CHAPTER SEVEN

SUPRACONDYLAR FRACTURES OF THE HUMERUS IN CHILDREN

THE reduction of a supracondylar fracture of the humerus can become a comparatively simple feat if it is undertaken without delay and if the surgeon who has the first opportunity of treating it has a clear mental picture of its mechanism. The first reduction is the one most likely to succeed; after subsequent attempts the elbow becomes so indurated that the swelling may obstruct even the most expert manipulator.

ANATOMY OF THE FRACTURE

In the supracondylar fracture of the humerus the fracture line passes more or less transversely through the metaphysis at a variable distance from the epiphyseal line. When the fracture line is extremely close to the epiphyseal line it sometimes appears in the X-ray almost as an epiphyseal separation, but in every case a thin shell of the diaphysis is adherent to the distal fragment.

There are three elements in the displacement of the distal fragment of the supracondylar fracture: (1) posterior displacement, (2) lateral (or medial) displacement, and (3) rotary displacement.

In the manipulative reduction to be described, the rotary deformity will more or less correct itself under the influence of the tense fascial structures in the course of the preliminary phase of reduction by traction. An error of 10 degrees of rotation will not affect the functional or cosmetic result, though it will give rise to interesting appearances in the radiograph which need special comment (see below).

The two principal deformities, *i.e.*, the posterior and the lateral (or medial) displacement, are reduced in two quite separate stages:

Posterior Displacement

Posterior displacement of the distal fragment results from the distal end of the shaft of the humerus passing forwards into the antecubital fossa in front of the distal fragment. The intact soft structures, which form the 'tissue hinge' in this reduction, are the periosteum on the dorsal surface of the fracture and the tendon of the triceps which overlies it. The periosteal tube on the anterior aspect of the fracture is ruptured and the proximal end of the humerus passes through the rent to threaten the brachial artery or the median and radial nerves (Fig. 79, A, lateral view). This penetration of the humerus into the antecubital

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fossa results from the action of the superincumbent body weight as the child falls on the outstretched hand. The temporary incarceration of important structures, such as nerves or the brachial artery, between the two fragments is probably a common accompaniment of this displacement; but it will cause no permanent damage provided that the surgeon releases them **before flexing the elbow.** The incarcerated structures are released by the preliminary traction phase in reduction.

Lateral Displacement

Lateral displacement of the distal fragment can be either medial or lateral, being determined by the direction of the forces at the moment of the fall on the outstretched hand. The nature of this displacement is self-evident; but less obvious is the possibility that some varus or valgus displacement might persist after reduction which will be concealed by the flexed position of the elbow. Attempts to assess the presence of these angular deformities by direct X-ray of the fracture site are futile because a deviation of 10 degrees cannot be detected in the short distal fragment at such a proximity to the axis of angulation. The commonest residual deformity is a cubitus varus which, in a few cases, may necessitate osteotomy at a later date.

Soft Parts involved in the Reduction

The reduction of this fracture illustrates well the importance of a mental picture of the intact soft structures associated with broken bones, rather than allowing the X-ray shadows to dominate the mind (Fig. 79, A, B, C). The intact soft parts lie on the dorsal surface of the lower end of the humerus, the most important being the tendon of triceps and the dorsal periosteum. By keeping the triceps taut, at first by longitudinal traction in the axis of the *arm*, and later when the elbow is flexed as longitudinal traction in the axis of the *forearm*, the tendon of triceps will draw the distal fragment into the reduced position. When the elbow is fully flexed the moulding force of the triceps tendon is at its maximum.

Mechanical Analogy

A crude but valuable analogy which illustrates the mechanics of this reduction is offered in the application of a rubber tourniquet to a limb. The first movement in the application of a rubber tourniquet is the longitudinal stretching of the whole length of rubber in a straight line; the second movement is the winding of the rubber, while still stretched, round the fulcrum presented by the limb. In this sequence the direction of the traction changes continuously as the hand of the surgeon sweeps round the limb, though the longitudinal pull is maintained within the rubber (Fig. 80). In the mental picture for the reduction of a supracondylar fracture the tendon of triceps is equivalent to the rubber of the tourniquet.

Thus far these remarks relate only to the mechanics of correcting posterior displacement of the distal fragment. The secret of correcting lateral displacement lies in the fact that **the elbow must never be flexed before lateral displacement**

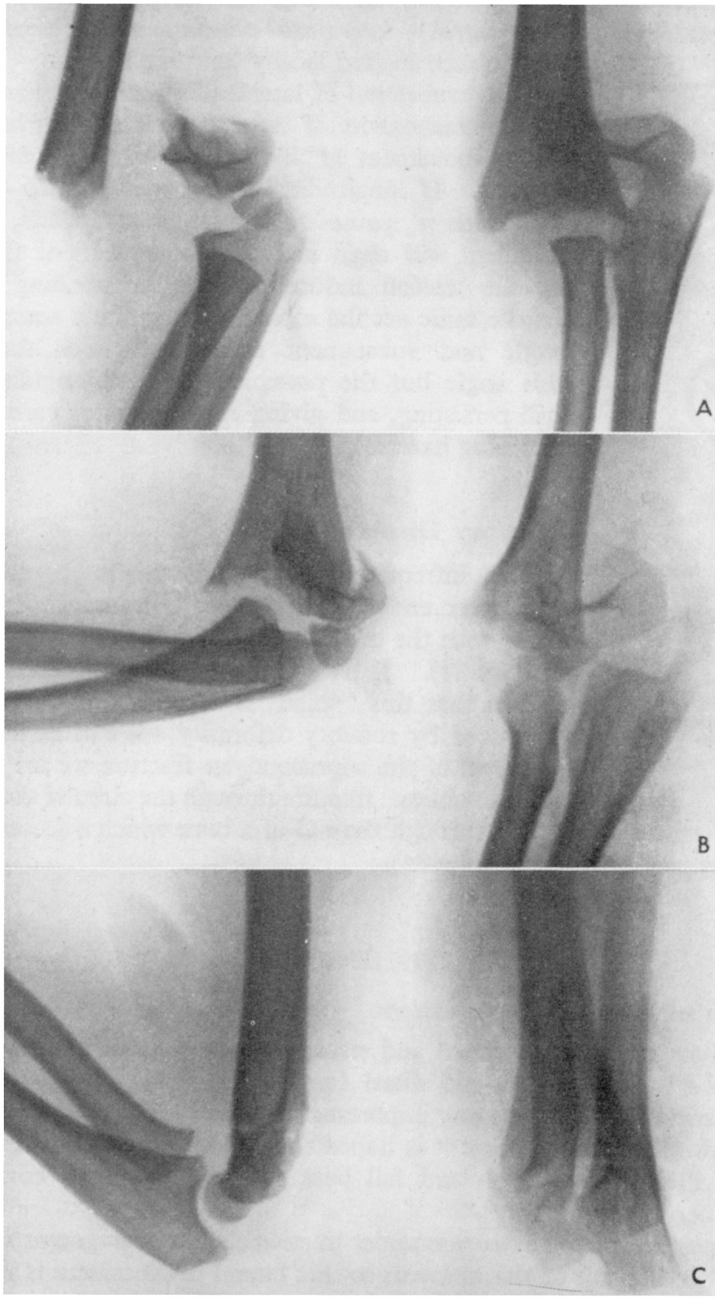

FIG. 79

A, Supracondylar fracture before reduction. Without knowledge of the action of the soft parts the reduction of this fracture by closed manipulation might seem impossible!

B, Faulty reduction: lateral displacement had not been corrected by adequate longitudinal traction, with the result that flexion locked the elbow in the position of lateral displacement.

C, Complete reduction secured by remanipulation, this time extending the elbow and applying traction prior to starting the flexion movement.

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has been corrected. By tightening the triceps tendon, *flexion of the elbow will lock the fragments in whatever degree of lateral mal-alignment existed prior to flexion;* no pressure applied locally can then shift it.

The correction of lateral displacement is an extremely simple manœuvre if adequate stress is laid on the initial movement of *longitudinal traction with the elbow straight.* If longitudinal traction is applied deliberately and with a pause for sufficient emphasis, the distal fragment will align itself with the shaft of the humerus by the tension induced in the surrounding soft parts. In the same act the elbow will acquire a neutral carrying angle and subsequent flexion will lock the elbow at this angle but the possibility of some angular deformity still persisting, and giving rise to cubitus varus, is always a lurking hazard.

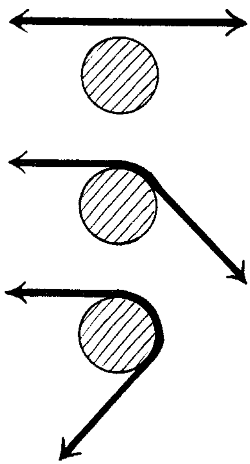

FIG. 80
Indicating the mechanical analogy of the anchor tourniquet applied to a limb. The rubber is stretched before being wound round the limb. During the winding round the limb tension is maintained though the direction of traction is continually altering.

Rotatory Displacement

Not infrequently a post-reduction radiograph will show the lower end of the humerus projecting forwards as a spike with the distal fragment incompletely reduced below it (Fig. 81). J. K. Wright (personal communication) has shown that this 'spike' is merely a radiological artefact produced by rotatory deformity. We often forget that at the level of the supracondylar fracture we are not dealing with an oblique fracture through the circular shaft of a bone but with a transverse fracture through the end of a bone which is flat and wide like the end of a paddle or spade (Fig. 82).

TECHNIQUE

Correction of Lateral Displacement

The elbow is gently extended and strong longitudinal traction is exerted by gripping the patient's wrist and distal forearm (Fig. 83). By this means the fragments are disengaged and any important structures incarcerated between them are released. In this manœuvre it is hoped that the distal end of the shaft of the humerus will retrace its path and fall back into the periosteal coverings from which it emerged anteriorly.

In the position of full extension under traction the distal fragment should move into line with the shaft of the humerus so that lateral displacement is automatically corrected by the tension of the surrounding soft parts.

It is important therefore to *pause at this stage to assess whether the lateral displacement has indeed been completely overcome before any attempt is made to hurry on to the next stage of the reduction.* If it has not been completely overcome,

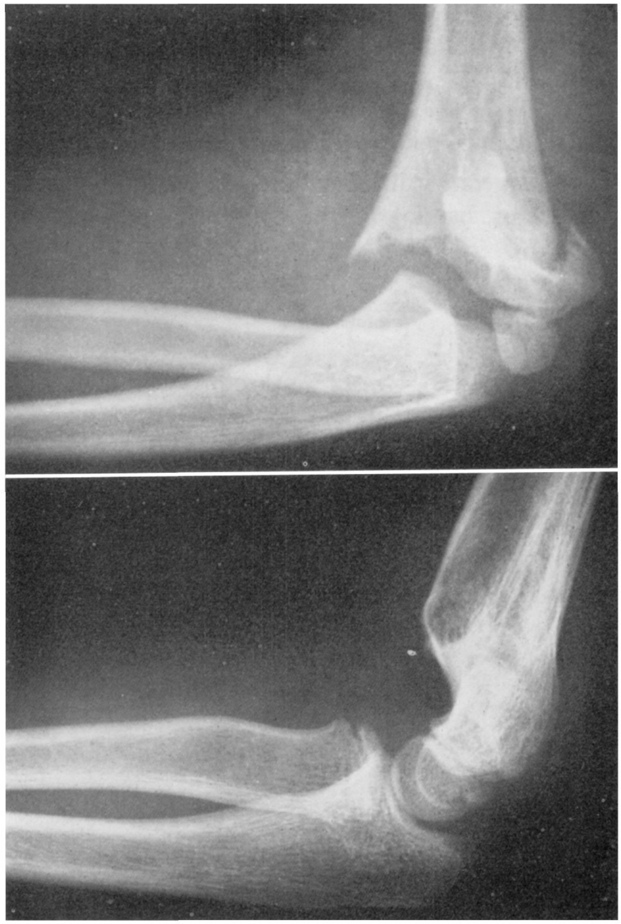

FIG. 81.—The forward projecting spike is the result of misalignment in rotation. Note how this deformity has 'remodelled' two years subsequently (lower figure).

FIG. 81

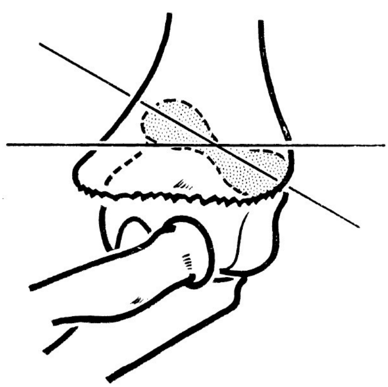

FIG. 82.—Rotatory deformity (see text). Compare with Fig. 81.

FIG. 82

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some lateral pressure while the elbow is still extended may complete the reduction of the lateral displacement. In the extended position of the elbow the carrying angle will be obliterated and this will be the final appearance of the elbow when healed.

Correction of Posterior Displacement

The surgeon, still maintaining traction on the patient's hand with his 'active' or 'reducing' hand, grips the lower end of the humerus in his 'passive' or 'fixing'

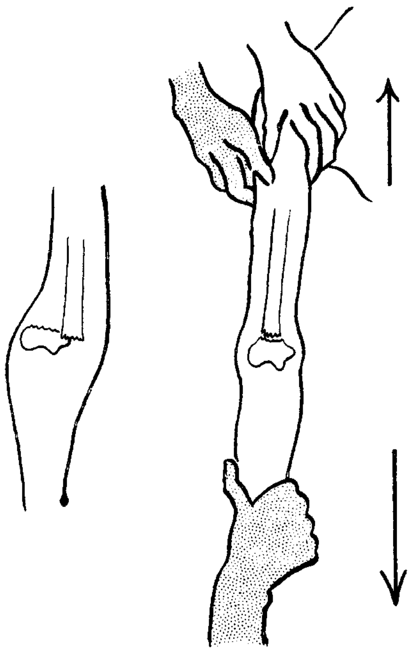

FIG. 83

Correction of lateral displacement by initial longitudinal traction. This alignment is produced by tension in the soft parts. This manœuvre releases any incarcerated artery or nerve which would suffer irreparable damage if the elbow were flexed without this having been done.

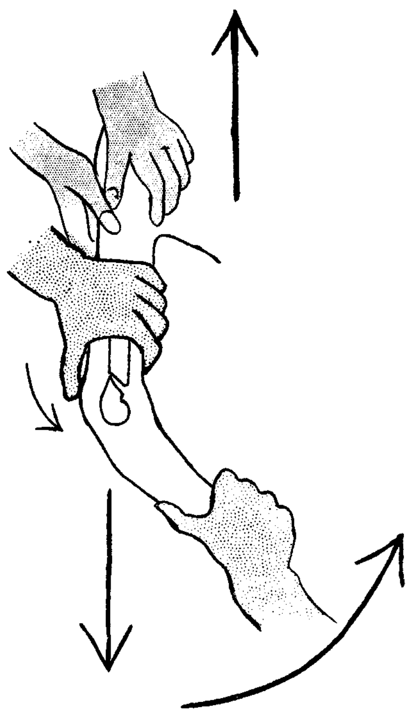

FIG. 84

Reduction started by flexing the elbow with traction still maintained.

hand to maintain counter-traction. The thumb of the fixing hand is applied over the olecranon.

With the active hand still applying longitudinal traction to the forearm, the active hand now flexes the elbow, *at the same time maintaining continuous traction in the axis of the forearm.* In order to maintain continuous traction a continuous counter-traction will have to be exerted by the fingers of the passive hand, and the direction of this counter-traction will have to change progressively as the elbow flexes (Fig. 84). *The critical point in the reduction occurs when the elbow is reaching the right angle ;* here the fingers of the passive hand are pulling the shaft of the

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humerus backwards while the pull of the active hand is directly drawing the distal fragment forwards (Fig. 85). The reduction is made or marred at this stage of the right-angle position of the elbow. Beyond the right-angle position further flexion does not improve the reduction but merely locks it by drawing the triceps tendon tight round the posterior surface of the fracture. If the reduction has not been secured at the right-angle position, further flexion will be resisted and may do damage if forced; **if lateral displacement has not been previously corrected, further flexion now will lock the elbow in lateral displacement.**

The reduction is now held by a collar and cuff in as much flexion as the

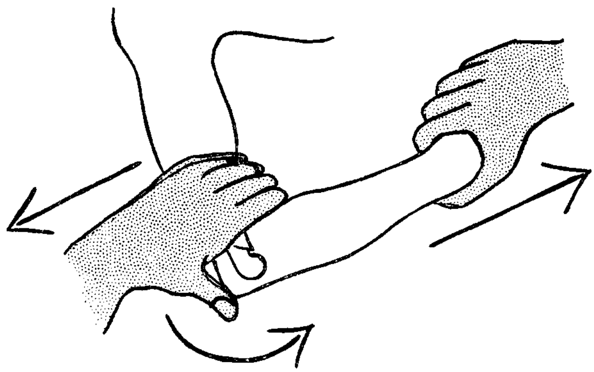

FIG. 85

Crucial phase of reduction ; traction maintained but now 90 degrees away from the original direction. Distal fragment being pushed into place by pressure from the surgeon's thumb and tension in the triceps tendon.

presence of the radial pulse will tolerate and the elbow is kept inside the child's clothing.

It is unnecessary to apply plaster of Paris to this fracture. I have never seen a good reduction maintained in a plaster cast if the elbow is at a right angle.

Checking the Reduction Clinically

If the elbow is not grossly swollen, and particularly if the fracture is only a few hours old, the success of the reduction can usually be estimated by the ease with which flexion is attained. Even if considerable swelling is present, a sure method of estimating a successful reduction is to note the relation of the point of the elbow to the axis of the humerus. Even if there is considerable swelling *the 'point' of the flexed elbow should lie in the axis of the humerus* and even slightly in front of it (Fig. 86). It is to be noted that by 'point' of the elbow I mean the visible or palpable point discovered clinically; in these growing bones this does not necessarily coincide with the X-ray shadow, because growing cartilage is present. The degree of lateral displacement is often difficult to assess clinically if the elbow is swollen, but should be automatically corrected if longitudinal traction has been used as previously described.

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If flexion of the elbow is secured easily, and if the point of the elbow lies correctly in the axis of the humerus or slightly in front of it, the surgeon should be able to say with some confidence that a reduction has been obtained, even before an X-ray is taken. Certainly this is true in a fresh initial reduction, but perhaps less so after previous unsuccessful manipulations have been attempted. Using the technique just described there should *never* be any necessity to perform open operations on these injuries except for nerve or arterial complications.

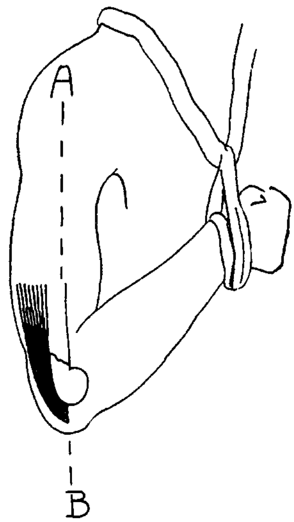

FIG. 86

Reduced fracture locked by the tension of the triceps tendon when the 90 degrees position of the elbow has been passed. This locking action is impossible at 90 degrees. The clinical test for reduction is seen by the point of the elbow lying in the axis of the humerus.

Criticism of Traction in Supracondylar Fractures

The application of traction during the reduction of a supracondylar fracture is sometimes criticised on the theoretical grounds that the brachial artery may be stretched and damaged. The danger of flexing the elbow before incarcerated structures have been completely drawn from between the fragments is much greater than the simple act of traction. *The fascial structures of the arm will not allow elongation under traction sufficient to threaten the neurovascular bundle.* However, if the surgeon cannot be convinced of the safety of applying traction with the elbow extended, it is still possible to apply longitudinal traction with the elbow at about 160 degrees instead of 180 degrees; but the patient's forearm must be grasped at its midpoint (*i.e.*, not holding the patient's hand) and this makes the subsequent movement of flexion combined with traction slightly difficult to execute precisely.

Difficulties with Circulation

The serious complication of Volkmann's ischæmic contracture is so well known that the importance of examining the radial pulse hardly needs much emphasis; but the absence of a radial pulse, on the other hand, is often possible without any fear of a Volkmann contracture. More important than the mere absence of radial pulse are: the warmth of the hand, the absence of extreme pain, the presence of circulation in the fingers, the absence of sensory loss, and the ability to extend the fingers passively.

In treating a child in whom there is a threat to the circulation the management of the case turns largely on the surgeon's concept of the cause of the obstruction. The obliteration of an artery by spasm is well known; but what factors cause this spasm, with the exception of local injury by the bone fragments, are less clearly understood. An important mechanical cause of arterial obstruction, which seems to me not to have received sufficient attention, results simply from flexing a tense and swollen elbow; it is possible that arterial spasm may later

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become superadded. These swollen elbows after a supracondylar fracture take on a turgidity akin to an inflated tyre, and it is the extended position of the elbow which reduces the internal pressure by allowing the greatest volume for its contents. Flexion of the unreduced elbow will increase the internal pressure. If a swollen elbow is flexed, a deep crease or kink will appear on the concave side which in itself is enough to obstruct the artery by direct pressure. This kink can be imitated by bending the finger of a rubber glove which has been distended with water (Fig. 87). If reduction is secured in a very swollen arm, it is often surprising how quickly the turgor of the tissues round the elbow will subside; after a successful reduction, often a distinct softening is appreciable by the time the child has recovered from the anæsthetic.

If, after preliminary traction in the manner described above, flexion of the elbow results in blanching of the hand and obliteration of the pulse when the 80 degrees position has been obtained (180 degrees equals extended position), the reduction will certainly slip if it is necessary to extend the elbow to 90 degrees. In such cases the child should be put to bed with skin traction applied from the elbow to the hand and with a plaster slab applied to hold the 90 degrees position. The arm should then be suspended from an overhead support with the child lying flat. If care is taken to see that the elbow cannot reach the surface of the bed, the weight of the arm will assist reduction and gravity will assist in the withdrawal of œdema. The suspension should be from a fixed point overhead, with an air space of about 2 inches between the bed and the elbow. After the first day and night a fretful child can usually be induced to put up with this situation, and it is not usually necessary to maintain it for more than four or five days (Fig. 88).

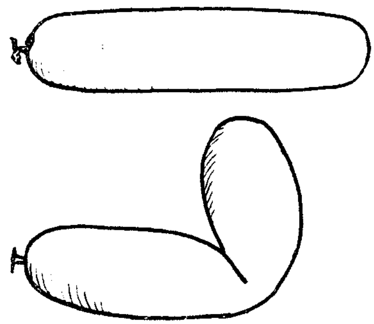

FIG. 87

Mechanical analogy of *kinking* a distended balloon to show the disastrous results of forcibly flexing the tensely swollen elbow of a supracondylar fracture.

In the illustration (Fig. 88) the limb is shown suspended with the elbow at about 100 degrees. This is because no plaster slab was used to hold the 90 degrees position achieved at manipulation. There is a danger that if the elbow is allowed to become partially extended, what was originally an incomplete, though satisfactory, reduction may relapse into considerable displacement. No plaster, by itself, will hold an incomplete reduction if the elbow is at 90 degrees, but when combined with traction it is possible to maintain whatever position was achieved by manipulation at 90 degrees. This is the only circumstance where I believe plaster is necessary in the supracondylar fracture.

In the arrangement of traction forces described by Dunlop (quoted and illustrated by Blount [1]) the counter-traction force is made more effective by passing a weighted strap over the front of the arm. This is a useful procedure

[1] BLOUNT, WALTER P. (1954). *Fractures in Children*, p. 35. Baltimore: Williams & Wilkins Co.

if, as the result of severe swelling, the elbow cannot be flexed as far as 90 degrees, but I find that it is rarely needed.

Remodelling of Displaced Supracondylar Fractures

It is well known that supracondylar fractures are capable of excellent remodelling and the recovery of full flexion which initially may be seriously blocked by the

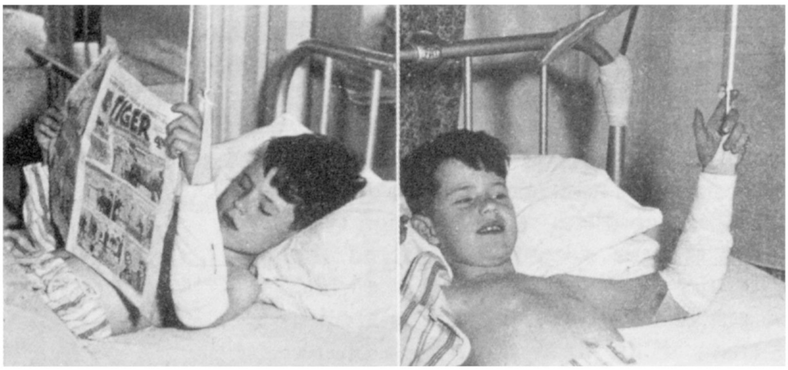

FIG. 88

Suspension of a swollen elbow when flexion to 90 degrees caused obliteration of pulse. (See text.)

forward projecting lower end of the upper fragment. This knowledge is very important in the handling of cases where several unsuccessful attempts to reduce

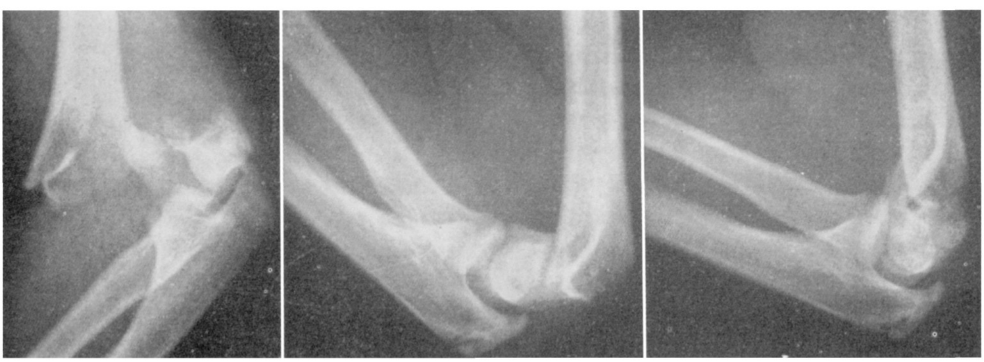

FIG. 89

Showing over-reduction of grossly displaced supracondylar fracture by too enthusiastic use of phase illustrated in Fig. 85. Over-correction reduced *secundum artem.*

have been made or where a threat to circulatory obstruction exists (Fig. 82, p. 109). So excellent can be the late results of remodelling that there is never any need to take any risk in re-manipulating this fracture. The only troublesome late deformity which persists after this fracture is cubitus varus.

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Over-reduction of the Supracondylar Fracture

During the reduction of a supracondylar fracture care must be taken not to apply so much traction that the distal fragment is pulled completely in front of the lower end of the proximal fragment (Fig. 89); when the elbow is reaching the 90 degrees position the traction force in the axis of the forearm must therefore be intelligently moderated. The position of the point of the olecranon in relation to the axis of the humerus is just as useful in checking over-reduction as it is in checking failure to reduce.

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