DISCUSSION
Photograph 24 (above) and 25 (below): Case no. 17. The patient was misdiagnosed as a case of suspected Type I fracture. A true lateral radiograph 5 days later told a different story (see text).
DISCUSSION

Supracondylar fracture of the humerus in children is the most common and a ‘troublesome injury’ of the elbow in children, and if not treated adequately, leaves in the wake of its healing a permanent deformity which may range from a mild unobservable one to a severe varus (usually) or valgus (rare & milder) deformity or even a gunstock deformity, in the untreated cases. However ‘the functional results are excellent’ Watson Jones.

The diagnosis of this injury is easy to make. A child of 3 to 12 years of age presents with a swollen semiflexed elbow (usually) left with the limb in semi prone position supported by the other hand or a sling. A history of trivial trauma classically fall on the outstretched hand is usually elicited. A radiograph of the easily visualises the fracture confirming the diagnosis and classifying the fracture.

But see photograph 24 & 25! The patient (case no. 17), was diagnosed after AP & ‘lateral’ x-rays as a case of probable undisplaced supracondylar fracture left. and was given an above elbow slab and was to be reviewed in the next OPD. Five days later the patient returned without x-rays or old OPD slip and to verify the diagnosis a re x-ray was done the x-ray now a true lateral view (recognized by the hour glass appearance of the distal metaphysis) showed a posteriorly displaced supracondylar fracture of the humerus of grade II. Such is the importance of a true lateral view in the diagnosis and grading of a supracondylar fracture in children. Campbell (8th edition) describes this difficulty of roentgenographic judgement as inability to interpret poor x-rays and thus accept the deformity.

Abraham (1982) claimed that metaphyseal remodelling further weakens the
already week area in the most susceptible 7.5 year age group. Haris (1978) claimed that the predisposiion was due to hyperextensibility at the elbow which stemmed from ligamentous laxity in those succumbing to this injury. Abraham (1982) experimentally demonstated that if force exerted on the hyperextended elbow it is transmitted to the anterior aspect of the elbow through the olecranon fossa. Thus not much force is required to cause this injury and a trivial trauma in the guise of a fall on the out streched hand is sufficient.

Thus Wilkins (1991) concluded that 3 predisposing factors made this region the weakest link in the chain.

(a) Bony architecture of the lower and of humerus in susceptible age group.

(b) Ligamentous laxity which allows hyperextension.

(c) Relationship of joint structures in hyperextension dut to fall on out streched hand.

Usually the elbow can be extended up to 0°. In this study group hyperextensibility was present in 61% of cases with some having as high as -16° to -19° of hyperextensibility.

In this study the peak incidence of injury was in the age groups 6 to 8 years with a clustering of cases from 4th to 8th year of life and yet another rise at 12 year age. Study claim a peak 7.5 years. However the central tendency in this study i.e. the mode was 7 years. Could this be because of earlier maturity of children in the tropics with an earlier age of remodelling.

The lever mechanics described by William probably also explain the reason for the injury occuring after trivial trauma in this study. In this series, 71% of cases (15 out
of 21) suffered minimal trauma, while in 6 cases (29%) a history of falling from height was elicited.

For obscure reasons the left elbow was predominantly involved. Literature quotes an incidence of 63% for left side involvement. In this series of 21 cases, 71% (15 cases) involved the left side while 6 cases (29%) involved the right side.

This left:right dominance tested true when compared individually in male and female patients giving again a ratio of 7:3 which is a little higher than the 63% quoted in other studies. An interesting finding was that though the left side was involved in 73% of cases with trivial trauma, in cases with fall from height the figure dropped to 66%.

In this study the peak incidence of injury was in late spring with another peak in late monsoon, which is in conflict with the usual summer peak quoted in literature. Though the summer heat may be claimed to decrease outdoor activity, this argument can not be sustained as most of the cases succumbed after trivial trauma. One reason for the discrepancy could be the relatively short one year span of study covering only one set of seasons.

For obvious reasons the injury has been described to be more common in boys than in girls in all age groups, except in the very young. In this study 66% of cases were males while 33% were females.

Holmberg (1945) described the grading system which is widely accepted and classifies fractures into 4 types which can be summarized as:

Type I # with displacement

Type II Displacements present but no rotation
Type III  Rotation present but fragments still in contact

Type IV  Completely displaced.

Gartland (1959) included II & III as Gartland type i.e. displaced but still in contact and IV as # Gartland III.

Bailey & Love claim that 50% are undisplaced type I while of the other 50% half are type II & III (Holemberg) and the other half are type IV. (i.e. 25% each)

In this study of displaced fractures 20 patients were type II, 30% type III while 50% were type IV. Thus half the cases had no contact while the other half were having partial contact which is a finding that appears to be a replica of the distribution fractures quoted in literature.

These fractures are usually associated with trivial trauma & thus simple; the incidence of compound supracondylar fracture of the humerus in children is quoted to be as low as 1% of total cases. Here the study results are in conflict as one case had compound fracture which raised the incidence to 4.8%. However this rise can be attributed to the relatively small size of the study population.

Lal & Bhan (1991) have reported the frequent occurrence in India of late presentation of patients to the hospital. They claim that it is not surprising for patients to seek definitive treatment after much attempts at bone setting by local quacks & bone setters, or even take no treatment at all.

In this series the minimum time of presentation was 2 hrs. while the maximum was 15 days. Two patients (case no. 11 & 12) gave a positive history of massage while in case no. 16 the quack had gone to the limit of applying a POP cast which had
in signs of impending V I C. Most cases (52%) presented on the day of injury and the mode i.e. the central tendency was six hours.

Early complications of the supracondylar fractures though not so common are none the less seen and include neurological, vascular complications and other injuries of the ipsilateral limb.

Studies by Biyani et.al (1989) have shown an annual incidence of 4.3 cases per year of population with supracondylar fractures of the humerus of ipsilateral fracture both bones forearm in their distal quarter, the combination described as the "floating elbow". The injuries were either a fracture of the ulna and radius or the radial epiphyseal seperation, at the distal end; the types being present in the ratio of 2:1. In this study there were three cases (no.2,9 &16) of floating elbow and the ratio between fracture and epiphyseal seperation of the distal radius was seen in the same ratio of 2:1 (case no. 2 had epiphyseal seperation while no. 9 & 16 had fracture of radius). The cases in this study showed no relationship with the severity of supracondylar fractures of the humerus, with various grades being seen in the different cases. This is in agreement with observation by Biyani who found these fractures even in undisplaced supracondylar fractures of the humerus. However one common finding in all cases in this series was the mode of injury, all had suffered trauma after fall from height. Thus one should rule out an associated supracondylar fracture of humerus in cases with fracture of both bone forearm and a history of fall from height.

William son & Cole (1992) have advised pinning of the supracondylar fracture and closed reduction and a below elbow slab for such cases, while Biyani has claimed good results with usual conservative means. In this series only one case (no.2)could be
followed in which there was a fracture separation of the radial epiphysis with fracture ulna, and a grade III supracondylar fractures of the humerus. Both the fractures could be reduced and maintained by an above elbow slab in pronation. On follow up the patient had full range of movements and minimal loss of carrying angle. Of the two other patients with similar injuries one absconded from treatment and the other was lost on follow up. The latter also had a compound fracture of the tibia (case no 9).

Another finding was a right side predominance is the incidence of floating elbow (2:1).

The incidence of neurological complications has been variously quoted between 5 to 17% Dormans JP (1995) found an incidence of 9.5% in his series while Crammer (1993) reports it as 15%. Probably the highest figure quoted has been by Campbell C.C.(1995) who in his series of 59 consecutive cases found the incidence as high as 50% (29 cases).

In this study there were 4 cases (no.4,5,16, & 21) with neurological deficits in (i.e. an incidence of nineteen percent). The increase in the incidence of neurological deficits (that is its detection) has been due to the realization that since most commonly the anterior interosseous branch of median nerve is involved it is difficult to detect it unless one looks out for the deficit. In this study there was a ratio of median nerve : anterior interosseous nerve involvement of 1:3. In all the cases the deficits were diagnosed retrospectively. Other neurological deficits that have been found to be associated with supracondylar fractures of the humerus are ulnar and radial nerves. However, neither of the two deficits were seen in any case in the series. Type III fractures dominated the cases with neurovascular injury (case no.16) and were present
in 75% of the cases while in one there was a type I fracture. In Campbells (1995) series 87% of the deficits were associated with the anterolateral spiking of the proximal fragment, the same mechanism was probably responsible in 3 cases while in the fourth, with Type I fracture pressure ischemia could have played a role.

All cases in this study were treated by watchful expectancy and all cases that were followed recovered completely by 3½ to 4 months time. Thus all were cases of neuropraxia. Case no.16 absconded from treatment and could not be followed.

Vascular compromise has been stated to be at 5% and the incidence of acute compartment syndrome is reported to be less than 1% of cases with supracondylar fractures of the humerus. In this series of 21 patients there were 5 cases presenting with an absent radial pulse. In case no.9 the medial spike of the proximal fragment had torn through the skin and the artery was found to be divided; both ends had to be ligated to stop the bleeding. However the rich collateral circulation around the elbows that has been described in literature was found to adequately perfuse the distal limb and the extremity remained viable. Case no.16 presented with signs of impending VIC, but absconded and could not be followed.

Of the other three cases in two (case no.2 & 5) there was an immediate return of the pulse on reduction while in case no. 3 it was palpable by the 3rd day. The fractures were of grade III (no.2,3, & 5) or (IV) (no.9) severity except case no.16 which was of grade I. All cases of vascular deficit with displaced fracture were of the extension type.

Various mechanisms described for vascular complications associated with supracondylar fracture of the humerus are the tethering of the brachial artery by the
medial spike of the proximal humerus, its kinking, getting trapped on reduction, acute compartment syndrome or its being torn (either intimal tear or a complete disruption). In this series probably the first factor played a role in cases 2, 3, & 5 while the last operated in case no 15 presenting with VIC.

Early reduction has been found to be associated with excellent prognosis as far as neurovascular deficit is concerned, unless there is a true vascular insufficiency with a non viable hand. In this series all patients followed underwent prompt reduction & watchful expectancy & those that could be followed (no. 2, 3, & 5) had no residual neurovascular deficit whatsoever.

A complication found this series which is not described in literature was seen with reduction or "over reduction" so to say. In case no. 15 a posterior and extension type had been converted by excessive traction to an anterior type. The initial fracture was of type IV (extension type), with the fracture line running obliquely & posteriorly (in the anterior type the fracture line runs obliquely upwards & forwards). The fracture was re-reduced but failed, continuing to be an "iatrogenic" anterior type. The other case was no. 17 in which a type II posterior fracture had been converted to a type III posterior fracture.

An issue of great significance today is the length of hospital stay that is associated with the treatment modality chosen. Proponent of conservative methods (i.e. closed reduction maintained by either percutaneous pinning or plaster back slab claim a short hospital stay and one reason why the traction method went into disrepute was that it needed 3 weeks of hospital stay.

However in this series the average duration of stay at hospital was 8-3 days.
Results of excessive traction An 'iatrogenic' anterior type.

Photograph 26: Case No. 15. An initially extension type of fracture was converted to a flexion type due to 'over reduction'. Note the oblique fracture line directed upwards and posteriorly. Open reduction was finally sought.
Thus the advantage of short hospitalization period was not seen in this serise of conservative management. But a closer look reveals certain fractors that led to this.

For one, all cases were maintained by POP cast without a check X-ray during reduction being taken and thus 15 out of the 21 cases needed a second attempt on a different date. The average period of hospitalization for a single attempt at reduction was 4 days while for 2 attempts it was 5.8 days. The longest period of hospitalization was 32 days (cases no. 1 & 2) and both had undergone operative intervention.

A second look at fig. 3 shows another interesting finding. Of the eighteen cases with POP initially applied in supination, seven cases when re-applied in prone position now had acceptable results. Thus one may deduce that if they had been initially maintained in pronation 12.6 (7x1.8) bed days could have been saved.

The results following supracondylar fracture have been evaluated according to various criteria set by Flynn Mitchell & Adams & Henrickson.

According to Watson Jones (1952 - 55) the results following supracondylar fracture are excellent and this series shows similar results.

None of the patients in this series had any restriction of pronation or supination movements. Since this movement involves the superior and inferior radio ulnar joints neither of which are affected in this injury this finding is not surprising!

In this study four patients had a loss of less than five degrees of extension while 3 cases had a loss of more than 10°. Persistent posterior angulation was found to correlate with the loss. Similarly the loss of flexion ranged from less than five degrees in 2 cases to >10° in 3 cases. The flexion & extension loss was greatest in cases with open reduction and internal fixation of the fracture.
Probably the most important cause of worry in supracondylar fractures is the residual deformity due to loss of carrying angle. Lyman Smith in his study of 150 normal children (between ages 3 to 11 yrs) found the carrying angle to be about 6.1° in girls and 5.4° in boys, with a range from 0° to 11°. He also found that 10% had cubitus rectus or no carrying angle. In this series 5.6% had a cubitus rectus and the range was from 0° to 11°. Furthermore, in this study the males had 6.3° a carrying angle of 5.25° on an average while the females had an average of 7 degrees.

In this study as far as the carrying angle was concern, in cases in which the forearm was kept in pronation, two cases had a loss of less than 5° while 6 cases had a loss of less than 15°. In cases where the forearm was kept supine after reduction, 3 had a loss of less than 5° while 4 had a loss of less than 15°; in one case it was 17°.

In two cases treated by open reduction one case had a loss of five degrees while the other had a loss of 20 degrees. The loss was paradoxically greatest in the case treated by open reduction and K wire fixation.

As the whole minimal loss was seen in cases treated with the hand in prone position. These findings are in agreement with the study by Arnold J.A. (1977) who found the best results as far as deformity was concerned, in cases with the hand stabilized in the prone position. According to him internal fixation or the accuracy of reduction achieved does not correlate with the final carrying angle.

As in this series none of the patients complained of pain, symptoms at work, and muscle contracture or persistent nerve deficit were not found at final evaluation the patients treated by various methods have been tested against the Mitchell and Adams (1961) criteria which is more strict than the criteria set by Henrickson (1960) but
Loss of Carrying Angle in cases treated by various modalities

According to Mitchell and Adams criteria
Loss of Range of Motion in cases treated by various modalities

PRONATION

- Good: 13%
- Excellent: 87%

SUPINATION

- Good: 25%
- Excellent: 75%

OPEN REDUCTION

- Unacceptable: 100%

According to Mitchell and Adams criteria
includes only loss of range of movements and loss of carrying angle for evaluation.

<table>
<thead>
<tr>
<th>Grade</th>
<th>Degrees change from pre-injury</th>
<th>Range of Motion</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Carrying Angle</td>
<td>Prone</td>
</tr>
<tr>
<td>Excellent</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Good</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>Unacceptable</td>
<td>0</td>
<td>1</td>
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Thus as far as carrying angle is concerned in the prone position 25% patients had excellent results while 75% had good results. In the supine position 37.5% had excellent results and 50% had good results while in one case (12.5%) the result was unacceptable. In the prone group none of the cases had unacceptable deformity. The worst results were seen in cases with open reduction where one had good while the other had unacceptable results and it was in this case that maximum loss in carrying angle occur.

As far as loss of movements was concerned none of the patients with conservative treatment had unacceptable results while both cases with open reduction had poor results. Between the pronation and supination groups the loss of range of movements did not vary significantly.