REVIEW OF LITERATURE
REVIEW OF LITERATURE

Epidemiology: Supracondylar fracture is the commonest elbow injury in children accounting for 80% of total paediatric fractures; 99% of these (variously quoted as 97.7%\textsuperscript{13} and 99%)\textsuperscript{6} are of the extension type, i.e., posteriorly displaced and the rest are flexion type or anteriorly displaced; about 1% of the total fractures are compound injuries.\textsuperscript{38}

Incidence with regards to age, sex, side and seasonal variations:

Supracondylar fractures occur between the 3rd to 12th year of life.\textsuperscript{38}

Some quote a clustering of cases in the 7.5 year’s age group.\textsuperscript{38}

Bongkers K.J. (1994) stated that there was a bimodal age of presentation of supracondylar fractures,\textsuperscript{8} one peaking in childhood and the other in advanced age in the elderly; in the latter group he claimed that the treatment is even more difficult as conservative treatment leads to stiffness and restricted functions while the usual operative methods are difficult to perform.

It is commoner in boys than in girls in all age group except the very young where the difference is not significant.\textsuperscript{38}

Left elbow is involved in 63% of cases and the peak incidence is in summer.\textsuperscript{38}
**Mechanism of Injury** :- Extension type of supracondylar fractures is produced by a fall on the outstretched hand with the elbow a little flexed and the fore arm pronated.

Wilkins (1991) described three predisposing factors:

(i) **Bony architecture of the lower end of humerus in the susceptible age group**:

The supracondylar area in children consists of lateral and medial columns of bone joined by an osseous membrane which forms the coronoid fossa anteriorly and olecranon fossa posteriorly; thus there is an inherent weakness in this area.

(ii) **Ligamentous laxity which allows hyper extension of the elbow**:

In 1978, Harris I and William J.F. concluded from their clinical and biomechanical study that though forced hyper extension of the elbow was the common mechanism of injury; children who had supracondylar fracture also presented with excessive hyperextensibility of the elbow (by comparing the range of extension of unaffected elbow with elbow of unaffected children) the association was stronger than could be explained by coincidence. This predisposed them to this injury.\(^{23}\)

(iii) **Relationship of joint structures in hyperextension due to fall on the outstretched arm**:

As the elbow is forced into hyperextension the olecranon impinges in its fossa serving as the fulcrum for these fractures; the collateral ligaments and the anterior joint capsule also resist hyperextension transmitting the stress to the distal humerus and initiating the fracture.\(^1\)
Abraham et al (1982) experimentally demonstrated that if force is exerted on the hyperextended elbow it is transmitted to the anterior aspect of elbow through the olecranon fossa, where the bone has been further weakened due to metaphyseal remodelling.¹

In extension type of supracondylar fracture, the fracture line is either transverse or oblique from front upwards and backwards with anterior angulation and posterior displacement.⁴⁵ The commoner 75% of displaced fractures are displaced medially with lateral angulation and medial rotation, the less commoner 25% show lateral displacement with medial angulation and lateral rotation.³⁸

Abraham et al (1982) described that a ‘hem of periosteum’ ie the anterior periosteum of the humerus is stretched over the distal end of the proximal fragment where as the posterior periosteum remains intact. A similar periosteal hinge has been described on the medial side also.¹ Supracondylar fractures show displacements of all grades. Holmberg (1945) described the grading which is widely accepted.²⁵

**Type I** fracture with no displacement, ie either there is a green stick fracture or complete fracture with displacement which has spontaneously reduced by itself.

**Type II** posterior displacement along with medial displacement with or without angulation

**Type III** along with posterior and medial displacement fragment is rotated yet
it is in contact with the upper fragment.

_Type IV_ total loss of contact between the fragments with considerable displacement.

Gartland has classified fractures as:²²

_Type I - un/minimally displaced_

_Type II - displaced with posterior cortex intact._

_Type III - completely displaced with no cortical contact._

The modified Gartland system of classification classifies¹⁵

_Type I fractures further into_

_IA un displaced or minimally displaced._

_IB minimally displaced, medial impaction._

**Acute Complications of Supracondylar Fractures:**

Associated acute injuries of the supracondylar fracture include, damage to the surrounding soft tissue structures as well as other ipsilateral upper extremity fractures. The soft tissues injured lead to the acute complications viz:

(i) Nerve injury either isolated or associated with

(ii) Vascular injuries

(i) Nerve Injury - Recent reports suggest that the incidence of neurological deficits following supracondylar fractures of the humerus has been
 underestimated in past reports.\textsuperscript{48}

The reason for the discrepancy is that the most commonly involved nerve in the anterior interosseous branch of the median nerve and as the deficit is only motor it is frequently over looked.\textsuperscript{48} The incidence of neurological deficit has been variously reported between 5 -17\%.\textsuperscript{16}

Dorman J.P. et al\textsuperscript{20} in their review of 200 type III extension supracondylar fractures of the humerus found an incidence of 9.5\% (19 patients.) while Brown IC and Zinar DM report its incidence in fourteen of their one hundred and sixty two patients with supracondylar fractures.\textsuperscript{11}

However in a retrospective review of 101 patients with this fracture Cramer KE et al identified 15 patients with neural lesions. All the fractures were displaced extension type.

Yet another study of 101 patients with this fracture found 18 acute neural lesions in thirteen of the children with some having combinations of nerve injuries.\textsuperscript{40}

Probably the highest figures quoted are by Campbell C.C. et al who found the incidence as high as 52\% (29 of the 59 consecutive type III Supracondylar fractures of humerus in children).\textsuperscript{12}

The most common nerve involved is the median nerve specially its anterior interosseous branch; the next most frequent is the radial nerve injury, followed by
ulnar nerve injury.

The incidence of median nerve involvement is approximately 50% in cases with nerve deficit though various studies quote an incidence of 52% \(^7\), 25%\(^4\) and 3.0%\(^6\) of the nerve deficit.\(^{48,11,39}\)

David, P Devito\(^{17}\) studied the incidence of isolated anterior interosseous nerve injury in supracondylar fractures of humerus in children and out of 15 patients with neurological lesions found anterior interosseous to be involved in six as an isolated injury and in four, in combination with another nerve injury, thus producing a sensory deficit in the latter cases. Two had a complete median nerve palsy. Only three of the fifteen patients had a neurological lesion that did not involve the anterior interosseous nerve; thus they concluded that though the over all incidence of neurological deficits (15%) was similar to other studies the incidence of anterior interosseous nerve lesion particularly an and isolated lesion was much higher and probably the reason for the overlooking of neurological injuries in supracondylar fractures of humerus in children (as it was only a motor deficit).

Dormans P et al\(^{20}\) found 7 cases of isolated anterior interosseous nerve injury out of the total of 19 cases with nerve deficit in their study, in two cases the diagnosis was made in a delayed fashion.
Photograph 1 (above): The patient (not part of the series) presented one month after injury. The fracture, a type III (Holmberg) posterior has united. The medial spike of the proximal fragment abuts anteriorly.

Photograph 2 (left): Same patient. Note the pointing index and trophic ulcer present on the tip of index finger.
The most common mechanism of injury of the median nerve and its anterior interosseous branch is by the lateral spike of the proximal fragment in a posterolaterally displaced supracondylar fractures of humerus in children\(^{48}\). In a study by Campbell C.C. et al\(^{12}\) it was associated in this way in 87\% of the cases.

In cases of median n.palsy one should be cautious to look for signs of vascular insufficiency with impending VIC as it may be masked by the neurological deficit.\(^{48}\)

The frequency of radial nerve palsy in cases of supracondylar fractures of humerus in children presenting with neurological deficit has been quoted variously as 25\% \(^{48}\), 28\% \(^{12}\) and 33\% \(^{11}\).  

Cambell C.C.\(^{12}\) et al found all cases of traumatic radial nerve palsy in supracondylar fractures of humerus in children to be associated with posterolateral displacement of a type III/IV supracondylar fractures of humerus in children. The nerve may be injured by an anterior spike of proximal fragment. usually the injury is associated with completely displaced (posterolateral) supracondylar fractures of humerus in children but according to a case report by Sairyo K et al a child with complete severence of the radial nerve was found to have a minimally displaced supracondylar fractures of humerus as seen on radiographs \(^{41}\).

Most nerve palsies resulting from supracondylar fractures of humerus in children
are neuropraxias and therefore will resolve spontaneously, within approximately 16 weeks. However, a median nerve palsy associated with vascular insufficiency suggests that these neurovascular structures are entrapped in the fracture site; motor function should recover by 12 weeks and sensory changes by 24 weeks.

In their study of 200 patients, Dormans J.P et al found a return of function in all patients 6 to 16 weeks post injury without any surgical intervention. Brown I.C. and Zinar D.N. found similar recovery periods in their study. However, in the study by Cramer K.E. et al, 66% of pts with neurological injuries required open reduction for definitive treatment.

Most studies indicate watchful expectancy for as long as 16-20 weeks following injury and only then should exploration be performed. Jones E.T., Louis D.S. suggest special exercises as well as supportive care to be started as soon as the fracture is healed.

In their case report of isolated radial n. injury, Sairyo K et al found complete return of nerve function five weeks after suture of the severed ends, even though the time elapsed since injury was twelve weeks complete function returned.

Culp Randal W. et al found spontaneous recovery of nerve function in nine
of the eighteen neural lesions at ten weeks, the remaining under went neurolysis after 7.5 months of watchful expectancy and all cases had functional recovery after an average follow up of 25 months by return of motion, grip strength and sensibility testing, thus they claim that neurolysis can be a rewarding procedure for neural lesions associated with supracondylar fractures of humerus in children that do not recover spontaneously.

The prognosis of nerve injuries associated with supracondylar fractures of humerus in children is thus excellent the motor function should in most cases recover by three weeks and sensory recovery should occur by 24 weeks.\textsuperscript{48} an isolated motor loss without sensory loss may have a better prognosis.\textsuperscript{48}

Ulnar nerve injury unlike the median and radial nerve are often iatrogenic (though they may be traumatic) either due to entrapment at the site behind the medial epicondyle following closed reduction or by the pin itself in percutaneous pinning. Various measures have been advocated for its prevention viz. only lateral fixation if swelling is gross and bony landmarks can not be palpated, localization of the nerve by stimulation with a needle and then anteriorly placing the pins thus avoiding the nerve.

In Ikrams\textsuperscript{26} series 4 patients. who developed iatrogenic ulnar nerve palsy
following percutaneous pin fixation by K wire in one patient the recovery was complete and immediate when the wire was removed within 48 hrs. of detection. In the other three an exploration had to be undertaken at 6 weeks after removal of K wires when the nerve was found to be trapped behind to medial epicondyle; release and subsequent transposition resulted in recovery.

(ii) Vascular injuries:

Vascular compromise occurs in about 5% of children with supracondylar fractures of humerus in children, however acute compartment syndrome with its sequelae of V I C occurs in less than 1%. Fractures with posterolateral displacement of distal fragment are more susceptible to vascular injuries since the medial spike of the proximal humerus can tether the brachial artery.48

On exploration of the antecubital fossa of 7 patients with SCFH with vascular insufficiency Schoeneker P.L. et al found that in 3 patients the artery was directly damaged or transected while in the other 4 it was kinked or trapped at the fracture site.42

In the event of a pulseless extremity, prompt reduction of the fracture usually restores palpable arterial flow. In cases where circulation is restored but somewhat diminished when compared to the other side watchful expectancy may be indicated. Complete vascular insufficiency is uncommon because the thick muscle envelope protects the artery. In their exploration of antecubital fossa in 4
cases for non restoration of pulse following reduction Kasser et al found an intimal tear in three and an arterial entrapment in one.\textsuperscript{27}

Vascular evaluation requires differentiation of a pulseless but viable extremity from one with true vascular insufficiency; the collateral circulation is vast and often provides enough distal perfusion despite brachial artery disruption. In a study of 410 with supracondylar fractures of humerus in children Sabharwal et al found a 3.2\% incidence (13 cases) of absent radial pulse.\textsuperscript{40} Continuous pulse oximetry has been considered a useful adjunctive for objective follow up of the patients by nurses.\textsuperscript{48} Brachial artery disruption can be reliably determined by obtaining differential Doppler pulse pressures in the hand. Other techniques for detecting patency of the brachial are segmental pressure monitoring, color flow duplex scanning and MRA, which are all non invasive and safe.\textsuperscript{40}

For persistent true vascular insufficiency (e.g. an avascular hand) specially if there is associated nerve palsy or inadequate reduction an open anterior reduction is recommended. In such cases the neurovascular structures are often found kinked at the fracture site and liberation restores the pulse. The fasciotomy decreases the incidence of compartment syndrome induced V I C. One should more cautiously search for compartment syndrome in cases with median nerve palsy which may mask the pain of impending acute compartment syndrome.\textsuperscript{48} An arteriogram is
not necessary for confirmation of non-functioning of brachial artery and only helps in delaying the immediate treatment, morbidity of surgical exposure is low and procrastination only increases morbidity.\textsuperscript{34}

The decision to perform vascular reconstruction if the vessel does not respond to local measures (e.g. adventitia stripping local lidocaine papaverine is less clear though repair of the damaged brachial artery with saphenous vein has been performed with good results in some studies.\textsuperscript{42}

Reconstruction is unnecessary if the distal extremity is well perfused in which case the grafted vessel may not even remain patent.\textsuperscript{40}

In their study of thirteen (3.2\%) patients (of the four hundred and ten with supracondylar fractures of humerus in children) presenting with an absent radial pulse Sabharwal et al found segmental pressure monitoring, colorflow duplex scanning and magnetic resonance imaging valid, non-invasive and safe techniques in evaluating the patency of the brachial artery and collateral circulation across the elbow. They found that the early revascularization of a pulseless but otherwise viable hand in children with type III supracondylar fractures of humerus in children though feasible and safe has a high rate of asymptomatic reocclusion and residual stenosis of the brachial artery. Therefore a period of close observation with frequent neurovascular checks should be done before more invasive correction of this problem is contemplated.\textsuperscript{40}
Photograph 4 (Left) : Case No. 9 presented with compound supracondylar fracture (Rt). The brachial artery was found to be divided at the time of operation and both ends had to be ligated. Note also the floating elbow.

Photograph 5 (below) : Same patient. After two attempts at closed reduction operative intervention had to be adopted. Note persistent rotation (fish tail sign) despite reduction under vision and internal fixation.
There is no clear evidence of a clinical problem with cold intolerance or exercise-induced muscle fatigue for the hand surviving on collateral vascularity but long term studies addressing this problem are lacking.\textsuperscript{50}

**The floating elbow:**

Ipsilateral supracondylar fractures of humerus and fore arm bones in children has been described in literature often referred to as the floating elbow.\textsuperscript{46}

In a large study conducted over a period of eight years comprising thirty four patients with the floating elbow Biyani A et al found that nineteen patients had a fracture of distal quarter of the fore arm bones while eight had a distal radial epiphyseal injury. Five of the patients had an undisplaced supracondylar fractures of humerus in children. All fore arm fractures were treated by closed reduction. Nine of the displaced supracondylar fractures of humerus in children could not be reduced by closed manipulation and were treated by olecranon pin traction in two cases and by percutaneous pinning in seven cases. Excellent or good results were found in twenty nine children after an average follow up of 3.8 years.\textsuperscript{7}

According to Williamson DM and Cole WG\textsuperscript{49} displaced supracondylar fractures of humerus in children with fractures of distal fore arm bones are best treated closed reduction and percutaneous pin fixation of the humeral fracture and a below elbow plaster blackslab for immobilization of the fore arm fractures. In their study 10 of the 11 patients had excellent results following this treatment policy while
Photograph 3 (above): Results of a mal-united supracondylar fracture (Rt). The patient (not part of the series) suffered injury 8 years back when a POP slab was applied in supination after reduction. No post-reduction x-rays were taken. The patient now present with the typical deformity. Movements however were preserved.

<table>
<thead>
<tr>
<th></th>
<th>Rt.</th>
<th>Lt.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extension</td>
<td>184°</td>
<td>186°</td>
</tr>
<tr>
<td>Flexion</td>
<td>132°</td>
<td>134°</td>
</tr>
<tr>
<td>Carrying angle</td>
<td>-15°</td>
<td>6°</td>
</tr>
</tbody>
</table>
the result in one case was poor because of development of VIC.

The late complication of Supracondylar fracture of the humerus:

These have been enumerated as

→ Malunion leading to deformities of

→ Limitation of movements

→ Pain

→ Persistence of acute complications

Malunion leads to

(a) Angulation

Varus

Valgus

Anterior

Posterior

(b) Rotation - usually medial and the

(c) Classic gunstock deformity (ie a combination of medial rotation and varus)

The Deformities (The pronated fore arm at the time of injury causing displacement):

The displacement of the distal fragment may be minimal but more commonly there is substantial complex displacement.\(^6\) This consists of the following elements

(I) Backward shift of the distal fragment.

(II) Backward angulation of the distal fragment
(III) Pronation of the distal fragment (because the hand is usually pronated at the time of injury). Pronation produces internal rotation of the distal fragment (the two movements are really the same). As a consequence the medial cortex of the distal fragment shifts posteriorly relative to the medial cortex of the shaft of the humerus whilst on the lateral side of the fracture the fragments often remain "hitched" to each other. The pull of the arm muscles then draws the medial side of the distal fragment proximally, posterior to the shaft of the humerus whilst leaving the lateral side roughly in its original anatomical position, the effect of this displacement is to adduct the distal fragment relative to shaft of the humerus, thus pronation results in internal rotation and adduction of the distal fragment. ⁶

Various Components of the Deformity:

The varus / valgus deformity: change in the carrying angle, is the most common complication which one has to deal with in the treatment of supracondylar fracture of the humerus. It is not only the most common but until recently the most neglected complication. ¹² Various studies have been published in which the incidence of carrying angle change after supracondylar fracture of the humerus has been as high 57% and the average in most groups has been approximately 30%. ⁴⁵

By definition 1° of carrying angle change at the elbow may be treated as a deformity. Obviously changes which are so minor as to be apparent only to
examination by an experienced surgeon are not of critical importance. Only a change which is of sufficient degree to be noted by the associates of the patient is excessive and should be avoided.

The carrying angle formed by the long axis of the humerus and ulna is subject to considerable individual variation as was emphasized by Aebi in a detailed study of its rotation to age and sex. His measurements of 100 subjects showed values considerably less than those usually quoted. The values in men averaged 6.5° with a range from 0° - 14°; in women the average was 13° with a range from 4° - 20°. The difference in the carrying angles in the two sexes did not appear until puberty.

In a study of 150 normal children comprising eighty girls and seventy boys, aged three to eleven years (the age when S/C are most common) Lyman Smith found the average carrying angle to be 6.1° in the girls with a range of 0° - 12° and 5.4° in boys, with range of 0° - 11°. These angles were determined by measuring the angle formed by lines joining the midpoint of the wrist and the midpoint of the humeral head as located by palpation, with the midpoint of the anticubital fossa with the elbow fully extended and the forearm in supination. It is of particular interest that 9% of these children had a cubitus rectus or no carrying angle and 48% had a carrying angle of 5° or less. If a child with such a slight carrying angle sustains supracondylar fracture and the fragments heal with disalignment of only a few degrees an obvious varus may be the result. A similar loss in a child
who started with 10° of valgus would not be noticeable; the final appearance depends on the starting point.

Growth Disturbance as a cause of changes in carrying angles:

Growth disturbance is frequently blamed as a cause of change in the carrying angle. Brewster and Karp examined eighty cases of cubitus varus deformity and found that clinical measurement of the length of the outside of the arm exceeded those of the inside by one quarter to three quarters of an inch in six. They concluded that this had been caused by stimulation of the external epicondylar and capitellar epiphysis. This explanation appears most unlikely as it has been demonstrated in the study by Smith that simple medial tilt of the distal fragment gives the same appearance. Furthermore it is difficult to explain the deformity on the basis of a pure growth disturbance in view of the overwhelming predominance (ten or more to one) of varus deformities; why should growth of the medial half of the distal epiphysis of the humerus be arrested so much more frequently than that of the lateral half, when the fracture is commonly equidistant from both or conversely why should the fracture stimulate growth of the capitellum so much more frequently than that of the trochlea? Although the roentgenograms of a healed fracture with cubitus varus, commonly show irregular ossification of the trochlea, these changes may well be the result of disalignment and disturbed joint mechanics rather than growth disturbance. Only if the deformity increases with growth can it be attributed
with certainty to growth disturbance.

In an analysis of 292 fractures, Siris found the cartilage plate to be involved in only 21 and of these only 12 showed a growth disturbance, the conclusion seems warranted that growth disturbance is a rare complication and seldom is the cause of a change in the carrying angle.\textsuperscript{13,44}

**Various Displacements of the Fragments and their effect on the Carrying Angle**

To determine the effect on the carrying angle caused by various type of displacements of the distal fragment, an experiment was carried out using an articulated right upper extremity.\textsuperscript{45} A trasverse supracondylar fracture was simulated by an osteotomy through the supracondylar region, the fragments being held together by a steel springs. The distal fragment was displaced in various ways and the influence of each position on the carrying angle was determined. It is apparent that only medial or lateral tilt of the distal fragment changes the carrying angle. However other displacement may lead to or contribute to tilting under certain circumstances.

(i) With an oblique fracture and smooth surfaces under compression as would occur with normal muscle and the elasticity of surrounding soft tissues any rotation about the longitudinal axis of the humerus will inevitably produce tilting; rotation of this type can readily occur in a long arm cast with the elbow in any degree of flexion. The greater the degree obliquity of the
fracture, the more will be tilt produced by a given amount of rotation.

In transverse Supracondylar fractures the so called transcondylar (diacondylar) fractures the fracture surfaces are very narrow in the anteroposterior direction, In these fractures the bearing surfaces are small and minimum amount of rotations combined with compression forces inevitably cause tilting.

If there is medial or lateral displacement in the presence of compression forces the fracture will be unstable and tilting of the distal fragment will occur, the amount being directly proportional to the amount of displacement. However if there was no end to end contact, the tendency for tilting would be low.

From the experiment it was clear that medial or lateral displacement of distal fragment and rotation of the distal fragment do not in themselves causes carrying angle changes.

Various modalities of treatment for displaced supracondylar fractures as well as variours works on them find their source to this troublesome varus deformity.

Closed reduction and immobilization by collar and cuff in acute flexion has got a long history with its strong supporters mainly in the veterans such as Sir Astely Cooper (1826), Sir Robert Jones (1921), Watson Jones (1952 - 55)and Charnely (1961) and it is widely accepted as an ideal treatment of supracondylar fractures whether fresh or old.16,30,47,15
Watson Jones (1952 - 55) advised immobilization in 110° - 120° of flexion by collar and cuff for 3 weeks under the shirt and 3 weeks over the shirt he claimed excellent results with this mode of treatment.47

Later plaster of paris was used for immobilization of the limb which was kept supine and in acute hyperflexion.

The closed reduction with immobilization was criticized on the grounds that it led to severe varus deformity. Lyman Smith deprecated the method stating that "when Waston Jones stated " The prognosis of supracondylar fractures is excellent he must have been speaking of restoration of function not of form.45

In search for a solution to the avoidance of cubits varus / valgus deformity the roll of traction in the treatment of supracondylar fractures was first described by Dunlop in 1939. He gave a straight lateral traction initially and to his surprise the fragments were in perfect apposition, however A.P. angulation remained a problem. Later he started giving a vertical counter traction on the distal arm with traction in a semiflexed elbow.21

Dunlop's method was found inconvenient for it needed a watch on the carrying angle and the need to take check x-rays which were fallible, though Allen and Gramse (1945), Dodge (1972), Jefferis (1977) and Alberger (1992) found it to be a useful method. Watson Jones (1952-55) suggested that traction be given for 3-
5 days for the swelling to subside and this be followed by reduction under G.A. with immobilization in full flexion. James Piggot et al (1986) reported comparatively better results if three weeks of traction was immediately followed by active exercises under supervision. 38

Traction has been divided into two groups:

(i) Skin Traction:
   (a) In flexion - Dunlop (1939) 21
   (b) In extension - E.L. Sharkawi and Fatten (1965) 43 who used POP cast with traction, Bosanquet and Middleton (1983) 9 who used the Thomas splint for the purpose and Jefferis (1976) 28 who used the straight lateral traction.

(ii) Skeletal Traction:

   Used only with the elbow flexed was first developed by Smith 45 where a K wire was passed through the olecranon. He used the three bony prominences behind the flexed elbow to guide in the reduction and described it as the visual method of observing for deformity without using the x-rays which he felt were not dependable and were inconvenient.

In the year 1978 Palmer et al 37 at Birmingham in order to overcome the problem of late varus deformity developed an overhead skeletal traction by means of winged traction screws and felt that the different holes provided a range of directions for applying traction and thus a better control over the deforming forces.
Later in 1984 Worlock and Colton used threaded pin which they claimed unlike Smith's wire stayed put in its position and thus did not change direction of soruce and reduced pintract infection.\textsuperscript{51}

Though none of these tractions claimed and accurate reduction the alignment, length and carrying angle was well controlled undervision and by AP x-rays. During the period of skin traction treatment deformity could be corrected from time to time. In sketal atl traction in flexed position one did not get these advantages and the disadvantages of pintract infection and damage to ulnar nerve were added.

The traction method was criticized on the grounds that it prolonged the duration of stay at hospital and that it was impossible to keep the infant still in bed even for a day leave alone weeks, though Lymán Smith claimed that use of chest restraints was an aqquate means of harnessing the child.\textsuperscript{45}

Open reduction and internal fixation was advised by various workers as a means of preventing the deformity by getting accurate reduction and maintaining it by internal fixation. However Watson Jones (1952 - 55) not only discouraged but condemned the procedure on the grounds that

(i) It is a difficult procedure.

(ii) It does not provide any added advantage but there are disadvantages like

(a) Pintract infection
(b) Myositis ossificans

(c) Stiffness of the joint due to capsular fibrosis

Canale (1987) proposed that the incidence of myositis ossificans can be reduced by operating within 5 days of injury.\textsuperscript{14}

Developed by a Polish surgeon Sokolowski in 1937 closed reduction with percutaneous pinning to fix the fractures site is the most commonly used methods in the more sophisticated centres. Many reports claim much lower incidences of deformity by this method. Proponents of this technique claim that closed reduction and casting without fixation have the highest incidence of residual deformity usually cubitus varus. It is also claimed that no cases of forearm compartment syndrome (i.e. ischemic) contrature have been identified in the cases treated with early pinning compared with casting which they claim is probably because the elbow does not have to be positioned above 90\degree of flexion to hold the reduction if the fracture has been pinned. The method is also considered advantageous to traction as it reduces the duration of hospitalization. Later displacement of the reduced fragment as occurs in the casting method does not occur thus the carrying angle is maintained.

The disadvantages of the method quoted by the adversaries to this modality are that

(i) The method is demanding in technique and armamentarium because it is best done under bi planar image intensifier.
(ii) Pintract infection

(iii) Nerve injury specially to the ulnar nerve by the medial pin

(iv) The technique relies heavily on the roegenograms which however is not infallible

The Fallibility of the Roegenograms:

In a study of 100 supracondylar fractures of the humerus radiographs were used in an attempt to forecast the result in each case in terms of the final carrying angle. unexpectedly it was found that the forecasts were wrong in well over 50% of the cases. A review of the literature showed similar inconsistencies. The apparent alignment of the fragments shown in the AP radiographs frequently was not consistent with the final carrying angle results recorded for the cases reported.34

The reasons for these discrepancies were contributed to:

(i) Superimposition of the radius and ulna in the AP view which can only be avoided by extending the elbow and losing the reduction.

(ii) Poor visualization of the small distal fragment which is largely cartilagenous int the younger age goups and

(iii) The influence of the position of the arm when the roegenograms are made on the amount of the angle visualized.

Klienfelter stated that 'angles are projected in correct size only if their axes are parallel to the plain of the film and perpendicular to the central roentgen ray.'32
Thus, if there is any error in the exact positioning of the extremity and the exact placement of the x-ray tube and the cassette any projected angulation will be inaccurate.

Yet this task is relegated to the x-ray technician who is faced with the heroic problem of the exact positioning of swollen elbow in the correct position. If the technician misses the positioning by a few degrees one way or the other, this can not be determined is the roentgenograms and the result will change. Only if the roentgenograms show perfect apposition of the fracture surfaces in all views is there certainty of restoration of the carrying angle.

As has been curtly stated in Campbell (8th ed) the three most common reasons for residual varus or valgus deformity are:¹³

(i) Inability to interpret poor roentgenograms and thus acceptance of less than adequate reduction.

(ii) The inability to interpret good roentgenograms because of a lack of knowledge of the pathophysiology of this fracture and

(iii) The loss of reduction.

Revival of the Pop Cast:

In the past the hyper flexed elbow was placed in an above elbow POP cast in supination, and it led to a high frequency of angulation.
The prone position of the fore arm has recently been gaining popularity in the relatively recent past.

Arnold JA, Nasca RJ and Nelson CL(1977) in their retrospective survey of eighty two children with Supracondylar fractures of the humerus found forty to have sufficient clinical and roentgenographic data to classify the fractures as varus or valgus and to determine the carrying angles at end results. The initial displacement (varus or valgus) of the distal fragment correlated with the final carrying angle, but the use of internal fixation, the adequacy of reduction achieved and the duration of traction or immobilization did not. The sixteen varus supracondylar fractures immobilized with the fore arm in supination had a mean varus deformity of about 16° where as the eight immobilized in pronation had a varus deformity of only 3°. The findings in the few valgus fractures suggested that the valgus angulation was less follow up if they had been immobilized in supination. Dissection of eight cadaver limbs and electromyographic studies of one normal limb suggested that the position of the fore arm affects the results by altering muscle tension.

This finding is further supported by the views and experiments of Khare et al in their report based on cadaveric experiments, peroperative observation and clinical study an exact mechanism was described by which full pronation of the forearm prevented cubitus varus deformity in supracondylar fractures of humerus. They
signified the position of the upper limbs in relation to the chest and demonstrated that even the posterolaterally displaced fractures are better are reduced and maintained in pronation.

According to D’Ambrosia RD(1972)\textsuperscript{18} the pronation of the fore arm tightened up the lateral and capsule and prevented varus tilt, however as most supracondylar fracture occur proximal to the capsular and ligamentous attachment this explanation is unlikely and displacement is probably controlled by releasing the tension of the flexion pronator muscle group as described by Arnold JA and supported by Khare GN.

OTHER DEFORMITIES:-

The rotational deformation (Most commonly medial rotation) though also not corrected by growth does not cause so much cosmetic abnormality. The external rotation of the shoulder compensates adequately for the rotation, though a higher incidence of osteoarthritis of the shoulder as a result there from claimed by some workers. The facts that one does a wedge osteotomy for significant persistent deformity and never a derotation osteotomy amply proves the point.

Extension of the elbow joint is limited by the olecranon process locking in the olecranon fossa of the humerus if the supracondylar fractures unite with the lower
Results following supracondylar fracture

Results following supracondylar fracture may be graded according to the criteria of Mitchell and Adams:

<table>
<thead>
<tr>
<th>Grade</th>
<th>Degrees change from pre-injury</th>
<th>Carrying Angle</th>
<th>Range of Motion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excellent</td>
<td>less than 5</td>
<td></td>
<td>less than 10</td>
</tr>
<tr>
<td>Good</td>
<td>5-15</td>
<td>10-20</td>
<td></td>
</tr>
<tr>
<td>Unacceptable</td>
<td>more than 15</td>
<td></td>
<td>greater than 20</td>
</tr>
</tbody>
</table>

or the criteria of Henrickson:

<table>
<thead>
<tr>
<th>Criterion</th>
<th>Supracondylar fracture outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Excellent</td>
</tr>
<tr>
<td>Change in carrying angle</td>
<td>+ / - 10</td>
</tr>
<tr>
<td>Limited E/F, P/S</td>
<td>0 - 10</td>
</tr>
<tr>
<td>Pain</td>
<td>None</td>
</tr>
<tr>
<td>Symptoms at work</td>
<td>None</td>
</tr>
<tr>
<td>Muscle contracture</td>
<td>None</td>
</tr>
<tr>
<td>Persistent nerve injury</td>
<td>No</td>
</tr>
</tbody>
</table>
fragment of the humerus carrying the olecranon fossa, tilted forwards 30° this locking occurs 30° before the normal limits of extension is reached.

Similarly uncorrected backward tilting of the lower fragment causes permanent limitation of flexion.

Other causes of limitation of movement are:

(i) Myositis ossificans
(ii) Capsular Fibrosis

The pronation supination movements are usually well preserved.

Evaluation of results:— It may be said that the evaluation of results following supracondylar fractures is an evaluation of the residual scars left by the injury in terms of deformity dys / function etc.

In Mitchell and Adam’s criteria the fractures are graded as excellent good or unacceptable only on the basis of degrees of change from pre-injury in the carrying angle and range of motion.

According to Henrickson’s criteria again the results are classified into excellent, good and poor based on:

(i) Change in carrying angle
(ii) Limited E/F,P/S
(iii) Pain
(iv) Symptoms at work
(v) Muscle contracture
(vi) Persistent nerve injury