

SOME OBSERVATIONS ON FRACTURES OF THE HEAD OF THE RADIUS WITH A REVIEW OF ONE HUNDRED CASES

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EXPERIENCE has taught the surgeon in his approach to the injured elbow to regard this complicated hinge joint with trepidation and with great respect.

The elbow-joint tolerates trauma very badly. Even a minor injury can be responsible for some residual loss of range of movement of the joint.

Fractures of the head of the radius have been variously estimated as forming 17 per cent (Jones, 1935) and 44 per cent (Murray, 1940) of all elbow injuries.

A survey in this area of all elbow fractures and dislocations, including the supracondylar fracture of the humerus of children, reveals some 30 per cent of fractures of the head of the radius.

ANATOMICAL CONSIDERATIONS

The head of the radius very grossly resembles the structure of the patella, consisting of the columnar type of dense cancellous bone running in a more or less longitudinal pattern. In consequence, fractures of the radial head tend to be oblique or longitudinal in direction. The head and its articular circumference are intra-articular, the articular circumference being deepest on the medial side where it articulates with the radial notch of the ulna.

During the flexion and extension movements of the elbow, the radial head glides to and fro over the capitellum of the humerus. The capitellum and the radial head are reciprocally curved; but actual contact between the surfaces is only present when the elbow is flexed to 130°, and the radius is in the mid-prone position. This can be demonstrated at operation and by dissection of the cadaver when the separation between the articular surfaces may be as much as ¼ in.

This consideration is of great importance. It means that in order for the flexion or extension range of movement of the joint to be limited, a moderately severe mechanical interference with this gliding motion must be present.

Cadaveral dissection and operation on the elbow-joint also reveal that full rotation at the proximal radio-ulnar joint requires accurate anatomical position of the head of the radius in the radial notch of the ulna. This is a tightly-fitting pivot joint held in position by the annular ligament.

Although during the backward and forward movement of the radial head on the capitellum, the head of the radius is moved on the radial notch of the ulna, and the annular ligament is slewed backwards and forwards at the same time, complete contact between the articular circumference of the radial head and the radial notch is always maintained. The supination and pronation movements at the proximal radio-ulnar joint, as judged by rotation of the elbow, are each in the nature of an arc of 160°. This corresponds with 320° of the articular circumference of the radial head. That portion of the head of the radius which forms the last 40° (one-ninth) of the articular circumference

on its lateral border does not articulate with the radial notch of the ulna. Theoretically, this would mean that if more than one-ninth of the lateral segment of the radial head is involved in the fracture, the range of rotation movement at the elbow-joint will be limited. This limitation will be further increased should the injury, by tilting the fractured sector, put out of line the tightly-fitting pivot radio-ulnar joint. This is only a theoretical consideration and its practical application will be discussed later.

MECHANISM OF THE INJURY

In what is probably one of the earliest detailed descriptions of this injury, Cutler (1926) states that direct trauma was responsible for the fracture of the radial head, and Flemming (1932) found that 75 per cent of his cases were caused by direct injury.

It is now generally agreed that indirect trauma through the long axis of the radius is the usual cause.

It is with great difficulty that the patients can recall the exact mode of falling other than that they may attempt to break fall with the hand.

Experimentally, if the ball of the hand of the cadaver is heavily struck, the wrist being pronated, fully dorsiflexed, and radially deviated with the elbow flexed to 130°, and held firmly in a vice, dislocations of the elbow-joint and Monteggia type of fractures can relatively easily be produced (Mason, 1953).

Dislocations of the elbow-joint associated with fractures of the head of the radius are of sufficient frequency that they may be considered as part of the same traumatic process.

These observations agree with those of Hein, who, in a discussion of Key's Report (1931), considered that dislocations of the elbow-joint and fractures of the head of the radius had a common origin. This important factor, I believe, has a bearing on the subsequent disability of the joint, and will be discussed later.

CLINICAL REVIEW

The purpose of this investigation is to follow up the end-results in 100 cases of fracture of the head of the radius treated by conservative and operative measures; to attempt to assess the loss of range of movement of the elbow-joint if present, in relation to the bony and soft-tissue injury suffered by it, and to discuss its significance. It is also intended to discuss the method of treatment adopted in relation to the final functional results.

Selection of Cases.—The 100 cases were selected at random. Only those patients were included in which the interval between the injury and the follow-up was twelve months or more. The epiphyseal displacement and neck fractures of children and young adults were excluded. No patient was included who had also sustained dislocation of the elbow, or fracture of the other components of the joint, apart from minor chip fractures.

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TYPES OF OPERATION
30, 1953)

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Each of the 100 cases was examined at a follow-up clinic. The function of the elbow was estimated, the actual range of movement of the joint measured in degrees, the presence of pain noted, and the interval between the injury and return to work recorded.

Sex Incidence.—There were 48 female patients and 52 male patients. Almost all the female patients



FIG. 151.—Case M. E. Anteroposterior radiograph taken 10 months after the original 'subchondral' fissure fracture of the radial head. The elbow-joint is normal. The fissure fracture is still visible. This is the usual phenomenon in any intra-articular fracture where callus formation might interfere with joint function. Function of the joint was full.

were housewives and most of the males were engaged in work of a heavy nature.

Age Group.—The average age of the 100 patients was 31 years. Most were between the ages of 20 to 40 years, probably the period of greatest muscular activity.

The average interval between the follow-up and the injury was 26 months, the longest being 60 months and the shortest 12 months.

Classification of the Fractures of the Head of the Radius.—The fractures were classified into three clinical types corresponding with a description of the radiological findings. No compound fracture was included. No 'flake' fractures of the head were encountered.

Type 1.—Fissure fractures or marginal sector fractures without displacement.

This type consists of the 'subchondral' crack fracture, and of fractures involving a sector of the lateral quadrant of the head of the radius without displacement.

Type 2.—Marginal sector fractures with displacement.

This is the type in which a segment of the lateral border of the radial head is separated from the other quadrants, is impacted and depressed, or is tilted out of line.

Type 3.—Comminuted fractures involving the whole head of the radius.

The actual classification of the 100 cases is shown in Table 1.

Table 1.—CLASSIFICATION OF FRACTURES OF THE RADIAL HEAD IN 100 CASES

	NUMBER OF CASES	PERCENTAGE
Type 1: Fissure or marginal fractures without displacement	62	62
Type 2: Marginal sector fractures with displacement	20	20
Type 3: Comminuted fractures involving the whole head of the radius	18	18
TOTAL	100	

Most of the radiographs and all the clinical notes taken at the time of injury were available for inspection.

It will be seen from Table 1 that 62 cases (62 per cent) of fracture of the head of the radius were uncomplicated by displacement, whilst 38 cases (38 per cent) were associated with displacement of the fragments.

CLINICAL ANALYSIS OF CASE GROUPS

It was decided to analyse in detail the series of cases of each type of fracture and to correlate the treatments of these patients with the findings on clinical and radiological examination.

ANALYSIS OF THE 62 CASES OF TYPE 1 FRACTURE (Fissure or Marginal Fractures without Displacement)

ORIGINAL TREATMENT.—Each of these 62 patients had been treated conservatively.

The limb had been immobilized in a sling, or in a plaster-of-Paris cylinder with the elbow at 90° of flexion for an average of 16 days.

If by then the traumatic hamarthrosis had been absorbed, active elbow exercises were commenced.

FINDINGS ON CLINICAL EXAMINATION.—**Pain in the Elbow-joint.**—Fifty-six cases made no complaint of pain. Six cases complained of an occasional ache on the medial side of the joint.

There was no joint laxity, no tenderness over the medial ligament, and no abnormality of the distal radio-ular joint in any of the 62 cases. The 'carrying-angle' was normal in all cases.

Range of Movement of the Elbow-joint.—Forty-two cases had a full range of movement of the elbow-joint. Twenty cases showed an average of 8° loss of extension movement of the elbow-joint, but supination and pronation movements were full. The loss of extension range of movement was no disability.

Function of the Elbow-joint.—Each of the 62 patients had full function of the elbow-joint and was doing his normal work without disability.

RADIOGRAPHIC EXAMINATION OF THE ELBOW-JOINT.—Ten cases were subjected to X-ray examination. They were selected at random.

Typically the elbow-joint was normal. The articular plateau of the radius was not distorted and the lateral and medial joint surfaces were regular in outline. There was no evidence of osteo-arthritis change.

The fissure fracture of the plateau of the radial head was often still visible. This is the usual phenomenon in intra-articular fractures where callus and new bone formation might interfere with joint function.

Fig. 151 shows the radiograph of a normal elbow-joint with a 'subchondral' fissure fracture. The original injury had been sustained nineteen months previously. The fissure fracture is still visible.

Fig. 152 shows the original and subsequent (thirty months later) radiographs of a typical marginal sector fracture without displacement. The fracture has united and the elbow-joint appears normal.

TIME OFF WORK.—The average duration of time between the injury and resumption of normal work was 4.8 weeks. The housewife usually recommenced her duties at 3-4 weeks, whilst the heavy worker recommenced his at 5-6 weeks.

This analysis demonstrates that each of the 62 patients with a Type 1 fracture of the radial head treated on conservative lines had regained full function of the elbow-joint and returned to normal work in an average of 4.8 weeks.

Six patients complained of minimal discomfort on the medial joint aspect.

Forty-two patients showed a full range of movement of the joint.

Twenty patients showed an average loss of 8° of extension movement of the elbow-joint.

ANALYSIS OF THE 20 CASES OF TYPE 2 FRACTURE (Marginal Sector Fractures with Displacement)

ORIGINAL TREATMENT.—

1. Cases treated Conservatively.—Fifteen of these 20 cases had been treated on conservative lines as for Type 1 fracture:—

Seven of these 15 patients had a segmental fracture less than one-quarter of the articular circumference of the radial head with depression of the fractured portion below the joint line without tilting.

The remaining 8 patients had been judged 'borderline' cases.

These patients had sustained sector fractures of the radial head in which the lateral segment was comminuted, or tilted, and displaced below the joint surface.

The fracture involved one-quarter or more of the articular circumference of the head, but the distortion of the articular plateau was not considered of a degree which would interfere with joint movement.

These cases were thought to be on the borderline between conservative and operative treatment, and excision of the head of the radius was not undertaken.

2. Cases treated by Operation.—Five patients had been treated by early total excision of the radial head. In these cases the segmental fracture was greater than one-quarter of the circumference of the head of the radius. The fracture was depressed and tilted so as to distort the articular plateau of the radial head.

FINDINGS ON CLINICAL EXAMINATION.—

Pain in the Elbow-joint.—

1. Cases treated conservatively: Six of the 15 patients treated conservatively were pain-free. Nine of them complained of some pain in the region of the radial head and there was crepitus in this region on rotation of the joint. Eight of these 9 patients were the originally considered 'borderline' cases.

There was no pain over the medial joint ligament, no joint laxity, and no loss of 'carrying-angle' in any of these 15 cases. In all 15 cases the distal radio-ular joint was normal.

2. Cases treated by operation: The 5 patients treated by excision of the head of the radius made no complaint of pain in the joint. No undue laxity of the joint was demonstrable in any of them, and in each case the

'carrying-angle' and the distal radio-ular joint were normal.

Range of Movement of the Elbow-joint.—

1. Cases treated conservatively: Seven of the 15 patients treated by conservative measures had a full flexion movement, but extension range of the elbow-joint was limited by an average of 10° of movement, and supination and pronation range of the joint was limited by an average of 15° of each movement.

The 8 'borderline' cases had a full flexion range, but extension range was limited by an average of 15° of movement.

Supination and pronation range of the joint was limited by an average of 30° of each movement.

2. Cases treated by operation: The 5 patients treated by operative removal of the whole head showed an average loss of extension motion of 20°, but a full rotation range of movement of the elbow-joint.

Function of the Elbow-joint.—

1. Cases treated conservatively: Seven of the 15 conservatively treated cases had full function, and 3 labourers amongst them were back doing their normal heavy work. The 8 'borderline' cases had good function, but 4 of them were now doing work of a lighter nature.

The extension loss of 15° was no disability to them, but the lack of rotation by a total of 60° was a severe handicap, especially for heavy shovelling work, or work involving the use of a screwdriver.

2. Cases treated by operation: The 5 patients treated by total excision of the radial head all had returned to their normal work.

They were housewives, and the loss of the last 20° of extension of the elbow-joint was no handicap to them.

RADIOGRAPHIC EXAMINATION OF THE ELBOW-JOINT.—

1. Cases treated Conservatively.—Ten of the 15 cases were selected at random and subjected to X-ray examination. Five of these patients originally had sustained a sector fracture of the radial head consisting of less than one-quarter of the articular circumference with depression of the fragment and no tilting. Typically the elbow-joint was normal with no osteo-arthritis changes. Fig. 153 shows one of these cases. The original radiograph is that of a typical Type 2 fracture, whilst the subsequent radiograph taken 15 months later shows a healed fracture with a normal elbow-joint.

The other 5 patients were 'borderline' cases. In these cases the lateral joint compartment was distorted. The articular plateau of the radial head was irregular and osteo-arthritis changes were evident. The medial joint compartment appeared normal.

Fig. 154 shows the original and subsequent (27 months later) radiographs of a case considered initially as 'borderline'. The original fracture is well defined, and involves more than one-quarter of the articular circumference. It is comminuted and tilted out of line. The fracture has healed with gross distortion of the articular circumference and the plateau of the radial head.

Fig. 155 shows the original and subsequent (42 months later) radiographs of another case of this group.

The fracture consists of one-quarter of the circumference of the head, but is tilted out of line. The subsequent radiograph shows a healed fracture with gross distortion of the radial head and early degenerative changes.

2. Cases treated by Operation.—Three of the 5 cases were subjected to X-ray examination. The radial head had been completely excised. The contour of the capitulum was normal and there was no osteo-arthritis change. Some new bone had formed around the neck of the radius.

TIME OFF WORK.—

1. Cases treated Conservatively.—Seven of the 15 patients treated by conservative methods were back at their normal work in an average of 5 weeks from the time of the original injury.

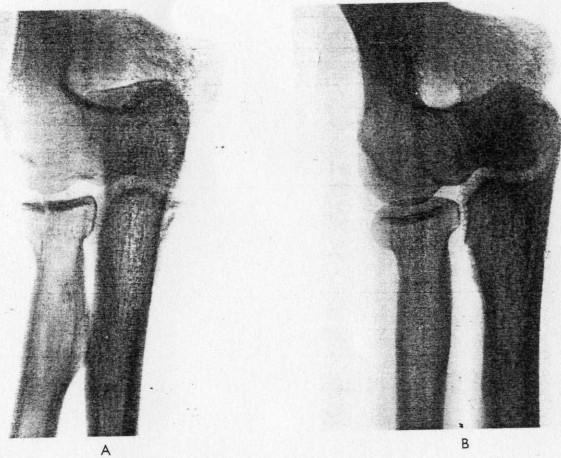


FIG. 152.—Case N. P. Anteroposterior radiographs showing a typical Type 1 fracture of the radial head. A, The original radiograph; B, The subsequent X-ray photograph taken 30 months later. The fracture has united and the elbow-joint appears normal. The function of the joint was full.

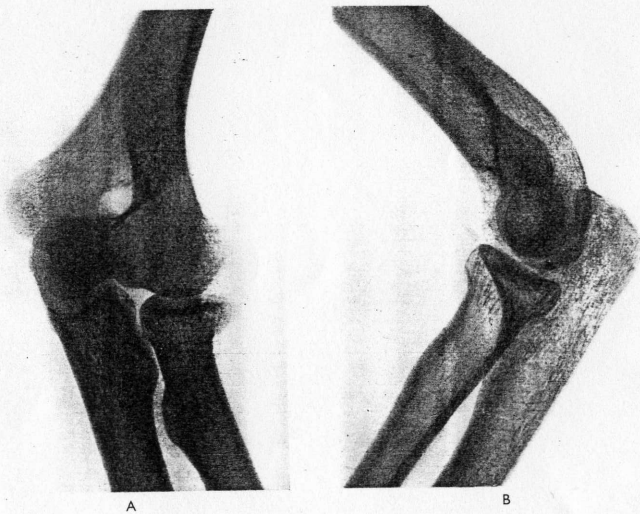


FIG. 153.—Case V. C. A, The original anteroposterior X-ray picture of a Type 2 fracture of the radial head. The sector fracture is less than one-quarter of the articular circumference, is depressed below the joint surface, and is not tilted. B, The lateral radiograph taken 15 months later. The plateau of the head of the radius is not distorted and the elbow-joint appears normal. Note the 'chip' fracture of the coronoid process visible in both radiographs. The function of the joint was full.

The 8 'borderline' cases were absent from their work for an average period of 11.5 weeks; but 4 of them had had to undertake work of a lighter nature.

2. Cases treated by Operation.—The 5 patients treated by excision of the head of the radius were doing their normal household duties in an average of 8.5 weeks.

This series of 20 cases of Type 2 fracture of the head of the radius demonstrates some interesting features.

The 7 patients of this group in which the segmental fracture consisting of less than one-quarter

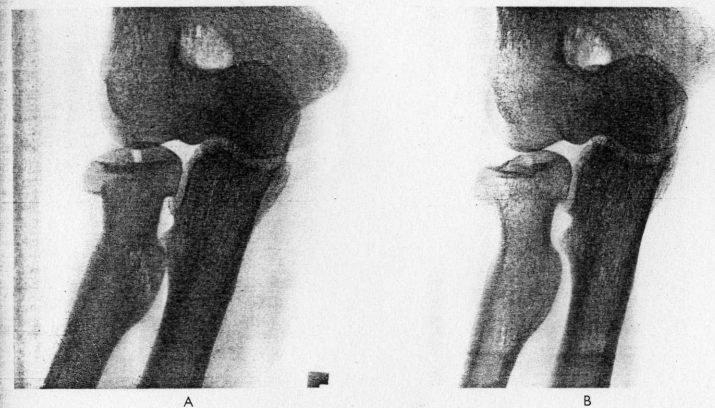


FIG. 154.—Case E. W. A, The original anteroposterior radiograph. The fracture of the head of the radius had been considered a 'borderline' case and treated conservatively. The fracture involves more than one-quarter of the articular plateau and it tilted out of line. B, The subsequent radiograph taken 27 months later. The fracture has united, leaving a grossly distorted radial head. Note the fissure still present in the articular plateau. This patient had lost 60° of rotation range of the elbow-joint and was now undertaking lighter work.

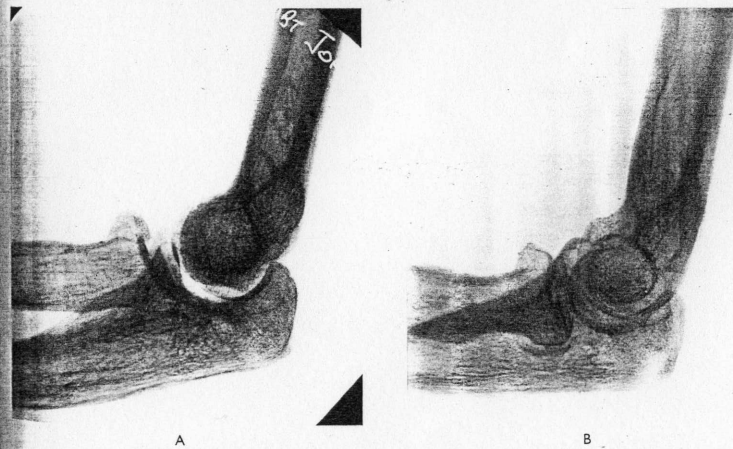


FIG. 155.—Case R. J. A, Showing the original lateral radiograph of a Type 2 fracture of the head of the radius considered 'borderline' and treated on conservative lines. The fracture involves one-quarter of the articular circumference, but is tilted out of line. B, The subsequent radiograph, taken 42 months later, shows a healed fracture with gross distortion of the articular plateau and early osteo-arthritis changes. This patient, on account of the loss of rotation movement, was forced to give up work involving the use of a shovel.

of the articular circumference of the radial head was depressed below the joint surface without tilting, had all regained full use of the elbow despite an average loss of 10° of extension movement and 30° of total rotation range of the elbow-joint. They



FIG. 156.—Case P. S. Anteroposterior radiograph taken 18 months after resection of the radial head for a Type 3 fracture. There is no osteo-arthritis and minimal new-bone formation around the radial neck. Function of the elbow-joint was full.

had returned to their normal work in an average of 5 weeks.

The 5 patients on whom excision of the head of the radius had been performed on account of distortion of the articular plateau, had full function despite the loss of the last 20° extension movement of the elbow-joint. They had regained a full rotation range of movement and had returned to their normal duties in an average of 8.5 weeks.

The 8 'borderline' cases had only regained good elbow function with an average loss of 15° extension movement, but with 60° loss of rotation range of elbow movement. They had returned to work in an average of 11.5 weeks, but 4 patients were unable on account of this rotation loss to return to their normal work.

Nine patients of these 20 complained of some pain over the radial head, but no pain over the medial joint ligament.

Eight of these cases were the 'borderline' cases.

It is proposed to discuss these 'borderline' cases below.

As with the Type 1 fracture, a constant feature of this series of 20 cases was the loss of extension motion of the elbow-joint even after excision of the radial head.

ANALYSIS OF THE 18 CASES OF TYPE 3 FRACTURE (Comminuted Fracture involving the Whole Radial Head)

ORIGINAL TREATMENT.—Each of these 18 cases had been treated by total excision of the radial head. They consisted of cases in which there had been complete disorganization of the head of the radius.

Excision had been carried out on an average of 6 days after the initial injury.

FINDINGS ON CLINICAL EXAMINATION.

Pain in the Elbow-joint.—Eight patients complained of minimal pain over the lateral joint line, and on rotation of the joint crepitus could be elicited in this area.

Ten patients made no complaint of pain. There was no pain over the medial joint line and no undue laxity in any of them.

No abnormality of the distal radio-ulnar joint was demonstrable in any of these 18 cases. The 'carrying angle' in each case was normal.

Range of Movement of the Elbow-joint.—None of these 18 patients had a full range of joint movement. In 17 of them extension was limited by an average of 25°. Supination and pronation range was limited by an average of 15° of each movement.

One patient who developed myositis ossificans had an elbow fixed in 90° of flexion. There was minimal range from this position.

Function of the Elbow-joint.—Seventeen of these patients had full use of the joint and were all doing their



FIG. 157.—Case M. B. Lateral radiograph taken 31 months after operative treatment for a Type 3 fracture. The joint surfaces are normal and there is minimal new-bone formation in the region of the radial neck. This patient was doing his normal work as a farm labourer.

normal work. Eight were housewives and 9 were men doing heavy work.

The loss of extension of 25° was no disability and none of the cases had noticed the 30° loss of rotation range of movement.

The one patient with myositis ossificans was coping with her housework, but had a poor function of the joint.

RADIOGRAPHIC EXAMINATION OF THE ELBOW-JOINT.—Eight of the 18 cases were selected at random and subjected to X-ray examination. Typically the radiograph showed complete excision of the radial head. There

was no evidence of degenerative change, and the joint surfaces were normal.

Some new bone had formed in the region of the radial neck, but did not encroach on the new 'joint space'.

Figs. 156 and 157 show the radiographs of two typical cases, taken 18 months and 31 months after resection of the radial head. There is minimal new bone formation and no osteo-arthritis.

TIME OFF WORK.—The average time off work for these 18 cases was 9.5 weeks.

The housewife had returned to her normal duties in 8 weeks, whilst the heavy worker had returned to his in 11 weeks.

This analysis of 18 cases of comminuted fracture of the radial head treated by early excision demonstrates that 17 patients had regained full use of the elbow-joint and were back doing their normal work in 9.5 weeks. Their function had been regained despite an average loss of 25° of full extension movement of the elbow-joint. This loss of extension range was no disability. The loss of 30° of rotation range likewise was no hazard to full work. One patient with myositis ossificans had no range of movement of the joint and poor function.

Eight patients complained of occasional pain over the lateral joint line, but it was insufficient to impair the function of the joint.

A constant feature in all these cases despite the absence of the head of the radius was the loss of extension movement of the elbow-joint.

DISCUSSION

Jones (1935) succinctly states that "the fracture of the head of the radius is a serious injury, and whilst the prognosis is good for recovery of a useful elbow, rarely is it a normal elbow".

This clinical review of 100 cases of all types of fracture of the head of the radius adequately bears out this statement.

Only 1 patient, complicated by myositis ossificans after excision of the radial head, had poor function of the elbow-joint. The remaining 99 patients had all recovered full or good function, and were able to return to their work, although 4 of them had had to undertake work of a lighter nature on account of a residual disability.

The aim of any orthopaedic procedure is to attempt to restore normal function whenever possible and as soon as possible.

Method of Treatment and the End-result.—A study of the detailed analysis of the cases of each type of fracture reveals some interesting considerations.

Each of the 62 cases of Type 1 fracture—fissure or marginal sector fractures without displacement—treated by conservative measures, had regained full function of the joint, whilst 42 of these patients having regained a full range of elbow movement, had also recovered a normal elbow. This function had been restored in an average of 4.8 weeks.

This indicates that for the best chance of a perfect result, the fracture of the head of the radius must be in perfect position.

An elbow-joint with full rotation range of movement, but with limitation of flexion and extension is a much more useful member than one in which

rotation is limited and the flexion-extension range is full.

The last 40° (one-ninth) of the articular circumference of the radial head plays no part in the rotation movement of the proximal radio-ulnar joint. This review indicates that a loss of 30° range of rotation movement does not adversely affect function. This means in effect that, providing the fracture of the lateral articular circumference of the head involves no more than an arc of 70°, the remaining 290° being intact, the rotation function will be preserved.

From the practical point of view, and despite the theoretical consideration of one-ninth (40°) if more than one-quarter (90°) of the articular circumference of the head of the radius is involved in the fracture, limitation of rotation sufficient to impair function will inevitably result.

Of the 18 cases of Type 3 fracture—comminuted fracture of the whole head treated by resection—17 had regained normal function of the elbow-joint in an average of 9.5 weeks, but none of these had a normal elbow. (The case of myositis ossificans was due to a prolonged unsuccessful search for a fragment of the radial head which was outside the joint capsule.) These 17 patients had recovered almost full rotation, the loss of range being 30°. The loss of extension range of 25° was no disability.

It is considered that this restoration of rotation range was responsible for the ability of these patients to resume their normal duties quickly and efficiently.

The fracture of the radial head without displacement, and the comminuted fracture of the head of the radius, give rise to no difficulty with regard to diagnosis, and there is general agreement on the necessary lines of treatment for each case, i.e., conservative treatment for the non-displaced fracture, and complete excision for the comminuted type of fracture.

The Type 2 fracture—marginal sector fracture with displacement—is unfortunately not so clearly defined.

The analysis of the 20 cases of this type of fracture shows that the 7 patients in whom the sector fracture was less than one-quarter of the circumference of the head, depressed below the joint line, but not tilted in any way, and which were treated conservatively, together with the 5 cases of this group treated by excision of the head on account of gross interference with the radio-humeral joint, had all returned to their normal duties in an average of 5 weeks and 8.5 weeks respectively.

None of these cases had a normal elbow-joint. All had lost full extension of the elbow-joint, but rotation range was full in the 5 resected cases and limited by only 30° in the conservatively treated cases.

Again, it is considered that the regain of full or almost full rotation range was responsible for the relatively early return to a fully-functioning elbow-joint.

The remaining 8 cases of this group labelled 'borderline', constitute a difficult problem. The borderline case, from the practical point of view, is difficult to define.

Most text-books attempt by radiographs to show the maximum displacement of the marginal sector

fracture which is compatible with full function of the elbow-joint if treated conservatively.

The 8 patients of this group were considered in this light, and, as has been shown, none of them



FIG. 158.—The lateral oblique radiograph of a case (not included in this series) in which the anteroposterior and lateral radiographs suggested a 'borderline' case. The segmental fracture appears to consist of one-quarter of the articular circumference of the head, but it is comminuted and tilted out of line. Complete excision of the radial head was performed. Figs. 159, 160 show photographs of the radial head after resection.

regained full function mainly on account of the 60° rotation loss of movement. Four of them, because of this loss of rotation, were forced to undertake lighter work. The average time before these 8

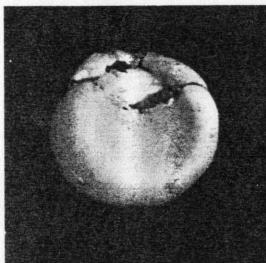


FIG. 159.—The 'end-on' photograph of the radial head after resection (see Fig. 158). The gross comminution is easily seen. The fractured segment involves one-third and not one-quarter of the articular circumference on its lateral border.

patients resumed work was 11.5 weeks, whilst the 5 patients of this group treated by early excision of the radial head were all back at their normal occupations with full function in 8.5 weeks.

It would appear, therefore, that unless the fracture is in perfect position, a more certain and quicker return to normal can be secured by early resection of the injured radial head than can be expected by conservative methods.

It is considered that the borderline case should not be regarded as an entity.

If the fracture of the radial head is not displaced, or if the fracture is no more than one-quarter of the articular circumference without comminution, depressed below the joint surface, and not tilted out of line in any way as judged by radiographs in anteroposterior, lateral, and oblique views, conservative measures may be adopted.

In all other cases, no matter how minimal the tilting and comminution of the fractured segment, excision of the head of the radius should be performed.

Fig. 158 shows a lateral oblique radiograph of a case (not included in this series) in which the fractured sector appears to consist of one-quarter of the articular circumference of the radial head, with comminution and obvious tilting of the fractured portion. The anteroposterior and lateral radiographs suggested that this was a borderline case. Complete excision of the radial head was performed.

Fig. 159 shows the 'end-on' photograph of the excised head. The fractured segment is grossly comminuted and, in fact, involves one-third of the articular circumference and not one-quarter.

Fig. 160 shows the lateral photograph of the excised head. The depression of the fractured sector is well demonstrated. The fracture of the articular circumference, however, is not longitudinal, but on account of the tilting of the fractured portion it is oblique in outline.

This obliquity of the fracture line means that at its base more than one-third of the articular circumference of the radial head is involved. Cases, therefore, in which the 'allowable' one-quarter of the articular circumference is damaged, but in which

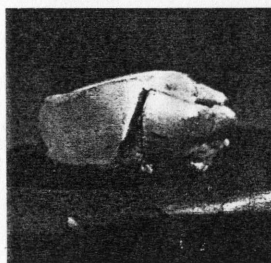


FIG. 160.—The lateral photograph of the radial head after excision (see Fig. 158). The depression of the fractured sector is easily seen. The fracture is not longitudinal, but oblique in outline. More than one-third of the base of the articular circumference is, therefore, involved.

there is tilting of the fractured portion so as to give an oblique fracture line, will, on this account, have severe limitation of rotation movement at the elbow-joint if treated conservatively.

This tilting out of line of the fractured sector is a most important factor in deciding the subsequent treatment.

The tightly-fitting pivot proximal radio-ular joint needs only minimal mechanical interference to impair its rotation function.

The axiom, I believe, with regard to the treatment of fractures of the head of the radius should be: "If in doubt—resect."

Loss of Extension Range of Movement.—A constant feature in 58 (58 per cent) of these 100 cases was the failure to regain full extension movement of the elbow-joint. The loss of range varied between 8° in the undisplaced fractures to 25° in cases with comminuted fractures. In 23 of these cases complete resection of the radial head had been carried out.

It is the general opinion that the cause of this loss of extension is the damage sustained by the capitellum of the humerus.

It is generally agreed that in the majority of cases the mechanism of injury is such that the capitellum is driven chisel-like into the radial head and that its articular cartilage in consequence suffers damage. This damage is often not apparent at operation, but may develop—in its grossest form as osteochondritis dissecans—at a later date.

The unfortunate patient who attempts to break fall with the hand, the wrist being pronated and dorsiflexed, imparts a tremendous valgus strain on the elbow-joint. At the moment of impact, however, the whole of the elbow-joint sustains a compression force through the long axes of both the forearm bones, and only thereafter, as the elbow sags acutely into valgus, does the radial head bear the brunt of the impact.

The degree of leverage through the radial head and the resultant angle of cubitus valgus determines the degree of displacement and comminution of the head of the radius, and the degree of tearing of the medial joint capsule and ligament.

On impact, however, the cartilage of the trochlea of the humerus and the trochlear notch (greater sigmoid fossa) of the ulna, suffers damage similar to that sustained by the capitellum and the radial head.

The humero-ular joint is the 'mainstay' of the elbow. Experimental removal of the head of the radius does not decrease the stability of the elbow-joint, whilst the removal of the olecranon with its trochlear fossa gives rise to a severe degree of laxity. The trochlear notch of the ulna is not perfectly congruent with the trochlea of the humerus, but the joint is nevertheless a tight fit and minimal damage to the cartilage of the joint causes limitation of extension of the elbow-joint.

It was shown earlier in this paper that dislocations of the elbow-joint and fractures of the radial head had a common causative factor.

This factor must, therefore, affect the whole joint and not half of it, and in consequence the cartilage of both the medial and lateral compartments of the joint suffers damage. Only after this has been inflicted, and then depending on the severity of the valgus strain, does bony damage to the radial head occur.

Fig. 153 shows the radiographs of a Type 2 fracture which has completely united. The 'chip'

fracture of the coronoid process visible in both the original and subsequent X-ray photographs can only be accounted for by initial damage to both compartments of the elbow-joint.

As has previously been stated, the capitellum and the radial head are not normally in contact. There may be separation of the articular surfaces to an extent of one-quarter of an inch.

For flexion and extension motion to be limited at this joint, a moderately severe mechanical interference is necessary.

A minimal interference with the cartilage of the humero-ular joint, however, limits flexion and extension motion.

During the operation for excision of the trochlear fossa of the ulna which can be inspected after the head has been removed often shows evidence of injury in the same way as the capitellum. It may not, however, be immediately apparent, but as with the capitellum, the cartilage may degenerate later.

Twenty-three cases (23 per cent) in this series of 100 patients had incomplete extension of the elbow-joint despite the fact that the radial head, having been completely excised, was not articulating with the capitellum. The damaged capitellum could not, therefore, act as a mechanical bar to this extension movement.

The damage to the trochlea of the humerus and the trochlear notch of the ulna was responsible.

It is considered that the capitellum, whilst certainly responsible for the bony damage to the head of the radius and at the same time suffering damage itself, has innocently been incriminated as the main cause of the loss of extension movement of the elbow-joint after a fracture of the head of the radius.

This loss of movement, in itself no disability, is a result of injury to the whole of the elbow-joint.

Pain in the Elbow-joint.—Pain in the elbow-joint after a fracture of the radial head was not a prominent feature in this series of cases and was never severe.

The interesting feature was that those patients complaining of pain over the medial joint area were patients who sustained fractures without displacement. Pain over the lateral joint area was only observed in patients with either a comminuted fracture of the head, which had been excised, or patients with a partially comminuted fracture, which had not been excised.

It is considered that the medial joint pain is due to the initial tearing sustained by the medial capsular ligament of the elbow-joint during the valgus strain sustained by it. The absence of medial joint pain in the comminuted variety of fractures is due to the dissipation of the abduction force as the radial head collapses, thereby sparing the medial joint ligament.

Pain over the lateral joint line is due to ligamentous damage, especially after resection of the radial head. This minimal pain is often accompanied by crepitus on rotation of the radius. It is of interest to note that this coarse crepitus, often heard and very easily felt, is accounted for by only minimal pathological changes in the articular cartilage when the lateral joint surfaces are inspected.

SUMMARY

1. The surgical anatomy of the elbow-joint, and the mechanism of production of a fracture of the radial head are discussed.
2. A review of 100 cases of fracture of the head of the radius is presented.
3. The end-results are analysed in detail with special reference to the function and range of movement of the elbow-joint, and to the time taken before recovery and return to work.
4. An attempt is made to show that the case which falls on the borderline between conservative and operative treatment should not be regarded as an entity.
5. The axiom in the treatment of fractures of the head of the radius should be: "If in doubt—resect."
6. The cause of the loss of extension movement of the elbow-joint after this type of injury is discussed, and it is considered that the damage to the

cartilage of the trochlea of the humerus and the trochlear notch of the ulna, shares a great deal of the responsibility for this loss of range.

7. The cause of pain in the elbow-joint after a fracture of the radial head is discussed.

I wish to thank Mr. R. C. Baird for his constant encouragement. I am indebted to my father, Mr. R. Mason, for the photographs and the radiographic reproductions, and to Mrs. Pamela Carpenter, clinical secretary, for her invaluable help.

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THE ANATOMY OF THE INTRARENAL ARTERIES AND ITS APPLICATION TO SEGMENTAL RESECTION OF THE KIDNEY

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PARTIAL nephrectomy is now advocated by many surgeons in the treatment of renal tuberculosis and calculus. Control of hæmorrhage is one of the technical difficulties of this operation and of the more established procedure of nephrolithotomy in which failure of hæmostasis sometimes necessitates nephrectomy. Knowledge of the vascular pattern of the kidney should assist the surgeon in carrying out these operations, but it is neither complete nor readily accessible. This investigation was, therefore, carried out to answer the following questions:—

1. Is there a constant pattern of the branches of the renal artery within the substance of the kidney?
2. If the pattern is constant, is there a collateral circulation between these branches?
3. Could knowledge of the two previous points be applied to segmental resection of the kidney?
4. In view of the density of the kidney substance, apart from anatomical knowledge, is there any method of determining the pattern and course of the intrarenal arteries either before or at the time of operation?

METHODS OF INVESTIGATION

The investigation was carried out by two methods:—

Injection of Post-mortem Specimens with Plastic.—The kidney and the surrounding tissue were removed *en bloc* with the adjacent part of the aorta. This was done so that any duplication of the renal vessels might be detected and examined. Liquid polyester resin (Marco Resin S.B. 61C) was injected into the renal artery and subsequently, when the resin had set, the kidney substance was removed by corrosion in concentrated hydrochloric acid. Casts were made of the renal vessels of more than thirty specimens.

Angiography of Post-mortem Specimens.—

Post-mortem kidneys were perfused at a pressure approximating to that which they had received in life. Angiograms were made by injection of 50 per cent and 70 per cent solutions of diodone into the renal artery. Similarly, venograms were made by perfusion of the renal veins.

ANATOMY AND NOMENCLATURE

On the basis of the arterial distribution, the kidney is divisible into five segments (Fig. 161). From above downwards these are:—

The Apical Segment is a cap of tissue which occupies the medial side of the upper pole of the kidney, mainly on its anterior surface.

The Upper (Anterior) Segment lies in the anterior plane of the kidney. It covers an area which includes the upper pole and part of the central area of the kidney.

The Middle (Anterior) Segment lies in the anterior plane of the kidney. It covers an area in the lower central part, between the upper and lower segments.

The Lower Segment forms the lower pole of the kidney. Unlike the middle and upper segments, it lies in both the anterior and posterior planes of the kidney.

The Posterior Segment lies entirely in the posterior plane of the kidney and occupies an area between the posterior part of the apical segment above, and the posterior portion of the lower segment below.

ANATOMY OF THE RENAL VESSELS WITHIN THE KIDNEY

Each segment is supplied by its own artery (Figs. 162, 163). The main stem of the renal artery divides at a variable point between the aorta and the

hilum of the kidney into an anterior and posterior division.

The *anterior division* gives rise to the upper, middle, and lower segmental arteries, and the apical segment artery usually arises from it.

The *posterior division* continues and supplies only the posterior segment, but it may give origin to the artery to the apical segment.

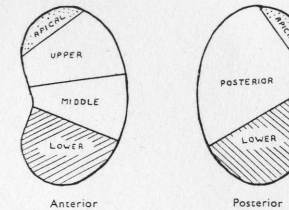


FIG. 161.—A diagram of the left kidney showing the segments which are based on the arterial distribution. Only the apical and lower segments occupy areas on both the anterior and posterior surfaces of the kidney.

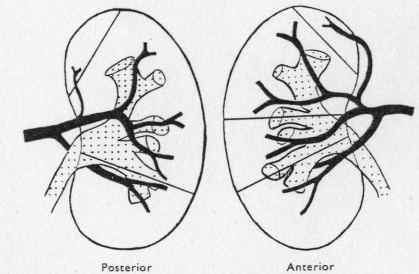


FIG. 162.—A diagram of the right kidney showing the arrangement of the arteries and the segments they supply. The artery to the apical segment is that of Type I. The arrangement of the remaining anterior segment arteries is that of Group I.

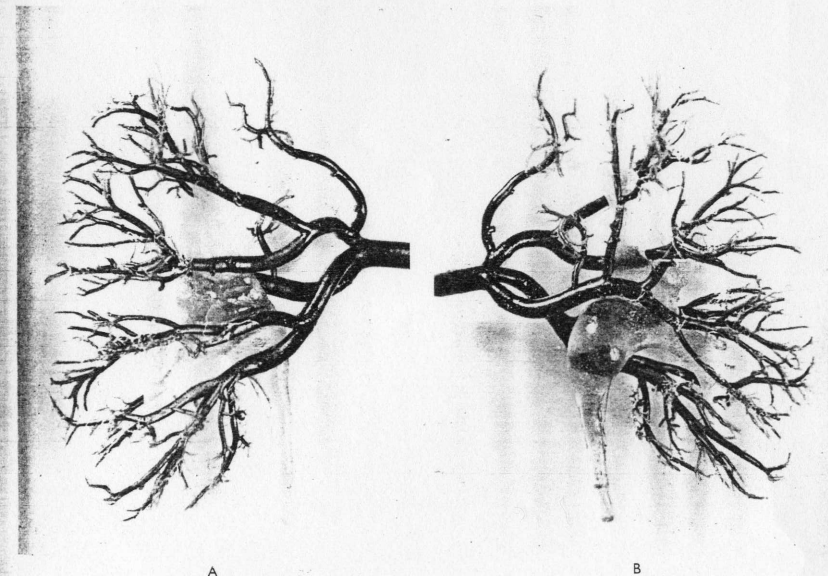


FIG. 163.—A cast of the intrarenal arteries of the right kidney. A. *Anterior view*. The apical segment artery arises from the artery to the upper segment, the apical and lateral branches of the latter being well developed. The middle segment artery arises from the side of the lower segment artery, as in Group II. B. *Posterior view*. The artery to the posterior segment lies close to the superior pelvi-caliceal junction; it gives rise to upper, middle, and terminal branches. Note the posterior branch of the lower segment artery from the anterior division.

The Segmental Arteries.—

The Apical Segment Artery.—The apical segment is supplied by an artery which most frequently arises from the anterior division. It is, however, a vessel

segment artery; from the junction of the anterior and posterior divisions with the main stems; from the main stem or the aorta; from the posterior division (see Fig. 164).