# MANAGEMENT OF SUPRACONDYLAR FRACTURES OF THE HUMERUS IN CHILDREN

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FEMORAL NECK FRACTURE has been termed the "unsolved fracture." In a similar vein, supracondylar fracture of the humerus in children might be called the "misunderstood fracture." By common consent, this is the most frequent fracture seen about the elbow in children. Blount states the incidence is 60 per cent. At the Fitzgerald-Mercy Hospital the incidence was 50 per cent from 1953 through 1957. In spite of its incidence, however, cases of severe residual bony deformity and dreaded Volkmann's contracture continue to be seen. In a recent article in the French literature, Fevre and Judet discuss in some detail their results in the operative treatment of 17 cases of established Volkmann's contracture. In 10 of these 17 cases, the initial trauma was a supracondylar fracture of the humerus.

Although methods of management for this injury are well documented, it is interesting to observe the trepidation with which men, otherwise versed in the management of trauma, approach a fresh supracondylar fracture. In many instances, their trepidation is justified because of the tragic complications that might ensue from this injury and the radical modifications in routine treatment that might be involved to prevent permanent functional loss, permanent cosmetic deformity, or damage to the overlying neurovascular structures. In his earlier years, the surgeon's confidence in his method of management is not strengthened by the fact that the opinions of authorities differ regarding reduction, immobilization, and after care. No problem should exist in the larger teaching centers where all types of skilled help and advice are available. How-

ever, a large proportion of these cases are seen in suburban and rural hospitals where, in the main, trained help is minimal.

Since cases of residual bony deformity and Volkmann's contracture continue to be seen, it is evident that the simple basic principles underlying the management of this fracture are still not universally understood by all those called upon to treat this injury. If one becomes responsible for the treatment of these cases, methods of management must be adopted that prove practical and successful from both the patient's and the doctor's standpoint.

This article is presented to re-emphasize the principles underlying the treatment of this common injury and to discuss a method of management which has proved practical and successful for any situation, and especially for hospitals where trained constant orthopedic supervision is not available, and where much of the immediate after care is supervised by personnel not yet fully trained in the management of fracture cases.

## TYPES OF FRACTURE

By definition the fracture line in this injury crosses the supracondylar area of the distal humerus, just proximal to the articular surface of the elbow joint. The fracture line may be transverse and jagged, or, less commonly, it may run obliquely upward and backward, beginning on the anterior surface of the humerus just proximal to the distal articular surface. This results in a small distal fragment composed of the lower articulating end of the humerus but to which is attached the elbow joint and forearm, and a larger proximal fragment which is the anteriorly spiked humeral shaft.

In the vast majority of cases, the distal fragment is displaced posteriorly but may, rarely, be displaced anteriorly depending on the direction of the fracturing force. The direction of the fracture line usually has an important bearing on treatment. As a rule, the fragments separated by a transverse fracture line are more easily reduced and held. Those separated by a long oblique fracture line are frequently more difficult to reduce and often slip during the postreduction period. The small distal fragment is most often intact but may be comminuted with extension into the lateral condyle, and medial condyle, or through one of the epiphyseal plates.

It is important to remember that the distal fragment is usually also rotated on the proximal fragment, more frequently internally. There are, therefore, two positional deformities to be corrected at reduction. If the rotary displacement is not corrected, it results in permanent abnormality of the carrying angle. Inadequate reduction of the posterior displacement results in limitation of flexion or extension.

It serves no useful purpose to subdivide these fractures further into dicondylar or transcondylar types. They are all fractures of the supracondylar area of the humerus, varying only in the degree of displacement and comminution. Normally, the distal articular surface of the humerus tilts forward at an angle of approximately 30 degrees with the shaft. The pathologic anatomy of this fracture, therefore, results in a loss of this angle plus a rotational spin of the distal fragment. Three types of supracondylar fractures are seen clinically. One is the non-displaced type, second is the minimal to moderately displaced type, and thirdly, the severely displaced fracture (Figs. 1, 2, and 3). The only question, then, that should concern the surgeon is what method of treatment will give the best result in each type.

## TREATMENT

Successful treatment of this injury involves adequate reduction and adequate immobilization. It is well to remember that the typical patient is an otherwise healthy active child, and the immobilizing apparatus will soon be called upon to withstand the stresses and strains of childhood. To be truly successful, treatment methods should be simple so that they can give consistent results in the smaller hospitals where trained orthopedic help is minimal.

Every child with a suspected elbow fracture should have an x-ray examination of both elbows. Immediate check should be made to determine the presence or absence of circulatory embarrassment or nerve damage. Treatment should be undertaken as soon as the diagnosis is established. This is one injury that brooks no delay. Swelling about the elbow enlarges with delay and increases the incidence of complication, both bony and vascular.

*Fracture with no displacement.* In these cases the fracture line is almost always transverse, and there is no posterior displacement of the distal fragment and no rotational deformity. The angle of the forward tilt of the distal articulating surface of the humerus may be normal, or may be decreased down as far as zero degrees. There will be generalized swelling about the elbow joint, sometimes moderately severe. As a rule, there will be no evidence of nerve or vascular complication.

In the presence of negligible or no displacement, no actual reduction is necessary. The injured arm is immobilized in a padded posterior plaster splint extending from the metacarpal heads, with the forearm in neutral rotation, to a comfortable height beneath the axilla. The forearm is flexed to 75 or 80 degrees. The position of acute flexion is unnecessary and only further compresses an already swollen elbow. The plaster splint is held in place by circular gauze bandage loosely applied so there are no tight edges cutting across the front of the flexed elbow. The status of the pulse is again checked after application of the splint.

The child is re-examined within a 24 hour period with special attention to elbow swell-
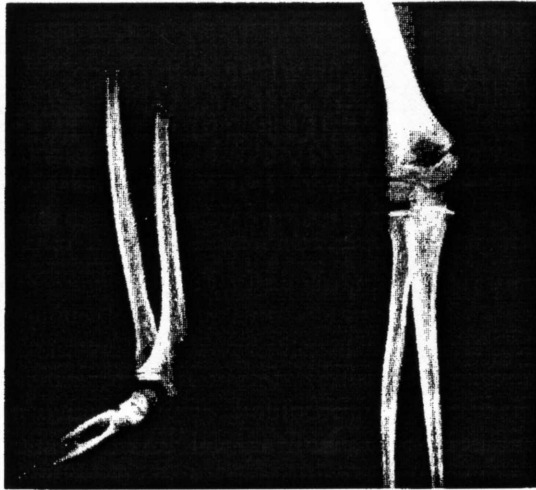
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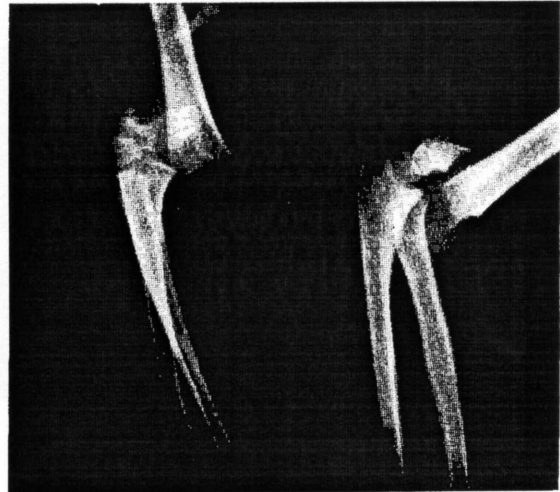FIG. 1. Roentgenogram showing minimal to no displacement.



FIG. 2. Roentgenogram in this instance shows moderate displacement.

ing, radial pulse, finger sensation, and pain. After 1 week, the plaster splint is removed and a long-arm circular cast is applied with the elbow in the same degree of flexion. The long arm cast is removed after a further period of 3 weeks and a roentgenogram is taken. If healing is adequate, as it usually is in this type of fracture at 4 weeks, active motion and hot soaks are started. No formal physical therapy treatments are used or needed. No passive stretching either by a second person or by the carrying of weights is ever indicated. Full functional return without deformity can be expected.

*Fracture with moderate displacement.* All children with moderately displaced supracondylar fractures should be admitted to the hospital for at least a 48 hour period because these fractures require a gentle closed manipulative reduction under a general anesthetic to realign the posteriorly displaced and rotated small distal fragment accurately. The incidence of vascular and nerve complication increases with displacement and swelling, making careful observation of the patient mandatory.

In the great majority of cases of moderate displacement, accurate reduction of the posterior displacement and rotational deformity can be obtained by gentle closed

manipulation (Fig. 4). Immobilization is again secured by means of a padded posterior plaster splint, as is used on the non-displaced fractures, with the elbow flexed to 75 or 80 degrees, and the forearm in neutral rotation. The rule of thumb usually given to determine the amount of flexion for the immobilized elbow is to flex the elbow to the point where the radial pulse weakens, then extend it 10 to 15 degrees. In the vast majority of cases, the final position of elbow flexion lies between 75 and 80 degrees.
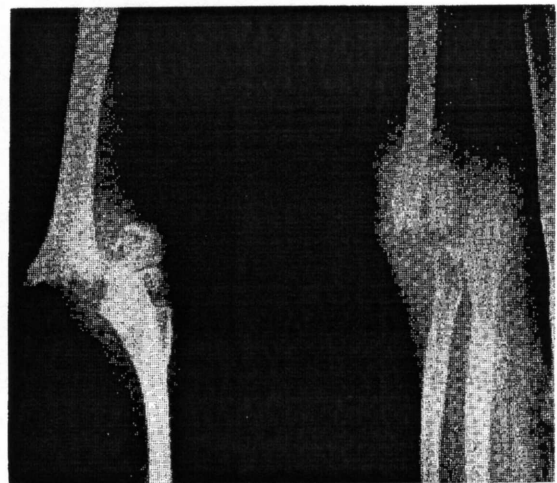


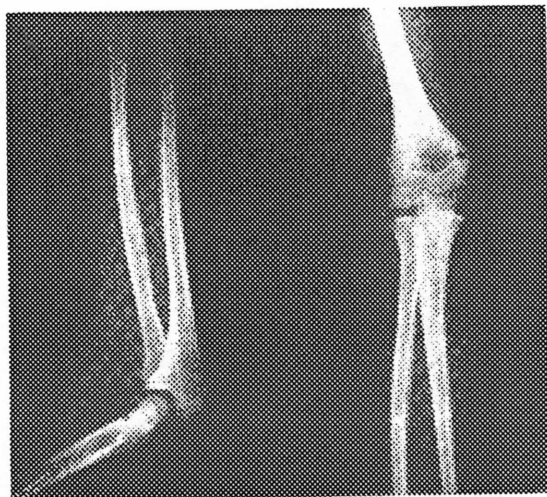FIG. 3. Roentgenogram in this instance shows severe displacement.

Fig. 1. Roentgenogram showing minimal to no displacement.



Fig. 2. Roentgenogram in this instance shows moderate displacement.

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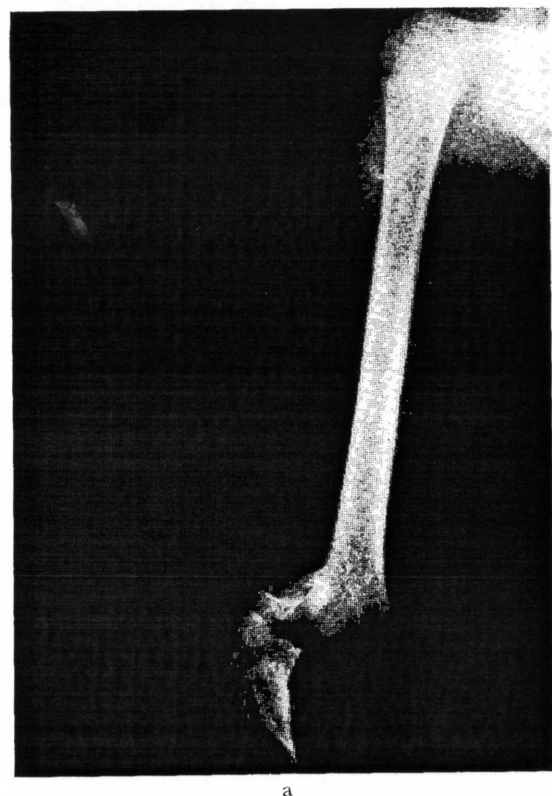
*Fracture with moderate displacement.* All children with moderately displaced supracondylar fractures should be admitted to the hospital for at least a 48 hour period because these fractures require a gentle closed manipulative reduction under a general anesthetic to realign the posteriorly displaced and rotated small distal fragment accurately. The incidence of vascular and nerve complication increases with displacement and swelling, making careful observation of the patient mandatory.

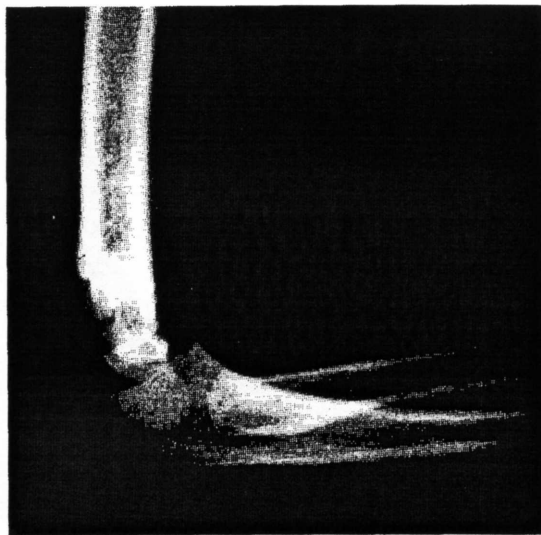In the great majority of cases of moderate displacement, accurate reduction of the posterior displacement and rotational deformity can be obtained by gentle closed manipulation (Fig. 4). Immobilization is again secured by means of a padded posterior plaster splint, as is used on the non-displaced fractures, with the elbow flexed to 75 or 80 degrees, and the forearm in neutral rotation. The rule of thumb usually given to determine the amount of flexion for the immobilized elbow is to flex the elbow to the point where the radial pulse weakens, then extend it 10 to 15 degrees. In the vast majority of cases, the final position of elbow flexion lies between 75 and 80 degrees.



Fig. 3. Roentgenogram in this instance shows severe displacement.

Fig. 4. a, Roentgenogram of fracture with moderate displacement. Prereduction view. b, Lateral view which was taken after manipulative closed reduction.

The volume of the pulse is again noted as soon as the splint is applied. The status of the reduction is checked by x-ray examination as soon as possible, and careful watch is kept on the patient as regards circulation, finger sensation, and amount of forearm pain with finger motion. The posterior splint is removed at the end of 1 week, and a long-arm circular cast applied with the elbow in the same degree of flexion and the forearm in neutral rotation. The long arm cast is removed after a further period of 5 weeks, and the status of the healing checked by x-ray examination. Gradual active motion and hot soaks can then be started.

Occasionally, a moderately displaced fracture will be seen that proves to be un-stable, and the reduction cannot be maintained by the plaster methods described. These are almost always oblique fractures and require overhead skeletal traction, as described in the next section, to insure accurate reduction and immobilization. The

skeletal traction is maintained for 2 to 3 weeks. A long-arm plaster cast is then applied for a further period of 3 to 4 weeks.

*Fracture with severe displacement.* Some fractures with severe displacement, especially if the fracture line is transverse, and if the distal fragment is not comminuted, reduce readily with closed manipulation, and prove stable in the postreduction period. These are handled by the plaster method already described. A greater number of severely displaced fractures occur in which the fracture line is oblique. These are unstable fractures and the reduction cannot be maintained by plaster immobilization. These fractures require overhead skeletal traction as their primary definitive treatment.

Properly, skeletal traction in these cases should be set up in the operating room under the usual operating room conditions, and using general anesthesia. A threaded Kirschner wire of adequate gauge is used. The wire is inserted with a hand drill through

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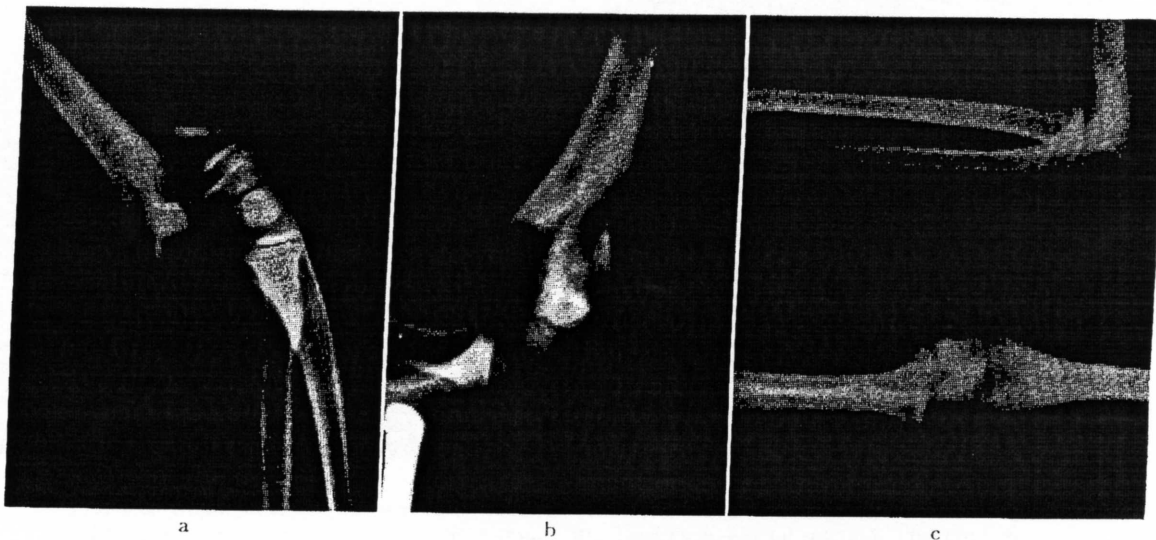a                                b                                c

FIG. 5. a, Comminuted supracondylar fracture. a, Olecranon skeletal traction elected as primary definitive treatment. b, Lateral view of same elbow after 2 weeks in skeletal traction. This position accepted. c, Same elbow 5 years later. Complete range of motion. No cosmetic deformity other than being palpably thicker than opposite elbow.

both cortices of the prominent border of the ulna, about 1½ inches distal to the olecranon tip. It is better to insert the wire from the medial aspect to avoid damage to the ulnar nerve. A yoke is attached to the wire and the wire ends are corked. The yoke is then attached to the rope and pulley system, and traction is instituted with the arm suspended over the patient's chest, with the elbow flexed to 90 degrees. A volar plaster splint is bandaged to the forearm and wrist to prevent the wrist and hand from hanging in a "wrist-drop" position. The forearm is suspended in a wide sling. Enough weight is added to the traction just to hold the shoulder slightly off the bed.

The status of the fragments should be rechecked by x-ray examination within 24 hours. If reduction is complete and satisfactory, traction is maintained for a 2 to 3 week period as the immobilizing agent. At the end of this time, traction is discontinued and the wire removed. A long-arm plaster cast is applied immediately with the forearm in neutral rotation, and the elbow is flexed to 90 degrees. Immobilization is continued for a total period of 6 weeks (Fig. 5). If the recheck roentgenogram reveals un-

satisfactory reduction, the solution is not to increase the amount of traction. It is better to manipulate the fragments manually into place under a second anesthesia without disturbing the traction force, and to continue the traction as the immobilizing agent. If necessary, even another manipulation could be carried out after several days, if the position is not acceptable. Once an acceptable reduction has been obtained, the traction is maintained for 2 to 3 weeks, followed by a long-arm cast for a total immobilization period of 6 weeks (Fig. 6).

In all cases in which the distal fragment is comminuted and in most compound fractures, overhead skeletal traction is the treatment of choice. In most compound cases, it is usually the sharp spike on the anteriorly displaced proximal humeral fragment that perforates the volar skin surface. It follows, therefore, that in this situation the fracture line will be oblique and the distal fragment will be severely displaced. After debridement of the wound, primary skeletal traction insures good reduction and adequate immobilization, and allows the wound to be observed and dressed without compromising the reduction.
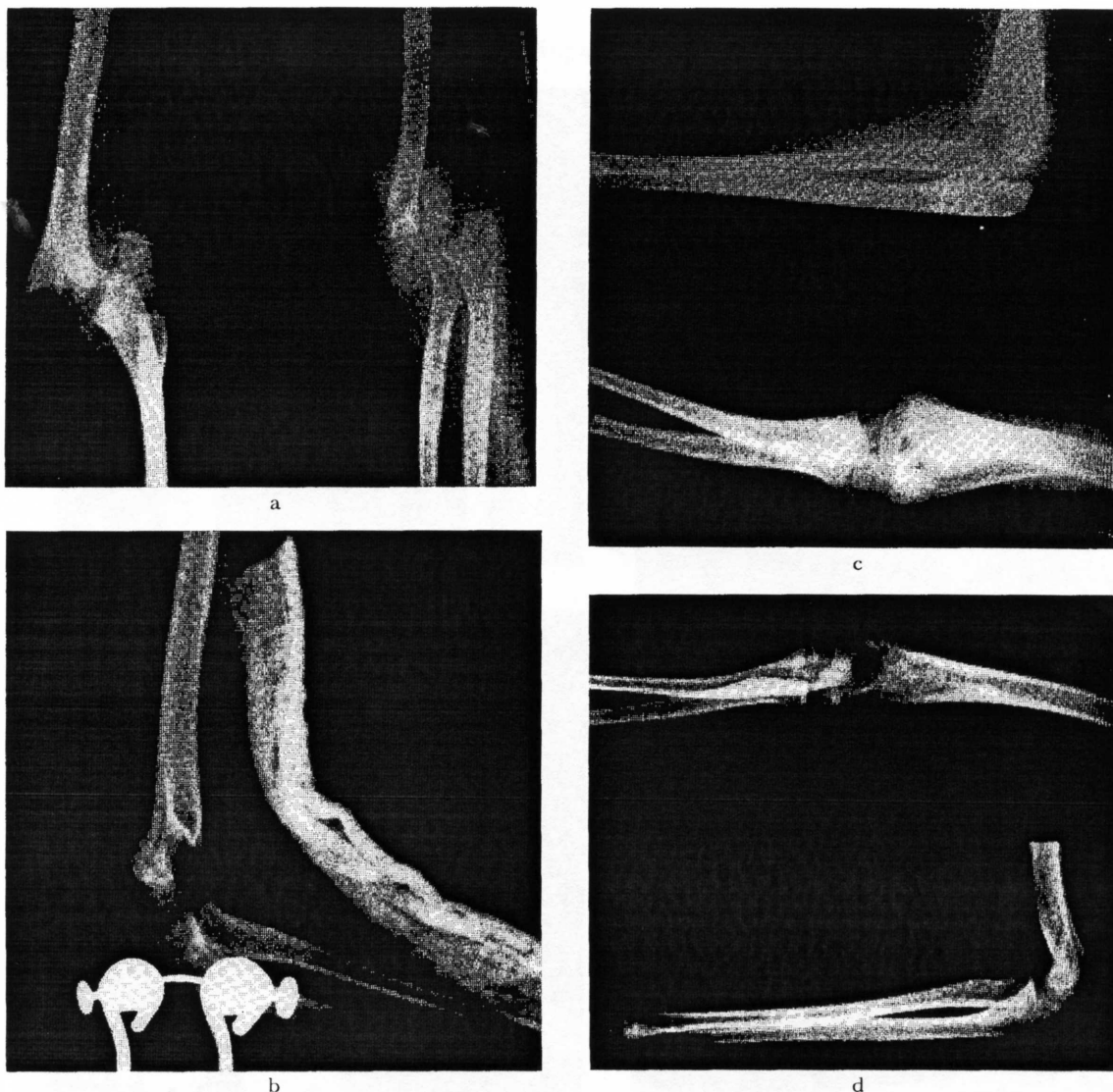
FIG. 6. a, Prereduction film showing severe displacement. b, Closed manipulative reduction unsuccessful and olecranon skeletal traction instituted. This is first check x-ray film after start of skeletal traction. Present position not acceptable. c, This patient had 1 closed manipulative reduction and 2 further manipulations under anesthesia after skeletal traction instituted. This is position when cast was removed at 6 weeks. d, X-ray appearance 4 years later. Range of motion and physical appearance completely normal.

## COMPLICATIONS AND THEIR MANAGEMENT

The complications of a supracondylar fracture arise because of: (1) inadequate reduction, (2) circulatory impairment, heralded by a weak or absent radial pulse, and (3) rarely, damage to the nerves passing over the fracture site.

*Inadequate reduction.* After closed reduction has been performed, a postreduction roentgenogram may show a partial reduction of a posteriorly displaced distal fragment, persistent overriding of the fragments, or a residual lateral or medial displacement.

Partial reduction of a posteriorly displaced distal fragment is acceptable provided the angle of the distal articular sur-

face of the humerus measures, at least, zero degrees with the shaft. Persistent posterior displacement is not acceptable. Angular deformity, at this site, does not correct with growth, and results in permanent limitation of flexion.

Persistent overriding is never acceptable. If not too great, it sometimes corrects with subsequent growth, but most often results in limited elbow function. Persistent overriding, therefore, justifies further attempts at reduction. If a second manipulation is not successful, overhead skeletal traction should be instituted and the fracture managed as those with severe displacement. Open reduction with or without metal fixation is not believed to be indicated in the treatment of a displaced closed supracondylar fracture.

Residual lateral or medial displacement, or *rotation of any significance, is not acceptable* and justifies remanipulation. Allowing this deformity to remain, even in the face of accurate reduction of the posterior displacement, will lead to a permanent alteration in the carrying angle with either a cubitus valgus or cubitus varus deformity. Residual rotation of the distal fragment is frequently difficult to detect clinically, especially when palpation is through a swollen indurated elbow area. Its presence can be determined if 3 x-ray views are obtained: (1) a true anteroposterior view of the arm with the shoulder and elbow joints visible on the film, (2) a true lateral view of the elbow joint, and (3) a Jones view, or an anteroposterior view through the flexed elbow (Fig. 7). If this type of displacement cannot be maintained in reduction because of instability at the fracture line, overhead skeletal traction should be instituted.

*Circulatory impairment.* The most dreaded complication of a supracondylar fracture is an extremely weak or absent radial pulse. This may be present before reduction, or may appear after the reduction, and may have several causes. An absent radial pulse may be due to direct impingement of the neurovascular structures on the distal sharp end of the anteriorly displaced proximal



FIG. 7. Jones' view of freshly reduced displaced supracondylar fracture.

fragment, or may be due to compression of the vessels at the elbow secondary to severe swelling, or, rarely, may be because of a lacerated or torn brachial artery.

Cases have been reported in which the radial pulse has remained absent, but the fingers maintained good capillary blood flow because of adequate collateral circulation. This is a fortunate circumstance but should not be depended upon. An absent radial pulse in the presence of a supracondylar fracture demands maximum effort as to its cause and correction. If ignored or uncorrected within a 6 to 8 hour period, Volkmann's ischemic contracture may result. In these cases mechanical occlusion of the venous circulation with ischemia and edema at the elbow, accompanied by vasospasm of the arterial tree, results in subsequent fibrosis of the volar musculature of the forearm and hand with severe crippling. This complication is entirely preventable.

When faced with an absent radial pulse

in a fresh supracondylar fracture, first thought should be given to reducing the fracture. The neurovascular structures are intimately bound to the distal fragment. Posterior displacement of the distal fragment causes the bundle to impinge on the distal sharp end of the anteriorly displaced proximal fragment. Therefore, if direct bone impingement is the cause of the absent radial pulse, the surest way of relieving compression of the brachial vessels is to reduce the fragments. Following reduction, the radial pulse should again be strong. The fracture is then immobilized in the indicated manner.

Several situations in regard to the radial pulse may present themselves. If direct bone impingement is the cause of the absent radial pulse, adequate reduction should restore the pulse. If the reduction is not adequate, further attention should be given to the fracture with either a remanipulation or the institution of overhead skeletal traction. If the reduction is adequate and the pulse remains precarious, search should be made immediately for another cause.

The most common cause of circulatory impairment is antecubital edema with subfascial tension and arterial vasospasm. In such a case, on first appearance the pulse may be adequate, but, after reduction, it may disappear with any attempt to flex the elbow, even to a right angle. As described in earlier communications (3, 5), the mixture of hyaluronidase and procaine offers an effective nonoperative method to relieve subfascial tension caused by edema and hemorrhage with great rapidity. The hyaluronidase rapidly disperses the offending fluid collection, and the procaine, which under the influence of the enzyme diffuses through a much wider area, relaxes any degree of arterial spasm present. Fifteen hundred turbidity reducing units of hyaluronidase mixed in 3 to 5 cubic centimeters of 1 per cent procaine injected into and about the antecubital fossa and into the fracture site will suffice to soften the elbow and restore the pulse in about 30 minutes, if this is the cause of the circulatory impairment. The fragments are then immobilized by either plaster or overhead skeletal traction, depending on the type of fracture.

One may be faced with a situation in which a radial pulse, absent before reduction, continues absent following reduction. The first step would be immediately to check the position of the fragments by x-ray examination. If the reduction proves satisfactory, the next measure would be the local injection of hyaluronidase and procaine as previously described. If the results from this are not completely satisfactory, it should be combined with a stellate ganglion block. If these measures are carried out correctly, the outcome will be satisfactory and surgical fascial release, specifically to relieve subfascial edema, will be unnecessary. Attention must also be given concurrently to maintaining the reduced fracture by either plaster fixation or overhead skeletal traction.

If all these measures prove unsuccessful, one is probably dealing with a torn or lacerated brachial artery. At this point, immediate exploration of the artery is indicated, with either repair or grafting in mind. Preliminary arteriography is believed to be an unnecessary hazard and is not recommended.

*Nerve damage.* Primary damage to the nerves passing over the elbow joint is uncommon with a supracondylar fracture. Stretching or contusion injuries to the median and ulnar nerves have been reported, but are rare. Occasionally, injury to the deep muscular branch of the radial nerve is noted.

The nerve damage in almost all cases is temporary and disappears in time without any specific treatment. It is important to pick up any evidence of nerve damage, if present, before the fracture is reduced. Its presence, however, does not modify the treatment except to see that further trauma is not given to the injured nerve. Definitive fracture care should be carried out just as if no nerve damage was present.

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## AFTER CARE

When the surgeon views the postreduction films, it is well to bear in mind what constitutes an acceptable reduction. The aim of treatment is to restore the normal anterior angulation of the distal articular surface of the humerus, plus the reduction of any medial or lateral displacement or rotation of the distal fragment. Partial reduction of a posteriorly displaced distal fragment is acceptable provided the angle of the distal articular surface of the humerus measures at least 0 degrees with the shaft. Mild residual overhang of the anterior surface of the proximal humeral fragment will resorb with growth and will not cause a flexion block. Acceptance of a negative angle at the distal articular surface of the humerus guarantees a flexion block because angular deformities are not improved by subsequent bone growth. Persistent posterior displacement, persistent overriding, persistent medial or lateral displacement, and residual rotation are not acceptable.

The duration of immobilization will vary from 4 to 6 weeks. In cases not requiring reduction, healing will be sufficient at the end of 4 weeks to start unprotected active motion. In cases in which manipulative reduction or skeletal traction is required, immobilization can usually be removed after 6 weeks. If it is planned to immobilize a supracondylar fracture for 6 weeks, it is wise to recheck position by x-ray examination at 3 weeks. A study of Colles' fractures (4) showed a surprising amount of the reduction to be lost while the wrist was in the cast. If the cast is loose at the time of the 3 week check, it should be replaced. If this film shows loss of reduction, it is quite possible to regain it at this time. It is impossible at 6 weeks.

Formal physical therapy is not required in these cases. Forceful passive stretching and the carrying of weights should be expressly forbidden. Children possess their own special brand of magic and will regain full function if left to their own devices and if the surgeon has done his part.

Myositis ossificans is rarely seen as a complication of a supracondylar fracture. It is quite frequently seen as a complication of posterior dislocation of the elbow, particularly if associated with fracture of the radial head. The reason for this can be seen in the anatomy of the area. The anterior elbow capsule is thin and loosely attached to the humerus. The brachialis anticus muscle overlies the anterior joint capsule and is attached to it. Anterior dislocation of the distal humerus at the elbow tears through the anterior capsule and brachialis muscle and the subsequent hemorrhage into the fibers of the brachialis muscle organizes and becomes ossified. In most supracondylar fractures, the anterior joint capsule remains intact and the hemorrhage is dissipated throughout the area because an escape route exists between the fragments. If myositis ossificans should complicate a supracondylar fracture, it frequently disappears if the immobilization is prolonged another 6 to 8 weeks. If it should not regress, operative removal of the anterior bone block should be postponed for 1 year. Early surgical intervention results in the formation of more bone.

Occasionally, residual bony deformity is seen as a complication in the follow-up period and results either in impairment of function or cosmetic deformity. With but 1 exception, this complication means the original reduction was inadequate. Subsequent growth over a long period of time may frequently correct a flexion block due to residual overriding, but it does not lessen a residual angular deformity, and never corrects residual rotation or displacement. Incomplete reduction of the posterior displacement results in limitation of flexion, and, if severe, requires an angular osteotomy of the distal humerus to restore an anterior angle. Incomplete reduction of medial or lateral displacement or rotation results in a cosmetic deformity due to cubitus valgus or cubitus varus. These are rarely associated with functional impairment. Correction of the carrying angle deformity requires a

rotational osteotomy of the distal humerus. The 1 exception occurs when the original fracture line injures the epiphyseal line at the distal humerus and the slow development of a carrying angle deformity in the late follow-up period becomes evident secondary to unequal bone growth. Here the deformity is cosmetic and will require a rotational osteotomy.

Tardy ulnar neuritis may be seen as a late complication in cases of supracondylar fracture. Its development is almost always secondary to a residual cubitus valgus deformity and requires an anterior transposition of the ulnar nerve for its treatment. Rarely, a symptomatic neuroma may form in the ulnar nerve because of irritation from the olecranon wire in cases in which overhead skeletal traction had been used.

The prognosis in supracondylar fracture should be excellent in regard to function and cosmetic alignment. Almost all the cases not classed as good or excellent are the result of inadequate reduction or improper management of complications. Except for problems arising from compounding, actual laceration or contusion of the neurovascular structures, or epiphyseal damage, all complications of supracondylar fractures are believed to be preventable.

REFERENCES

1. BLOUNT, WALTER. Fractures in Children. Baltimore: The Williams & Wilkins Co., 1954.
2. FEVRE, MARCEL, and JUDET, JEAN. Treatment of the sequels of Volkmann's ischemic contracture. Rev. chir. orthop., Par., 1957, 43: 437.
3. GARTLAND, J. J., and MACAUSLAND, W. R., JR. Use of hyaluronidase in soft tissue injury and its influence on experimental bone repair. Arch Surg., 1954, 68: 305–314.
4. GARTLAND, J. J., and WELEY, C. W. Evaluation of healed Colles' fractures. J. Bone Surg., 1951, 33-A: 895–907.
5. MACAUSLAND, W. R., JR., GARTLAND, J. J., and HALLOCK, H. The use of hyaluronidase in orthopaedic surgery. J. Bone Surg., 1953, 35-A: 604–609.