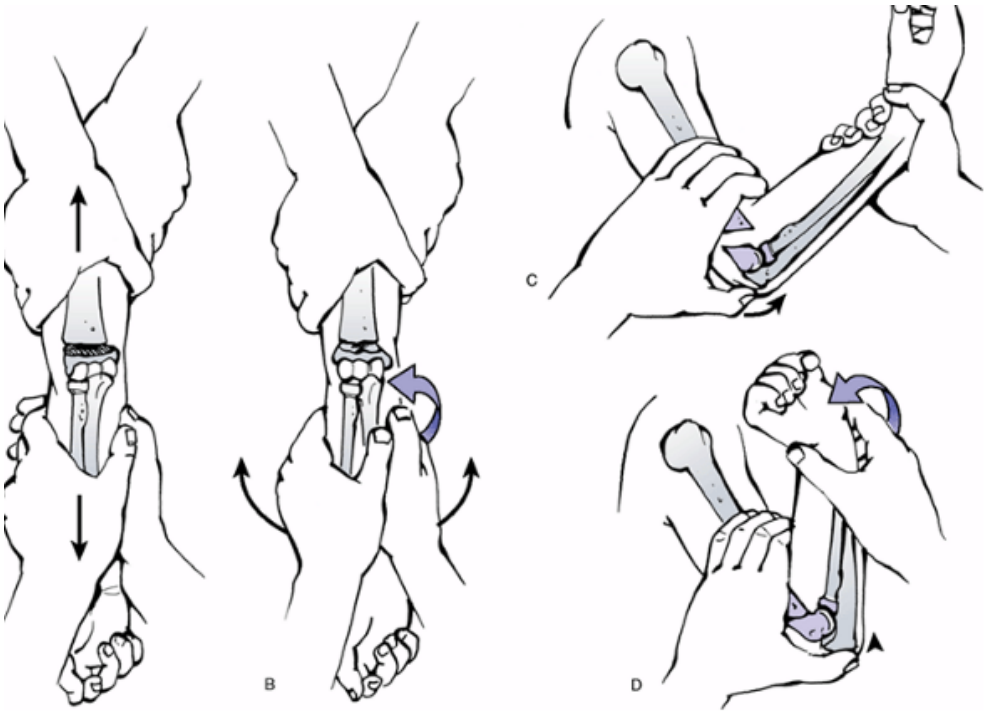
There is no controversy regarding treatment of un-displaced supracondylar fractures. Un displaced supracondylar fractures require simple immobilization of the elbow in above elbow plaster of paris slab with the elbow in 90^0 flexion. The plaster is kept for three weeks, later the plaster of paris slab is removed and active elbow movements are encouraged.

Treatment options available for displaced supracondylar fracture include closed reduction and plaster of paris slab application, skin traction, overhead skeletal traction, open reduction and internal fixation and closed reduction and percutaneous pin fixation.

1. Closed reduction and plaster of paris slab application[2,30,37]:

Closed reduction is done under general anaesthesia with image intensification. Firstly, longitudinal traction is applied with the elbow in hyperextension and forearm in supination. While the traction is maintained, the medial or lateral displacement is corrected by applying a valgus or varus force at the fracture site. The posterior displacement of the distal fragment is then corrected by applying a force to its posterior aspect while the elbow is gently hyperflexed. The position of reduction is then assessed by antero-posterior and lateral image intensification (c-arm) and above elbow pop slab is applied with the elbow at greater than 120^0 flexion.

Diagram showing the closed reduction of supracondylar fracture of humerus in children



2. Skin traction (Dunlop Traction)[2,9,30,41]:

When there is circulatory embarrassment it is commonly worsened by flexing the elbow to reduce the fracture, and in these circumstances simple skin traction on the forearm as described by Dunlop is a safe and valuable method of treatment. With the child recumbent, the arm is abducted to a right angle at the shoulder, the elbow put over the side of the bed and flexed through about 60^0, skin traction is applied in the line of forearm using about 3lb (1.5 kg) suspended from a convenient overhead beam or a drip stand. The elbow is prevented from extending by a vertical sling placed over the fracture site, to which is attached a weight of 2lb (1 kg).

Children tolerate this treatment very well and can be nursed in this position until there is sufficient radiographic evidence of callus formation to allow the application of a plaster.

There is growing tendency to use this for the treatment for all difficult supracondylar fractures, but it must be emphasized that the reduction obtained is by no means perfect and although varus or valgus tilt is usually corrected, a significant amount of backward angulation may persist.

3. Over-head skeletal traction[2,9,30,41]:

It is claimed that overhead olecranon traction, with either a threaded pin or a special traction screw, allows the forearm to be pronated, preventing the tendency to varus deformity. It is suggested that the incidence of varus deformity is higher when Dunlop traction is used because the forearm usually lies in supination. Although the surgeons advocating this method of traction report a very small incidence of pin track infection, pins through the olecranon are known to have caused disastrous stiffness as a result of infection and it is doubtful if the small gain is worth the risk of complications from the pin track infection. Dunlop traction produces the same results with fewer hazards.

4. Open reduction and internal fixation[2,30]:

The major indications for open reduction are

- Open fracture
- A fracture requiring vascular exploration
- An irreducible fracture

The complications of open reduction include infection, myositis ossificans, loss of range of motion and cubitusvarus deformity.

5. Closed reduction and percutaneous 'K' wire fixation[30,37,40,42]:

Operative Technique:

Closed reduction was done under general anaesthesia with image intensification. Firstly, longitudinal traction is applied with the elbow in hyperextension and forearm in supination. While the traction is maintained, the medial and lateral displacement is corrected by applying a force to its posterior aspect while the elbow is gently hyperflexed and the elbow is secured in hyperflexion. The elbow is placed in the lateral position directly on the image intensification. If fracture is a posteromedial type III**,**the medial pin is placed first. The medial pin is directly placed through the apex of the medial epicondyle. The lateral pin is placed at the centre of the lateral epicondyle. The fractures are secured with 1.5mm to 2.0mm K-wires depending upon the age of the patients. In the coronal plane, the pins are placed with an angle of 30^0 with the long axis of the humerus. Both pins are placed percutaneously. After the pins are placed, the elbow is extended and the carrying angle is measured and compared to that on the unaffected side. The adequacy and stability of reduction is checked under image intensification. The pins are bent to prevent migration and cut off outside the skin to allow removal in the outpatient clinic without anaesthesia.

Postoperatively, the extremity is placed in a well-padded posterior splint with the elbow flexed only 90^0.

COMPLICATIONS OF SUPRACONDYLAR FRACTURES[2,30,43]

The complications can be divided into immediate and delayed. The immediate complications are also called as primary complications. They are:

1. Vascular
2. Neurologic

The delayed complications are also called as secondary complications. They are:

1. Mal union :
    - Cubitusvarus
    - Cubitusvalgus
2. Myositis ossificans
3. Tardy ulnar nerve palsy
4. Elbow stiffness

Primary complications:

1. Vascular complications:

Vascular complications occurring with extension type of supracondylar fractures are probably one of the most serious squeale of any fracture seen in the paediatric age group. The outcome can range from fibrosis of the muscles and nerves with loss of motor-sensory function, to gangrene and subsequent amputation.

The spectrum of vascular injuries includes both the primary and secondary effects from the fracture itself. The primary effects are the result of direct injury to the

brachial artery by the fracture fragments. This degree of injury may vary from a simple compression of vessels by the fracture fragments to a complete rupture. Even if the injured artery remains in continuity, occlusion of the involved segment can be caused by an intimal tear or vascular spasm. The secondary effects depend on the type and degree of ischemia that develops distal to the fracture site.

Type III supracondylar fractures have significant incidences of brachial artery injury, vascular insufficiency, compartment syndrome and Volkmann ischemic contracture.

1. **Neurologic complications:**

    In most modern series, the incidence of neurologic deficit with supracondylar fracture is 10% to 20%. In modern series, the anterior interosseous nerve(AIN) appears to be the most commonly injured, with loss of motor power to the flexor pollicislongus and the deep flexor to the index finger as first described by Spinner in 1969.

    The direction of displacement of the fracture determines the nerve most likely to be injured.

    If the distal fragment is displaced postero-medially, the radial nerve is most likely to be injured. Conversely, if the displacement of the distal fragment is posterolateral, the neurovascular bundle is stretched over the proximal fragment, injuring the median nerve or AIN or both.

    In flexion type of supracondylar fracture, which is rare, the ulnar nerve is the most likely nerve to be injured.

Secondary complications:

1. **Cubitusvarus:**

   In the past , the incidence of cubitusvarus deformity after supracondylar fracture ranged from 9% to 58%. Pirone et al reported cubitusvarus deformities in 14% of patients treated with cast immobilization compared with 3% in patients with percutaneous pin fixation.

   The usual etiology of cubitusvarus deformity is the malunion of the distal humeral fragment rather than growth arrest.

   As noted by Wilkins and others, horizontal rotation predisposes to coronal tilting, and a combination of horizontal rotation coronal tilting and posterior displacement results in a three dimensional deformity of cubitusvarus.

2. **Cubitusvalgus:**

   Cubitus valgus is rare. It mostly occurs with the posterolateral type of fracture pattern, especially when the distal fragment is laterally rotated.

   In this situation, the insertion of triceps and biceps is now lateral to the long axis of the humeral shaft and therefore tends to angulate the distal fragment laterally. The deformity is much less noticeable because it is simply an accentuation of the normal valgus carrying angle. The major concern is the development of tardy ulnar nerve palsy in later life.

3. **Myositis ossificans:**

   The occurrence of myositis ossificans is rare. This complication has been described after open reduction, but vigorous post-operative manipulation or physical therapy is believed to be the most common associated factor.

4. **Tardy ulnar nerve palsy:**

Tardy ulnar nerve palsy is extremely rare and is associated with cubitus valgus deformity

5. **Elbow stiffness:**

Loss of motion after extension type of supracondylar fracture is rare in children. Although loss of motion is usually minimal, significant loss of flexion can occur. This is generally caused by either posterior angulation of the distal fragment, posterior translation of the distal fragment with anterior impingement, or medial rotation of the distal fragment with a protruding medial metaphyseal spike proximally. In young children with significant growth potential, there may be significant remodelling of anterior impingement. It has been shown that posterior angulation does not remodel significantly.

MATERIALS AND METHODS

Twenty displaced closed extension type of supracondylar fractures(Gartland's type III) of the humerus in children were treated by closed reduction and percutaneous fixation with kirschner wires between October 2010 to April 2012.

This study was conducted in B.M. Patil Medical College hospital and Research Center, Bijapur, Karnataka.

Inclusion criteria:

1. Age less than 15 years.
2. Diagnosed cases of closed supracondylar fracture of humerus.

Exclusion criteria:

1. Age more than 15 years
2. Open supracondylar fracture of humerus
3. Supracondylar fracture of humerus with neurovascular complications.
4. Failed closed reductions.
5. Fractures of more than 3weeks duration.
6. Patients with associated ipsilateral upper extremity injuries.

All the patients selected for this study were admitted in B.M. Patil Medical College hospital and Research Center and examined according to the protocol and associated fractures if any, were noted. Then the patients radiographs were taken, both anteroposterior and lateral views of elbow joint.

All fractures were classified according to Gartland's classification

Gartland's Classification

Type I	Non displaced
Type II	Displaced(with intact posterior cortex)
Type III	Displaced(no cortical contact) a. Posteromedial b. Posterolateral

Before surgery the necessary laboratory investigations were done. Closed reduction and percutaneous K wire fixation was done in all patients within 3weeks of initial trauma.

Operative technique:

Under general anaesthesia the patient was placed in the supine position on the operating table. The image intensifier machine was used as the operating table.

Closed reduction was performed under image intensification. Firstly, longitudinal traction was applied with the elbow in hyperextension and forearm in supination. While the traction was maintained the medial or lateral displacement was corrected by applying a valgus or varus force at the fracture site. The posterior displacement of the distal fragment was then corrected by applying a force to its posterior aspect while the elbow was gently hyperflexed and the elbow was secured in hyperflexion. Site of the surgery was thoroughly scrubbed, painted with iodine and spirit and draped. The main tube of the image intensifier was draped so that the upper

arm and elbow lie on the image intensifier. The elbow was placed in lateral position directly on the image intensifier. If fracture was a posteromedial type, the medial pin was placed first. The medial pin was placed directly through the apex of medial epicondyle. The lateral pin was placed in the centre of the lateral epicondyle. The fractures were secured with 1.5 mm to 2.0 mm K-wire depending upon the age of the patients. In the coronal plane, the pins were placed with an angle of 30^0 with the long axis of the humerus. Both pins were placed percutaneously. After the pins were placed, the elbow was extended and the carrying angle was measured and compared to that on the unaffected side. The adequacy and stability of reduction was checked under image intensification. The pins were bent to prevent migration and cut off outside the skin to allow removal in the outpatient clinic without anaesthesia.

Post-operatively, the extremity was placed in well-padded posterior splint with the elbow flexed only $90^0$and patient was shifted to the ward after recovery from anaesthesia.

For all patients, immediate post-operative radiographs were taken to determine the maintenance of reduction on radiographs.

The follow-up examination consisted of measuring range of motion and carrying angle.

Patient under general anesthesia and hyperflexed position

Maintaining the elbow in reduction of the fragment after traction

Insertion of lateral K- wire

Both K-wires in situ and bent

Post-operative management:

- The operated limb was elevated
- A careful observation for any neurovascular deficit was observed at regular intervals
- Appropriate antibiotics and analgesics were used
- Patients were discharged on advise to come for regular follow-up
- For all patients immediate post-operative radiographs were taken to determine the maintenance of reduction on radiographs.

Follow-up:

- Four weeks later the splint and pins were removed
- Active range of motion exercises were encouraged
- A special mention and warning were given after the removal of the splint about avoiding massage and passive stretching of the elbow joint.
- Further follow-ups were done at 3 weeks, 6 weeks and 3 months.
- The patients were examined clinically and radiological assessment was done for range of motion and carrying angle.

Functional results:

The final results were evaluated by Flynn's criteria[7].

The results were graded as excellent, good, fair and poor according to loss of range of motion and loss of carrying angle.

Flynn's Grading System

Result	**Rating**	**Cosmetic factor: Carrying angle loss (degrees)**	**Functional factor: motion loss (degrees)**
Satisfactory	Excellent	0 – 5	0 - 5
	Good	6 – 10	6 - 10
	Fair	11 – 15	11 - 15
Unsatisfactory	Poor	➢ 15	➢ 15

OBSERVATIONS AND RESULTS

The following observations were made from the data collected during this study.

Twenty patients with closed displaced supracondylar fractures were treated by closed reduction and percutaneous fixation with kirschner wires and follow-up done at 3weeks, 6 weeks and 3 months post-operatively.

Age Distribution

Age in years	No. of patients	Percentage
4 – 6	12	24
7 – 9	15	30
10 – 12	17	34
13 – 15	6	12

In our series, age distribution was 4 to 15 years.

Majority of the patients i.e17(34%) were from 10 – 12 years age group, followed by 15(30%) patients in 7 - 9 years age group. The average age of patient was 8.9 years.

Sex Distribution

Sex	No. of patients	Percentage
Male	35	70
Female	15	30

Majority of the patients were males i.e., 35(70%) and15(30%) patients were females.

Mode of injury

Nature of trauma	No. of patients	Percentage
Fall from bicycle	**15**	**30**
Fall from tree	**7**	**14**
Fall while playing	**28**	**56**

The major causes of fracture in our study was fall while playing in 28(56%) patients followed by fall from bicycle in 15(30%) patients and in 7(14%) patients was due to fall from tree.

Side Affected

Side	No. of patients	Percentage
Left	**34**	**68**
Right	**16**	**32**

The fracture occurred on the left side in 34(68%) patients and on the right in 16(32%) patients, more in left side.

Fracture Pattern

Fracture Pattern	No. of patients	Percentage
Type IIIA(Posteromedial)	**36**	**72**
Type IIIB (Posterolateral)	**14**	**28**

In our study, we had36 (72%) patients with posteromedial displacement and 14(28%) patients with posterolateral displacement. More patients had posteromedial displacement.

Stay in Hospital

No. of days	No. of patients	Percentage
Three	**34**	**68**
Four	**16**	**32**

Patients stayed for 3 days is 34(68%) and16(32%) patients for 4 days. The average hospital stay in our study was 3.32 days.

Complications

Complications	No. of patients	Percentage
Superficial pin track infection	**4**	**8**
Iatrogenic ulnar nerve injury	**2**	**4**
Cubitusvarus deformity	**3**	**6**

We had 4 cases of superficial pin track infection which was treated by appropriate antibiotics.

We had 2 cases of iatrogenic ulnar nerve palsy and they showed progressive improvement with time and regained full neurologic function within 4 months.

In our series we had 3 cases of cubitusvarus deformity which was later treated by corrective osteotomy.

Loss of range of motion:

Loss of range of motion (degree)	No. of patients	Percentage
0- 5	**30**	**60**
6 – 10	**15**	**30**
11 – 15	**4**	**8**
>15	**1**	**2**

At the final follow-up, 0-5^0 loss of range of motion of the affected extremity was noted in 30 patients and more than 15^0 loss of range of motion was noted in only one patient and mean loss of range of motion was 6.8^0in our study.

Carrying angle loss

Carrying angle loss (degrees)	No. of patients	Percentage
0- 5	**34**	**68**
6– 10	**9**	**18**
11 – 15	**6**	**12**
>15	**1**	**2**

At the final follow-up 0-5^0 carrying angle loss of the affected extremity was noted in 34 patients. More than 15^0 carrying angle loss was noted in only one patients and mean loss of carrying angle was 5.14^0 degrees in our study.

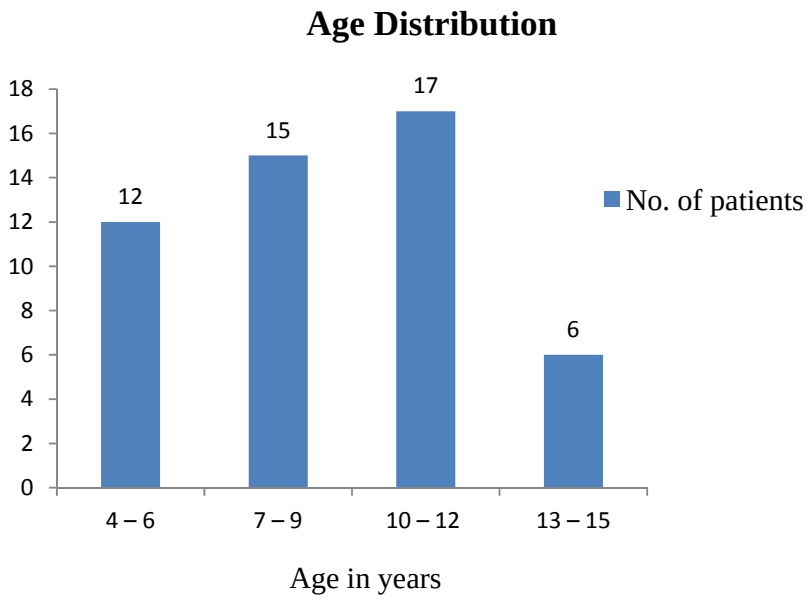
Functional results:

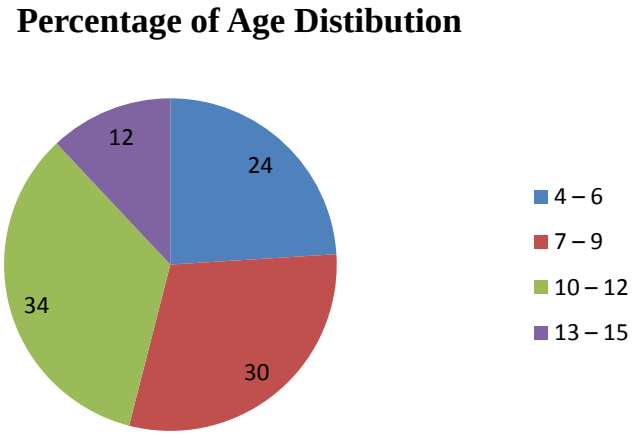
The final results were evaluated by Flynn's criteria.

Flynn's Grading System and functional outcome

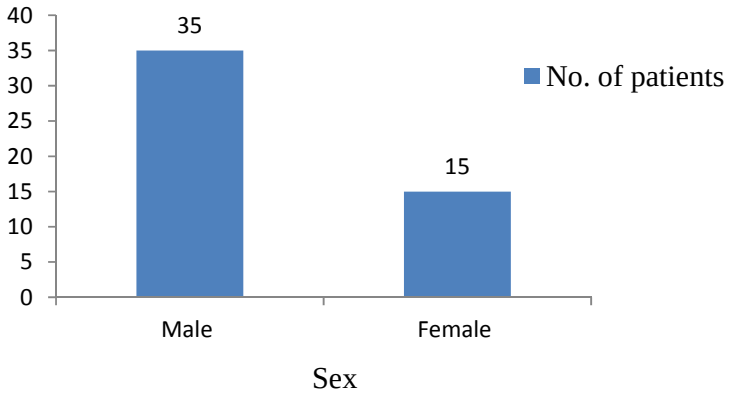
Result	Rating	No. of patients	Percentage
Satisfactory	**Excellent**	**34**	**68**
	Good	**10**	**20**
	Fair	**5**	**10**
Unsatisfactory	**Poor**	**1**	**2**

In our study 49 patients had satisfactory results, of these patients, 34 patients were rated as excellent,10 patients were rated as good and 5 patients were rated as fair. Only one patient had unsatisfactory result, which was rated as poor.

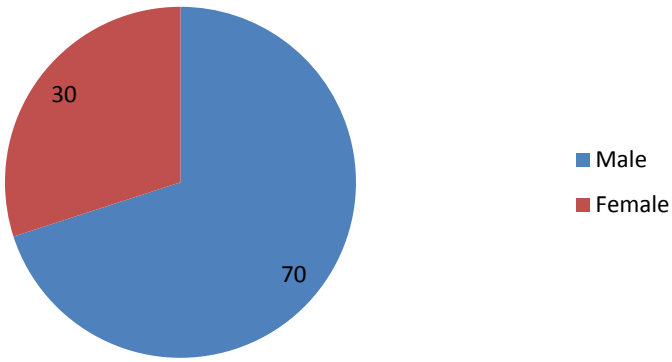

Age Distribution
18
16
14
12
10
8
6
4
2
0
12
15
17
6
4 – 6
7 – 9
10 – 12
13 – 15
No. of patients
Age in years

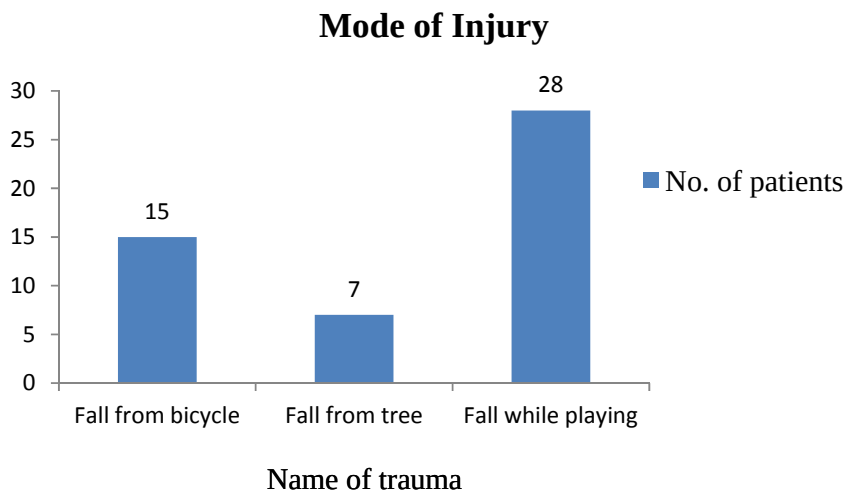

Percentage of Age Distibution
12
24
34
30
4 – 6
7 – 9
10 – 12
13 – 15

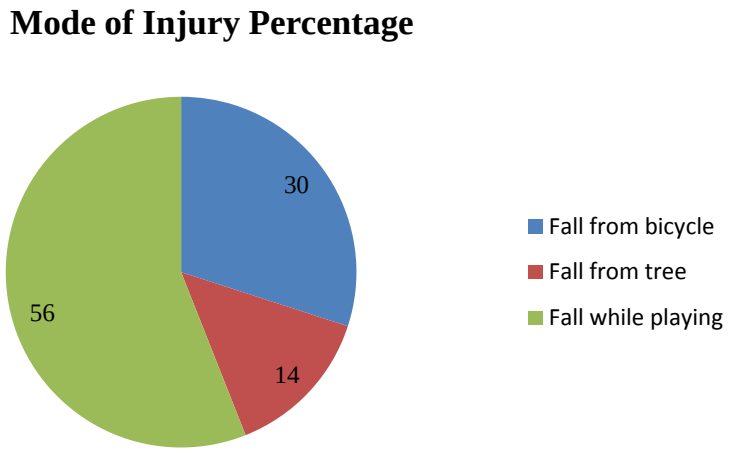
Sex Distribution

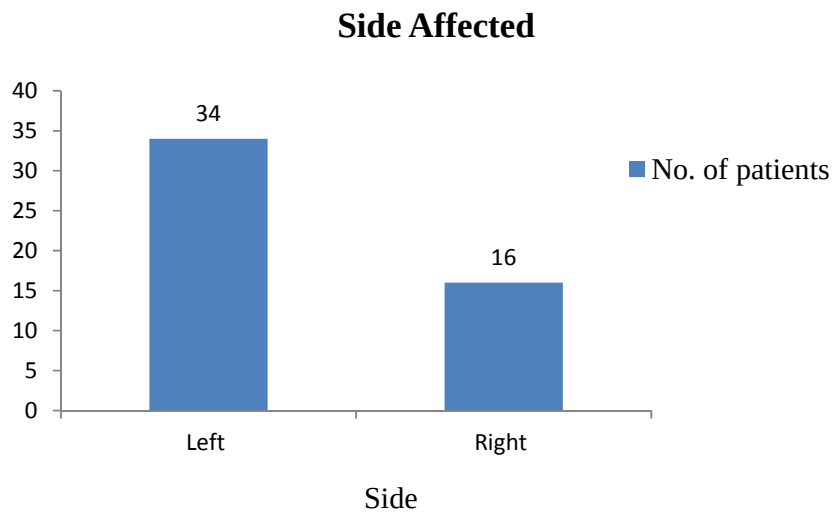


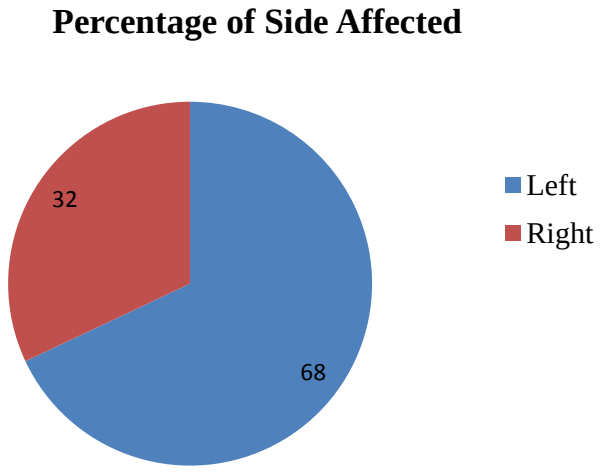
Percentage of Sex Distribution



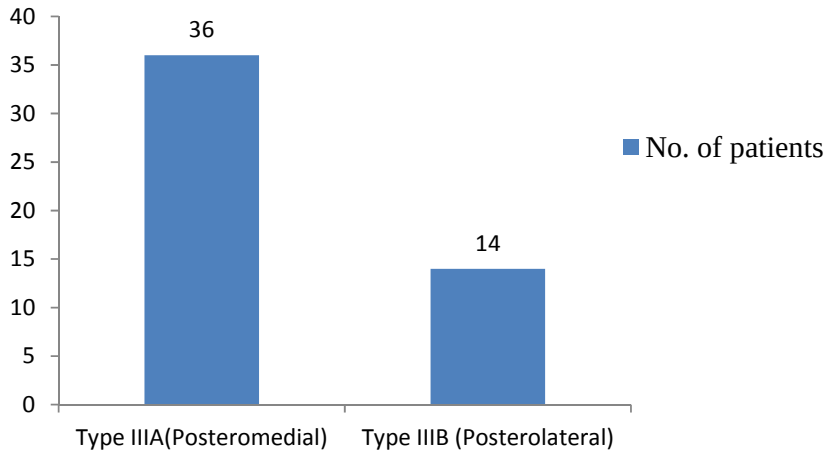

Mode of Injury
30
25
20
15
10
5
0
15
7
28
Fall from bicycle
Fall from tree
Fall while playing
No. of patients
Name of trauma


Mode of Injury Percentage
30
14
56
Fall from bicycle
Fall from tree
Fall while playing

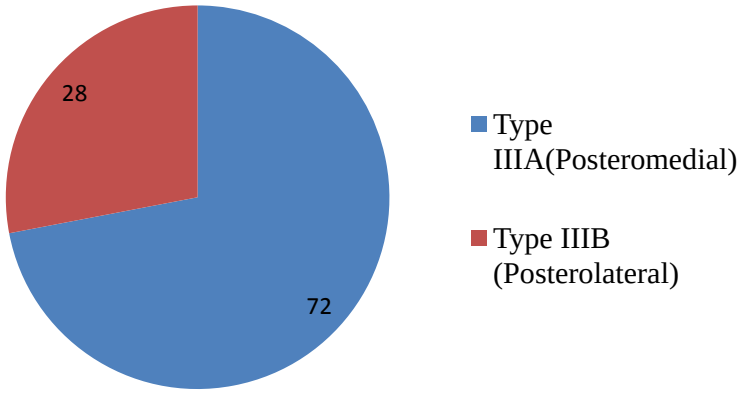

Side Affected
40
35
30
25
20
15
10
5
0
34
16
Left
Right
No. of patients
Side


Percentage of Side Affected
32
68
Left
Right

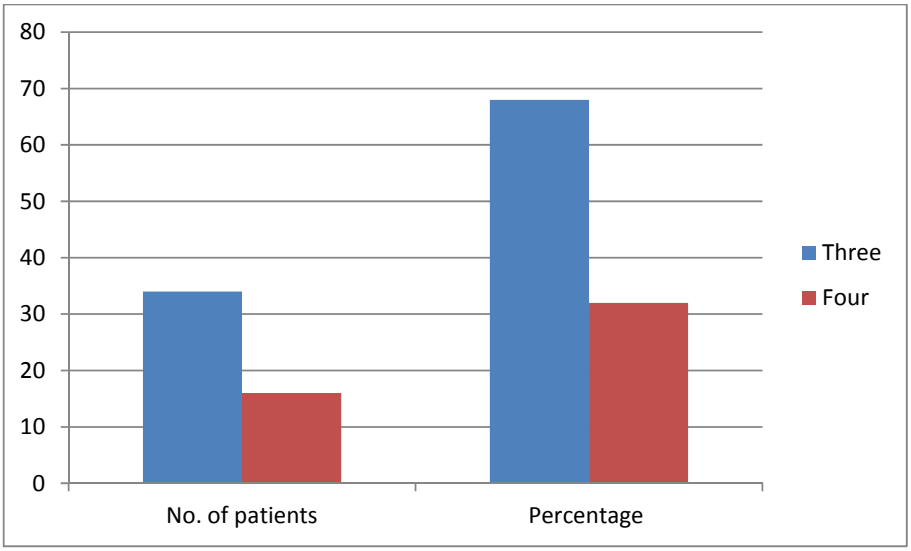
Fracture Pattern



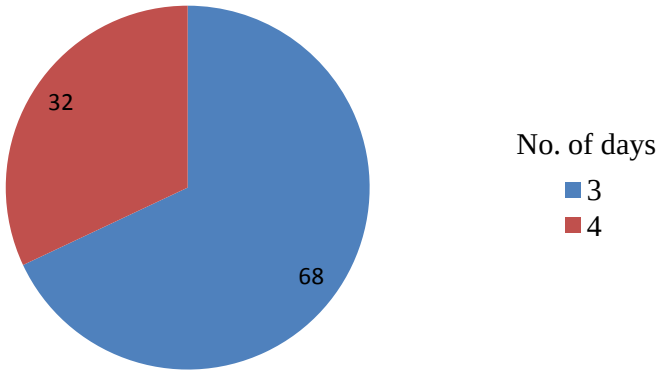
Percentage of Fracture Pattern



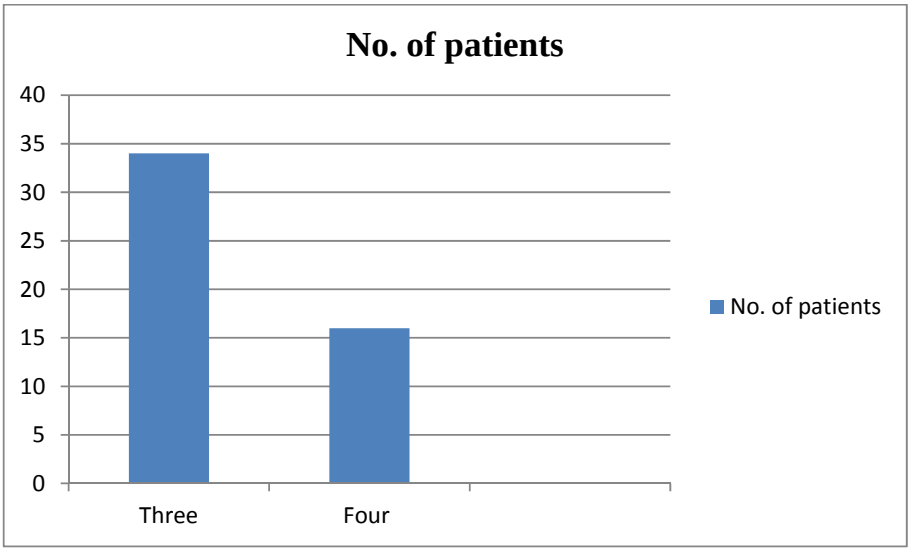
Stay in hospital



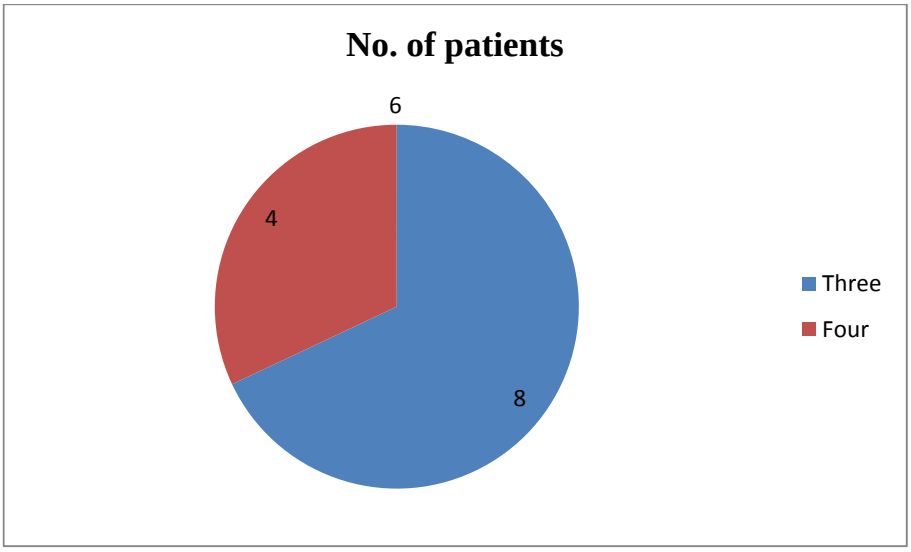
Percentage of stay in hospital



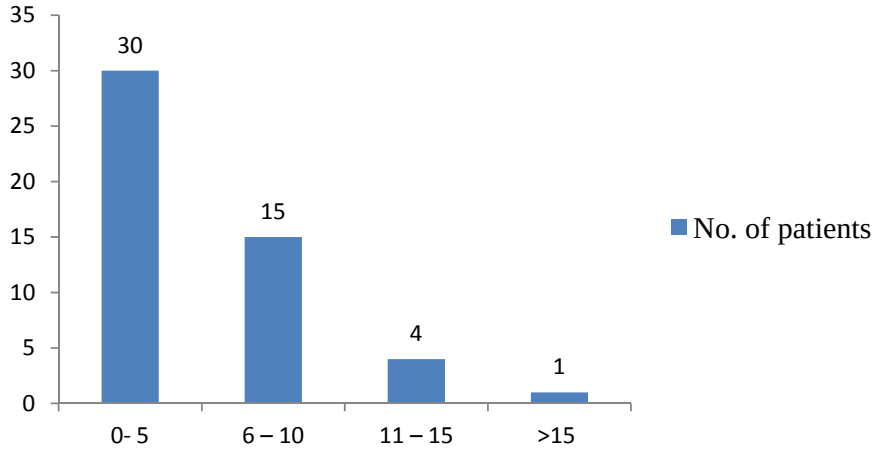
Complications



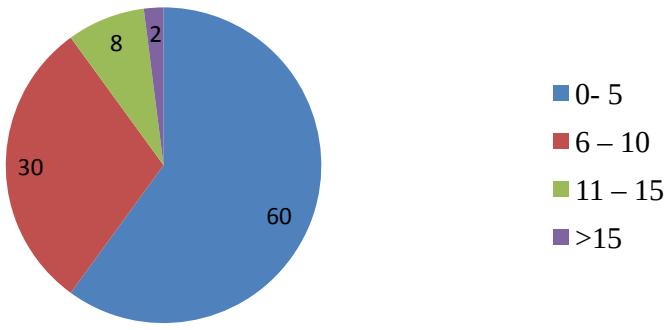
Percentage of complications



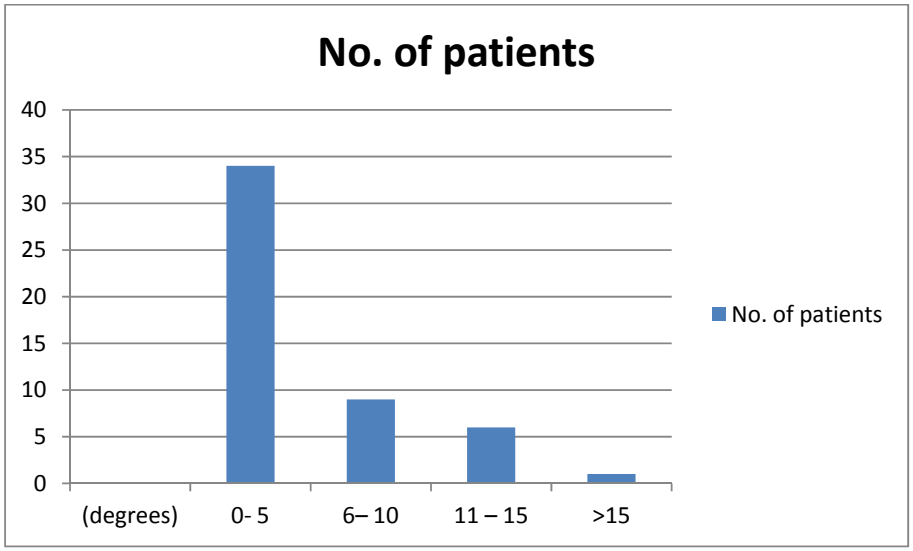
Loss of Range of Motion



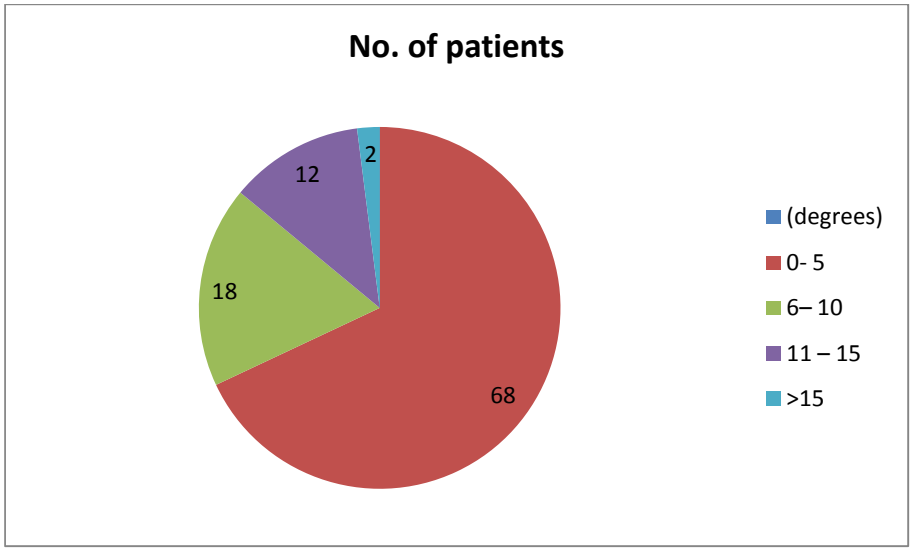
Percentage of Loss of Range of Motion(degree)



Loss of Carrying Angle

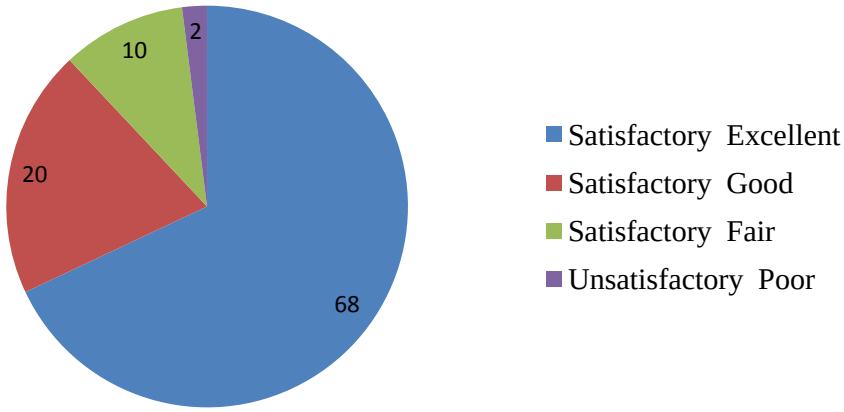


Percentage Loss Of Carrying Angle



Flynn's Grading System Result

Percentage of Flynn's Grading System



CASE – 2

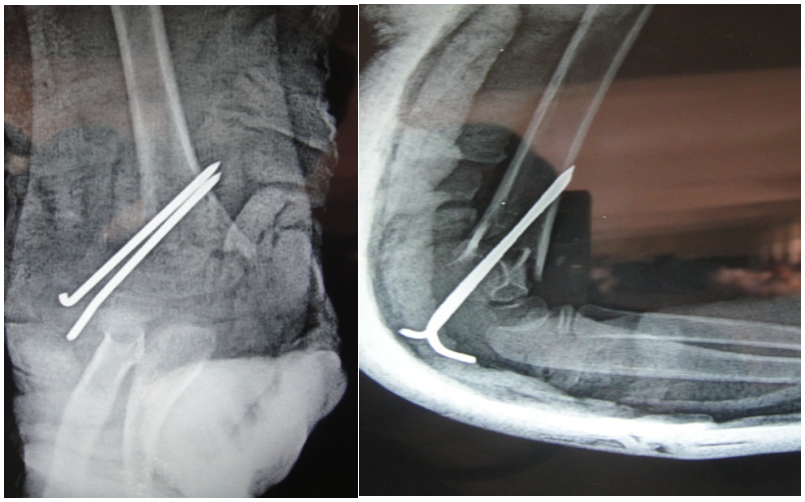
Normal Carrying Angle

Extension

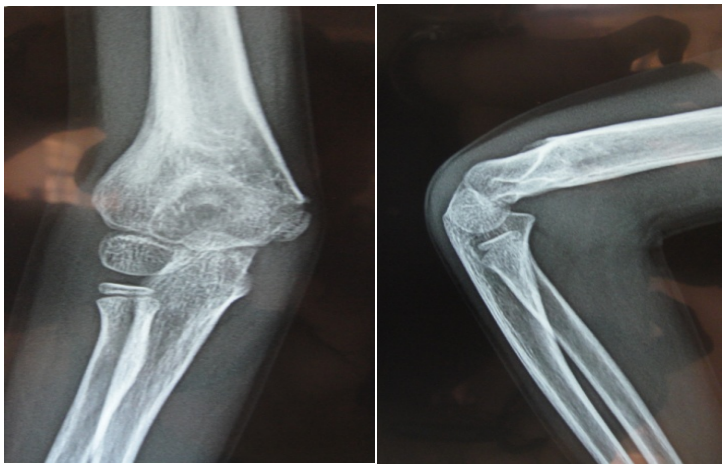
Flexion

RADIOGRAPHS

Prereduction



Immediate Postoperative



Final Followup

CASE – 10

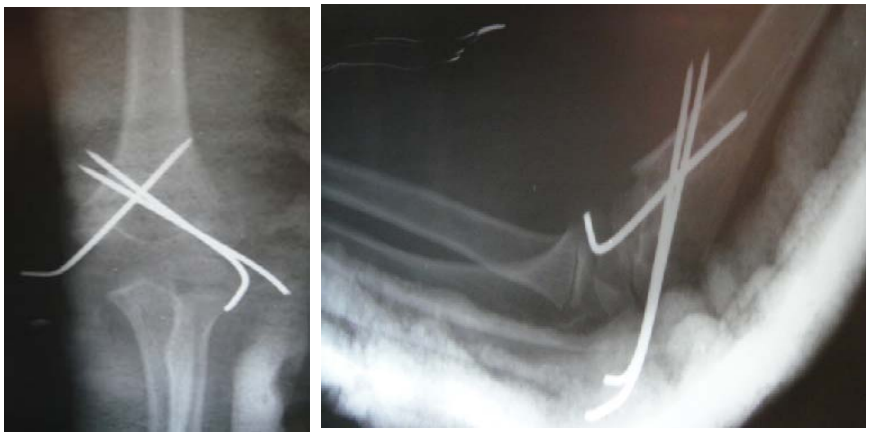
Normal carrying angle

Extension

Flexion

RADIOGRAPHS

Pre Reduction



Immediate Postoperative

Final Followup

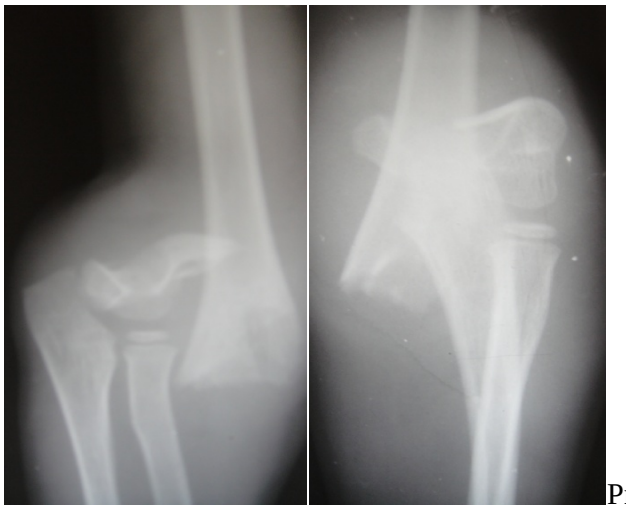
CASE – 15

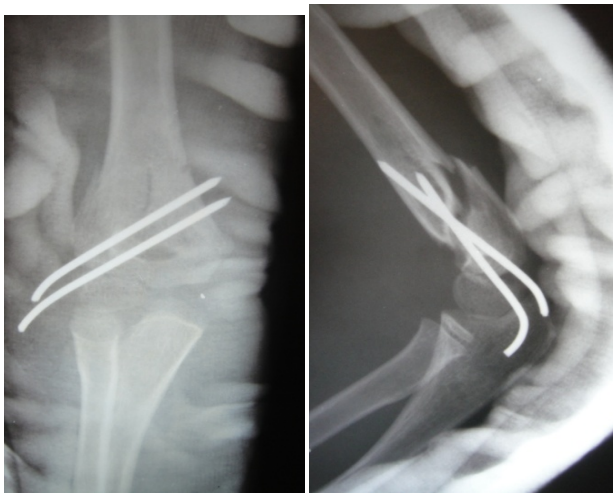
Normal Carrying Angle

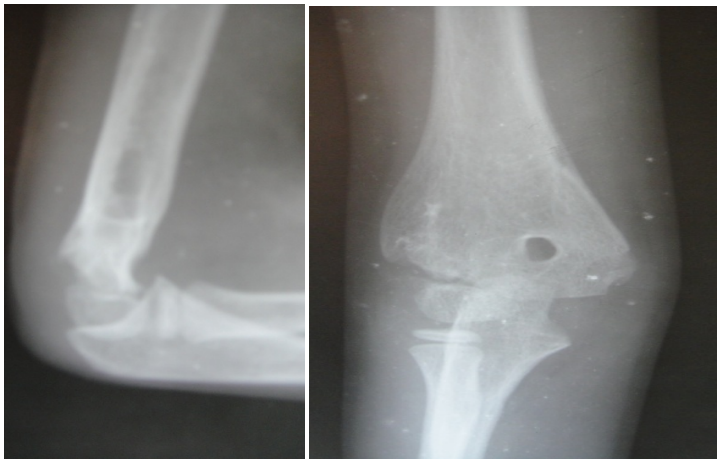
Extension

Flexion

RADIOGRAPHS


Prereduction


Immediate Post Operative


Final Followup

CASE – 35

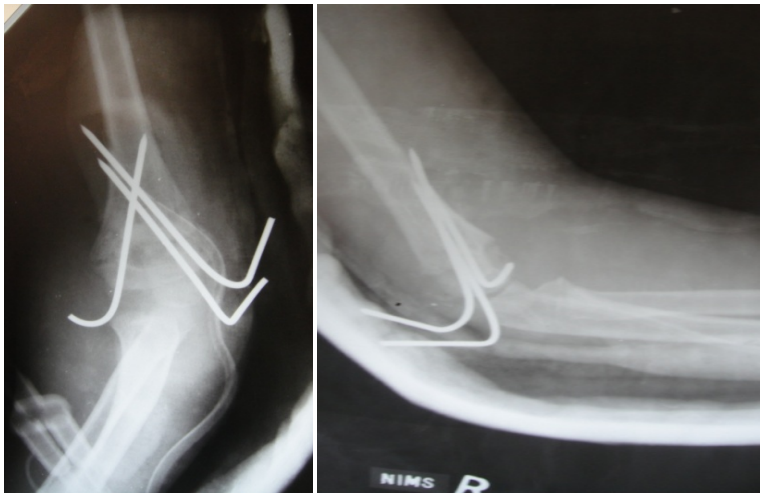
Normal Carrying Angle

Extension

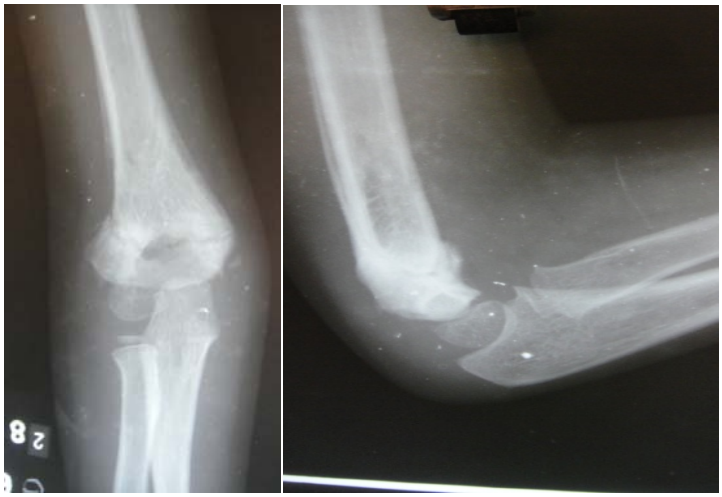
Flexion

RADIOGRAPHS


Prereduction



Immediate Post Operative


Final Followup

DISCUSSION

The aims of the treatment of supracondylar fractures are to achieve functionally and cosmetically satisfactory results and to avoid complications. Assuring a low cost and decreasing the hospitalization period are very important for both surgeons and patient's parents.

Traction is still an effective method of treatment but has many drawbacks. First, it is expensive. Second, when the extremity is swollen, it is very risky to attempt skin traction. Third, when skeletal traction is attempted, it poses some problems and prolongs the hospitalization period.[8]

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 criticised has been the posterior approach which is claimed to be the method most likely to cause loss of elbow movement, and infection. Because of this problem, the major indications for a primary open reduction include an open fracture, failure to achieve an adequate closed reduction or vascular compromise that worsens especially with the manipulative technique[37].

Hence closed reduction and percutaneous pinning have become a popular method recently.

Rosemount IL, recommend that CRPP be done within 8-12 hours if there is no neurovascular compromise, tenting of the skin or worsening edema[38].

The present study was conducted to assess the results of closed reduction and percutaneous fixation with kirschner wires for displaced extension type of supracondylar fractures of the humerus in children.

Age incidence:

In the present study 64% of the patients were from 7-12years age group with the average being 8.9years.

Fowles JV. Et al ., in their study , reported that the majority of the patients were from 5-10 years age group[43].

The average age in **Wilkins K E et al.,** study was 6.7years[2].

The average age in **Fransworth CL. et al.,** study was 5.9±2.8 years[44].

The average age in **Pirone AM. et al .,** study was 6.4years.

Sex incidence:

In the present study 70% of the patients were males and 30% patients were females. Many authors have also reported male predominance.

Wikins KE. et al., reported in his series 62.8% were males and 37.2% were females[2]. **Pirone AM et al** ., reported 52%were males and 48% were females[5].

Aronson DD .et al., reported 75% were males and 25% were females[4]. This male predominance can be explained as boys are more active and are more prone for falls.

Mode of injury:

The major cause of fracture in our study was fall while playing in 28 patients (56%) followed by fall from bicycle in 15 patients (30%).

Fransworth et al., in their study, reported that fall from a height was the major cause of injury in 70% of the cases[44].

Side affected:

In the present study, fracture occurred on the left side in 34 patients (68%) and on the right in 16 patients (32%)

Aronson DD. et al ., reported 13 (65%) fractures on the left side and 7 (35%) on the right side in their study of 20 cases[4].

Mazda K et al ., reported 65(56%) fractures on the left side and 55 (44%) on the right side in their study of 116 cases[20].

Wilkins KE. et al., reported in their series, 60.8% on the left side and 39.2% on the right side[2].

Flynn JC. Et al., reported 48 (66.7%) fractures on the left side and 24 (33.3%) on the right side in their study of 72 cases[7].

Fracture pattern:

In the present study, there are 36(72%) patients with posteromedial displacement and 14 patients (28%) with posterolateral displacement.

Mostafari. HR. et al., reported 34 (81%) patients with posteromedial displacement and 8 (19%) patients with posterolateral displacement[1].

Aronson DD. et al., noted 15(75%) fractures displaced posteromedially and 5 (25%) posterolaterally in their study of 20 cases[4].

Stay in hospital:

The average duration of hospital stay in the present study was 3.32days.

The average hospital stay was 4.2days in the study conducted by **Nacht JL. Et al.**[9]

The average hospital stay was 2.4 days in the study conducted by **Flynn JC. Et al.**[7]

Kramhaft et al., conducted a study on skeletal traction management of the displaced supracondylar fractures in children. The average hospitalization in their study was 2.6weeks[39].

Compared to the above studies, the average duration of hospital stay was less in our study i.e. 3.32 days.

Complications:

Complications	**No. of patients**	**Percentage**
Superficial pin track infection	4	8
Iatrogenic ulnar nerve injury	2	4
Cubitusvarus deformity	3	6

We had 4 cases of superficial pin tract infection which was treated by appropriate antibiotics.

We had 2 cases of iatrogenic ulnar nerve palsy and they showed progressive improvement in time and regained full neurologic function within 4 months.

In our series we had 3 cases of cubitusvarus deformity which was later treated by corrective osteotomy.

Boyd et al preferred two parallel laterally inserted K-wires for percutaneous fixation, if fracture is stable. If it is unstable, they prefer crossed medial and lateral K- wires. In their series,70 of 71 patients had satisfactory results. Six patients had neurovascular complications. One Ulnar and two interosseus nerve palsies were documented before surgery, and two cases treated with crossed medial and lateral pins had iatrogenic ulnar nerve palsies at post-operative clinical examinations. All nerve palsies had completely recovered by the time of follow up evaluation[42].

Loss of range of motion:

Loss of range of motion	No. of patients	Percentage
0 – 5	30	60
6 – 10	15	30
11 – 15	4	8
>15	1	2

At the final follow up, $0\text{-}5^0$ loss of range of motion of the affected extremity was noted in 30(60%) patients and more than 15^0 loss of range of motion was noted in only one (2%) in our study.

The mean loss of range of motion was 6.8^0 in the present study.

Nacht JL et al., noted mean loss of range of motion was 7.8^0 at the final follow up in their study[9].

Carrying angle loss:

Carrying angle loss (degrees)	No. of patients	Percentage
0 – 5	34	68
6 – 10	9	18
11– 15	6	12
>15	1	2

In the present study, at the final follow-up, $0 – 5^0$ carrying angle loss of the affected extremity was noted in 34(68%) patients. More than 15 degrees carrying angle loss was noted in only one (2%) patient and mean loss of carrying angle was 5.14^0.

Nacht JL et al., noted mean carrying angle loss of 5.8^0 degree (range $2^{0-}15^0$) in 20 patients and increased carrying angle in 4 patients by an average of 6.8^0 at the final follow-up examination[9].

Flynn JC. Et al., reported mean loss of carrying angle was 6.2 degrees[7].

Pirone et al reviewed 230 patients treated by different methods. Highest percentage of excellent results was achieved by percutaneous krischner wire fixation (78%), skeletal traction (67%) and open reduction with internal fixation (67%). No ulnar nerve injuries were attributed to the medial pin and two pin track infection occurred in percutaneous pin fixation group[5].

Flynn .et al reported 52 patients treated by closed reduction and percutaneous pin fixation. 51(98%) patients had satisfactory results by their own criteria. They reported that one patient had transient ulnar neuropathy due to medial pin insertion. Two

patients had loss of reduction. There were no pin track infections, broken pins or growth disturbances[7].

France et al reported a large series treated with different methods. They found significantly better clinical results in the patients treated with closed reduction and percutaneous pin fixation. On the other hand, when they compared the two groups, treated with two lateral pins and crossed medial and lateral pins, they found no significant difference between the groups. Only one patient had ulnar nerve palsy in the crossed medial and lateral pins[41].

Neurological complications of supracondylar fractures of the humerus in children have often been reported. Injuries to the nerves or blood vessels may be more serious than the fracture itself. Neurological deficits are common and involve all major nerves of the forearm, such deficits usually recover with conservative therapy[32,33,34].

In our study all fractures united around 4 weeks. We had 4 cases of superficial pin track infection which were treated by appropriate antibiotics. We had 2 cases of iatrogenic ulnar nerve palsy resulting from the medial pin due to improper pin insertion or stretch of the ulnar nerve over the medial pin. They showed progressive improvement in time and regained full neurologic function within 4 months. We had 3 cases with cubitusvarus deformity which require corrective osteotomy later. No patient had pain or symptoms related to the elbow.

- The final results were evaluated by Flynn's criteria. In our study, 49(98%) of patients had satisfactory results. Only 1(2%) patients had unsatisfactory results.

- In conclusion, closed reduction and percutaneous fixation using K-wires is the most commonly accepted treatment of displaced supracondylar fractures of the humerus in children.
- The result of the present study compare favourably with those of other previously reported methods of treatment of the displaced supracondylar fractures of the humerus in children.

Comparison between present study and other methods of treating displaced supracondylar fracture

Treatment	Author	Total no. of cases	Flynn's grading system			
			Excellent	Good	Fair	Poor
Closed reduction and application of a cast	Pirone et al	101	**51(51%)**	**27(27%)**	**3(3%)**	**20(20%)**
Percutaneous kirschner-wire fixation	Pirone et al	96	**75(78%)**	**15(16%)**	**1(1%)**	**5(5%)**
Skeletal traction	Pirone et al	24	**16(67%)**	**5(21%)**	**1(4%)**	**2(8%)**
Open reduction and internal fixation	Pirone et al	9	**15(66%)**	**1(11%)**	**0(0%)**	**2(22%)**
Percutaneous kirshcner wire fixation	Flynn et al	52	**42(80%)**	**7(14%)**	**2(4%)**	**1(2%)**
Percutaneous kirschner wire fixation	Present study (2012)	50	**34(68%)**	**10(20%)**	**5(10%)**	**1(2%)**

SUMMARY

Fifty displaced extension type of supracondylar fractures of the humerus in children were treated by closed reduction and percutaneous fixation with kirschner wires between October 2010 and April 2012 at shri B.M. Patil Medical College and Research Centre, Bijapur, Karnataka.

- The mean age of the patients in our study was 8.9 years and maximum number of patients 32 was between 7-12 years of age and 35 patients were males and 15 patients were females. The fracture occurred on the left side in 34 patients and in right side in 16 patients. Fall while playing was the main cause of fracture, amounting to 28. All the fractures were closed type.
- 36 patients with posteromedial displacement and 14 patients with posterolateral displacement.
- None the patients had other associated fractures.
- The average hospital stay was 3.32 days.
- In our study, all fractures united around 4 weeks. We had 4 cases of superficial pin track infection which were treated by appropriate antibiotics. We had 2 cases of iatrogenic ulnar nerve palsy resulting from the medial pin due to improper pin insertion or stretch of the ulnar nerve over the medial pin. They showed progressive improvement in time and regained full neurologic function within 4 months. We had 3 cases of cubitusvarus deformity which was later treated by corrective osteotomy.
- The final results were evaluated by Flynn's criteria. In our study 49 patients had satisfactory results. Only one patient had unsatisfactory results.

- In conclusion, closed reduction with percutaneous fixation using ‘K’ wires is the most commonly accepted treatment of displaced supracondylar fractures of humerus in children.

CONCLUSION

From our study we concluded that closed reduction and percutaneous pin fixation is a safe and efficient method for fixation of displaced supracondylar fractures of the humerus.

- Common in 7-12 years age group.
- Most common in males than females.
- Usually left is affected more than the right hand.
- The commonest mode of injury is fall while playing.
- Posteromedial displacement is commoner than posterolateral displacement.
- It does not expose the patient to an undue risk of infection and elbow stiffness unlike open reduction and internal fixation.
- It reduces the length of hospital stay, thus reduces the cost of treatment.
- It decreases the morbidity and dependency of the patient.
- The most common complication, cubitusvarus, is rare.
- With the fracture stabilized by pins, an elbow with severe swelling can be extended beyond 90^0 , thus vascular compromise is avoided.
- Closed reduction and percutaneous pin fixation for displaced supracondylar fractures of the humerus in children gives excellent functional and cosmetic results.

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PROFORMA

Name :

Age : Sex: I.P. No:

Occupation : D.O.A:

Address : D.O.S:

Date of injury: D.O.D:

1. COMPLAINTS: Pain,
   Swelling,
   Deformity.

2. HISTORY: Fall,
   Vehicular accident,
   Assault.

3. PAST HISTORY:

4. FAMILY HISTORY:

5. GENERAL PHYSICAL EXAMINATION:

a. pallor: c. cyanosis:

b. pulse: d. B.P:

6. SYSTEMIC EXAMINATION:

a. C.V.S: c. R.S:

b. P.A: d. C.N.S:

7. LOCAL EXAMINATION:

Inspection:

a. Attitude.

b.Swelling.

c. Deformity.

Palpation:

a. Tenderness.

b. Crepitus.

c. Shortening.

d. Bony irregularity.

8.MEASUREMENTS:

a)Length of arm R L

b)Length of forearm R L

c) Shortening or lengthening

9.MOVEMENTS:

a) Elbow : Flexion ; Extension

b) Forearm : Supination ; pronation

10.NEUROLOGICAL STATUS:

Ulnar nerve,

Radial nerve,

Median nerve.

11.VASCULAR STATUS:

Radial pulse,

Capillary refilling.

12.INVESTIGATION:

Blood: Hb%: TC: DC: ESR:

Urine: Albumin: Sugar: Microscopy:

BT: CT:

Blood grouping and typing:

RBS: Blood urea: Serum creatinine:

HIV: HbsAg:

X-ray A.P &Lat: NO: Date: Report:

13. MANAGEMENT:

Preliminary treatment on admission Plaster of Paris slab,

Limb elevation,

Anti-inflammatory drugs,

Analgesic drugs.

Check X-ray following reduction.

Immobilization after surgery.

Surgery: Closed reduction and percutaneous k-wire fixation under c-arm image intensifier.

Distal pulse is checked.

Neurological status is checked.

Drugs advised : Antibiotics,

Analgesics,

Anti-inflammatory.

Check X-ray : No: Date: Report:

14.FOLLOW UP:

After 3 weeks Chest X-ray no: date: report:

Plaster removal date:

K-wire removal date:

Clinical findings:

Pain,

Swelling,

Deformity,

Movements.

Physiotherapy advised after plaster removal

Elbow range of motion,

Wax bath to elbow.

After 6 weeks

Movements,

Carrying angle,

Neurological.

After 3 months

Movements,

Carrying angle,

Neurological.

15.COMPLICATION:

Immediate: Vascular,

Neurological.

Delayed: Infection,

Restricted flexion,

Restricted extension,

Cubitus varus,

Cubitus valgus,

Myositisossificans.

16.ASSESSMENT OF RESULTS

BY FLYNN'S CRITERIA (1974)

EXCELLENT	Loss in carrying angle<5 degrees or Loss of elbow movements <5 degrees
GOOD	Loss in carrying angle 6-10 degrees or Loss of elbow movements 6-10 degrees
FAIR	Loss in carrying angle 10-15 degrees or Loss of elbow movements 10-15 degrees
POOR	Loss in carrying angle >15 degrees or Loss of elbow movements >15 degrees

CONSENT FORM

TITLE OF RESEARCH: EVALUATION OF MANAGEMENT OF SUPRACONDYLAR FRACTURES OF THE HUMERUS IN CHILDREN TREATED BY CLOSED REDUCTION AND PERCUTANEOUS K-WIRE FIXATION.

Principle Investigator : Dr K.NATESH.

P.G. Guide name : Dr ASHOK NAYAK M.S (ORTHO)

All aspects of this consent form are explained to the patient in the language understood by him/her.

1 Informed part

i. Purpose of study

I have been informed that this study will test the effectiveness of one particular method of open reduction and internal fixation of supracondylar fractures humerus. This method requires hospitalization.

ii. Procedure

I will be selected for the treatment after the clinical study of my age, type of fracture, condition of bone seen in radiograph and after study of fitness for anesthesia and surgery. I will be admitted immediately. I will have to attend follow-up to OPD regularly. I will be assessed in physiotherapy department also.

iii. Risk and discomfort

I understand that i any experience some pain and discomfort during the post-operative period. This condition is usually expected. These are associated with the usual course of treatment.

iv. Benefits

I understand that my participation in this study will have no direct benefit to me other than the potential benefit of treatment which is planned to heal my fracture in the shortest possible period and restore my function.

v. Alternatives

I understand that, the various alternative modes of treatment available to me in this fracture pattern with their merits and demerits have been explained to me.

vi. Confidentiality

I have been assured that all information furnished to the doctor by me regarding my medical condition will be kept confidential at all times and all circumstances except legal matters.

vii. Requires for more information

It has been clear to me that i am free at all time under any circumstances to touch based with doctor by directly approaching or otherwise to satisfy any query, doubt regarding any aspect of research concerns.

viii. Refusal or withdrawal of participation

It has been made clear to me that participation in this medical research is solely the matter of my will and also right to withdraw from participation in due course research at any time.

2 CONSENT OF PATIENT

I undersigned, have been explained by Dr ASHOK NAYAK in the language understood by me. The purpose of research, the details of procedure that will be implemented on me,the possible risks and discomforts of surgery and anesthesia have been understood by me. I have also been explained that participation in this medical research is solely the matter of my will and also that i have the right to withdraw from this participation at any time in due course of medical research.

Signature of participant/patient: Date: Time:

Signature of witness: Date: Time:

MASTER CHART

Sl. No.	Name	I.P No./opd no	Age(yrs)	Sex	Fracture Type/Sid	Displacement	Carrying angle	InjurySurgery	Stay in hosnital	Complications	Results
1	Sachin	23836	12	M	L	PM	6	3	4	SPTI	GOOD
2	Swetha	27150	7	F	R	PL	0	1	4	-	EXCELLENT
3	Ningannagowda	27149	9	M	L	PM	10	3	3	-	GOOD
4	Vinod	4559	11	M	R	PL	4	3	4	SPTI	EXCELLENT
5	Lakshmi patil	4684	10	F	L	PM	5	1	3	-	EXCELLENT
6	Akshatha	250259	13	F	R	PM	5	3	3	-	EXCELLENT
7	Mohammad	27858	14	M	L	PL	13	3	4	CV	FAIR
8	Shivanandbiradar	32980	9	M	R	PM	5	3	3	-	EXCELLENT
9	Ramesh biradar	39490	10	M	L	PM	6	3	3	SPTI	GOOD
10	Mohammed mustaf	4256	14	M	L	PM	0	1	3	-	EXCELLENT
11	Akashjadav	50373	6	M	L	PM	3	2	4	-	EXCELLENT
12	Channappa	77825	10	M	R	PL	13	3	3	CV	FAIR
13	Ravatappapatil	90969	8	M	L	PM	4	1	3	-	EXCELLENT
14	Shankar patil	6251	4	M	R	PL	3	3	4	-	EXCELLENT
15	Tejaswini	8530	9	F	L	PM	0	3	3	-	EXCELLENT
16	Kalmesh	22253	12	M	L	PM	7	3	3	SPTI	GOOD
17	Amitash	23132	7	M	L	PM	4	3	3	-	EXCELLENT
18	Siddappa	26760	13	M	L	PL	3	3	4	-	EXCELLENT
19	Anirudh	26931	12	M	L	PM	5	1	3	-	EXCELLENT
20	Chandrashekarmulgad	58679	15	M	R	PM	8	2	3	-	GOOD
21	Ningamma Kohler	63234	5	M	L	PL	0	3	3	-	EXCELLENT
22	Jayashreemuled	72869	10	F	L	PM	19	2	4	CV	POOR
23	Prajwalmankeri	166383	6	M	R	PM	3	1	3	-	EXCELLENT
24	Mahadev	109114	8	M	L	PM	4	3	3	-	EXCELLENT
25	Shivanipatil	8987	8	F	L	PM	4	3	3	-	EXCELLENT
26	Ashok patil	129778	5	M	L	PL	5	3	3	-	EXCELLENT
27	Randugowda	151179	5	M	R	PM	14	3	3	-	FAIR
28	Akashrathod	12344	7	M	R	PM	3	2	4	-	EXCELLENT
29	Deepthi	119074	10	F	L	PM	7	3	3	-	GOOD
30	Anil	137554	10	M	L	PM	3	3	3	-	EXCELLENT
31	Kiran	14654	10	M	L	PM	4	3	3	-	EXCELLENT
32	Ramu	549	6	M	L	PM	2	1	4	-	EXCELLENT
33	Swetha	876	6	F	R	PL	3	2	3	-	EXCELLENT
34	Sangappa	25071	4	M	L	PM	0	3	3	-	EXCELLENT
35	Deepak	4576	9	M	L	PM	4	3	4	INI	EXCELLENT
36	Prabhu	79630	14	M	R	PM	0	3	3	-	EXCELLENT
37	Deepthi	86160	10	F	L	PM	5	1	3	-	EXCELLENT
38	Praveen	112263	12	M	L	PL	0	2	3	-	EXCELLENT
39	Hariprakash	104080	12	M	R	PL	7	2	4	-	GOOD
40	Prakashbiradar	10402	7	M	C/L	PM	3	3	3	-	EXCELLENT

41	Sudarshan	21181	4	M	C/L	PM	12	2	3	-	FAIR
42	Ambreshnaik	25364	8	M	C/L	PL	0	3	3	-	EXCELLENT
43	Kauvejapatel	70149	11	F	C/R	PM	7	2	3	-	GOOD
44	Javalasamulat	87612	11	F	C/L	PM	3	3	4	-	EXCELLENT
45	Chachavva	15097	7	F	C/R	PM	0	3	3	-	EXCELLENT
46	Ravanappa	18757	7	M	C/L	PL	8	1	3	INI	GOOD
47	Lakxmibai	25043	8	F	C/R	PM	4	3	4	-	EXCELLENT
48	Raju	27307	6	M	C/L	PM	15	2	4	-	FAIR
49	Sujatha	220	6	F	C/L	PM	10	3	3	-	GOOD
50	Sailajabiradar	2940	8	F	C/L	PL	4	2	4	-	EXCELLENT

Key to master chart :- PL – posterolateral, PM – posteromedial, R – right side, L – left side,

SPTI – superficial pin track infection, CV – cubitusvarus, INI – iatrogenic nerve injury.