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TREATMENT OF CLOSED FRACTURES OF RADIUS AND ULNA *

BY

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It seems logical to adopt a standard form of treatment for certain fractures, if such is followed by a normal and lasting function, and is achieved in as short a time as possible. Axis and skeletal traction are considered up to date in the treatment of fractures. In forearm fractures my experience in their use is small and is never likely to be greatly increased, as other methods appear preferable. It is my intention to lay stress on the appreciation of the anatomical relationship of the radius and ulna at the superior and inferior radio-ulnar joints when fractures of the forearm are treated.

In the review of nearly 400 cases of forearm fractures it has been interesting to study the length of time each case has been under treatment. To make this possible the cases reported are only those treated from start to finish in one institution. Cases treated in nursing homes and other hospitals and those referred after some treatment—a considerable number—are excluded. This method of investigation has advantages in that the work has been in one clinic and the immediate setting has been carried out in the greater number of cases during a five-year period by casualty officers and orthopaedic house-surgeons, who show the utmost keenness and are severely critical of the success of their work, but are in no sense of the word experienced until it is time for them to pass to other appointments. Hence methods are advocated which are considered the simplest and seldom necessitate the admission of the patient to hospital: further manipulative or operative methods are employed only when they fail. Of 374 fractures it is found that twenty-eight were treated by open operation (7.4 per cent.). This low figure is accounted for by the large number of greenstick fractures in the series, for 75 per cent. of the fractures occurred in patients under the age of 20.

It is obvious that hospitals in industrial areas have in their clinics a far greater proportion of closed forearm fractures in adults than occur in this series, and my own experience is enlarged by accidents seen elsewhere. However, the detail of the treatment of the common injury, simple as it may appear, is worthy of consideration.

Group I—Bamboo and Greenstick Fractures with Little or No Displacement

After x-ray examination a plaster is applied, usually no anaesthetic being required. Records show that some of the slight injuries were treated on Carr's splint. A child

is safer at school with the plaster on, and seldom does a parent meddle with it. The type of plaster employed is standardized for all the fractures under discussion.

	No. of Cases	Upper Third	Middle Third	Lower Third	Average Time Under All Treatment (Weeks)	Longest Time Any One Case Under Treatment (Weeks)
Radius and ulna	31	0	9	22	6.2	12
Radius ..	58	0	5	53	5.8	9
Ulna ..	4	1	2	1	6.7	10
Group as a whole	93	1	16	76	6.2	12

METHOD OF APPLYING PLASTER-OF-PARIS BANDAGE

The elbow is bent to a right-angle, and the forearm supinated and wrist slightly dorsiflexed. A thin slab of plaster is applied to the back of the arm and extensor surface of the forearm, extending from the lower border of the axilla to the metacarpal necks. This fits accurately on to the skin, and by two lateral cuts is made to fold round the elbow, coming forwards just over the epicondyles. It should cover slightly more than the posterior half of the skin area of the limb. A piece of wool is placed in front of the elbow. A flannel or plaster wool bandage is applied round hand, forearm, and arm to secure the plaster to the skin and to act as padding for the flexor surface of the forearm and antecubital fossa. A plaster bandage is wound round the limb from metacarpal necks to lower axillary border. This is never pulled tight, but folded to and fro and moulded in. The most distal turn should be round the neck and head of the metacarpal of the index finger and not in the apex of the web between thumb and index finger. A second bandage similarly applied may be required. During the moulding process an attempt should be made to produce a slight furrow along the front and back of the forearm in the line of the space between radius and ulna, but the inclusion of a piece of wood in the plaster to serve this purpose is unnecessary.

When the plaster extends only to "just above the elbow" some movement will take place at that joint, so that the plaster will cut in at the back of the arm and in front at the fold of the joint.

The patient is instructed to move the shoulder, fingers, and thumb straight away, and in some cases is advised to attend the massage department for assistance. Swelling of the hand may result from the injury itself or a plaster splint applied too tightly or incorrectly. Flexion contracture of the fingers may be due to haemorrhage in the forearm muscles, too tight a plaster, or the beginning of Volkmann's ischaemic contracture.

* Read in the Section of Orthopaedics and Fractures at the Annual Meeting of the British Medical Association, Aberdeen, 1939.

Group II—Greenstick Fractures with Angulation of One or Both Bones, which were Treated by Closed Methods

	No. of Cases	Upper Third	Middle Third	Lower Third	Average Time Under All Treatment (Weeks)	Longest Time Any One Case Under Treatment (Weeks)
Radius and ulna	114	11	64	39	8.6	16
Radius ..	44	1	11	32	7	11
Ulna ..	6	1	3	2	7.7	11
Group as a whole	164	13	78	73	7.8	16

When any angulation is present the child is anaesthetized and the fracture is completed, so that the forearm bones can be fixed in plaster in anatomical alignment. If this is not carried out deformity will follow which may or may not straighten out subsequently. If one bone only is affected the supination-pronation range of movement may be limited for some time and the other bone may bow as it grows. The completion of the fracture is simple if carried out over a rubber-padded wedge of wood. At first there is a fear of doing damage or of causing displacement, but it is quickly overcome. When one bone is angled in the upper third and the other two or three inches lower down, the forearm should be placed obliquely over the wedge. Reference will be made to re-fractures in children later; because of these, six weeks' complete fixation and a week in the posterior half of the plaster is considered necessary.

Group III—Fractures Other than Greenstick, which Required no Reduction, or in which Reduction was Contraindicated

	No. of Cases	Upper Third	Middle Third	Lower Third	Average Time Under all Treatment (Weeks)	Longest Time Any One Case Under Treatment (Weeks)
Radius and ulna	5	0	3	2	9.5	20
Radius ..	10	0	3	7	8.4	19
Ulna ..	14	2	6	6	14.8	20
Group as a whole	29	2	12	15	10.9	20

The injuries recorded in this group have been treated on similar lines. The patient usually reaches hospital wearing a first-aid appliance with the forearm pronated. Manipulation into full supination is painful, so that an anaesthetic is necessary for the application of the plaster. The fractures of interest in Group III are those of the ulna alone. If there is a crack only, or a fracture with one or more loose fragments lying close to the bone, union will not be delayed. Both the fractures of the upper third of the bone took longer than the average time to unite, and one took twenty weeks. The average is nearly double that recorded for the radial fractures, but possibly extra care was employed. In this series there was no case of non-union in the lower third, the recognized danger area.

There is no doubt that the basis of Baldwin's operation is well founded, as periodically patients seek treatment for non-union of the ulna three inches or so above the wrist when fixation has been brief. When further fixation or physiotherapy fails to produce union a bone graft is

advisable. Consolidation of graft and bone is more likely to occur if a tibial graft is used in preference to a sliding graft from the ulna.

Group IV—Fractures Other than Greenstick with Overlap or Angulation, which were Treated by Closed Reduction

	Total	Upper Third	Middle Third	Lower Third	Average Time Under All Treatment (Weeks)	Longest Time Any One Case Under Treatment (Weeks)
Radius and ulna	39	2	17	20	9.3	26
Radius ..	14	3	2	9	9.3	24
Ulna ..	7*	2	2	3	9.4	13
Group as a whole	60	7	21	32	9.3	26

* Includes two cases of fracture of the upper third of the ulna with dislocation of the upper end of the radius.

Treatment of fractures in this group is one of the most difficult problems in fracture surgery. Success in alignment by closed reduction is economical in the patient's time and saves pain and further operative treatment.

Radius and Ulna.—When there is *angulation* this is corrected and a plaster is applied under an anaesthetic. When there is *overlap* the patient is anaesthetized and traction and countertraction applied. Manipulation will frequently succeed in reducing the transverse and, less often, the oblique fractures. If neither bone hitches the fractured ends are turned backwards towards the extensor surface of the forearm and an attempt made to hitch them. This method is easily understood by those who employ it in open reductions. Should this fail a method worthy of trial is to manipulate the radius only and, if this hitches, employ the radius as a lever and pull out to full length the fragments of the ulna. The reverse of this is less easy.

(i) If alignment and end-to-end apposition are achieved—that is, “both bones hitched”—plaster is applied in the manner described. For its application with the patient recumbent the arm is abducted to a right-angle, the elbow flexed to a right-angle, and the fingers, pointing to the ceiling, held by an assistant. It is most important to mould in the interosseous space to prevent it “being crowded,” as there is a great tendency for the upper radial fragment to tilt towards the ulna.

(ii) If neither bone can be hitched the decision has to be made as to whether to employ fixation with the bones in the position of overlap or to proceed to another method of reduction. It is universally accepted that unreduced fractures of the lower third of both bones, at the same level, in children are followed by full function and a perfect radiographic appearance after a few years. This may also apply to fractures of the upper third, but the prognosis is less certain. In adults overlap of both bones should be corrected.

(iii) If one bone is hitched and the other not, the decision whether full function will be obtained is usually difficult. In children, when the radius is hitched and not the ulna, plaster is applied; but when the ulna is hitched further treatment is advised. In adults, risk as to ultimate function is taken if alignment is not restored. Should it be found that good alignment with ample separation of the radius and ulna cannot be obtained with the forearm fully supinated, but is possible, say, in mid-position, the limb should be put in plaster in this position. Similarly, full wrist dorsiflexion or slight palmar flexion—although undesirable on general principles—may enable the surgeon to place the bones in better alignment.

The treatment advocated when manipulation has failed is considered subsequently, when operations on forearm bones are discussed.

The value of physiotherapy in these cases of imperfect reduction is worthy of consideration. The most valuable form is what may be termed "preventive." If the patient moves the fingers and thumb from the day of the fracture, which is always possible in closed fractures, there should be no stiffness of finger-joints, and the wrist and elbow will regain their movements if their fixation has been in the correct position. As pronation is a movement of necessity, the patient will regain this if the mechanical relations of bones and radio-ulnar joints allow it and the muscles and their nerve supply are intact. The muscles will be assisted by physiotherapeutic measures when fixation can be released.

RADIUS

As overlap of the radius may be associated with a complete separation of the lower epiphysis of the ulna,

FIG. 1.—Sketch to illustrate fracture of radius with overlap and dislocation of inferior radio-ulnar joint.

or in adults with subluxation or dislocation of the inferior radio-ulnar joint, it is important that the skiagram should include the wrist-joint. Theoretically, it should be easier to reduce by manipulation a fracture of the radius alone than one of both bones, as the ulna can be used as a lever. This is seldom the case, as fractures of the radial shaft are usually oblique and will not hitch. If manipulation fails to correct an overlap in the distal half of the radius, further measures should be adopted to correct this in an adult, but it is not always necessary in a child. If the inferior radio-ulnar joint is not in anatomical alignment open reduction is advisable (see below).

ULNA

No discussion on fractures of the ulna alone is complete unless adequate thought is given to the "fracture of the ulna in its upper third associated with an anterior dislocation of the upper end of the radius." The anatomy of the fracture is an angulation or overlap of the ulna, with displacement of the head of the radius above the capitellum, the orbicular ligament being torn. The radial head may be within or have penetrated the anterior ligament of the elbow-joint. There is shortening of the length of the forearm. The injury is most common in childhood, when the ulna is usually broken in the upper third; after the age of 15 the ulna tends to be broken nearer the centre of the shaft. The injury is not to be confused with (a) oblique fracture of the olecranon with forward dislocation of the radius and ulna, with intact orbicular ligament usually occurring in the early "teens"; nor with (b) fracture of the upper third of the ulna with fracture of the radial neck in adults.

A correct diagnosis is essential for the treatment. Error may occur owing to the skiagram not including the elbow-

joint, so that there is lack of appreciation of the dual injury. Early and correct treatment should produce a normal elbow. Unsuccessful treatment or delayed treatment may be followed by limitation of movement and weakness, particularly if a false joint is formed at the site of ulnar fracture. All the cases that have been treated by manipulation and plaster, or by operation, within a few days have full movement and no disability, whereas all cases operated on after delay have disability, including the case of a boy aged 4. The immediate treatment consists of reduction and fixation.

Reduction.—Unless the head of the radius has passed through the anterior part of the capsule, which is probably rare, the reduction of this dislocation causes no difficulty. As length is given to the forearm by such a manipulation, the ulna tends to come into alignment. However, this is not sufficient, for the length of the forearm should be maintained by the ulna, so that there is joint space between the head of the radius and the capitellum. If the surgeon relies on the length of the forearm being maintained by the radius, the radial head is likely to be pressed against the capitellum. In that position redislocation is liable to occur, or if it does not erosion of articular cartilage and subsequent traumatic arthritis will follow. Hence the alignment of the ulna is the primary consideration. When the fracture is transverse or oblique with a notch, it should be possible to manipulate the bone until it is hitched and full length obtained. Probably during the manipulation the upper end of the radius has slipped back into place. If the ulnar reduction is difficult traction and counter-traction with manipulation can be tried, or the manipulation can be repeated after reduction of the head of the radius.

FIG. 2.—Sketch of typical fracture of upper third of ulna with forward dislocation of upper end of radius.

Fixation.—As soon as the surgeon feels confident that he has achieved the reduction, a plaster is applied as for a fracture of the forearm. At the same time traction and countertraction should be applied by a band round the arm tied to a hook or held by an assistant, and by traction on the fingers. Moulding to keep the upper half of the radius back is as important as that to maintain the ulnar alignment. This plaster is removed in six weeks, and the posterior half worn for another two weeks.

There is likely to be criticism of this position of the arm, as acute flexion is reputed to be the position of choice after setting this fracture-dislocation. But it is recognized by advocates of this position that redislocation may occur. In acute flexion no attempt is made to keep a joint space,

and the cup on the head of the radius may not remain in correct relation to the capitellum. Further, the alignment of the ulna is far more difficult to control in this position than when the elbow is at a right-angle. Although some orthopaedic surgeons may favour the acute-flexion position and take exception to the position advocated, probably all agree that the best functional end-results are to be expected if the ulna has been allowed to heal with no deformity or shortening.

INDICATIONS FOR OPEN OPERATION

On the Ulna.—(a) Failure to reduce the overlap of the ulna. (b) Rare cases when the upper end of the lower ulnar fragment has penetrated the skin. An open reduction is likely to enable the surgeon to hitch the ulna and give it full length, and internal fixation is not required unless there is a constant tendency to angulation. (c) In late cases with angulation of the ulna or non-union of the fracture.

On the Radius.—(a) When reduction is not achieved by manipulation the outer side of the elbow-joint should be explored and the entanglement of the head in the soft structures relieved. (b) When redislocation of the radius occurs: it is contended that this is not an indication for operation on the radius, as it can be controlled by proper reduction of the ulna and moulding of the plaster. (c) In late cases of unreduced dislocation the question may arise whether a greater range of movement will occur if open reduction is employed. It is considered that an open reduction of the dislocation and of the fracture by separate incisions is indicated if the patient is seen during the second to sixth week or so.

After a long interval in an unreduced case it may be tempting to remove the head and neck of the radius, but little is to be gained by this, and the arm is likely to be weaker.

On the Orbicular Ligament.—Fascial grafts to repair or replace the orbicular ligament can be employed. If an open reduction of the dislocation is indicated a stitch without a graft will assist in the healing. When a case is operated on a few weeks after the injury an attempt to make a new ligament is desirable. In the late unreduced cases such a repair is not likely to be followed by good function. The fixation of the fascial graft to the ulna is difficult.

OPERATIVE TREATMENT OF FRACTURES OF RADIUS AND ULNA

If manipulation fails to correct displacement of the fracture the surgeon has to decide on the next procedure. This decision should be made immediately, because an operation will be more difficult after a few weeks, and its result is likely to be less effective than if it is undertaken as soon as the skin is adequately prepared. It has been stated already that failure to correct overlap of forearm bones in children does not necessarily indicate that further intervention is advisable. The procedures possible are:

Closed Reduction by Mechanical Methods.—(a) By axis or skeletal traction: neither of these has appealed to me in treating the fractures under discussion, and my experience is limited. (b) Manual traction assisted by manipulation of Steinmann's pins inserted into one or both fragments.

Open Reduction.—When carried out within a few days of the injury open reduction makes it possible to restore anatomical alignment with little trauma to the tissues. The pain is slight after two days, and function is restored in a reasonable time. Provided adequate skin prepara-

tion is undertaken and the operation is done under such conditions as are suitable for any bone surgery, the risks of complications are minimal.

Group V—Fractures Other than Those Shown in Groups I-IV which were Treated by Open Operation owing to Overlap, and Failure of Closed Reduction

	No. of Cases	Open Reduction	Plating One or Both Bones	Bone Graft	Average Time Under All Treatment (Weeks)	Longest Time Any One Case Under Treatment (Weeks)
Radius and ulna	22	16	5	1	20.2*	112
Radius	4	0	4			
Radius lower third with separated ulnar epiphysis	1	1				12
Ulna upper third with dislocation upper end radius	1	1				12
Group as a whole	28	18	9	1		

* If 2 cases under treatment for 112 and 52 weeks are excluded, the average length of time under treatment is 15 weeks.

OPERATION

This is as follows. (a) Application of pneumatic tourniquet after exsanguination of the limb. (b) Exposure of the fracture and a length of the shaft above and below this. (c) Incision and raising up of the periosteum and attached muscles in the axis of the limb. (d) Elevation of each end of the fracture by grasping the shaft an inch from the fracture with bone-holding forceps which will fit the radius or ulna. (e) Removal of clot and other intervening substance. (f) Realignment and hitching of the bones by grasping each fragment; this is possible by traction, or angulation into the wound, hitching, and straightening. It may be necessary to carry out this on each bone. It is my routine to restore the radius first. If the ulna has hitched as the length of the forearm is re-established, the bone is not exposed. If the ulna has not hitched the radial wound is packed and the ulna realigned through a second incision. The ulnar fracture will generally dovetail in and fit snugly. This wound is closed and the radius is then realigned.

(g) *Fixation.*—(i) In most cases requiring operation the fracture of the radius and ulna is oblique, but there are notches at the fracture, which can be fitted in. So the operation is limited to an open reduction. If the bone fits snugly and does not bow, the periosteum and overlying muscles are stitched, the wound closed, and plaster applied. A small dressing is used and a plaster slab applied to skin and dressing on the extensor surface of the limb. More padding is applied before circular turns are made. (ii) Internal fixation is advisable in all cases of fracture of the radius in the upper third owing to the tendency for the upper fragment to swing inwards, and in every case in which there is doubt as to whether the radius will stay in correct alignment. A thin plate with two screws in each end is used. Obviously the risk of inserting a plate by Lane's technique is small, and nothing can be more disheartening than the occurrence of angulation or slipping of the bones during the closure of the wound or application of the plaster-of-Paris after an "open reduction" without fixation. Plating of the ulna is seldom necessary. A bone graft may be employed if a long loose fragment makes the application of a plate to the two ends of the

shaft difficult. Cases of non-union of bone after plating radius and ulna are known to us. It is usually possible to obtain the history and serial skiagrams. This serious complication appears to be due to fixation of the plate to the shaft although the fractured ends are not in apposition, to loosely fitting screws, to the introduction of sepsis, or to splinting of an inadequate type or for too short a period. In some cases more than one of these factors has been present.

All the cases reported in Group V are known to have full function. The case under treatment for 112 weeks is interesting in showing difficulties which may be encountered.

A girl aged 8 had a transverse fracture at the junction of the middle and lower thirds of the radius and ulna, with overlap of the bones. At the time of the primary reduction, which was satisfactory, it was noted that she had blue sclerotics. She had not broken any other bones. Just before she was due for discharge she fell down and re-fractured the limb, producing a similar fracture. It was again reduced satisfactorily. Shortly after the child left hospital the mother thought the plaster was dirty, so she immersed the whole limb in water. When this plaster was removed the arm was tense and the child developed the signs of an ischaemic paralysis. She was under treatment for many months for this, and union of the bone was delayed. While still under treatment she broke it again, but the setting was not satisfactory and an open reduction was carried out. That was in 1936, and the child now has a normal arm.

The patient under treatment for one year was a man of 36 who had the radius and ulna plated. The records suggest that he wished to attend hospital until litigation was settled. Apart from these two cases the average period of treatment is 50 per cent. longer than when treatment is by closed reduction.

Complications

Swelling of the forearm is a frequent sequel to reduction and application of plaster-of-Paris. This should be treated by incising the plaster up the middle of the front of the forearm, and not by enlarging the opening for the fingers and thumb. If the patient is not relieved the incision should extend the whole length of the plaster. The plaster should be prised open, and later can be fixed together by elastoplast. *Re-fracture* occurred in this series in ten children; of these, three had re-fractures twice and one three times. It is difficult to determine how many of these sustained a subsequent injury sufficient to break a normal bone. When some years ago it was first noticed that re-fractures were occurring, the length of fixation was increased; but study of the records does not suggest that this eliminated the complication, to which attention was drawn by me (Buxton, 1926). *Volkman's ischaemic contracture* (Garber, 1939) occurs in a small number of cases treated either in plaster casts or splints. It may be accompanied by median nerve paralysis. Its recognition should be followed by removal of splinting and elevation of the limb. If pain persists and voluntary movement is still greatly restricted, operation is indicated within a few hours. *Median nerve paralysis* without contracture was seen in one case in the series. Delayed operation restored function. Ulnar nerve injury has not been observed. *Synostosis* of radius and ulna is recorded as a not uncommon sequel to infected fractures of radius and ulna, but must be rare in closed fractures. *Decalcification* of the forearm bones and carpus may follow closed fractures in children and adults, but is less common than around the ankle. It appears that imperfectly reduced fractures are more liable to this complication than those which have been perfectly aligned.

Conclusion

In the treatment of forearm fractures two principles must form the basis of treatment: the correction of displacement of the bones and the fixation of the limb for a sufficient length of time to prevent the risk of displacement. The patient has seldom to be in bed, for even after operation he can be up in a few days. The shoulder and fingers should be moved by the patient himself from the beginning of the treatment. The superior and inferior radio-ulnar joint must be in perfect anatomical position after setting a forearm fracture.

Summary

The progress of nearly 400 fractures treated in one hospital has been studied. These are considered in five groups.

Stress is laid on recognition and treatment of dislocation or subluxation of the superior or inferior radio-ulnar joint with fracture of a single forearm bone (fracture of upper half of ulna and forward dislocation of upper end of radius, and fracture of lower third of radius with dislocation of inferior radio-ulnar joint).

Volkman's ischaemic contracture is recorded.

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CLINICAL SIGNIFICANCE OF TUBERCLE BACILLI IN THE URINE

BY

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The term "urinary tuberculosis" is used to describe a clinical condition characterized by tuberculous lesions in the urinary tract, by the presence of urinary symptoms, and by the excretion of pus and tubercle bacilli in the urine. The term "tuberculous bacilluria" is employed to cover an occult or subclinical tuberculous infection associated with the excretion of tubercle bacilli in the urine but unaccompanied by any urinary symptoms. Tubercle bacilli are to be found in the urine in both these conditions, but it is important to decide whether the case is one of established urinary tuberculosis or of simple bacilluria. The object of this paper is to compare the results of urine tests in these two conditions.

Tuberculous Bacilluria

Tuberculous lesions of the urinary organs, whatever be their location, are almost invariably the consequence of a blood-stream infection from an active tuberculous lesion in some other organ in the body. All the evidence goes to show that the kidney is the first part of the urinary tract to be affected and that the renal lesion is at first bilateral. Tubercle bacilli brought to the kidney by the blood stream give rise to minor tuberculous lesions unaccompanied by signs or symptoms. Most of these are undetected and heal spontaneously without causing any discoverable injury. So long as these minor lesions persist, tubercle bacilli may be excreted in the urine in small numbers. Conversely, whenever tubercle bacilli are found in the urine it may be assumed that pathological lesions exist in the kidney, though a particularly thorough examination