# UNUNITED FRACTURES DUE TO WAR INJURIES: WITH END-RESULTS OF OPERATIVE TREATMENT IN 100 CASES.

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As a result of the frequency of ununited fractures in gunshot injuries of the extremities, the operation of bone-grafting acquired greater importance and has required to be extensively practised. In this paper it is not proposed to discuss the relative merits of the operations in use and experimental work that has been done in regard to the fate of bone-grafts, but to record the results of the experience gained from a personal study of 77 patients in the Military Orthopædic Hospital at Bangour during a period of three years ending March 31, 1921, and also of 23 cases during a period of eighteen months in Craigleith Ministry of Pensions Hospital; to describe the operations which the writer was led to adopt; and, by illustrative cases, to bring forward for consideration some of the important points in connection with the pre- and post-operative treatment.

The question of the fate of bone-grafts when in process of conversion into normal bone is reserved for a subsequent communication in which the results of an experimental investigation, not yet complete, will be fully discussed.

## GENERAL CONSIDERATIONS.

In 61 cases the operation carried out by the author has been a primary one aiming at bone replacement, and in 24 cases unsuccessful attempts had been previously made by other surgeons.

It is important to note that the hundred cases for this study are unselected. The gap between the ends varies from 1 to 12 cm. and is filled with fibrous tissue. The fragments are frequently tapering, brittle, and sclerosed, and the medullary canal is closed. When this osteosclerosis is extreme, it extends for two or three inches along each fragment, the periosteum being replaced by fibrous tissue. The surrounding soft tissues are also fibrosed and adherent to the bone. As such tissues bleed freely, and the bleeding is difficult to arrest—this being a not uncommon occurrence in cases of the tibia and humerus —a complete excision of all fibrous tissue is advisable. The presence of lurking bacteria with a hæmatoma might result in failure of the operative treatment.

The importance of general causes of non-union of fractures is largely academic, and it is to be emphasized that local causes play a vastly greater rôle. The causes acting locally in the cases in the present series were as follows:—

| | | |
|---|---|---|
| 1. | Primary loss of substance .. .. .. .. | 55 cases |
| 2. | Displacement .. .. .. .. .. | 12 ,, |
| 3. | Sclerosis and latent sepsis .. .. .. .. | 5 ,, |
| 4. | Sclerosis with plating and wiring .. .. .. | 4 ,, |
| 5. | Sclerosis and gap .. .. .. .. .. | 12 ,, |
| 6. | Sclerosis .. .. .. .. .. | 12 ,, |

The publication of the results has been delayed so that a sufficient period might elapse for most of the patients to resume civil employment and test the strength and utility of the reconstructed limb. Since the majority of the patients are pensioners from Edinburgh and neighbouring counties, it has been possible to keep them under observation from the time of operation up to the present date, and to make frequent radiographic examinations.

*Table I.*—Analysis of Cases.

| Bone | Number of Cases | Union by Operation | Failure | Partial Success | Union by Conservative Treatment | No Treatment required owing to Slight Disability |
|---|---|---|---|---|---|---|
| Ulna .. | Left = 26<br>Right = 10 | 30 | 0 | 0 | 0 | 6 |
| Radius .. | Left = 18<br>Right = 8 | 20 | 1 | 1 | 3 | 1 |
| Humerus .. | Left = 6<br>Right = 13 | 16 | 1 | 2 | 0 | 0 |
| Tibia .. | Left = 4<br>Right = 11 | 10 | 1 | 0 | 4 | 0 |
| Femur .. | Left = 2<br>Right = 1 | 1 | 0 | 0 | 2 | 0 |
| Fibula .. | Right = 1 | 0 | 0 | 0 | 0 | 1 |
| | Total 100 | 77 | 3 | 3 | 9 | 8 |

## PRE-OPERATIVE TREATMENT.

The operation result and ultimate function of the limb are influenced to some extent by the nature of the pre-operative treatment that has been employed. Whilst the bone lesion may be the chief cause of the resultant disability, other tissues have frequently suffered considerable damage with consequent loss of function. A prolonged sepsis of the gunshot wound has frequently resulted in considerable destruction of muscle tissue and loss of function—marked limitation of pronation and supination, stiff fingers, and maybe loss of movements at the wrist, elbow, or shoulder joint; and lastly, an important nerve may have been severed or partially destroyed. All cases should have the benefit of hydrotherapy, massage, and active and passive exercises.

As regards deviation of the hand resulting from non-union in the lower third of the radius or ulna, very little can be done at a late stage by pre-operative treatment, but in the early cases this deformity can be avoided by means of a short plaster-of-Paris splint. This pre-operative period therefore need not be wasted, as non-union is seldom the only thing wrong with the limb.

## OPERATIVE TREATMENT.

As it is impossible to state after what period gunshot wounds are quite free from the danger of latent sepsis, my practice has been never to proceed to the bone-graft operation until the wound has been soundly healed for at least twelve months. Referring to the tabulated data of the cases, it is shown that in most instances the original wounds had been healed fifteen months or longer before the patients came under my care for the appropriate reconstruction operation. Further, it is interesting that latent infection was first encountered in 6 cases all operated on within the last year.

Since there is no sure means of determining whether or not latent infection exists, an operation in two stages has been carried out by some surgeons. Such a procedure should certainly be adopted where prolonged sepsis of the original wound has resulted in extensive scarring of all tissues at the site of non-union. At the preliminary operation all sclerosed tissue is completely excised. The wound is then closed and a period of fourteen days allowed to elapse before proceeding to the grafting operation. Should a flare-up occur during this period, the infection can be much more easily controlled than if the complete operation had been carried out. But infection and a successful graft are

not incompatible. *Case* 17 illustrates this ability of a graft to thrive despite severe infection of the surrounding tissues. *Figs.* 194 and 195 show the condition present before, and five months after, operation. Nevertheless, of the attributable causes of failure in bone-grafting, it must be admitted that, above all other causes, sepsis is the great bane of this operation.

The key-note of surgery in ununited fractures should be absolute simplicity. The most perfect carpentry will not be followed by osseous union strong enough to restore satisfactory function if, in carrying out the graft operation, the following anatomical, pathological, and general technical principles have received insufficient attention :—

1. The importance of making the skin incision of sufficient length.
2. Complete excision of scar-tissue and removal of sclerosed bone until healthy vascular bone is exposed.
3. Extensive surface of contact between graft and host-bone.
4. The preparation of a healthy muscle bed.
5. The avoidance of metallic or non-absorbable sutures for internal fixation of graft.
6. Scrupulous attention to asepsis and perfect hæmostasis.
7. Immobilization by plaster-of-Paris until firm osseous union has occurred between graft and host-bone.

FIG. 194.
Ulna from *Case* 17.
Before graft operation.

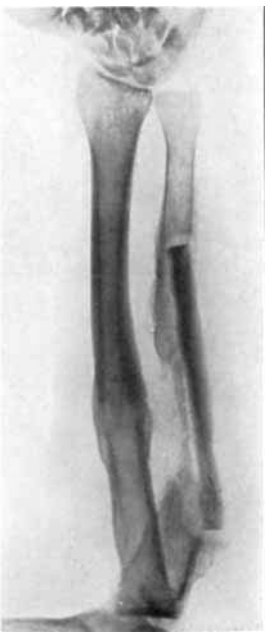

FIG. 195.—The same case as *Fig.* 194. Graft survived severe latent infection. Callus thrown out from the ends of host and new bone creeping along the graft. Five months after graft operation.

In every case of ununited fracture the success or failure of the operative treatment will depend upon the correct appreciation of these factors. The inlay cortical graft as popularized by Albee has not proved so successful as may have been expected in ununited war fractures. The technique of this operation will not permit of the placing of a very broad piece in the fragments, and it was on account of many failures observed that the author was led to try a different type of operation. Practically all failures can be definitely attributed to technical errors, such as too small a graft, infection, or inadequate fixed bony approximation of the graft to the host-bone.

Before describing in detail the operation that has given excellent results, it is desirable to consider briefly certain important factors in regard to the bone-graft itself.

In my experience the autogenous tibial graft, including periosteum, compact bone, and medullary tissue, has proved most satisfactory. The bone is easy of access and from it a graft can easily be cut of any shape, length, or thickness required. Rapid regeneration of bone soon fills the gap left in the tibia, so that no permanent disability results. Occasionally a hæmatoma may develop, but no serious complications have ever occurred. As a rule, the wound is strongly healed at the end of a fortnight.

In very few cases were grafts free of periosteum employed. The results of those in which the periosteum was not included were just as satisfactory. Although no reliance can be placed on the periosteum for production of bone, I am satisfied that it facilitates the secondary vascularization of the graft and also protects the graft in the event of the lighting up of latent sepsis. Stripping up of the periosteum during the course of an

operation should therefore be carried out with the greatest care, and to the minimum amount, to avoid underlying necrosis should infection ensue. It has been my practice, when intramedullary grafts were considered necessary, and employed successfully in 7 out of 10 cases, to remove the periosteum from that part of the graft which is fitted into the medullary cavity of the host-bone. Whilst the compact bone does not seem to take an active part in osteogenesis after transplantation, it supplies the strength to withstand the strain of function when union is complete.

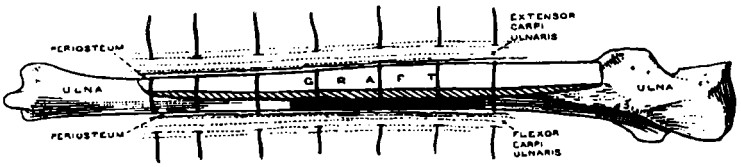


FIG. 196.—Diagram showing autogenous massive tibial graft as employed in ununited fracture of ulna.

The medullary tissue, however, would appear to be the main route along which new bone formation extends between the fragments of the host-bone. It is, therefore, advisable to include as much as possible of this tissue in any graft (*Fig.* 196).

The size of the graft is important. It must be cut long enough, not only to bridge the gap, but to have contact with a wide surface of the host-bone on either side. The

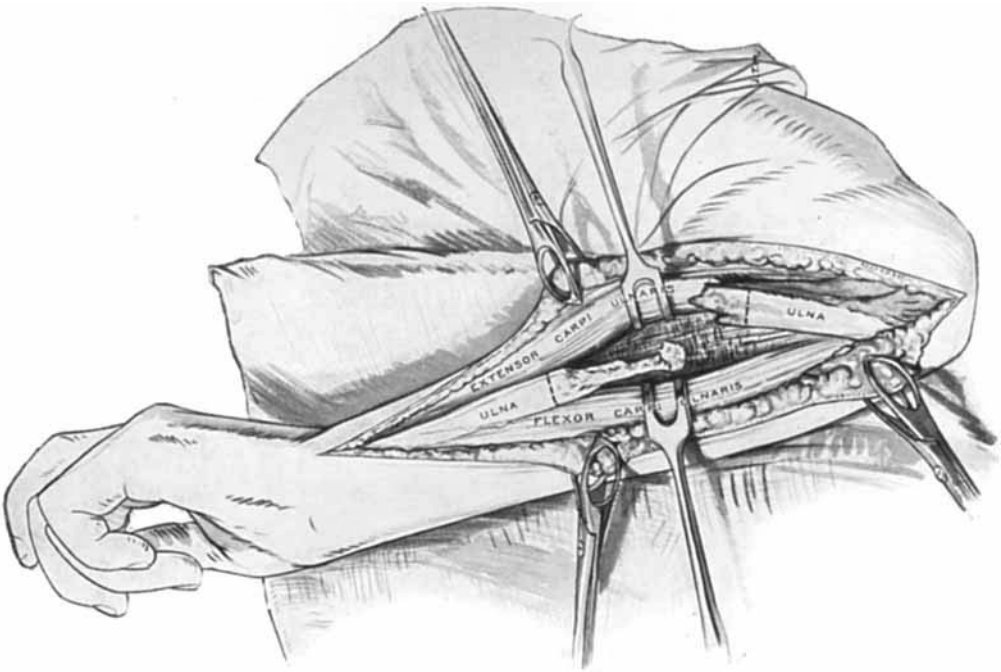


FIG. 197.—Diagram showing skin incision and dissection to prepare ununited fragments of ulna and musculo-osseous bed for reception of graft.

usual length is found to be from two to three times that of the gap. This is an important technical point, and cannot be too strongly emphasized. The graft is seldom less than four inches. A long graft affords, not only better and firmer fixation, but also a larger surface of contact between the host and the graft, which increases the means of access for

the new blood-supply. Further, the more the graft approximates in size to the bone to be replaced, the less liable it is to fracture, and the more quickly will full strength be obtained in the reconstructed limb.

I now come to the operation which has engaged my special attention for some time past. No claim is made as to its being entirely original in conception, but its application in a large number of ununited war fractures having proved so highly successful seems to justify my personal experience of its effectiveness being put on record.

In my experience the autogenous graft obtained from the subcutaneous inner surface of the tibia, and employed as a massive lateral graft, has formed the most satisfactory method of dealing with non-union of the ulna, radius, and tibia following upon gunshot injuries. The operation will be described as it is carried out for the ulna.

The bone should be approached along its postero-internal border between the flexor and extensor carpi ulnaris. Too great emphasis cannot be placed upon the importance of making a skin incision of sufficient length (*Fig.* 197).

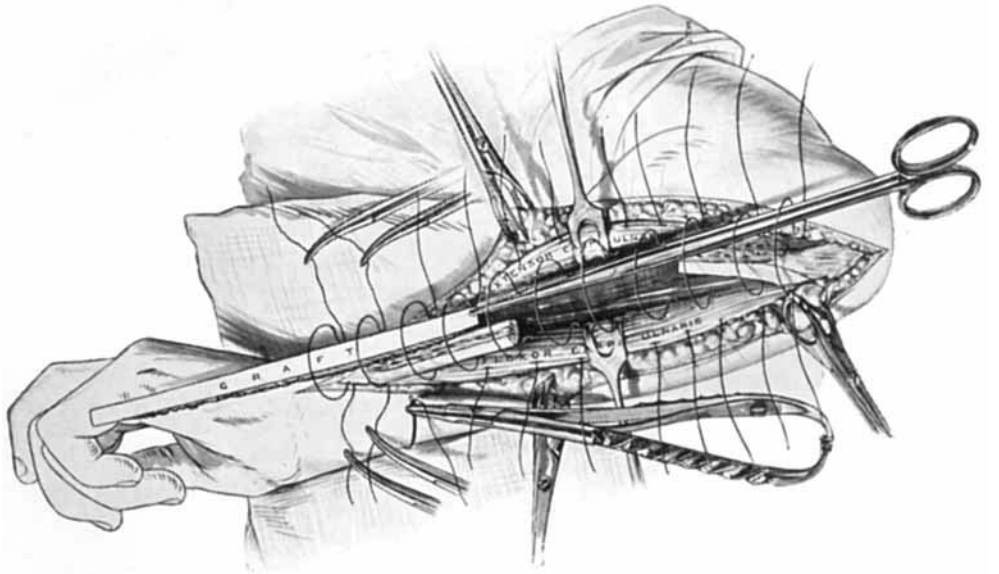


FIG. 198.—Diagram of musculo-osseous graft and bed on postero-internal surface of ulna completed. Method of placing graft under looped sutures of strong tanned catgut.

The first step of the operation should be to excise all scar-tissue, whether in the skin or deeper tissues. In regard to the former, this should be done as a preliminary operation whenever the skin cicatrix is extensively adherent to the underlying structures. Otherwise, if a large skin scar has been left to cover the tissues, it will, within a few days, necrose in part and leave a troublesome superficial ulcer to heal. The deep scar-tissue between the bone fragments must also be regarded as tissue of poor vitality, deficient circulation, and weak resistance. Such a preliminary operation was carried out in 10 cases. A bone-graft implanted in scar-tissue would most probably be absorbed, or at least atrophy, and fracture easily.

In the next step of the operation the ends of the host fragments are exposed, and all sclerosed and ragged bone between the fragments removed until healthy vascular bone appears. All sclerosed bone is of very low osteogenetic power. The muscles, along with the periosteum, are then stripped from the bone for fully two inches from the fractured ends, and for practically one-fourth of the circumference of the bone (*see Fig.* 197). Next, beginning in a direction away from the point of fracture, and extending the whole

length of the exposed bone, a thin layer of bone is removed with a fine osteotome or chisel, the cut being made deep enough to expose the medullary canal in places. The same procedure is repeated in the other fragment. Care should be taken that the bed for the graft is cut on the surface of the fragments that will be in continuity when the limb is in the desired position. In most cases it is found convenient to prepare the osseous bed for the graft on the postero-internal surface of the ulna (*Fig.* 198).

Internal fixation of the graft is most essential for a successful result, and depends to a considerable extent upon accurate suturing. Interrupted sutures of strong 'tanned' catgut have been employed throughout the series almost without exception. They are passed through the reflected periosteum and muscles on either side of the prepared bed (*Fig.* 199). Metallic sutures generally were not used, on account of the irritation and atrophy of the tissues they are liable to produce. They are necessary at times—for example, in the humerus—but always to be avoided if possible. No difficulty need be experienced in securing firm fixation by catgut, provided the loop method is employed (*Figs.* 198 and 199). The musculo-osseous bed is now ready for the reception of the tibial graft.

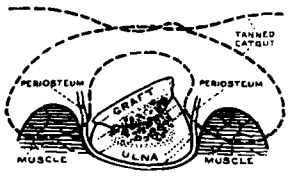


FIG. 199.—Diagram showing method of introducing looped tanned catgut sutures for fixation of graft.

It is clear that in the method described an extensive surface of contact is obtained between the graft and the freshened bone, and the medullary surface of the graft is in close apposition to the openings into the medullary canal. Broad and accurate contact, efficiently maintained, is the best guarantee of rapid and strong union (*Fig.* 200).

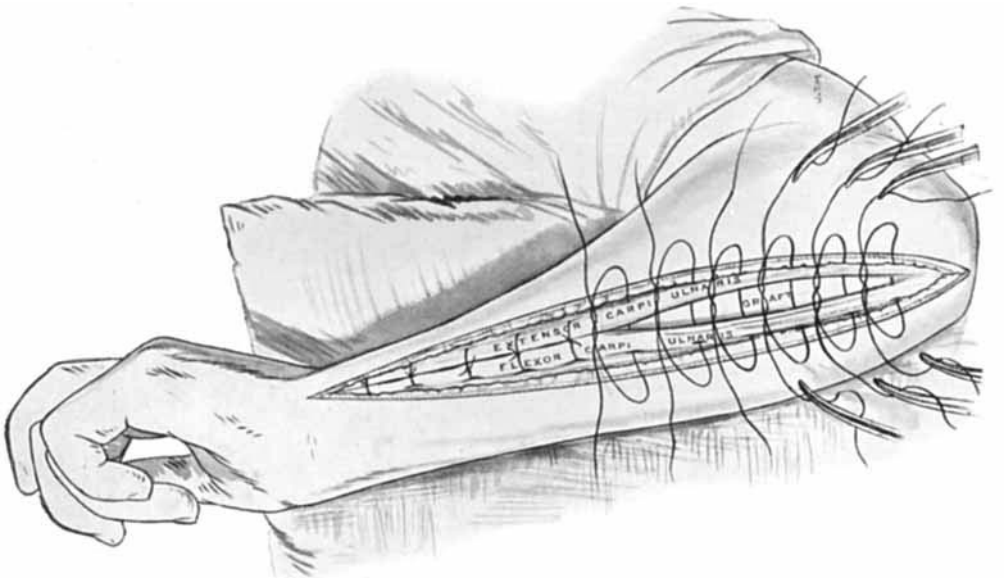

FIG. 200.—Diagram showing graft in position and broad and accurate contact maintained by tanned catgut sutures.

A pliable probe is laid in the defect and bent to the exact length of the graft required. The wound is packed with gauze to stop oozing, and covered with a sterile towel whilst the graft is obtained. An incision of suitable length is made along the outer side of the anterior border of the tibia. The bent probe is then laid on the bone, and the exact length of the graft required is marked off. The portion to be removed is completely marked out by incising the periosteum. The removal of the graft is carried out by a

circular saw (preferably single) electrically driven. While the saw is cutting, it is constantly sprayed with saline solution. The transplantation should be made immediately. I am convinced that it is a mistake to wash the graft in saline lotion or leave it in saline while something else is being done. The best results follow immediate closure of the deep tissues round it, and suture of the surface wound. The graft is placed underneath the catgut loops as shown in *Fig.* 198, and held in close apposition to the raw surfaces of the parent bone whilst the ligatures are being tied. A few additional catgut sutures are necessary to unite the surrounding muscles and so ensure a complete covering for the graft (*Fig.* 200). The skin wound is closed with interrupted silkworm-gut stitches.

The limb must now be securely controlled in correct position by a plaster-of-Paris case, which is the only adequate post-operative dressing. It should be applied with the utmost care over a thin padding of cotton-wool or flannelette bandage, which fixes the wound dressing, moulded to the bony contours of the extremity, and should always include at least one joint above and one joint below the bone involved. In the forearm cases the position of the limb is important. The elbow is flexed to a right angle, and the forearm supinated as completely as possible. The limb should be held in the desired position throughout.

### POST-OPERATIVE TREATMENT.

The protection of the graft from undue stress subsequent to the operation is best attained, in the writer's view, by the application of a plaster-of-Paris casing from the fingers to the mid-humerus and applied at the time of operation. The padding employed usually prevents any excessive swelling of the limb. However, should œdema develop, the cast ought immediately to be split down the whole length of the aspect furthest from the graft. The condition is quickly relieved and no harm is done. A plaster case may be made considerably lighter by reinforcing it at the points of special strain by wire or narrow strips of metal.

Absolute immobilization of the part involved is maintained for six weeks. During this period the graft is establishing a vascular continuity with the host at either end and with the surrounding tissues, and it is not necessary to interfere with the plaster case.

After the expiration of six weeks, the skin stitches are removed, and before a second plaster casing is applied the degree of union between the graft and host-bone is determined by a radiographic examination (*Fig.* 201). Success is unlikely if the graft is not firmly united with the host at both ends.

In the case of the forearm, the elbow is again flexed to a right angle, and a small window is cut on the anterior and posterior aspects of the forearm so that gentle faradic stimulation of the flexor and extensor muscles may be carried out. A small short cock-up splint should be incorporated with the plaster, to permit the hand being left free for exercises and massage without straining the graft. Such measures unquestionably stimulate bone growth by allowing the graft to functionate as early as possible and within the limits of safety.

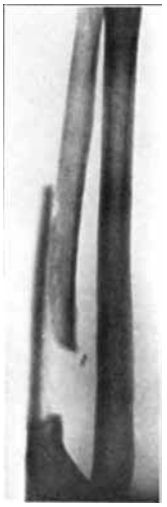

FIG. 201.—Ulna from *Case* 13. Massive lateral tibia graft united strongly with host-bone at both ends. Seven weeks after graft operation.

At the end of three months from the date of operation the plaster is dispensed with, and the nutrition of the limb is gradually restored by massage, faradism, and active use.

The time involved by the change from the stage of partial function to that of complete function depends upon : (1) The presence or absence of other serious disabilities, e.g., nerve lesion, muscle destruction, etc. ; (2) The state of union between the host-bone and graft ; (3) The individual bone involved. The growth and union of the graft are easily estimated by radiograms, which should be taken every six or eight weeks (*Fig.* 201). During the transitional period it is advisable that the forearm be supported by the wearing of a short

cock-up splint, and particular attention be given to exercises to encourage the return of the movements of pronation and supination. As regards the tibia, the plaster casing should be worn for a period of six months at least subsequent to operation, and for a further three months an external metal support is essential. Such conservatism will certainly avoid the occurrence of some failures.

## CONSIDERATION OF INDIVIDUAL BONES.

**Radius.**—Non-union of the radius is more important than that of the ulna, owing to the considerable weakness of grasp resulting. It may occur in any part of the shaft, but is especially frequent in the lower half (*Fig.* 202). In most cases a bone-grafting operation is necessary. The hand is attached to and articulates mainly with the radius, so that loss of the support of the latter owing to non-union is associated with considerable weakness of grasp, and with radial deviation of the hand, which deformity is kept up by contracture of the radial tendons, these stretching like a bow-string across the gap in the bone (*Fig.* 203). The lower fragment of the bone tilts towards the ulna and the hand is deviated towards the radial side, the styloid process lying at a higher level than that of the ulna (*Fig.* 204). Where the lower fragment of the radius is less than an inch in length,

FIG. 202.—Radius from *Case* 39. Non-union from the loss of bone between the fractured ends. Marked deviation of distal fragment, with consequent radial deviation of hand (*see Fig.* 203). For result of grafting operation see *Figs.* 205 and 208.

FIG. 203.—*Case* 39. Illustrates radial deviation of hand. Contracture of radial extensors of wrist well seen. For result after operation see *Fig.* 205.

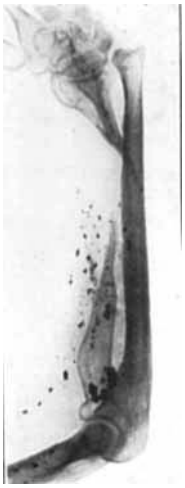

FIG. 204.—*Case* 19. Large portion of shaft missing and considerable deviation of distal fragment. For result of grafting operation see *Fig.* 211.

shortening of the ulna to correct radial deviation and allow direct union of the radial fragments has been recommended. This procedure is not advisable, as it is sometimes followed by non-union of the ulna: the hand deviation can be as satisfactorily corrected by lengthening of the contracted radial tendons (*Fig.* 205).

There are often associated injuries of the tendons and muscles, particularly of the extensor muscles of the thumb. An injury to the median nerve is not an uncommon complication. Large adherent scars are also frequent, and are important because these may interfere with the success of an operation unless they can be completely removed at a preliminary operation.

The radius is best exposed along the line which separates the radial extensors of the

FIG. 205.

FIG. 206.

FIG. 207.

FIG. 205.—*Case* 39. Radial deviation of hand almost completely corrected by lengthening of contracted radial extensors of the wrist at grafting operation. For result of bone-graft see *Fig.* 208.

FIG. 206.—*Case* 34. Posterior subluxation of lower end of ulna, occasionally a complication of non-union of radius in its lower third.

FIG 207.—Radius from *Case* 27. Modified intramedullary graft—pegging one end of graft into medulla, and the other fitted into gutter. Result 2 months after operation. Ultimately strong union.

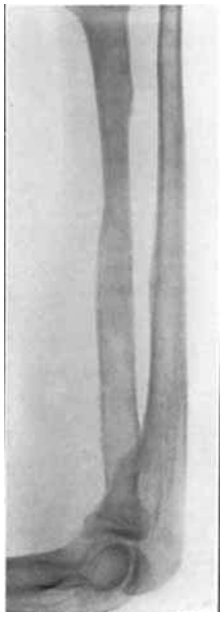

FIG. 208.

FIG. 209.

FIG 210.

FIG. 211.

FIG. 208.—*Case* 39. Same as *Figs.* 202, 203, 205. Final result 29 months after grafting operation for non-union of radius, August, 1919. Medullary canal completely re-formed. Massive tibial graft employed.

FIG. 209.—*Case* 20. Final result of tibial graft for non-union of radius—three years after operation, February, 1919. Complete canalization of graft.

FIG. 210.—*Case* 41. Final result of tibial graft for non-union of radius—two years after operation, January, 1920. Canalization of graft almost complete.

FIG. 211.—*Case* 19. Same as *Fig.* 204. Final result of tibial graft for non-union of radius—22 months after operation, November, 1919. Lengthening of flexor carpi radialis and brachioradialis in addition to radial extensors of wrist required to correct extreme degree of radial deviation of hand.

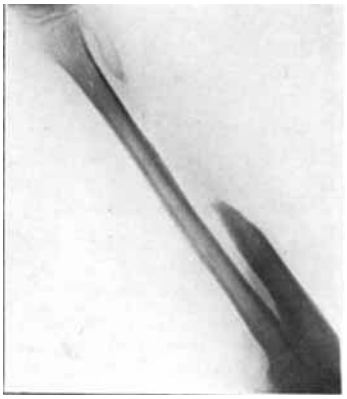

FIG. 212.—Ulna from *Case* 2. Large portion of shaft missing. For result of grafting operation see *Fig.* 219.

wrist from the extensor communis digitorum. In its distal third the extensor pollicis brevis and the abductor pollicis longus crossing the tendons of the radial extensors of the wrist often render access to the tilted lower fragment somewhat difficult; whereas exposure in the upper two-thirds is a comparatively simple dissection. To secure proper alinement it is necessary to lever the lower fragment away from the ulna and to rotate it into the supinated position. A slight radial deviation of the hand may remain, but this is not of importance. A posterior subluxation of the lower end of the ulna (*Fig.* 206) is by no means a rare complication, and occasionally gives rise to pain in the neighbourhood when the patient has resumed his employment, and particularly if this is of a laborious nature.

The graft is preferably applied to the posterior surface of the host-bone. In fractures above the level of the insertion of the pronator radii teres, it is important to remember that, whereas the proximal fragment is found completely supinated, the distal is fully pronated. In some cases when the site of non-union is close to the wrist-joint it is impossible to obtain a satisfactory bed and coverings for a lateral graft.

FIG. 213.—Ulna from *Case* 3. Non-union middle of shaft. For result of grafting operation see *Fig.* 221.

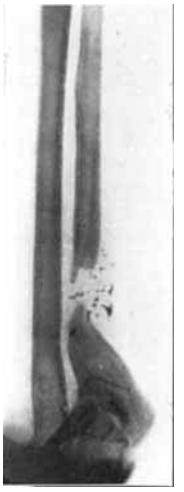

FIG. 215.—Ulna from *Case* 5. Non-union in upper third. Proximal fragment flexed and tilted towards the radius. For result of grafting operation see *Fig.* 217.

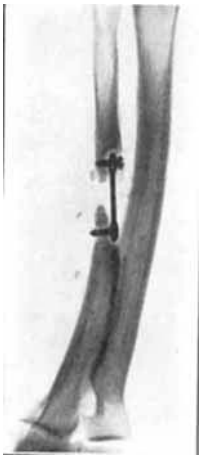

FIG. 214.—Ulna from *Case* 9. Condition of non-union when patient admitted to Bangour Hospital.

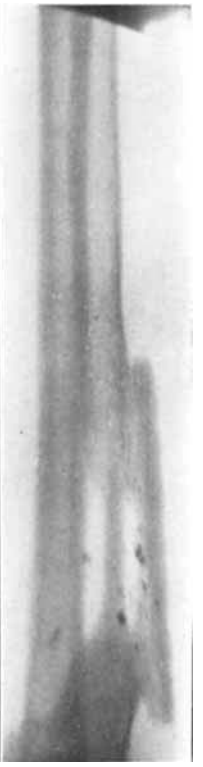

FIG. 216.—*Case* 5. Same as *Fig.* 215. In addition to massive tibial graft an intramedullary peg was employed to correct deviation of proximal fragment. For operation result see *Fig.* 217.

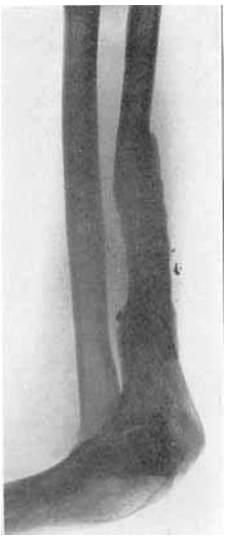

FIG. 217.—*Case* 5. Same as *Figs.* 215, 216. Final result 18 months after double graft—intramedullary and lateral massive.

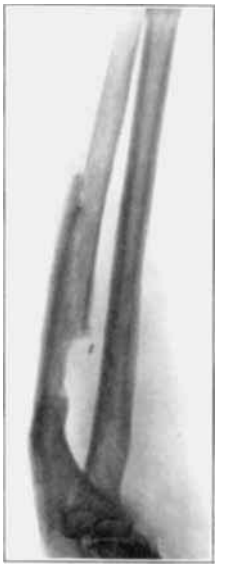

FIG. 218.—*Case* 13. Same as *Fig.* 201. Final result of tibial graft for non-union in upper third of ulna — 8 months after operation, September, 1921.

Firm fixation of the graft is also essential. For such cases a modified intramedullary peg proved successful. This method consisted of pegging one end of the graft into the medulla of the proximal fragment and fitting the other into a gutter made in the short distal fragment (*Fig.* 207).

**Ulna.**—Non-union of the ulna is of frequent occurrence, but is much less important (*Figs.* 212–214). Whilst most ununited fractures of the radius require bone-grafting, some ununited fractures of the lower third of the ulna, or of the olecranon, cause so little disability that this is not necessary. When it occurs low down in the shaft it affects the utility of the hand comparatively little, and any deformity is slight.

There is usually no considerable displacement of the fragments to be corrected except when the

FIG. 219.—*Case* 2. Same as *Fig.* 212. Three months after grafting operation for large gap in ulna.

FIG. 220.—*Case* 3. Same as *Fig.* 213. Result 15 months after grafting.

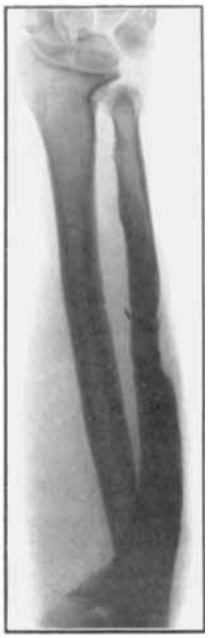

FIG. 221.—*Case* 9. Same as *Fig.* 214. Final result 28 months after grafting operation for non-union of ulna.

fracture involves the upper third, the proximal fragment often being flexed and tilted towards the radius (*Fig.* 215). It is advisable to correct this deviation and maintain proper alinement by an intramedullary peg (*Figs.* 216, 217), this being additional to the usual lateral graft employed. Preliminary excision of the skin cicatrix has been more frequently required in the case of the ulna.

The ulna, being a less vascular bone than the radius, with usually a considerable thickness of sclerosed bone at the common site of non-union in the upper third, it is essential to prepare the best available musculo-osseus bed.

It is rare to find both bones of the forearm ununited. Shortening of both to allow direct union, and a bone-graft of the ulna to ensure adequate fixation, is probably the best operative procedure.

FIG. 222.—Humerus from *Case* 81. Non-union in middle third. For operation result see *Fig.* 223.

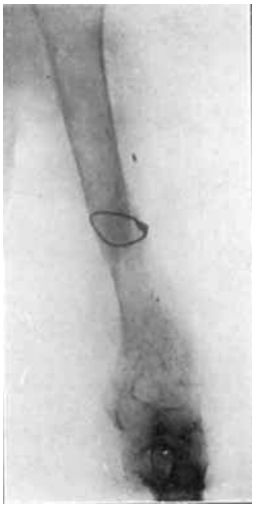

FIG. 223. — *Case* 81. Same as *Fig.* 222. Result 8 months after step-cut operation. Good union.

**Humerus.**—The cases of non-union of the humerus numbered 19, and generally constituted a difficult surgical problem.

FIG. 224.—Humerus from *Case* 68. Non-union in region of neck. For result of operation see *Fig.* 225.

FIG. 225.—*Case* 68. Same as *Fig.* 224. Result two years after squaring of fragments, intramedullary peg, and sowing of iliac bone chips. Good union. Function of shoulder excellent.

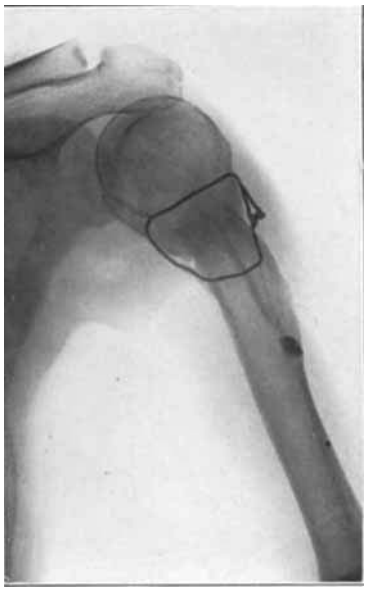

FIG. 226.—Humerus from *Case* 67. Non-union in region of neck. Result 32 months after intramedullary peg and squaring of fragments. Additional fixation by wire in case of absorption of intramedullary graft. Strong union. Function of shoulder excellent.

It has been stated that in proportion to the number of fractures sustained by this bone, non-union is more frequent than in any other bone in the body. The chief reason for this relatively high occurrence is that fixation is particularly difficult to maintain. Of

the patients, 2 had musculospiral paralysis at the time of operation, and 10 cases had been previously operated on elsewhere, not infrequently as often as three times. Freshening the ends of the bone and fixation by wiring, plating, and inlay grafting had been practised, and with persistence of

FIG. 227.—Humerus from *Case* 87. Non-union in region of neck treated by removal of sclerosed bone, impaction of distal fragment into the proximal, and obtaining internal fixation by kangaroo tendon. Result 7 months after operation. Strong union. Function of shoulder good.

FIG. 228.—Humerus from *Case* 94. Double graft employed. Absorption of intramedullary graft. For final result see *Fig.* 229.

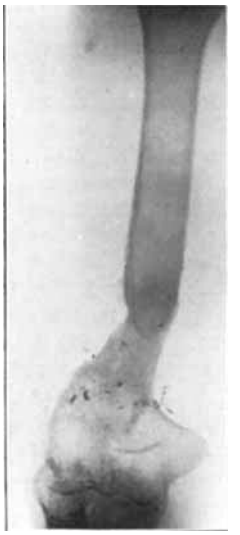

FIG. 229.—*Case* 94. Same as *Fig.* 228. Result 16 months after grafting operation. Strong union.

non-union, which is found to occur frequently in the lower third of the shaft. These results clearly indicate the unsatisfactory nature of the operative procedure employed in the early humerus cases. Whilst all are agreed that the autogenous bone-graft has given the best results in the radius, ulna, and tibia, it cannot be employed so generally in the case of the humerus. Bone-grafting is of little value in filling gaps in the shaft of the humerus. Ununited fracture of the humerus is most certainly remedied by the step-cut operation, and the steps should be long (*Figs.* 222 and 223). Shortening of the arm is of minor importance. This method was successfully employed in 9 out of 10 cases.

FIG. 230.—Humerus from *Case* 93. Non-union in lower third. For result of grafting operation see *Fig.* 231.

FIG. 231.—*Case* 93. Same as *Fig.* 230. Final result 9 months after grafting. Very strong union. Function of elbow excellent.

Alternative operative measures are best determined according to, (1) The site of non-union; (2) The gap in the bone; (3) The condition of the neighbouring joints. Non-union in the region of the neck can be successfully treated (*Fig.* 224): (1) By freshening the ends of the fragments, employing an intramedullary peg as an internal splint, and sowing in the fracture site small chips of bone obtained from the iliac crest (*Figs.* 225, 226); or (2) After thorough removal of sclerosed bone,

impacting the distal fragment into the proximal portion and obtaining fixation by wire or kangaroo tendon (*Fig.* 227).

Ununited fractures of the lower third of the humerus complicated by ankylosis of the elbow-joint are undoubtedly amongst the most difficult cases to treat. The reason for this lies in the real difficulty of providing adequate internal fixation of the fragments. This is more especially the case when the distal fragment is short, tapering, and brittle. The step-cut operation is generally not advisable ; but combined with Parham's metallic bands, the desired result can be obtained. Equally satisfactory results have followed the use of the intramedullary peg supplemented by a lateral graft or chips of iliac-crest bone (*Figs.* 228, 229, 230, 231).

Whichever operative measures are adopted, it is essential to fix the whole arm and chest in plaster-of-Paris at the time of operation. The arm is abducted to about a right angle, and the elbow is flexed, this being done to prevent any undue strain upon the fracture site. Fixation in this position is maintained for about eight weeks, at the end of which period the stitches are removed and the plaster cast is replaced by a suitable splint should the radiograms show that strong osseous union has occurred. In the majority of cases, however, it is safer to employ a plaster cast for a period of twelve to sixteen weeks. This need not interfere with the postoperative treatment, as the arm portion of the plaster-cast can be bivalved.

**Tibia.**—The following groups may be distinguished :—(1) *Fractures of the tibia with fibula intact* ; (2) *Fractures of the tibia with old fracture of fibula at opposite point.*

FIG. 232.—Tibia from *Case* 64. Non-union with 2-in. gap. Transverse fracture of fibula at opposite point. For result of grafting see *Fig.* 235.

FIG. 233.—Tibia from *Case* 73 before operation. Non-union with lateral displacement of upper fragment. For result of grafting see *Fig.* 234.

FIG. 234.—*Case* 73. Same as *Fig.* 233. Result 6 months after introduction of two massive grafts from opposite tibia. Grafts survived violent latent infection. Strong union.

*Group* 1.—There is usually very little displacement, and the rigid intact fibula prevents apposition of the fracture ends. The line of fracture is transverse or slightly oblique. The primary loss of osseous tissue is small, so that a single lateral graft suffices. The operative technique is similar to that carried out in the case of the ulna.

*Group* 2.—Whilst fracture of the tibia is of the large short-splinter type, followed by chronic osteomyelitis and necrosis with a resultant gap of ½ to 2 inches, that of the fibula

has been transverse (*Figs.* 232, 235). The displacement is always more marked in the tibia when the fibula has been simultaneously involved. There is frequently an angular displacement, the leg appearing to form a curve with a marked anterior concavity. In addition, some lateral displacement is generally present (*Fig.* 233). The lower fragment usually shows a certain degree of rotation on the long axis of the bone, resulting in internal or external displacement of the foot, and almost always a degree of pes equinus. In consequence of extensive scarring of overlying skin and also muscular injury, bone-grafting may be a very difficult procedure. It is beneficial in all such cases to carry out at a preliminary operation a complete excision of all superficial and deep scar-tissue at the site of non-union. About a month later the grafting operation is performed. It is advisable to insert two massive lateral grafts whenever possible (*Fig.* 234) in order to induce more rapid and entire replacement of the bony loss and to increase the strength of the resulting union. Unfortunately, re-fracture is by no means a rare occurrence, and for this reason there should be no undue haste in dispensing with the plaster casing, which should be worn for a period of six months at least subsequent to operation. For three months more the patient wears an external metal support.

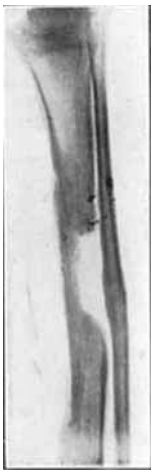

FIG. 235.—*Case* 64. Same as *Fig.* 232. Result 6 months after grafting operation. Single massive graft. Strong union. Function of leg good.

**Femur.**—Whilst delayed union of the femur is frequent, non-union is of very rare occurrence. In fact, the diagnosis of non-union should not be made unless, after a prolonged trial (not less than twelve months) of conservative measures (Thomas splint, 'hammering and damming', ionization, faradism, and diathermy), there is no evidence of union either clinically or in radiograms.

The site of delayed union and non-union in all three cases of the present series was about the middle third of the shaft. When non-union does occur in this region it appears to be due to latent sepsis. Invariably the infection has spread to the knee-joint, whose movements become so limited that there is almost a fibrous ankylosis. In short, the function of the limb is considerably reduced.

FIG. 236.—Radius from *Case* 28. Early fracture of intramedullary peg. Strong union of graft with proximal fragment, but non-union with distal fragment. Strict and prolonged immobilization failed to bring about union.

The operation for non-union of the femur is at all times a serious one. Only one of the femur cases under review required operative interference, this consisting of freshening the fracture ends, complete excision of sclerosed bone and of intervening fibrous tissue, insertion of an intramedullary peg, and additional fixation by wire. The whole limb, including the pelvis, is put up in plaster-of-Paris for three weeks or a month, after which period a Thomas splint with extension is substituted.

**Graft Fractures.**—In the series of 83 cases subjected to the operation of transplantation of bone, 7 graft fractures occurred—3 in the ulna, 2 in the tibia, and 1 each in the radius and humerus. All but one were massive tibial grafts, and the fractures occurred at a late stage in 6 of the cases after osseous union between the host-bone and graft was complete. The exceptional case was an intramedullary peg, which at an early stage showed firm union with the proximal end of host-bone, but a false joint at the distal end (*Fig.* 236). The early fractures happen six to eight weeks after operation, and occur at one end exactly opposite the junction of the graft and the host-bone. Such a fracture may even occur inside a well-fitting plaster case, and is due to inadequate contact between the graft surface and the medullary tissue of the host-bone. If an intramedullary peg has been employed, the site of fracture becomes a typical non-union, the extremity of the fracture

becoming peg-shaped (*Fig.* 236). After the fracture is complete, little further absorption appears to take place. Strict immobilization after the fracture was discovered failed to bring about union in the case shown in *Fig.* 236.

FIG. 237.

FIG. 238.

FIG. 239.

FIG. 240.

Late fractures occur several months after the bone-grafting operation. Their site is almost always about the middle of the graft. The graft has been entirely successful, being firmly united at both ends, and the host-bone almost entirely replaced. The patient has probably returned to his civil occupation and as a result of some strain, the fracture is produced (*Figs.* 237–241). Many cases will re-unite, although a prolonged period is required for the union to take place.

FIG. 237.—Ulna from *Case* 12. Traumatic or late graft fracture through middle of graft. Six months after successful graft operation.

FIG. 238.—*Case* 12. Same as *Fig.* 237. Result 8 months after accident—graft fracture strongly united. Well-marked callus thrown out.

FIG. 239.—Ulna from *Case* 4. Traumatic or late fracture through middle of graft. Six months after succes-ful graft operation.

FIG. 240.—*Case* 4. Same as *Fig.* 239. Result 10 months after accident—graft ununited, but no resultant disability.

FIG. 241.—Tibia from *Case* 62. Late graft fracture about middle of graft, occurred seventeen months after successful graft operation. Strong union resulted from second graft operation.

FIG. 241.

*Table II.*—Analysis of Results.

| Bone | Number of Cases | Failures | Partial Successes | Complete Successes | Cases not requiring Operative Treatment |
|---|---|---|---|---|---|
| Ulna .. | 36 | 0 | 0 | 30 | 6 |
| Radius .. | 26 | 1 | 1 | 20 | 4 |
| Humerus .. | 19 | 1 | 2 | 16 | 0 |
| Tibia .. | 15 | 1 | 0 | 10 | 4 |
| Femur .. | 3 | 0 | 0 | 1 | 2 |
| Fibula .. | 1 | 0 | 0 | 0 | 1 |
| Total | 100 | 3 | 3 | 77 | 17 |

## SUMMARY AND CONCLUSIONS.

The series of cases studied was unselected and comprised 100 patients with ununited fractures due to war injuries. Of the 100, 83 required operative treatment. Of these, 70 were subjected to the operation of autogenous bone-grafting. In 67 (95·8 per cent) the grafting operations were successful, and 3 (4·2 per cent) were failures. The cause of failure was latent infection, and the graft was lost in consequence—in 2 of the cases with persistence of non-union. In the series of 83 operations there were 6 cases of latent infection. These six cases had been operated on previously, and all but one had had infection previously. The cause of infection depends upon the type of case rather than on the operative technique. It is probable that the general adoption of a two-stage operation would lower the percentage of infections. However, infection of a wound and a successful graft are not incompatible. In 61 cases the operation carried out has been a primary one, and in 24 cases unsuccessful attempts had been previously made by other surgeons.

Autogenous massive grafts obtained from the subcutaneous inner surface of the tibia have proved very successful, particularly in the ulna, radius, and tibia. They should be of good size—as large as the bone which is being replaced, and two to three times as long as the gap. The more the graft approximates in size to the bone it is to replace, the less liable it is to fracture. The medullary tissues would appear to be the main route along which new bone formation extends between the fragments of the host-bone. It is therefore advisable to include as much as possible of this tissue in any graft. Compact bone is required for strength to withstand the strain of function when union is complete. The presence or absence of periosteum on the graft does not appear to affect the vitality or growth of the graft. Internal fixation of the graft is most essential for a successful result, and depends to a considerable extent upon accurate suturing. Interrupted and 'looped' sutures of strong tanned catgut have been employed throughout the series almost without exception. The only adequate post-operative dressing is a plaster-of-Paris case applied at the time of operation. Absolute immobilization of the part involved is maintained for six weeks, during which period firm union should occur. The degree of union between the graft and host-bone can be determined by frequent radiographic examinations. During the transitional period adequate support (plaster or splint) of the graft is essential.

The bone-graft as usually employed in the intramedullary and inlay methods is too small, and not suited for ununited fractures due to war injuries.

In conclusion, my thanks are due to Mr. A. F. McConnochie, and also Dr. John W. L. Spence and Mr. J. McGill of the Radiological Department of the Ministry of Pensions Hospital, Craigleith, for the radiographic prints. The drawings illustrating the operative treatment are the work of Mr. J. T. Murray, to whom I am indebted for the great care expended in their preparation.

## SYNOPSIS OF 100 CASES OF UNUNITED FRACTURES DUE TO WA

| CASE | DATE OF WOUND AND WHEN HEALED | CAUSE AND PERIOD OF NON-UNION | BONE AND SITE OF NON-UNION | PREVIOUS OPERATIONS |
|---|---|---|---|---|
| *Case* 1.—C. A. | Sept. 1917<br>July, 1919 | 1 in. gap<br>25 months | L. ulna<br>Middle third | Sequestrectomy and evacu<br>tion of abscess |
| *Case* 2.—A. B.<br>*Figs.* 212, 219 | Oct. 1917<br>April, 1918 | 3½ in. gap<br>17 months | R. ulna<br>Lower half. Lower fragment of ulna remaining, 1¾ in. | Excision of scar and freeing<br>tendons |
| *Case* 3.—R. B.<br>*Figs.* 213, 220 | Sept. 1918<br>Jan. 1919 | 1 in. gap<br>10 months | R. ulna<br>Middle third | Suture of median nerve |
| *Case* 4.—J. B.<br>*Figs.* 239, 240 | April, 1918<br>Sept. 1918 | 2 in. gap<br>33 months | L. ulna<br>Middle third | Suture of median nerve |
| *Case* 5.—G. C.<br>*Figs.* 215, 216, 217 | April, 1918<br>Aug. 1918 | 2 in. gap<br>30 months | L. ulna<br>Upper fourth | Suture of ulnar nerve |
| *Case* 6.—J. D. | Oct. 1918<br>Feb. 1919 | 1 in. gap<br>16 months | L. ulna<br>Middle third | Nil |
| *Case* 7.—S. McL. | June, 1918<br>Aug. 1918 | 3 in. gap<br>27 months | L. ulna<br>Middle third | Removal of F. B. |
| *Case* 8.—A. M. | May, 1917<br>Sept. 1917 | 1 in. gap<br>25 months | R. ulna<br>Middle third | Freeing of median nerve |
| *Case* 9.—N. S.<br>*Figs.* 214, 221 | April, 1915<br>Nov. 1917 | 1½ in. gap<br>Sclerosis and plating<br>44 months | L. ulna<br>Middle third | 23 operations for removal<br>dead bone, also plating<br>ulna which was subsequentl<br>removed |
| *Case* 10.—G. T. | June, 1918<br>Sept. 1919 | 2½ in. gap<br>18 months | L. ulna<br>Middle third | Nil |
| *Case* 11.—T. S. | Nov. 1918<br>Dec. 1918 | 1½ in. gap<br>13 months | L. ulna<br>Upper fourth | Three preliminary sequest-<br>rectomies |
| *Case* 12.—J. J.<br>*Figs.* 237, 238 | Sept. 1915<br>Aug. 1916 | 1 in. gap<br>Sclerosis and wiring<br>64 months | L. ulna<br>Middle third | Sliding graft and fixation b<br>wire. Wire subsequently re<br>moved |
| *Case* 13.—J. A.<br>*Figs.* 201, 218 | Sept. 1918<br>Nov. 1918 | 1½ in. gap<br>36 months | R. ulna<br>Upper fourth | Sequestrectomy |
| *Case* 14.—T. M. | May, 1918<br>Aug. 1920 | 4 in. gap<br>41 months | L. ulna<br>Middle third | Preliminary excision of scar |
| *Case* 15.—A. T. | Sept. 1918<br>April, 1919 | 2½ in. gap<br>37 months | L. ulna<br>Middle fourth | Nil |
| *Case* 16.—T. W. | Oct. 1917<br>Mar. 1918 | 2 in. gap<br>47 months | L. ulna<br>Middle third | Nil |
| *Case* 17.—H. B.<br>*Figs.* 194, 195 | Sept. 1918<br>Jan. 1920 | 1¾ in. gap<br>41 months | L. ulna<br>Middle third | Sequestrectomy. Bone-graf<br>June, 1920, which had to b<br>removed on account of sepsi |
| *Case* 18.—A. C. | Aug. 1918<br>Jan. 1919 | Sclerosis and wiring<br>37 months | L. radius<br>Junction lower third and upper two-thirds | Three operations (2 wiring) fc<br>ununited fracture |

**JURIES, WITH END-RESULTS OF OPERATIVE TREATMENT.**

| Date and Type of Operation | Result | Remarks |
|---|---|---|
| Oct. 1919<br>Tibial graft | Success | Operation delayed owing to persistent sinus and slow formation of sequestra. Complete range of pronation and supination. Resumed pre-war occupation |
| Mar. 1919<br>Tibial graft | Success | Exceptionally long graft required—6 inches. Fracture of graft detected Feb. 1920—strongly united Mar. 1921. Marked formation of callus. When the fracture was detected patient was not aware of anything wrong with forearm. Range of movement between $\frac{3}{4}$ complete supination and $\frac{3}{4}$ complete pronation. Resumed employment as a joiner |
| July, 1919<br>Tibial graft | Success | Range of movement between complete supination and the mid-position. Employed as a rabbit trapper |
| Jan. 1921<br>Tibial graft | Success | Six months later fell and injured his arm. Fracture was exactly in middle of graft; no callus thrown out; no movement elicited at site of graft fracture. As patient felt arm just as strong as before the fracture, no further operation was performed. Range of movement between $\frac{3}{4}$ complete supination and $10^{0}$ from the mid-position. Employed in a garage |
| Oct. 1920<br>Double tibial graft, lateral and intramedullary | Success | Forearm range of movement between $\frac{3}{4}$ complete supination and the mid-position. Employed as a caretaker, and contemplates farming in Canada, for which he is quite fit |
| Feb. 1920<br>Tibial graft | Success | Some superficial erosion of graft in early $x$-rays. Forearm range of movement between complete supination and $\frac{3}{4}$ complete pronation. Resumed pre-war occupation as a mason |
| Sept. 1920<br>Tibial graft | Success | Forearm range of movement between complete supination and 10° of pronation from the mid-position. Employed as a postman |
| June, 1919<br>Tibial graft | Success | Forearm range of movement between complete supination and the mid-position. Employed as a clerk |
| Dec. 1919<br>Tibial graft | Success | Forearm range of movement between complete supination and $\frac{3}{4}$ complete pronation. Unemployed. Does not think he will be fit for pre-war occupation as a miner |
| Dec. 1919<br>Tibial graft | Success | Forearm range of movement between complete supination and 10° pronation from the mid-position. Employed as an engineman |
| Dec. 1919<br>Tibial graft | Success | Forearm range of movement between $\frac{3}{4}$ complete supination and the mid-position. Employed as a postman and finds his arm as strong as previously |
| Jan. 1921<br>Tibial graft | Success | Injured reconstructed forearm six months after operation—fracture of graft, which was found to be strongly united three months later. Employed as a miner |
| Sept. 1921<br>Tibial graft | Success | Forearm range of movement between complete supination and 10° of the mid-position. Discharged from hospital to commence out-patient treatment |
| Oct. 1921<br>Tibial graft | Success | Forearm range of movement between complete supination and $\frac{3}{4}$ complete pronation |
| Oct. 1921<br>Tibial graft | Success | Also had fracture of radius at same level, but strongly united with fair alinement. Forearm range of movement between $\frac{1}{2}$ complete pronation. Still receiving massage and electricity |
| Sept. 1921<br>Tibial graft | Success | Fit to resume employment in brick works. Forearm range of movement between $\frac{1}{2}$ complete supination and the mid-position. Still receiving massage and electricity |
| Feb. 1922<br>Tibial graft | Success | Severe latent infection followed second bone-graft—both forearm and leg—no damage to graft or tibia resulted. Still receiving massage and electricity |
| Sept. 1921<br>Tibial graft | Success | Forearm range of movement between $\frac{3}{4}$ complete pronation and $\frac{1}{2}$ complete supination. Still unemployed |

*Continued on next page*

## SYNOPSIS OF 100 CASES OF UNUNITED FRACTURES DUE TO WA

| CASE | DATE OF WOUND AND WHEN HEALED | CAUSE AND PERIOD OF NON-UNION | BONE AND SITE OF NON-UNION | PREVIOUS OPERATIONS |
|---|---|---|---|---|
| *Case* 19.—W. B. *Figs.* 204, 211 | July, 1917<br>May, 1918 | 3 in. gap<br>28 months | L. radius<br>Middle third | Freeing of median nerve |
| *Case* 20.—W. D. *Fig.* 209 | Oct. 1917<br>Feb. 1918 | 1¼ in. gap<br>16 months | L. radius<br>Middle third | Nil |
| *Case* 21.—R. M. | Aug. 1917<br>Feb. 1918 | Latent sepsis and sclerosis<br>31 months | R. radius<br>Lower third | Freeing of flexor muscle<br>Suture of median nerve |
| *Case* 22.—A. M. | Aug. 1918<br>Mar. 1919 | 1 in. gap<br>15 months | L. radius<br>Junction upper and middle thirds | Removal of F.B. |
| *Case* 23.—A. M. | Mar. 1918<br>July, 1918 | 2½ in. gap<br>12 months | L. radius<br>Junction upper and middle thirds | Sequestrectomy |
| *Case* 24.—A. M. | Oct. 1917<br>Dec. 1917 | ¾ in. gap<br>17 months | L. radius<br>Junction middle and lower thirds | Nil |
| *Case* 25.—A. P. | June, 1918<br>Nov. 1918 | 3½ in. gap<br>13 months | L. radius<br>Middle third | Freeing extensor muscles<br>forearm. Transplant |
| *Case* 26.—J. S. | Oct. 1917<br>Dec. 1917 | ¼ in. gap<br>Sclerosis and wiring<br>12 months | L. radius<br>Junction upper and middle thirds | Wiring of fracture |
| *Case* 27.—R. S. *Fig.* 207 | April, 1917<br>Dec. 1917 | ½ in. gap<br>Sclerosis<br>36 months | R. radius<br>Junction lower fifth and upper four-fifths | Excision of scar and correctio<br>of radial deviation of han<br>by plaster-of-Paris |
| *Case* 28.—T. C. *Fig.* 236 | Sept. 1917<br>May, 1918 | 1⅛ in. gap<br>30 months | R. radius<br>Lower fifth | Nil |
| *Case* 29.—J. C. | April, 1917<br>Dec. 1918 | 1½ in. gap<br>31 months | R. radius<br>Through lower third | Nil |
| *Case* 30.—H. C. | June, 1915<br>Feb. 1918 | 1¼ in. gap<br>45 months | L. radius<br>Lower third | Suture of median nerve i<br>lower third of forearm |
| *Case* 31.—A. M. | April, 1917<br>Sept. 1918 | ½ in. gap<br>20 months | L. radius<br>Lower fourth | Nil |
| *Case* 32.—R. McK. | Sept. 1918<br>Jan. 1919 | 1¾ in. gap<br>10 months | R. radius<br>Junction lower and middle thirds | Freeing of median nerve an<br>extensor muscles of forearm |
| *Case* 33.—P. G. | April, 1915<br>Oct. 1918 | Sclerosis<br>¼ in. gap<br>55 months | L. radius<br>Middle third | Nil |
| *Case* 34.—J. K. *Fig.* 206 | May, 1917<br>Aug. 1917 | Sclerosis<br>No gap<br>29 months | R. radius<br>Junction lower and middle thirds | Nil |
| *Case* 35.—D. D. | Aug. 1918<br>April, 1919 | Sclerosis<br>½ in. gap<br>40 months | L. radius<br>Junction lower and middle thirds | Plating of radius. Plate su<br>sequently removed as<br>union resulted |

**JURIES, WITH END-RESULTS OF OPERATIVE TREATMENT—*continued.***

| DATE AND TYPE OF OPERATION | RESULT | REMARKS |
|---|---|---|
| Nov. 1919<br>Tibial graft | Success | Extensive removal of sclerosed bone necessitated graft 6 in. long. Forearm movements between mid-position and ⅔ complete pronation. Employed as a clerk |
| Feb. 1919<br>Tibial graft | Success | Forearm range of movement between ¾ complete supination and ⅔ complete pronation. Able to resume pre-war employment as a printer |
| Mar. 1920<br>Tibial graft | Success | Forearm range of movement from mid-position to 15° pronation. Employed as a telephone operator |
| Nov. 1919<br>Tibial graft | Success | Forearm held almost in complete supination. Few degrees of movement possible. Almost complete canalization of graft |
| Mar. 1919<br>liding graft from radius | Success | Forearm range of movement between complete supination to 10° from the mid-position. Employed as a clerk |
| Mar. 1919<br>Sliding graft from radius | Success | Ulna was fractured at opposite point and strongly united without operation. Forearm range of movement between ¼ complete supination and the mid-position. Resumed pre-war occupation as a miner |
| July, 1919<br>Tibial graft | Success | Septic dermatitis of arm so persistent that amputation was advised. This condition, however, was cured by lipoid paraffin. Forearm range of movement between complete pronation and the mid-position. Resumed pre-war occupation as railway clerk |
| Oct. 1918<br>Tibial graft | Success | Forearm range of movement between complete supination and ⅔ complete pronation. Complains of pain in the lower end of the ulna, this being due to subluxation which may have resulted from attempting heavy work as a labourer |
| April, 1920<br>tramedullary tibial graft | Success | This type of graft employed on account of inadequate coverings for a lateral graft. Employed in an office |
| Mar. 1920<br>tramedullary tibial peg | Partial success | Upper end strongly united; lower end failed to unite. This type of graft was employed on account of inadequate coverings for a lateral graft. Training as a picture frame maker |
| Refused operation<br>Nov. 1919 | — | — |
| Mar. 1919<br>ortening of ulna (1⅝<br>ı. removed), wiring<br>f radius and ulna | Failure | Radial deviation of hand corrected, and consequently able to work as a labourer. Almost a new wrist-joint formed at site of ununited fractures. Strong flexion and extension present |
| Dec. 1918<br>aft operation at-<br>empted, but im-<br>ossible owing to<br>æmorrhage | — | Radial deviation of hand very marked. Posterior subluxation of lower end of ulna. Unable to resume work as miner, but found suitable employment |
| July, 1919<br>Tibial graft | Success | Forearm range of movement between ¼ complete supination and 10° of pronation from the mid-position. Unable to resume pre-war occupation in pits, but has secured suitable work |
| peration inadvisable<br>wing to mal-union<br>t the opposite point<br>Nov. 1919 | — | Quite a serviceable arm, although not fit for pre-war occupation as a tailor |
| nited without opera-<br>ion whilst awaiting<br>dmission to hospital<br>Sept. 1919 | — | Forearm range of movement between complete supination and ¾ complete pronation. Also had posterior subluxation of the lower end of the ulna. Employed as a labourer |
| Dec. 1921<br>Tibial graft | Success | Preliminary operation for removal of plate and correction of radial deviation of hand. Forearm range of movement between ⅔ complete supination and ⅔ complete pronation. Still receiving massage and electricity |

*Continued on next page*

**SYNOPSIS OF 100 CASES OF UNUNITED FRACTURES DUE TO WA**

| CASE | DATE OF WOUND AND WHEN HEALED | CAUSE AND PERIOD OF NON-UNION | BONE AND SITE OF NON-UNION | PREVIOUS OPERATIONS |
|---|---|---|---|---|
| *Case* 36.—J. M. | Nov. 1915<br>Feb. 1919 | 1 in. gap<br>72 months | L. radius<br>Junction lower and middle thirds | Bone-graft in another hospi which was subsequently moved owing to seps Excision of scar |
| *Case* 37.—W. H. | April, 1917<br>Feb. 1919 | Sclerosis<br>55 months | L. radius<br>Junction lower fourth with remainder | Sequestrectomies. Plati operation; removal of pl as no union resulted |
| *Case* 38.—C. McG. | Aug. 1917<br>Oct. 1917 | 1½ in. gap<br>23 months | L. radius<br>Middle third | Nil |
| *Case* 39.—G. G.<br>*Figs.* 202, 203, 205, 208 | Sept. 1918<br>Dec. 1918 | 1¼ in. gap<br>11 months | R. radius<br>Lower third | Nil |
| *Case* 40.—D. G. | May, 1918<br>Nov. 1918 | 2½ in. gap<br>20 months | L. radius<br>Middle third | Sequestrectomy |
| *Case* 41.—J. B.<br>*Fig.* 210 | Oct. 1918<br>Dec. 1918 | 1½ in. gap<br>15 months | L. radius<br>Junction lower and middle thirds | Nil |
| *Case* 42.—J. B. | Nov. 1916<br>Nov. 1917 | Sclerosis<br>½ in. gap and plating<br>34 months | L. radius<br>Middle third | Plating operation. Remov of plate. Freeing of uln nerve |
| *Case* 43.—A. N. | July, 1916<br>Mar. 1917 | 1¾ in. gap<br>Marked sclerosis<br>69 months | R. ulna<br>Middle third | Sequestrectomy |
| *Case* 44.—J. C. | Aug. 1917<br>Dec. 1917 | 2½ in. gap<br>Displacement upper fragment<br>56 months | L. ulna<br>Upper third | Suture of ulnar nerve. E cision of scar |
| *Case* 45.—J. McI. | April, 1917<br>June, 1917 | 1¼ in. gap<br>58 months | L. ulna<br>Junction upper and middle thirds | Excision of scar |
| *Case* 46.—J. C. | Aug. 1917<br>Nov. 1917 | 1¾ in. gap<br>14 months | R. ulna<br>Junction lower and middle thirds | Nil |
| *Case* 47.—L. M. | April, 1917<br>Oct. 1917 | 1 in. gap<br>Still ununited | L. ulna<br>Junction lower and middle thirds | Sequestrectomies. Freeing extensor tendons in forea |
| *Case* 48.—P. C. | Feb. 1918<br>Nov. 1918 | ½ in. gap<br>Still ununited | L. ulna<br>Junction lower and middle thirds | Nil |
| *Case* 49.—D. S. | Dec. 1917<br>Sept. 1918 | 3 in. gap<br>Synostosis between upper end of ulna and opposite point of radius | R. ulna<br>Upper 3 in. with olecranon process missing | Nil |
| *Case* 50.—A. S. | Oct. 1915<br>Sept. 1916 | Sclerosis<br>¼ in. gap | L. ulna<br>Lower fifth | Nil |
| *Case* 51.—E. B. | May, 1918<br>Dec. 1918 | ½ in. gap<br>Still ununited | L. ulna<br>Lower fourth | Suture of median nerve. S questrectomy of ulna |

**IURIES, WITH END-RESULTS OF OPERATIVE TREATMENT—*continued.***

| DATE AND TYPE OF OPERATION | RESULT | REMARKS |
|---|---|---|
| Nov. 1921<br>Tibial graft | Success | Forearm range of movement between $\frac{3}{8}$ complete supination and $\frac{3}{8}$ complete pronation. Is receiving massage and electrical treatment |
| Nov. 1921<br>Tibial graft | Success | Still in hospital. Forearm range of movement between complete pronation and $\frac{3}{8}$ complete supination |
| July, 1919<br>Tibial graft | Success | Forearm range of movement between $\frac{1}{4}$ complete supination and 10° of pronation from the mid-position. Employed as a labourer, and when working feels pain in inferior radio-ulnar joint |
| Aug. 1919<br>ial graft. Marked dial deviation of and corrected by agthening of mus-es | Success | Forearm range of movement between complete supination and the mid-position. Employed as a glass-blower |
| Jan. 1920<br>Tibial graft | Success | Forearm held in position of $\frac{1}{4}$ complete supination. Very good grip. Resumed pre-war occupation in paper mill |
| Jan. 1920<br>Tibial graft | Success | Forearm range of movement between complete supination and $\frac{1}{4}$ complete pronation. Employed as a traveller |
| Sept. 1919<br>Tibial graft | Success | Forearm range of movement between complete supination and the mid-position. Employed as a motor driver |
| April, 1922<br>Tibial graft | Success | Still under treatment |
| April, 1922<br>ouble tibial graft | Success | Still under treatment for ulnar nerve paralysis. Employed as a caretaker |
| Feb. 1922<br>Tibial graft | Success | Still under treatment |
| Oct. 1918<br>Tibial graft | Success | Employed as a clerk |
| No operation | — | As site of fracture immediately above lower end of ulna, grafting operation considered inadvisable. Employed as a printer |
| No operation | — | Operation not advised owing to site of non-union. Resumed pre-war employment as a miner, and can lift a 56 lb. weight with injured arm |
| No operation | — | As range of all movements, voluntary power of muscles, and stability of joint all good, operation not advised |
| No operation | — | Operation not advised as patient suffered little disability from fracture |
| No operation | — | Operation not advised as site of fracture low down |

*Continued on next page*

**SYNOPSIS OF 100 CASES OF UNUNITED FRACTURES DUE TO WA**

| CASE | DATE OF WOUND AND WHEN HEALED | CAUSE AND PERIOD OF NON-UNION | BONE AND SITE OF NON-UNION | PREVIOUS OPERATIONS |
|---|---|---|---|---|
| *Case* 52.—A. M. | Aug. 1918<br>Mar. 1919 | 1¾ in. gap<br>44 months | L. ulna<br>Junction upper fourth and lower three-fourths | Bone-graft of radius |
| *Case* 53.—R. T. | Aug. 1918<br>Jan. 1920 | 2½ in. gap<br>17 months | R. ulna<br>Middle third | Sequestrectomy |
| *Case* 54.—D. W. | April, 1917<br>April, 1918 | Sclerosis and latent sepsis<br>58 months | R. femur<br>Middle third | Sequestrectomies. Several a scesses. |
| *Case* 55.—G. D. | April, 1917<br>Aug. 1919 | Sclerosis<br>¾ in. gap | R. tibia<br>Junction lower and middle thirds | Nil |
| *Case* 56.—J. B. | April, 1918<br>Mar. 1919 | 2 in. gap<br>11 months | R. tibia<br>Middle third | Sequestrectomies. Fibul bone-graft, excision of sc in other hospitals |
| *Case* 57.—W. C. | Oct. 1918<br>June, 1919 | Sclerosis and displacement<br>17 months | R. tibia<br>Middle third | Nil |
| *Case* 58.—P. S. | Aug. 1917<br>Sept. 1918 | ¾ in. gap<br>21 months | R. tibia<br>Middle third | Nil |
| *Case* 59.—B. W. | May, 1915<br>Jan. 1916 | Sclerosis<br>Still ununited | L. tibia<br>Middle third | Nil |
| *Case* 60.—J. McL. | April, 1917<br>June, 1920 | Sclerosis<br>38 months | L. tibia<br>Middle third | Nil |
| *Case* 61.—T. H. | Sept. 1918<br>Mar. 1921 | 2 in. gap<br>39 months | L. tibia<br>Junction middle and upper thirds | Excision of skin scar. Cicat and scar-tissue |
| *Case* 62.—H. K. A.<br>*Fig.* 241 | May, 1917<br>April, 1918 | 2 in. gap<br>33 months | R. tibia<br>Junction upper and middle thirds | Excision of skin. Cicatrix a scar-tissue |
| *Case* 63.—J. G. | May, 1915<br>June, 1919 | 1¾ in. gap<br>62 months | R. tibia<br>Through middle third | Excision of wound. Plating tibia, removal of plate |
| *Case* 64.—L. F.<br>*Figs.* 232, 235 | Oct. 1917<br>June, 1919 | 2½ in. gap<br>22 months | L. tibia<br>Middle third | Sequestrectomy |
| *Case* 65.—C. R. | Mar. 1918<br>Nov. 1918 | Sclerosis and displacement<br>51 months | L. humerus<br>Junction of lower and middle thirds | Exploration of musculospi nerve. Transplantation tendons |
| *Case* 66.—J. McK. | Mar. 1918<br>Aug. 1918 | Sclerosis<br>24 months | L. humerus<br>Junction lower fifth and upper four-fifths | Suture of musculospiral ner Suture of ulnar nerve and bo graft of humerus which v subsequently removed. M culospiral nerve re-suture |
| *Case* 67.—H. B.<br>*Fig.* 226 | Oct. 1918<br>Mar. 1919 | Sclerosis<br>12 months | R. humerus<br>Anatomical neck | Unsuccessful bone-graft other hospital |
| *Case* 68.—A. R.<br>*Figs.* 224, 225 | Oct. 1918<br>June 1919, | Sclerosis<br>16 months | R. humerus<br>Surgical neck | Sequestrectomy and excis of sinus |

**UURIES, WITH END-RESULTS OF OPERATIVE TREATMENT—*continued.***

| DATE AND TYPE OF OPERATION | RESULT | REMARKS |
|---|---|---|
| April, 1922<br>Tibial graft | — | Still in hospital. Almost complete canalization of radius graft |
| Jan. 1920<br>Tibial graft | Success | Forearm range of movement between complete supination and ¾ complete pronation. Resumed employment in gas meter works. |
| United without operation<br>Feb. 1922 | — | Owing to the persistence of latent sepsis, the question of operation could never be considered. Treatment consisted of: (1) Extension by Thomas's splint; (2) 'Hammering and damming'; (3) Calcium ionization and calcium salts internally; (3) Endocrine gland tablets; (4) Faradism |
| United without operation | — | Osteogenesis was delayed by sepsis |
| Mar. 1919<br>Tibial graft | Failure | Graft fixed by wire: partial death of graft, this portion removed along with wires. Non-union again resulted |
| Mar. 1920<br>Tibial graft | Success | Unemployed. Still wears a steel support, as he is afraid to bear his whole weight on reconstructed limb |
| May, 1919<br>iding tibial graft | Success | Would have been able to resume pre-war occupation as a miner but for 3 in. shortening of the leg as a result of fracture of the femur. Wears a high boot. Employed as a motor-man in the mines |
| No operation | — | Refused treatment |
| United without operation | Success | 'Hammer and dam' treatment |
| Dec. 1921<br>ouble tibial graft | Success | Portion of host tibia was utilized when filling up gap between the two grafts. Although still under treatment, firm union has resulted |
| Feb. 1920<br>ial graft (Bangour)<br>Oct. 1921<br>ial graft (Craigith) | Success | In the case of the first graft, both ends strongly united; fracture over upper end occurred July, 1921, which did not unite, and necessitated second graft. All evidence points to very satisfactory result |
| July, 1920<br>Tibial graft | Success | Walks without a caliper |
| Aug. 1919<br>Tibial graft | Success | Able to resume his work as a farmer. Does not require to wear a caliper. Required small skin-graft for necrosis of scarred skin |
| June, 1922<br>pping operation of<br>merus | Success | Wound healed. Firm union. Still under treatment |
| Mar. 1920<br>ne-graft of humer-<br>, intramedullary<br>ial peg, and chip<br>m iliac crest | Success | Resumed farming in Canada |
| Oct. 1919<br>ramedullary peg,<br>uaring of fragments | Success | Arm can be fully and strongly abducted to angle 70°. Good firm union at site of fracture. Radial movements from extension practically normal. Flexion at shoulder almost to a right angle. Hopes to resume work as a riveter |
| Feb. 1920<br>ramedullary tibial<br>g, squaring of<br>gments, and chips<br>m iliac crest | Success | Necrosis of iliac chips and consequent sinuses. Ultimate result of graft satisfactory. Abduction at shoulder to angle 60°, flexion almost to a right angle. Works on a farm |

*Continued on next page*

## SYNOPSIS OF 100 CASES OF UNUNITED FRACTURES DUE TO WA

| CASE | DATE OF WOUND AND WHEN HEALED | CAUSE AND PERIOD OF NON-UNION | BONE AND SITE OF NON-UNION | PREVIOUS OPERATIONS |
|---|---|---|---|---|
| *Case* 69.—S. D. | Sept. 1918<br>Oct. 1919 | 2 in. gap | R. fibula<br>Upper and middle third | Nil |
| *Case* 70.—J. E. | Nov. 1918<br>Mar. 1921 | Sclerosis<br>28 months | L. femur<br>Lower and middle third | Sequestrectomies |
| *Case* 71.—D. H. | April, 1918<br>July, 1918 | *Sclerosis*<br>1½ in. gap<br>17 months | L. humerus<br>Lower third | Nil |
| *Case* 72.—J. A. | Sept. 1915<br>Nov. 1916 | Sclerosis<br>¼ in. gap<br>35 months | L. humerus<br>Lower fourth and upper three-fourths | Two bone-grafts in Switz land, and sequestrecto Also inlay bone-graft whi fractured and had to removed |
| *Case* 73.—T. McC.<br>*Figs.* 233, 234 | May, 1915<br>Dec. 1920 | Sclerosis<br>and displacement<br>76 months | R. tibia<br>Middle third | Sequestrectomies |
| *Case* 74.—J. R. | Feb. 1918<br>May, 1918 | 2½ in. gap<br>17 months | R. tibia<br>Middle third | Sequestrectomies |
| *Case* 75.—N. McD. | Aug. 1917<br>Sept. 1919 | Sclerosis<br>and displacement<br>42 months | R. tibia<br>Lower third | Two bone-grafts in otl hospitals which were successful. Removal of w from graft |
| *Case* 76.—J. G. | Sept. 1917<br>April, 1918 | Latent sepsis<br>11 months | R. tibia<br>Upper third | Abscess in leg opened |
| *Case* 77.—W. H. | Oct. 1916<br>Mar. 1917 | Lower third of humerus missing, complicated by flail elbow<br>27 months | R. humerus<br>Lower third | Transplantation of tendo Tibial bone-graft in anot hospital which had to removed |
| *Case* 78.—R. G. | Oct. 1916<br>July, 1917 | Articular surface of humerus absent, part of olecranon process absent, complicated by flail elbow<br>28 months | R. humerus<br>Lower third | Tibial bone-graft in anot hospital which had to removed |
| *Case* 79.—T. W. | Aug. 1916<br>Nov. 1919 | *Sclerosis*<br>53 months | R. humerus<br>Middle of lower third | Sequestrectomies, Stepp operation for humerus— successful |
| *Case* 80.—T. W. | Aug. 1917<br>April, 1918 | Sclerosis<br>27 months | R. humerus<br>Junction of lower and middle thirds | Sequestrectomies: wiring humerus |
| *Case* 81.—J. C.<br>*Figs.* 222, 223 | Aug. 1918<br>Mar. 1919 | Sclerosis and displacement<br>9 months | R. humerus<br>Middle third | Transplantation of tendons drop-wrist |
| *Case* 82.—J. B. | April, 1917<br>Nov. 1917 | Displacement<br>1½ in. gap<br>29 months | R. humerus<br>Middle third | Tibial bone-graft in anot hospital, removal of g owing to sepsis |

**JURIES, WITH END-RESULTS OF OPERATIVE TREATMENT—*continued.***

| DATE AND TYPE OF OPERATION | RESULT | REMARKS |
|---|---|---|
| No operation | — | Operation unnecessary as no disability complained of. Employed as a labourer |
| No operation | Success | Femur first united Mar. 1920; refractured by slipping on floor, June, 1920, also causing wound to break down. Treatment consisted of: (1) Extension by Thomas's splint; (2) 'Hammer and dam'; (3) Calcium ionization and calcium salts internally; (4) Endocrine gland tablets; (5) Diathermy; (6) Faradism. Fracture started to reunite definitely middle of April, 1921, and was firmly united by Nov. 1921. Employed as a lawyer |
| Sept. 1919<br>pping operation of humerus | Success | Ankylosis of elbow and wrist. Bone-marrow of humerus similar in appearance to that in leukæmia. Employed as a clerk |
| Aug. 1918<br>pping operation of humerus | Success | Had fibrous ankylosis of elbow, and required transplantation operation for drop-wrist. Employed as a clerk |
| Sept. 1921<br>ouble tibial graft | Success | Marked recrudescence of latent sepsis; notwithstanding this, grafts did not die, and strong union resulted |
| July, 1919<br>Tibial graft | Success | Graft was fixed by wire. Employed as a miner |
| Feb. 1921<br>ouble tibial graft | Success | Was discharged to out-patient treatment and allowed to bear weight on leg too early, with partial fracture of one graft. Slight recrudescence of latent sepsis occurred after graft operation. This did not affect ultimate strong union. Employed as a fisherman |
| United without operation<br>Aug. 1918 | — | Fracture was transverse with very slight loss of bone. By means of Bier's congestion and 'hammer and dam' treatment, good union resulted. Employed as a miner |
| Jan. 1919<br>ing of humerus, ius, and ulna, induction of chips m iliac crest | Partial success | Increased control of flail joint, and with aid of splint patient is able to work as an electrical engineer |
| Feb. 1919<br>hrodesis of elbow | Success | Able to work as a labourer. Has several degrees strong flexion and extension of elbow |
| Jan. 1921<br>amedullary tibial ;, lateral tibial ft, and chips from c crest | Partial success | Absorption of intramedullary graft, union of lateral graft to lower end of humerus, non-union of graft to upper end due to recrudescence of latent sepsis. Latent sepsis still present |
| Nov. 1919<br>epping operation for humerus | Failure. Diabetes. | No union resulted. Ankylosis of elbow. General health unsatisfactory owing to diabetes. Marked osteoporosis of lower end of humerus, which fractured when stepping operation was carried out |
| May, 1919<br>epping operation for humerus | Success | Elbow range of movement from angle 160° to angle 170°. Resumed pre-war occupation as a postman |
| Sept. 1919<br>epping operation humerus, and re-val of wire | Success | Elbow range of movement between angle 150° and angle 90° |

*Continued on next page*

## SYNOPSIS OF 100 CASES OF UNUNITED FRACTURES DUE TO W

| CASE | DATE OF WOUND AND WHEN HEALED | CAUSE AND PERIOD OF NON-UNION | BONE AND SITE OF NON-UNION | PREVIOUS OPERATIONS |
|---|---|---|---|---|
| *Case* 83.—G. T. | Aug. 1916<br>Sept. 1917 | Sclerosis<br>38 months | R. humerus<br>Junction of lower and middle thirds | Nine operations for remova dead bone and metal pl Squaring and rawing humerus and fixation aluminium wire which subsequently to be remo |
| *Case* 84.—A. N. | Mar. 1918<br>May, 1919 | 1½ in. gap<br>Displacement<br>24 months | R. humerus<br>Junction of lower and middle thirds | Sequestrectomies. Ten transplantation for drop-w |
| *Case* 85.—T. S. C. | Oct. 1918<br>Nov. 1918 | Sclerosis and latent sepsis<br>19 months | L. femur<br>Junction lower and middle thirds | Nil |
| *Case* 86.—J. B. C. | Sept. 1918<br>Jan. 1919 | —<br>20 months | R. radius<br>Through middle third | Tibial bone-graft which been applied with fragme of host-bone not in pro alinement |
| *Case* 87.—J. V.<br>*Fig.* 227 | April, 1918<br>April, 1920 | Sclerosis<br>½ in. gap<br>42 months | R. humerus<br>Surgical neck | Sequestrectomies |
| *Case* 88.—G. B. | Sept. 1918<br>Oct. 1919 | Whole of shaft missing<br>43 months | L. humerus<br>Lower two-fifths | Sequestrectomies. Tibial bo graft in other hospital wh was ultimately removed ow to sepsis. Several skin-f operations |
| *Case* 89.—W. McD. | Oct. 1918<br>Aug. 1919 | 1½ in. gap<br>Displacement<br>40 months | R. humerus<br>Junction lower and middle thirds | Nil |
| *Case* 90.—J. H. | Aug. 1918<br>Feb. 1919 | 2 in. gap<br>Sclerosis<br>45 months | R. ulna<br>Junction lower and middle thirds | Freeing of ulnar nerve lengthening of flexor tend for contracted fingers. cision of scar |
| *Case* 91.—T. T. | April, 1915<br>Dec. 1915 | Displacement and sclerosis<br>85 months | R. humerus<br>Junction of lower and middle thirds | Transplantation of tendons |
| *Case* 92.—J. H. | July, 1916<br>Mar. 1918 | 1¾ in. gap | L. ulna<br>Junction lower and middle thirds | Freeing of ulnar nerve |
| *Case* 93.—T. B.<br>*Figs.* 230, 231 | Aug. 1918<br>May, 1919 | Sclerosis and sepsis<br>19 months | L. humerus<br>Lower and middle thirds | Nil |
| *Case* 94.—W. H.<br>*Figs.* 228, 229 | April, 1918<br>Feb. 1919 | ¾ in. gap<br>Sclerosis<br>27 months | L. humerus<br>Junction of lower fourth and upper three-fourths | Suture of musculospiral ne Wire operation. Ten transplantation. Bone-g |
| *Case* 95.—J. McK. | Feb. 1918<br>(Accident) | Ununited fracture of styloid process of ulna<br>22 months | L. ulna<br>Styloid process | Nil |

**JURIES, WITH END-RESULTS OF OPERATIVE TREATMENT—*continued.***

| DATE AND TYPE OF OPERATION | RESULT | REMARKS |
|---|---|---|
| Oct. 1919<br>)pping operation for for humerus | Success | On examination three years later a very satisfactory result was found. Employed as a haulage engineman in the mines. Finds no disability from his arm. Ankylosis of elbow |
| Mar. 1920<br>Tibial graft | Success | Strong union with good alinement |
| May, 1920<br>ramedullary tibial 'aft, chips from ac crest, and iring | Success | Walks without a caliper |
| May, 1920<br>)vious graft re-oved and new tibial 'aft inserted with dius fragments in 'oper alinement | Success | First graft had been inserted with upper fragment of radius completely supinated and lower fragment completely pronated, so that forearm movements reduced to nil. By means of fresh graft and correction of alinement good forearm movements obtained |
| Oct. 1921<br>tepping operation | Success | Abduction of shoulder to angle 70°. 10° of external and internal rotation. Elbow completely ankylosed angle 120°. Forearm fixed in mid-position. Strong union resulted. He is satisfied that he can return to his pre-war occupation on the railway |
| April, 1922<br>uble tibial graft, :ed by Parham's etallic bands | Success | Still under treatment. Most violent recrudescence of latent infection occurred in the axilla and left flank. Operation scar and graft bed remained intact. |
| Feb. 1922<br>pping operation for imerus, fixed by arham's metallic nds | Success | Still under treatment. Ankylosis of elbow made stepping operation more difficult. Strong union has resulted |
| May, 1922<br>Tibial graft | Success | Still under treatment |
| May, 1922<br>pping operation for imerus, fixed by rham's metallic nds | Success | Still under treatment |
| — | — | Graft operation could not be carried out as patient had to return to Canada |
| Mar. 1920<br>amedullary tibial ift with chips m iliac crest | Success | Elbow movement from angle 160° to angle 80°. This case is remarkable for the large amount of callus thrown out after bone-graft operation. Strong union has resulted. Resumed farming work in Canada |
| July, 1920<br>ible tibial intra-dullary and lateral ne-graft | Success | Elbow range of movement from angle 170° to a right angle. Complete absorption of intramedullary graft; although lateral graft fractured partially, very strong union resulted. Training in commercial work |
| Dec. 1919<br>ing graft of ulna. efing of lax cap-ar ligament | Success | Employed as a commercial traveller. This operation was performed for recurrent anterior dislocation of the lower end of the ulna complicated by ununited fracture of the styloid process of the ulna |

*Continued on next page*

**SYNOPSIS OF 100 CASES OF UNUNITED FRACTURES DUE TO WA**

| CASE | DATE OF WOUND AND WHEN HEALED | CAUSE AND PERIOD OF NON-UNION | BONE AND SITE OF NON-UNION | PREVIOUS OPERATIONS |
|---|---|---|---|---|
| *Case* 96.—J. H. | Mar. 1917<br>Jan. 1918 | 1¾ in. gap<br>37 months | R. ulna<br>Junction of lower and middle thirds | Nil |
| *Case* 97.—C. S. | Sept. 1918<br>May, 1919 | 1¼ in. gap<br>44 months | L. ulna<br>Through upper third | Sequestrectomies. Suture ulnar nerve |
| *Case* 98.—A. C. | May, 1915<br>Nov. 1917 | 2 in. gap<br>85 months | L. ulna<br>Lower third | Sequestrectomies |
| *Case* 99.—G. M. | June, 1917<br>Mar. 1919 | 1½ in. gap<br>60 months | L. ulna<br>Lower third | Plating of ulna |
| *Case* 100.—C. A. | Jan. 1920<br>(Propeller accident) | Displacement<br>3 months | R. styloid process of ulna, complicated by fibrous union junction lower and middle thirds of radius, and anterior dislocation lower end of ulna | Attempted reduction unc anæsthetic in another h pital ; failure |

**JURIES, WITH END-RESULTS OF OPERATIVE TREATMENT—*continued.***

| Date and Type of Operation | Result | Remarks |
|---|---|---|
| April, 1920<br>Tibial graft | Success | Forearm range of movement between complete supination and complete pronation |
| May, 1922<br>Tibial graft | Success | Marked impairment of pronation and supination |
| June, 1922<br>Tibial graft | Success | Still under treatment |
| June, 1922<br>Tibial graft | Success | Still under treatment |
| April, 1920<br>emoval of styloid<br>rocess of ulna. Re-<br>luction of disloca-<br>ion. Excision of<br>lbrous union of<br>adius | Success | Remained in army |