Subluxation or dislocation of the distal radio-ulnar joint has been regarded as one of the rarer complications after fracture of the head of the radius. Brockman (1930) and Essex-Lopresti (1950) each reported two cases, and Essex-Lopresti recalled that Murray (1940) had found no obvious wrist changes in 459 such fractures. Burton (1942) none in fifty, and Gaston, Smith and Baab (1949) none in 113 cases. Discussing Brockman’s paper, Aitken (1930) recalled seeing a similar complication in one of his own patients who complained of weakness of the grip for a long time; Elmslie (1930) and Dunn (1930) differed as to whether the complication was important functionally or cosmetically. When Cherry (1953) advocated replacement of the fractured radial head with a prosthesis he asserted that this would prevent any tendency to upward displacement of the radius. There was considerable diversity of opinion on this occasion, Jeffrey (1953) stating that he had examined a large series of patients who had had the radial head excised, and in none was he able to find evidence of subluxation. Watson-Jones (1953) believed that there was a place for the operation in the uncommon cases in which fracture of the radial head was associated with rupture of the interosseous membrane and marked upward displacement of the radius.
CLINICAL STUDY

During a review of 100 fractures of the head of the radius (Table I) a number of patients were seen who complained of pain and weakness of the wrist, and a closer study indicated that the complaints were referable to changes at the distal radio-ulnar joint. Accordingly the wrist joints of all in the series were carefully examined. Comparable radiographs of both wrists were obtained with every effort to prevent distortion, and it was possible to demonstrate displacement of the distal radio-ulnar joint due to an upward shift of the radius in twenty-five cases. The displacement varied from a minimal shift, only recognisable radiologically, to a subluxation or dislocation that was obvious clinically. Of the twenty-five patients five had severe displacement, six moderate and fourteen mild. All except one occurred after removal of the head of the radius.

<table>
<thead>
<tr>
<th>TABLE I</th>
<th>CLINICAL DETAILS IN 100 FRACTURES OF THE HEAD OF THE RADIUS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total</td>
</tr>
<tr>
<td>Number of patients</td>
<td>94</td>
</tr>
<tr>
<td>Number of fractures</td>
<td>100</td>
</tr>
<tr>
<td>Treated conservatively</td>
<td>56</td>
</tr>
<tr>
<td>Head excised</td>
<td>44</td>
</tr>
<tr>
<td>Upward displacement of radius</td>
<td>25</td>
</tr>
<tr>
<td>Severe</td>
<td>5</td>
</tr>
<tr>
<td>Moderate</td>
<td>6</td>
</tr>
<tr>
<td>Mild</td>
<td>14</td>
</tr>
<tr>
<td>Number with symptoms</td>
<td>12</td>
</tr>
</tbody>
</table>

CLASSIFICATION

From a study of the patients we reviewed we have classified distal radio-ulnar displacement associated with damage to the radial head into three main groups.

GROUP 1

Displacement consequent upon removal of the radial head before the cessation of growth. In children, removal of the radial head before growth at the epiphysis has ceased results in an upward shift of the radius. McFarland (1953) stated that he had not found a tendency for the radial shaft to migrate upwards, even when the radial head had been excised in children, but Fairbank (1930) quoted the case of a child who had had the head of the radius removed at the age of three, and at the age of twelve had two and a half inches shortening of the bone.

Case 1—A boy aged fourteen years had the head and part of the neck of the radius removed on account of an osteoclastoma. Ten years later the severe wrist changes confirm Fairbank's observation (Fig. 1).

It is an accepted principle that in the treatment of injuries to the head and neck of the radius in children the growing epiphysis should be preserved.

GROUP 2

Displacement recognised at the time of injury.
FIG. 2
Case 2—Fracture-dislocation of the head of the radius and dislocation of the inferior radio-ulnar joint occurring simultaneously at the time of injury.

FIG. 3
Case 2—Radiographs taken five years later showing excised head and the degree of displacement at the wrist at that time.
Case 2—A farmer aged forty-seven was thrown forcibly from a motor-cycle and landed on his left hand. On admission to hospital he complained of pain at the elbow and wrist, and radiographs showed a fracture-dislocation of the radial head and subluxation of the inferior radio-ulnar joint, with upward displacement of the radius (Fig. 2). The displacement was corrected by manipulation, and a few days later the radial head was excised. Subsequent radiographs showed a recurrence of the subluxation at the wrist, but it was decided to accept the position. Five years later the displacement had increased, and osteoarthritic changes were present (Fig. 3). Elbow movement was from full flexion to 165 degrees extension; pronation was 50 degrees and supination 45 degrees. The patient’s capacity for work was reduced, there was pain on heavy lifting, and the grip tested on a dynamometer registered 35 kilograms as compared with 90 kilograms on the normal side.

A similar case was published by Curr and Coe (1946), who up to that time could find no reference to such an injury in the literature. Failing to reduce the subluxation by manipulation they exposed the inferior radio-ulnar joint at operation, and found that the articular disc [triangular fibrocartilage] was badly torn and prevented reduction. A year later the patient had full flexion, lacked 30 degrees of extension, and had only 5 degrees of rotation. Essex-Lopresti recognised the upward displacement of the radius at the time of the injury in his second case, and in an effort to maintain reduction the head was reconstructed and not excised. Seven months later movement at the elbow was from 135 degrees to 60 degrees, and the total range of rotation was 45 degrees, but there were arthritic changes in the radio-humeral joint.

GROUP 3

Displacement after excision of the radial head. Subluxation of the distal joint may occur some time after removal of the radial head for fracture. Watson-Jones (1930) suggested that this was not infrequent because the radius was shortened, but he gave no figures of its incidence.

The displacement may be recognised soon after removal of the radial head, or several years may pass before it is noticed. The onset may be heralded by pain and swelling round the wrist, or it may be symptomless. The severity of the symptoms is not always related to the degree of displacement, but rather to the amount of use to which the wrist is subjected.

Case 3—A soldier aged twenty was thrown some distance in a bomb explosion and fell heavily on his right hand. He sustained a fracture of the radial head, which was excised. For a number of years after the operation he noticed an increasing prominence of the head of the ulna, but it was not until ten years after the injury that pain in the wrist made him seek advice. The inferior joint was subluxated (Figs. 4 and 5) but no arthritic changes were present.

Case 4—A concrete worker aged seventeen fell while playing football and injured his right elbow. He was found to have a fracture of the radial head with some displacement, and the radial head was excised. Nine years later the inferior radio-ulnar joint was found to be subluxated (Fig. 6). The function of the wrist had been excellent until a few months before, when he began to suffer pain. He was right handed, but the grip on the injured side registered only 30 kilograms as compared with 55 kilograms on the left side.

Case 5—Seven years after excision of the right radial head in a boy of eighteen years, a coach-builder, there was a distinct subluxation, but apart from some weakness of grip the wrist was symptomless (Fig. 7).

Case 6—A labourer was crushed by a concrete mixer in 1952 and sustained a fracture of the left radial head, which was excised. Four years later the inferior radio-ulnar joint was subluxated. Arthritis was present in both wrists, but more marked on the left side (Fig. 8).

Case 7—An airman aged nineteen had the head of the right radius removed after an injury. One year later he complained of pain and swelling of the wrist, and there was slight subluxation (Fig. 7). An enthusiastic tennis and badminton player, he finds his activities curtailed.

The examples quoted demonstrate the marked variability of the condition. All the cases with severe symptoms were in males; in females the displacement tended to be slight, and symptoms, if present, were confined to a feeling of weakness and pain after heavy work.
Case 3. Figure 4—Subluxation at the right distal radio-ulnar joint ten years after excision of the head of radius. Figure 5—Elbow showing amount of radial head resected.

Case 4—Dislocation at the right distal joint nine years after removal of the radial head for fracture. The normal wrist is shown for comparison.
Case 5—Dislocation seven years after excision of radial head. The normal wrist is shown for comparison.

Case 6—Radiograph showing dislocation at the left inferior radio-ulnar joint four years after excision of head of radius. Both wrists showed evidence of arthritis, but this was more marked in the left wrist.
Case 7—Slight displacement, but with considerable disability, one year after excision of head of radius. The normal wrist is also shown.

DISCUSSION

Our figures are in strong contrast to those of the writers mentioned above who found no evidence of inferior radio-ulnar displacement in the cases they reviewed. In the few cases of displacement recorded, opinions differed on the mechanism of the displacement. Curr and Coe believed that the upward shift had been permitted by tearing of the interosseous membrane, but Essex-Lopresti found no evidence of damage to the membrane in his cases. In the one immediate upward shift in this series there was nothing to suggest that there had been tearing of the interosseous membrane on clinical examination, and subsequent radiographs showed no evidence of any bone changes that might have been expected if the membrane had been torn. When dislocation followed removal of the radial head a close study was made of the case histories and radiographs, but in none was there any evidence to suggest that the interosseous membrane had been torn.

Experimental displacements—In an effort to ascertain the mechanism of inferior radio-ulnar subluxation and dislocation, experiments were carried out in the post-mortem room.

After a radiograph had been taken of a normal wrist the head of the radius was removed. When firm pressure was applied to the radially deviated hand, radiographs showed a typical displacement of the inferior radio-ulnar joint, as found in the cases described above (Fig. 11). A small lever was next inserted into the elbow at the point where the neck of the radius had been divided, and pressure was applied in a distal direction. An equivalent downward shift of the radius at the wrist was demonstrable (Fig. 12). After division of the articular disc, firm pressure applied to the hand produced no increase in the displacement, and division of both disc and inferior joint capsule gave rise to no material increase in the subluxation.
Mechanism of displacement—The sacciform nature of the synovial membrane in both upper and lower radio-ulnar joints clearly allows for an up-and-down movement of the radius as well as the more commonly recognised rotatory movement, a fact pointed out by Thompson (1924) and demonstrated by Ogilvie (1930). "Pulled elbow" is an exaggeration of the downward movement in children. Up to the age of four years the head of the radius is not much larger than the neck, and when forcible traction is applied to the hand, the head slips down into the narrower part of the annular ligament which encircles it tightly, a fact that we have demonstrated in the post-mortem room. In the adult the head is much larger than the neck, and it can no longer be displaced downwards through the annular ligament.

The radius and ulna can be likened to two parallel struts fastened at the ends by the radio-ulnar joints, and in the centre by the interosseous membrane. Because of the direction of its fibres the interosseous membrane, when taut, can transmit to the ulna some of the pressure that is more directly exerted on the radius through the hand. That this is not the chief function of the membrane, however, is evident when one finds that it is not taut during pronation, which is the position most commonly assumed when pressure is transmitted from the hand (Frazer 1933). Upward migration of the bone is prevented by impact of the head of the radius against the capitulum, and when the stabilising influence of the head is lost after its removal the radius can move up until the slack in the interosseous membrane is taken up (Fig. 14), or the neck reaches the capitulum.

In a further experiment we removed the head of the radius and divided the interosseous membrane but produced only the same degree of displacement as in the other experiments. It appears from these experiments that the interosseous membrane need not be torn to allow of the upward displacement of the radius.
Factors influencing the displacement—Displacement of the radius was not found in every case in which the radial head was excised; so certain factors must influence its occurrence. In our experiments we were able to produce varying degrees of displacement of the radius in different specimens; so we believe that there is a varying degree of tension in the interosseous membrane and the structures around the inferior radio-ulnar joint in different individuals. The amount of strain to which the forearm is subjected must play a considerable part, and we found the displacement most marked in men who were engaged in heavy manual work, or who were active in athletic pursuits that entailed the use of the hands. The natural action of the flexor and extensor muscles, and of the biceps, is to pull the radius proximally, and this is another factor that may account for the higher incidence of displacement in men. The amount of the head and neck resected must influence the degree and rapidity of the upward displacement, but we could find no evidence to suggest that repair of the annular ligament could have any material influence in preventing it, as has been stated by other writers.

The annular ligament is attached to the anterior and posterior margins of the lesser sigmoid cavity and forms a socket in which the head rotates. It is not directly attached to the radius, but is funnel shaped, and the narrower distal circumference slopes down and closes on the neck. When the head is removed, the controlling action of the ligament is lost, and it cannot prevent dislocation. In addition, there exists a degree of mobility of the upper radial shaft which is no longer held firmly against the lesser sigmoid notch, and when this increased movement occurs it is reflected in the relationship of the articular surfaces of radius and ulna at the wrist joint.

CONCLUSIONS

In this paper our object has been to try to correlate the many seeming anomalies that have appeared in the literature on this subject, and not to discuss the merits of removal of the head of the radius, or of its replacement by a prosthesis, an operation of which we have no experience. The conclusions we have reached are as follows.

If an injury is severe enough to disrupt both radio-ulnar joints and to dislocate the head of the radius, or to crush it severely, the upward shift of the radius occurs at the time of injury. If the injury is only severe enough to damage the radial head, and it is thereafter excised, any subsequent displacement is due to a gradual stretching of the articular disc and perhaps of the interosseous membrane, from pressure on the hand and muscle pull.

SUMMARY

1. Dislocation or subluxation of the inferior radio-ulnar joint in association with fractures of the head of radius is discussed.
2. The incidence of the complication is greater than is generally supposed, and figures are given to support this finding.
3. The subluxation is not always associated with symptoms, and the degree of displacement may not be sufficient to be recognised clinically.
4. The anatomy and mechanism of the displacement have been investigated experimentally, and the results of the experiments are described.

We wish to thank Mr. J. Patrick for permission to report these cases, and Professor T. Symington for the facilities he has afforded us in the Pathology Department. We are also indebted to Professor G. Wyburn of Glasgow University.

REFERENCES
