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## FRACTURES AND DISLOCATIONS IN THE REGION OF THE ELBOW<sup>1</sup>

PHILIP D. WILSON, M.D., F.A.C.S., BOSTON  
From the Fracture Service, Massachusetts General Hospital

**F**RACTURES and dislocations in the region of the elbow are extremely common, and on account of the toll of deformities and disabilities they have levied in the past have won a reputation for formidableness that is scarcely equalled. Although much has been written about these injuries, there still remain sufficient gaps in our knowledge to justify further study of them. It will be our purpose in this article to present a more or less comprehensive view of all the different lesions that are designated by the title "Fractures and Dislocations of the Elbow." Many of the injuries are multiple, and it is only by including all in the study that an accurate picture can be presented of the whole.

For the purpose of gathering material we have reviewed the records of 352 patients with 439 fractures or dislocations of the elbow that have been treated by the staff of the fracture service of the Massachusetts General Hospital between the years 1924 and 1930, inclusively. Of these, 174 patients with 213 injuries about the elbow were treated as in patients, and have been carefully studied and followed. End-result clinical and X-ray examinations have been made at a period longer than 1 year after discharge from the hospital in 140 patients with 176 elbow injuries, representing 82 per cent of all the house cases. The other patients were treated in the emergency ward and out patient department of the hospital. For the most part their injuries were of less severe type so that hospital admission was not considered necessary. The records of these patients are incomplete, and contain notes only of the diagnosis and treatment at the time of the first visit. These have been used chiefly for statistical purposes in order to give as complete a picture as possible of the entire problem. During the 7 year period covered by the study the total number of patients with fractures and dislocations treated in all departments of the hospital was 4,066, and the total number of skeletal injuries was 4,536 so that the fractures and dislocations of the elbow

represented approximately 10 per cent of the entire group.

A word of explanation is necessary in respect to the system of grading end-results that is employed at the Massachusetts General Hospital. The result is evaluated from three standpoints, A (anatomic), F (functional), and E (economic), and is expressed by numbers ranging from 0 to 4, the former representing the minimum and the latter the maximum. Considerable latitude is permitted by the numbers, 1 representing from 0 to 25 per cent, 2 from 25 to 50 per cent, 3 from 50 to 75 per cent, and 4 from 75 to 100 per cent. "Anatomic" refers to bony alignment, and is determined from the X-ray; "functional" takes into consideration the range of joint motion, muscular strength, and the presence or absence of pain; while "economic" refers to working and earning ability. For example, A<sub>3</sub> F<sub>4</sub> E<sub>4</sub> means that the X-ray shows slight bony deformity, but that functionally the patient is practically normal, and that he is able to do the same work and earn the same wage as before injury. A<sub>1</sub> F<sub>2</sub> E<sub>3</sub> indicates less than 25 per cent of normal alignment, less than half of the normal motion, and only about 75 per cent of the previous earning power.

*Types of injury.* It is important to make an accurate diagnosis of the exact type of fracture or dislocation of the elbow as the methods of treatment are different, and each carries its own particular dangers. Many of the unsatisfactory results that are seen after injuries of the elbow are the result of failure to distinguish between the different types and the attempt to treat all without distinction by one common method.

*Epiphyses.* The lower end of the humerus lacks a single common epiphysis similar to that at its upper end or to those at the ends of the radius, femur, and tibia. Instead, ossification proceeds from several distinct epiphysal centers which unite with the shaft at different age periods. Any of these epiphyses, such as the capitellum or medial epicondyle,

<sup>1</sup>Quotation on Fractures, presented at the meeting of the Clinical Congress of the American College of Surgeons, St. Louis, October 17-21, 1932.

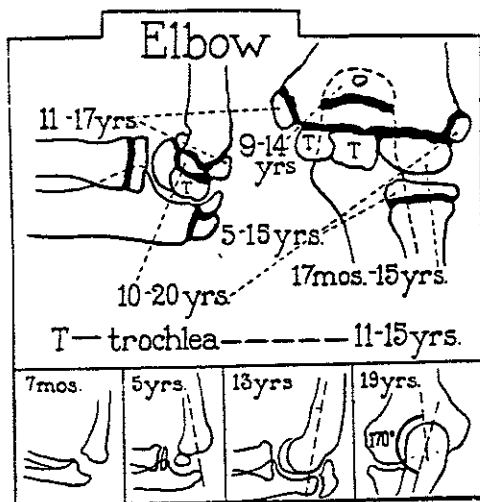


Fig. 1. Diagram showing ossification of the epiphysis of the elbow. (From Camp and Cilley. Am. J. Roentgenol. 1931, xxvi, Dec.)

may become separated as a result of trauma during the period when it is vulnerable, but epiphyseal fracture of the entire lower end of the humerus almost never occurs, and no single instance of it was found in our series. A

TABLE I.—GRAND SUMMARY SHEET

	House cases			Emergency ward		
	Number	Per cent	Results	Cases	Total	Per cent
Supracondylar	57	.267	46	25	82	.19
Medial epicondyle	14	.065	12	22	36	.082
External condyle	6	.028	6	14	20	.046
Internal condyle	5	.023	3	11	16	.036
Intercondylar	12	.056	12	2	14	.032
Capitellar epiphysis	10	.046	8	1	11	.025
Lateral epicondyle	0	.0	0	7	7	.016
Fracture of capitellum	3	.014	3	0	3	.007
Total lower end humerus	107	.502	90	82	189	.433
Head and neck radius	30	.141	24	45	75	.17
Olecranon	33	.155	25	28	61	.14
Coronoid	7	.032	6	8	15	.036
Upper end ulna into joint	3	.014	3	0	3	.007
Total fractures	180	.85	148	163	343	.78
Anterior dislocation radial head	3	.014	3	0	3	.007
Dislocations	30	.14	25	63	93	.21
Total injuries	213	1.00	176	226	439	1.00

knowledge of the normal X-ray appearance of the epiphyses and of the age at which they unite is essential for the proper treatment of fractures (Fig. 1).

*Frequency of the various injuries.* The relative frequency of the different types of fractures and dislocations about the elbow is shown in Table I. The most common injuries in order of frequency were first, dislocations; second, supracondylar fractures; third, fractures of the head and neck of the radius; fourth, fractures of the olecranon process.

*Multiple injuries.* Many of the skeletal injuries about the elbow are multiple. This is particularly true of the dislocations which are frequently accompanied by fractures and of the fractures of the olecranon, upper extremity of the radius, coronoid process, and medial epicondyle, which are often associated with other injuries either fractures or dislocations. The incidence of the complicating injuries in respect to the various fractures and dislocations of the elbow is shown in Table II.

*Nerve injuries.* Injury of one of the main nerves of the arm complicated the fracture or dislocation in 9, or 5 per cent, of the 174 house patients. All of these injuries were of the nature either of contusions or stretching of the nerve, and spontaneous recovery occurred in every instance. The various lesions are shown in Table III.

*Age distribution.* It may be seen from the graph (Fig. 2) that fractures and dislocations of the elbow occur with the greatest frequency among children; actually 101, or 58 per cent, of the house patients were under 15 years of age. This fact should prove a stimulus to the surgeon because childhood is the most favorable age for recovery from skeletal injuries, and on that account failure to avoid functional impairment seems doubly tragic.

#### I. SUPRACONDYLAR FRACTURES OF THE HUMERUS

The supracondylar fractures were numerically the most frequent of the injuries in the region of the elbow, and constituted 19 per cent of our group of cases. The incidence was highest in childhood, and 92 per cent of the patients were under 15 years of age, and 84 per cent below the age of 10. There seemed to

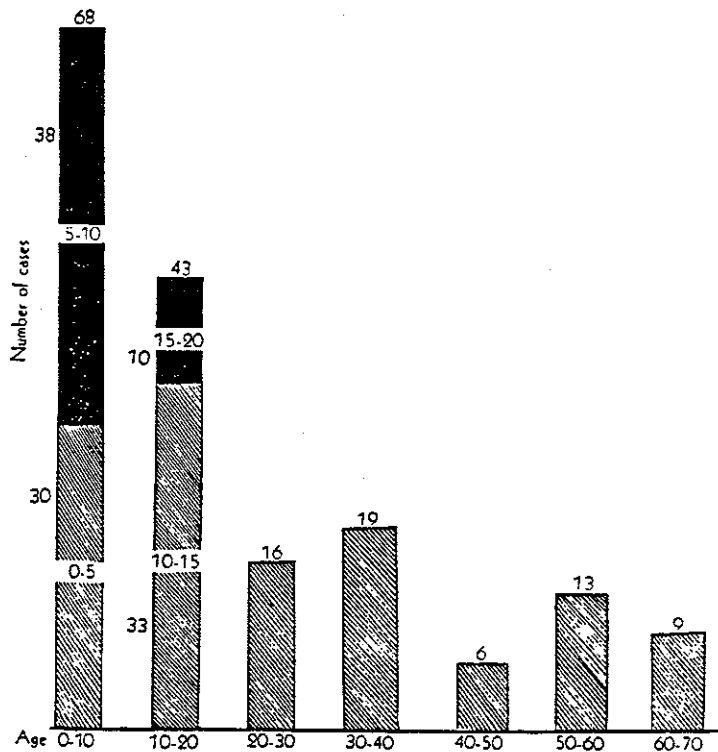


Fig. 2. All injuries of the elbow (174 house patients). Age distribution by decades.

be an extraordinary resistance to this injury in adult life judging by the absence of any instance of it between the ages of 20 and 50 years. It was re-encountered in the elderly group, and 4 of our patients were in the sixth decade (Fig. 3).

The fracture is more accurately described as diacondylar than supracondylar, but since the latter term is better known, it will be retained. The fracture line passes transversely

through the upper part of the condyles instead of above them, and in the lateral plane it slopes obliquely downward and forward. It is usually produced by a fall on the outstretched hand with backward and upward thrust on the forearm. The lower fragment is displaced backward, and the lower end of the upper fragment

TABLE II.—COMPLICATING INJURIES OF ELBOW FRACTURES

	Cases	Multiple injuries of elbow elsewhere		Fracture elsewhere Cases
		Cases	Per cent	
Supracondylar.....	82	2	2.4	4
Medial epicondyle.....	36	15	42	1
Lateral epicondyle.....	7	2	28	—
Condylar fracture.....	50	4	8	3
Dislocation of elbow... ..	93	56	60	4
Head and neck of radius	72	17	23	5
Olecranon.....	61	15	24	6
Coronoid (E.W.).....	15	12	80	1
Capitellar epiphysis....	11	1	9	0
Capitellum.....	3	2	66	1

TABLE III.—NERVE INJURIES

Nerve	Primary lesions	Secondary lesions	Total
Radial.....	2	2	4
Ulnar.....	5	0	5
Median.....	0	0	0
			9

*Radial nerve*

Intercondylar fracture of humerus.....	1
Supracondylar fracture of humerus (1 post-reduction).....	2
Fracture head and neck of radius (post operative)	1

*Ulnar nerve*

Dislocations of elbow with fracture of medial epicondyle.....	4
Comminuted fracture of olecranon and upper ulna.....	1

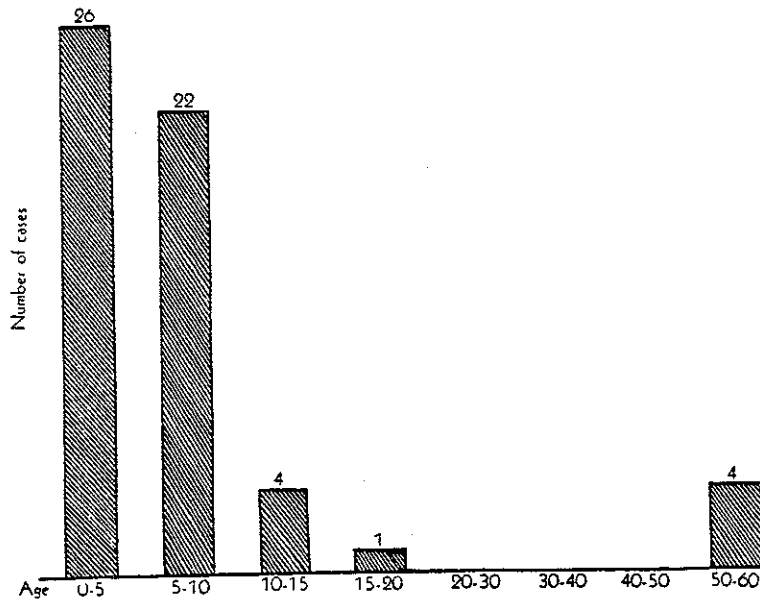


Fig. 3. Supracondylar fractures (57 house patients). Age distribution by decades.

comes to lie anteriorly and medially in close relation to the brachial vessels. Occasionally it escapes through the skin producing an open or compound fracture. In the group of patients (57) studied there were two with compound fractures, or an incidence of  $3\frac{1}{2}$  per cent.

The flexion type of supracondylar fracture, although rare (3 examples in 57 cases, or 5 per cent), needs to be distinguished from the common hyperextension type of fracture. It generally results from a fall on the flexed elbow and the deformity is reversed, the lower fragment being displaced forward instead of backward. Closed reduction is brought about by extension of the elbow instead of by flexion and, if correction is obtained, splints should be applied with the elbow in this position. The deformity is generally increased by the position of acute flexion. In the group of patients studied, there were 3 examples of this type of fracture. Two were adults and one a child. Open reduction was necessary in the two former, and closed reduction was satisfactory in the latter.

In the common type of supracondylar fracture when the patient is seen within a few hours of the injury, reduction can generally be

accomplished by the manipulative method and the correction maintained by the position of acute flexion of the elbow. It needs to be emphasized that the position of acute flexion is not a means of reducing the fracture but of retaining alignment after reduction has been accomplished. Reduction may be performed as follows: with the patient anesthetized and an assistant making countertraction on the upper arm, traction should be exerted on the forearm, the elbow being extended. The elbow should be drawn downward and rotary displacement corrected. The lower fragment should then be pushed forward and the elbow slowly flexed. If the reduction is performed within a few hours of the injury before there is any vascular interference from swelling, and if the replacement is complete, it will be possible to bring the elbow into a position of complete hyperflexion without obstructing the radial pulse, and it should then be fixed in that position either by the application of a snug bandage or by a molded posterior plaster splint. Retention by a circular strip of adhesive plaster, in our opinion, is dangerous and likely to interfere with the circulation.

*Ischæmia.* The great menace of the supracondylar fractures is much more from vascular

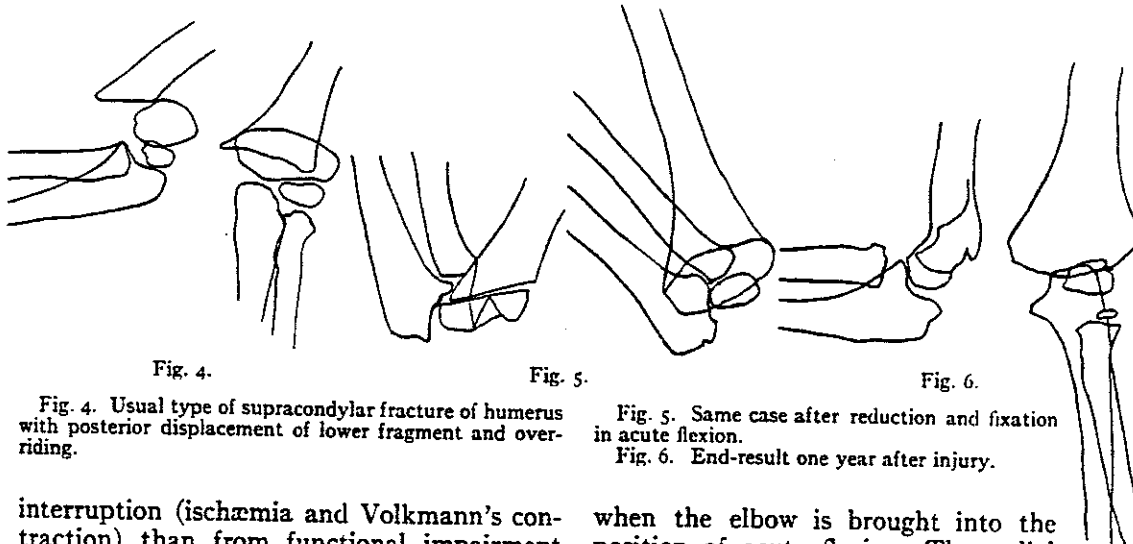


Fig. 4.

Fig. 5.

Fig. 6.

Fig. 4. Usual type of supracondylar fracture of humerus with posterior displacement of lower fragment and overriding.

Fig. 5. Same case after reduction and fixation in acute flexion.

Fig. 6. End-result one year after injury.

interruption (ischæmia and Volkmann's contraction) than from functional impairment due to faulty reduction of the fracture. Ischæmia, that dreadful complication, often equivalent to total loss of the arm, is ever imminent, and this danger must always be kept in mind. While in most instances it is a consequence of the injury rather than of the treatment, and may develop in the complete absence of all constrictive dressings, there is little doubt that failure to recognize it when impending, and therefore to take all needful steps to prevent or check it, may make a great deal of difference in respect to the amount of function that may be saved. Examination should never be confined to the region of the fracture, but should include the entire extremity and tests of the circulation, cutaneous sensibility, and motor power of the hand and wrist should always be made.

Absence of the radial pulse, pallor and coldness of the hand, inability to flex or extend the fingers, and loss of cutaneous sensibility are the signs of fully developed ischæmia, and, in our opinion, demand immediate operative intervention as will be described later. But it is equally necessary to recognize the signs of incomplete circulatory disturbance, and in that case to adopt a plan of treatment that will take into account both the needs of the fracture and those of the circulation as well. By these signs I refer to the presence of marked swelling about the elbow, cyanosis of the forearm and, above all, to interruption of the radial pulse

when the elbow is brought into the position of acute flexion. The radial pulse must be the guide post not only during the reduction of the fracture but also throughout the immediate after-treatment and must always be carefully watched. Disappearance of the radial pulse while the elbow is being flexed following the reduction of the fracture is a sign either of incomplete reduction or of such great extravasation into the soft parts and infiltration of the tissues that the brachial artery becomes compressed as a result of the postural tension. In either case, it is an indication for the return of the elbow to a position in which the radial pulsation can again be felt, and for the application of splints in that position to maintain the best alignment possible. When the circulatory balance is particularly bad, it may be the part of wisdom to abandon all attempts at reduction for the moment, and instead to concentrate on improving the circulation by such measures as elevation, application of radiant heat, and even operative intervention, if indicated. After a few days, when the swelling has subsided, a second attempt at closed reduction may be made, or open reduction may be performed. An alternative method that has given successful results is the application of skeletal traction from an overhead frame by means of a Kirschner's wire inserted in the olecranon process. This obtains reduction of the fracture, permits the elbow to assume the position of flexion from the unsupported weight of the forearm, and

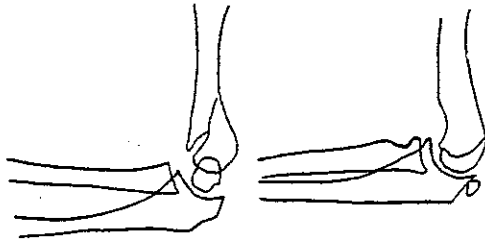


Fig. 7. A. Roentgenologic appearance of malunited supracondylar fracture of humerus three months after injury. Note: that union has taken place with the lower fragment lying posteriorly and that the lower end of the proximal fragment projects anteriorly and appears to block flexion. B. Same elbow three years later showing correction of deformity by process of growth.

at the same time secures elevation and relieves swelling.

Frank, established ischæmia requires immediate operative intervention. Let no one depend upon closed reduction of the fracture as a means of relieving pressure upon the vessels. Our own tragic experience with 2 patients shows the futility of this method (see Table IV). On the other hand, gratifying results were obtained in 2 patients by incision along the inner side of the elbow, evacuation of the hæmatoma, and by exposure and freeing of the vessels. In one case the latter were found twisted about the upper fragment and the pulsation immediately returned upon freeing them. This experience was particularly

encouraging, and holds out hope that by immediate operation in the early stage Volkmann's ischæmic contraction can be prevented either completely or partially. Ischæmia developed in 5 of our 82 patients, or 6 per cent. Data concerning these patients is shown in Table IV.

Vascular disturbance of greater or lesser degree was present in a large proportion of the patients studied, and in these the treatment of the fracture was made secondary to safeguarding the circulation. In 22 of our 57 house patients more than one closed reduction was performed. This was usually due to the fact that the radial pulse was shut off by the position of acute flexion of the elbow, and that correction could not be maintained with the elbow in a less favorable position. Open reduction was performed in 11 cases. Five of these operations were necessitated by failure of closed reduction, 1 was in a compound fracture where open reduction was combined with immediate débridement, and the 5 remaining were in patients who were admitted late, that is, from 4 to 10 days after injury.

The treatment after either closed or open reduction consisted of immobilization for a period of about 3 weeks followed by protection in a sling for 1 or 2 weeks longer. No effort was made to employ early massage and movement. End-result examinations were made in

TABLE IV.—SUPRACONDYLAR FRACTURES WITH ISCHÆMIA—FIVE CASES OR SIX PER CENT OF EIGHTY-TWO CASES

Identification	Age	Time after injury	Examination of hand	Treatment	Result
C.H. (O.252417)	4	3 hrs. No previous treatment	Pallor, and loss of sensation and power. Absent pulse	Immediate closed reduction. Right angle flexion; elevation; heat	Volkmann's contraction. A <sub>4</sub> F <sub>2</sub> E <sub>2</sub>
R.H. (W.265957)	8	2 hrs. No previous treatment	Pallor, loss of sensation and power. Absent pulse	Immediate closed reduction. Right angle flexion; elevation; heat	Volkmann's contraction. A <sub>3</sub> F <sub>2</sub> E <sub>3</sub>
W.H. (W.285639)	5	6 days. Reduction performed elsewhere and elbow fixed in flexion	Hand swollen, cyanotic and tender. Loss of sensation and power. Absent pulse. Elbow swollen. Pressure sore	Splint removed, elbow extended. Elevation, heat. Closed reduction 10 days after injury. Right angle flexion	Volkmann's contraction. Neurolysis 3 mos. after injury. End-result unknown
C.R. (W.293820)	3	24 hrs. Two attempts at reduction made elsewhere	Hand swollen, cyanotic and tender. Diminished sensation. Loss of extension of fingers and wrist. Feeble radial pulse. Elbow swollen	Splint removed. Elbow extended and elevated. At end of 5 days, closed reduction. Pulse disappeared. Incision over elbow, evacuation of blood clot. No reduction. 140° extension	Slight flexion contraction of fingers. Cleared up with physical therapy. A <sub>3</sub> F <sub>1</sub> E <sub>4</sub>
M.T. (E.278179)	5	2 hrs. No previous treatment	Hand pale. Loss of sensation and motor power. Absent radial pulse	Immediate operation. Medial incision; lower half did not bleed. Exposure and freeing of vessels found twisted about upper fragment. Fixed with elbow extended. Later, closed reduction unsuccessful	Pulse returned. No contraction. A <sub>4</sub> F <sub>4</sub> E <sub>4</sub>

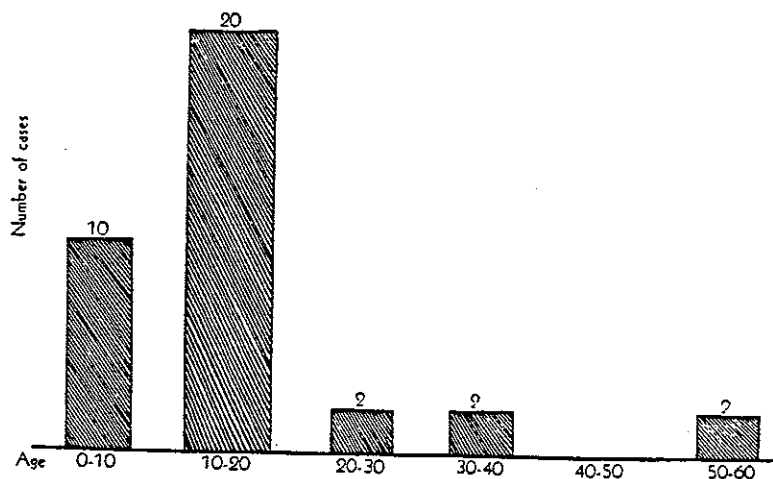


Fig. 8. Medial epicondyle fractures (36 cases). Age distribution by decades.

45 of the 57 patients more than 1 year after discharge from the hospital, and the gradings are shown in Table V. The outstanding impression from their study is the excellence of the results. They were graded excellent or good, meaning practically normal function in 37, or 82 per cent. There were 3 poor results, 2 due to ischæmia, and 1 due to gas bacillus infection developing in a patient with a compound fracture who had been treated elsewhere and in whom disarticulation of the shoulder had to be performed immediately upon admission. Five results were graded as fair, meaning some alteration of alignment and moderate limitation of elbow function. Only 3 of these were attributed to our treatment, one being a case of ischæmia, another a patient admitted only after a delay of 10 days in whom an open reduction was done, and the third the case of a patient with a compound fracture who re-fractured the elbow 7 months after the first injury.

It remains to be added that a considerable number of good and even excellent results were obtained even in the absence of complete reduction. Several patients with old malunion and uncorrected complete posterior displacement of the lower fragment have been followed in the fracture clinic and in the end obtained useful elbows. Bony consolidation always took place, and, although in the beginning there was an ugly deformity which seemed to block flexion of the elbow, even this

was eradicated in the course of time as growth from the lower epiphysis elongated the humerus and pushed the elbow away from proximity to the point of injury. This should be remembered when dealing with fractures associated with vascular disturbance. Change in the carrying angle of the elbow was noted in some of the end-result examinations, but rarely exceeded 5 to 10 degrees, and seemed to be of little functional significance. It would seem that the alteration must be of a rather gross type if it is to constitute a handicap. The ability completely to extend the elbow was

TABLE V.—RESULTS IN SUPRACONDYLAR FRACTURES

	Total	Excel- lent A <sub>1</sub> F <sub>4</sub> E <sub>4</sub>	Good A <sub>2</sub> F <sub>3</sub> F <sub>4</sub> E <sub>4</sub>	Fair A <sub>3</sub> F <sub>2</sub> E <sub>4</sub>	Poor	Un- known
<i>Flexion type of fracture</i>						
Closed reduction	1		1			
Open reduction	2		1			1
<i>Hyperextension type of fracture</i>						
No displacement	1	1				
Old malunion (physical therapy)	2		1	1		
Closed reduction	38	23	4		1, 2	0
Open reduction	10	3	3	2		2
Refused treatment	1			1		
Compound fractures	2			1	A, 1	
Totals	57	27	10	5	3	12

I.—Ischæmia; A.—Amputation.

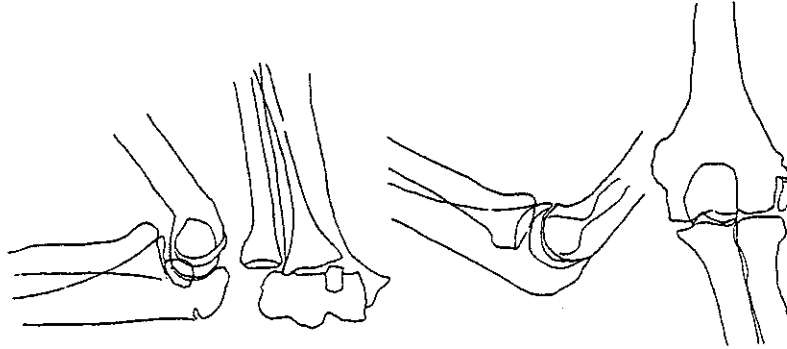


Fig. 9, left. Posterior dislocation of elbow with fracture of medial epicondyle following reduction. Note that the epicondylar fragment has been caught in the joint space. This patient had ulnar palsy.

Fig. 10. Same case as Fig. 9 showing end-result 13 months after injury. The epicondylar fragment was removed, and the patient has recovered from the ulnar nerve lesion. There is a small area of calcification in the lateral portion of the joint capsule.

recovered in almost all cases, restriction of 10 to 15 degrees being found only in a few.

## II. FRACTURE OF EPICONDYLES

Fracture of the medial epicondyle is common, while fracture of the lateral epicondyle is rare. There were 36 patients with the former injury, or 8.2 per cent of the entire group, while there were only 7 instances of the latter injury (1.7 per cent) all insignificant and none requiring admission to the house. The difference in the frequency of the two injuries is accounted for by the difference in ossification of the two processes, the medial epicondyle having a large, separate center of ossification, while there is only a tiny center of ossification for the lateral epicondyle, which is well protected, and does not serve as an important point of attachment for muscles or ligaments. The epiphyseal center for the medial epicondyle appears at about the ninth year and unites from the fourteenth to the fifteenth year.

Most of the fractures affecting the medial epicondyle are in reality epiphyseal separations. This is shown by the age of the patients—of the 14 patients with this injury 13 occurred between the ages of 10 and 17 years (Fig. 8).

The medial epicondyle is most commonly fractured in association with posterolateral dislocation of the elbow, being pulled away by the attachment of the strong internal lateral

ligament. This association was found in 14 of the 36 examples of this injury, or 40 per cent. The injury may be complicated by other bony injuries due to the dislocation, such as fracture of the head or neck of the radius and of the coronoid process. In the cases of fracture unaccompanied by dislocation, the injury is the result either of direct violence applied to the epicondyle or of an adduction strain of the elbow.

The treatment of fractures of the medial epicondyle is chiefly the treatment of the associated injuries, that is reduction of the dislocation if present followed by fixation of the elbow in the position of acute flexion. Nothing can be accomplished in the way of direct closed reduction of the fracture, but the position of acute flexion secures relaxation of the flexor muscles of the forearm which are attached to the epicondyle, and thus tends to bring about replacement.

No functional impairment need be anticipated following fracture of the epicondyle unless there is an accompanying dislocation. When the two occur in association the prognosis is that of the dislocation. In our group of 14 house patients of which 11 had associated dislocations, end-result examinations were made in 11. The functional results were excellent in 10, although in 3 the epicondyle had united by fibrous union only. One result was poor, but this was due to the dislocation and not to the fracture.



TABLE VI.—DISLOCATION OF THE ELBOW WITH FRACTURE OF THE MEDIAL EPICONDYLE AND DISPLACEMENT INTO THE JOINT

Identifica- tion	Age	Length of time after injury	Reduction of dislocation	Ulnar palsy	Treatment	Result
W.I.I. (O.290721)	15	Few hours	Immediate closed reduction	Complete	Excision of fragment. Transplant of ulnar nerve	A <sub>4</sub> F <sub>1</sub> E <sub>1</sub>
G.W.M. (W.310488)	12	3 days	Dislocation reduced by outside physician	Complete	Excision of fragment. Transplant of ulnar nerve	A <sub>4</sub> F <sub>1</sub> E <sub>1</sub>
K.L. (O.208864)	16	Few hours	Immediate closed reduction	No	Immediate operative replacement of fragment	Immediate result good. End-result not known
D.A.T. (E.283279)	16	5 months	Dislocation reduced by outside physician. Had limited elbow function	Complete	Transplantation of ulnar nerve. Nothing done to fragment	A <sub>2</sub> F <sub>1</sub> F <sub>1</sub> Recovered nerve function but had limited flexion and extension of elbow
P.Z. (O.286236)	15	24 hours	Dislocation reduced by outside physician	Complete	Excision of fragment. Transplantation of ulnar nerve	A <sub>4</sub> F <sub>1</sub> E <sub>1</sub>

II A. DISPLACEMENT OF THE MEDIAL EPICONDYLE INTO THE ELBOW JOINT WITH ULNAR PALSY

There is one complication that must always be looked for in patients with dislocation of the elbow and fracture of the medial epicondyle. This is displacement of the epicondylar fragment into the elbow joint and imprisonment of it there when the dislocation is reduced. The ulnar nerve being attached to the epicondyle is carried along with it into the joint and later becomes pinched between the articular surfaces when reduction of the dislocation is effected with resulting ulnar palsy. Usually the first warning of the presence of this complication is the appearance after reduction of the characteristic signs of ulnar nerve injury. An X-ray examination should be made, however, both before and after the reduction and in the first films the appearance of the epicondylar fragment lying widely displaced and slightly to the outer side of the medial ridge of the trochlea should lead one to anticipate its occurrence while in the postreduction films the inter-articular position of the fragment is clearly shown (Figs. 9 and 10).

The treatment of the condition necessitates immediate operation to remove or replace the fragment and to free the nerve. The longer the nerve is compressed the greater the time that will be required for its recovery. Occasionally ulnar palsy is absent, but even then the intra-articular fragment should be removed as it will interfere with elbow function. In our opinion it is preferable to excise rather than to replace the fragment as this elimi-

nates the problem of fracture healing and the patient may be treated as for an uncomplicated dislocation alone. If the fragment is removed, it is advisable to transplant the nerve to the front of the elbow for the sake of safety. Excision of the fragment causes no functional impairment.

In our group of 14 patients with fracture of the medial epicondyle associated with dislocation of the elbow, the epicondylar fragment was caught in the joint after the reduction in 5 instances. In 4 of the 5 cases there was complete ulnar palsy. The treatment and results are shown in Table VI.

III. FRACTURES OF THE CONDYLES OF THE HUMERUS

The group of the condylar fractures includes fractures of the medial and lateral condyles and the intercondylar or so-called T fractures. The fractures of the single condyles are usually oblique splits extending downward from the lateral or medial supracondylar ridge respectively into the trochlear or capitellar

TABLE VII.—FRACTURE OF THE CONDYLES OF THE HUMERUS

The group of condylar fractures comprised 50 cases divided as follows:

	House cases	E. W. cases
Internal condyle.....	5	11
External condyle.....	0	14
Intercondylar.....	12	2
	<hr/>	<hr/>
Total.....	23	27

Total..... 50

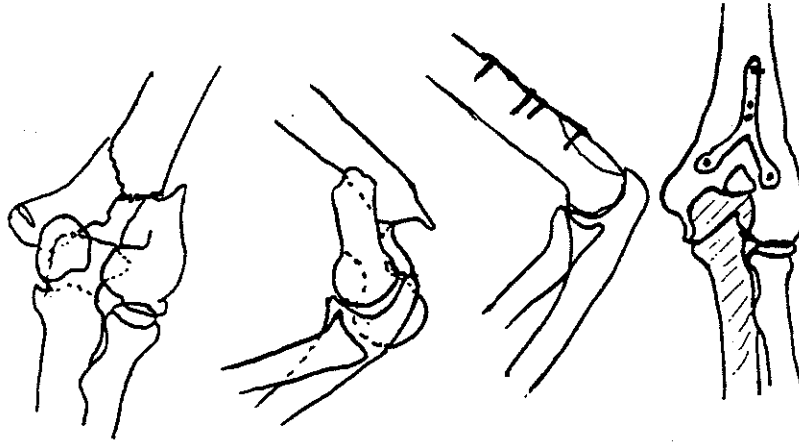


Fig. 11. Intercondylar fracture of lower end of humerus treated by open reduction and internal fixation. A and B. X-rays showing the deformity upon admission to the hospital. C. and D. X-rays taken one year later showing end-result after open reduction.

TABLE VIII.—FRACTURES OF THE CONDYLES OF THE HUMERUS (INTRA-ARTICULAR)

Internal Condyle

Identification	Age	Period after injury	Complications	Displacement	Treatment	Result
H.B. (E.308240)	10	Few hours	None	++++	Closed reduction unsuccessful. Open operation performed with excision of condyle	A <sub>2</sub> F <sub>2</sub> E <sub>2</sub> A poor result
H.M. (E.260357)	12	Few hours	None	++++	Closed reduction with fixation at right angle flexion. Second closed reduction performed later with fixation of elbow in acute flexion	A <sub>4</sub> F <sub>3</sub> E <sub>4</sub> Slight limitation of extension
A.P. (O.274878)	34	Few hours	None	++++	Closed reduction unsuccessful. Open reduction performed with fixation of fragment by a steel screw	A <sub>4</sub> F <sub>3</sub> E <sub>4</sub> Slight limitation of extension
C.H.A. (O.278522)	58	Few hours	Recent operation for cataract	+++	Closed reduction performed with fixation of elbow in acute flexion. Mobilization begun at end of 12 days	Immediate result good. No end-result
J.A.M. (E.300704)	68	Few hours	Diabetes. Fractures of patella and carpal scaphoid	++ Previous old fracture of elbow	Reduction not considered necessary. Fixation with sling only. Early massage and mobilization	Immediate result good. End-result not obtained

External Condyle

A.C. (O.258092)	2	Few hours	None	+	No reduction. Fixed in acute flexion	A <sub>4</sub> F <sub>3</sub> E <sub>4</sub>
S.M. (O.288835)	20	Few hours	None	+	No reduction. Fixed in acute flexion	A <sub>4</sub> F <sub>3</sub> E <sub>4</sub>
P.K. (O.267455)	38	Few hours	None	++	Closed reduction unsuccessful. Open reduction performed, no internal fixation. Elbow fixed in acute flexion	A <sub>4</sub> F <sub>3</sub> E <sub>4</sub>
A.S. (O.310337)	37	Few hours	Fracture of toes	++	Closed reduction performed and elbow fixed in acute flexion for 24 days. At the end of 6 months very little motion of elbow. Operation: resection of lateral condyle	A <sub>2</sub> F <sub>3</sub> E <sub>2</sub> Flexion 80° Extension 10°. An industrial compensation case
M.F. (O.269552)	18	Few hours	Posterior dislocation of elbow	+++	Closed reduction performed. Elbow fixed in acute flexion	A <sub>4</sub> F <sub>3</sub> E <sub>4</sub>
P.H. (O.271284)	35	Few hours	Wound over olecranon, not compound	+	Débridement of wound. Closed reduction performed with fixation of elbow in acute flexion	Immediate result excellent. End-result not obtained

TABLE IX.—FRACTURES OF THE CONDYLES OF THE HUMERUS (INTRA-ARTICULAR)

Intercondylar (T) Fractures						
Identification	Age	Period after injury	Complications	Displacement	Treatment	Result
H.McW. (O.358355)	23	Few hours	Fracture external malleolus	++++	Closed reduction, traction and suspension with elbow in right angle flexion. Poor position	A <sub>2</sub> F <sub>2</sub> E <sub>2</sub> About 1/2 limitation of motion
G.McA. (E.279327)	12	Few hours	Primary injury of radial nerve. Later, recovered spontaneously	++++	Closed reduction unsuccessful. Operative reduction with fixation of condyles by screw. About 1/2 limitation of motion	A <sub>2</sub> F <sub>2</sub> E <sub>2</sub>
A.B. (W.265817)	39	Few hours	Old ununited fracture of capitellum	+++	Closed reduction attempted on three different occasions without success. Later, open reduction performed with fair position but resulted in ankylosis. Excision of elbow performed	A <sub>2</sub> F <sub>2</sub> E <sub>2</sub> Fair motion; but elbow is weak and unstable
E.J. (E.288923)	35	Few hours	Compound and badly soiled	++++	Débridement performed with excision of the condyles. Fixation in traction and suspension with elbow at right angle	A <sub>2</sub> F <sub>2</sub> E <sub>2</sub> Excellent motion but elbow is weaker than normal
T.H. (O.307720)	70	1 year	Ununited fracture	++++	Compound fracture treated by outside physician with failure of union. On account of age, no operation advised. Brace fitted	A <sub>2</sub> F <sub>2</sub> E <sub>2</sub> Patient died 16 mos. later
G.D. (E.310221)	21	Few hours	Old infantile paralysis affecting arm	++	Closed reduction performed and elbow fixed in acute flexion	A <sub>2</sub> F <sub>2</sub> E <sub>2</sub>
L.Z. (E.284930)	14	Few hours	Fracture of head of radius	++++	Treated by traction and suspension with elbow in different positions for 3 weeks	A <sub>2</sub> F <sub>2</sub> E <sub>2</sub>
L.R. (W.286775)	8	24 hours	Fracture of lower end of radius	++	Closed reduction. Elbow fixed in acute flexion	A <sub>2</sub> F <sub>2</sub> E <sub>2</sub>
L.D. (W.276845)	14	Few hours	None	++++	Closed reduction unsuccessful. Open reduction performed with fixation of condyles by screw	A <sub>2</sub> F <sub>2</sub> E <sub>2</sub> Moderate limitation of extension
F.W. (E.268634)	40	Few hours	None	++	Closed reduction. Elbow fixed in acute flexion	A <sub>2</sub> F <sub>2</sub> E <sub>2</sub>
E.P. (W.272431)	10	11 days	Scarlet fever	++	Closed reduction performed twice, elbow fixed in acute flexion	A <sub>2</sub> F <sub>2</sub> E <sub>2</sub>
P.G. (E.305427)	38	Few hours	Feeble-minded. Post-operative infection	++	Open reduction performed 4 days after injury. Fixation with 2 plates and screws. Developed sinus but no osteomyelitis. Healed after removal of plates	A <sub>2</sub> F <sub>2</sub> E <sub>2</sub> Slight limitation of extension

portions of the articular surface of the humerus. The intercondylar fractures are often of the T or Y type—that is, a transverse fracture through the shaft of the humerus at its junction with the condyles combined with a vertical split down between the condyles. These are often accompanied by comminution of greater or lesser extent (Fig. 11).

The condylar fractures are severe injuries and seriously menace the future function of the elbow joint. Extensive pathological changes are produced in the articular surfaces and joint capsule both as a result of the injury and of the reparative process. The displacement on the one hand may be of an extreme type with separation and rotation of the condyles and overriding of the shaft fragment, or on the other, may be almost completely absent. Between these extremes all degrees of

displacement may be found. Because of this variation the treatment of condylar fractures is always an individual problem and must be decided after consideration of the nature of the fracture, the extent of the displacement, and the age of the patient.

Our group of condylar fractures comprised 50 cases (11 per cent of the entire group) divided as shown in Table VII. The salient facts about the individual patients are shown in Tables VIII and IX.

It will be noted that a little more than half of the patients (54 per cent) were treated in the Emergency Ward only. All of these were fractures with little or no deformity for whom house admission was not considered necessary. In view of the prevalent impression of the invariable severity of condylar fractures it is a matter of interest to have found among them

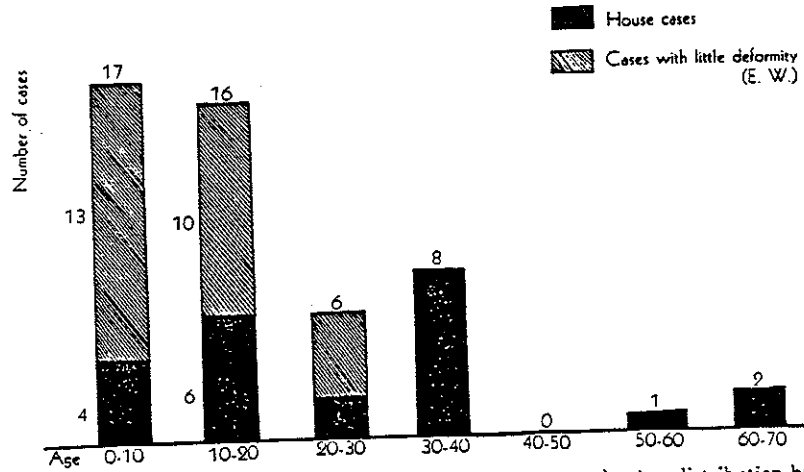


Fig. 12. Fractures of the condyles of the humerus (50 cases). Age distribution by decades.

such a high proportion of injuries that appeared to have but slight functional significance. Such injuries occurred chiefly in the first two decades of life while the fractures with deformity reached their peak in the age group between 30 and 40 years.

End-result examinations were obtained in 20 of the 23 house cases, and the gradings are shown in Table X. From an analysis of these cases the following conclusions seem justified:

1. The method of closed reduction is of value in the condylar fractures with slight or moderate deformity, but is not effective in the comminuted fractures with severe deformity, especially those of the intercondylar type.
2. In condylar fractures with severe deformity the choice would appear to lie between

open reduction preferably with internal fixation of the major fragments by screws or plate, or treatment in suspension and traction with early mobilization of the elbow joint. The decision between these methods should take into consideration the patient's age, occupation, and general condition, and the facilities available for performing technically difficult and potentially dangerous operations upon the bones and joints.

3. Following closed reduction of fractures of the medial condyle, retention of position is favored by the position of acute flexion which secures relaxation of the muscles attached to the condylar fragment; for the same reason in fractures of the lateral condyle the position of complete extension is the more favorable.

TABLE X.—END-RESULTS (1 YEAR) AFTER CONDYLAR FRACTURES (INTRA-ARTICULARLY)

Method of Treatment	Results				
	Excellent A3-4 F4 E4	Good A2-4 F3 E4	Fair A2 F2 E4	Poor A1-2 F1-2 E2-2	Unknown
No reduction; fixation only	1	1			
Old ununited fracture; brace fitted				Later excision 1	
Closed reduction and acute flexion	3	3		Later excision 1	2*
Traction and suspension	1		1		
Operative reduction	1	3	1	1	
No reduction, early motion			1	1	1*
Excision of condyles (early)					3
Total	6	7	3	4	3

\* Immediate results good.

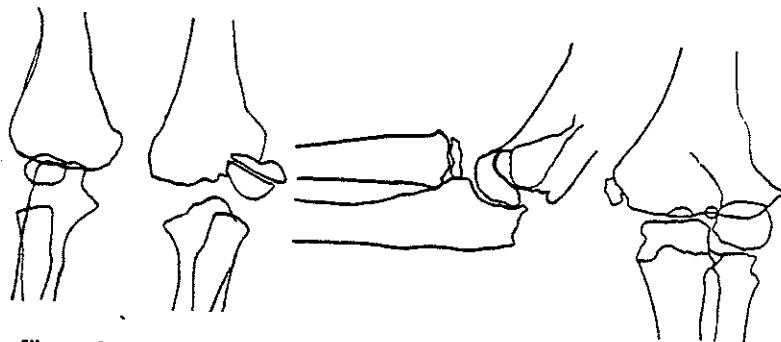


Fig. 13, left. Fracture of capitellar epiphysis with small plaque of bone attached. There is moderate rotary displacement. The normal elbow is shown for comparison.  
 Fig. 14. Same case as shown in Fig. 13 showing end-result two years after injury. The capitellar epiphysis was replaced by open operation and sutured. There was no arrest of growth.

4. Following open reduction, early mobilization is to be urged, and this is facilitated by secure internal fixation of the fragments. Postoperative support is best provided by the application of traction and suspension apparatus. This protects the elbow and also permits mobilization.

5. Skeletal traction by means of a wire (Kirschner) passed through the olecranon may prove of value in the treatment of comminuted fractures of the condyles with deformity, but was not used in any of these patients. It offers a means of securing continuous extension in the axis of the humerus while at the same time permitting the elbow joint to be maintained in the position of right angle flexion.

6. Excision of the condyles should not be performed, except immediately in certain badly soiled compound fractures as a step in the operation of débridement or late in case of complete ankylosis of the elbow. In the latter condition arthroplasty is preferable to excision, and results in a more stable joint.

#### IV. FRACTURES OF THE CAPITELLUM

Two types of injury affecting the capitellum must be distinguished: first, those involving the epiphysis, which occur only in children below the age of 15, and second, those involving the capitellar portion of the articular surface in adults. Both are serious injuries, but the epiphyseal fracture is the more common and therefore the more important of the two injuries.

#### IV A. FRACTURE OF THE CAPITELLAR EPIPHYSIS

Of the epiphyseal fractures one must distinguish between those with incomplete and those with complete displacement.

*Incomplete displacement.* Many fractures of the capitellar epiphysis are associated with such slight displacement that there is failure to recognize the nature of the injury even upon X-ray examination. The patient is dismissed with a diagnosis of sprain or contusion. Adequate protection of the elbow is not provided, and it is only later when continued irritation has resulted in persistent pain and stiffness that a correct diagnosis is made.

In order to recognize pathological variations it is important to know the normal anatomic features. In the lateral roentgenogram the osseous center of the capitellar epiphysis projects forward and downward from the humeral shaft and gives an appearance somewhat similar to that of a hockey stick with a shortened head. The anterior surface of the epiphysis forms a continuous line with that of the humeral shaft except for the interruption in the shadow due to the cartilaginous plate. In the fractures with incomplete displacement the epiphysis is displaced somewhat posteriorly, and there is a distinct jog in the line of the anterior surface. The roentgenogram must be made with the tube accurately centered so as to produce a true lateral view or this slight displacement will not be recognized. The anteroposterior view fails to show any abnormality, the fracture line being invisible since it coincides with the cartilaginous disk.

## SURGERY, GYNECOLOGY AND OBSTETRICS

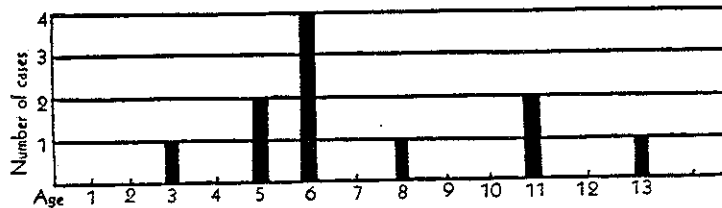


Fig. 15. Capitellar epiphyses fractures (11 cases). Age distribution.

Epiphyseal fracture should be suspected in any child who presents objective signs of injury to the elbow such as pain, swelling, tenderness, and limitation of motion, yet whose roentgenograms at first glance fail to show any evidence of bony injury. The relations of the capitellar epiphysis to the humeral shaft should be scrutinized closely in such cases and a second X-ray examination should be made if any doubt exists as to one of the views being a true lateral one. Films should also be made of the uninjured elbow for purposes of comparison with the normal.

The injury is not of great importance when treated properly. It is unnecessary to correct the displacement, as a rule, as this is too slight to cause any functional disturbance. Exceptions to this rule, however, must be recognized. Fixation of the elbow is, however, necessary, preferably in the position of acute flexion. This should be maintained for a period of 2 to 3 weeks following which mobilization may be begun.

*Complete rotary displacement.* Fracture of the capitellar epiphysis with complete rotary displacement is a distinct clinical entity which has not heretofore received adequate recognition. The mechanism of the injury is apparently a medial or varus deviation of the forearm from indirect violence, throwing strain upon the lateral ligament of the elbow, which in turn pulls off the capitellar epiphysis, usually with a thin layer of bone attached to the cartilaginous plate. The epiphysis is dislocated outward and rotated upside down by the pull of the extensor muscles attached to its lateral surface (Figs. 13, 14).

There is complete loss of contact between the fractured surfaces and failure of union is bound to result unless replacement is secured. This can be accomplished with certainty only by the open method and in our opinion no

other form of treatment should be attempted. Open reduction is easy when performed early; the epiphysis can be fitted back into position and secured by one or two chromic gut sutures passed through the ligamentous attachments and periosteum. Following operation the elbow should be splinted in the position of right angle flexion or partial extension to secure relaxation of the extensor muscles of the fingers and wrist.

Several children with ununited fracture of the capitellar epiphysis have been followed on the fracture service of the Massachusetts General Hospital, and the end-results of the same condition have also been seen in adults. There is increasing deformity of the lower end of the humerus over a period of years due to absence of growth from the capitellar epiphysis. The medial side of the humerus outgrows the lateral side, and there develops marked cubitus valgus deformity. This not infrequently causes elongation or stretching of the ulnar nerve with late or delayed ulnar palsy sometimes not coming on until 15 to 20 years after injury. The loose fragment displaces in and out of the elbow joint on movement, and although a fair range of motion is retained, there is instability and loss of power. In patients with ununited fractures of the capitellum who are seen within 3 to 4 years after injury improvement can be obtained by an operation designed to bring about union between the loose fragment and the shaft with the aid of a bone graft, and the benefits of surgical treatment even at this stage should be more generally recognized.

In our group of elbow fractures there were 11 instances of epiphyseal fracture of the capitellum. The ages of the patients varied from 3 years to 13 years but the peak of the incidence was at the sixth year (Fig. 15). The types of epiphyseal injury that were

TABLE XI.—EPIPHYSEAL FRACTURES OF THE CAPITELLUM

Identification	Age	Age of injury	Displacement	Treatment	Result			
					A	F	E	
<b>Fractures with Slight Displacement</b>								
F.W. (W.294103)	11	6 wks.	+	Fracture healed. Slight deformity. Active use advised	4	3	4	Good
W.B. (E.W.)	5	Fresh	o	No attempt at reduction. Elbow bandaged in acute flexion	4	4	4	Excellent
R.W. (E.293059)	13	24 hrs.	+	Only slight deformity. No reduction. Elbow fixed in acute flexion	3	4	4	Excellent
<b>Complete Fractures with Rotary Displacement</b>								
J.Z. (O.268888)	11	Fresh	++++	Closed reduction attempted but was unsuccessful. Open reduction was performed and good position obtained	3	4	4	Excellent
G.R. (E.291828)	6	7 days	++++	Open reduction was performed with complete replacement. Elbow fixed in acute flexion	4	4	4	Excellent
R.W. (E.301774)	6	5 days	+++	Closed reduction attempted but was unsuccessful. Open reduction was performed with complete replacement. Fixed in acute flexion				End-result not obtained. Immediate result good
M.D. (O.286259)	3	Fresh	+++	Open reduction was performed with complete replacement. Fixed in acute flexion				End-result not obtained. Immediate result excellent
L.P. (O.301478)	6	4 years	Non-union of epiphysis	Open operation was performed. Old fractured surfaces were freshened. Bone graft was interposed between fragments to restore normal articular plane. Fragments fixed with 3 steel screws. Elbow fixed by posterior plaster splint in right angle flexion	3	4	4	Good
<b>Complete Epiphyseal Fractures with Lateral Displacement but No Rotation</b>								
J.S. (E.262454)	5	Fresh	++	Closed reductions were performed twice with fixation of the elbow in acute flexion but with little improvement. Patient developed bronchitis, making operative or further attempts at reduction unwise	3	4	4	Excellent
F.L. (O.270550)	8	19 days	Post-lat. dislocation of elbow	Atypical lateral rotation of epiphysis. Open reduction was performed with suture of fragment. Excellent position was obtained	4	4	4	Excellent
B.P. (O.297389)	6	25 days	Fracture already united	Considerable deformity. Epiphysis was displaced outward but not rotated. Open reduction was considered but rejected. Active use was advised				End-result not obtained

encountered together with the methods of treatment employed, and the end-results so far as they are known, are shown in Table XI. No instances of arrest of growth were encountered and this is due to the fact that the fracture line passes proximal to the epiphyseal plate instead of through it.

#### IV B. FRACTURES OF THE CAPITELLUM (ADULTS)

Fracture of the capitellum in the adult usually takes the form of a separation of a portion of the articular surface with forward and upward displacement of the loose fragment and the formation of a free body in the joint. Occasionally the fracture is of the compression type, the articular surface being driven upward and impacted into the under-

lying bone. The fracture is apparently produced by force transmitted upward through the radius, the head being driven against the articular surface of the capitellum. The fracture is frequently associated with other injuries in the region of the elbow such as fracture of the head of the radius or dislocation of the ulna on the humerus. The treatment depends entirely upon consideration of the individual case. When a loose fragment has been separated, it may be necessary to remove this by open operation; in other types of fracture open reduction may be indicated. It is generally impossible to influence the deformity by closed methods.

There were 3 instances of this fracture in our group of 439 elbow injuries, the ages of

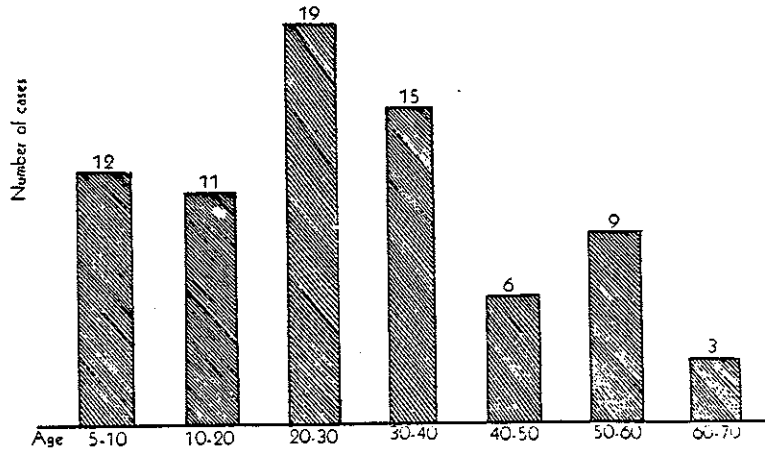


Fig. 16. Upper end of radius fractures (75 cases). Age distribution by decades.

the patients being 42, 51, and 69 years, respectively. In one case the fracture was complicated by posterior dislocation of the elbow; this was reduced and the result at the end of 1 year was graded  $A_4 F_3 E_2$ . In the second case there was an accompanying fracture of the olecranon process. This was treated by operative suture with wire. The patient later died of coronary thrombosis. The third patient was only admitted 4 months after injury at which time there was a bony ankylosis of the elbow. Arthroplasty was performed with the insertion of a free flap of fascia lata, and at the end of 1 year the result was graded  $A_2 F_2 E_3$ . There was a nearly normal range of motion but some instability and loss of power.

#### V. FRACTURES OF THE HEAD AND NECK OF THE RADIUS

Fractures of the head and neck of the radius numbered 75 cases, or 17 per cent, of the entire group. After the supracondylar fractures of the humerus and the dislocations of the

elbow they constituted the third largest group of elbow injuries. The accompanying graph (Fig. 16) showing the age incidence of the fracture indicates that it is more commonly an injury of adult life than of childhood, and that the peak is reached in the age group between 20 and 40 years.

The injury may be produced either by indirect violence, the force being transmitted along the shaft of the radius and driving the head against the capitellum, or by direct violence acting on the lateral aspect of the upper forearm or elbow. In a fairly high proportion of the cases (27 per cent in our series) the fracture occurs in association with some other injury of the elbow, particularly posteromedial dislocation of the elbow or fracture of the olecranon process. This shows the vulnerability of the head to articular displacements of any kind. The list of complicating injuries is shown in Table XII.

Several different types of fracture of the radial head can be distinguished, and their

TABLE XII.—FRACTURE OF THE HEAD AND NECK OF THE RADIUS

List of Complicating Injuries of the Elbow—75 Patients	
Posteromedial dislocation of the elbow (with fracture of coronoid process—5)	8
Fracture olecranon process	10
Fracture upper third of ulna into elbow joint	1
Intercondylar fracture lower end of humerus	1
	20 or 27 per cent

TABLE XIII.—FRACTURES OF THE HEAD AND NECK OF THE RADIUS

Types of Injury and Incidence in 30 Patients	
Epiphyseal fractures, upper end of radius	3
Fissure fractures of radial head without displacement	3
Fractures of radial head with displacement	11
Fractures of radial neck with displacement	8
Comminuted fractures involving both head and neck	5
Total	30
Compound fractures	3



differentiation is important from the viewpoint of treatment. The list of these together with their incidence in our group of 30 carefully studied house patients is shown in Table XIII.

The epiphyseal fractures numbered 3, or 10 per cent, in our group of 30 house patients. Two of the patients were aged 8 years and one 13 years. Below the age of 7 years the epiphysis is largely cartilaginous and able to resist injury, and it unites with the shaft at the age of 14 to 15 years so that the age period in which epiphyseal fracture may be produced is relatively short. The osseous center represents only a thin disk of bone and corresponds to the radial head. When the epiphysis is fractured and displaced, it is quite likely to become isolated as a loose body in the joint, devoid of blood supply. This occurred in one of our 3 patients when no operation was performed to replace the epiphysis. In the 2 other patients open reduction was performed and consolidation in good position was obtained (Fig. 17). No method of internal fixation was employed, the fragment being retained in alignment by the position of acute flexion of the elbow. Obliteration of the epiphyseal cartilage occurred in both cases, but no appreciable shortening of the radius resulted since the amount of growth contributed by the upper epiphysis at this age is slight. Table XIV presents summaries of the records of the patients with epiphyseal fracture.

Fractures of the head and neck of the radius, if associated with displacement, commonly cause serious impairment of elbow joint function. Not only does the bony deformity limit or prevent rotation of the upper articular

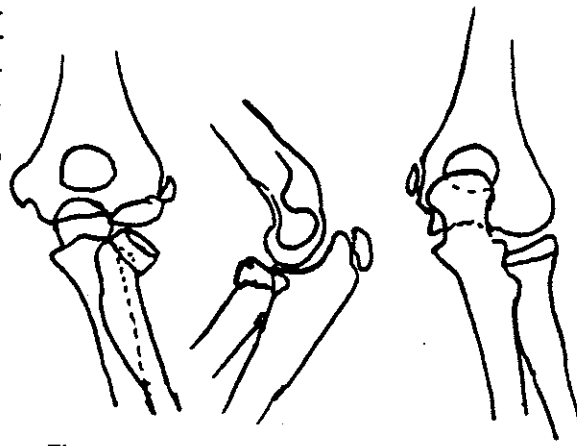


Fig. 17. Epiphyseal fracture of the upper end of radius. A. Roentgen appearance on admission showing tilting of the head. B. Following open reduction. C. Two months later showing union.

element in the lesser sigmoid cavity of the ulna with loss of the ability to pronate and supinate the forearm, but there is frequently limitation of extension of the elbow as well. This is due to scar formation and thickening in the anterior capsular ligament, usually the result of the displacement of a fragment of bone in this direction. To prevent future disability it is necessary to correct the bony deformity, but the situation and nature of the fracture are such as to render it impossible except by open operation. This may take the form of open reduction, excision of the displaced fragments, or resection of the entire radial head. When the bony deformity is absent or slight, no impairment of function should follow, and the only treatment indicated is protective splinting for a period of 2 to 3 weeks with gentle daily mobilization.

TABLE XIV.—EPIPHYSEAL FRACTURES UPPER END OF RADIUS

Identification	Age	Age of injury	Complications	Displacement	Treatment	Result (1 year)			
						A	F	E	
R.E. (W.266360)	13	2 days	Fracture of olecranon without displacement	Marked +++	Open reduction performed 5 days after injury. No internal fixation. Elbow splinted in acute flexion	4	4	4	Epiphysis closed
N.K. (W.276613)	8	6 days	Fracture of olecranon without displacement. Feeble-minded	Marked ++++	Elbow fixed in sling at right angle flexion. Reduction not attempted	3	3	3	Supination lacks 15°; extension lacks 20°. Loose body in joint
L.P. (O.276712)	8	14 days	Greenstick fracture of ulna	Marked +++ Callus present	Open reduction performed. Fragment loosened and replaced. Held in apposition by fixation of elbow in position of acute flexion	3	2	4	Only about 20° rotation of forearm. Flexion and extension normal

TABLE XV.—THE RESULTS OBTAINED IN FRACTURE OF THE HEAD AND NECK OF RADIUS

	Total	Good	Fair	Poor	Un- known
No reduction or operation performed	10	3	2	2	3
Open reduction and replacement—Early	5	1		1	3
Late	1		1		
Excision of fragments—Early	4	2	1	1	
Late	1	1			
Excision of head—Early	5	4	1	0	
Late	4	1	1	2	
Total	30	12	6	6	6

In our group of 30 house patients with fracture of the head and neck of the radius, operative treatment was employed in 20. The end-results in these cases are shown in Table XV. In grading these results the term "good" was used to designate 75 per cent or better restoration of pronation and supination and of flexion and extension.

Following the study of these cases and an analysis of the end-results, it seemed fair to draw the following conclusions in respect of treatment:

1. Open reduction ought not to be attempted except in the case of epiphyseal fractures and occasionally in fractures of the radial neck.
2. Excision of loose bone fragments should be performed only in the case of fractures involving the radial head when there is a single fragment and when at least two-thirds of the circumference of the head remains intact, including the inner half that articulates with the ulna.
3. In all comminuted and displaced fractures of the head and neck, resection of the head should be advised.
4. Better results are obtained when resection is performed early (within the first 2 weeks) rather than late.
5. A common complication is ossifying hæmatoma or myositis, particularly in fractures associated with dislocation of the elbow. This may follow resection of the radial head, but is not necessarily the result of operation.
6. To guard against this complication at the time of operation it is necessary to obtain

careful hæmostasis and to avoid leaving behind any loose bone fragments. (This is a common error.)

7. Following the excision of a single fragment or the resection of the radial head, the elbow should be splinted in the position of right angle flexion for the period of 1 week, following which mobilization should be begun.

8. Fracture of the head or neck of the radius is a serious injury and while the prognosis is good for the recovery of an useful elbow rarely is it a normal elbow. On the whole the results in this group of injuries were less good than in any other type of fracture or dislocation of the elbow.

#### VI. FRACTURES OF THE OLECRANON

Fractures of the olecranon constituted the fourth largest group of the injuries of the elbow, and numbered 61 or 14 per cent of the entire group. Of these, 33 were treated in the hospital as in patients, while 28 were treated as out patients. For the most part, these latter represented incomplete fractures or fractures without displacement. They have been used chiefly for statistical purposes. End-result notes (1 year or more after discharge) are available on 25 of the 33 house patients, or in 75 per cent.

The age distribution of the fracture as shown by the accompanying graph (Fig. 18) is fairly even throughout the various decades, but with the peak in the first three.

The injury may be produced by a fall on the outstretched hand, the elbow being in a position of semi-extension, or in rare instances, by direct violence, as from a fall on the flexed elbow or a direct blow. The former is the common mechanism, the olecranon giving way and fracturing as a result of the forcible flexion of the elbow against the resistance of the triceps muscle. In this type of injury the fracture is generally transverse, but there may be one or two small fragments in addition to the main ones. The olecranon fragment is generally retracted and separated from the rest of the ulna by the pull of the triceps, especially when the elbow is flexed. Separation of the fragments depends, however, upon the extent of laceration of the lateral aponeuroses of the triceps tendon which blend with the fascia of

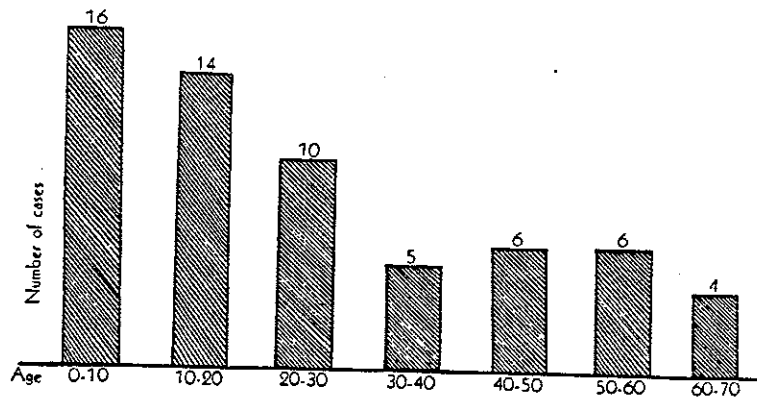


Fig. 18. Olecranon fractures (61 cases). Age distribution by decades.

the forearm and provide a second point of insertion for the triceps muscle. When these are intact, they limit or prevent displacement. Direct violence tends to produce a comminuted type of fracture, and the rarity of this mechanism is shown by the fact that only one example of this was found in 33 fractures. Separation of the fragments sufficient to necessitate operative repair was present in 24 cases; it was slight in 3, and absent in 4.

Complicating bony injuries were present in 14, or 42 per cent of the cases, and of these 9, or 27 per cent, represented other injuries in the region of the elbow. Fractures of the head or neck of the radius were most common and occurred in 6 or 18 per cent of the patients.

The treatment of olecranon fractures depends chiefly upon the amount of displacement that is present. Fractures without separation may be splinted with the elbow in the right angle position for a period of about 3 weeks, but the splints may be removed every day for physical therapy and mobilizing exercises. When the separation is slight, good contact between the fragments can usually be brought about by complete extension of the elbow. The reduction should be verified by X-ray examination, and when the position is shown to be satisfactory, the elbow should be immobilized in this position. Mobilizing exercises should not be started until the end of 3 weeks. When gross separation of the fragments is present, we believe that open reduction and suture is the best method of treatment. It has the advantages of securing close approximation of the fragments, of removing

interposing tendinous fibers which interfere with bony consolidation, and of securing bony, instead of fibrous, union. Operative repair, when properly carried out, shortens the period of convalescence and obviates the necessity of prolonged fixation of the elbow. It should be remembered, however, that it exposes the patient to the risk of infection, and that this hazard can be overcome only by skilful surgery and meticulous technique.

We believe that operative repair should bring about such close and firm fixation of the fragments that there should be no need for external splinting, or at the most, for splinting of short duration only. Prolonged postoperative fixation with the elbow in extension always results in slow recovery of function and should be avoided. Kangaroo tendon and chromic catgut are inadequate as suture materials and do not provide the secure fixation of the fragments necessary for early mobilization. We have seen several instances of secondary displacement following operation when these materials have been used. Metallic wire, steel screws, or flanged nails may be used successfully for this purpose, but for a number of years we have been partisan of the use of living fascia lata suture—a method that has been developed and used extensively by the surgeons of the fracture service of the Massachusetts General Hospital for the treatment both of fractures of the olecranon and of the patella. A fascial strip one-half to three-quarters of an inch in width is passed through holes one-quarter of an inch in diameter drilled in both fragments, the ends are tied,

TABLE XVI.—RESULTS OF TREATMENT OF  
OLECRANON FRACTURES  
Thirty-three House Cases

	Total	Excel- lent	Good	Fair	Poor	Unknown but good at dis- charge
No. cases treated with- out operation	10	3	1	1		5
No. cases in which oper- ative repair was done	23	16	1		3	3
Total	33	19	2	1	3	8
Materials used for in- ternal fixation						
Wire	2	2				
Beef bone screw	1	1				
Steel nail	1	1				
Chromic catgut suture	4	3				1
Kangaroo tendon suture	1				1	
Fascial suture (drill holes)	10	8			1	1
Fascial transplant over surface	3	1			ankyl- osis 1	1
Complicated case of non union	1		1			
Total	23	16	1		3	3
Compound	3	1				2

and the knot made secure by transfixion with interrupted sutures of fine silk. Such fascial sutures live, and do not constitute foreign bodies. On account of their great tensile strength, they secure firm fixation, and the elbow may be flexed to the right angle without danger of separating the fragments. No splinting is required beyond the use of large, soft dressings. Active motion may be begun at the end of 1 week, and the function is quickly regained. A second method of fascial reinforcement that was tried consisted in suturing the fragments with kangaroo tendon and then laying a free flap of fascia lata over the fracture line on the posterior surface and suturing it to the triceps tendon and adjacent soft tissues. This method seemed less good than the other.

The results 1 year or more after injury obtained by the various types of treatment in our group of 33 patients are shown in Table XVI. It is gratifying to note that in 21 of the 25 patients (84 per cent), these were graded as excellent or good. Of the 10 patients treated

without operation, 4 had fractures without displacement, and the elbow was fixed only by a sling; in 3 the separation was slight, and the arm was splinted with the elbow in extension; in 2 the elbow was suspended in right angle flexion from an overhead frame. Of the latter 2 patients one had a comminuted fracture without separation, and the other an uninfected, compound fracture without much displacement. One other patient with an accompanying fracture of the head of the radius was admitted to the hospital 4 months after injury. The head of the radius was excised, but the fractured olecranon had healed and did not require treatment.

Open reduction was performed in 23 patients, but 3 operations were required in 1 case so that there was a total of 25 operations. There were 2 postoperative infections, one severe and resulting in ankylosis, the other minor and leading to no functional impairment. The three poor results were caused; first, by postoperative sepsis leading to ankylosis; second, by a complicating fracture of the head of the radius, the functional impairment here probably being accounted for by this rather than by the fracture of the olecranon; and third, by a failure to secure good approximation of the fragments by fascial suture. The latter patient was discharged with what was considered satisfactory although not perfect reduction of his fracture. He drifted into other hands, and 5 months later underwent a second operation on the elbow. When examined at the end of 1 year, it was found that the olecranon had been removed, there was a complete ulnar nerve palsy, and the patient had considerable functional impairment of the elbow. It is fair to question whether this patient would not have had a better result if he had been left alone. One patient with an ununited fracture of the olecranon of 3 months' duration required three operations. At the first the fragments were freshened and sutured with kangaroo tendon, but the postoperative X-rays showed the fragments had re-separated. A second operation was performed 10 days later, and the fragments were fixed with wire. Consolidation was obtained with good function, but 5 months later re-fracture occurred as a result of a fall. A third

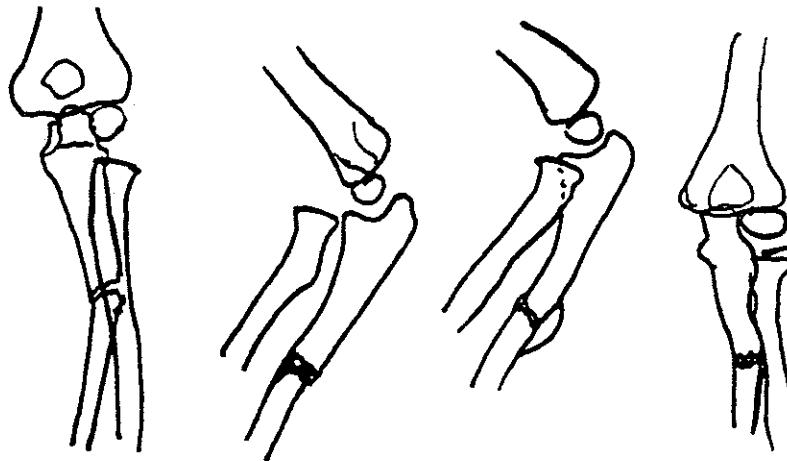


Fig. 19. Anterior dislocation of head of radius associated with fracture of shaft of ulna. A. and B. The deformity at the time of admission. C. and D. Appearance following open reduction of the head of the radius.

operation was performed, and the fragments were sutured with wire and fascia lata. The result at the end of 1 year was graded A<sub>3</sub> F<sub>3</sub> E<sub>3</sub>. There were no other instances of refracture. There were 3 compound fractures, and in 2 immediate débridement was performed with suture of the lateral expansions of the triceps. Both of these wounds remained clean, and the reduction of the fracture was satisfactory, but the end-results are unknown. The third patient was admitted 5 days after injury, and the wound, a pin point opening, remained clean.

It may be said in conclusion that:

1. The results of fracture of the olecranon process are in general excellent.
2. The fracture is complicated in about 25 per cent of the cases by other injuries of the elbow, and of these the most frequent are fractures of the head or neck of the radius. Such complicating injuries, when present, modify considerably the prognosis of fracture of the olecranon.
3. Fractures with little or no displacement may be treated with the elbow splinted in extension or supported in a sling at right angle flexion. They may be treated by early massage and mobilization.
4. Fractures with separation should be subjected if possible to operative repair with firm fixation of the fragments by wire, screw, or fascial suture. Internal fixation should be

secure enough to obviate the necessity of external splinting and to permit active mobilization at the end of one week.

#### VII. FRACTURE OF THE CORONOID PROCESS

In the group of 174 house patients with elbow injuries there were 7 instances of fracture of the coronoid process of the ulna. All of the patients were adult, 2 being in the third decade, 1 in the fourth, and 4 in the sixth. Six of the 7 fractures occurred as complications of dislocation of the elbow, and of these 4 were also associated with fracture of the head or neck of the radius, and 2 with fracture of the medial epicondyle. In the seventh patient the fracture of the coronoid complicated a fracture of the olecranon process.

The fracture is apparently caused by posterior displacement of the ulna upon the humeral condyles, the projecting tip of the process being knocked off. The small fragment may be retracted upward by the pull of the brachialis anticus muscle, but in our group of patients the amount of separation was never great. Healing may take place by fibrous instead of bony consolidation, but this of itself ought not to result in any functional impairment. The particular menace of fracture of the coronoid, however, lies in the danger of ossification of the hæmatoma that develops in the region of the fracture and of the anterior capsule. This complication occurred in one of

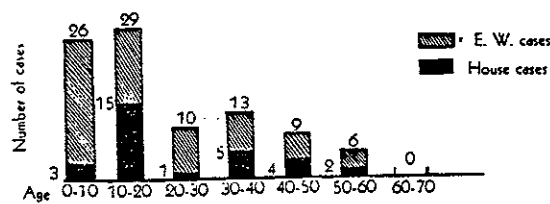


Fig. 20. Dislocations of the elbow (93 cases). Age distribution by decades.

our patients following an operation for an old unreduced dislocation of the elbow. An ossifying hæmatoma developed and resulted in complete bony ankylosis. We are inclined to feel that this resulted from the operation rather than from the accompanying fracture of the coronoid process. In general, fracture of the coronoid rarely needs to be considered from the standpoint of treatment, and all attention may be focused on the treatment of the accompanying dislocation or fractures.

Of the 7 patients 3 were treated by reduction of the dislocation and fixation in acute or right angle flexion; 2 with fractures of the head and neck of the radius underwent operation for excision of the head of the latter bone. In one of these cases the tip of the coronoid was also excised, and this patient obtained a good result. One patient with an accompanying fracture of the olecranon process was treated by operative suture of the ulnar fragments. The results at the end of 1 year were graded as excellent in 3, good in 1, poor in 2, and unknown in 1. Both of the poor results were to be attributed to the accompanying fractures or dislocation rather than to the fracture of the coronoid process.

#### VIII. DISLOCATION OF THE UPPER END OF THE RADIUS

In the group of 439 elbow injuries there were only 3 instances of isolated dislocation of the

radial head, and in all of these the displacement was in the anterior direction. In all 3 patients there was an accompanying fracture of the shaft of the ulna, and in 1 there was a fracture of the olecranon as well. The fracture of the ulna was compound in one instance. The ages of the patients were 8, 17, and 28 years, respectively. The trauma was a blow or fall on the extensor surface of the forearm.

The radial head is retained in its articulating position with the lesser sigmoid cavity of the ulna by the orbicular ligament, and as long as the ulna remains intact the interosseous membrane also constitutes a strong retaining ligament. For these reasons anterior dislocation is almost invariably accompanied by a fracture of the shaft of the ulna, either in the upper or middle thirds. This association is so definite that whenever a displaced fracture of the ulnar shaft is seen without accompanying fracture of the radius, an X-ray examination should be made of the elbow and a dislocation of the upper end of the radius looked for.

Treatment of the dislocation should take into consideration that either the orbicular ligament has been ruptured, in which case operative repair is indicated, or that the head has escaped from under the ligament, in which case replacement can be accomplished only by operative exposure. Furthermore, the relation of the dislocation to the fracture of the ulnar shaft must be borne in mind, and reduction of the ulnar deformity must be accomplished simultaneously with that of the dislocation. Open reduction of the dislocation should be performed through an anterior incision after preliminary exposure and isolation of the radial nerve. After replacement of the dislocated bone, the orbicular ligament should be sutured, and the fracture of the ulna reduced by open operation and plating if neces-

TABLE XVII.—ANTERIOR DISLOCATION OF RADIAL HEAD

Identification	Age	Age of injury	Complications	Treatment	Result
J.H.C. (O.276537)	8	7 days	Fracture of shaft of ulna. Temporary postoperative radial nerve palsy	Open reduction and suture of orbicular ligament	A <sub>4</sub> F <sub>4</sub> E <sub>4</sub> Perfect
E.R. (E.300468)	28	Fresh	Compound comminuted fracture upper third of shaft of ulna into joint	Immediate débridement of compound wound, simultaneous open reduction of head of radius	A <sub>3</sub> F <sub>3</sub> E <sub>4</sub> Incomplete reduction.
J.L. (E.269902)	17	Fresh	Fracture of shaft of ulna, fracture of olecranon	Open reduction of fracture of olecranon with open replacement of radial head	A <sub>4</sub> F <sub>4</sub> E <sub>4</sub>

sary. The best position for retention is with the elbow in acute flexion and with the forearm supinated in order to relax the pull of the biceps muscle. Mobilization of the radius in pronation and supination may be started at the end of 7 to 10 days, but the fracture of the ulna requires protection for from 3 to 4 weeks.

It has been claimed that reduction of the radial head is unnecessary for good function, but this is not borne out by our own observations. Instability of the head of the radius results and may be painful, but in any case is associated with weakness that makes heavy work impossible.

The histories of our 3 patients together with the end-results are shown in Table XVII.

IX. DISLOCATION OF BOTH BONES AT THE ELBOW

During the 7 year period under study our records showed 93 patients with dislocations of the elbow. They constituted the largest class of all the elbow injuries, exceeding even the supracondylar fractures, and represented 20 per cent of the entire group. The age distribution is shown in Figure 20. The peak of the incidence is found in the first two decades, and 59 per cent of all the dislocations occurred in this period. There is a marked drop in the incidence in the later decades.

Complicating fractures in the region of the elbow were very common, and were found in 53 patients, or 59 per cent. The list of injuries associated with elbow dislocations in the 30 carefully studied house patients is shown in Table XVIII. From a study of these multiple injuries, it appears that complicating fractures are rare with dislocations in the first decade when the ends of the bones are largely cartilaginous. In the second decade they are common due chiefly to the vulnerability of the epiphysis for the medial epicondyle during this period. They are rare again in the third decade, but after that dislocation is commonly accompanied by a fracture of one of the bony elements—the upper end of the radius, the coronoid process, external condyle, or capitellum.

Dislocation of both bones at the elbow may take place in the posterior, medial, lateral, or anterior directions, that is, the ulna carrying

TABLE XVIII.—TABLE OF FRACTURES COMPLICATING DISLOCATION OF THE ELBOW

Thirty Patients Treated in House

	Cases	Per cent
Fractures of elbow in order of frequency		
Medial epicondyle.....	13	43
Head or neck of radius.....	7	23
Coronoid process.....	5	16
External condyle of humerus.....	2	6
Capitellum.....	1	3
Fractures as found in combination with other injuries:		
Fracture of medial epicondyle alone.....		11
Fracture of head or neck of radius alone.....		3
Fracture of head or neck of radius and of coronoid process.....		2
Fracture of head of radius, coronoid process, and medial epicondyle.....		1
Fracture of coronoid process alone.....		1
Fracture of coronoid process and medial epicondyle.....		1
Fracture of head of radius, external condyle of humerus and surgical neck of humerus.....		1
Fracture of external condyle of humerus.....		1
Fracture of capitellum.....		1
Fracture of surgical neck of humerus.....		1
Fracture of both bones of the forearm.....		1
Epiphyseal fracture lower end of radius.....		1

with it the radius may displace from the humerus in any of these directions. We believe it is preferable and more in accord with usage in dislocations elsewhere to describe the dislocation in this manner rather than to observe the traditional method which treats the ulna as the fixed point and designates the type of dislocation according to the direction of the displacement of the humerus. In the group of 30 house patients with dislocations, the displacement was found to be posterolateral in 10, directly posterior in 11, posteromedial in 5, lateral in 3, and undetermined in 1. Thus posterior displacement of one or another type was present in 26 of the 30 patients. There were no instances of anterior dislocation, and this type usually associated with fracture of the olecranon is known to be very rare. In respect to the mechanism of the injury it was impossible to determine the number in which the dislocation was caused by direct violence from a blow or fall on the elbow or in which it resulted from a fall on the outstretched hand. The latter mechanism appeared more common.

From the standpoint of treatment the first and most important requirement is to make an exact diagnosis of the nature of the injury. This ought to be fairly obvious from local examination, but an X-ray examination should

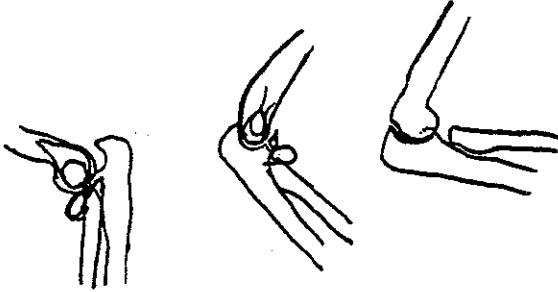


Fig. 21. Posterior dislocation of the elbow associated with fracture of the head of the radius. A. Appearance of deformity at time of admission. B. Following reduction of the dislocation. The radial head is still displaced. C. Following excision of the head of the radius.

always be made to confirm it, and to reveal any accompanying fracture that may be present. In spite of this long established rule there were included in the group 6 patients with late, unreduced dislocations varying from 28 days to 5 months after injury in which a correct diagnosis had never been made.

Dislocation of the elbow, whether or not complicated by fracture, requires immediate reduction. Closed reduction becomes increasingly difficult with the lapse of time, and the earlier it is performed, the easier it is to accomplish, and the less the danger of damaging any of the joint structures. The patient should be anesthetized in order to obtain complete muscular relaxation and to permit of reduction without the use of excessive force. The elbow should be hyperextended to unlock the coronoid process from the olecranon fossa, and while an assistant exerts gentle traction on the wrist, the operator should apply both thumbs to the olecranon and press the olecranon forward. When the ulna lies in a medial or lateral relation to the humerus it should first be pressed into a directly posterior relationship and then reduced. When reduction is accomplished, the elbow should be flexed to make the reduction secure, and fixed either in acute or right angle flexion depending upon the amount of swelling and circulatory impairment. We commonly make use of a posterior molded plaster splint for this purpose. Post reduction roentgenograms should be made immediately to make sure that complete reduction has been accomplished, and that the relations are normal in both planes.

TABLE XIX.—RESULTS OF TREATMENT OF DISLOCATIONS OF THE ELBOW

	Excellent A <sub>4</sub> F <sub>4</sub> E <sub>4</sub>	Good A <sub>4</sub> F <sub>3</sub> E <sub>4</sub>	Fair A <sub>1</sub> F <sub>2</sub> E <sub>3</sub>	Poor A <sub>2</sub> F <sub>1</sub> E <sub>2</sub>	Unknown
Fresh dislocations treated by closed reduction	13	5	1 <sup>1</sup>		5
Old unreduced dislocations treated by open reduction		2 <sup>23</sup>	1 <sup>4</sup>	3 <sup>547</sup>	

<sup>1</sup>Developed ossifying hæmatoma with large mass of bone lying anterior to head of radius.

<sup>2</sup>Unreduced dislocation 19 days old complicated by fracture of capitellum treated by open reduction.

<sup>3</sup>Unreduced dislocation, 90 days old, complicated by fracture of capitellum treated by open reduction.

<sup>4</sup>Unreduced dislocation, 63 days old, treated by open reduction.

<sup>5</sup>Unreduced dislocation, 56 days old, treated by open reduction.

<sup>6</sup>Unreduced dislocation, 30 days old, incompletely reduced by closed manipulation.

<sup>7</sup>Unreduced dislocation, 56 days old, complicated by fracture of coronoid process, treated by open reduction. Developed ossifying hæmatoma with ankylosis.

In case of fracture of the medial epicondyle one should make sure that the fragment has not become caught in the joint (see "Fracture of Medial Epicondyle") and that there is no evidence of ulnar palsy.

In uncomplicated dislocations the elbow should be immobilized for a period of from 7 to 10 days at which time massage and mobilization may be started, the elbow being supported at right angles by a sling. If there is a complicating fracture it may be necessary to prolong the period of fixation, but it is rarely necessary to make it longer than 2 weeks. Fractures of the radial head or neck with displacement when present as complicating injuries should be subjected to operation with excision of the head of the radius at the end of 6 to 8 days.

The special menace of dislocation is calcifying hæmatoma which usually develops in front of the anterior capsule of the joint. When this process has started, very little can be done to check it, but there can be but little doubt that repeated manipulation of the elbow may be a causative or aggravating factor. Forcible passive movements to increase extension of the elbow are particularly dangerous and should be avoided. Whenever there is slow return of function and the motion is painful and guarded, the possibility of the development of this complication should be borne in mind, and an X-ray examination made. If beginning cloudiness in the soft parts anterior



to the elbow is demonstrated, then the elbow should be put at complete rest. Operative removal of the calcified mass should never be undertaken until after the lapse of 1 year, at which time the ossifying process will have reached a stage of quiescence, and there will be less chance of recurrence. In 3 of our 30 house patients, ossifying hæmatoma developed. It caused restriction of motion and limitation of working ability in 2 and resulted in complete ankylosis in the third. Small areas of calcification in the anterior capsule were noted in 4 other patients, and may have been responsible for slight limitation of extension of the elbow.

Of the 30 house patients 24 were fresh dislocations and were admitted from a few hours to 3 days after injury. Reduction was accomplished in all by the closed method. One patient had a compound dislocation, the lower end of the humerus coming out through a wound on the anterior surface of the arm. Débridement was performed with reduction of the dislocation immediately after admission to the hospital, and the wound healed without infection. There were 6 patients with old unreduced dislocations of the elbow varying in time from 19 to 90 days after injury. Open reduction was performed in all but one. This patient, a boy of 12, was admitted 30 days after injury. Closed reduction was performed, but later was discovered to be incomplete. The result in this case was less good than in any other, and shows the wisdom of resorting immediately to open operation in any elbow dislocation of more than 3 weeks' duration.

The end-results more than 1 year after injury are shown in Table XIX. When it is

remembered that 24 out of the 30 house cases were complicated by varying types of fracture, it is gratifying to find such a high proportion of good results. They were classed as excellent or good in 20 patients. The immediate results in the 5 patients listed as unknown were good at the time of leaving the hospital. This accounts for 25 cases or 83 per cent of the entire group. Five of the 6 patients with results listed as poor or fair were only admitted 2 months or more after injury. The results demonstrated that when fresh dislocations of the elbow are recognized and reduced immediately after injury, the prognosis is excellent, and no functional impairment need be expected.

#### SUMMARY

An attempt has been made to present a bird's eye view of the various injuries designated under the title "Fractures and Dislocations of the Elbow." The different types of injury have been described, the treatment indicated, and attention called to the special dangers that must be avoided in each of the various fractures and dislocations. End-result notes made 1 year or more after discharge from the hospital in 176 of the 439 injuries studied have been presented in order to portray as accurately as possible the outcome that may be expected. We feel justified in concluding that fractures and dislocations of the elbow are not formidable when properly understood and correctly treated. They are a challenge to the surgeon's vigilance and skill, but the victory can be won here as it has been in the other domains of surgery by the use of the weapons already at hand when resourcefully used.

