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ISOLATED FRACTURES OF THE PROXIMAL END OF THE RADIUS IN CHILDREN EPIDEMIOLOGY, TREATMENT AND PROGNOSIS

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DEFINITION

Fractures through the head and neck of the radius without simultaneous lesions in other parts of the same elbow are discussed. The age-group consists of children 0–15 years of age.

REVIEW OF LITERATURE

According to *Murray* (1940) fractures of the head and neck of the radius are the most common fractures in the elbow and in his material made up 44 per cent of all elbow fractures and 4.5 per cent of all types of fractures. In materials consisting only of children, the incidence is not so high (*Judet et al.* 1962, *Radin* 1966), 4.5 per cent of elbow fractures according to *Blount* (1954). Many authors (*Arner, Ekengren & von Schreeb* 1956, the Committee on trauma, 1949, *Door* 1964, *Dougherty* 1966, *Hamon, Ducloux & Carlier* 1963, *Keon-Cohen* 1966) have observed that the difference in type of fracture between adults and children is that the transverse type more often occurs in the latter. The sex incidence varies. *Arner et al.* had 58 per cent women, *Azzini & Iure* (1964) 49 per cent, *Door* 60 per cent, *Radin* 55 per cent, *Reidy & van Gorder* (1963) 30 per cent, *Hamon* (1963) 35 per cent. The therapy can simply be immobilisation by collar- and cuff or by plaster of Paris (*Cave* 1958, *Ehalt* 1961, *Svinukhov* 1965) but in displaced fractures reduction can be achieved by extension and supination (*Patterson* 1934) or by digital pressure under pronation- supination of the forearm which is pressed into varus (*Blount* 1964, *Judet et al., Lorthior* 1965).

Severely displaced fractures can be treated by open reduction with or without osteosynthesis according to *Carstam* (1950), *Cave* (1958), *MacLennan* (1937), *Murray* (1940), *Weller* (1965).

The prognosis according to *Wilson* (1933) is grave, the fractures giving often a useful, but seldom a normal elbow. *Reidy et al.* found the results best in children under 10 years of age, whereas Blount is more uniformly optimistic.

MATERIAL

The material is taken from all elbow lesions (1579 cases) treated at Children's Hospital, Gothenburg, during 1930–50. 91 cases (5.8 per cent) were isolated fractures of the head or neck of the radius. 55 of these have been reexamined and are the material for this article.

The age- and sex-distribution is seen in Figure 1, from which is clear that the sexes are equally frequently represented (28 boys, 27 girls), thereby contrasting with all other types of elbow fractures, in which boys are preponderant. The difference in statistically significant.

The ages most commonly affected are 7–12 years, the mean age 9.7 years.

The fractures of the head of the radius are found in older children with a mean age of 12.6 years.

The most common type of lesion in this part of the radius in this age is fracture of the neck of the radius. In this material there were 50 cases, whereas fracture of the head of the radius made up only 5 cases.

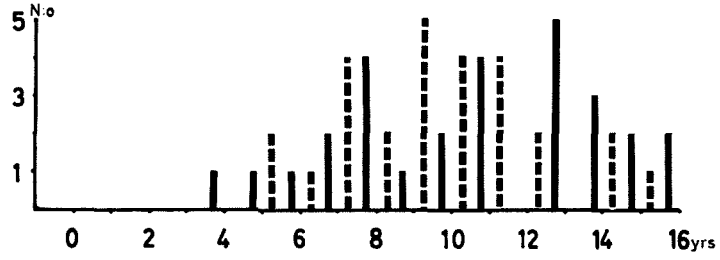


Figure 1. Age- and sex-distribution in fractures of proximal end of radius. Girls: interrupted columns. Boys: uninterrupted columns.

The displacement was slight in all of the cases with fracture through the head of the radius and the fragment held less than half of the articular surface.

The most common type of displacement of the head of the radius in fractures of the neck of the radius was slightly radially (16 cases). Some degree of radial displacement was seen in 44 cases. Displacement to the volar aspect was seen in 24 cases and to the dorsal side in 5 cases. As to the degree of displacement the fractures have been divided into three groups with no, slight or severe displacement of the fragment.

Severe displacement includes 23 cases with the head of the radius displaced more than half the breadth of the bone and/or angulated more than 45°. Slight displacement includes 25 cases with displacement less than in the former group and in 2 cases there was no visible displacement.

Table 1. Distribution of fractures of proximal end of radius according to primary displacement, type, treatment and result of reduction.

Site of fracture	Neck of radius 50						Head of radius 5	Total 55
Primary displacement	No 2		Slight 25		Severe 23		Slight 5	55
After reduction	No 2	No 1	Slight 24	No 5	Slight 6	Severe 12	Slight 5	55
Type of treatment								
None or unknown			2					2
Immob. in splint	2		17			5	3	27
Closed reduction + immob.		1	3	4	4	3	1	16
Open reduct.				1	4	3		5
Traction			2			1	1	4
Excision						1		1

The therapy is clear from Table 1. The most commonly used therapy was immobilisation in splint without any reduction. This method has been used even in severely displaced fractures, totally in 50 per cent of the cases.

Closed reduction and immobilisation was used in 16 cases, open reduction in 5 and traction in 4 cases. Excision of the radial head was performed in one case and the result of reduction, according to the clinical findings is classified as bad.

The reduction is difficult and only 12 fractures were less displaced after reduction, whereas 41 remained unreduced.

The reduction was generally performed with the patient in general anesthesia, the elbow in extension, pressed in varus and by digital pressure the operator tried to reduce the head of the radius which was usually displaced radially. Immobilisation was performed with a plaster or cardboard splint with the elbow flexed 90° for 4–5 weeks.

Primary complications such as nerve or vessel injuries did not occur. In one case a paralysis of the ulnar nerve was noted after an open reduction. The nerve re-

covered in the course of 3–4 years and at after-examination no difference in fingergrips, sudomotor function or two-point discrimination could be measured. In one case the fracture was primarily poorly reduced and the mobility impaired. The head of the radius was removed in another hospital nine years after the accident. After that there was pain in the ulnar part of the arm and an ulnar paralysis developed. The ulnar nerve was transposed to the anterior side and then the pain vanished. Two-point discrimination was 1 mm wider in the little finger on the injured side than on the healthy one. The force was not diminished.

METHODS

All roentgenograms made between 1930 and 1950 at the Children's Hospital, Gothenburg, were re-examined and all cases with elbow fractures or dislocations were selected and registered. 60 per cent of the patients with fractures of the head or the neck of the radius were after-examined clinically and roentgenologically by the author 1961–62, 28–11 years after the accidents.

At personal after-examination the subjects were interviewed regarding the cause of the fracture, what they were doing at the time of the accident, severity of the trauma and present sensation of pain, sensibility disorders and decreased working capacity, if any.

Maximal flexion and extension, pronation and supination were measured on both arms as well as carrying angle and circumference of upper and lower arms. All angles were measured going out from the position of the humerus as zero, flexion and extension on the dorsal side of the arm, carrying angle on the ulnar side and pronation and supination as the position of the hand compared to that of the vertically held humerus.

Frontal and lateral Roentgen pictures were taken of both elbows. Frontal views were taken with the elbow extended and the lower arm supinated with the volar aspect facing the Roentgen tube. Lateral views were taken with the elbow flexed at right angles and the forearm supinated and one picture with the forearm pronated.

The position and range of motion of the elbows were noted in 100 sex- and age-matched children and 50 adults without known fracture in their histories were used as controls. The healthy arm in each subject was also used as control.

RESULTS

The incidence of fracture of the proximal end of the radius was compared to an approximate average population in the age-group in Gothenburg of 60050 children, during the time investigated. A mean of 4.3 fractures were treated annually and thus per 1000 of average population up to the age of 15, 0.07 fractures were treated annually. The mean age was 9.7 years, in boys 9.8, in girls 9.5 years. In fractures of the neck the mean age was 9.3 years, in fractures of the head of the radius the mean age was 12.6 years.

According to *Ruckensteiner* (1931) the epiphysis of the head of the radius is visible in the Roentgen pictures earliest at the age of 3 and

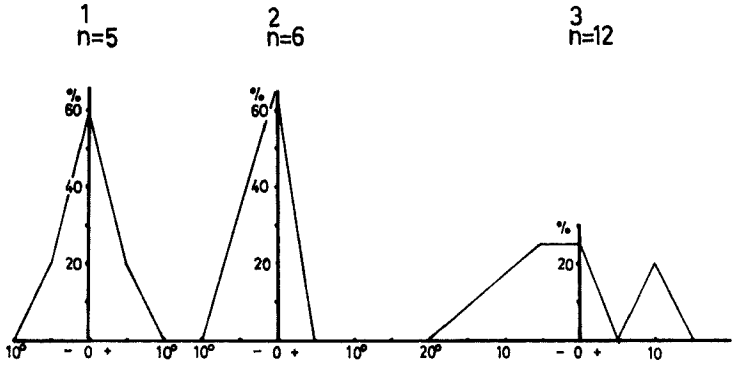


Figure 2. Difference in carrying angle between injured and uninjured arms in severely displaced fractures of the neck of the radius. 1) no displacement after reduction. 2) slight displacement after reduction. 3) severe displacement after reduction. + indicates varus on the injured side as compared to the uninjured arm.

is fusing with the rest of the bone at 14–18 years of age, earlier in girls than in boys.

The carrying angle of the healthy arm in this material was on the average 159°, whereas this angle in the controls and in the healthy arm in all other types of elbow fractures was 162°. The difference is significant. The difference in carrying angle between the injured and uninjured arms varied only between + 10° and — 15°, most among the severely displaced fractures. Their distribution is seen in Figure 2, where the percentage of difference between the healthy and the injured arms is represented split into groups according to result of reduction.

Flexion and extension vary little after these fractures and only the severely displaced fractures impaired these movements. Compare Figure 3, where the difference in movement is represented in relation to displacement. Pronation and supination are very vulnerable to injuries in the proximal end of the radius, which is clear from Figures 4, 5, 6, and 7, showing difference in ability to pronate and supinate between healthy and injured arms after severely displaced fractures. The fractures without displacement did not impair the movements. The slightly displaced fractures with remaining displacement impaired pronation by 20° in one case and by 10° in one. Supination was impaired by 10° in one case.

Working capacity in relation to the primary injury and result of reduction is given in Table 2. Only 2 patients had severe symptoms, 11 had mild symptoms.

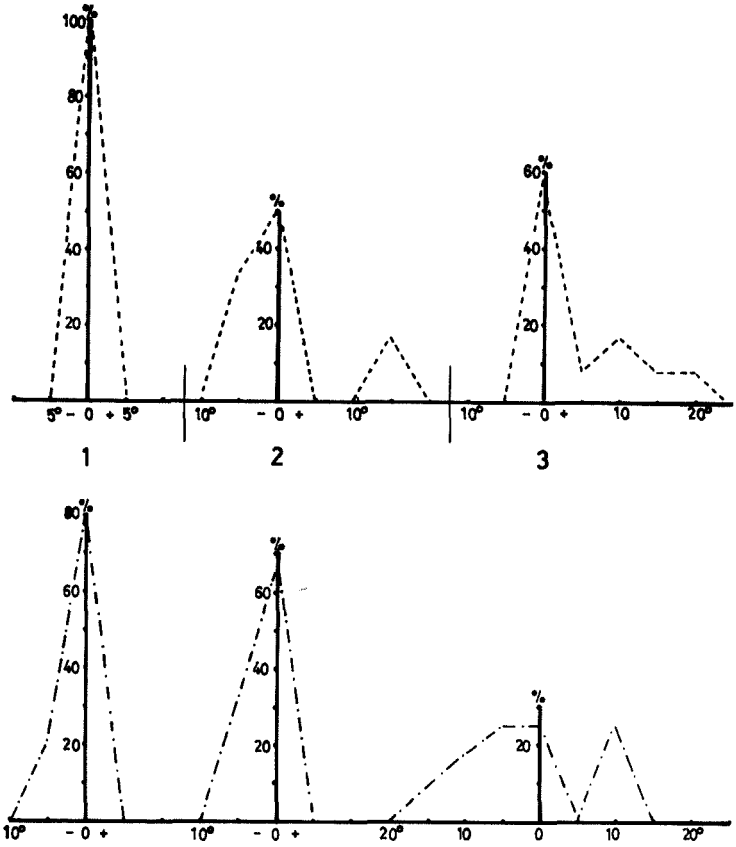


Figure 3. Difference in flexion (above) and extension (below) between injured and uninjured arms in severely displaced fractures of the neck of the radius. 1) No displacement, 2) slight displacement, 3) severe displacement after reduction. + indicates a more obtuse and — a more acute angle in the injured arm as compared to the contralateral one.

Remoulding of the bone plays an important part in the prognosis after fractures in children. This is true also in this group, as is clear from Table 4, which shows the position of the fragments at the beginning and after the treatment as well as at after-examination.

Among the fractures of the head of the radius, no displacement was found at the after-examination. The 8 fractures of the neck of the radius which had no primary displacement or had been ideally reduced showed no displacement at after-examination. In 30 cases the displacement after treatment was slight. 27 of these had no displacement at after-examination, whereas the remaining 3 had not been totally

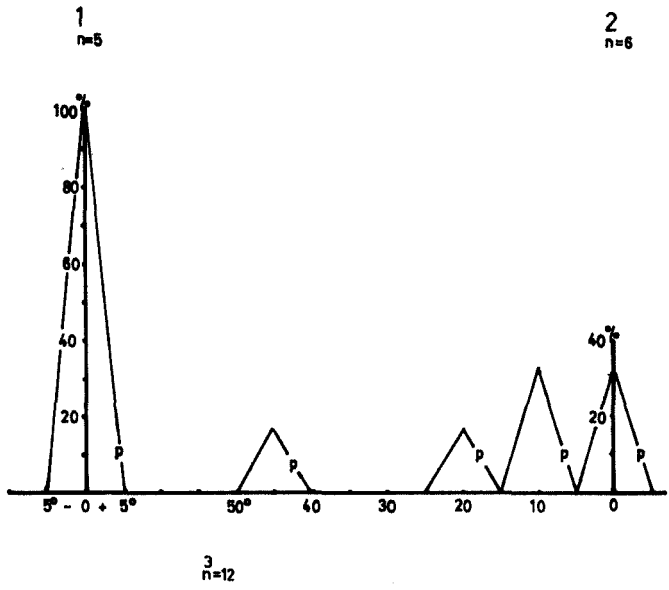


Figure 4.

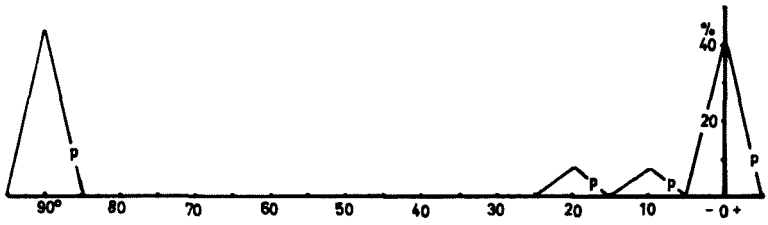


Figure 5.

Figures 4–5. Difference in pronation between injured and uninjured arms in severely displaced fractures of the neck of the radius. 1) No displacement, 2) slight displacement, 3) severe displacement after reduction. + indicates that pronation was greater and — that it was smaller on the injured side.

rebuilt. Out of the 12 fractures left in severely displaced position after treatment 5 showed no displacement, 4 slight and 3 still severe displacement.

In 3 cases there had developed a synostosis between radius and ulna. All of these had been severely displaced primarily. Osteoarthritis at after-examination was seen in the Roentgen-pictures in 8 cases, 5 in fractures of the neck and 3 in fractures of the head of the radius. All

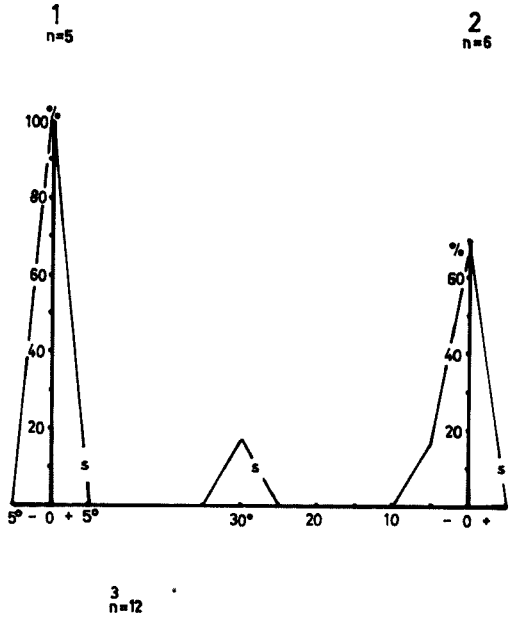


Figure 6.

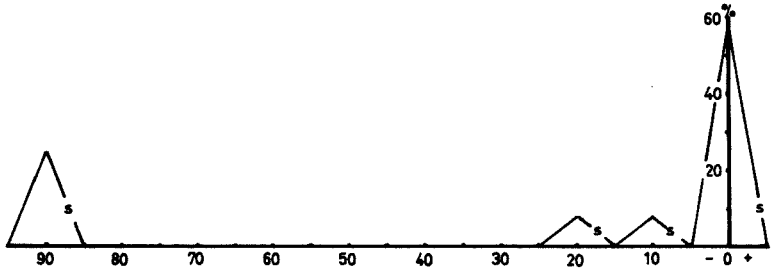


Figure 7.

Figures 6–7. Difference in supination angle between injured and uninjured arms in severely displaced fractures of the neck of the radius. 1) No displacement, 2) slight displacement, 3) severe displacement after reduction. + indicates that supination was greater and — that it was smaller in the injured arm.

of the fractures of the neck had been severely displaced primarily and no one had been properly reduced.

The results were evaluated in the following manner: Criteria for the result to be judged as "good" are: Difference in carrying angle and/or limited flexion, extension, pronation, supination ± 15–20° and/ or

Table 2. Working capacity in relation to type of fracture, primary displacement and result of reduction.

Site of fracture			Neck of radius 50				Head of radius 5	Total 55
Primary displacement	No 2		Slight 25		Severe 23		Slight 5	55
After reduction	No 2	No 1	Slight 24	No 5	Slight 6	Severe 12	Slight 5	55
Light work, without sympt.	2	1	15	3	3	3	4	31
Light work, mild sympt.			2		1	4		7
Light work, severe sympt.						2		2
Heavy work, without sympt.			5	2	2	2		11
Heavy work, mild sympt.			2			1	1	4

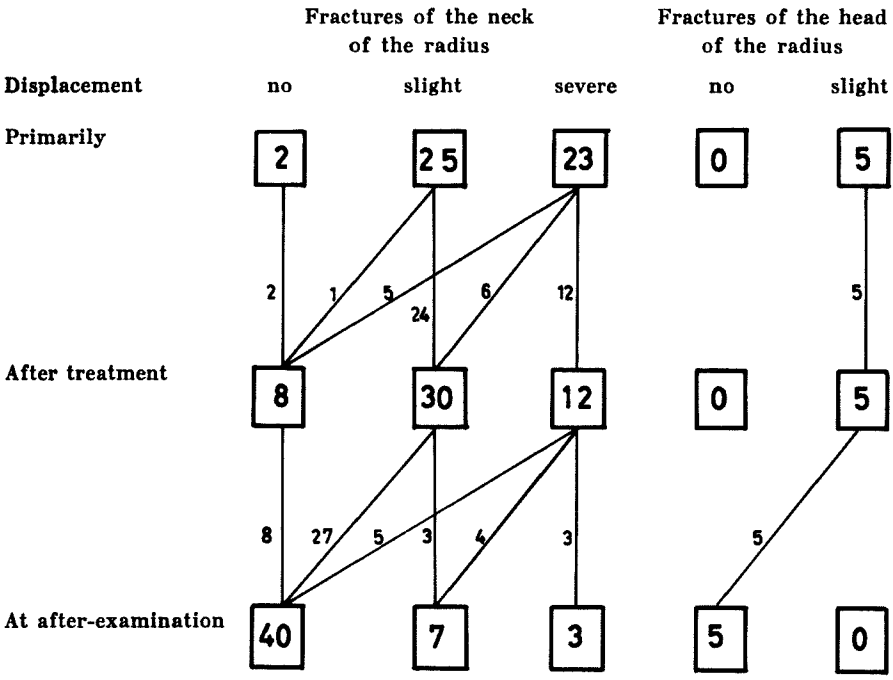
Table 3. Distribution of end results according to type of fracture, primary displacement and result of reduction.

Site of fracture			Neck of radius 50				Head of radius 5	Total 55
Primary displacement	No 2		Slight 25		Severe 23		Slight 5	55
After reduction	No 2	No 1	Slight 24	No 5	Slight 6	Severe 12	Slight 5	55
Excellent	2	1	19	5	3	3	3	36
Good			5			4	2	11
Poor					3	5		8

mild symptoms during work. If the result was better, it was judged as "excellent" and if it was worse it was judged as "poor".

According to these criteria, 36 cases had excellent result, 11 good

Table 4. Position of fragments primarily, after treatment and at after-examination.



and 8 had poor result. Their distribution among various types of displacement and the results of reduction are given in Table 3.

DISCUSSION

It has been shown above that cubitus valgus in both elbows is significantly more common in subjects who have had a fracture in the neck or the head of the radius than in healthy subjects and people who have had other types of elbow fracture. This seems to depend on that when a strain is put on the hand, the elbow extended, the pressure between the head of the radius and the capitellum of the humerus will increase with sinus of the supplement angle of the measured angle of valgus. The mean supplement angles are thus 21° in the patient with fractures of the head or neck of the radius and 18° in all other types of elbows, broken or not. According to this, the force in the radial part of the elbow is 12 per cent greater in the former group, than in the second one with the same kind of trauma, fall against the outstretched hand. As dislocations and fractures of the ulnar epicondyle of the humerus

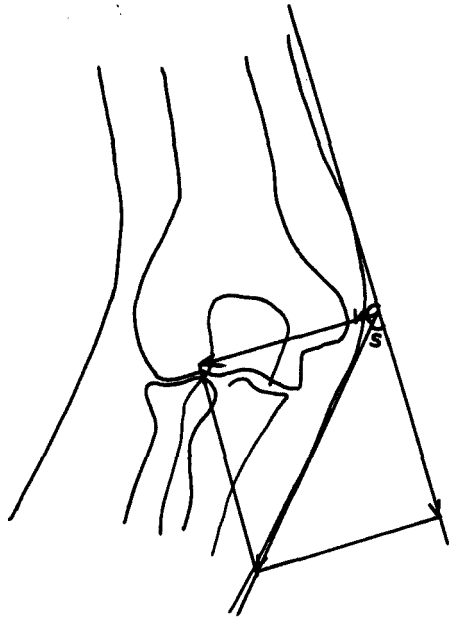


Figure 8. Showing the force in stopping a fall on the outstretched hand and the dividing of the force into two components, the magnitude of which are proportional to sinus of the supplementary angle (s) of the measured angle of valgus (v).

In fractures of the neck and head of the radius $v = 159°$, $s = 21°$, $\sin s = 0.358$
In other elbows $v = 162°$, $s = 18°$, $\sin s = 0.309$

have been excluded from this group, the pulling force in the ulnar part of the elbow has not been overcome. See Figure 8.

Although the patients in this group start with a cubitus valgus that is more pronounced than in other types of elbow injuries or in healthy subjects, only 2 cases showed an increased valgus in the injured arm of more than 10° as compared to the healthy one. The displacement after reduction was slight in one case and in the other, the head of the radius was removed several years after the accident. The support to the capitelium of the humerus thus seems to be only part of the stabilising structures in the elbow. In one case, treated by excision of the head of the radius primarily, there was no difference in carrying angle between the healthy and the injured arms.

Impairment of flexion and extension is uncommon and in this series does not exceed 20°.

Impairment of pronation and/or supination, on the other hand is common in fractures of the head and neck of the radius and is the most

Figure 9. Fracture of the neck of the radius in a girl, aged 10. Although there was a significant displacement, the treatment was only immobilisation in a cardbord splint, without reduction. At after-examination 28 years after the accident, the patients has no complaints and no limitation in movements of flexion, extension, pronation or supination as compared to the healthy arm. The strength in the arms and hands are equal. Cubitus valgus was increased by 5° in the injured arm.

disabling factor. All of the cases with severely impaired rotation movements had had fractures with severe displacement which had not been properly reduced or had been subject to excision of the head of the radius with a complete synostosis between radius and ulna.

Although the series is so small that there is no statistical significance in the figures, there can be no doubt that the chances for full mobility are better if the reduction has been exact.

Excision of the fragment includes a great risk of synostosis between radius and ulna, and is thus dangerous.

Many authors (*Blount* 1954, *Ehalt* 1961, *Judet et al.* 1962, *Keon-Cohen* 1966) warn against excision of the head of the radius in children, as the result is often a cubitus valgus. Furthermore there is a risk of synostosis, which can be even more disabling.

The reduction is difficult. As can be seen from Table 1, only 5 out of 23 severely displaced fractures were exactly reduced. Closed reduction was successful in 4 cases out of 11, open in 1 case out of 5. The problem of retaining the fragment has been solved by *Judet et al.* by transfixation with a Kirschner wire. This incurs a risk of stopping the epiphyseal growth. *Weller* (1965) denies this and proves experimentally that the wire can be left in the epiphysis, which continues to grow.

As compared to the frequency of osteoarthritis in supracondylar fractures of the humerus, 2 per cent according to *Henrikson* (1966), the frequency is very high in this series. There is also a marked difference in this respect between the fractures of the neck and the fractures of the head of the radius. In the fractures of the neck, the risk increases with the primary displacement and the displacement after reduction, whereas the fractures of the head lead to osteoarthritis in 3 out of 5 cases although the displacement was not severe in any of these cases.

The reason seems to be, that the fracture line with callus formation is apt to interfere more with the joint when it is crossing the supporting joint surface. The head of the radius makes two kinds of movement, a flexion-extension movement and a rotational one, which may increase the development of orteoarthritis, as the surfaces are more movable against each other than in the ulnar part of the joint.

SUMMARY

Of 1579 subjects who had during childhood had elbow injuries which had been treated at the Children's Hospital, Gothenburg, during the

period 1930–50 1071 were after-examinated in 1961–62. Of these 6 per cent had fracture of the proximal end of the radius and of these 55 have been the material for this article.

Incidence: 0.07 fractures annually per 1000 children 0–15 years of age. The mean age was 9.7 years, the sex distribution 28 boys/27 girls. Cubitus valgus is more common both in the healthy and the injured arms in these cases than in other patients with elbow fractures or healthy subjects. The end-results were classified as excellent in 36 (65 per cent), as good in 11 (20 per cent) and as poor in 8 cases (15 per cent). The excellent results emanated mostly from fractures with no or slight primary displacement or such fractures which had been properly reduced, but also some fractures with remaining displacement. The poor cases emanated from fractures with severe primary displacement, which had not been properly reduced.

Deformity is not so common after these fractures as one could expect as the ulnar collateral ligament prevents the arm from slipping into valgus. Flexion and extension is not commonly impaired. Pronation and supination are impaired by remaining displacement and also by excision of the head of the radius which may lead to synostosis.

The fractures in the proximal end of the radius, although not common in children, are important in that they not seldom give poor results, especially depending on restricted pronation and supination. This impairment of movement may be prevented in some cases by adequate reduction.

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