FRACTURES OF THE UPPER END OF THE RADIUS AND ULNA

FRANK D. DICKSON, M.D., F.A.C.S., Kansas City, Missouri

A FRACTURE into the elbow joint is always a threat to the usefulness of this articulation because serious impairment of function so frequently results. The importance of the elbow joint need not be elaborated upon, as it is common knowledge that the loss of, or serious interference with, flexion and extension or pronation and supination, movements which take place in this joint, may interfere with the ability to earn a livelihood and the performance of many acts necessary to satisfactory and gracious living.

Fractures into the elbow joint numerically comprise an important group, as they make up a considerable portion of the fractures which must be dealt with both in private practice and in large fracture clinics. Supracondylar fractures are the most frequent fractures of childhood and adolescence, and comminuted fractures of the lower end of the humerus are increasing in frequency in the youth and adult groups largely because of the reprehensible habit of driving an automobile with an elbow projecting from the window, a habit which is quite prevalent today. When to these two groups are added fractures of the upper end of the radius and ulna, it is evident that there is a rather formidable list of fractures which may be expected to result in some permanent impairment of the function of the elbow joint. Philip Wilson in the Fracture Oration of 1932 under the title, "Fractures and Dislocations of the Elbow," discussed injuries to this region in a very comprehensive way and left little of importance to be added. The chief emphasis in that analysis, however, was placed upon fractures of the lower end of the humerus; this presentation which deals only with fractures of the upper end of the radius and ulna should serve to bring into focus the part played by fractures of these elements of the elbow joint

in the production of pathology, which causes impairment in its function.

Anatomically, by the term "elbow joint" is meant the articulation between the lower end of the humerus above and the ulna and head of the radius below (Fig. 1). The articulation between the ulna and the head of the radius forms the superior radioulnar joint, which does not belong to the elbow joint proper. However, the movements of flexion and extension, which take place in the elbow joint, and the movements of pronation and supination, which take place between the radius and the ulna centered in the superior radioulnar joint, are so intimately related that from a functional point of view these two joints must be considered as one. The intricate movements the forearm and hand are called upon to carry out are possible only through coordination of the movements of flexion and extension and pronation and supination, and this coordination depends not only upon the proper alignment of the ulna and the head of the radius with the lower end of the humerus but also upon proper alignment between the head of the radius and the ulna. Any disarrangement in these alignments, no matter where it occurs, can not fail to impair function in the elbow joint either in the direction of flexion and extension or pronation and supination or both. It is with those fractures of the upper end of the radius and ulna which interfere with the proper alignment of the bones which comprise the functional elbow joint that this discussion is concerned.

The fractures to be considered are: (1) fractures of the head of the radius, (2) fractures of the olecranon, (3) fractures of the upper end of the ulna with dislocation of the head of the radius (Monteggia fracture).

FRACTURES OF THE HEAD OF THE RADIUS

Fracture of the head of the radius results from a fall on the outstretched hand. When such an accident occurs, the elbow is almost

completely extended and the radius pronated so that the anterolateral section of the head of the radius is driven with considerable violence against the capitellum of the humerus. The damage sustained by the head of the radius depends upon the force of the impact; usually it is possible to differentiate three types of fracture of the radial head by roentgenogram: (1) a fissure fracture with no or mild displacement; (2) a marginal fracture with displacement of a sector of bone; (3) a comminuted fracture involving most of the head of the radius.

Fracture of the head of the radius should be readily diagnosed, as the symptoms complained of are classic; these are tenderness over the head of the radius on palpation, limitation of extension of the elbow joint with onset of acute pain if extension is even mildly forced, and limitation of pronation and supination with production of pain if these movements are persisted in. While the symptoms enumerated are common to all three types of fracture of the head of the radius, the form of treatment indicated varies with the type to be dealt with; this fact must be held constantly in mind in planning the management of radial head fractures.

Treatment. It is important to remember that a fracture of the head of the radius is not the trivial injury it may appear and that intelligent treatment based on clear roentgenograms carefully studied is demanded if permanent impairment of elbow joint function is to be avoided. Furthermore, injury to the cartilage of the capitellum and even fracture of the capitellum, the result of the impact of the head of the radius against it, and ligamentous damage are complications that not infrequently are associated with this fracture, and such possible complications must be considered in any plan of treatment decided upon. For clarity, the treatment of each type will be discussed separately.

Fissure fractures (Fig. 2). The injury is a subperiosteal crack which separates slightly a sector of bone from the radial head, usually from its outer border. In young individuals the injury may consist in a tilting of the head on the neck. Although the displacement in this type of fracture is minimal, if permitted to persist an incongruence between the head of the radius and the capitellum will develop and result in permanent limitation of extension and pronation and supination. Such fractures should be treated by supporting the elbow at a right angle in a sling for a week to 10 days to allow the traumatic reaction to subside; at the end of this period the sling should be removed four or five times a day and active flexion and extension and pronation and supination carried out by the patient. There should be no passive manipulation or forcible stretching at any time as such maneuvers are likely to cause a serofibrous reaction and the formation of calcareous deposits in the capsule of the joint with permanent impairment of function. On the other hand active movements, which the patient himself controls, will be guarded and so unlikely to be forced sufficiently to cause an unfavorable reaction. The purpose of daily movement is to mold the distorted radial head to the capitellum while the fracture is still in a plastic state; by so doing even if an anatomical reduction is not secured, a satisfactorily functioning joint results. At the end of 3 weeks, the sling may be discarded and use continued until healing is complete; this usually requires from 8 to 10 weeks. A few degrees of limitation of extension will usually persist, but this is not incapacitating.

Marginal fractures with displacement (Fig. 3). In this type of fracture of the head of the radius, a sector of bone, usually from the lateral-anterior part of the head, is depressed and impacted or tilted out of position, or completely separated from the main fragment. When the fragment is impacted or tilted out of place but still in contact with the remainder of the head, conservative treatment is indicated. Such conservative treatment is the same as that used in type one, namely immobilization of the elbow at right angles for 10 days to 2 weeks, preferably in a posterior plaster mold in this fracture for more complete immobilization. At the end of this time the splint may be replaced by a sling and active flexion and extension and pronation and supination movements carried out by the patient five or six times daily. Again it should be emphasized that passive manipulation and forcible stretching are harmful and may lead to permanent interfer-
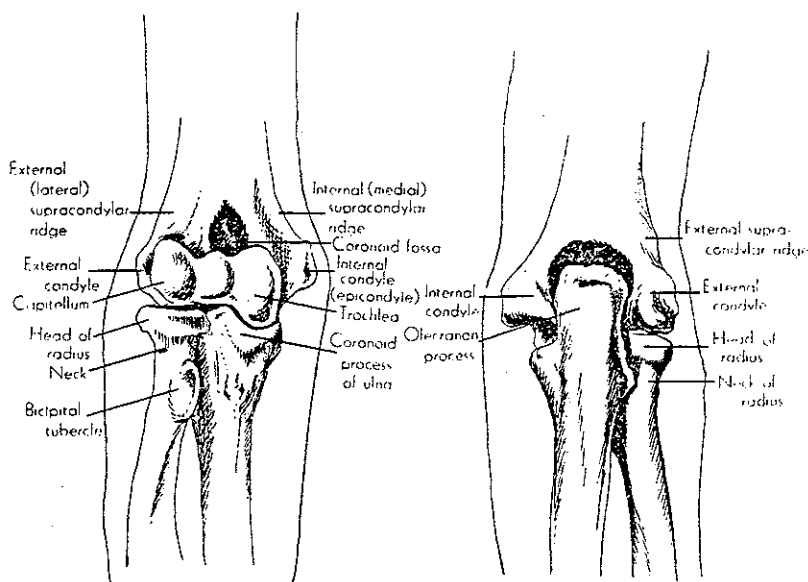
Fig. 1.   The elbow and superior radioulnar joints.

ence with function. The same molding of the distorted head to the capitellum is brought about by early guarded movements in this fracture as in type one, and an essentially normal range of joint motion will result.

When the fractured-off sector is completely separated from the main fragment (Fig. 4), conservative measures should be abandoned and surgery resorted to as ossification of the intervening hematoma produces an irregularly-shaped head which will not articulate properly with the capitellum or the ulna and limitation of both flexion and extension and pronation and supination will follow. The surgery carried out depends upon the degree of damage suffered by the radial head. If the fragment is but a small sector and the remainder of the head is intact, simple removal of the loose fragment is all that is necessary. If the fractured sector comprises a large segment of the head (Fig. 5) or if there is any degree of comminution present, the entire head should be resected as arthritic changes will certainly develop later.

When dealing with fractures falling in type 2, it is necessary to make the decision early as to whether they should be treated conservatively or by surgery. If arthrotomy is to be performed and the fragment removed or the head resected, it should be done within 10 days

of the injury; delay for several weeks will almost invariably give a less satisfactory result with definite impairment of function. As in type 1, some limitation of extension and perhaps slight limitation of pronation and supination are to be anticipated.

Comminuted fracture of the head of the radius (Fig. 6). In this type the head of the radius is broken up into a number of fragments which lie loose in the joint or the head is entirely fractured off and completely turned on itself. Conservative measures have no place in the treatment of such fractures, as dense adhesions between the fragments and the capsule rapidly form. Excision of the entire radial head is necessary if joint function is to be preserved (Fig. 7). The optimum time for surgery is within 7 to 10 days of the injury, for if surgery is delayed for several weeks or months, limitation of joint motion will already have developed, and late removal of the head seldom improves the result.

When the radial head is to be removed, the incision should be placed over the head of the radius posterior to the extensor muscle mass where the field is almost bloodless. The neck of the radius should be cut across cleanly with an osteotome at the level of the upper border of the orbicular ligament. The raw surface of

the neck should be covered with a flap, comprised of stripped back periosteum or flaps dissected from surrounding soft tissues, to seal it off and to prevent proliferative changes at this point. The most frequent error made is failure to resect far enough distally. When this error is made, the expanded part of the neck is left behind and adhesions between it and the ulna frequently form and limit pronation and supination. Placing the incision too far forward brings it near the posterior interosseus nerve, damage to which will result in wrist drop.

FRACTURES OF THE OLECRANON

Fractures of the olecranon may be caused by direct violence, such as a fall or blow on the tip of the elbow, or by indirect violence in the form of forcible flexion of the elbow against the strong resistance of the powerful triceps muscle. Some fractures of the olecranon result in slight or no separation of the fragments (Fig. 8); such fractures cause little disturbance in the elbow and present no problem in treatment. When, however, there is separation of the fragments of even as little as one-fourth inch, a definite problem in treatment is involved (Fig. 9). With displacement of the proximal fragment the triceps tendon, which is attached to it, is relaxed and loses its power to extend the elbow actively. Permanent relaxation of the triceps tendon, which must occur unless the fragments are brought into contact and a firm, bony union secured, will result in continuing weakness of active extension of the elbow, which prevents reaching for objects above the shoulder level and weakens the ability to push against resistance. If the fragments are not brought into apposition and a fibrous union occurs, degenerative arthritic changes in the articular cartilage of the elbow joint may be anticipated, and limitation of flexion and extension will occur in a very considerable percentage of cases. Even if bony union takes place in spite of separation of the fragments an incongruence of the joint surface develops and serious limitation of flexion and extension is the usual outcome. It may be stated, then, that fractures of the olecranon like fractures of the head of the radius can not be considered to be trivial injuries but on the contrary may lead to serious disability in the elbow joint.

Treatment. There are two objectives to be sought for in treatment of fractures of the olecranon: (1) the restoration of normal length and tension of the triceps muscle so that it may function properly; (2) the securing of a normal contour of the upper end of the ulna, which must articulate accurately both with the trochlear surface of the humerus and the olecranon fossa, into which the olecranon fits when the elbow is extended, if normal function is to be restored. Unless both these objectives are attained, normal or even useful elbow function will be jeopardized.

Fractures of the olecranon without separation can be dismissed with brief comment. If flexion of the elbow does not cause separation of the fragments, the elbow should be treated by immobilization in a posterior plaster mold in right angle flexion. If flexion causes even the slightest separation, the fracture should be treated in extension in an anterior plaster mold extending from the axilla to the palm. If the extended position is necessary, it is desirable to initiate flexion movements as early as possible, but such movements should not be started too early. Many advise starting flexion in 3 weeks; our experience, however, has been that this is too early and that 5 weeks is as soon as flexion exercises should be carried out. Separation of the fragments with disastrous results has occurred in several cases which have come under our observation in which early motion had been insisted upon. Recovery of motion should be achieved by active movements carried out by the patient. Passive movements and forcible stretching are contraindicated because of the danger of setting up a fibrosis in the capsule. Ample time should be allowed for recovery, as some limitation of movement may persist for 8 or 10 months.

Fractures of the olecranon with separation of the fragments present quite a different problem in treatment. Restoration of length and tone to the triceps muscle and proper modeling of the upper end of the ulna must be attained to insure a satisfactory outcome. If extension of the elbow and manipulation of the proximal fragment do not result in perfect apposition, surgery must be resorted to in practically all cases. One other method of closed reduction
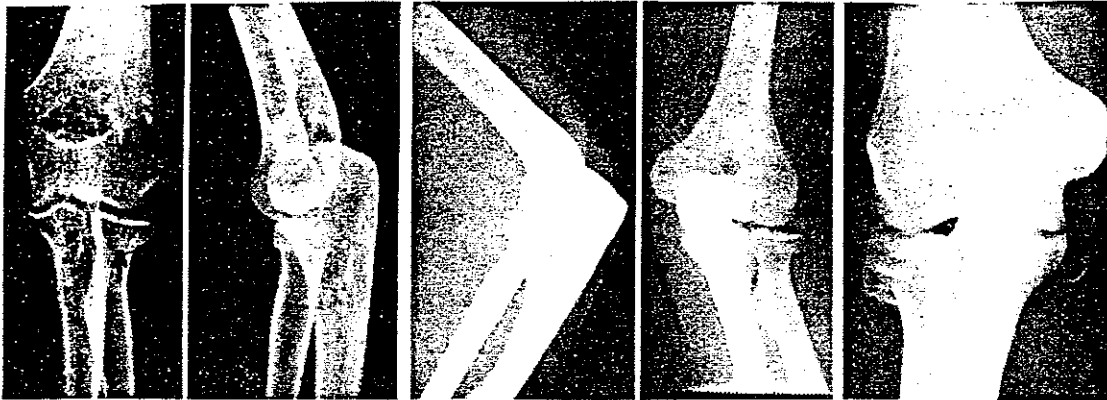
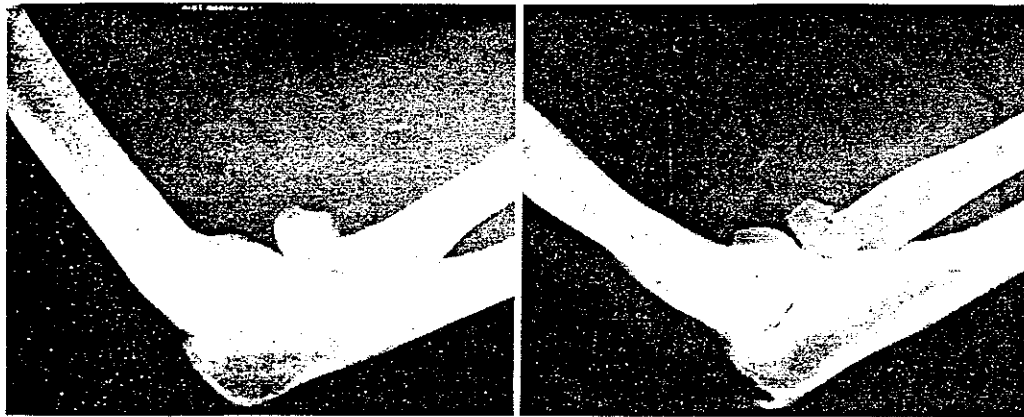Fig. 2.   Fig. 3.   Fig. 4.

Fig. 5.   Fig. 6.

Fig. 2. Fissure fracture of the head of the radius; no displacement. (Type 1)

Fig. 3. Marginal fracture of the head of the radius. Type 2 suitable for conservative treatment.

Fig. 4. Marginal fracture of the head of the radius, type 2; fractured fragment should be removed.

Fig. 5. Marginal fracture of the head of the radius, type 2; head should be resected if fractured segment is large or comminution is present.

Fig. 6. Comminuted fracture of the head of the radius, type 3; entire head should be resected if joint function is to be preserved.

and immobilization may be employed when the olecranon fragment is large (Fig. 10). In this method the fragment is transfixed with a Steinmann pin and levered into position. After reduction has been accomplished, the pin is driven down into the ulna a sufficient distance to anchor firmly the fragment in position. A plaster cast should then be applied with the elbow at right angles. The end of the Steinmann pin is allowed to project through the cast and fixed in position with a few turns of plaster. When this method is used, the alignment of the fracture should be checked by fluoroscope or roentgenograms before the pin

is driven home in the ulna. Our experience indicates that the pin should be driven into the ulna in such a way as to engage the cortex of the bone rather than pass down in the medullary canal, as better fixation is secured. Plaster fixation should be maintained for 5 weeks, after which time the pin may be removed and active exercises started. This form of treatment has given satisfactory results in 5 cases in which it was used and unsatisfactory results in 3 cases. The method is not without drawbacks and should be used only in selected cases; frequent check of position by roentgenogram should be made during the first 2 weeks. The

Fig. 7a.   Fig. 7b.   Fig. 8.
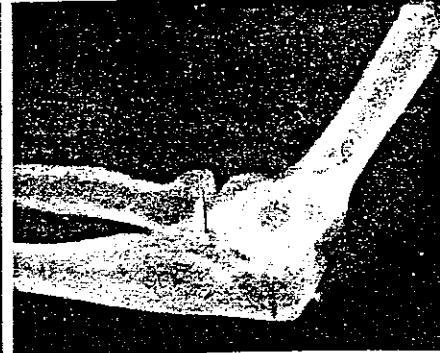

Fig. 9.   Fig. 10.   Fig. 11.

Fig. 7. a, Head of radius fractured completely off; b, head has been resected at correct level.

Fig. 8. Fracture of olecranon without displacement.

Fig. 9. Fracture of olecranon with displacement.

Fig. 10. Steinmann pin used to reduce and fix a fracture of the olecranon. The head of the radius has been resected

Fig. 11. Unsatisfactory result of Steinmann pin fixation in case shown in Figure 10. Arthritic changes and definite limitation of motion; an unsuitable case because of associated fracture of the head of the radius.

unsatisfactory results were those in which arthritic changes occurred with definite limitation of motion (Fig. 11).

Practically all fractures of the olecranon with separation are best treated by surgery since active extension of the elbow can be expected only if the triceps is re-united to the ulna without lengthening of its tendon and normal flexion and extension only with accurately fitting joint surfaces in the hinge between the ulna and the trochlea of the humerus and accurate seating of the olecranon in the olecranon fossa. The normal length and tone of the triceps can be restored by one of two surgical procedures: (1) open reduction of the fracture with the use of internal fixation so that bony union in perfect position will result; or (2) by excis-

ion of the olecranon fragment and reattachment of the triceps tendon with its lateral aponeurosis to the upper end of the ulna.

When open reduction is chosen, fascia lata should be used as the fixation material. Fine stainless steel wire may be used, but screws and nails are less desirable because of the early and late tissue reaction which they may excite. The fracture is exposed and cleaned of all interposing tendon fibers which may have fallen between the fragments and interfere with bony contact. A hole should be drilled transversely in the distal fragment of the ulna and a suture passed through the drill hole and around the proximal fragment, engaging the entire triceps insertion in which it is buried (Fig. 12). This suture should cross over the fracture so that
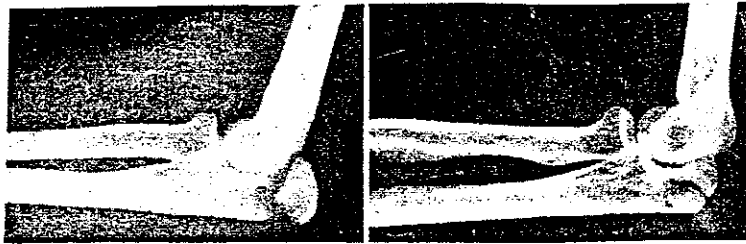
Fig. 12.

Fig. 12. Open reduction of fracture of the olecranon with fascia lata suture used, single drill hole.

Fig. 13. Open reduction of fracture of the olecranon; stainless steel wire used as suture. Crossing suture to prevent displacement is shown as well as extra suture running from fragment to fragment.

Fig. 14. a. Compound, comminuted fracture of the olecranon; b, wire and single screw used for fixation because of comminution, with malalignment and limitation of motion; c, later resection of the olecranon with restoration of practically normal range of motion.
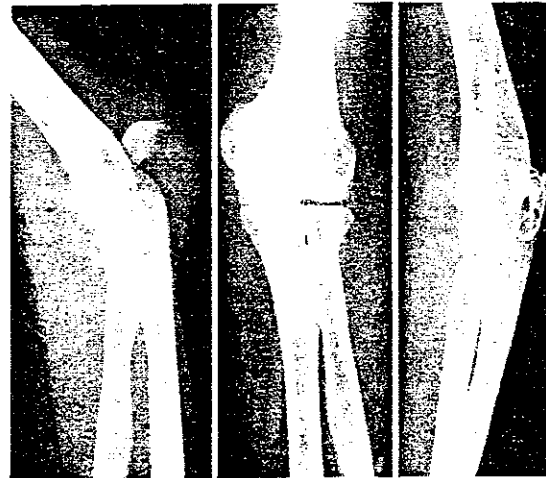

a   b   c

Fig. 13.

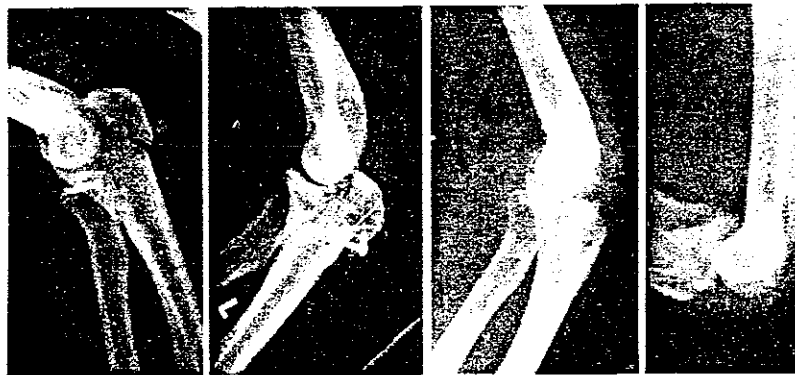a   b   c   d

Fig. 14.

when tied it will approximate the fragments and prevent tilting and lateral displacement. If the olecranon fragment is large, it is better to drill a tunnel through each fragment and add a second suture passing directly from drill hole to drill hole (Fig. 13). The elbow should then be gently flexed to about a right angle and the position of the fragments carefully checked to see that accurate reduction is maintained. The elbow should be immobilized in plaster at right angles for 5 to 6 weeks. Active movement is carried out as in the closed method.

Fig. 15. Primary resection of proximal fragment. Normal function in 8 weeks.

Excision of the olecranon fragment is, in our experience, a much simpler and more certain method of treating fractures of the olecranon with separation than is open reduction. Even with accurate reposition, malalignment of the proximal fragment may develop in the course of healing (Fig. 14). This displacement may prevent the tip of the olecranon from seating properly in the olecranon fossa, and limited extension follows. Degeneration of the articular cartilage on the ulna and even on the trochlea may take place, the result of the trauma suffered at the time of injury, and such degenerative changes produce a traumatic arthritis in the elbow joint with limitation of flexion and

extension although alignment may be perfectly maintained. When the olecranon fragment is excised, all danger of any incongruence between the olecranon and the olecranon fossa is removed, and the danger of traumatic arthritis due to degenerative changes in the articular cartilage of the ulna is eliminated. Return of normal flexion and extension movements takes place rapidly, and the convalescent period is markedly shortened (Fig. 15).

The essential part of the operation is not the excision of the olecranon fragment but reattachment of the triceps tendon. The fragment should be shelled out by close, sharp dissection, preserving all attachments of the triceps tendon. Two drill holes should be made in the proximal end of the ulna. Mattress sutures of fascia lata are placed in the triceps tendon and passed through the drill holes in the ulna, firmly anchoring the tendon to bone. Additional fixation is secured by suturing with catgut the lateral margins of the triceps tendon to the fascia on each side of the ulna. The elbow should be immobilized in plaster at right angles for 10 days to 2 weeks, and then active exercises should be carried out to restore use which will usually return rapidly. There is no danger of forward displacement of the ulna even if quite a large fragment must be removed, as the strong triceps muscle prevents this. Only failure to reattach the triceps tendon properly and adequately will allow forward displacement to occur. We have found resection so satisfactory that it is used routine-
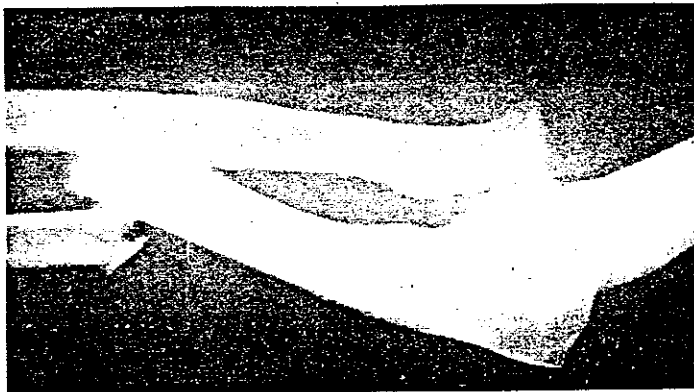

Fig. 16.

Fig. 16. Typical Monteggia fracture of the ulna with dislocation of the head of the radius.
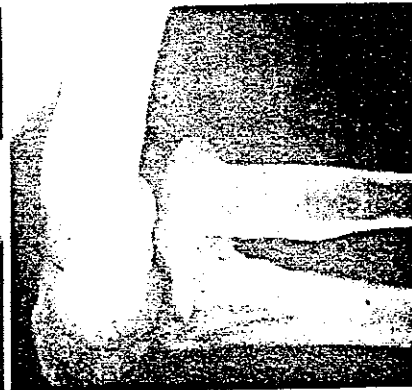

Fig. 17.

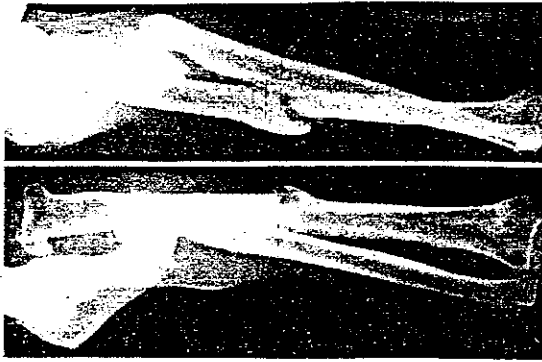Fig. 17. Atypical Monteggia fracture, really an anterior dislocation of the elbow.

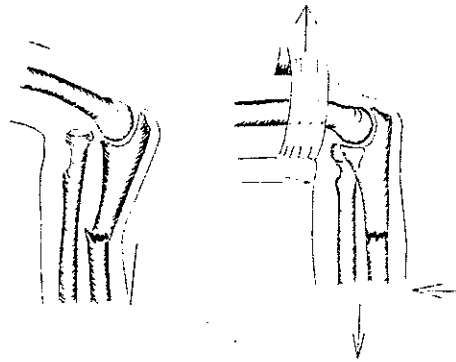Fig. 18. Unreduced Monteggia fracture with extensive disability.

Fig. 19. Diagram of method of closed reduction of Monteggia fracture.

Fig. 20. The result of inadequate internal fixation; wire loop failed to hold fracture in place.

Jy in our clinic unless there are complicating factors which make it undesirable.

MONTEGGIA FRACTURES

Fracture of the upper end of the ulna with dislocation of the head of the radius, first described by Monteggia a century ago, is one of the most disastrous fractures which occurs about the elbow joint so far as impairment of elbow function is concerned. Statistics indicate that in approximately 90 to 95 per cent of cases permanent disability of a high grade follows this fracture. The typical Monteggia fracture (Fig. 16) of the ulna occurs 3 to 4 inches below the olecranon, but the line of fracture may lie closer to the joint (Fig. 17). The solution in the continuity of the ulna is complicated by rupture of the orbicular ligament and dislocation of the head of the radius. Satisfactory reduction and maintenance of reduction of the fracture of the ulna are difficult

so that malunion is frequent, and extensive damage to the orbicular ligament often makes it impossible to maintain the head of the radius in position after it is reduced. Malunion of the ulna and permanent dislocation of the head of the radius mean an elbow joint in which both flexion and extension and pronation and supination will be permanently limited and to a serious extent (Fig. 18).

Treatment. A Monteggia fracture of the usual type is reduced by flexing the elbow, apply-
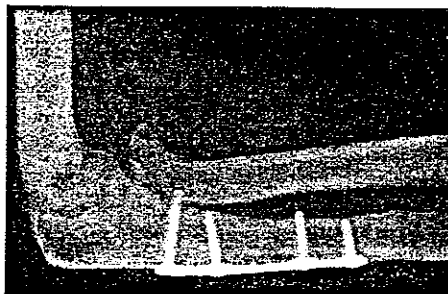

Fig. 21.

Fig. 22.

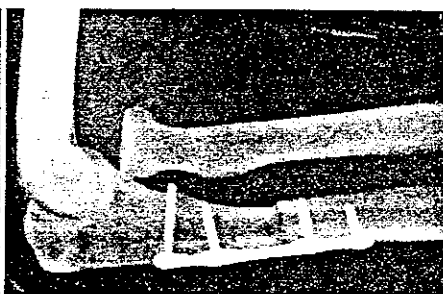Fig. 21. Adequate fixation of fracture of ulna; head of radius apparently reduced.
Fig. 22. Same fracture as shown in Figure 21, 2 weeks later showing redislocation of head of the radius.

Fig. 23. Late resection of the head of the radius in a Monteggia fracture with practically normal function.

ing traction, and manipulation (Fig. 19). Unfortunately, these maneuvers give a satisfactory reduction of the fracture of the ulna and replacement of the dislocation of the head of the radius in comparatively few cases, and in these there is a strong tendency toward displacement. Very few Monteggia fractures are successfully reduced by manipulation, and open reduction with internal fixation is demanded from the start. The fracture should be exposed, accurate reduction secured, and the fragments immobilized with an adequate bone plate (Fig. 20). Perfect reduction of the ulnar fracture will, as a rule, bring about replacement of the dislocated head of the radius (Fig. 21). If the head of the radius fails to reduce, it should be manipulated into place; it should not be exposed and open reduction and repair of the orbicular ligament undertaken. Open replacement of the dislocated radial head if carried out at the same operation as plating of the ulna almost invariably leads to ankylosis or limitation of motion in the upper radioulnar joint because of ossification about the head and neck of the radius, which usually follows. Watson-Jones considers this ossification to be due to the deposit of calcium in the hematoma disseminated into the muscles and ligaments by surgical interference. If the displacement of the head of the radius can not be corrected by reduction of the ulna and manipulation, it should be allowed to remain displaced, and 2 or 3 months later the head should be resected. Contrary to what occurs in fractures of the head of the radius, late removal of the dislocated radial head gives excellent function as regards flexion and extension and pro-

nation and supination. In a certain number of cases, the head of the radius will replace when the ulna is brought into alignment, but within a few days or a week or two, it will redislocate because the orbicular ligament fails to repair itself (Fig. 22). When this complication occurs, it is best to do nothing about it for 2 or 3 months and then resect the radial head (Fig. 23). There are many with wide fracture experience, who prefer to reconstruct the orbicular ligament rather than resect the head of the radius; if this is done it should be postponed for at least 2 months as is resection of the head and for the same reason. In our experience, late resection of the radial head has given more satisfactory results than attempts to reconstruct the orbicular ligament, as it is rarely possible to anchor the head of the radius securely in place by an artificial ligament, and the radioulnar joint is so relaxed that it may be unreliable, painful, and later develop arthritis.

The elbow joint from childhood is vulnerable to injury. The mechanics of the functional elbow joint are so complex that any injury which interferes with the proper alignment of its component parts can cause impairment of function of serious degree. Because this is so, fractures which involve the upper end of the radius and ulna, important elements in the joint, demand careful appraisal and the selection of that form of treatment which will insure restoration of the most advantageous relations between the articular surface of the ulna, the head of the radius, and the lower articular surface of the humerus. Anatomical alignment is important, but a satisfactorily functioning elbow joint is more so, and restoration of function must be the aim of treatment. The first step to this end is understanding that no fracture which enters the elbow joint is a trivial injury but one which carries with it the possibility of permanent impairment. The second step is never to overlook the susceptibility of the elbow joint to form adhesions and so avoid in the after treatment of elbow fractures, including those of the upper end of the radius and ulna, the use of passive motion and forceful manipulation, which promote the formation of adhesions, and these always result in limitation of movement in one or more directions with varying degrees of disability.