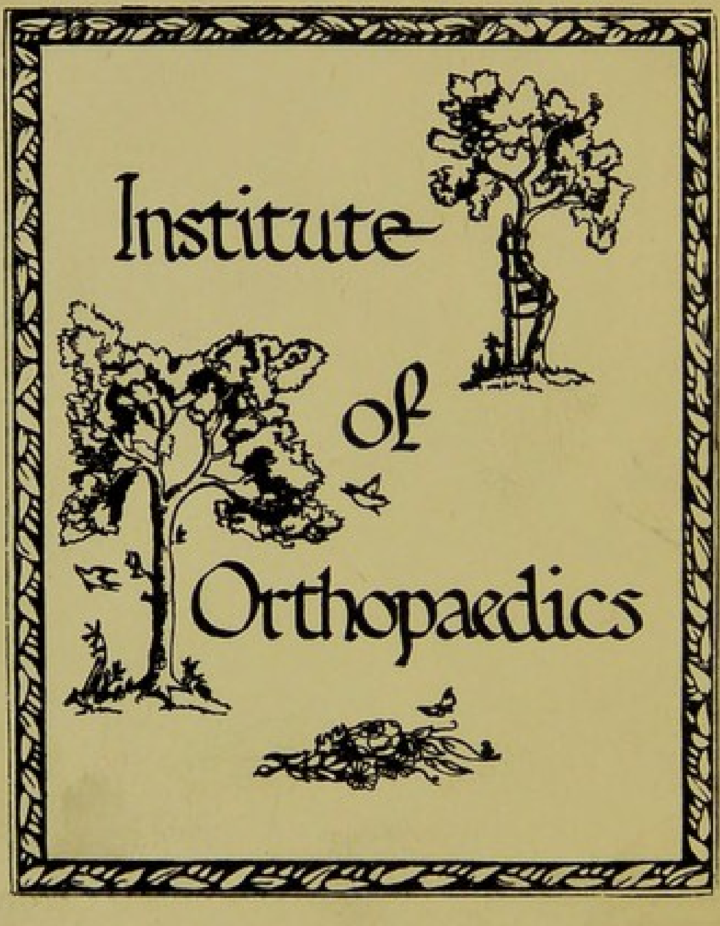
THE OPERATIVE TREATMENT OF FRACTURES

W. ARBUTHNOT LANE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OPERATIVE TREATMENT OF FRACTURES

BY

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PREFACE.

IN preparing this second edition on the 'Operative Treatment of Fractures,' I have merely added such radiograms as I felt would be of service in demonstrating more clearly the best mode of reduction of fragments and their retention in position.

I am indebted to Mr. Schlesinger for much help.

W. ARBUTHNOT LANE.

21, Cavendish Square;
1914.

THE OPERATIVE TREATMENT OF FRACTURES.

Twenty-two years have elapsed since I made it my habitual practice to operate on all cases of simple fractures of the long bones in which I was not able to obtain accurate apposition of fragments when the restoration of the bone to its normal form was of mechanical importance to the individual.

I feel, therefore, that after this interval of time I might put together some facts as to the results of the treatment I then urged on the profession, and also endeavour to show that the views which I originally enunciated in support of these operative procedures on simple fractures have since been most fully verified.

The Changes which the Skeleton undergoes from the Habitual Assumption of Attitudes of Activity or of Rest.

My attention was first attracted to the unsatisfactory nature of the treatment of fractures when in 1885 I was pursuing investigations concerning the changes which the skeleton undergoes when any attitude or sequence of attitudes of activity or any attitude of rest is habitually assumed. As these have a most important bearing on the principles involved in the treatment of fractures I will proceed to describe them. I found that the several deformities which were described as lateral curvature, dorsal excurvation, knock-knee, bow-legs, flat-foot, etc., were in the first instance the temporary fixation of a normal physiological attitude of rest in subjects the texture of whose skeletons was more or less abnormal, or was reduced in density as the result of bad feeding, old age, etc., these being variously termed rachitic, senile, etc. According to my observations, as time progressed the fixation became permanent, the deformity being progressively exaggerated. The alteration in the usual form of the growing skeleton when nearly normal in texture was brought about by the consequent abnormal growth of the epiphysial lines, the result of deviation from the ordinary mode of transmission of pressure through them. The degree of bone-formation in the several portions of a growing or epiphysial line varies inversely as the pressure transmitted through them. These changes in the growing line are exaggerated in rickets, and there is associated with them a bending of the shafts of the bones which are abnormally soft.

My investigations concerning the results of arduous occupations on the skeleton proved that the changes in the articular surfaces up to about thirty or forty years of age were such as would tend to render the joints more secure. They consisted in the formation of bone and cartilage about the margins of the articular surface, by means of which its area was increased. After middle life the cartilage and bone at the seats of excessive pressure underwent the several changes regarded by the pathologist as evidence of disease, the so-called "osteo- or rheumatoid arthritis."

I classified these pressure changes in the joint surfaces under the terms "mechanical or traumatic arthritis." Those which existed in young life, and which were more or less advantageous, I called, for the sake of convenience, "active or adaptive changes," while to the destructive condition of later life I applied the term "passive."

From a study of the various pressure changes in the several decades of life one learnt that any specialisation in the mode of transmission of force through a joint resulted in an alteration in the form of that joint, the character of such alteration varying considerably with the age of the individual.

Passing on to the consideration of the fixation of the

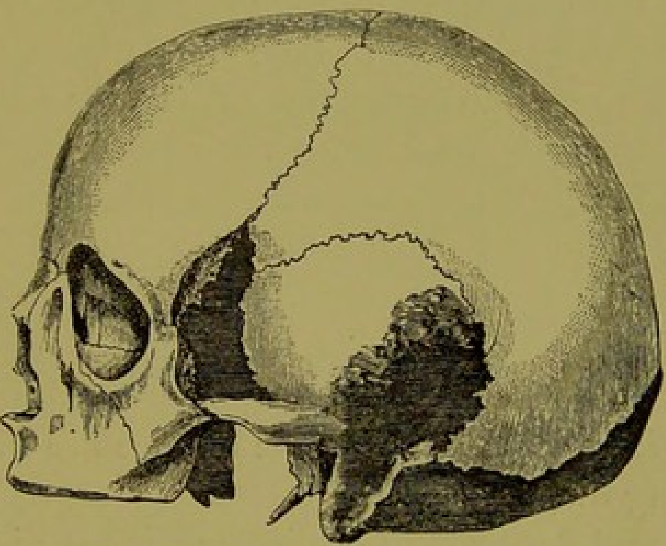


FIG. 1.—Skull of early mollities ossium.

attitudes of rest as seen in feeble old age, similar changes were observed. They consisted in the destruction of the soft parts intervening between bones, and an alteration in the texture and even in the form of the bones. In feeble old age an exaggerated degeneration of the skeleton resulted. When this became a very marked feature it was called "mollities ossium." In a paper in the 'Transactions of the Pathological Society of London' in 1884, entitled "Cases of Mollities Ossium, Rheumatic Arthritis, and Charcot's Disease," I endeavoured to disprove the view of the pathology of mollities put forward by Rindfleisch, who regarded the fibrillation as part of a degenerative process, whereas it appeared to me to be reparative and analogous to changes in rickets and osteitis deformans. Fig. 1 represents the skull of a case of early mollities; the shaded parts indicate the areas in which the softening was most advanced.

My investigations brought out the further fact that the brain has for its greater security a special claim on the supply of bone-forming material. Rickets and mollities ossium afford striking illustrations, since in both conditions the softening of the vault of the skull has associated with it a corresponding deposit of material on its outer surface, rendering it thick and resistant. This deposit is out of all proportion to that present on the surfaces of the other bones of the skeleton. This was described in a paper of mine in the 'Lancet,' April 28th, 1888, "The Factors that determine the Hypertrophy of the Skull in Mollities Ossium, Osteitis Deformans, Rickets, and Hereditary Syphilis."

Many of the changes in feeble old age are illustrated in the following diagrams:

Figs. 2 and 3 represent vertical median sections through the bodies of feeble old subjects. Note the resting position of complete flexion of the several parts of the spine. In the lower part of the spinal column the habitual flexion of the lumbo-sacral joint has resulted in an abrupt bend of the sacrum in the one case and in the other of a more general yielding, producing in both a considerable diminution of the conjugate diameter of the pelvic brim. The inter-vertebral discs disappear at the points of greatest pressure, their total bulk being proportionately very much less than in vigorous life. The shading represents alteration in the structure of the bones, loss of function of a part rendering the cancelli less conspicuous, while the transmission of an excessive pressure exaggerates them.

Fig. 2.

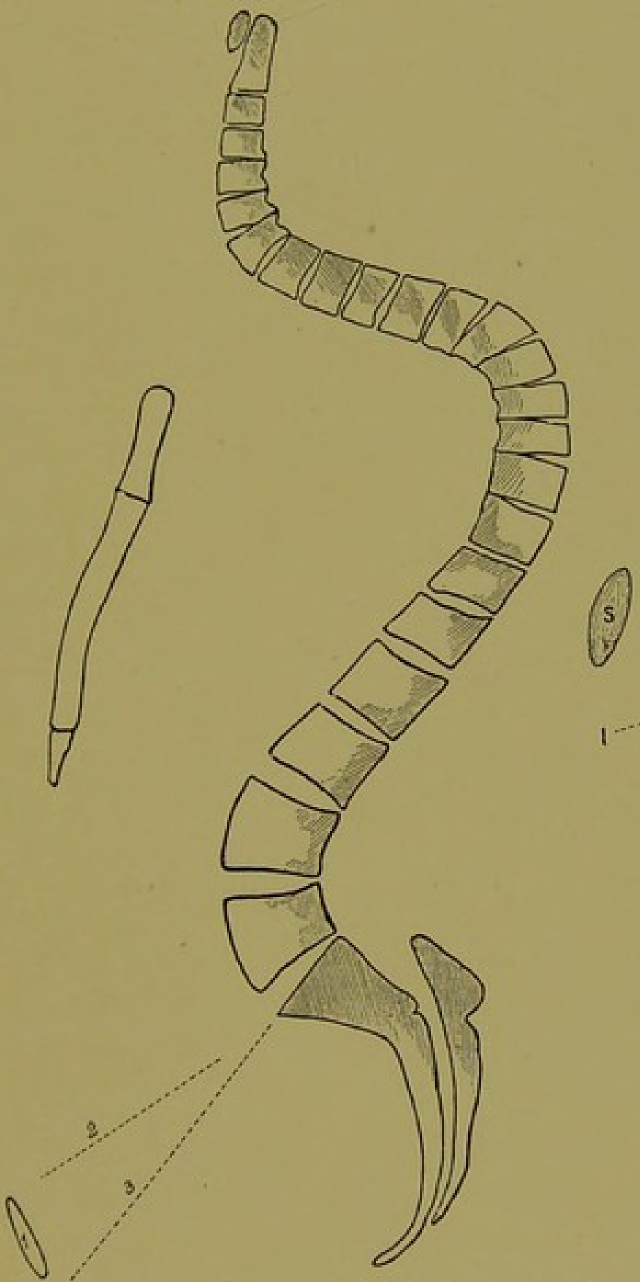


Fig. 3.

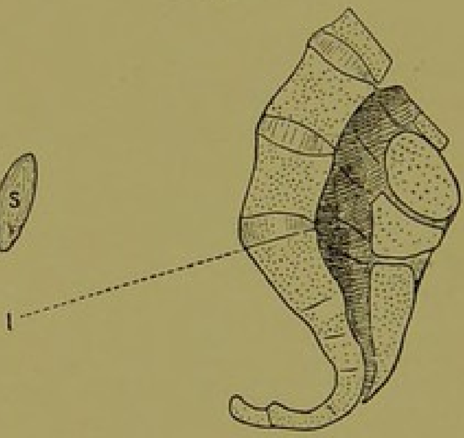


Fig. 2.—Spinal column of old woman.
Fig. 3.—Lower part of spine of feeble old subject.

Attitudes of Activity.

In the fixations of attitudes of activity shown by the skeletons of the labourers similar facts were elicited. In them the subject had generally reached maturity when the form of labour was commenced. The growing lines were therefore uninfluenced, the changes being limited to the articular surfaces and to the texture of the bones. Both of these were modified proportionately to the pressure transmitted, and the changes varied with the age of the individual. If, however, a laborious occupation was pursued in young life, the deformity was still further exaggerated by a modification of the growth at the epiphysial lines.

I do not propose to go into these changes in detail, but will confine myself to calling attention to the changes shown by illustrations of several of these conditions. They represent the process of evolution telescoped into the duration of a single lifetime. To those who are unfamiliar with these changes, the variation from the normal is most striking and interesting, for the skeletons of many of the labourers differ from the usual type in a most remarkable manner. In other words, the form of the skeleton depends upon and varies with the mechanical relation of the individual to his surroundings.

Fig. 4 represents portions of the spine and thorax of a brewer's drayman, and shows the fixation and exaggeration of the attitude of activity which is assumed when a heavy barrel is supported on the right shoulder. In this attitude numerous tendencies to change exist, and by its habitual assumption these tendencies become actualities. The change in form is occasioned by the bending of the ribs, by the destruction of the fibro-cartilages and the bone at the seat of greatest pressure, and the formation of thick osseous lips at the margins of the articular surfaces to increase the security and strength of the spine. In this manner an almost rigid shelf is formed on which the barrel can be supported and through which the weight can be transmitted with a minimum expenditure of muscular energy.

Figs. 5 and 6 represent the spine of a coal-heaver. They

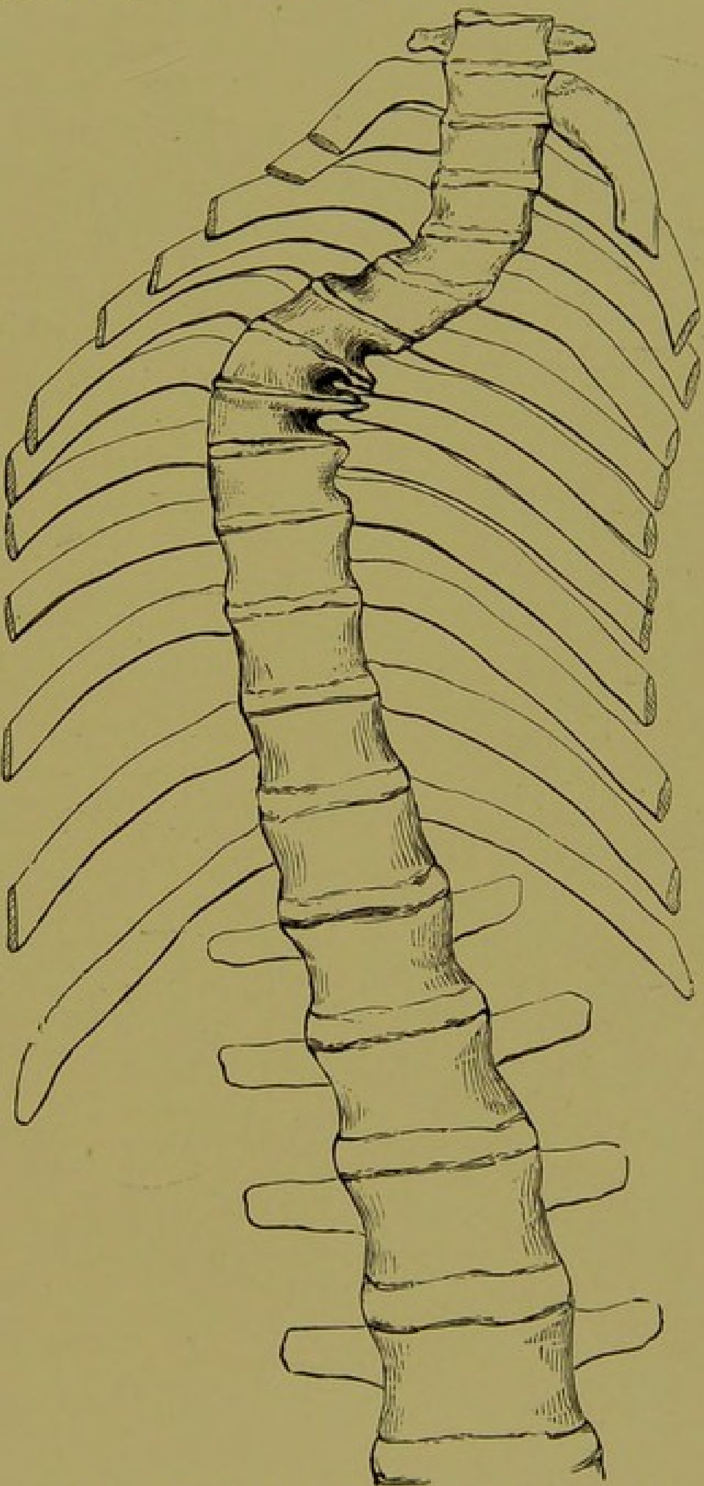


FIG. 4.—Spine and ribs of a brewer's drayman.

show much destruction of fibro-cartilages and the fixation of the margins of the vertebræ one to another by dense

Fig. 5.

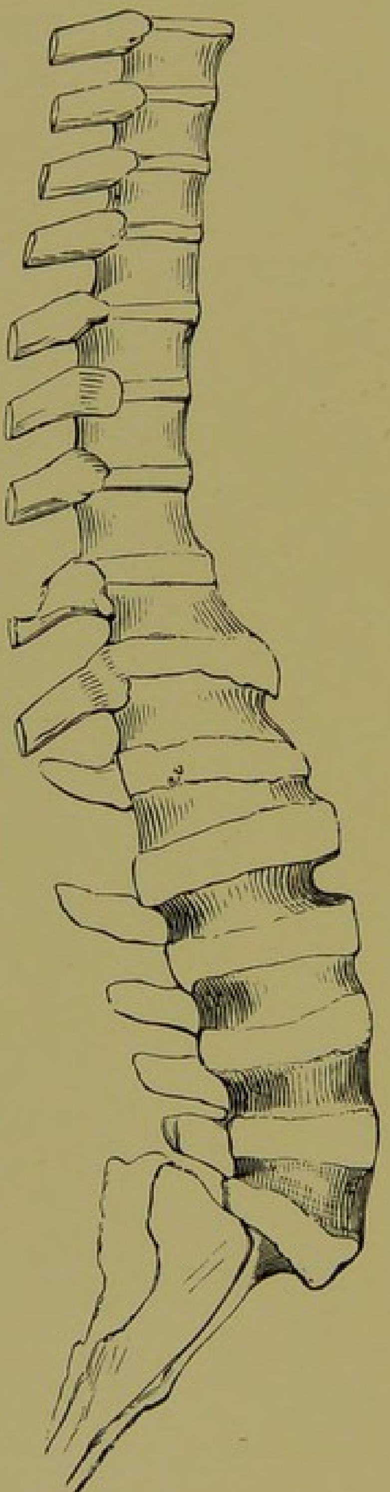
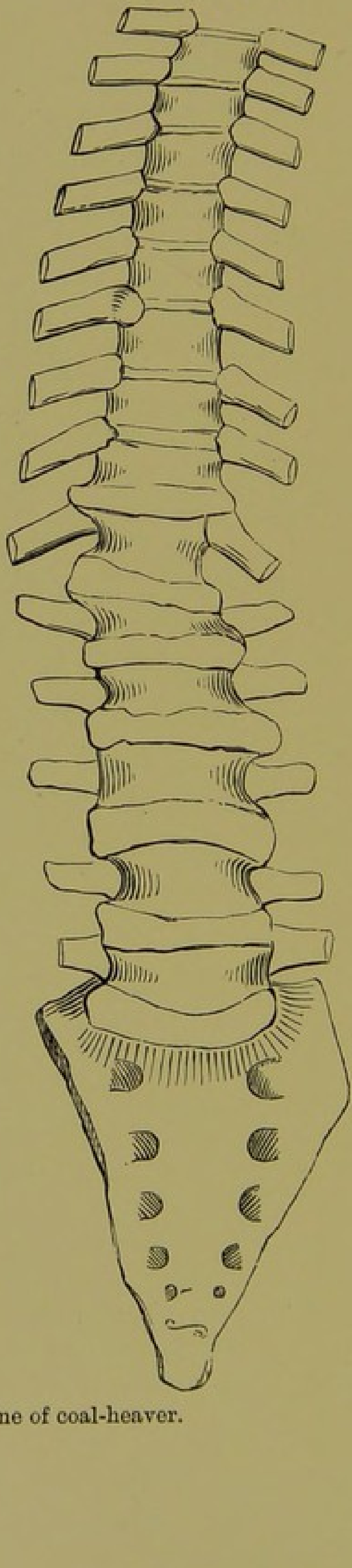


Fig. 6.



Figs. 5 and 6.—Spine of coal-heaver.

lips of bone which practically render the lumbar spine immobile. In Fig. 7 the last lumbar vertebra is displaced forwards, and is ankylosed to the sacrum, forming a variety of spondylolisthesis. Contrast the conditions present here with those in Fig. 8, where an arthrodial joint has been developed. This specimen was obtained from the body a labourer whose business it was to carry loads, lifting

Fig. 7.

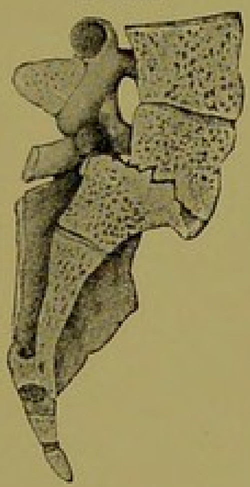


Fig. 8.

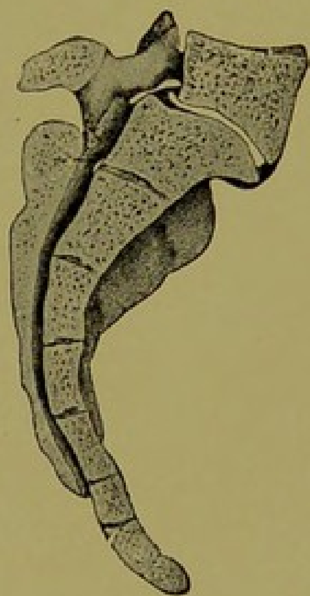


Fig. 7.—Fourth and fifth lumbar vertebræ and sacrum of coal-heaver.
Fig. 8.—Fifth lumbar vertebra and sacrum of deal-porter.

them from the ground and replacing them. I need hardly call attention to the importance of the study of the manner in which spondylolisthesis is produced. It enabled much light to be thrown upon a condition on which the obstetricians held various opinions.

During flexion of the lumbo-sacral joint there exists a tendency to the forward and downward displacement of the last lumbar vertebra off the sacrum. The habitual assumption of this attitude, aided by the transmission of a considerable pressure in the coal-heaver, results in the actuality, the bone becoming displaced. An examination of the spinal columns of the various monkeys, presenting differences in the number of vertebræ, and of those of man with a partial or complete dissociation of the first sacral vertebra, and with a more or less complete fusion of the last lumbar vertebra with the sacrum, show how the tendency to change consequent on the habitual assumption of an attitude of flexion or of extension during many generations may result in the actuality of that change.

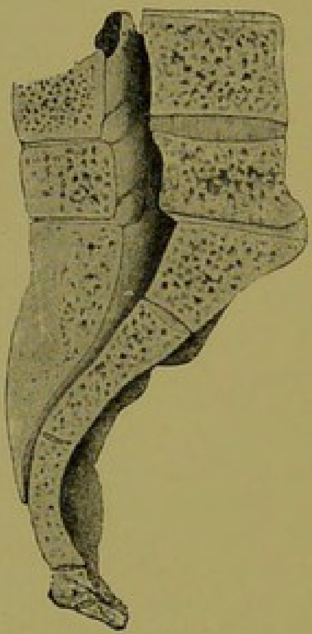


FIG. 9.—Fourth and fifth lumbar vertebræ and sacrum of labourer who carried loads in front of him.

This hereditary transmission of tendencies is dealt with in a communication published in the 'Journal of Anatomy and Physiology,' Jan., 1888, entitled, "Can the Existence of a Tendency to Change in the Form of the Skeleton of the Parents result in the Actuality of that Change in the Offspring?"

In contrast with Figs. 7 and 8, Fig. 9 shows the condition of the lower part of the spinal column in a labourer who was habitually engaged in carrying loads in front of him. The constant over-extension of the spine resulted in a backward displacement of the fifth lumbar vertebra on the sacrum, and an exaggerated development

Fig. 10.

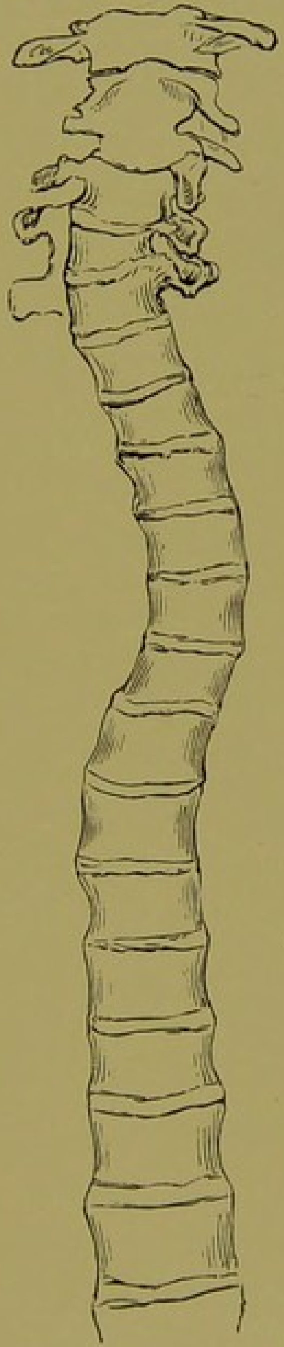
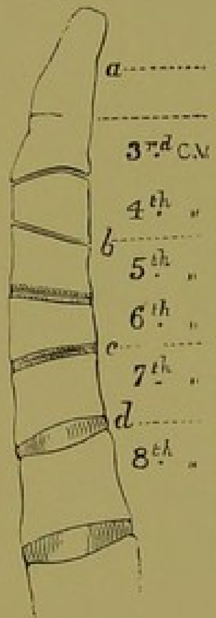


Fig. 11.



Figs. 10 and 11.—Spine of labourer who carried loads on his head.

of the spines of the lumbar vertebræ and sacrum, which articulated with one another, transmitting a considerable proportion of the superjacent weight. This subject is dealt with in a paper published by me in the 'Transactions of the Obstetrical Society,' vol. xxix. The destruction of fibro-cartilage occurs as in all other laborious occupations.

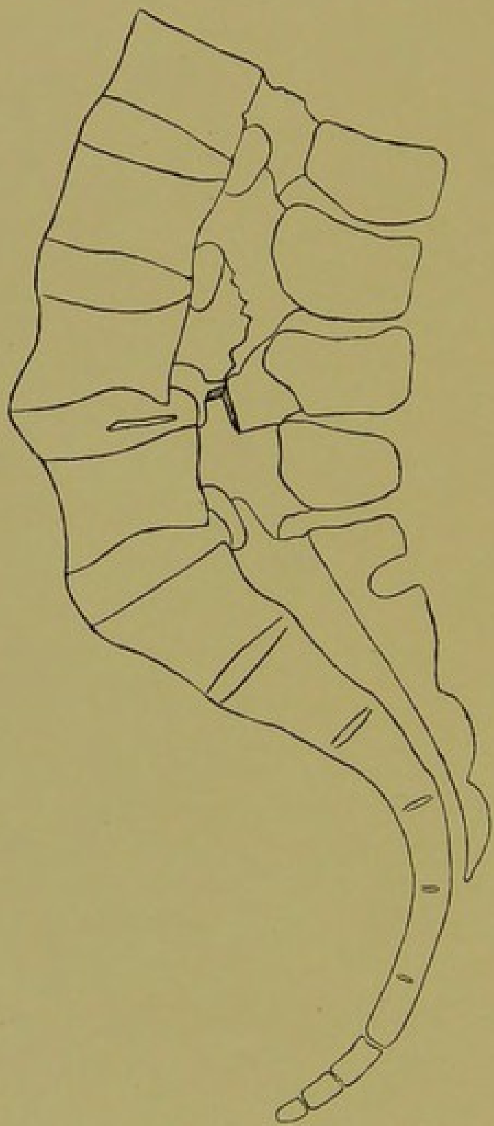


FIG. 12.—Lumbar vertebræ and sacrum of coal-trimmer.

Figs. 10 and 11 show the changes which result from habitually carrying heavy loads on the head. Fig. 11 is a vertical antero-posterior section of the same specimen. The lateral curves should be noted, serving presumably to render the column less rigid. The destruction of fibro-cartilage, the formation of arthrodial joints in the upper part of the cervical spine, and the ankylosis of the second and third cervical vertebræ, are also indicated.

Fig. 12 is a vertical median section through the lower

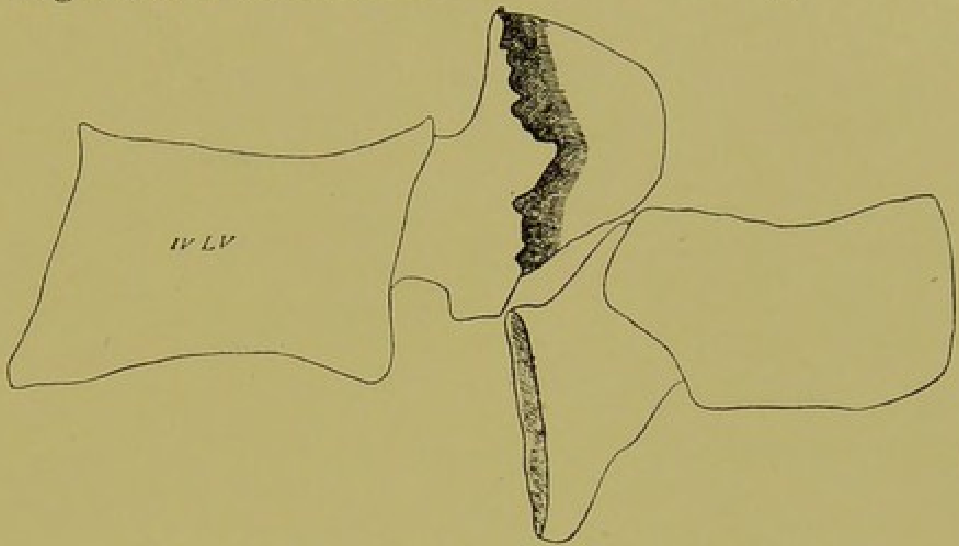


FIG. 13.—Fourth lumbar vertebra of coal-trimmer.

part of the spinal column of a coal-trimmer. It shows the formation of an arthrodial joint in the fibro-cartilage between the fourth and fifth lumbar vertebræ, and the fourth arch divided at two points. This division is seen more clearly

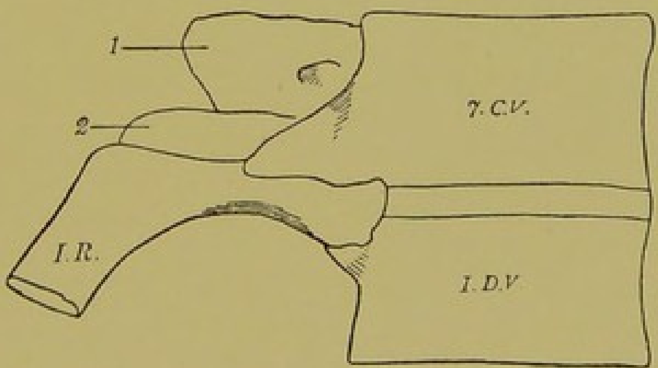


FIG. 14.—Seventh cervical and first dorsal vertebræ of coal-trimmer.

in Fig. 13, and has resulted from the forcible rotation of the spine on a vertical axis. This takes place when coal is thrown with great force to a considerable distance behind this labourer when engaged at his work. Fig. 14 represents the seventh cervical and first dorsal vertebræ with the first rib, and the arrangement by means of which the head of the first rib is secured so as to obtain a firm and powerful hinge joint.

Figs. 15 and 16 illustrate the changes which develop in the right femur of the coal-trimmer in consequence of the special functions it performs, also the altered shape of the

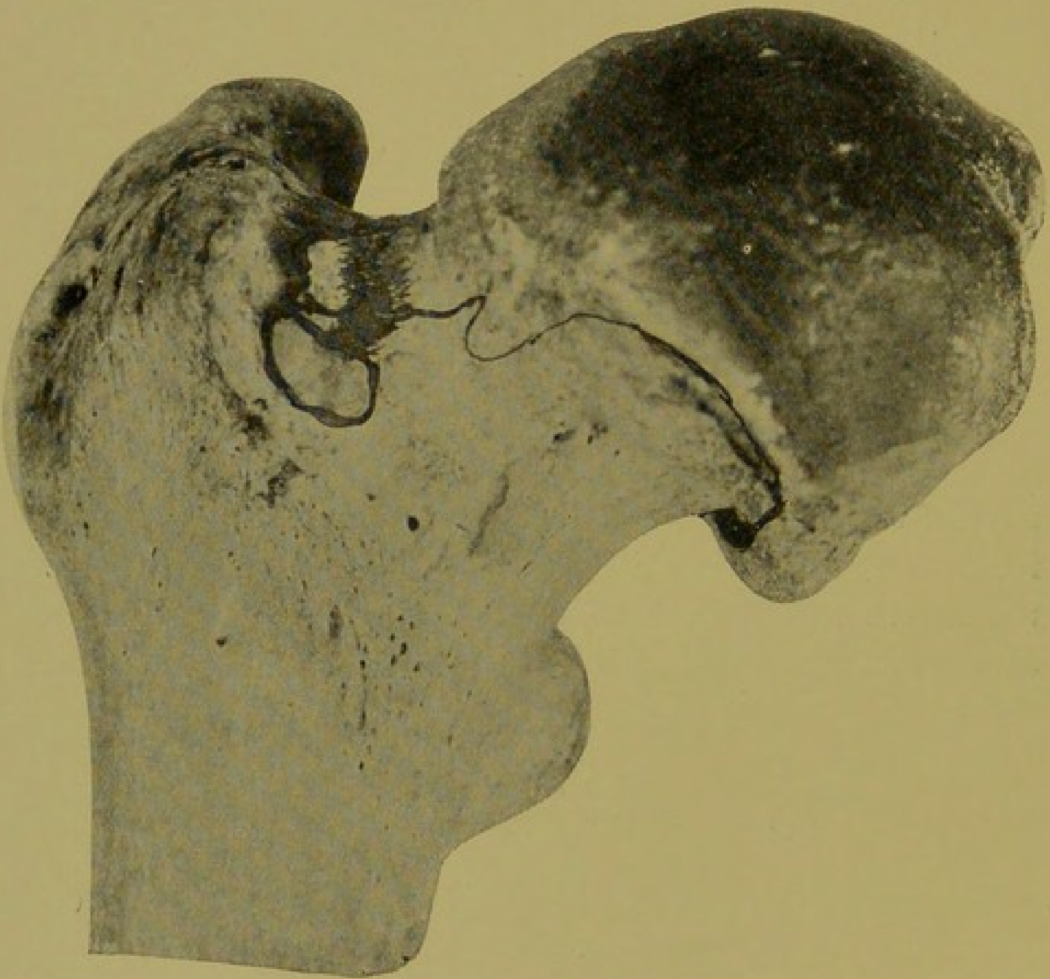


FIG. 15.—Anterior aspect of upper extremity of right femur of coal-trimmer.

head and the extension of the articular surface outwards to the base of the great trochanter, where the margin of the acetabulum has impacted habitually. Posteriorly the articular surface is extended outwards in a mushroom-like manner considerably beyond the normal limit of the head of the bone.

Figs. 17, 18, and 19 represent the right elbow of the coal-trimmer. In Fig. 17 the joint is shown at its limit of flexion. The manner in which the humero-ulnar segment is strengthened by buttresses of bone which increase the area of the articular surfaces and render the fit more accurate is noteworthy. The range of flexion and extension is much limited for reasons of economy by the forma-

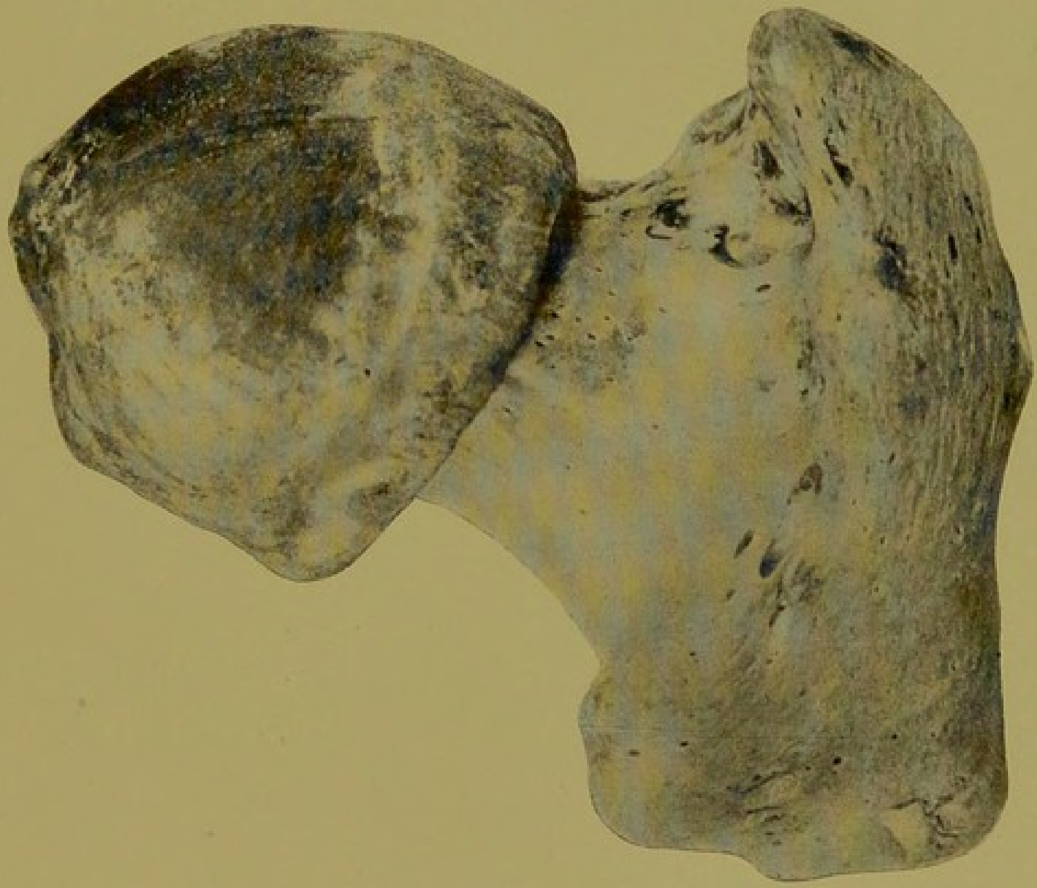


Fig. 16.—Posterior view of upper extremity of right femur of coal-trimmer.

tion of bone in the coronoid and olecranon fossæ. These are seen in Fig. 18, where the coronoid fossa and the depression for the head of the radius are considerably altered. The surface of the radial head of the humerus is deprived of articular cartilage and is polished and eburnated. The area of the margin of the head of the radius is increased to render the joint as secure as possible. For details of the physiology and anatomy of this labourer

I would refer to a paper in the 'Journal of Anatomy and Physiology,' vol. xxi, April, 1887, entitled "A Remarkable

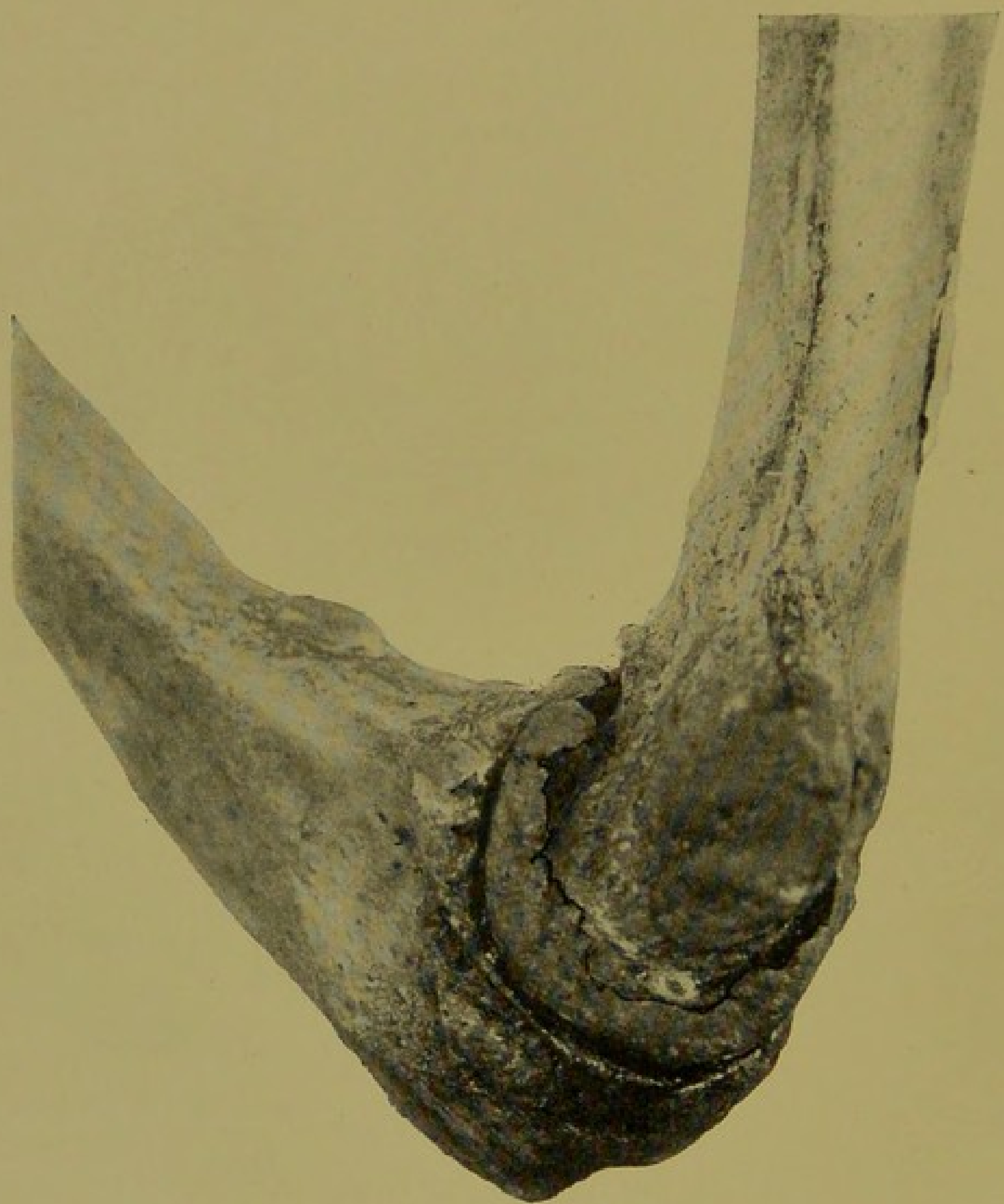


FIG. 17.—Right elbow-joint of coal-trimmer.

Example of the Manner in which Pressure Changes in the Skeleton may reveal the Labour History of the Individual."

Figs. 20 and 21 represent the right thumb of the fully developed shoemaker. It shows the fixation and exaggeration of the attitude of activity assumed on a single occasion in pulling the thread through the leather. During the jerk the head, which is held somewhat obliquely as regards an antero-posterior axis upon the spine, is rendered more secure by the formation of a lateral buttress of bone which

Fig. 18.

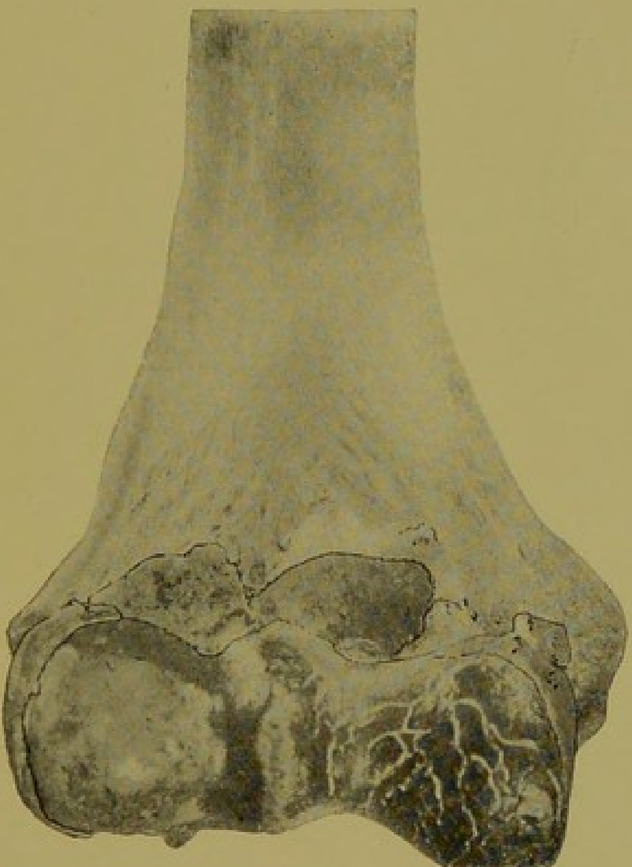


Fig. 19.

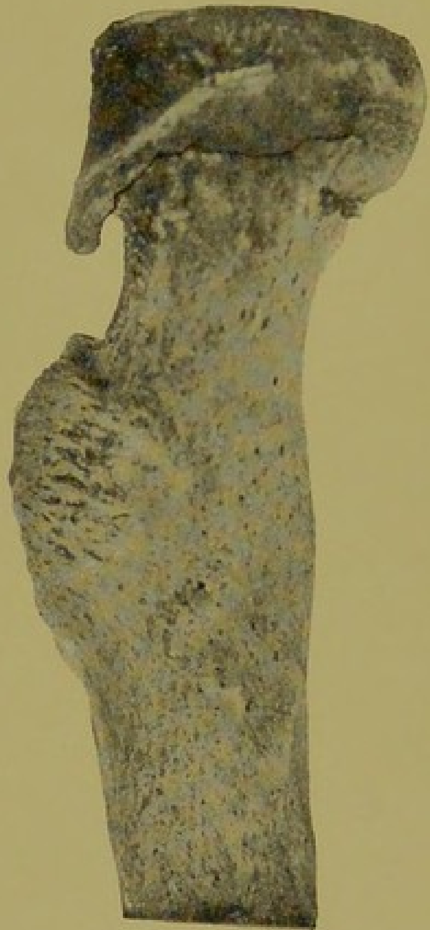


Fig. 18.—Lower end of right humerus of coal-trimmer.
Fig. 19.—Upper end of right radius of coal-trimmer.

extends upwards from the lateral mass of the atlas on one side and articulates by means of an arthrodial joint with the jugular process of the occipital bone. This is shown in Fig. 22, which represents the under surface of the occipital bone, "c" being the acquired facet.

Fig. 23 represents the anterior surface of the atlas with a prolongation upwards from its anterior arch, also the large quadrilateral column of bone which stood upon the upper surface of the left lateral mass and articulated with the jugular process of the occipital bone.

Fig. 24 represents the axis and third cervical vertebra of the shoemaker, the prolongation upwards of the odontoid

Fig. 20.—Right thumb of shoemaker.

process, with its articular facet, the formation of a layer of bone connecting the arches of the axis and third cervical vertebra, and the position of the ankylosed articulation of the articular process. The cause of the destruction of the intervening soft parts, and the union of the vertebræ to one another in this as in other laborious pursuits, is fully explained in the original paper in the 'Journal of Anatomy and Physiology,' July, 1888, "The Anatomy and Physiology of the Shoemaker." I have frequently seen this condition exhibited as cured tubercular or other disease of the spine by surgeons, and congenital union of bone by anatomists.

Fig. 21.

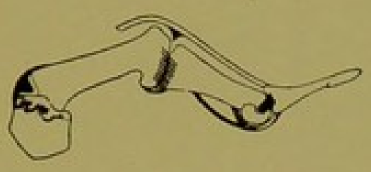


Fig. 22.

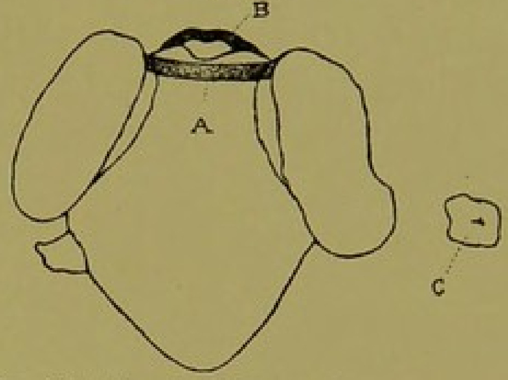


Fig. 21.—Tendons and ligaments in right thumb of shoemaker.
Fig. 22.—Occipital bone of shoemaker.

That the changes in the form of bones in labourers are not limited to the articular surfaces is shown very well by Figs. 25 and 26. These two bones afford an excellent illustration of the mode in which the form of the several

Fig. 23.

Fig. 24.

Fig. 23.—Atlas of shoemaker.
Fig. 24.—Axis and third cervical vertebra of shoemaker.

parts of the skeleton is entirely dependent on simple mechanical laws.

These represent respectively the scapulæ of a shoemaker and of a deal-porter, the latter carrying his load habitually on the right shoulder. Fig. 26 shows the result of strain exerted chiefly on the trapezius and levator anguli scapulæ, and Fig. 25 the very great breadth of the acromion process, which develops in consequence of the strain on the back of the deltoid, and the eversion of the margins of the supraspinous fossa from that sustained by the supraspinatus muscle. The strain of the infraspinatus and teres major muscles, and upon the rhomboids during the process of pulling the threads by the shoemaker has left a very definite impress upon the bone.

Fig. 25.

Fig. 26.

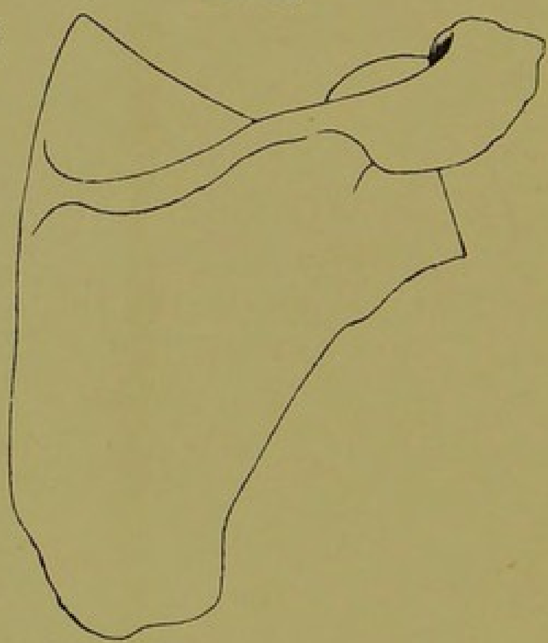
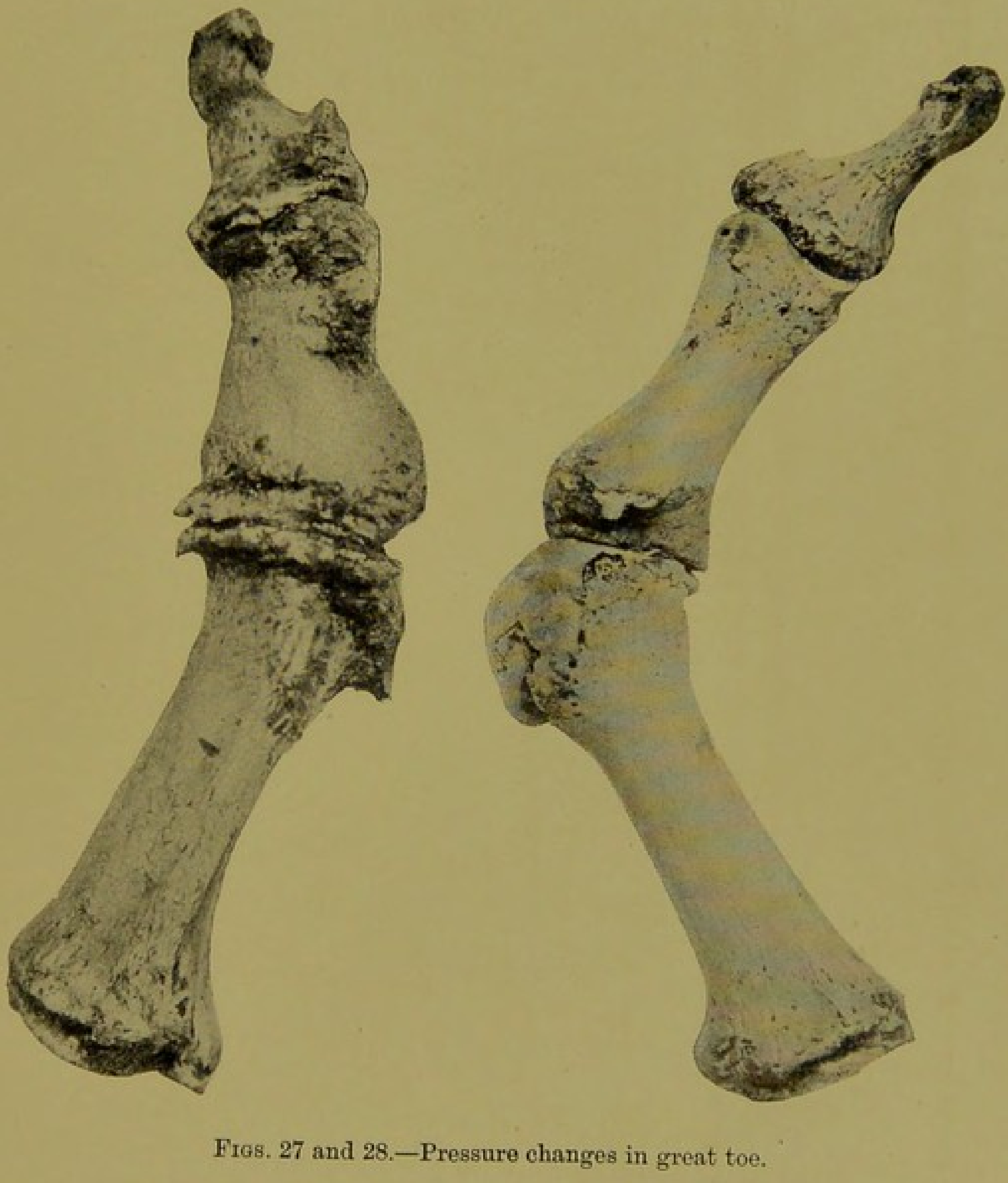


Fig. 25.—Scapula of shoemaker.
Fig. 26.—Scapula of deal-porter.

The Changes which the Skeleton undergoes in Consequence of an Alteration in the Function of a Part which is exposed to an Abnormal and Prolonged Pressure.

Owing to the habits of civilisation, as for instance the wearing of boots, force is transmitted abnormally through the several bones of the foot, and more especially through the great toe. The normal mechanical relationship of the foot to its surroundings is modified by the fact of its being encased in a boot. Certain portions of the articular surfaces are exposed to excessive pressure, while other portions no longer perform articular functions, and painful

Fig. 27. Fig. 28.



Figs. 27 and 28.—Pressure changes in great toe.

deviations from the normal arise for which an abundant and complicated pathology and nomenclature have been compiled.

Fig. 27 shows the changes that result from distal and lateral pressure. They consist in a fixation of the great toe and terminal joints by alterations in the form of the articular surfaces which are flattened, their areas being increased by a marginal deposit of bone: asymmetry of both phalanges is also a consequence.

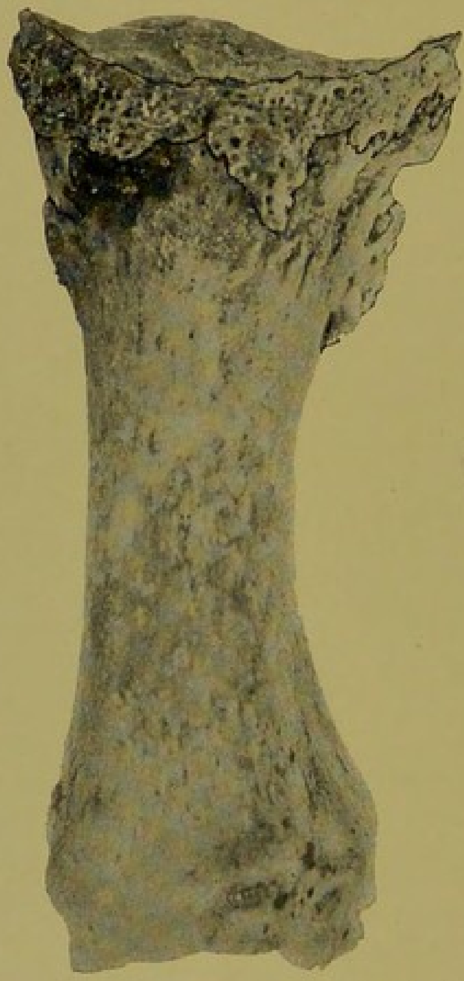


Fig. 29.—Pressure changes in first metatarsal bone.

In Fig. 28 the pressure is almost wholly lateral. The inner half of the head of the metatarsal bone is rendered functionless, while the articular cartilage and the prominent inner portion of the bone have disappeared. The outer part is changed in form to articulate with and accommodate the altered base of the displaced phalanx. The terminal phalanx shows distinct asymmetry.

Fig. 29 represents the first metatarsal bone from a case of so-called hallux flexus. In this the great toe was much longer than the second, a serious disadvantage in anyone, but especially in the poor, who wear ready-made boots. There is no outward displacement of the toe, but the distal pressure has forced the joint into a position of partial flexion, and this position has become fixed by the formation of lips of bone.

In all the conditions to which I have referred up to the present, the changes have resulted from the habitual transmission of force in certain specified directions over a long period of time.

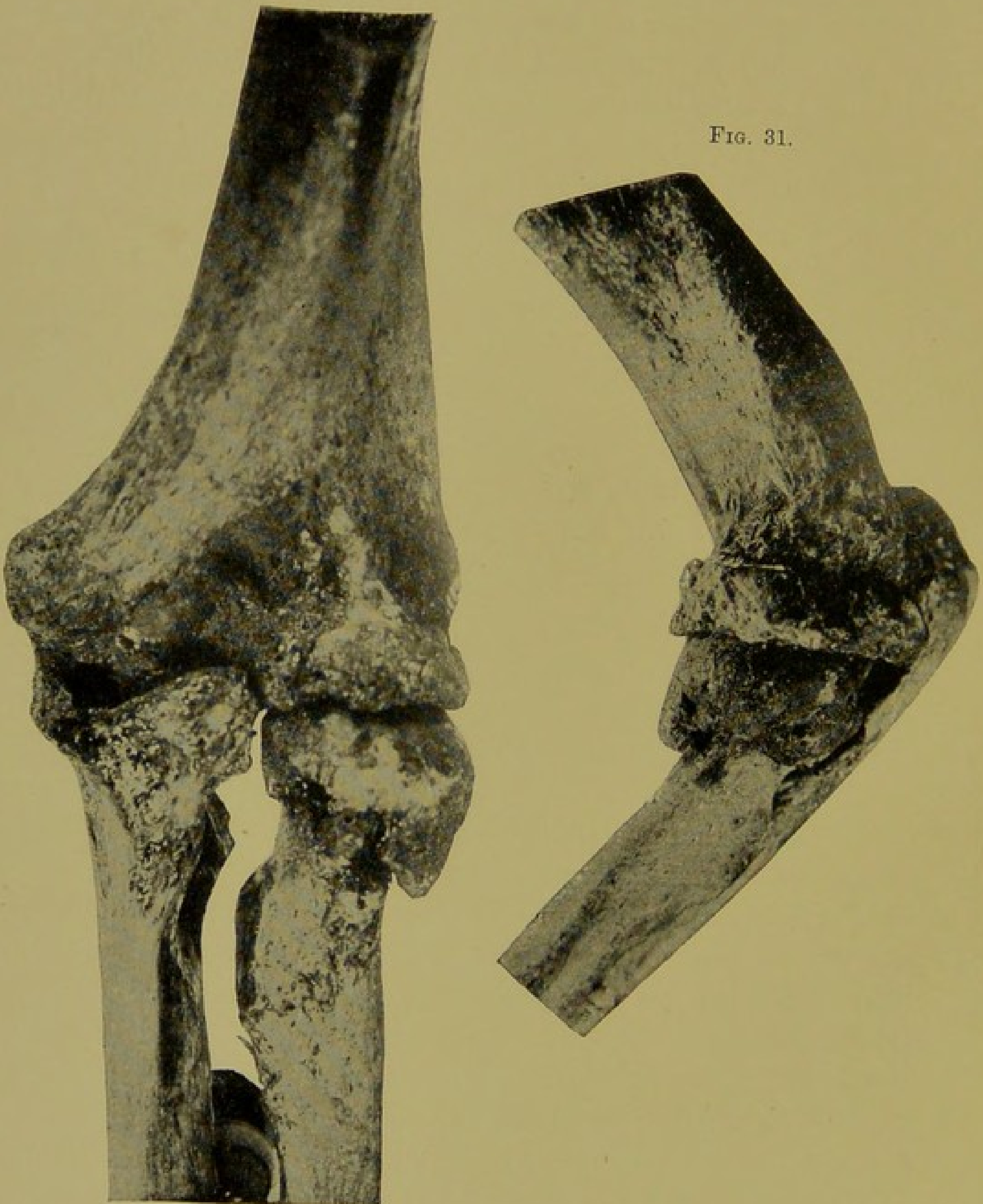
The Changes which the Skeleton undergoes in Consequence of the sudden Transmission of a Force in excess of what it can transmit without undergoing Alteration.

I would now call attention to the results of the transmission of an excessive force on a single occasion, such force not being sufficient to cause fracture but sufficient to modify the nutrition of articular cartilages, producing progressive changes in them and later in the bones and structures immediately about them.

Figs. 30 and 31 represent the anterior and the outer aspects of the elbow of an elderly woman. She fell heavily on her palm, the large bulk of the force being transmitted through the radius to the radial head of the humerus. This produced destructive changes in the affected opposing surfaces of articular cartilage, the cartilage being worn away, leaving the bone bare. The changes in the radio-humeral joint progressed and extended later to the radio-ulnar and humero-ulnar articulations. These changes illustrate exceedingly well the several functions of the radius, ulna, and humerus, in the transmission of force, almost the whole of this being transmitted

Fig. 30.

Fig. 31.



Figs. 30 and 31.—Elbow-joint of old woman.

from the radius to the humerus. The chief function of the ulna is to retain the radius in such a position upon the humerus that it can transmit force satisfactorily to the humerus. By the transmission of an excessive force through the radius, producing damage to the articular cartilage, the conditions called tennis-elbow, golf-elbow, etc., are produced.

Fig. 32 shows the changes in the femur which result from the sudden transmission of a degree of force through the hip-joint greater than can be borne by it without undergoing change. The injury is a comparatively common one. The patient falls on the outer surface of the femur

Fig. 32.

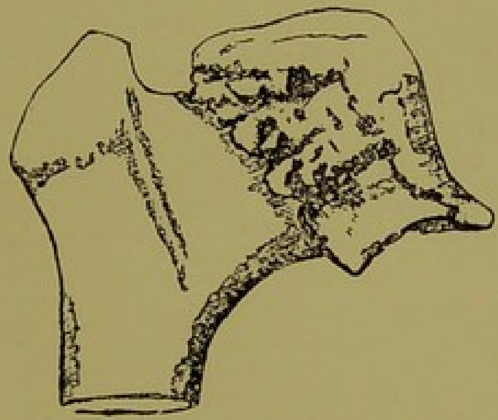


Fig. 33.

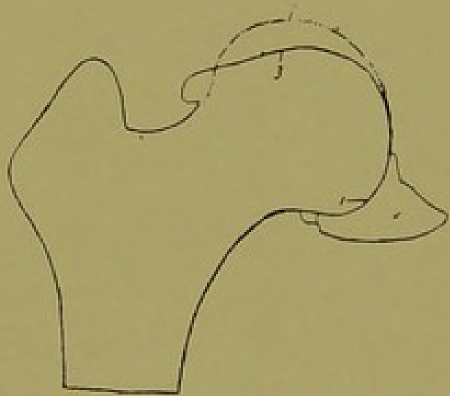


Fig. 32 and 33.—Pressure changes in head of femur.

and great trochanter, the capsular ligament is exposed to an enormous strain, and the articular cartilage covering the upper surface of the head of the femur and the corresponding area of the acetabulum is bruised sufficiently to result in its absorption. The progressive frictional changes which ensue are represented superficially in Fig. 32, and in vertical transverse section in Fig. 33.

From a study of this injury one learns the manner in which the corresponding portions of the head and acetabulum are injured in young life, producing a damaged area which, if not kept at rest, becomes so often infected by tubercle.

Fig. 34 shows the changes which take place in the shoulder-joint in consequence of the severe bruising of opposing articular surfaces in a subject past middle age. The patient from whom this specimen was obtained fell heavily on the outer surface of his left shoulder, so that the areas of articular cartilage covering the centres of the head and of the glenoid cavity were bruised sufficiently to result in their absorption, and in the progressive changes which of necessity follow.

In the young subject the transmission of an excessive force may result in changes which are quite distinct from those which occur in people past middle life should the

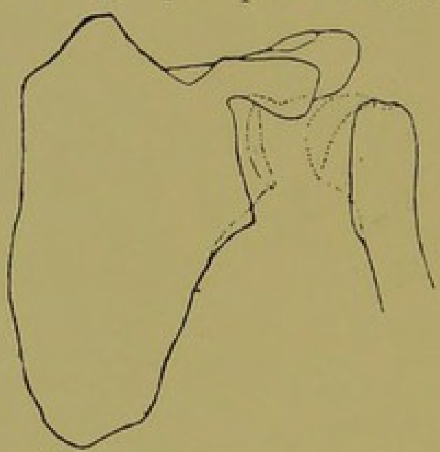


FIG. 34.—Pressure changes in shoulder-joint.

injured textures not become infected by tubercle. Instead of the changes being destructive, bone and articular cartilage are formed in abundance, and an abnormally large deformed joint results. This sequence occurs perhaps more commonly in the temporo-maxillary and radio-humeral articulations than elsewhere.

Changes which ensue in the Skeleton consequent on Fracture of one or more Bones, the Fragments of which have not been restored to their normal Relationship.

I have examined the skeletons of several bodies in which bones, and especially the long bones, were fractured, these injuries existing very commonly among the subjects in the dissecting-room. What surprised me most was the very unsatisfactory nature of the results of treatment. Though experience had taught me to regard the statements in anatomical and surgical works with very strong suspicion, I was not prepared to find that the teaching of the causation, pathology, and the treatment of fractures and the results of such treatment was often absolutely false in almost every detail.

It was evident that the displaced fragments of a broken bone were never or hardly ever restored to their normal position, and that the so-called "setting of fractures" was a myth. In most cases the recognised explanation of the mode of production of the fracture was equally absurd, and the treatment by manipulation and splints was not based on any scientific or mechanical principle.

The articular changes consequent on the variation in the lines of pressure through the joints whose functions were modified more or less materially by the alteration in the axes of the two portions of the broken bone were most marked. They varied with the age of the individual and with the degree of change in the fractured bone. They were precisely similar in character to those observed in the conditions illustrated and described by me, and in their evolution they obeyed the same simple laws.

In the younger subject the mechanical or traumatic changes were of the type I described as "active" or "adaptive," while in the older subject they were "passive" in character.

Passive changes are seen in Fig. 35, which shows the usual displacement of the fragments in fracture of the femur in this situation, also the several changes in the form of the articular surface of the head of the femur and of its lower extremity which have resulted from the modification in the mode of transmission of force through them consequent on the alteration of the axes of the two fragments of the bone. It is in consequence of the development of these arthritic changes that the pain and disability which so often follow on fractures are due.

FIG. 35.—Old fracture of right femur.

Nature does what it can in all cases to restore the skeleton as far as possible to its normal form. The skeleton is best regarded as the crystallisation of lines of force. These when occupying the same directions are laid down as compact tissue, and when occupying various directions as cancellous tissue whose complexity varies with that of the lines of forces. If in the young child a long bone is broken and the fragments are displaced, a portion of the original shaft is removed and a new one transmitting force from the two articular extremities of the bone is laid down. The degree of restoration of form to that of the normal varies inversely with the age of the subject.

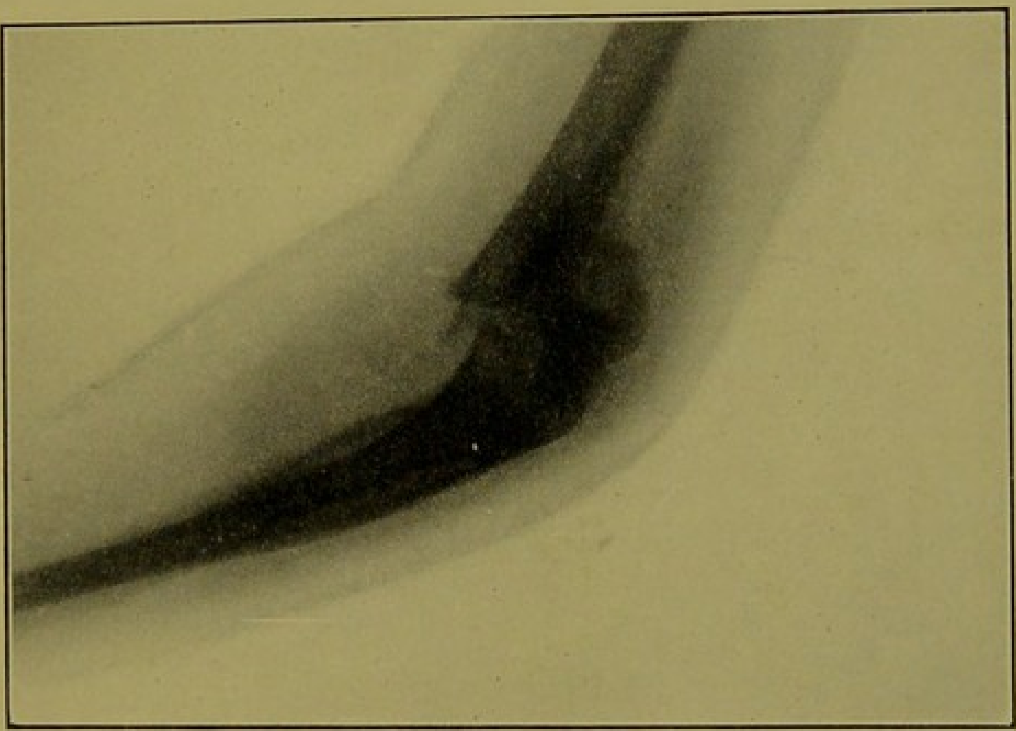


FIG. 36.—Fracture of lower end of humerus.

Fig. 36 represents a fracture through the lower end of the humerus in a child æt. 6. As is usual in these cases, when treated in the ordinary way the lower fragment is seen to be displaced backwards and upwards, and is rotated somewhat on a transverse axis, so that its articular surface is directed more backwards than in the normal bone. The lower extremity of the upper fragment is very irregular, and by impacting on the coronoid process limits flexion. When this skiagram was taken a month had elapsed since the receipt of the injury, and a layer of callus is seen to extend from the lower fragment upwards

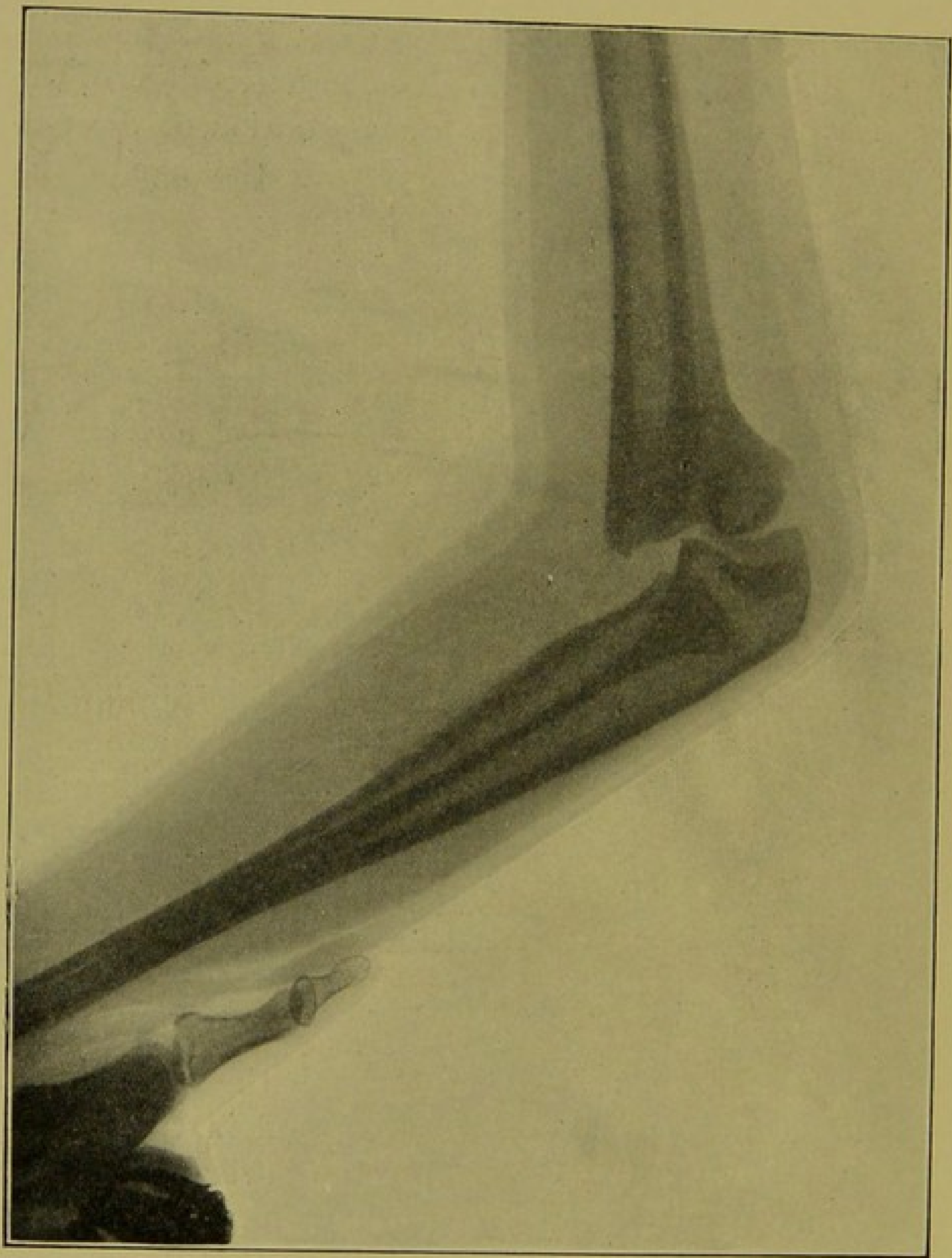


Fig. 37.—Fracture of lower end of humerus.

along the back of the shaft. This only represents such portion of the new formation as is dense enough to cast a definite shadow comparing in density with the shaft. An examination of radiographs obtained by varying lengths of exposure shows that the callus or new material extends from the displaced fragment along the whole length of the shaft to its upper extremity. The younger the subject the

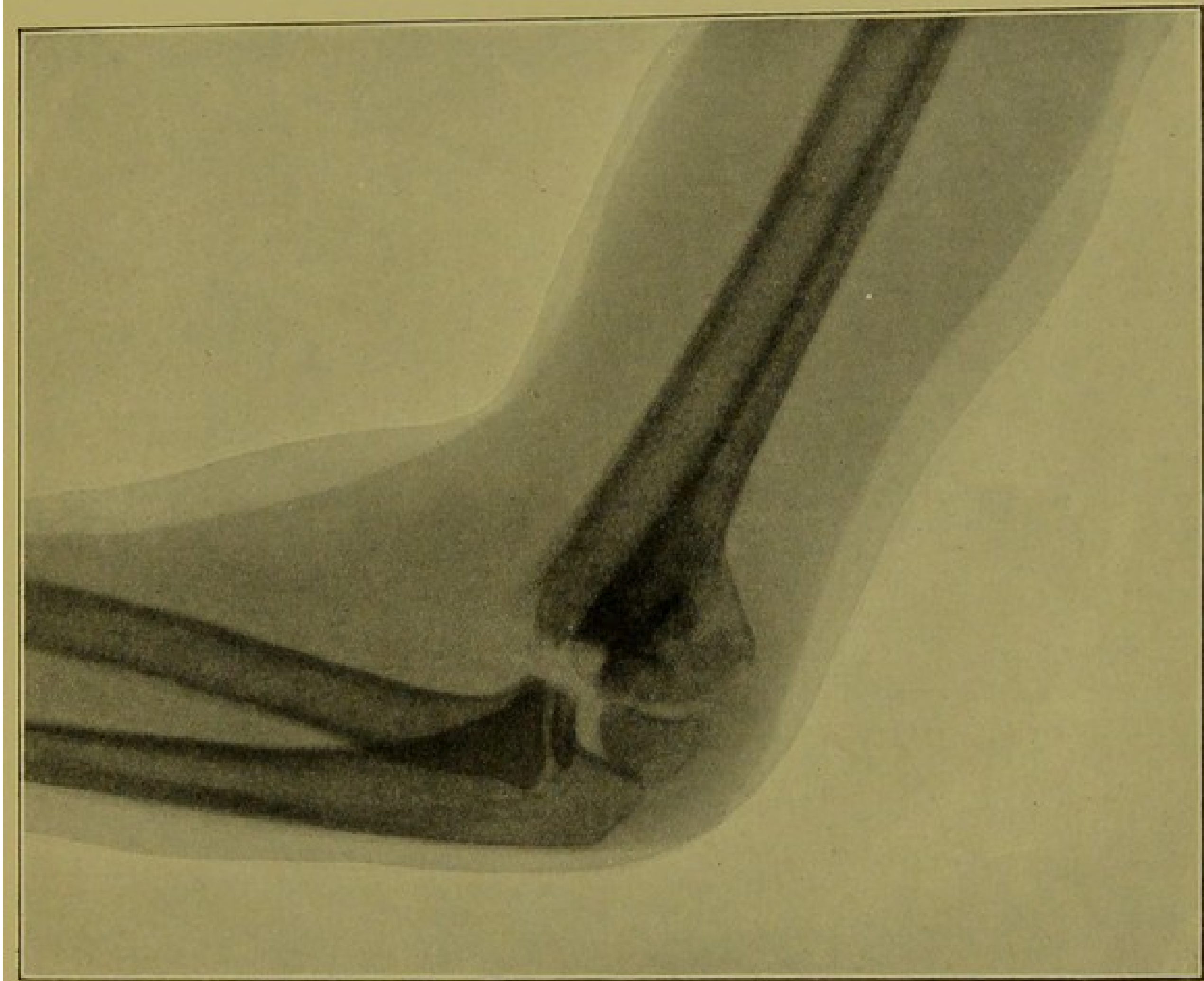


FIG. 38.—Fracture of lower end of humerus.

greater is the extent of this new formation, while later in life it is practically limited to the immediate vicinity of the ends of the broken bone.

Fig. 37 represents the condition three months after the injury. The perceptible layer of callus extends a greater distance up the back of the shaft. The shadow formed by it is much darker, equalling that produced by the original shaft.

Fig. 38 shows the parts six months after the injury.

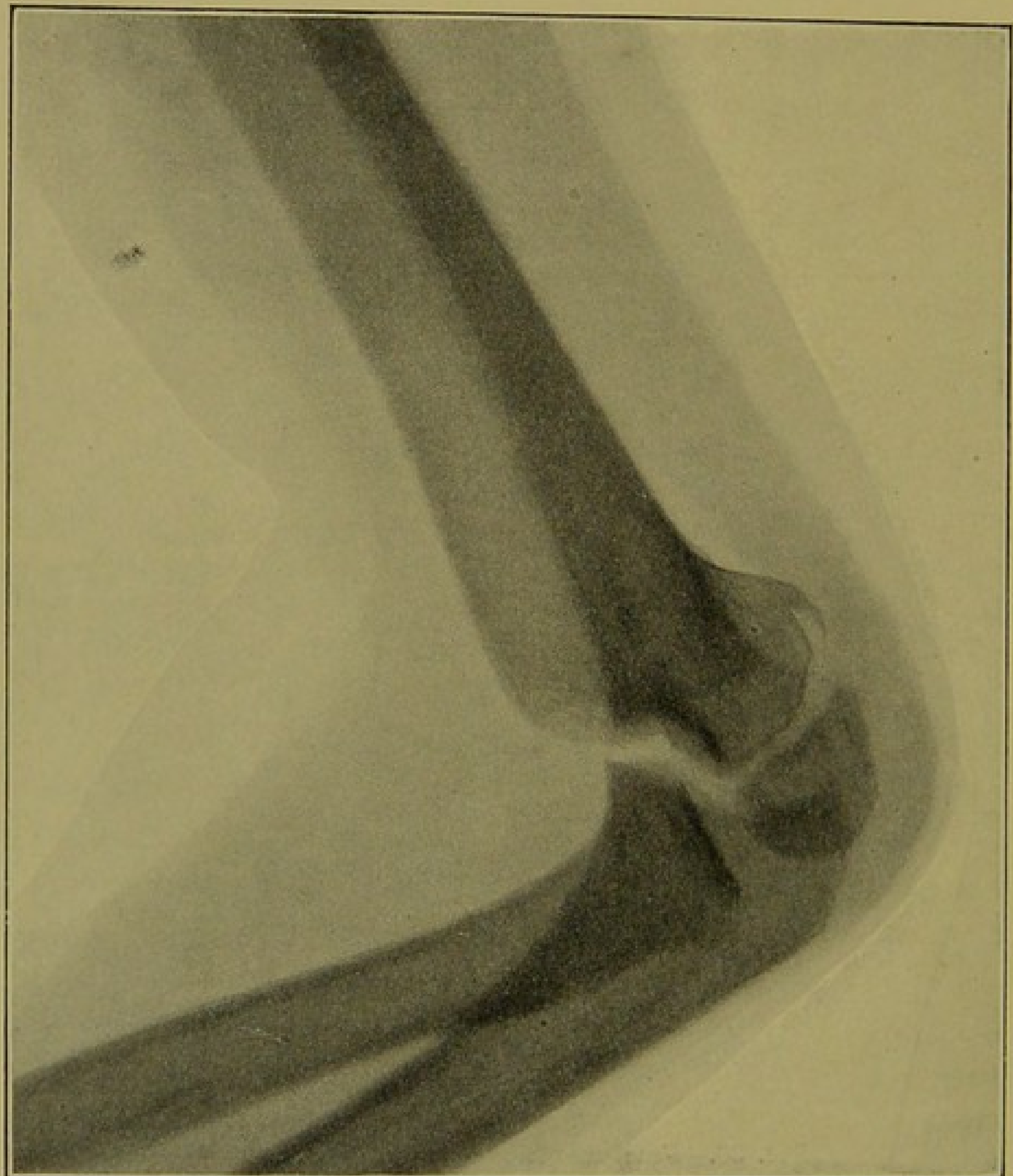


Fig. 39.—Fracture of lower end of humerus.

The range of flexion has increased partly by the absorption of the end of the shaft and partly by that of the coronoid process. The layer of new material which is extending much farther up the shaft is denser, while the shaft is relatively lighter.

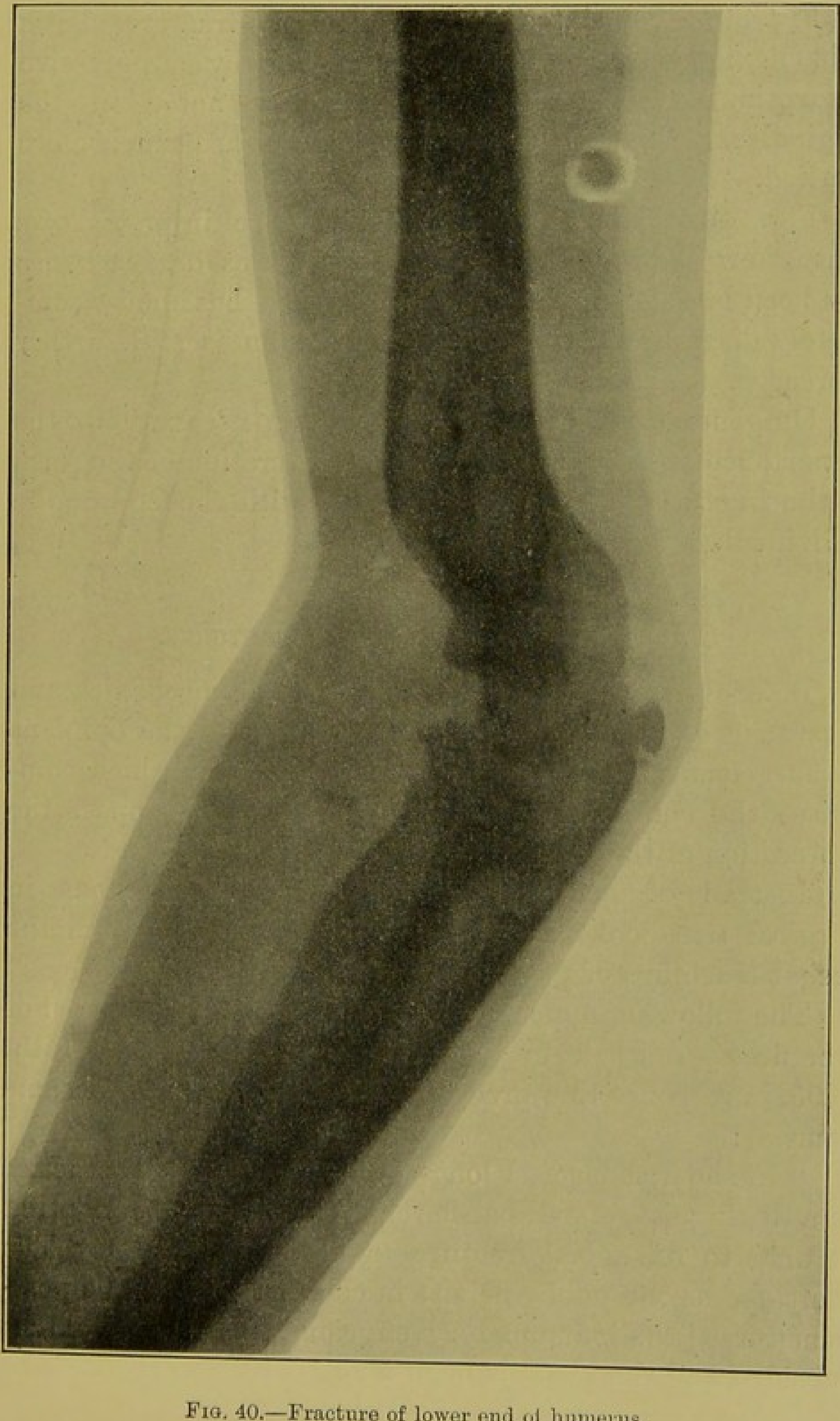


FIG. 40.—Fracture of lower end of humerus.

Fig. 39, taken sixteen months after the fracture, shows that flexion is still further increased by progressive absorption, while the changes already noted in the original shaft and in the new formation are much more marked.

Fig. 40, taken three years after the injury, shows that a new shaft connecting the extremities of the bones has been laid down, while the original one has almost completely disappeared. The range of flexion is still further increased.

On general principles we see that the necessity or the importance of effecting a complete restoration of the form of the fractured bone varies directly with the age of the individual.

The Treatment of Simple Fractures.

Before giving in detail my views on the mechanics and treatment of fractures I will call attention to the opinions of surgeons on the subject of the treatment, which comprises the consideration of the factors which oppose the restoration of the broken bone to its original form.

Instead of quoting the fossilised reproductions in surgical text-books, I prefer to furnish extracts from the recent teachings of prominent surgeons in England.

The following appeared in a lecture on the treatment of fractures published in the 'Clinical Journal,' May 15th, 1895, in response to a preceding article of mine in the same Journal:

"In the first place, I long ago learned from the practice of a distinguished surgical baronet the folly of attempting at once to fix a bad fracture in accurate position. The 'setting,' as the public persist in calling it, should be postponed until the inflammatory effusion has to some extent subsided and the blood is beginning to be absorbed. The spasmodic contraction of muscles, so marked when they are at first irritated and partially lacerated, subsides markedly in a week or ten days."

"Mr. Lane's second point, that the shortening is due to hæmorrhagic effusion and inflammation rather than to muscular contraction, seems to me hardly proved. Indeed, I cannot but hold that the contrary is the case, seeing the remarkable manner in which great shortening and deformity can be reduced under deep ether anæsthesia. This I have witnessed so often that I cannot be mistaken. Should the parts be left displaced for weeks or months until structural softening of the muscles occurs from the organisation of inflammatory material, I could then understand the immense resistance encountered by Mr. Lane; but this, with ordinary careful treatment, should not occur. Though muscular contraction may have been over-rated in producing the deformity in fractures, I feel sure that the consideration and treatment of it in practice is of the greatest importance."

The following teaching of another eminent surgeon is taken from the 'Lancet,' January 4th, 1896:

"I would remind you how important it is, in fractures of the leg particularly, that the fracture should be set thoroughly and accurately. Of course I know well that there are many difficulties. Immediately after the accident all the muscles of the limb are more or less in a state of spasm, and tend, therefore, to pull the bones into abnormal positions; but that state of spasm passes off in the course of a few hours, and you can generally manage, with care and patience, to put the limb into a proper position; and unless that is done, and done accurately, the surgeon has not treated the case properly."

"In the average case, however, you can set the fracture in the way I have described without much trouble, and in compound fractures you can manage it with greater ease; and, moreover, you can insert your finger and feel if the two ends are in accurate apposition."

"But I cannot perceive how anybody can believe that it is justifiable to convert a simple into a compound fracture; and of this I am quite certain, that the majority of surgeons for the present will remain content with the usual methods of treatment."

These two gentlemen appear to have very different views about the manner in which the same cause acts. They both assert that spasmodic muscular contraction is the important obstacle to reconstitution of the fractured bone. How does this knowledge guide them in their treatment? The one considers that "this spasmodic muscular contraction passes off in a few hours," and presumably he postpones placing the fragments in accurate apposition till such time has elapsed, and then does it, as he supposes, effectually and at once.

The other states that "the spasmodic contraction of muscles subsides markedly in a week or ten days," when he proceeds "to get the fracture into good position."

I have extracted the following from an address by another leading surgeon on the "Treatment of Fractures," published in the 'Lancet,' June 12th, 1897:

"Having arrived at a full and correct diagnosis, the next point to attend to is to reduce the fragments at once, at the earliest possible moment, remembering that lapse of time always increases the difficulties in doing this, never lessens them, and even makes them insuperable. This reduction of the fragments must be complete or perfect at once; we must not rest in any half-way house, content with improvement to-day in the hope of still further correction to-morrow." Also: "The causes of this displacement [of the fragments] are either the fracturing force, the action of gravity, or the pull of muscles."

These three factors would appear to constitute the "difficulties" previously referred to, but how they are exaggerated by delay is not very clearly stated. Contrast this with "the folly of attempting at once to fix a bad fracture in accurate position," as stated in the first lecture quoted from the 'Clinical Journal.'

I call your attention to these statements to show that while surgeons hold very similar views as to the mechanical factors that oppose the reduction and retention of the fragments of a broken bone in accurate apposition, yet they would appear to obtain equally good—in fact, if one can interpret their language according to its usually accepted signification, perfect results by methods which to the ordinary mind are mechanically absolutely antagonistic both in practice and in principle.

I expected to experience opposition in two directions. I believed that many surgeons would say that the statements I had made as to the bad results obtained by the treatment of fractures by manipulation and splinting were very much exaggerated, and that they were able to succeed in restoring the broken bone to its original form, and that the mechanics of their patients and their wage-earning capacity were, but slightly, if at all, affected in consequence of the accident; also that they would substantiate this by the production of the subsequent history of cases that had been under their care, and which I presumed could be obtained with little difficulty.

In order to meet this objection I made very extensive inquiries of medical men practising largely among the labouring classes, of instrument-makers, of large employers of many kinds of labour, of the labourers themselves, and of those who have to do with assisting the poor both inside and outside our infirmaries.

In consequence of them I was satisfied that the teachings contained in the text-books as to the possibility of restoring the form of broken bones and the satisfactory results of their treatment were absolutely false.

The discovery and application of the X-rays some years later verified my opinion as to the impossibility of putting displaced fragments of broken bones in accurate apposition without operative interference in the manner described.

The Mechanics of Fractures.

I will now proceed to deal with (1) the factors causing the displacement of fragments; (2) the factors opposing their replacement in accurate apposition, and (3) the methods by which the broken bone may be restored to its original form.

Much stress used to be laid upon the question as to whether the fracture was produced by what is described as direct or indirect violence. The practical import of the differences between fractures produced by direct and indirect violence is that in the former the soft part may be much damaged by the force producing the fracture, while in the latter the soft parts sustain no injury except that brought about by the fragments themselves.

The force that breaks a bone does so either by impact upon it or by torsion of it in its length or by both combined. Force applied directly or indirectly to a long bone at right angles to its length breaks it obliquely or more or less transversely, the direction of the fracture varying within wide limits with the mode of application of the force. In certain conditions comminution of the fragments results. In consequence of the action of this force, the ends of the fragments are displaced more or less completely off one another, and the hæmorrhage into the bruised soft parts and the inflammatory process which follows produce an over-riding of the broken ends.

We may consider that the muscles and the soft parts surrounding the long bones of the extremities are inextensile ties in their length. If a long bone be twisted on its long axis by a force sufficient to break it, it yields in a spiral fashion, the length of the spiral varying with the accuracy of the rotation and with the circumference of the bone.

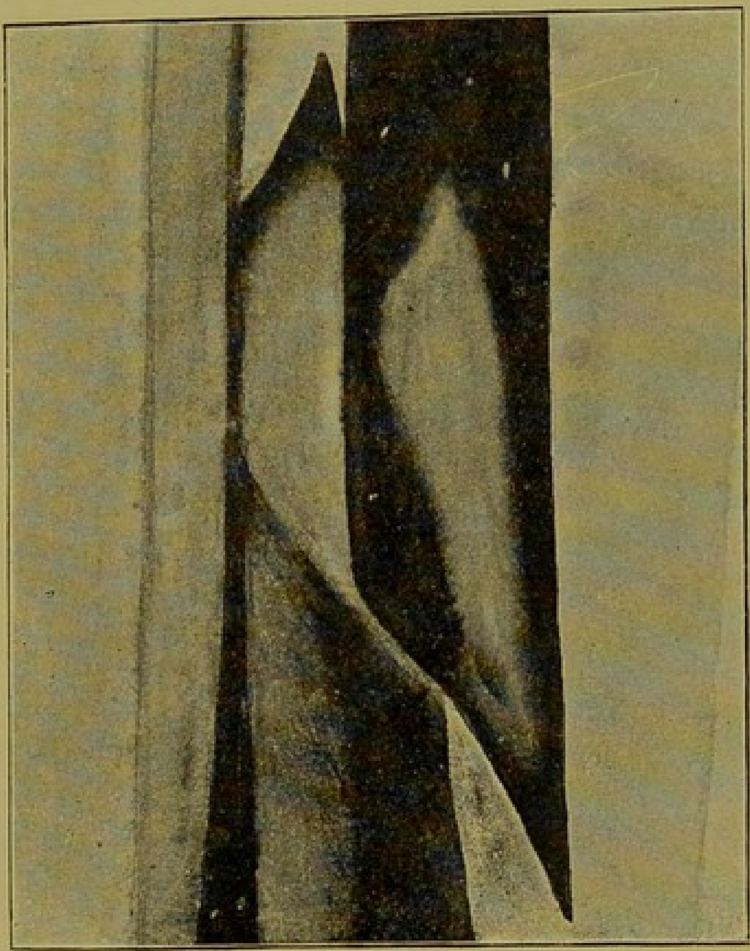


FIG. 41.—Spiral fracture of tibia.

The form of the spiral is such that each fragment terminates in a sharp angle, while at the other end of the spiral it presents an angular interval which was occupied by the portion of bone forming the sharp extremity of the other fragment. This is represented in Fig. 41, which has been touched up slightly to make it more diagrammatic. The soft parts surrounding the bone forming inextensile ties in the length of the long bone produce an overlapping of the fragments, since they are shortened by the torsion of the fragments of the broken bone. As the pointed extremities of the fragments are very sharp and chisel-shaped, they travel, not only upwards and downwards, but away from each other laterally. The over-riding is increased by the hæmorrhage into the soft parts, and is still further exaggerated later by the ensuing inflammatory process. In most circumstances there is added to the force which twists the bone on its axis another acting along the length of the bone. This force drives the fragments still further over each other, increasing correspondingly the interval between them. I can best illustrate these points by reference to fractures of the long bones of the leg; the fractures of these bones are much more frequently spiral than those of the upper extremity, chiefly because of the transmission of the weight of the body through the former, and because of the resistance and leverage offered by the foot.

To obtain a thorough grasp of the causation of these injuries, it is necessary in the first instance to consider some important points in the anatomy and physiology of the foot and ankle. The movement of the ankle-joint takes place around a transverse axis only. The movement round a vertical axis in complete extension which was described by anatomists as occurring in this joint is absolutely non-existent. To remind the reader of this view I will quote from Gray's 'Anatomy,' 1887: "A certain amount of lateral motion is permitted when the foot is in the extended position. This is in consequence of the shape of the articular surface of the astragalus, which is considerably wider in front than behind, and of the tibio-fibular mortise, which is also broader in front than behind; hence in complete extension the narrowest part of the astragalus is lodged in the widest part of the tibio-fibular arch, and therefore a certain amount of lateral movement is possible." That this is still supposed by many to be the correct teaching is shown by the following, under the heading of "Movements" in Morris's 'Anatomy,' 1902: "This being a true hinge-joint, flexion and extension are the only movements of which it is capable, there being no lateral motion, except in extreme extension, when the narrowest part of the astragalus is thrust forward into the widest part of the tibio-fibular arch." The fallacy of this description I dealt with fully in the 'Journal of Anatomy and Physiology,' April, 1888, "Anatomy and Physiology of the Ankle-joint."

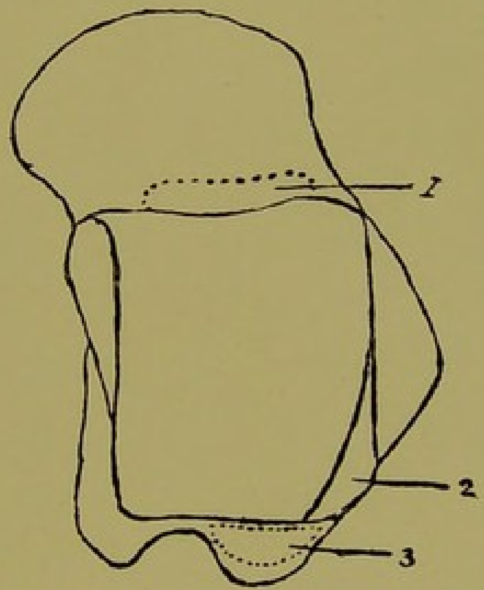


Fig. 42 represents the upper surface of the astragalus, 1 being the facet formed by the habitual impact of the anterior margin of the tibia in extreme flexion of the ankle-joint, 2 being the facet produced by the impact of the posterior margin of the tibia in habitual extreme extension, and 3 being that portion of the external articular surface of the astragalus over which only ligament glides.

Like many other incorrect descriptions of the functions of joints, etc., it has clearly been evolved out of the inner consciousness of someone and reproduced in slightly varying language in almost every succeeding English work on the subject. The movements of extreme flexion and extreme extension are limited by the impact of the margins of the tibial facet upon the surfaces of the astragalus immediately in front of and behind the upper articular surface. In many bodies these facets on the tibia and astragalus are very distinct, and are covered with articular cartilage. Those on the astragalus are represented in Fig. 42. Of the two on the tibia the anterior is by far the better marked. In a labourer whose occupation has entailed his habitually carrying loads up ladders this facet is most distinct and defined.

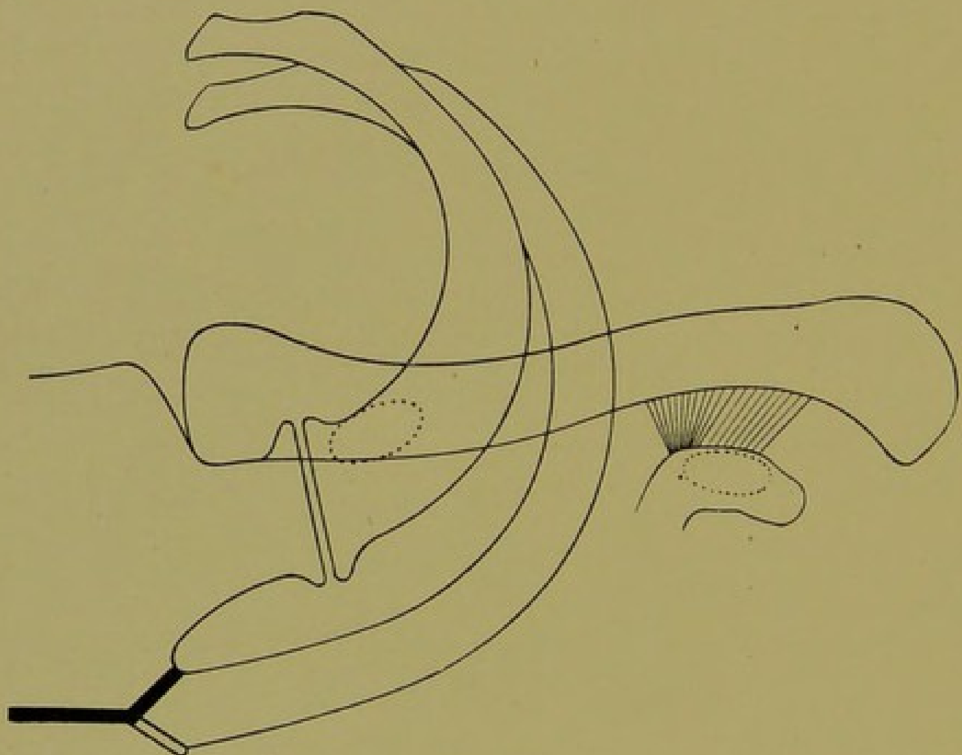


Fig. 43 represents the left first and second costal arches, with the manubrium, clavicle, and coracoid process, of a labourer. The manubrio-gladiolar joint is amphiarthrodial in character, while the joint which has developed in the ossified first costal cartilage is freely arthrodial. The position of the costo-clavicular articulation is indicated by the dotted outline on the first arch. On the upper surface of the coracoid process the facet which articulates with the clavicle forming the coraco-clavicular joint is similarly indicated.

The mechanics of the several bearings or joints of the body are so arranged that, where possible, as in this case, extreme movements are limited by the impact of bone against bone. Besides affording a much greater security, it reduces the expenditure of muscular energy considerably. In the hip-joint, for instance, flexion is limited by the impact of the neck of the femur against the acetabular margin, the point of impact varying with the degree of adduction or abduction of this joint (see Figs. 47, 48, and 49). In the ankle-joint, as shown in Fig. 42, flexion and extension are limited by the impact of bone against bone, and in labourers, in which such extreme movements take place habitually, facets form on impacting areas, described by me in the 'Lancet,' May 26th, 1900, p. 1490, in a communication entitled "Operative Treatment of Simple Fractures."

In the shoulder-joint flexion is limited, and the scapula

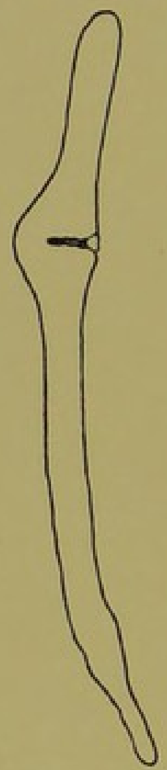
Fig. 44 represents the under surface of the clavicle with the articular facets which correspond with those on the costal arch and coracoid process.

fixed, by the impact of the coracoid process against the under surface of the clavicle, while in the sterno-clavicular joint the constant forcible impact of the clavicle upon the first costal arch in the position occupied in carrying heavy loads results in the formation of facets and a new joint at the point of impact of the clavicle on the costal arch. Finally an arthrodial joint forms in the ossified first costal cartilage, and the manubrio-gladiolar articulation becomes more or less completely obliterated. Figs. 43, 44, 45, and 46 illustrate these points which are fully treated in my papers entitled "Mode of Fracture of First Rib Alone," published in the 'Transactions of the Pathological Society,' 1885, "The Changes Produced by Pressure in the Skeleton of the

Trunk and Shoulder Girdle," published in the 'Guy's Hospital Reports,' 1885, and " The Mode of Fixation of the Scapula, suggested by the Movements of that Bone in Extreme Flexion of the Shoulder-joint: its Bearing upon

Fig. 45.

Fig. 46.



Figs. 45 and 46 show the changes that take place in the manubrio-gladiolar joint in consequence of the transmission through it of great pressure. These specimens were obtained from the bodies of labourers who had been engaged in heavy porterage work at the docks. In Fig. 45 it is seen that the opposing surfaces of bone have been increased in area considerably, while the intervening ligamentous tissue has been rendered scant and dense. In Fig. 46 the joint has been almost completely obliterated by being bridged over in front, and by the formation of masses of bone in the ligament posteriorly.

Fracture of the Coracoid Process," published in the "British Medical Journal,' May 19th, 1888.

In the elbow, extension and flexion are both limited by the impact of bone against bone, and in the knee extension is limited in the same manner. Indeed, in the labourer the tendency is to obtain in joints bony limits which do not exist in the so-called normal subject.

In complete flexion and extension of the ankle there is no possibility of the astragalus rotating at all around a vertical axis, as any such movement is rendered impossible by the resistance offered by the anterior or posterior fasciculi of the internal and external lateral ligaments,

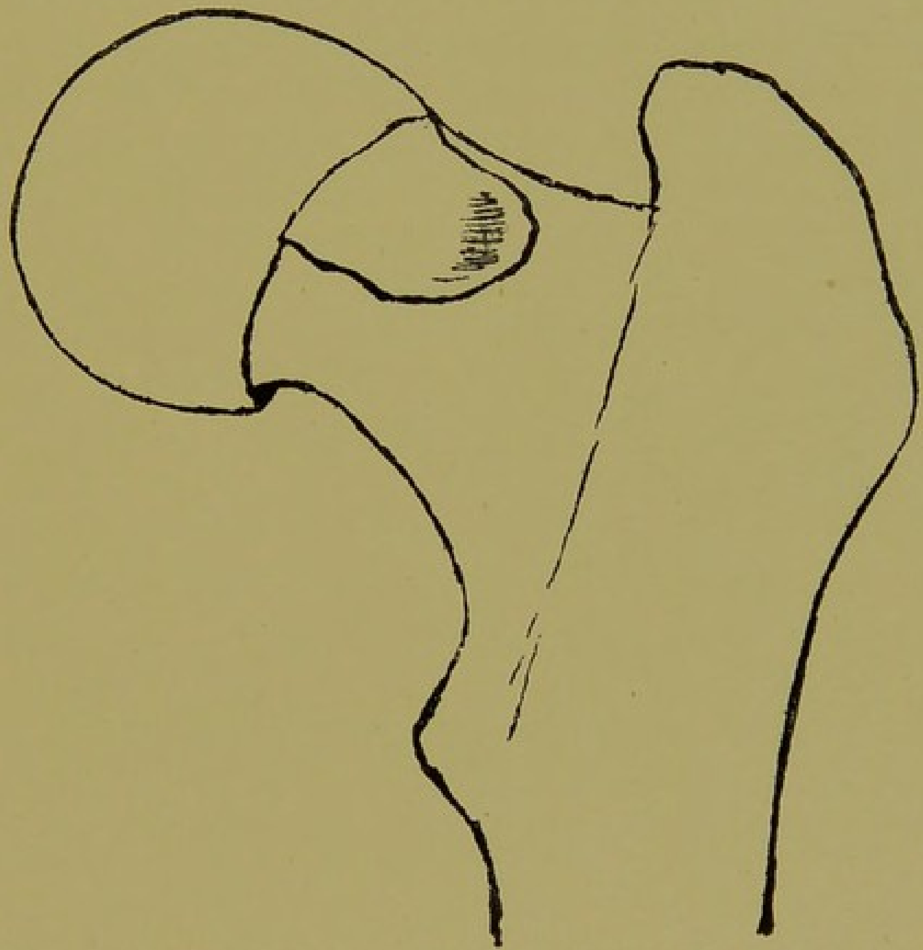


Fig. 47 represents diagrammatically the anterior surface of the femur of a man who has been engaged in carrying heavy loads upon his back. It shows an increase in the area of articular cartilage due to an extension outwards from its upper part on to the neck. Also the depression on the part of the neck which came habitually into contact with the margin of the acetabulum in extensive flexion and slight adduction. The upper surface of the head is on a lower level than normal, and is also flatter. On the under surface of the head an alteration described earlier is indicated.

which are stretched to the utmost in these positions. Though in the extremes of flexion and extension there is no appreciable rotation of the fibula, yet when the foot occupies a position intermediate between that of complete extension and flexion of the ankle-joint, and the anterior and posterior fasciculi of the lateral ligaments are not very tense, forcible abduction of the foot produces a slight rotation of the fibula upon its vertical axis.

The forces which produce this rotation are two, namely, the impact of the front portion of the facet on the outer surface of the astragalus upon the anterior margin of the corresponding facet on the inner surface of the external malleolus, and the very considerable strain exerted upon the inner aspect of the posterior part of the lower end of

Fig. 48.

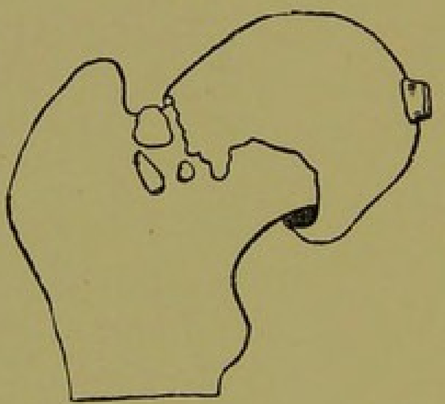
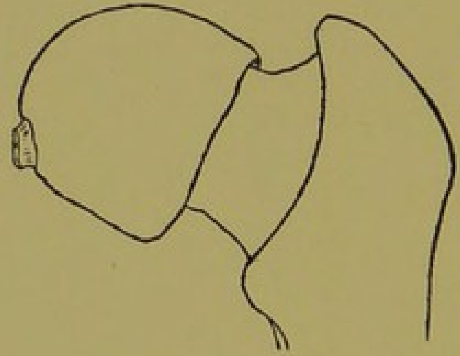


Fig. 49.



Figs. 48 and 49 represent diagrammatically the anterior and posterior aspects of the right femur of the coal-trimmer, Fig. 48 showing the extension of the articular surface of the head of the femur to form a facet for articulation with the acetabular margin. This facet is supplemented by three small additional facets.

the fibula by the powerful posterior fasciculus of the external lateral ligament. The fibula is also forced a little upwards. This is associated with a relaxation of the inferior interosseous tibio-fibula ligament and of the interosseous membrane, permitting of a slight separation of these two bones. The hold which is exerted upon the astragalus by the two malleoli is relaxed in consequence. The external malleolus is displaced backwards, and occupies a position in a vertical transverse plane behind and above the normal. It is this displacement which produces the overlapping of the fibula fragments in Pott's fracture. In adduction of the foot the fibula is rotated on its own axis in a vertical direction to a much less extent, owing to the strain exerted along the anterior fasciculus of the external lateral ligament in a direction which is downwards, forwards and inwards. This strain pulls the lower end of the fibula forwards and downwards, so as to alter its relationship with the vertical transverse plane in which the internal malleolus lies. This displacement of the fibula causes its very forcible approximation to the tibia, owing to the resulting increased obliquity of the interosseous membrane and ligament, so that the astragalus is held in the grip of the malleoli, which is as large and as secure as possible.

For all practical purposes, then, the ankle-joint may be regarded as a fairly perfect hinge-joint, in which any very slight rotation of the astragalus outwards around a vertical axis in abduction of the foot is associated with a torsion of the lower end of the fibula on its long axis by force acting at a great mechanical advantage; while in adduction what torsion there is is trivial in range and in the reverse direction, and is exerted with very much less force.

The movement of adduction is produced chiefly by the action of the tibialis posticus muscle, which by raising the tuberosity of the scaphoid winds up the spiral calcaneo-scaphoid ligament, narrowing the angular interval between the sustentaculum tali and the scaphoid, and displacing the head of the astragalus outwards on to the os calcis.

Abduction of the foot, which is usually a passive movement when associated with fracture, results from the relaxation of the tibialis posticus, which allows the tuberosity of the scaphoid to drop, the calcaneo-scaphoid capsule to unwind, and the head of the astragalus to pass inwards into the angular interval between the sustentaculum tali and scaphoid, now increased to its extreme limit. I need hardly say that the usual comparison of the mechanics of the bones of the foot to arches is merely imaginary; no such arrangement exists.

All this I described fully in the 'Guy's Hospital Reports,' 1886, p. 252, in a communication entitled "The Causation, Pathology, and Physiology of several of the Deformities which Develop during young Life," yet I still find in students' text-books the same incomprehensible descriptions of the movements of the joints of the foot, and of the mechanics of the part, that I plodded hopelessly through as a student.

In 1894 I brought before the Clinical Society of London a paper dealing with the results of the treatment of simple fractures by operation. In it I pointed out that operative measures offer to the patient the following advantages:

"(*a*) They at once relieve the patient from the pain produced by any movement of the fragments upon one another.

"(*b*) They free him from the tension and discomfort due to the extensive extravasation of blood between and into the tissues.

"(*c*) They shorten the duration of the period during which he is incapacitated from work, since union is practically by first intention, and, consequently, very rapid and perfect.

"(*d*) Lastly, and by far the most important, they leave his skeletal mechanics in the condition in which they were before he sustained the injury."

In that paper I gave the reasons according to which I advised operation in suitable circumstances, and appended a list of results of cases, treated by manipulation and splints, which were most unsatisfactory. These were taken in sequence from the reports of the hospital, and extended over a considerable period of time.

This, and the papers which I wrote later, raised a storm of opposition, and have continued to do so practically up to the present time.

The conclusions which I arrived at as to the prognosis of fractures were briefly the following:

(1) That accurate, or anything approaching accurate, apposition of displaced fragments in a fracture was only very rarely obtained.

(2) That the treatment of fractures, as it existed, was a disgrace to surgical practice, because those who had sustained fractures, especially of the leg, only too often experienced enormous physical disability. When dependent on labour for their income, they frequently suffered great financial depreciation in their wage-earning capacity. In not a small proportion the depreciation in certain occupations amounted to a hundred per cent.

All my subsequent experience of fractures, treated by means other than operative, has fully borne out the accuracy of the statements which I then made.

Age is no barrier to operation; indeed, in old people an operation is often more imperatively called for than in vigorous life, for the reason that prolonged recumbency in old age is a very serious matter, often entailing of necessity a fatal result. The shock sustained from surgical interference is trivial, old people bearing operations well. Alcoholic patients, in whom the soft parts about the fracture have been very severely damaged as a result of direct violence, incur more risk from the injury than healthy ones, so it follows that the additional risk consequent on operation in these cases is naturally greater than in the normal subject, not because of the operation but because of the conditions in which the operation is performed. In other words, alcoholism and direct injury to soft parts increase the danger of fractures and also add to the risk of their operative treatment. I have found the bones of chronic alcoholics to be frequently thin and friable.

I propose to consider here mainly the mechanical principles involved in the rational treatment of certain fractures, and do not intend to write a systematic treatise on fractures in general.

Fractures of the Lower Extremity.

Abduction Fractures of the Ankle-joint.

Excessive abduction of the foot produces injuries of varying degrees of severity.

(1) The areas of the articular surfaces of the ankle-joint which sustain the greatest pressure are the anterior portions of the facets on the outer malleolus and on the astralagus. A bruising of these segments of the articular surface is a factor of the greatest importance in so-called sprain of the ankle. The damage sustained by the opposing surfaces of articular cartilage is very liable to determine the development of mechanical or traumatic arthritis, the tendency varying directly with the age of the individual.

(2) The pressure upon the anterior portion of the malleolar facet may be sufficient to produce a torsion fracture of the fibula, the locality of which may vary within comparatively wide limits.

The fracture may extend vertically through the malleolus when there may be little or no displacement of fragments, or spirally through the shaft above the joint when the displacement of the ends of the bone on one another may be very considerable.

The amount of displacement of the fragments on one another is a matter of great importance as regards the security of the ankle-joint.

(3) If the foot be abducted still further, strain is exerted upon the internal ligament, and through it upon the internal malleolus. On occasions the ligament may yield, but in most cases the malleolus breaks transversely.

(4) A continued abduction produces a rupture of the interosseous ligament uniting the fibula to the tibia (see

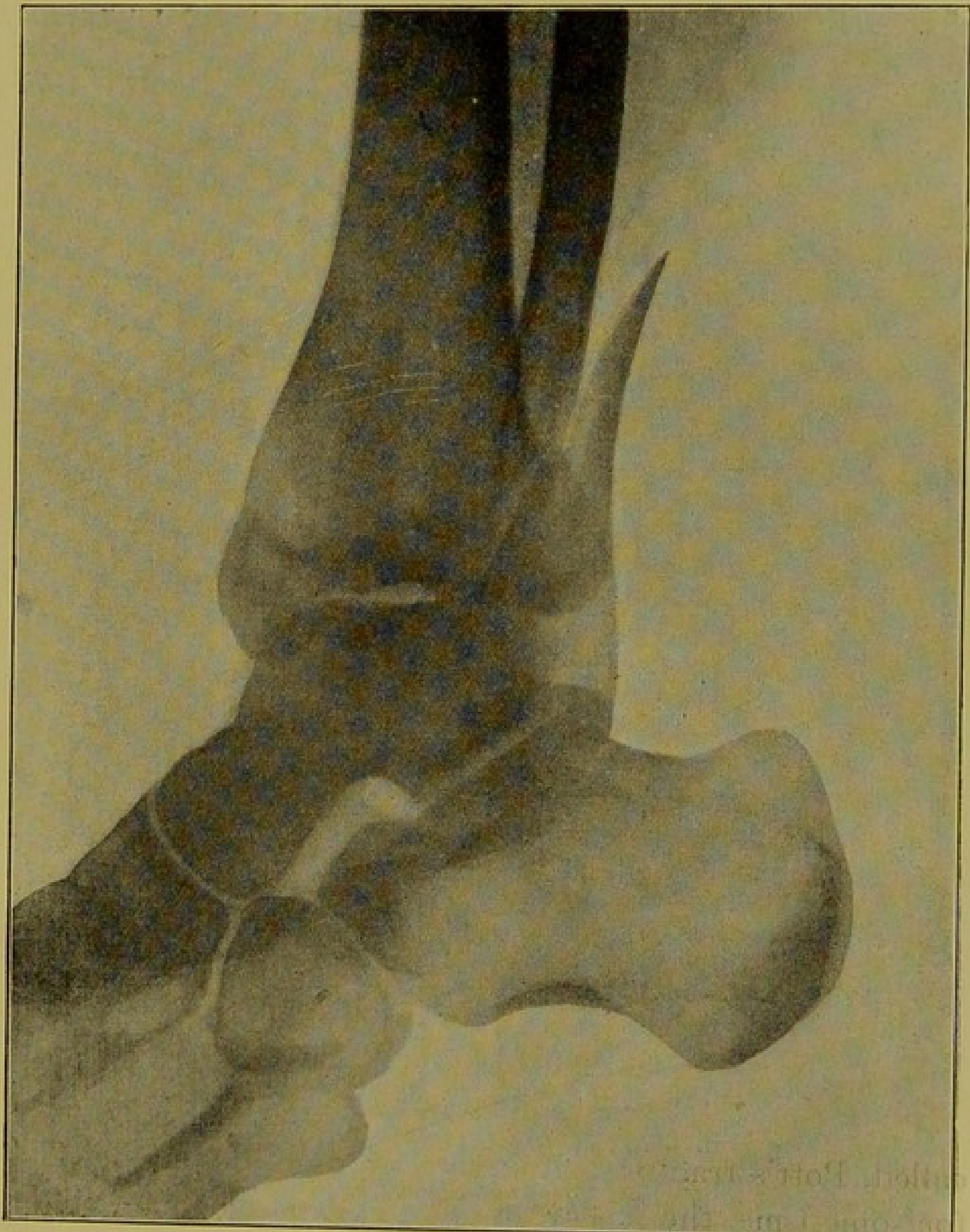


Fig. 50.

Fig. 54), or more frequently it results in a tearing away of the wedge of the outer and back part of the lower end of the tibia, to which the interosseous ligament is attached (see Figs. 52 and 53). The fragment of tibia is much larger in Fig. 52 than in Fig. 53.

I believe I was the first to call attention to this particular variety of abduction fracture, or, as it is more commonly

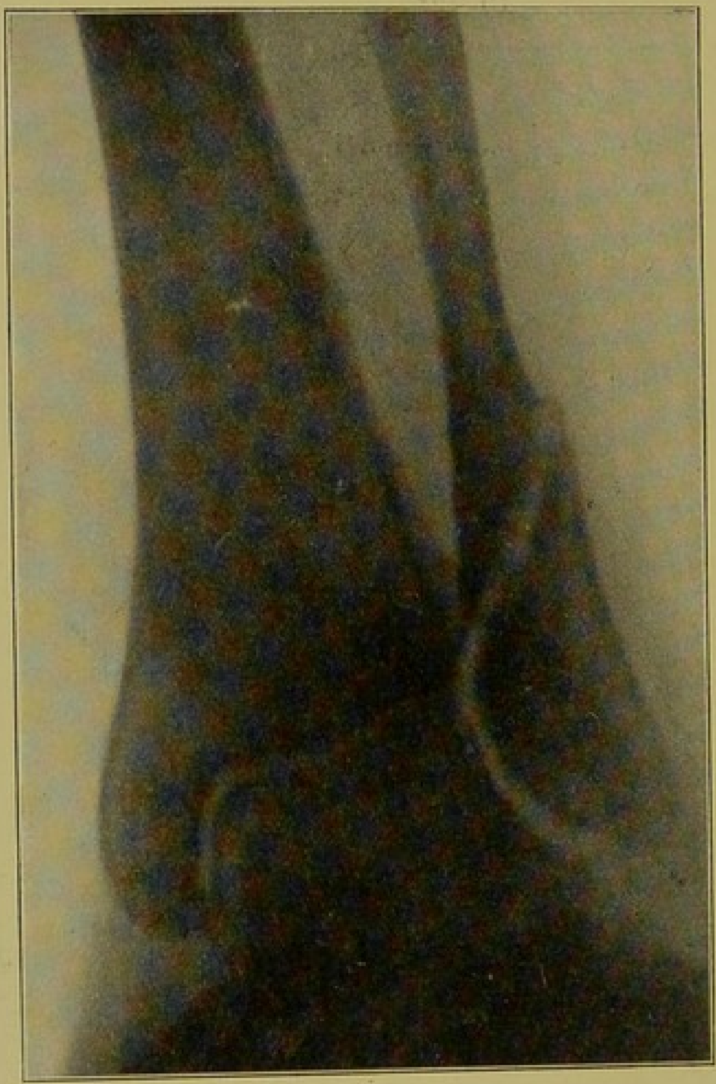


Fig. 51.

called, Pott's fracture. If such a fracture is left unreduced for some time, the displaced fragment of tibia, ankylosing in an abnormal position, forms an insuperable barrier to the perfect restoration of the functions of the ankle-joint.

Fig. 50 represents the first degree of abduction fracture, seen laterally.

Fig. 51 the same fracture from before backwards.

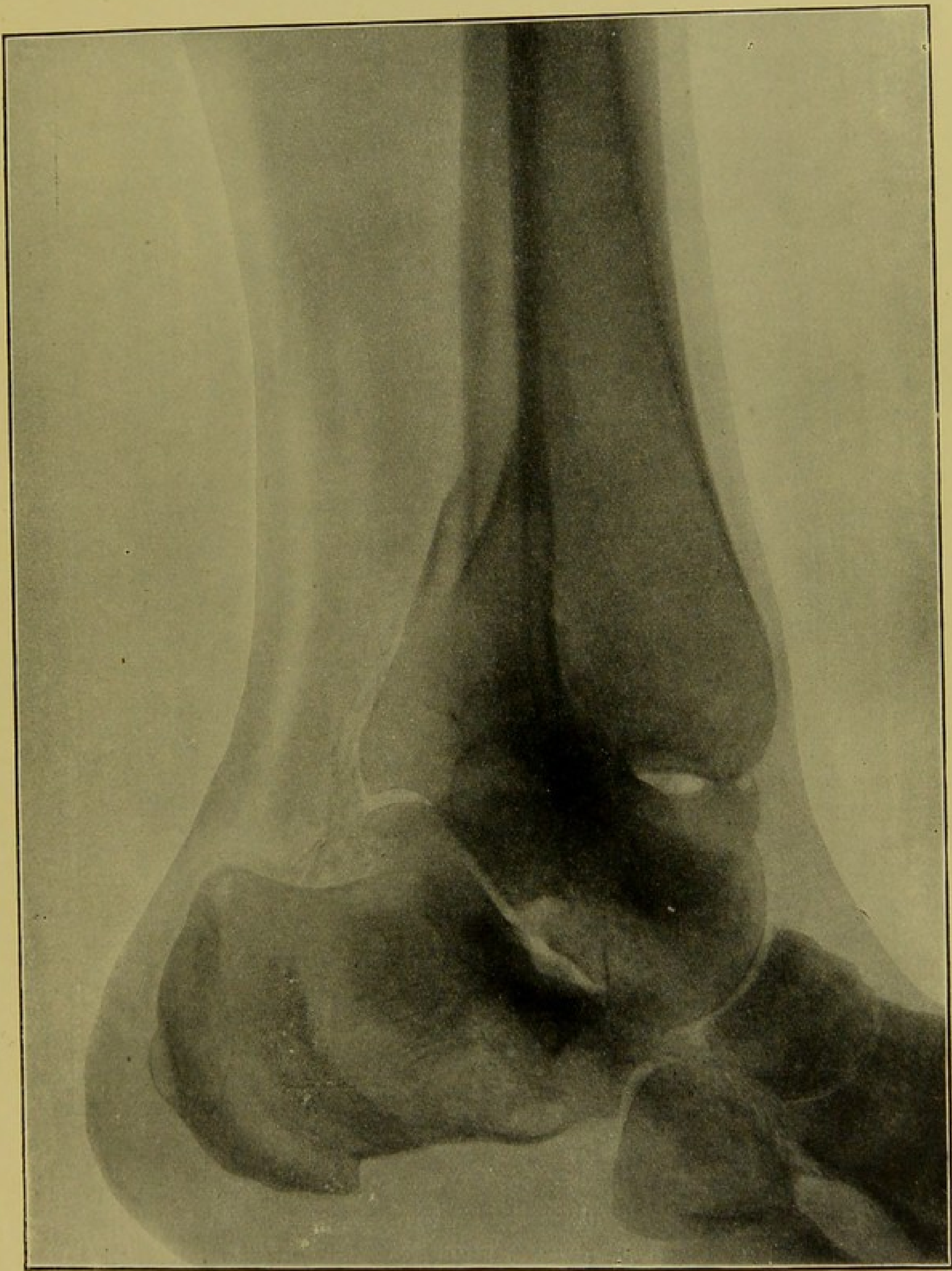


Fig. 52.

Fig. 55 shows an abduction fracture of the ankle of

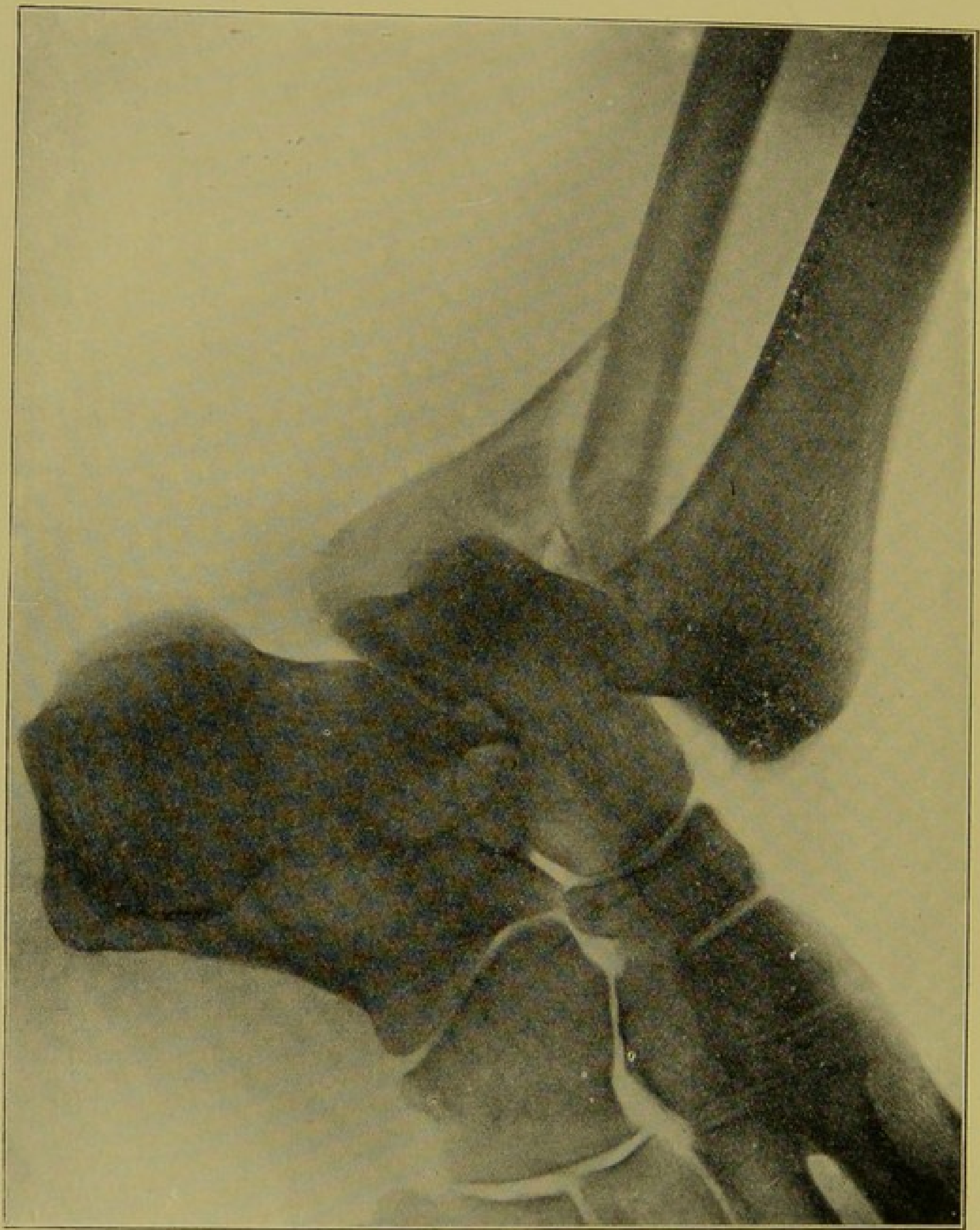


Fig. 53.

the first degree, the fibula being broken in its lower fourth. The fragments were much displaced. They were placed in

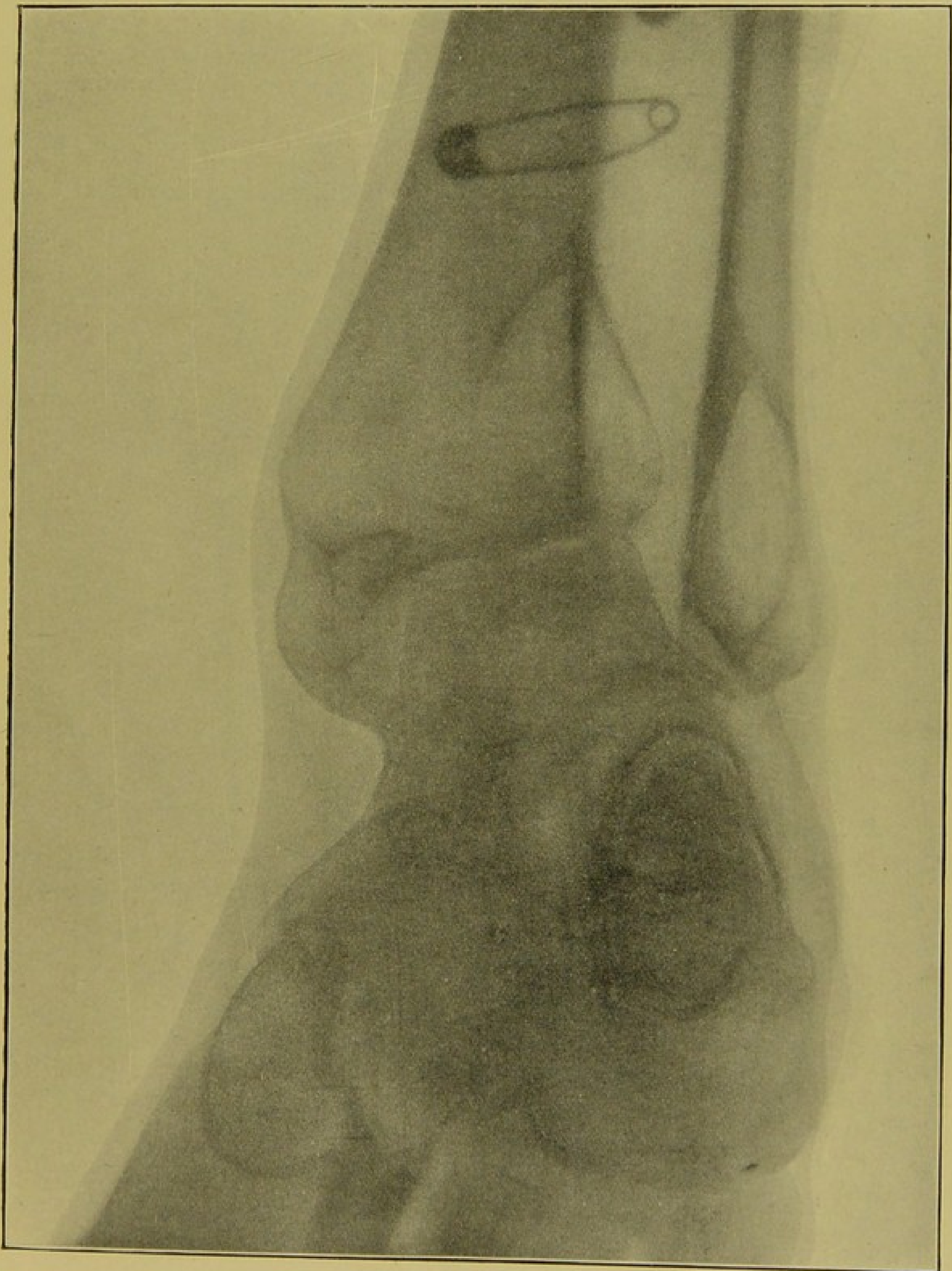


Fig. 54.

perfect position and were secured by a plate and screws with the result shown in Fig. 56.

Figs. 52 and 53 show the third degree of abduction fracture from side to side.

The fibula is broken spirally. Attached to it is the triangular wedge of tibia, and the internal malleolus is broken off transversely at its base.

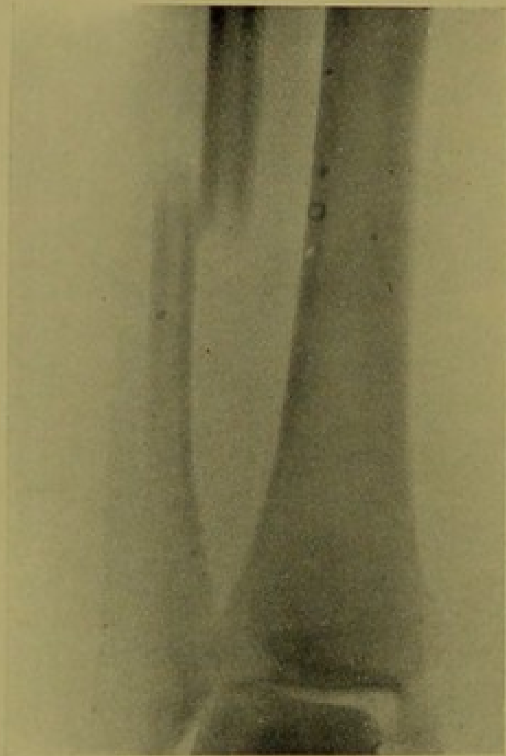


Fig. 55.

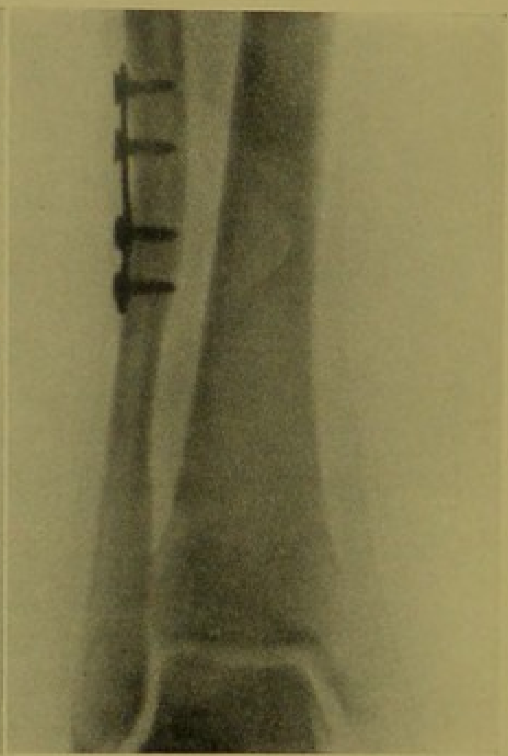


Fig. 56.

As to whether it is necessary or not to operate on an abduction fracture depends on the degree of the fracture and on the displacement of the fragments, and also upon the wishes of the patient.

In all varieties of abduction fracture the operative procedure is identical. It consists in exposing the fibular fragments by means of a vertical incision, and in restoring them to their normal relationship. This can always be effected in recent fractures, whatever the degree of the fracture and whatever the displacement of the fragments, and the surgeon can rest assured that if he has effected accurate apposition of the fibular fragments he has also

Fig. 57.

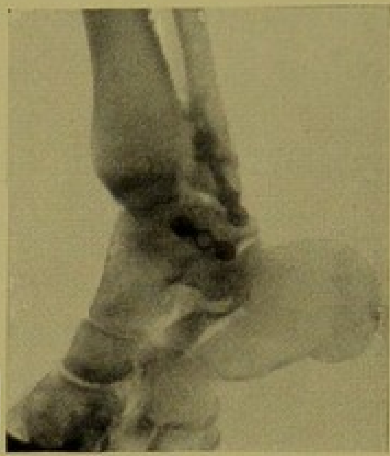


Fig. 58.

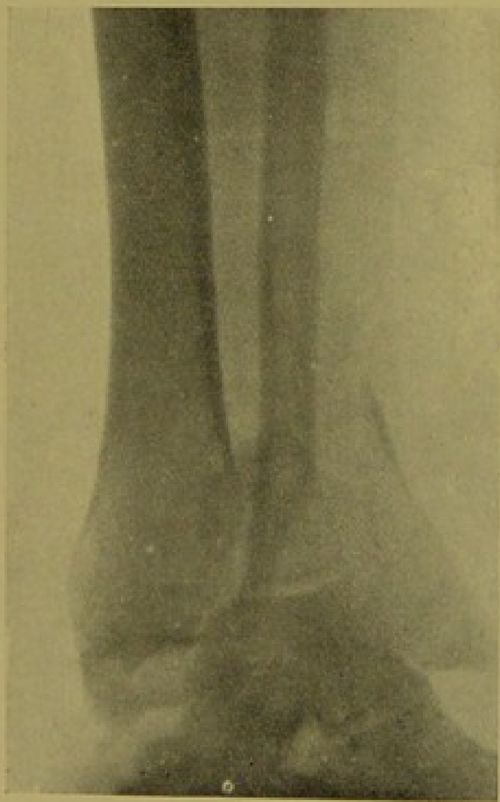


Fig. 59.

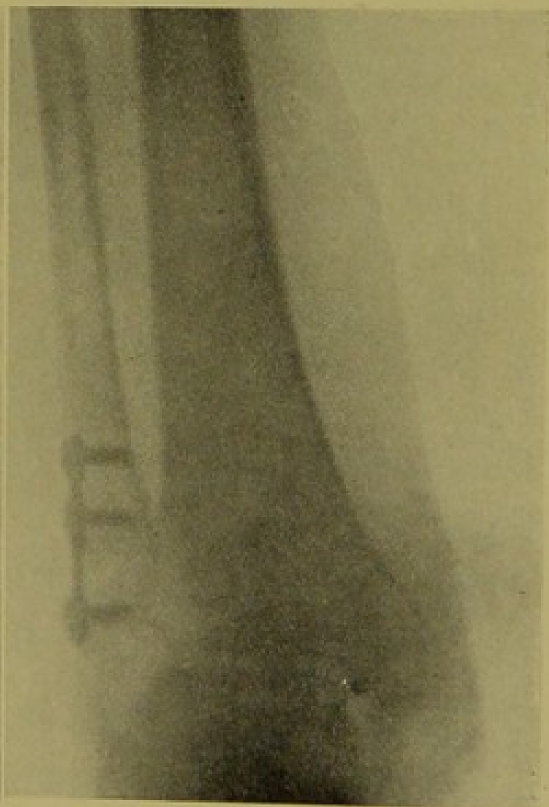


Fig. 60.

restored the internal malleolus and the tibial fragment to their normal positions. The fibular fragments are secured by means of a steel plate and screws. As a rule, a single plate and four screws are sufficient, two screws securing the upper fragment, and two the lower. In some cases it may be necessary to supplement the single plate by one or two others, or by a screw alone. Fig. 57 represents an abduction fracture of the third degree in which two additional plates had to be employed to secure the fragments

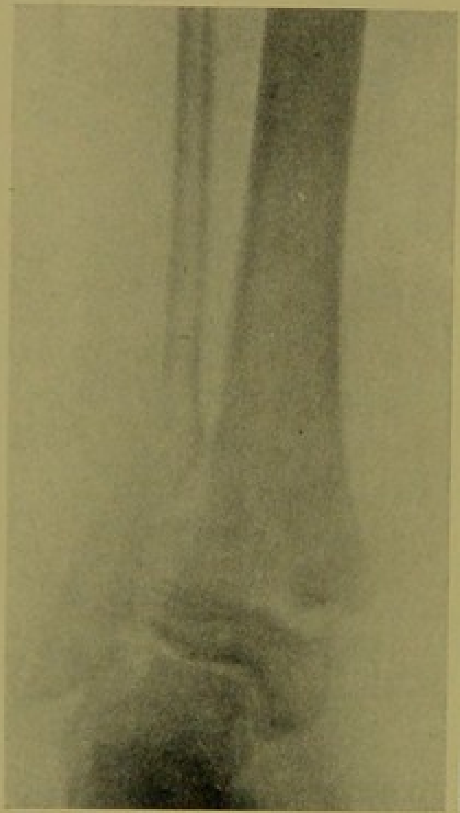


Fig. 61.

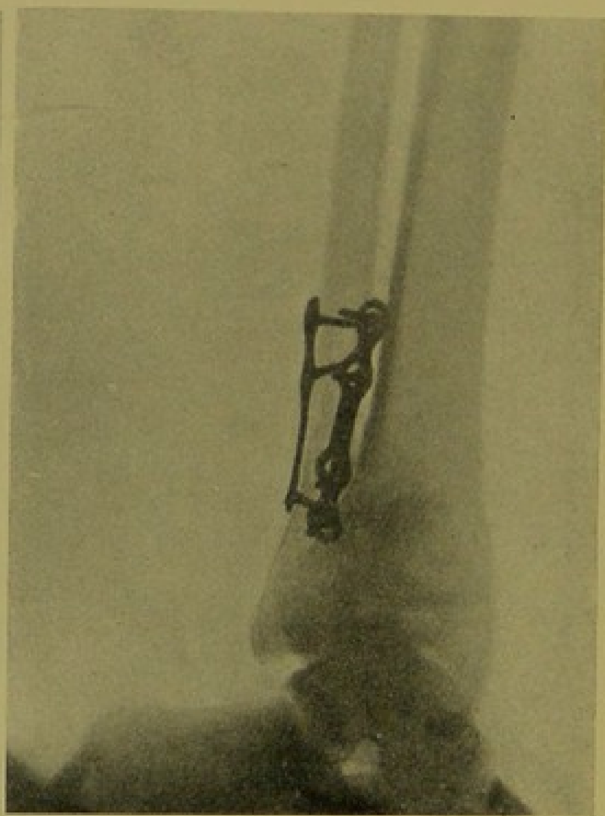


Fig. 62.

firmly in accurate apposition (Fig. 58). Note the mass of tibia attached to the lower end of the fibula.

Fig. 59 illustrates an abduction fracture of the ankle in third degree. The fragments of the inner malleolus, tibia, and fibula were replaced in position and were maintained firmly by means of a plate and three screws fixing the fibular fragments, as shown in Fig. 60.

It happens occasionally that the effect of excessive abduction of the foot in certain conditions, as when a foot is caught between railings, is to produce a fracture somewhat different to the typical abduction fracture.

Fig. 61 represents such a fracture, and Fig. 62 shows the means by which the bones were restored to their normal form and functions.

Adduction Fractures of the Ankle-joint.

If the foot is adducted with a force greater than the

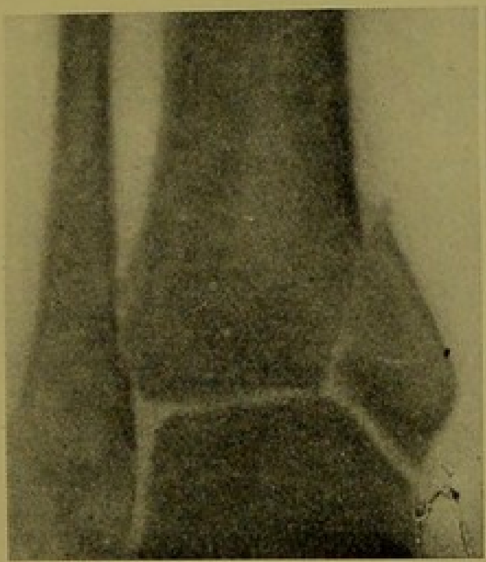


Fig. 63.

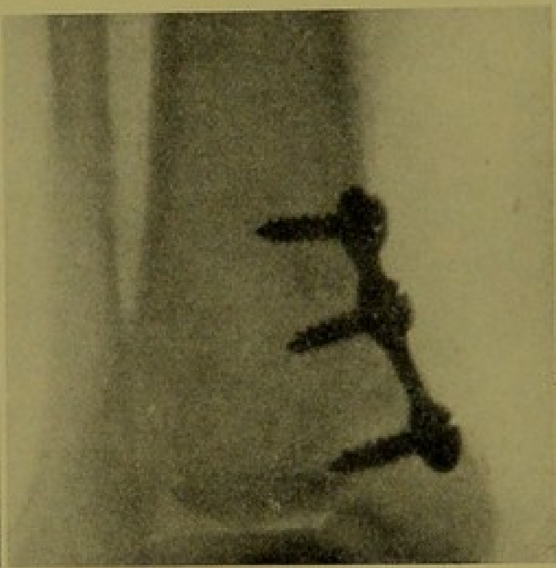


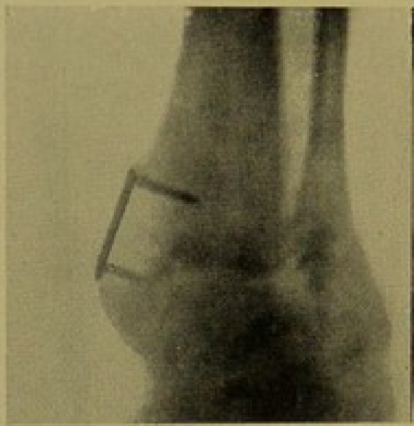
Fig. 64.

skeleton is able to bear, without undergoing change, two varieties of fractures may result:

(1) The direct inward impact of the astragaloid facet upon the internal malleolus results in a more or less vertical fracture of the tibia, the line of fracture passing upwards so as to carry away the internal malleolus and a triangular area of the shaft of the tibia, which fragment remains displaced upwards. This degree of adduction fracture is shown in Fig. 63.

(2) If this force is continued, strain is exerted upon the external malleolus through the external lateral ligament and in consequence the lower end of the fibula is broken in

a scrunch fracture over the sharp lower and outer limit of the shaft of the tibia (see Figs. 65 and 66).



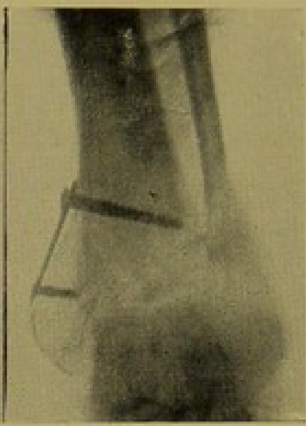


Fig. 65. Fig. 66.

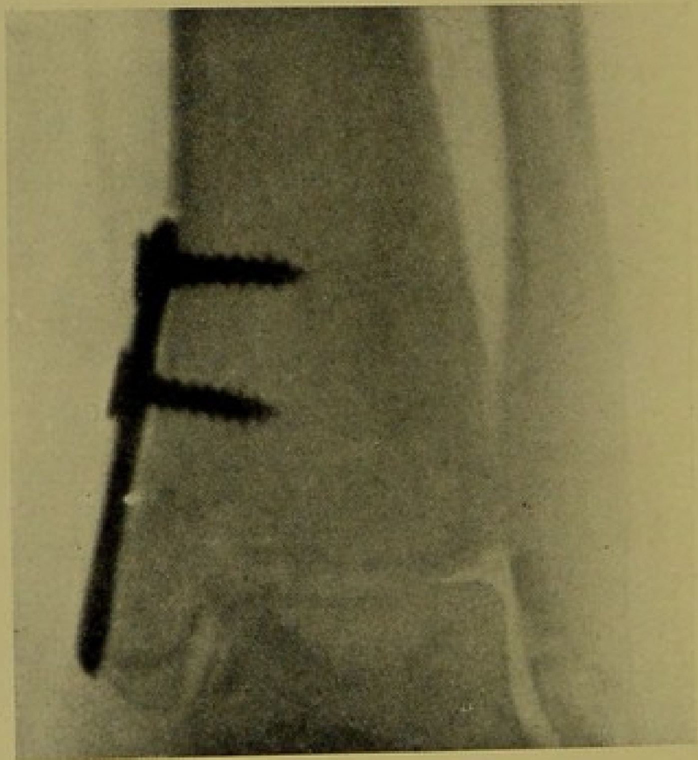


Fig. 67.

In operating on these fractures a vertical incision is made over the internal malleolus, which is forced downwards by means of an elevator till the form of the bone is restored. It is retained accurately in position by means of a plate and screws as shown in Figs. 64, 65, 66 and 67. Figs. 65 and 66 show two adduction fractures of the ankle-joint of the second degree, the tibia having been broken obliquely upwards and inwards while the fibula had been smashed over the sharp lower and outer margin of the tibia. The same treatment was adopted in the two cases. The direction of the tibial fracture which is practically vertical

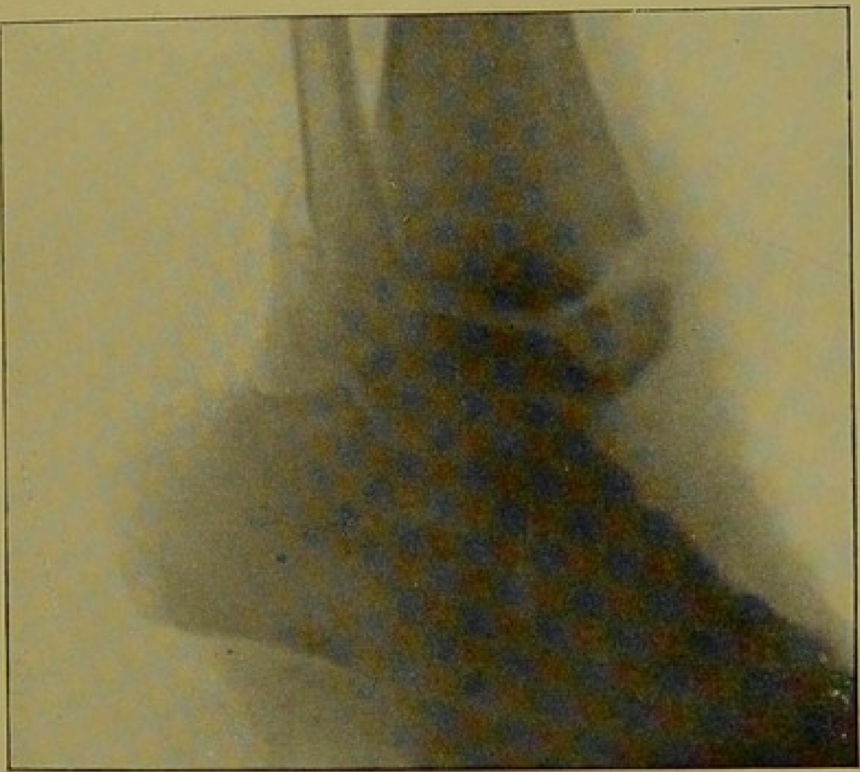


FIG. 68.

can be readily recognised in both radiograms. If the external malleolus is broken also the surgeon has the satisfaction of knowing that the replacement of the internal malleolus is accompanied by that of the outer. In these fractures of the ankle, as in all fractures, it is well to secure the fragments as firmly as possible in order to permit of early movement of the joint without fear of displacement, so that the surgeon must not hesitate to use plates and screws strong enough to effect this purpose.

Fig. 68 represents an adduction fracture of the ankle-joint. The direction of the fracture through the tibia is upwards and inwards, while the fibula is broken transversely. Fig. 69 shows how this fracture can be treated by means of a single screw in certain suitable cases.

In either adduction or abduction fractures, after the functions of a leg have been perfectly restored, it may on rare occasions be advisable, in the labouring classes

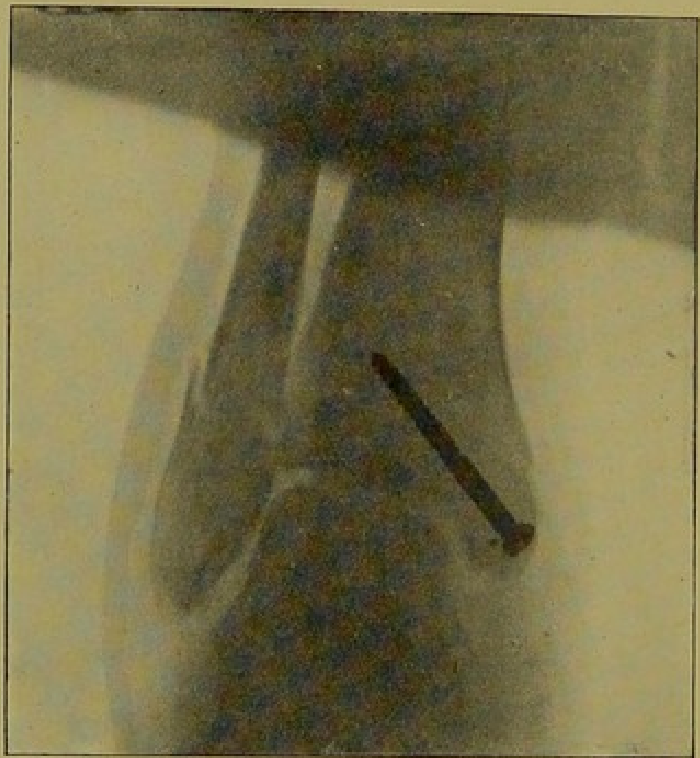


FIG. 69.

especially, to remove the plate to avoid irritation of the skin over it from the pressure of a heavy boot. This applies to all plates which have to be placed subcutaneously in localities exposed to pressure or injury. Except for this condition it is needless to say, that a plate put into a simple fracture should never require to be removed.

Fractures of the Bones of the Foot.

Many fractures of the bones of the foot are best treated by operative interference.

A good example is afforded by Fig. 70, which represents a fracture of the upper part of the tuberosity of the os calcis which was torn off and displaced upwards by the violent contraction of the muscles of the calf. It was found impossible to replace the fragment by manipulation, so it was exposed by a median incision and was forced into

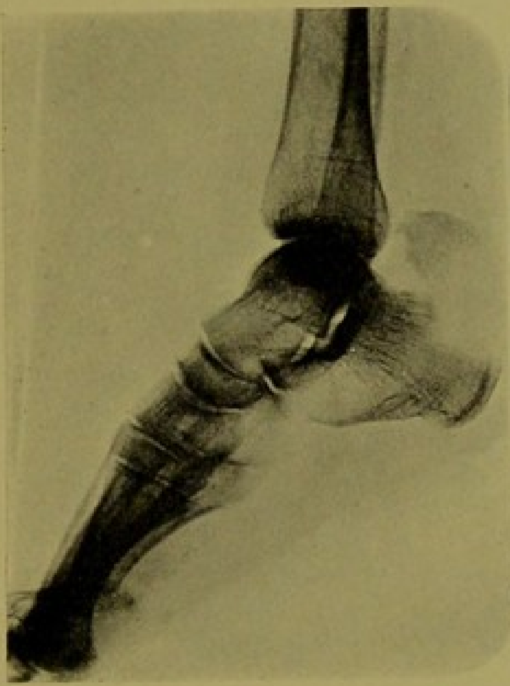


Fig. 70.

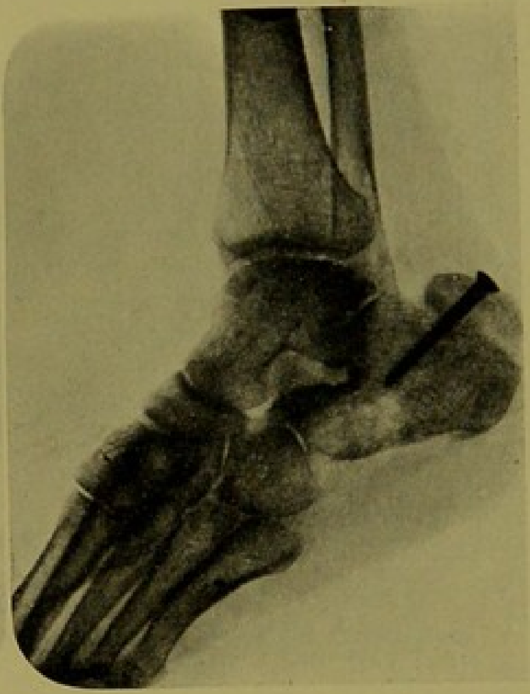


Fig. 71.

position and retained by means of a long screw. Fig. 71 shows the result of the operation.

Fractures of the Tibia and Fibula.

There are two distinct forms of fracture of the shaft of long bones. Those that are produced by direct violence and those brought about by indirect violence, or as I prefer to call them, "torsion fractures."

The laceration sustained by the soft parts when the bone is broken by direct injury is vastly greater than when the fracture results from torsion. In the latter the soft parts are punctured by the chisel-shaped spikes of bone which ascend and descend in the surrounding muscles, and as the fragments overlap one another and in proportion as they overlap, so they tend to separate. The greater the overlapping of fragments the larger is the quantity of muscle intervening between them.

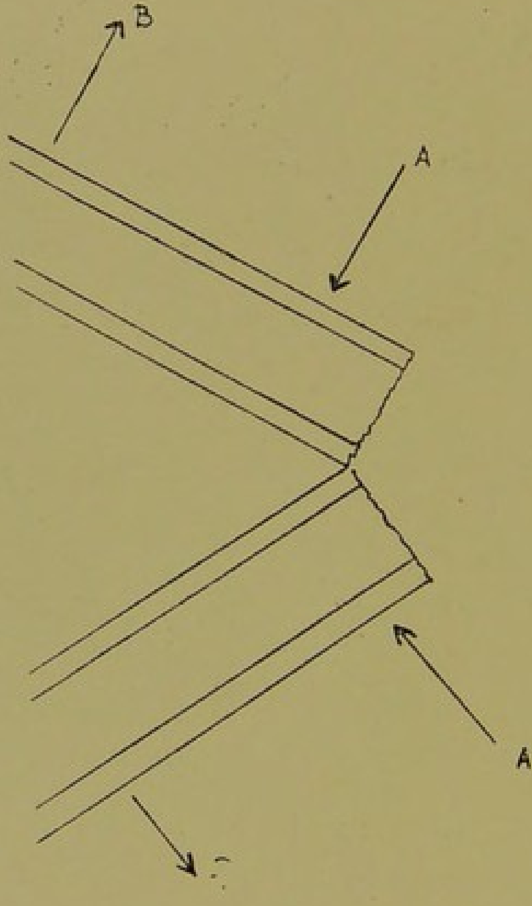


FIG. 72.

When a bone is broken by force applied directly to it, the soft parts are damaged not only by the displacement upon one another and the over-riding of two large blunt ends of bone, but they are torn and lacerated by the force which itself broke the bone.

Consequently, the soft parts which form ties in the length of the limb are shortened up to a greater extent in direct fractures than in indirect, and afford much more resistance to the replacement of the fragments in position. In both cases the resistance to replacement is increased by the length of the interval which is allowed to elapse between the receipt of the fracture and the operation.

In fractures of the tibia and fibula by direct injury, the tibial fragments are replaced by grasping them in powerful bone forceps and by raising them from the wound. The broken surfaces are held in such a relationship to one

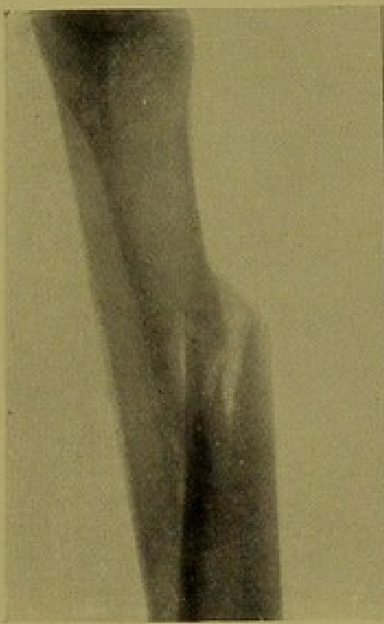


Fig. 73.

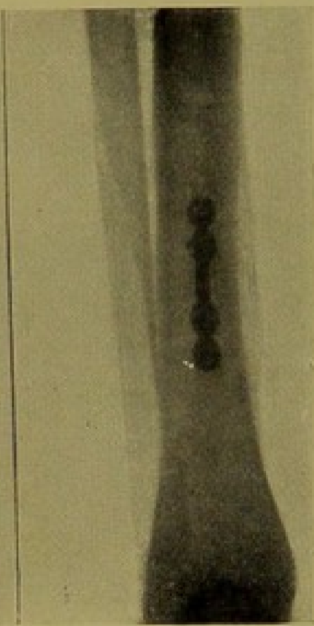


Fig 74.

another that the forcing back of the fragments into the wound results in their accurate coaptation. During this process of replacement the foot is held firmly, strain being exerted upon it (see Fig. 72, which represents the fragments of bone forced out of the wound) The edges are placed in apposition while force is exerted in the direction of the arrows A A, while the fragments are extended on one another in the direction of the arrows B B).

Fig. 73 represents a fracture of the tibia by direct injury, showing the displacement of fragments before operation, while the result of operation is shown in Fig. 74.

Fig. 75 shows the conditions present in a fracture of the tibia and fibula produced by direct violence, in which, after many weeks, practically no union had taken place. The fracture of the tibia was exposed and freed of the soft

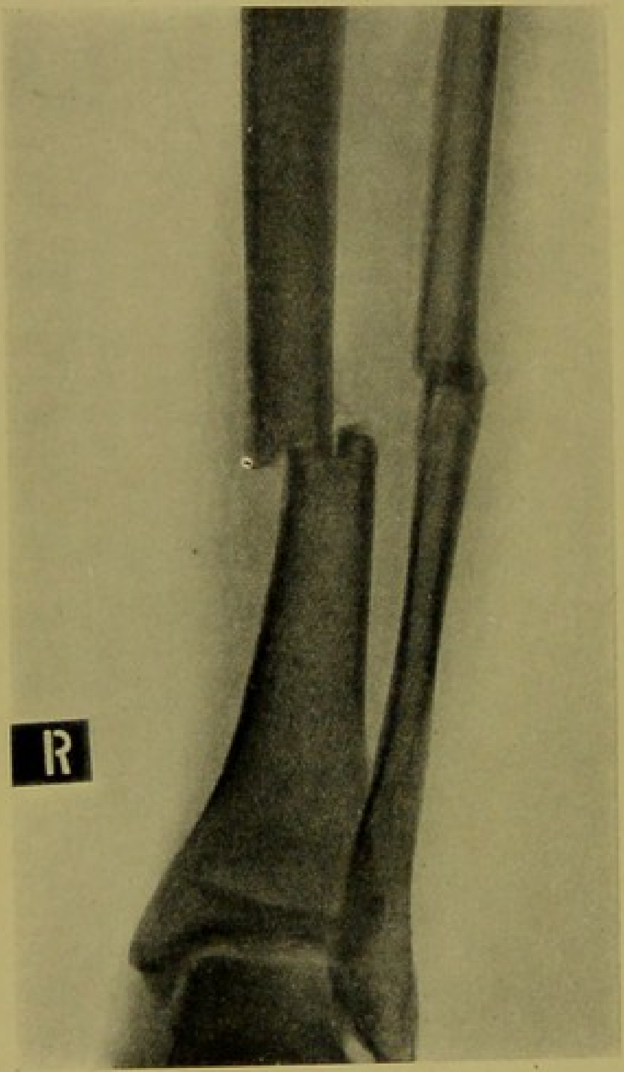


FIG 75.

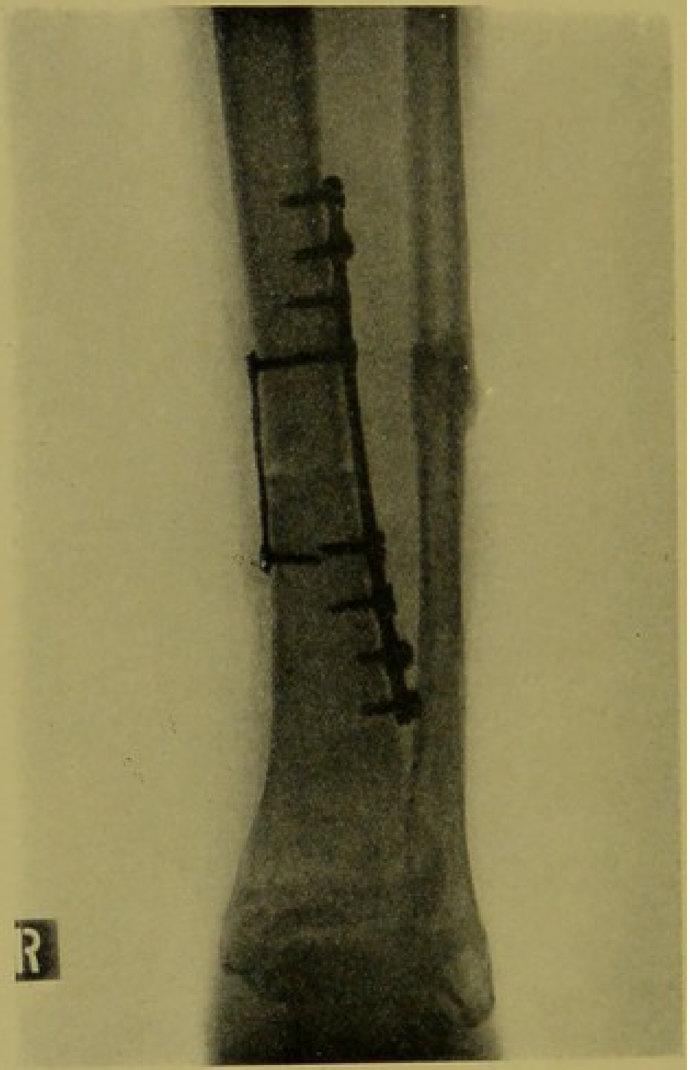


FIG. 76.

callus which surrounded it. The fragments were then placed in accurate apposition and were retained by a very stout external plate and a thin subcutaneous plate.

The bones were restored to their normal form and function, and the man was freed from a very tedious convalescence and was saved from permanent disability. Fig. 76 shows the radiogram of the result.

Comminution of the fragments may increase the difficulty of effecting perfect apposition, but with a little patience the result should be perfect. Figs. 77 and 78 show, before and after operation, such a fracture accompanied by great swelling of the soft parts.

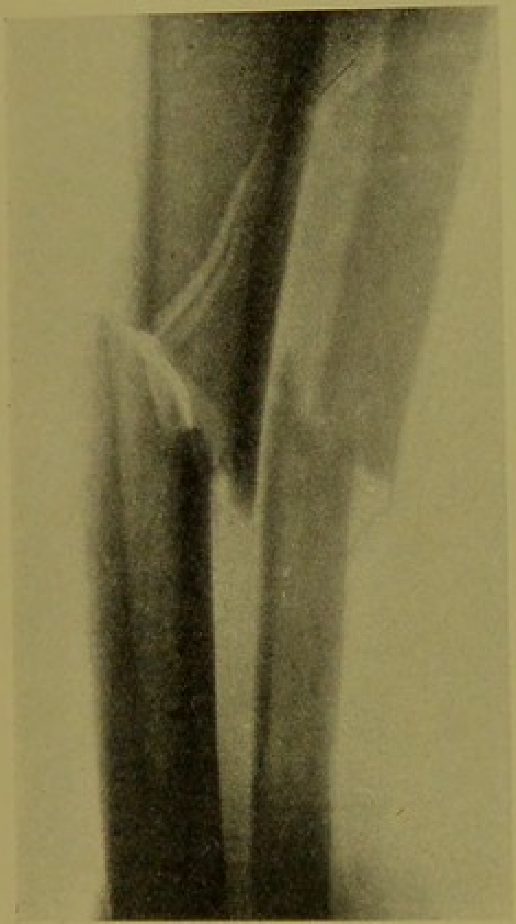


Fig. 77.

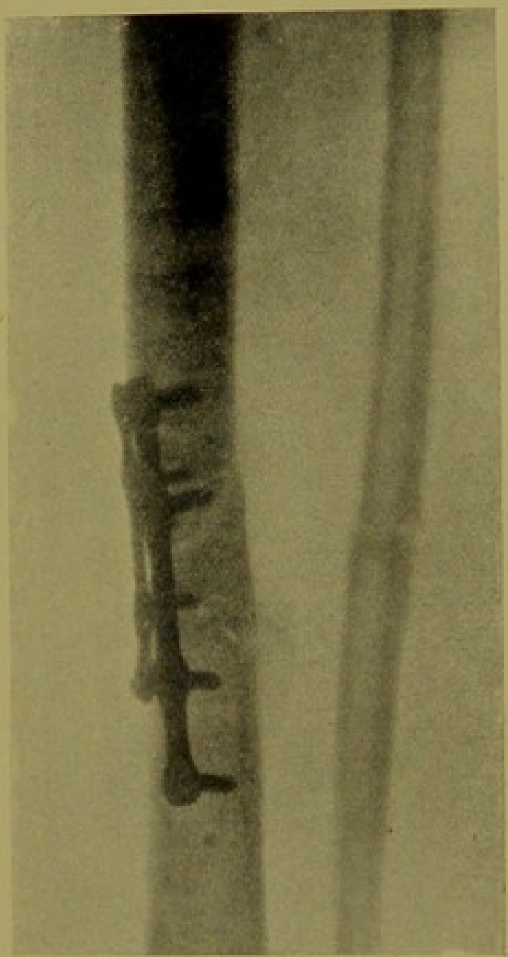


Fig. 78.

As regards the fibular fragments, these generally fall together when the tibia has been restored to its normal form. Here I would point out that since the chief function of the fibula is to grasp the astragalus securely, any overlapping of its fragments is of importance according as the fracture approaches the inferior tibio-fibular joint. Displacement of the fragments in fracture of the upper part of the fibula interferes only slightly, if at all, with the security of the ankle-joint, whereas the same amount of

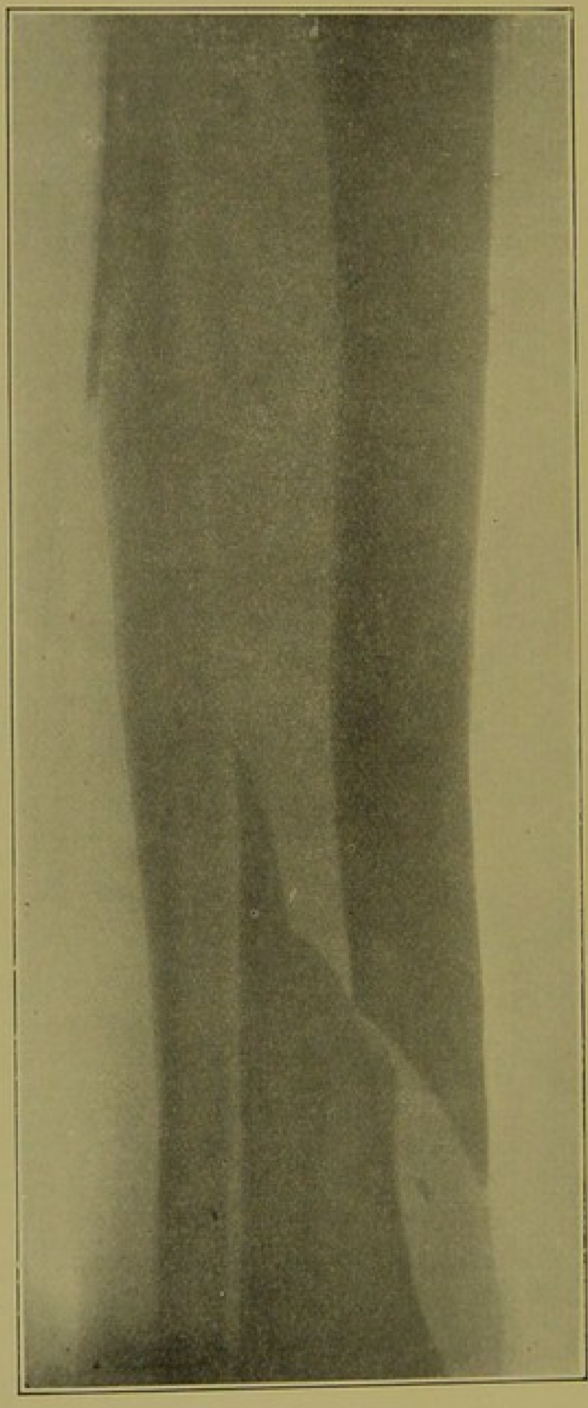


Fig. 79.

displacement within a couple of inches of its lower end may result in great physical disability and call for operative interference. The plate which is to secure retention of the tibial fragments should usually be placed on the outer surface of that bone for the reason that a thick plate can be buried beneath the muscles at a distance from possible

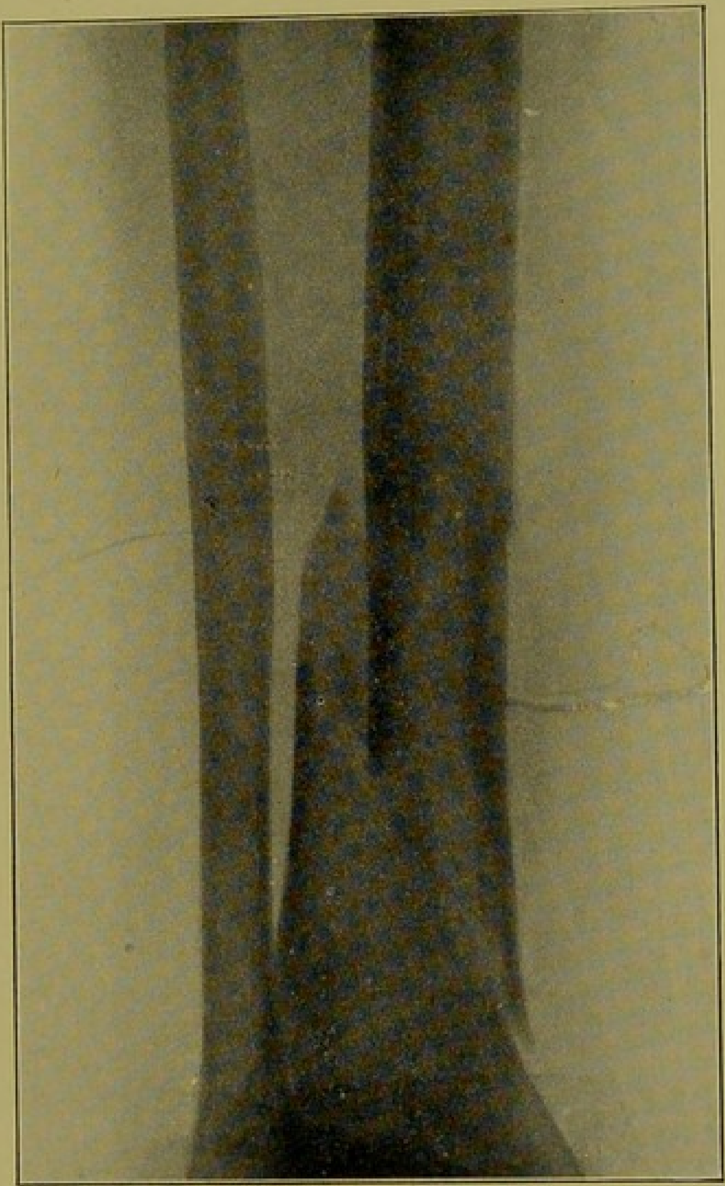


Fig. 80.

pressure which might cause irritation if it were merely covered by skin.

Great swelling of the soft parts sometimes renders accurate apposition of the edges of the skin very difficult indeed, and the surgeon may on occasions be put to his wit's end to effect it. A curved incision, a loosening of the skin from the subjacent deep fascia, and the employment of

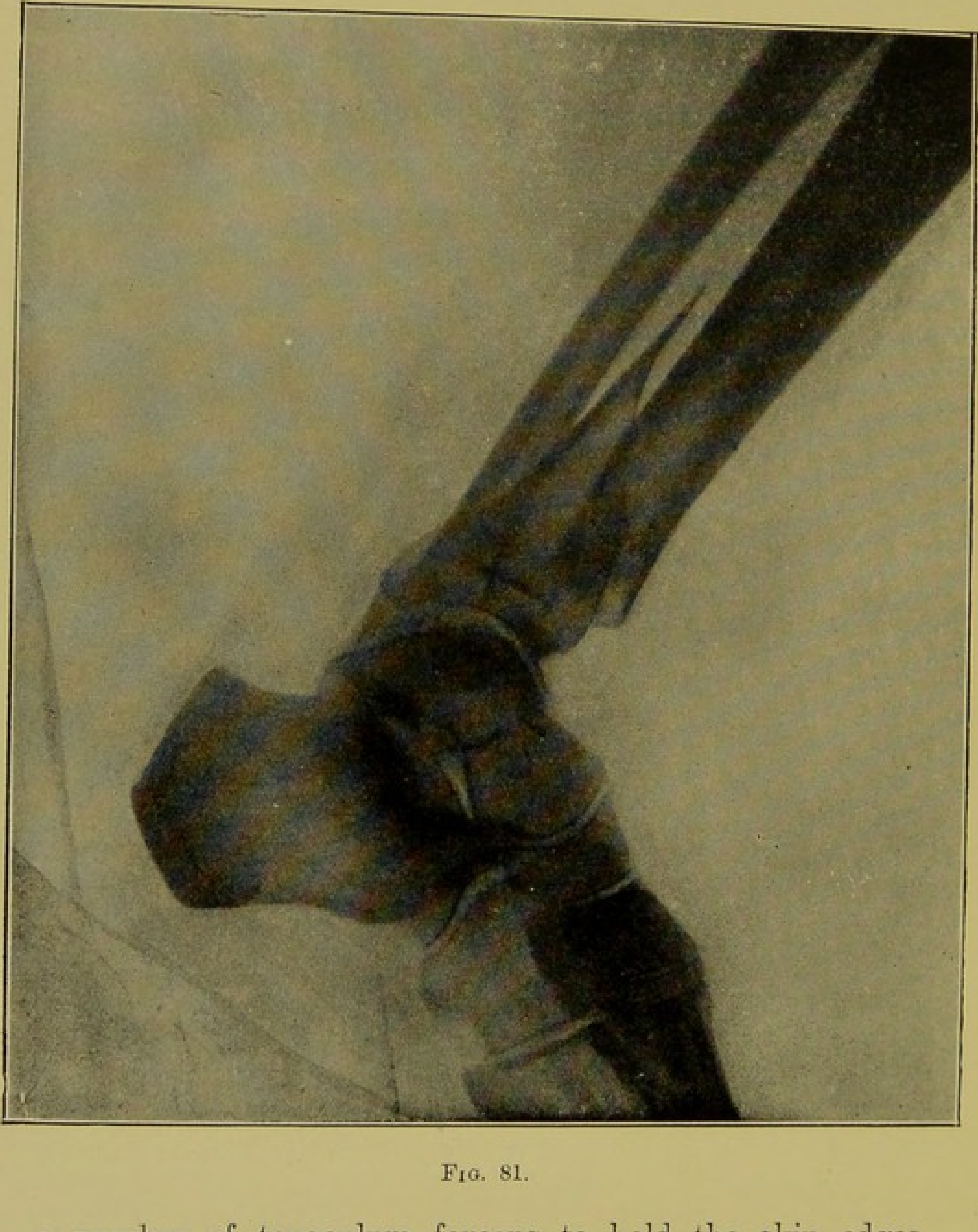


Fig. 81.

a number of tenaculum forceps to hold the skin edges together almost always enables him to attach a sufficient number of Michel's clips to effect this. In any case, when

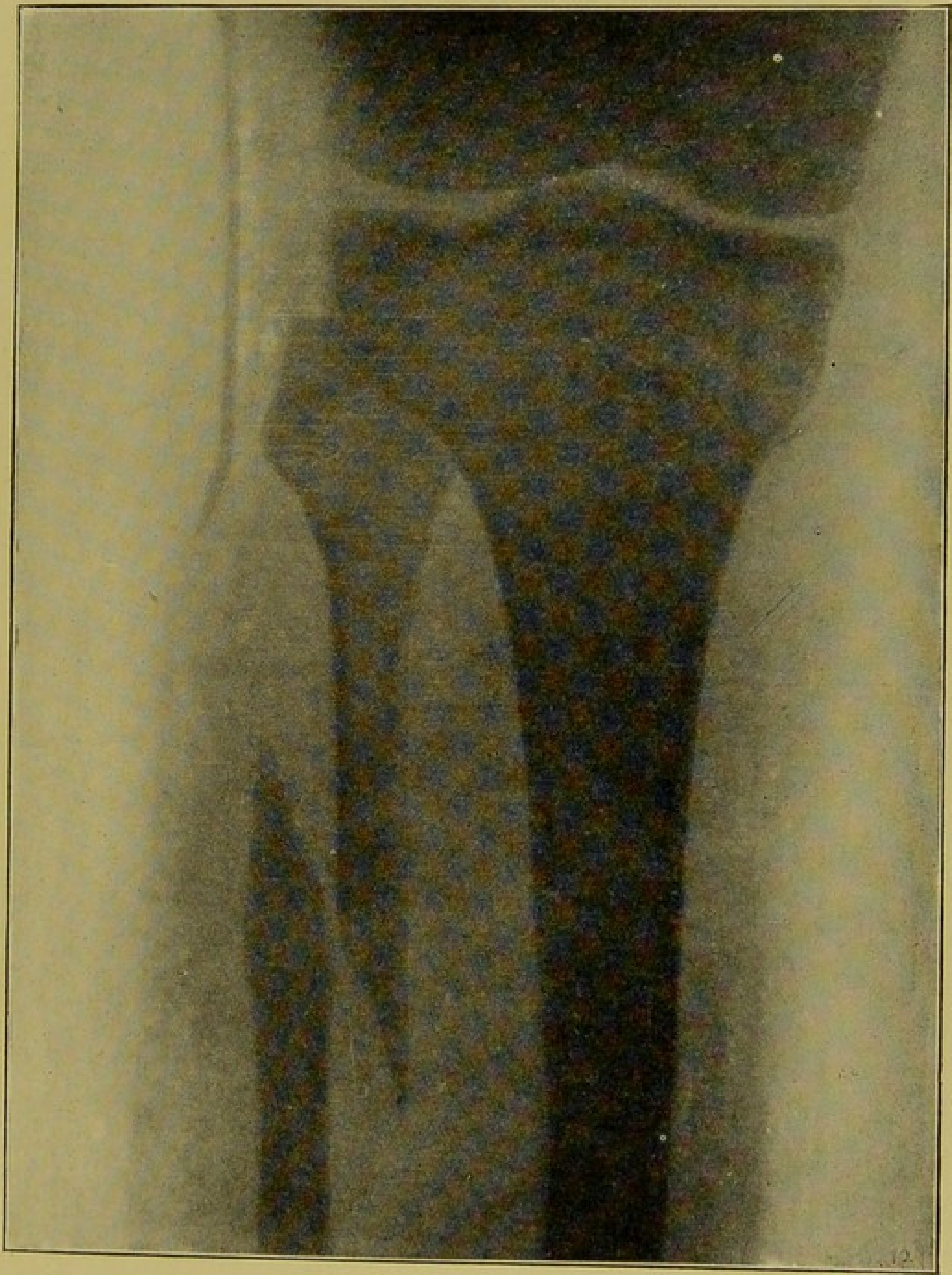


Fig. 82.

there will obviously be much difficulty in closing the wound, the incision must not be made directly over the surface to

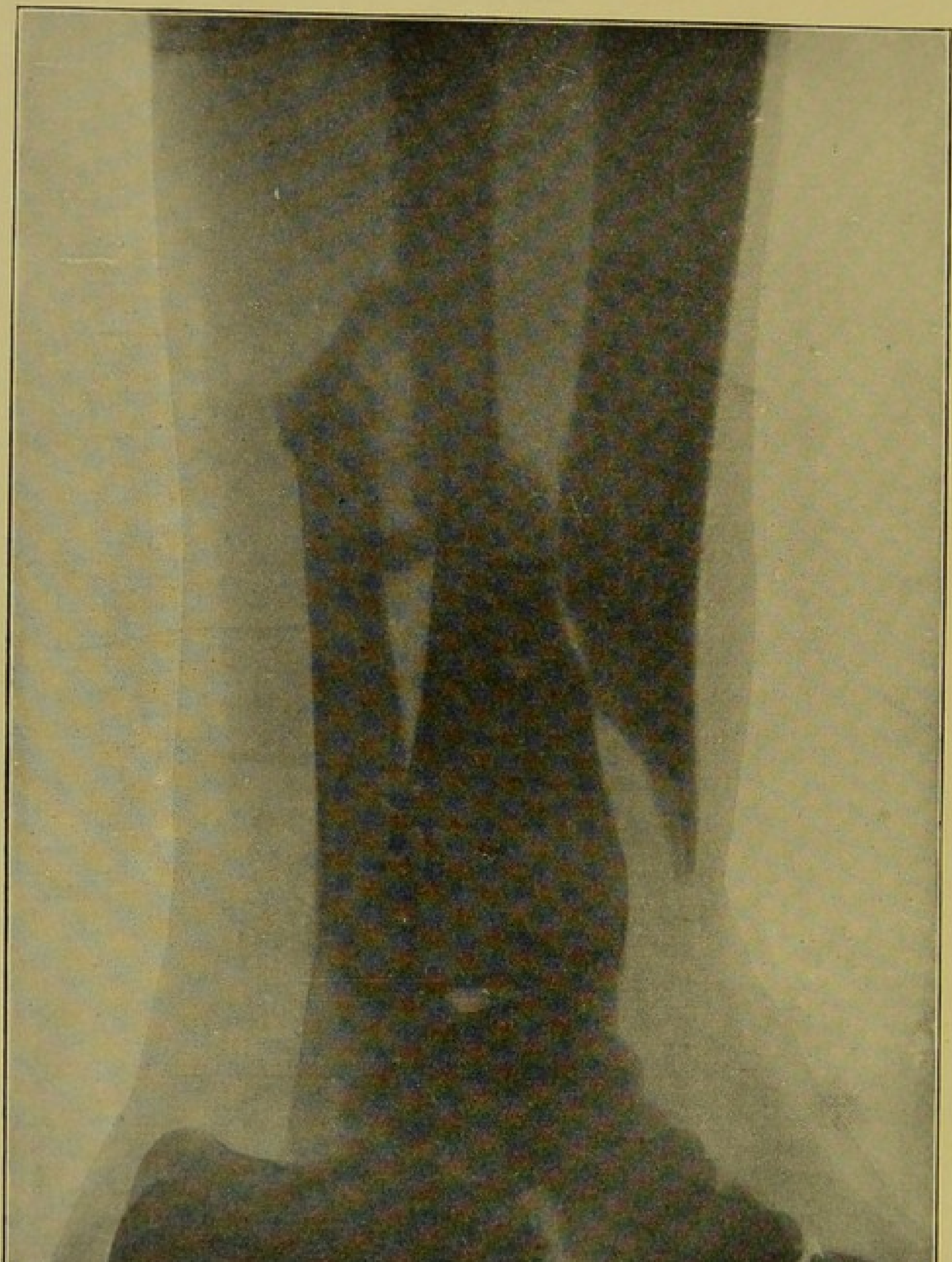


Fig. 83.

which the plate has to be applied, but should be made at a distance from it so as to secure the plate against infection in the event of any raw surface intervening between the skin edges.

In torsion or spiral fractures of the tibia, if the fibula be broken also, it gives way high up in the shaft, where accurate replacement is not important (see Figs. 79 and 82, which illustrate these conditions).

Fig. 79 is a spiral fracture of the tibia with a fracture of the fibula at a much higher level.

Fig. 80 shows the common type of spiral fracture of the tibia as seen from before backwards.

Fig. 81 shows the common type of spiral fracture of the tibia as seen from side to side.

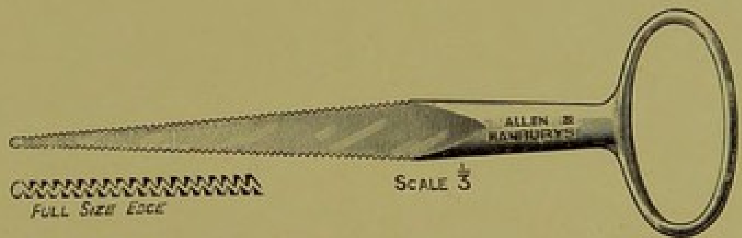
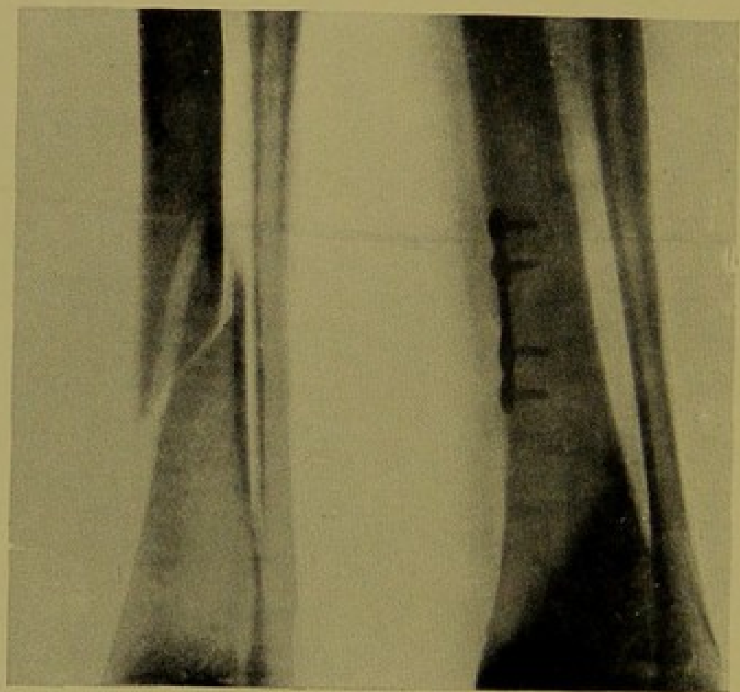


Fig. 84.

Fig. 83 represents the displacement of fragments in a case of fracture of the tibia by torsion followed by a snapping across of the fibula almost on the same level. The fibular fracture in this case is produced by the fall consequent on the yielding of the tibia and not by torsion.

It is necessary to employ very little force to place the spiral surfaces of the tibia accurately in position. The foot is held firmly, a moderate strain being exerted on it. The fragments of the tibia are gripped by the blades of a long, powerful forceps, and, on the principle of the double inclined plane, these bony surfaces are readily moved upwards and downwards on one another by a rotation of the forceps on its long axis. This movement may be assisted by using two pairs of controlling forceps, and in some cases by the introduction between the opposing surfaces of a sharpedged elevator — an instrument which is represented in Fig. 84.

By rotating this on its axis the fragments held forcibly in apposition by the forceps are moved on one another with an irresistible power. The surgeon should not desist till he has obtained accurate apposition of the fragments, and this can always be effected (see Figs. 85 and 86). When comminution is present a second plate is sometimes useful, as



FIGS. 85 AND 86.—Represent a spiral fracture of the tibia treated by operation.

in Figs. 87 and 88. I see many cases which have been operated on in which the fragments have been secured in a faulty position by a plate and screws, not infrequently sinuses leading down to dead bone or to the plate being present also. It is only too apparent that operative interference in the hands of many surgeons has been disastrous to the patient partly from carelessness and partly from ignorance. Too often the operator has attempted to perform the operation without proper instruments or without any familiarity with their use, and with imperfect asepsis. This form of incompetency will probably disappear shortly under the influence of education or as the result of damages in the law courts.

Though a plate and screws form by far the most ready

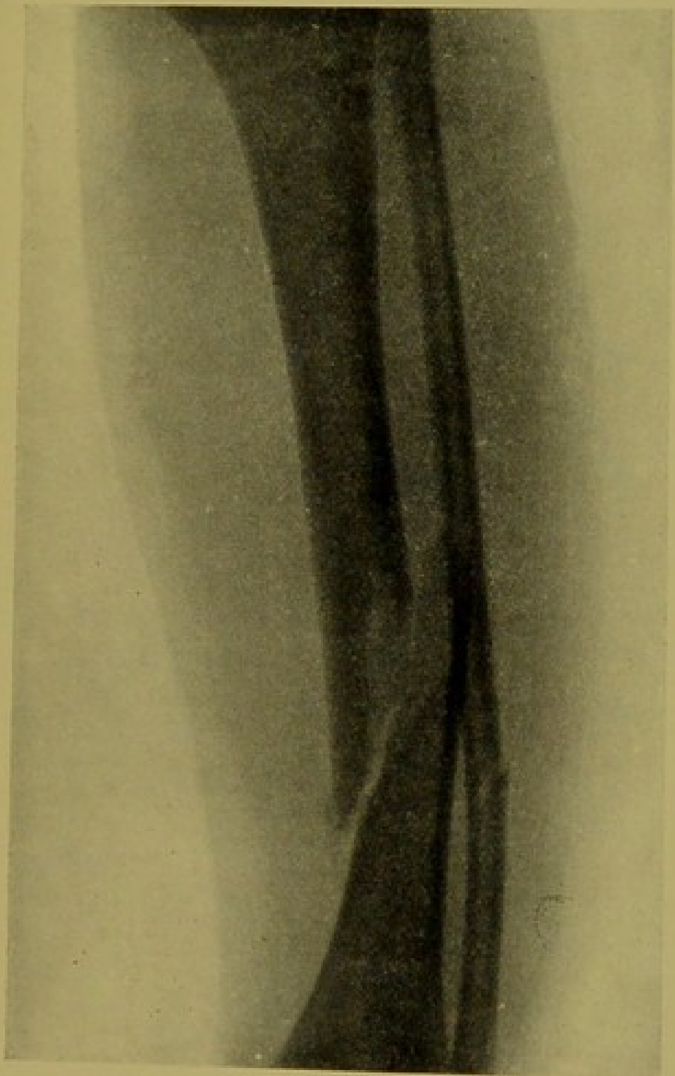


Fig. 87.

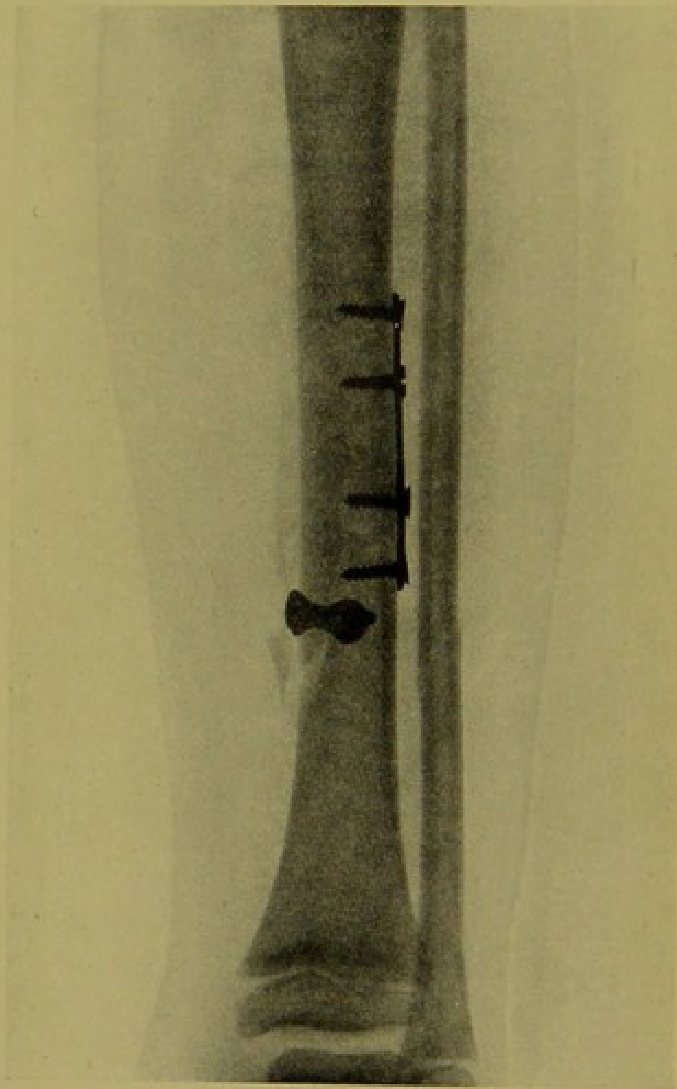


Fig. 88.

means of retaining the fragments of a spiral fracture in accurate apposition, the same purpose may be effected by means of a wire or screw, as is shown in Fig. 89 and Fig. 90.

Fig. 89 is a skiagram of a spiral fracture of the tibia and fibula, in which the fragments of the fibula having been replaced in apposition, were secured by means of stout silver wire which perforated them.

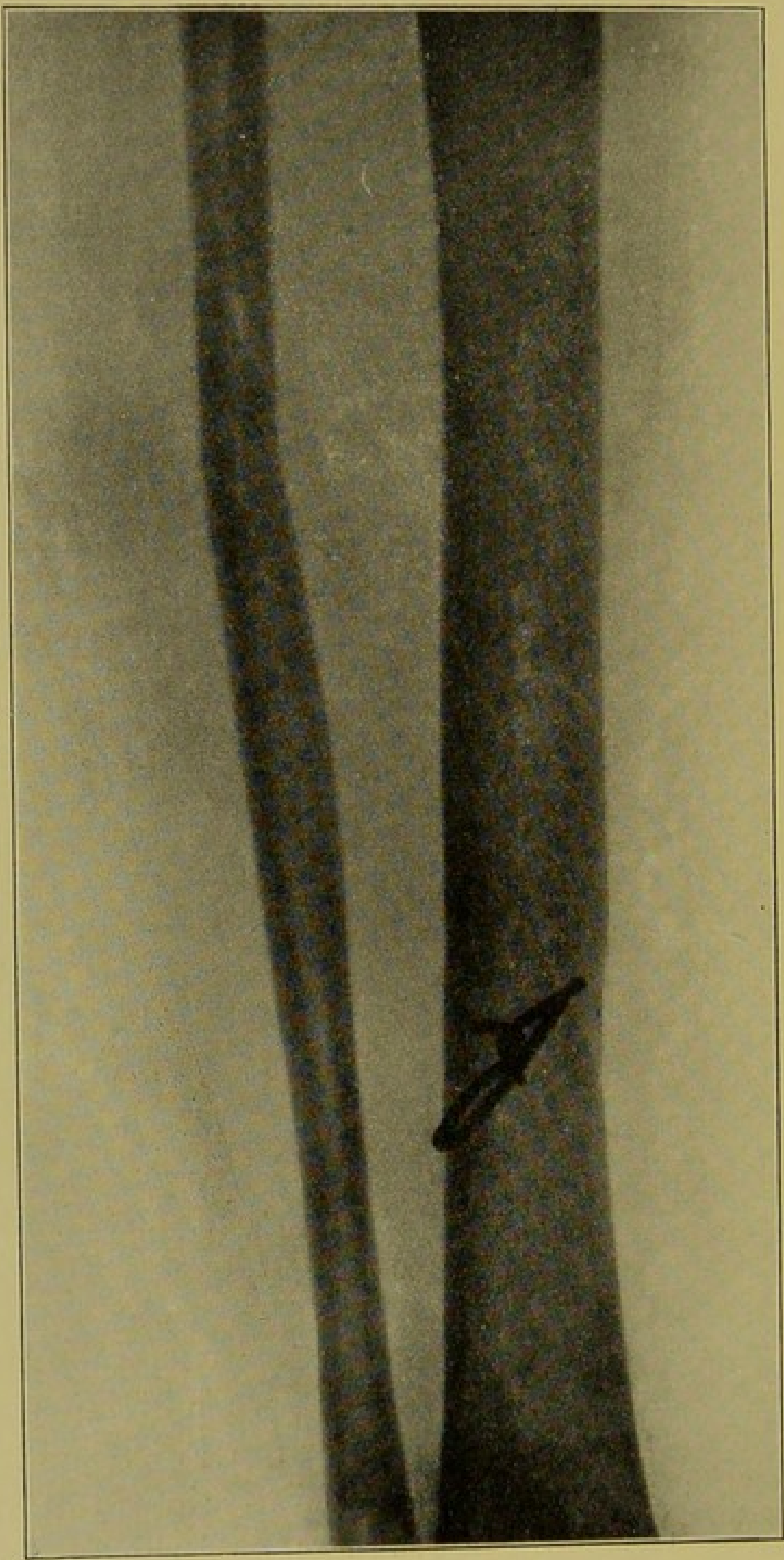


Fig. 89.

The line of fracture of the tibia can be recognised while

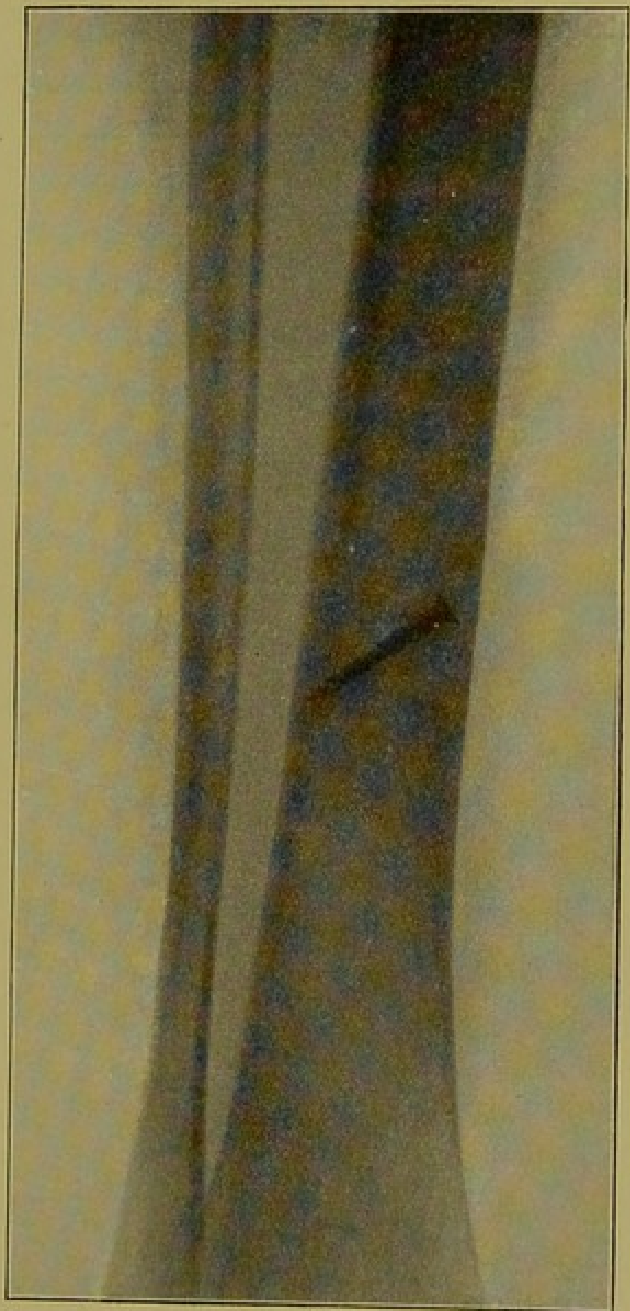


Fig. 90.

the fibular fragments are seen to have fallen into perfectly accurate apposition.

Fig. 90 shows a spiral fracture of the tibia in which the fragments having been replaced in position are held together so securely by a single screw that no indication of the fracture can be seen in the radiogram.

The advantage afforded by the stout steel plate and

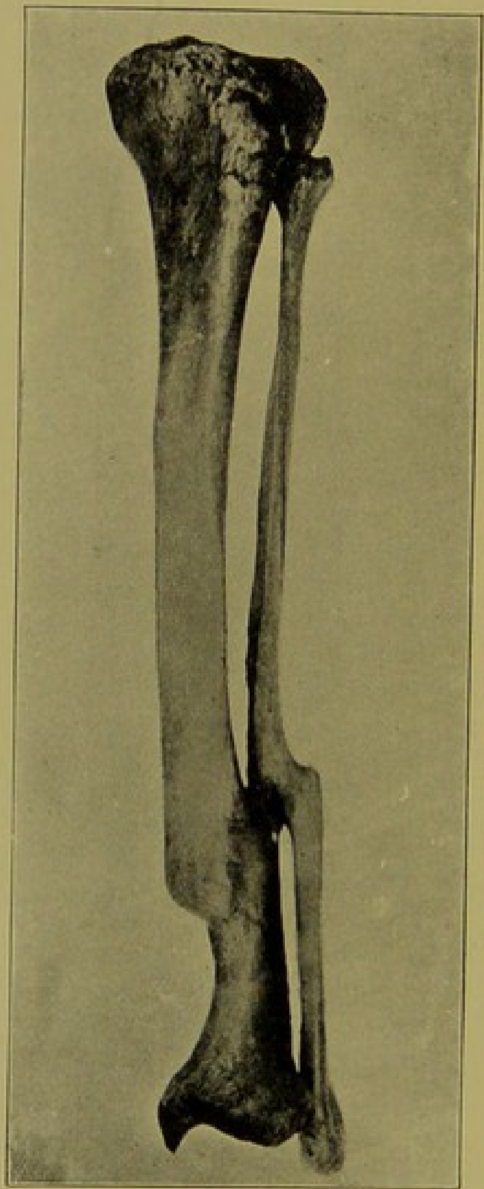


Fig. 91.—Fracture of tibia and fibula.

screws over wire or screws alone is that the surgeon need have no anxiety as to the security of the junction, and consequently the adjacent joints can be moved at an early date and the activity of the muscles can be stimulated by electricity, etc.

Fig. 91 illustrates a fracture of the tibia and fibula produced by direct violence and treated by splints, etc. The lower fragments have been rotated on their long axes through an angle of about 45°.

This faulty position was consequent on the use of the ordinary vertical foot piece which is placed at right angles to the horizontal plane quite irrespective of the fact that in the resting supine posture the thigh rotates outwards till the inner margin of the foot includes an angle of 45° with the vertical. I described the principles involved in a paper in the 'British Medical Journal,' 1893, entitled "The Fallacy of the Vertical Foot-piece."

Fractures of the Femur.

When the femur is broken by indirect violence, the character of the fracture and the form of the fragments are similar to those which exist in a spiral fracture of the tibia and fibula, while the displacement is usually in the same direction, the lower fragment being displaced upwards, backwards, and outwards, and the upper fragment downwards, forwards, and inwards. The torsion of the femur in these cases usually results from a fall upon the abducted foot, the trunk rotating on its axis in the opposite direction upon the abducted femur.

That torsion of the femur may be exerted in various directions is obvious, and the displacement of fragments must vary in consequence.

The force required to break a femur by direct violence is often very considerable, so that in this variety of fracture the laceration of the soft parts may be very great.

The treatment of fractures of the femur is based on precisely the same principles as those of the tibia.

In both varieties the fragments are exposed by incisions, extending, in some cases, along the whole length of the outer aspect of the thigh.

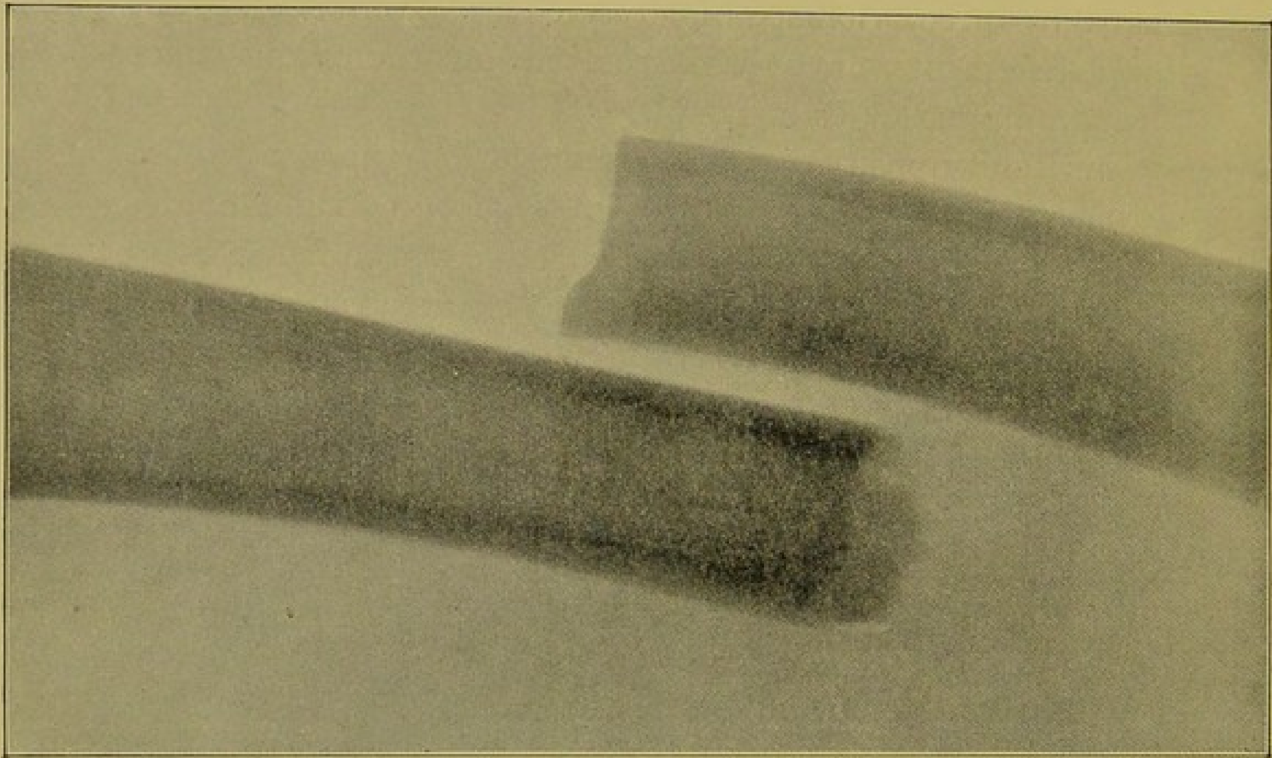


Fig. 92.

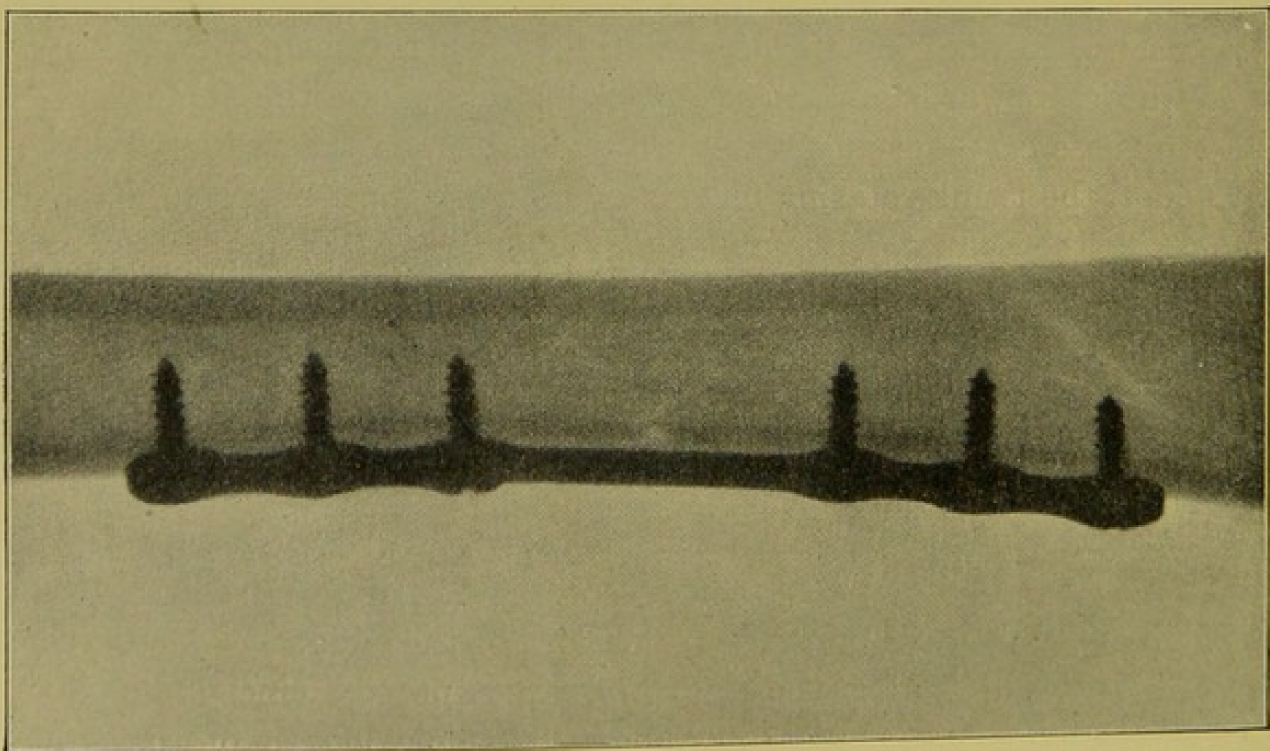


Fig. 93.

If the fracture be the result of direct injury the fragments are held in forceps and are withdrawn from the wound, the lower leg being carried simultaneously over the other leg till the fragments of the femur form an angle of 90° or less with one another in a horizontal plane. The inner edges of the fragments are held in apposition by the forceps. The leg is straightened, while the fragments are forced back into the wound, so that the broken surfaces are brought into accurate apposition, and the bone is

Fig. 94.

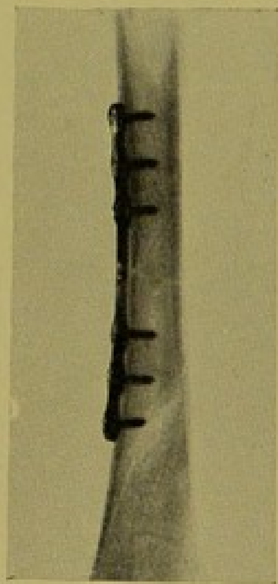


Fig. 95.

restored to its normal form and function. This has already been indicated diagrammatically in Fig. 72. In this manner coaptation is effected with the use of a minimum of force and a maximum of skill, in the simplest and easiest manner possible. The fragments are then retained in position by means of a stout steel plate and screws (see Figs. 92 and 93).

Fig. 92 shows a fracture of the shaft of the femur in a child, about its centre, produced by direct injury.

Fig. 93 shows the result of operative interference.

Figs. 94 and 95 show the same fracture on a smaller scale, but with greater length of bone.

Fig. 96 shows the displacement of fragments in an antero-posterior plane in an old badly united fracture, the

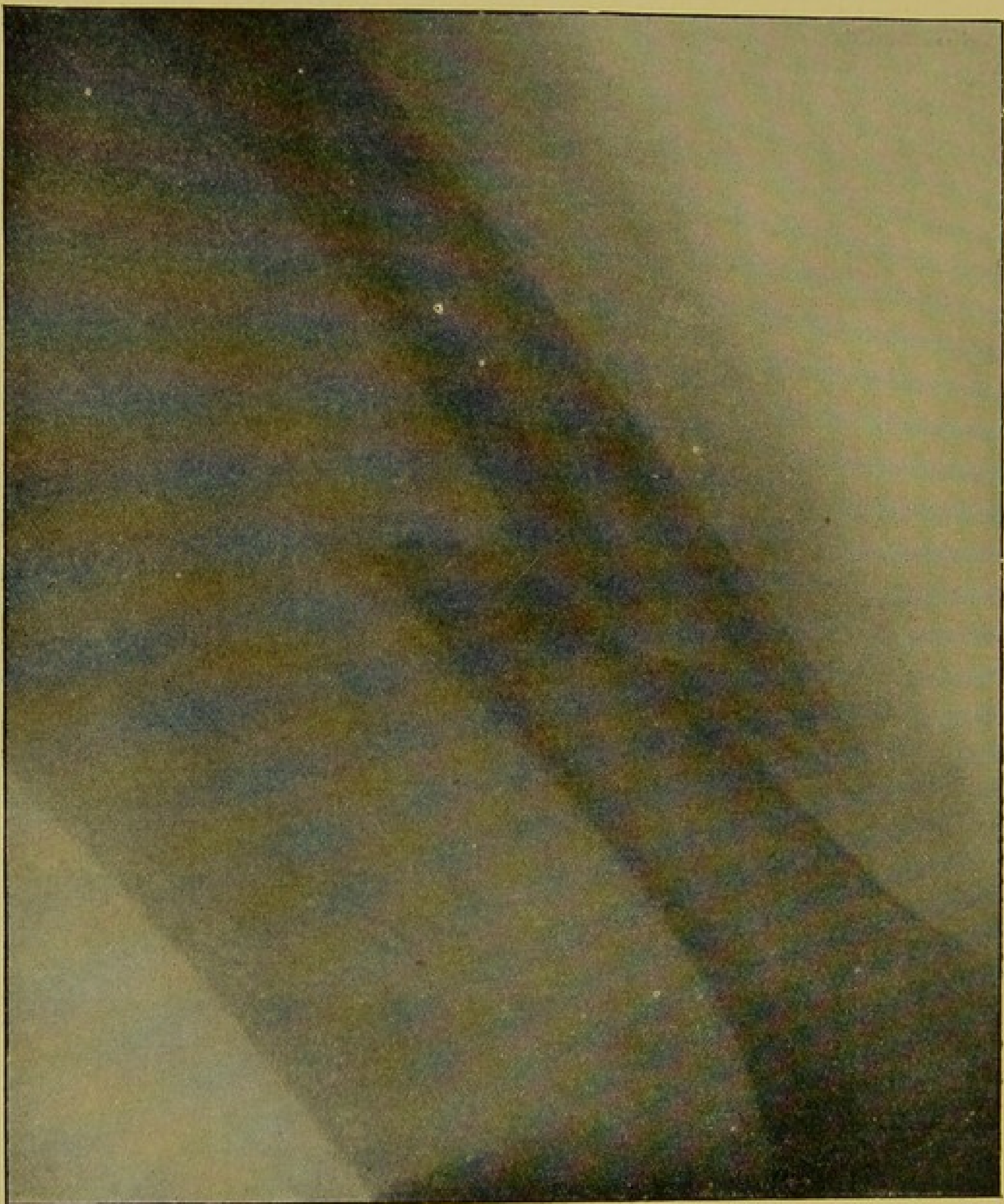


Fig. 96.

result of direct injury. The influence of the malposition of the fragments on the mechanics of the knee joint was disastrous to its functions. The nearer to the extremity of a long bone that the fracture takes place the greater are the alterations in the mechanics and functions of the adjacent joint.

Fig. 97 shows a not uncommon variety of fracture of the upper limit of the shaft of the femur which results from direct violence, for example, from the impact of the bonnet of a motor car. This occurred in a young girl. The difficulties of effecting accurate apposition were very

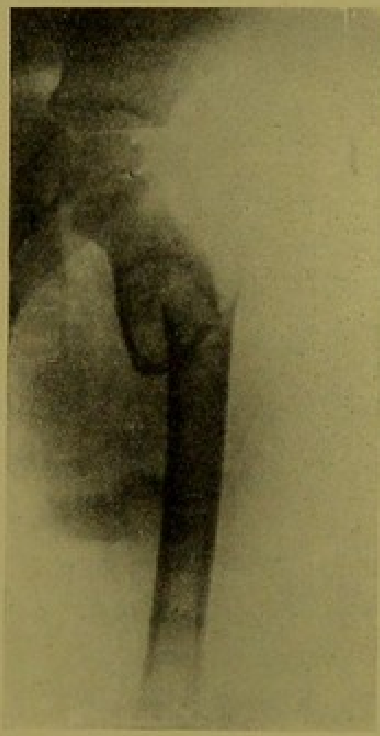


Fig. 97.

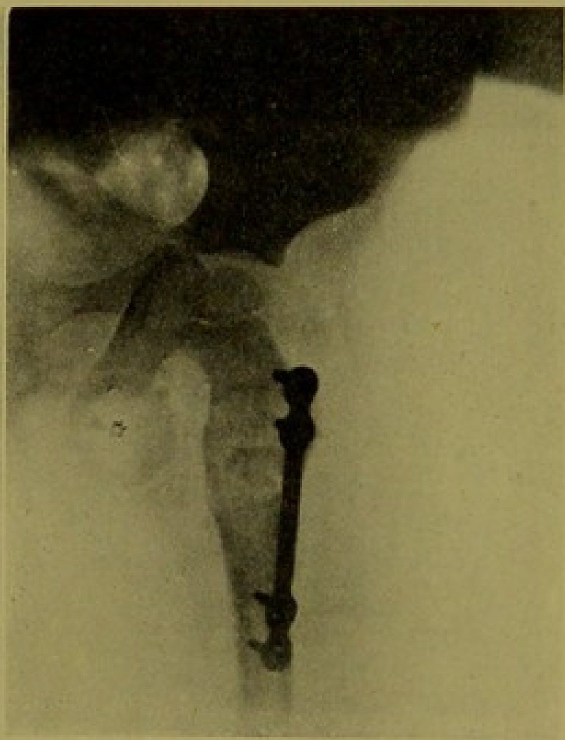


Fig. 98.

materially increased by the fact that it was impossible to grasp the fragile upper fragment in forceps.

The bone was restored to its normal form, the fragments being secured by a plate and screws as illustrated by Fig. 98.

The child obtained a limb that was perfect anatomically and functionally.

I do not hesitate to operate and to ensure a perfect result even when the displacement is inconsiderable. It is obvious that the only way in which a perfect functional result can be obtained for certain is by accurately restoring

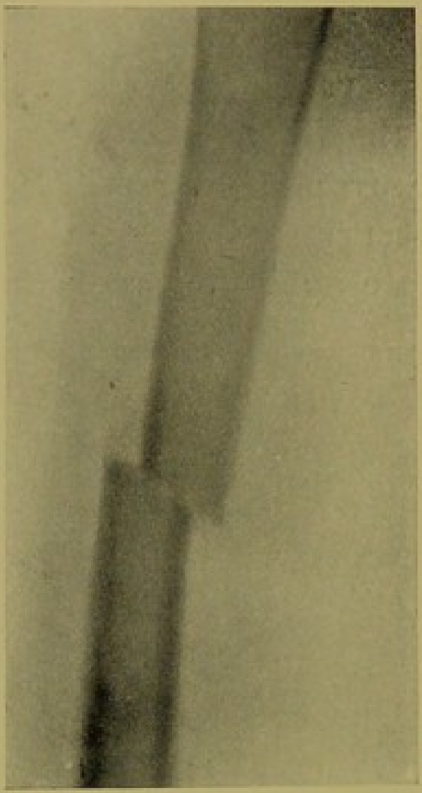


Fig. 99.

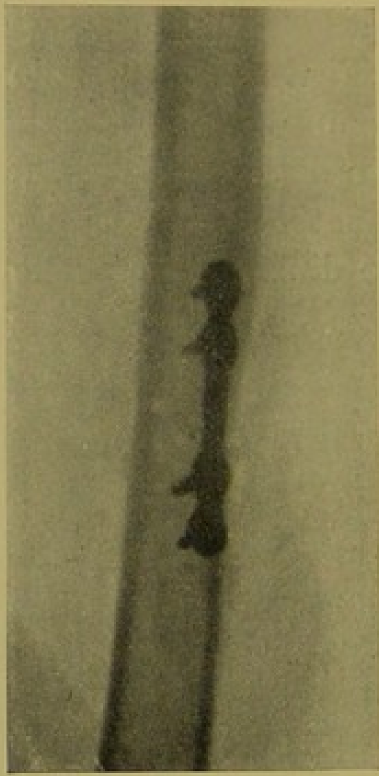


Fig. 100.

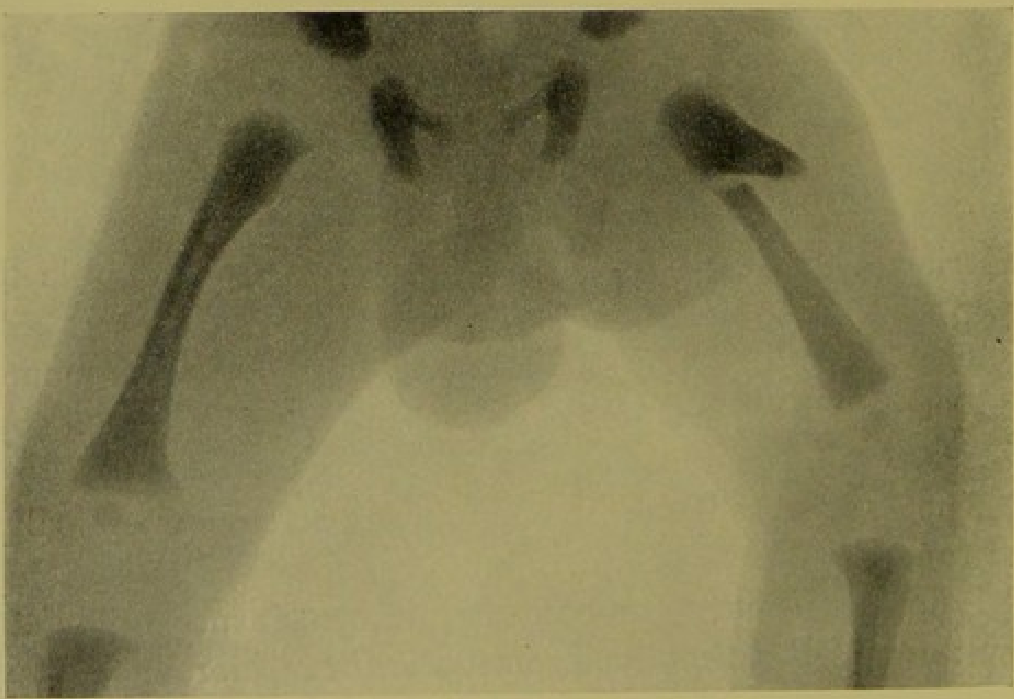


Fig. 101.

the bone to its normal form. This can only be done by operation. Operative treatment not only ensures a perfect anatomical and functional result, but it telescopes the period of disability by enabling the patient to use the

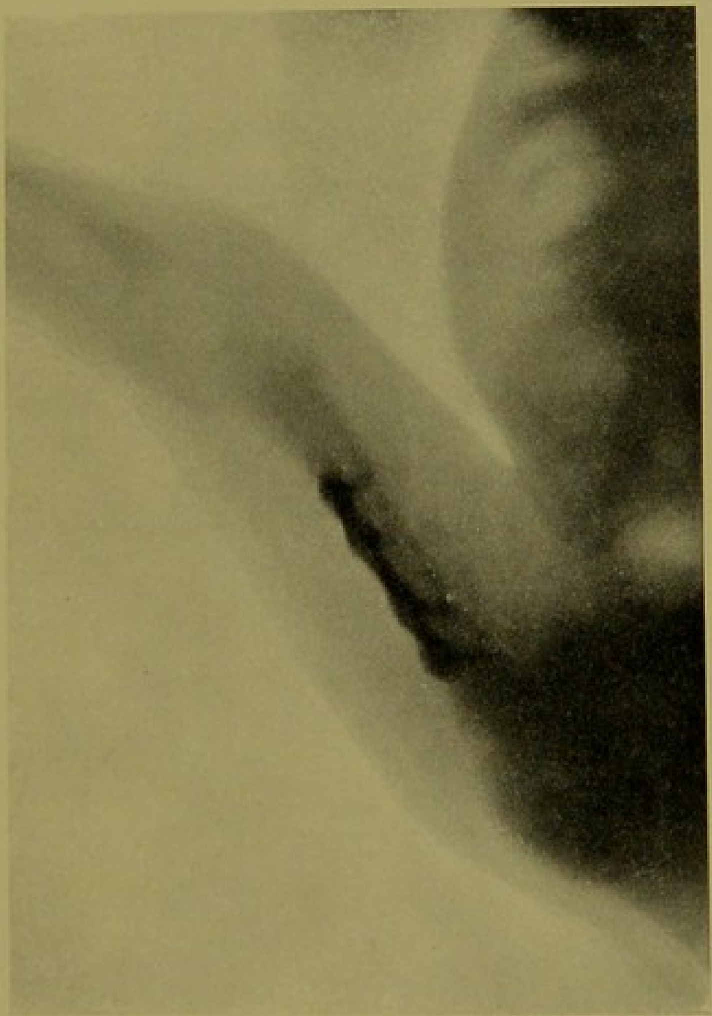


Fig. 102.

muscles and joints of the damaged limb from the date of operation. It also frees the surgeon from any anxiety as to the result, and it relieves the patient from all pain subsequent to this operation.

Fig. 99 shows a fracture of the femur produced by direct violence with comparatively little displacement of fragments, and Fig. 100 the result of operative interference.

Fig. 101 represents a fracture of the femur which was produced at birth. It is obvious, from an examination of the radiogram, that by no possible means could the fragments be replaced in position and retained there by any means other than operative. This was fully confirmed at

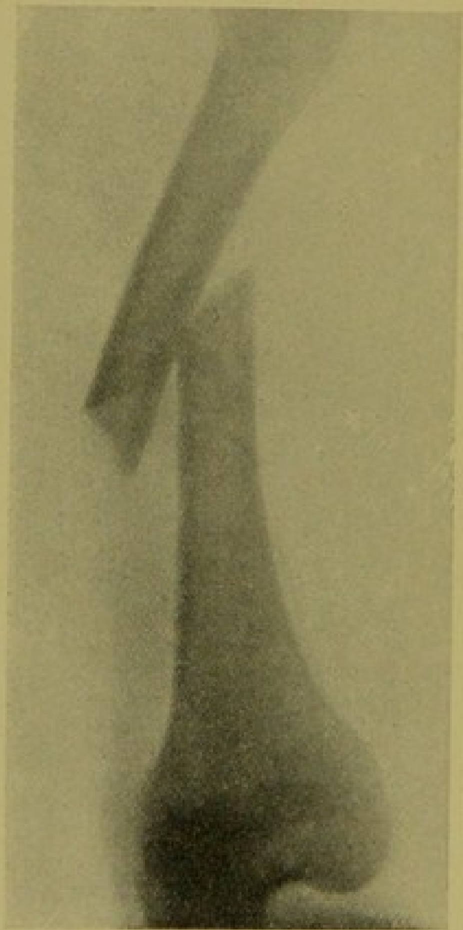


Fig. 103.

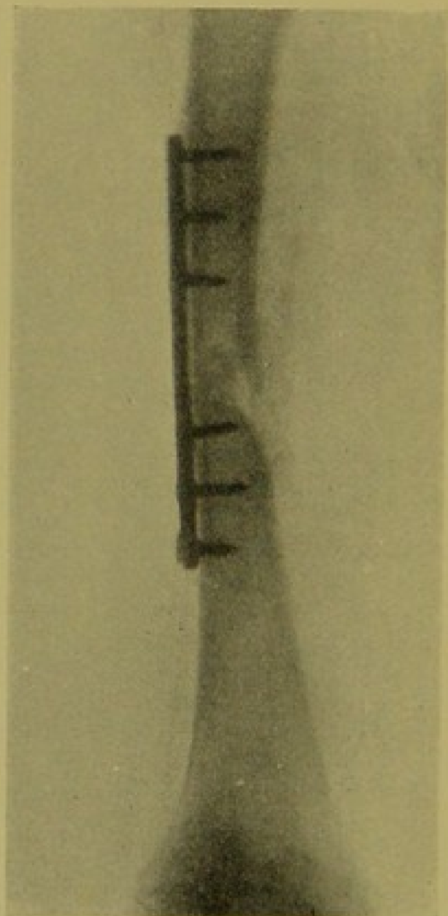


Fig. 104.

the operation when the bone was restored to its normal form and functions. The fragments were secured by a plate and four screws (see Fig. 102, which shows thigh flexed on abdomen).

The operation was performed during the second day of the child's life.

This case alone shows the absurdity of adopting any means other than operative in similar circumstances.

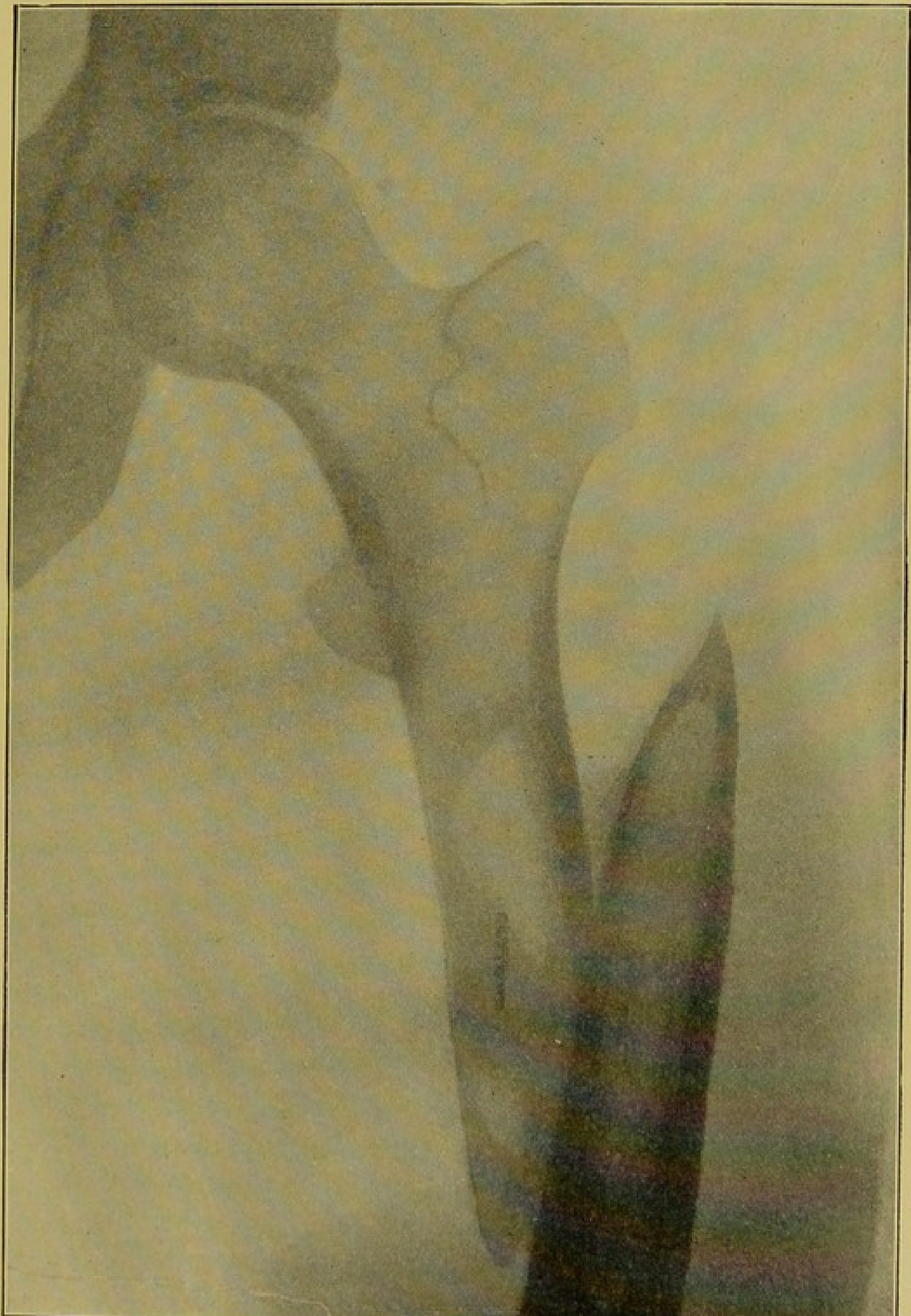


Fig. 105.

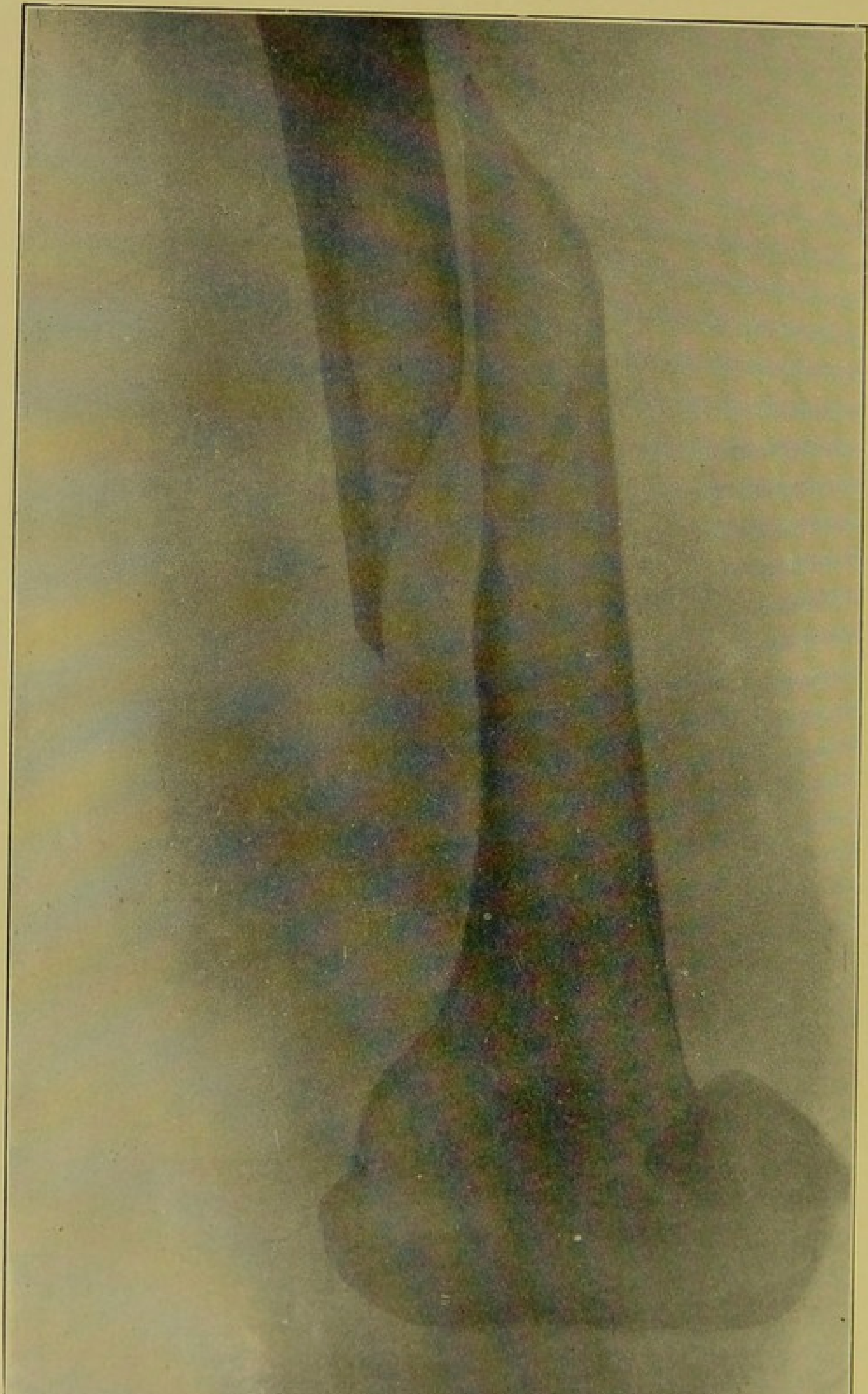


Fig. 106.

Fig. 103 shows a fracture of the femur produced by direct injury and Fig. 104 the result of operation.

Figs. 105 and 106, taken some months after the injury, show the relative position of the fragments of the femur in

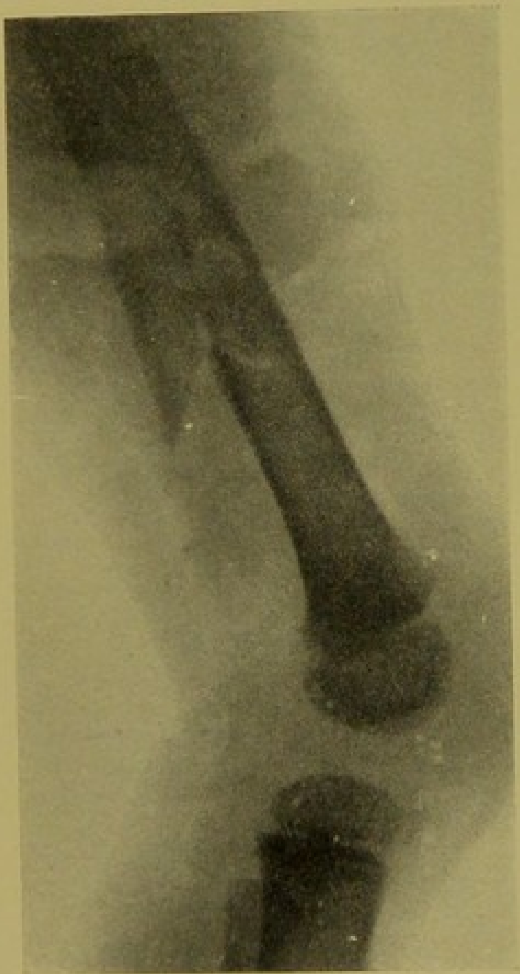


Fig. 107.

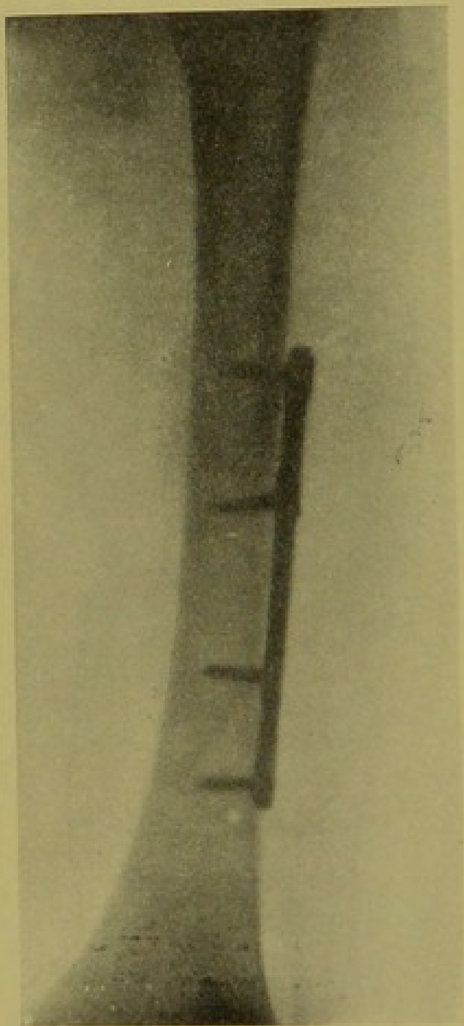


Fig. 108.

cases of spiral or torsion fracture. The ends of the bone have undergone changes consequent upon the lapse of time.

Fig. 107 shows a recent spiral or torsion fracture of the femur, and Fig. 108 the result of operative interference. When the femur is broken spirally the fragments are restored to their normal position by holding the leg in a condition of strain and by manipulating the fragments upon one another by means of a couple of long powerful forceps, which readily control them. The shorter the spiral fracture the more difficult is it to secure perfect coaptation, since one spike or one edge so readily gets beneath the other fragment. A short spiral fracture of the femur in a

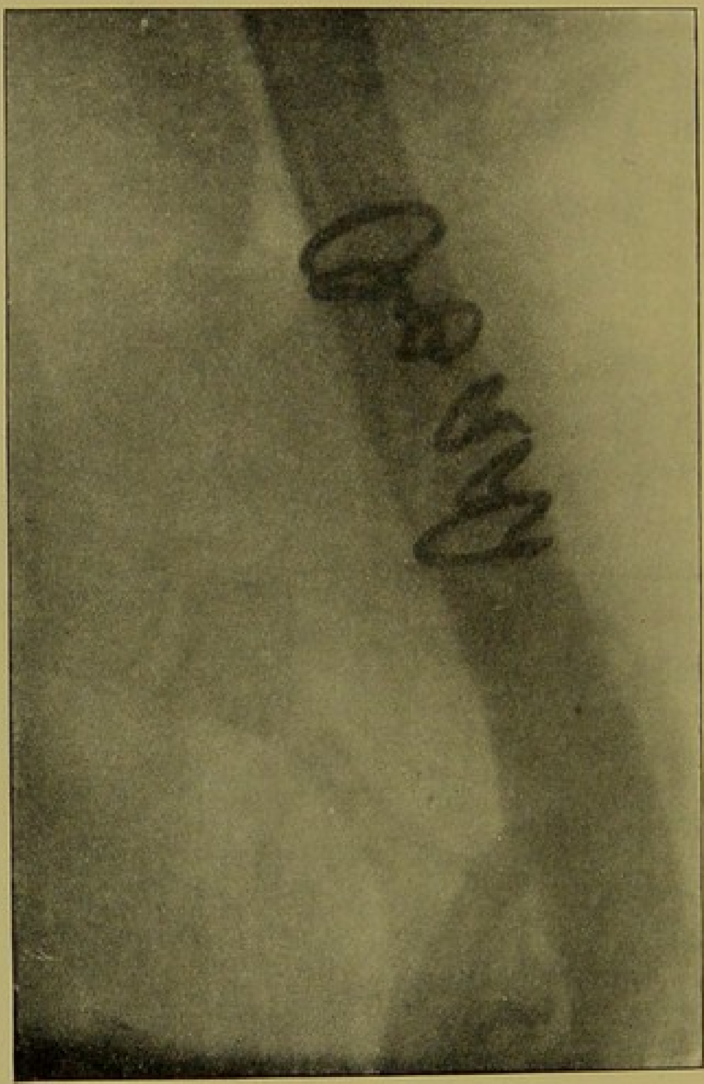


Fig. 109.

young child may make great demands on the skill and patience of the surgeon and his assistants.

No surgeon possessed of an atom of sense would ever imagine that the removal of a spike or portion of a fragment could possibly facilitate the restoration of the bone to its normal form. I mention this as I have known large portions of spiral fractures of the femur removed and very considerable shortening and disability result from the incapacity of the surgeon.

If much comminution of fragments exists it is best to secure a long steel plate with continuous holes to the stronger and stouter fragment, which is usually the lower, and then to connect up the intervening fragments to the

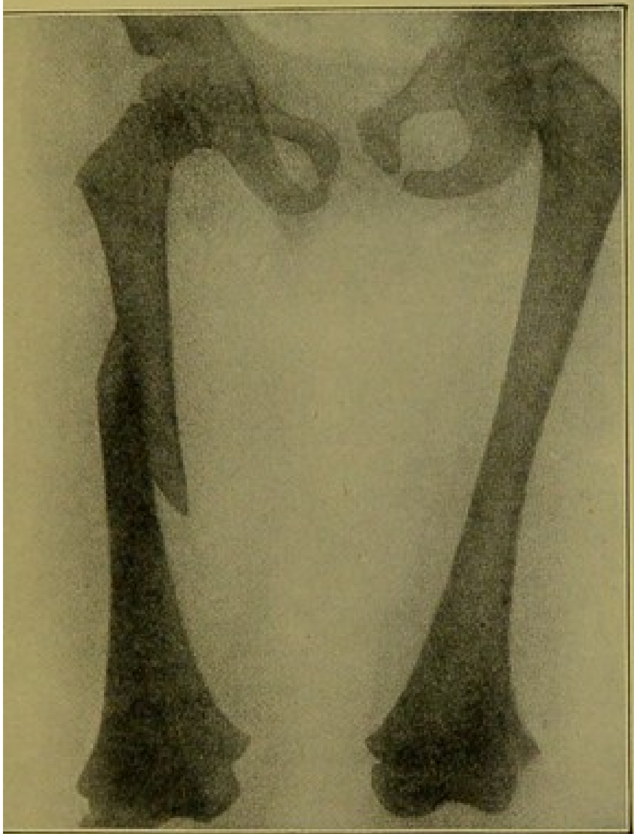


FIG. 110.

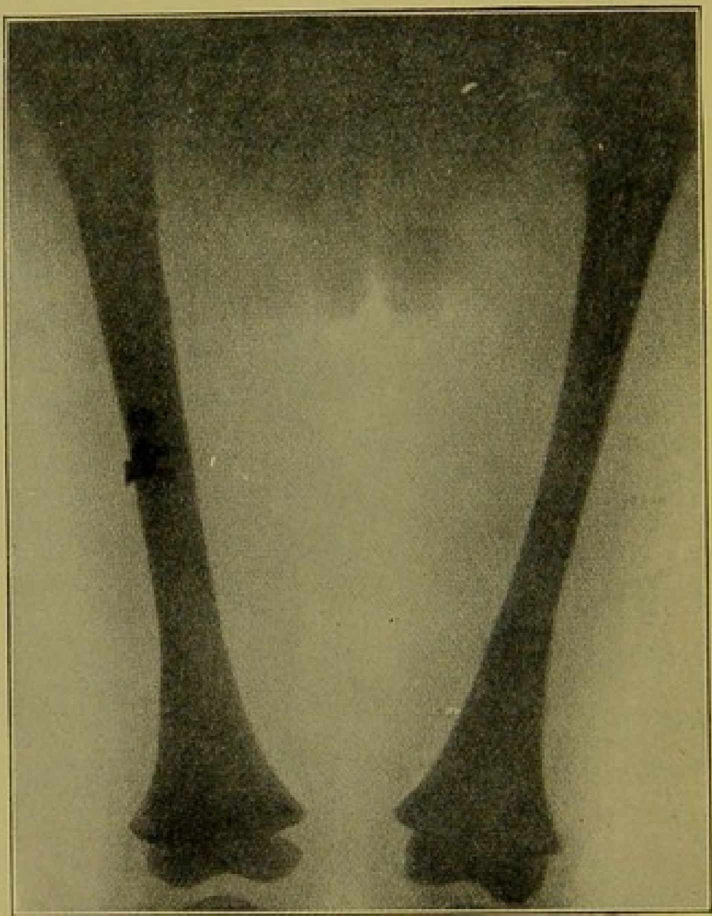


FIG. 111.

plate, finally fastening the plate to the upper fragment. In some cases it may be necessary to employ a number of small plates in addition, in order to fasten the smaller fragments together.

Sometimes the bone may be too thin to hold screws, when the surgeon must employ such other methods as he can devise in the circumstances. For instance, Fig. 109 represents a spiral comminuted fracture of the femur of an old woman, whose hip-joint had been ankylosed since childhood in a position of considerable flexion and abduction. As the bone, from age and want of use, was too thin to afford any secure grip for screws, wire loops, which perforated the several fragments, were employed with complete success.

Figs. 110 and 111 show before and after operation a long

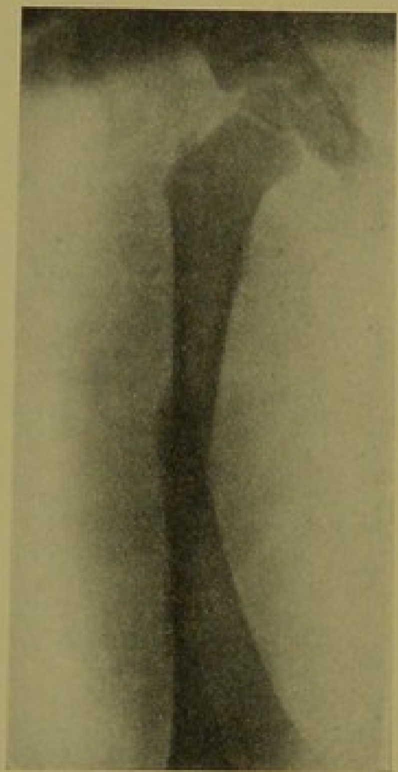


Fig. 112.

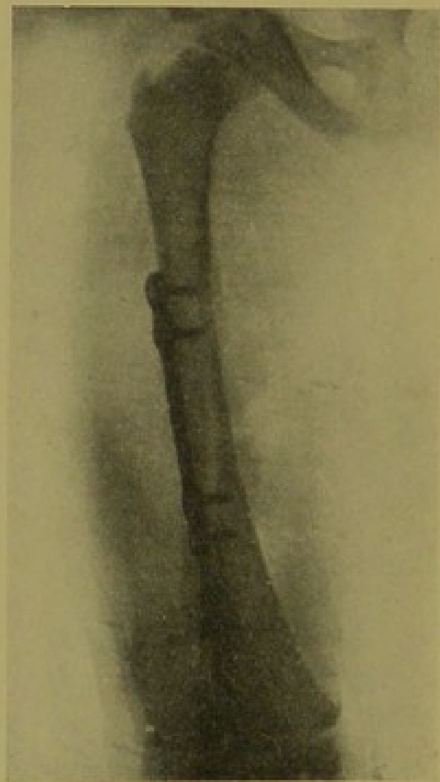


Fig. 113.

spiral fracture of the femur treated by a plate fixed transversely to the length of the shaft, supported by an additional screw. This is not so secure as the long vertical plate.

Figs. 112 and 113 show a spiral fracture of the middle of the shaft of the femur, with the result of operation.

Sometimes the spiral fracture is exceedingly short, and superficially approaches the result of a direct injury in its character. As in spiral fractures of the femur generally, the result of treatment other than operative is most unsatisfactory.

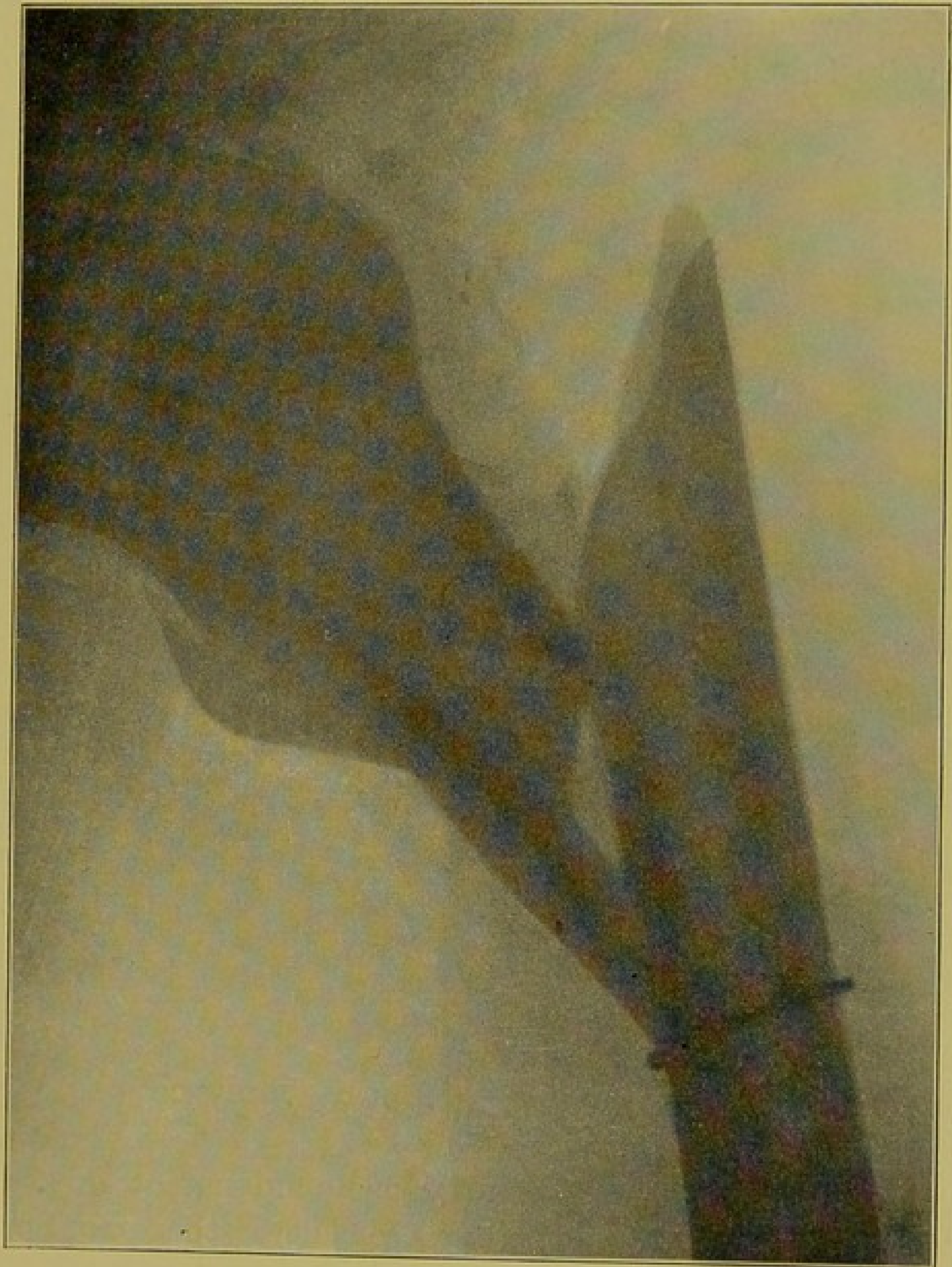


FIG. 114.

In several cases of fracture of the femur which had been previously treated by extension, the fragments were cleared of recent callus, and the bone restored to its normal form. Curiously the callus which had already formed (previous to the operation) continued to develop in spite of the fixation of the fracture. This is always the case. Nature provides abundant callus to fill in the large interval between the displaced fragments, and apparently she is

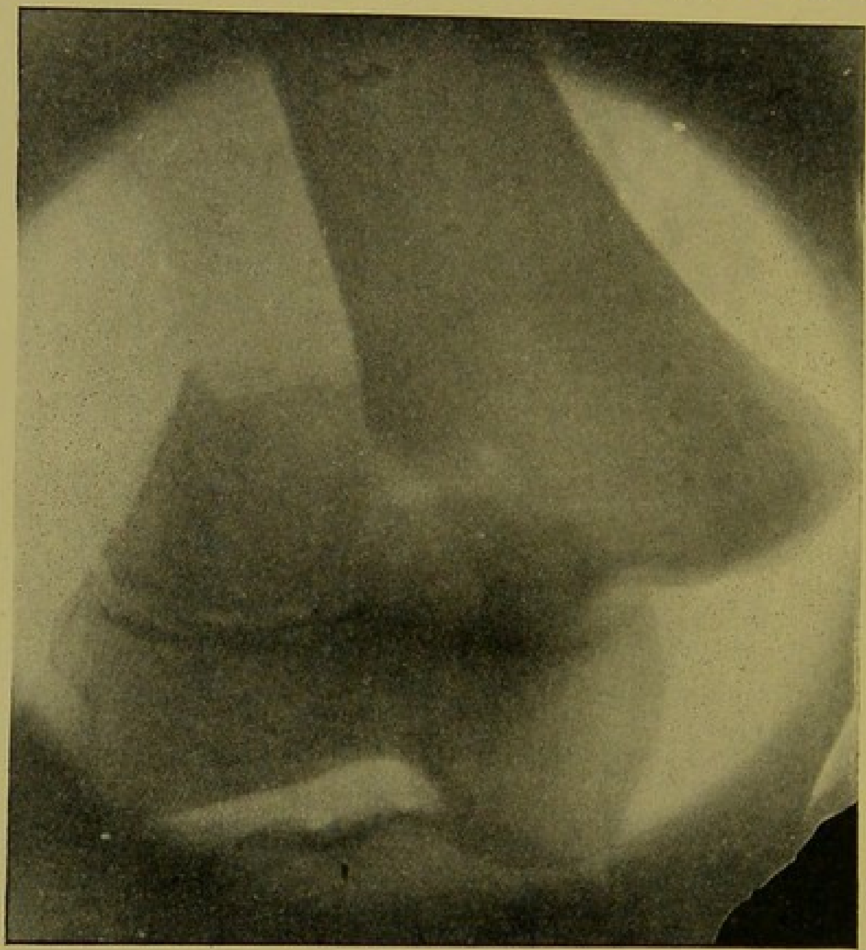


Fig. 115.

unable to stop its formation when it suddenly ceases to be requisite.

Fig. 114 shows how a surgeon should not attempt to treat a fracture. When one considers the enormous leverage exerted by the leg, to apply an encircling loop of wire to a spiral fracture of such a bone as the femur is manifestly useless.

In all fractures of the femur the surgeon should bear in mind the great importance of moving the knee-joint at the earliest possible moment. I have experienced far more trouble in dealing with ankylosis of the knee consequent on the usual treatment of fracture of the femur by splints, etc., than I have in restoring the displacement of the fragments by operation. For this purpose I employ a splint which was devised by Mr. Harold Chapple, and which is illustrated later.

The surgeon should not control a growing line by a plate or other means. If he is obliged to do so in order to retain the fragments in position, he should remove the control when union has taken place. As I pointed out, "the rate of growth in the several portions of a growing line varies inversely as the pressure transmitted," and a neglect to remove the controlling apparatus results in a cessation of growth over the area of the growing line that is affected.

Fig. 115 shows a fracture partly through the inner part of the epiphysial line, and partly through the shaft of the femur. The fragments could be replaced in apposition by force, but it was impossible to retain them without the use of some apparatus.

Consequently, I introduced several staples, as they were more adaptable to the situation than a plate (see Fig. 116). I did so on the understanding that I was to be permitted to remove them when union had taken place. When the boy got well the parents refused to allow of their removal. When I saw him a year later he had developed a bowing of the leg, due to cessation of growth in the inner segment of the growing line.

Fractures of the upper end of the femur are often best treated by operation.

So-called intra-capsular fracture of the neck of the femur is produced by the yielding of the neck at or near its point of impact against the margin of the acetabulum.

If the bone is sufficiently dense to render it probable that it will afford enough grip for a screw, the neck and outer surface of the trochanter should be freely exposed, when the edges of the fragments can be coapted accurately and retained in position by two or more screws passing through the great trochanter, neck and head of the bone from without inwards. Great care should be taken in

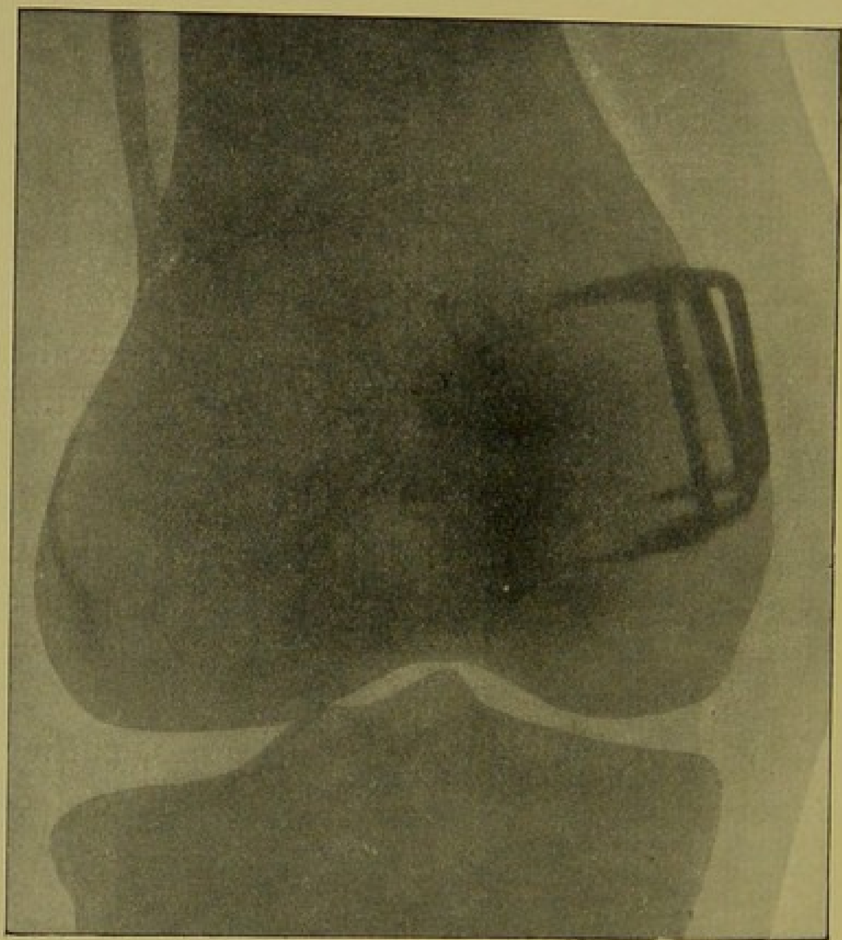


Fig. 116.

ensuring that the screws employed are not too long, otherwise they may perforate the cartilage of the head, or even the acetabulum. Measurements obtained from a good radiogram will eliminate this risk. In fractures of the neck of the femur produced by a fall on the trochanter, commonly called extra-capsular, if operation appears advisable to restore the form of the bone, the seat of fracture should be exposed in front, the fragments should be put in position

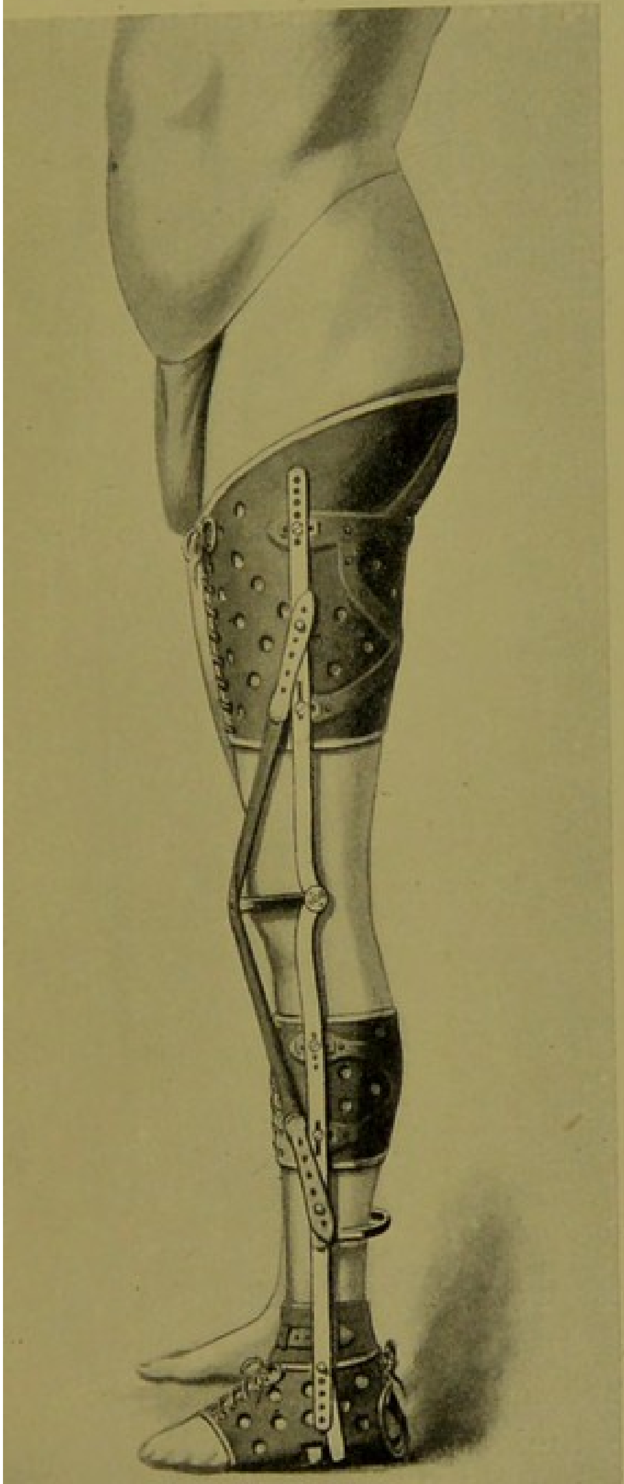


Fig. 117.

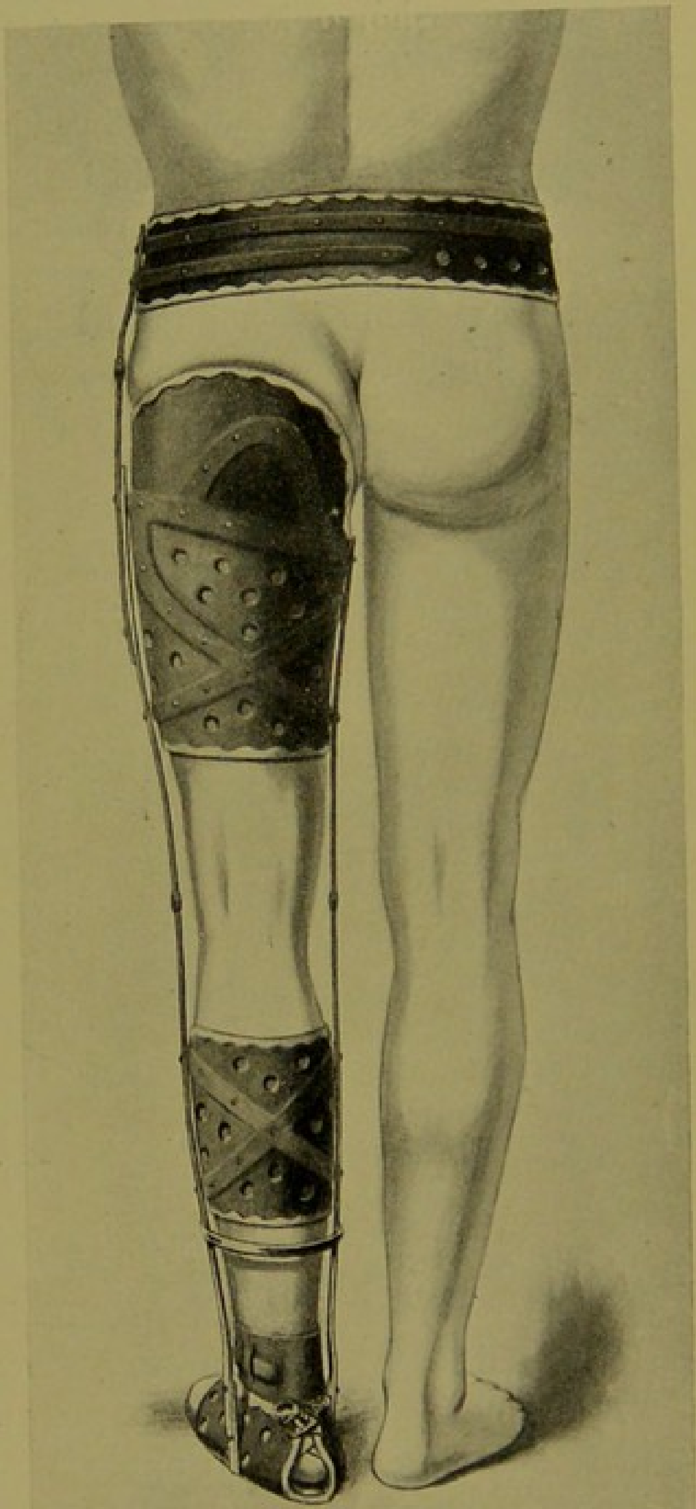


Fig. 118.

and retained as securely as possible by means of plates and screws fixed to the anterior and outer aspect of the bone.

Should it not seem advisable to operate, I have found Hoefftcke's ambulatory splint most useful, especially in fractures of the neck in old and feeble subjects.

Figs. 117 and 118 represent Hoefftcke's splint and show how counter-pressure is obtained by the impact of the upper part of the splint on the tuber ischii, while extension is maintained by the use of a spat as shown in Fig. 119.

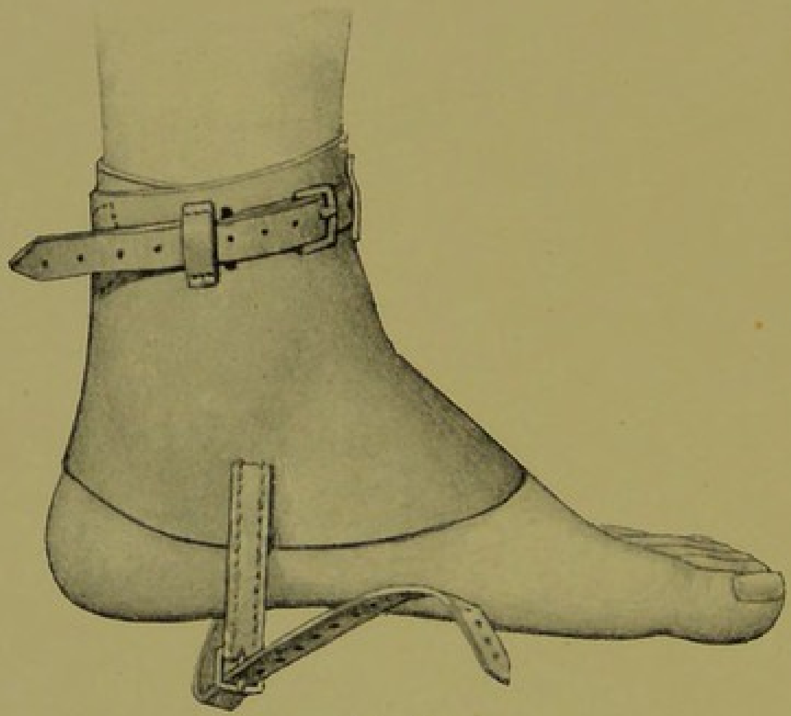


FIG. 119.

Fractures of the Patella.

Fracture of the patella is best treated by the use of a thin steel plate and two screws. In some cases it may be necessary to use two plates, especially when the bone is comminuted. To apply a plate the fragments should be brought into accurate apposition and held securely in a powerful pair of forceps. For this purpose I employ a forceps with very long sharp curved teeth which, perforating the muscles and tendon above and below the patella, force and hold the broken surfaces together. The front of the patella is cleared of all fibrous tissue over a sufficiently large area, and the plate is bent to fit the surface of the bone accurately. A couple of screws, usually No. 5 gauge and half an inch long, are introduced. By this means a coaptation of the fragments is secured, which is more accurate and more efficient than can be obtained in any other way. (See Figs. 120 and 121, which show a fracture of the patella before and after operation.)

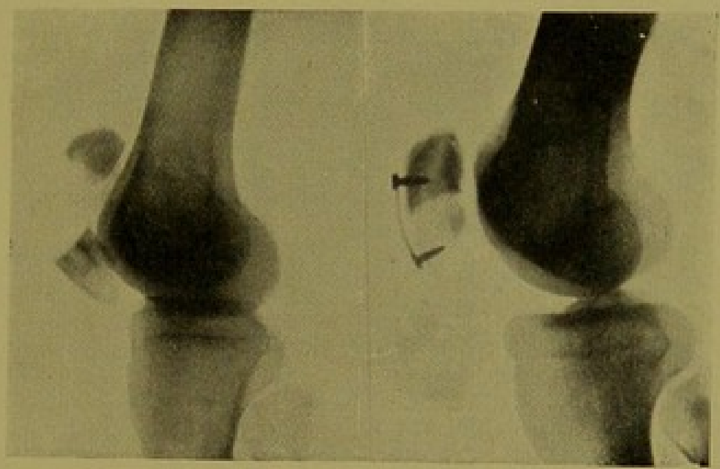


Fig. 120. Fig. 121.

Fractures of the Upper Extremity.

Fractures of the Scapula.

Fractures of the scapula occasionally call for operation, and their performance is at times very difficult. Sometimes the displacement, which may be most disabling in its consequences unless the fragments can be accurately coapted by operation, can be dealt with in a very simple manner. This is well illustrated by the following case.

Fig. 122 shows a vertical fracture passing through the spine and body of the scapula. In addition to this the acromion had been torn away from the outer end of the clavicle. In consequence the outer fragments, carrying the shoulder, had dropped downwards and forwards in such a manner as to disable the man, who was a labourer, from continuing to follow his employment.

I exposed the spine of the scapula at the seat of fracture, and by manipulating the fragments on one another was enabled to restore the scapula to its normal form. The fragments were retained in apposition by means of a plate and four screws secured to the free edge of the spine. The anatomical and functional result was perfect (Fig. 123).

It was unnecessary in this case to secure the acromio-

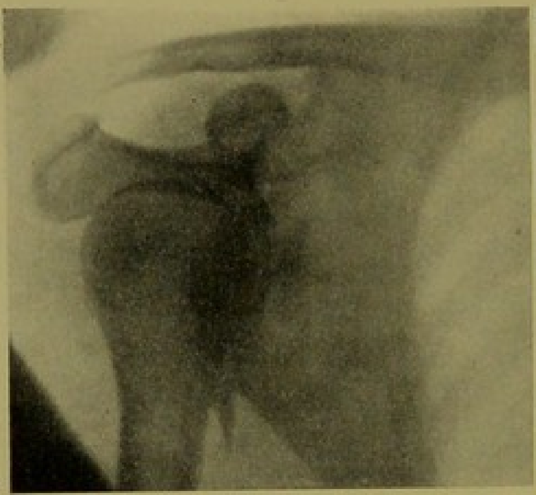


FIG. 122.

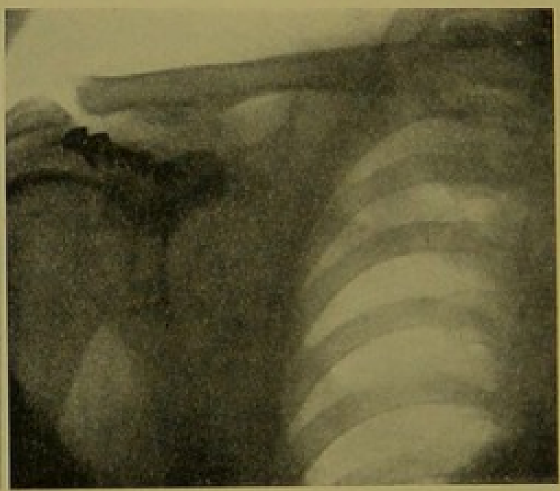


FIG. 123.

clavicular joint by means of a plate and screws, as I usually do when this articulation is dislocated, since the joint was restored to its normal form by the operation on the scapula.

Fractures of the Clavicle.

Fracture of the clavicle results from the transmission through its outer end of a force greater than it is able to bear. The clavicle usually behaves as a lever of the second order, the sterno-clavicular joint forming the fulcrum and the point of impact on the first, and, later, on the second costal arch, the points through which the weight is transmitted.

When the clavicle yields, the outer fragment holding the upper extremity falls forwards and downwards. Union in this position results in a shortening of the clavicle and in an alteration in the relationship of the shoulder-joint to the trunk.

A moderate amount of shortening and displacement impairs but slightly the function of the shoulder-girdle, but if it be marked, deformity and disability may be considerable.

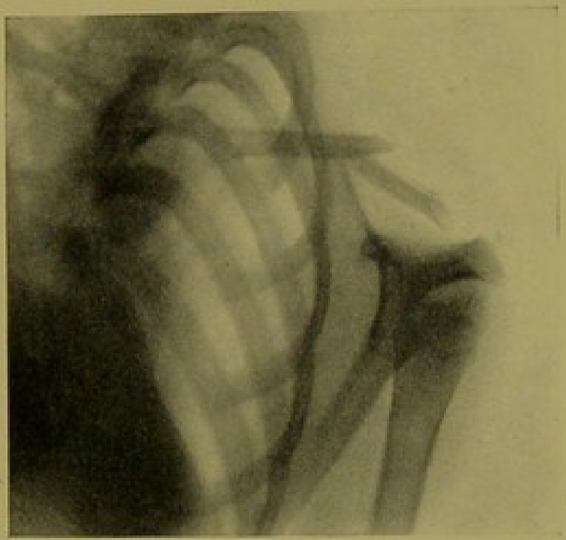


Fig. 124.

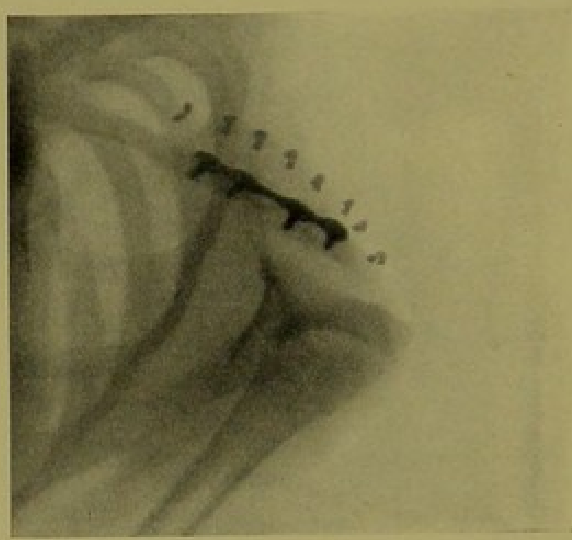


Fig. 125.

Not infrequently the fracture is comminuted and a wedge-shaped fragment, which is usually derived from the lower portion of the bone, may be displaced in various directions and cause harm and inconvenience.

No bone lends itself more readily to operative interference than the clavicle, since it lies immediately beneath the skin and its texture is always of sufficient density to hold screws securely.

The only risk in the operation is that, in the hand of a clumsy operator, the drill may perforate the distal compact tissue and damage the subclavian vessels.

In society women the objection of a scar in a somewhat conspicuous situation is to be balanced against the deformity and disability.

Fig. 124 shows the displacement of the outer end of the clavicle and of the shoulder and arm in a case of fracture in a child, aged 8 years, and Fig. 125 illustrates the result of operation. The Michel clips had not yet been removed.

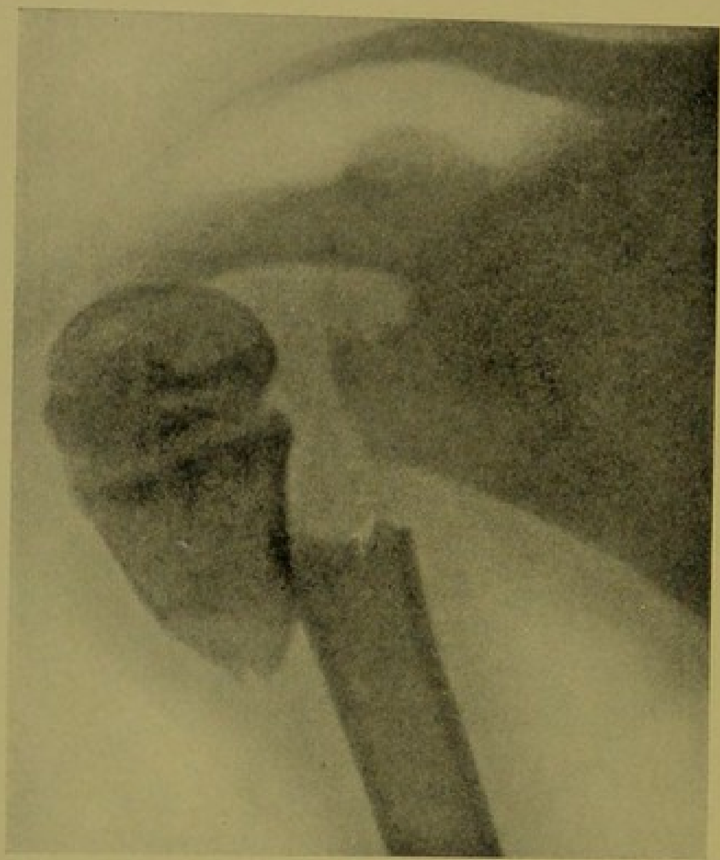


Fig. 126.

The shoulder was restored to its normal form and the functions of the clavicle were perfect.

Fractures of the Humerus.

Fractures of the humerus must be treated on their merits. The accurate replacement of fragments is not as important in the upper as in the lower extremity, since in the latter the weight of the body is transmitted through the femur and tibia. Still, there is a large number of fractures of the humerus, especially those in the vicinity of joints, where operative treatment is the only means by which accurate apposition of fragments can be effected.

Spiral fractures are less common than fractures produced by direct injury, since, except in complete flexion, the shoulder joint does not afford a sufficiently secure hold on

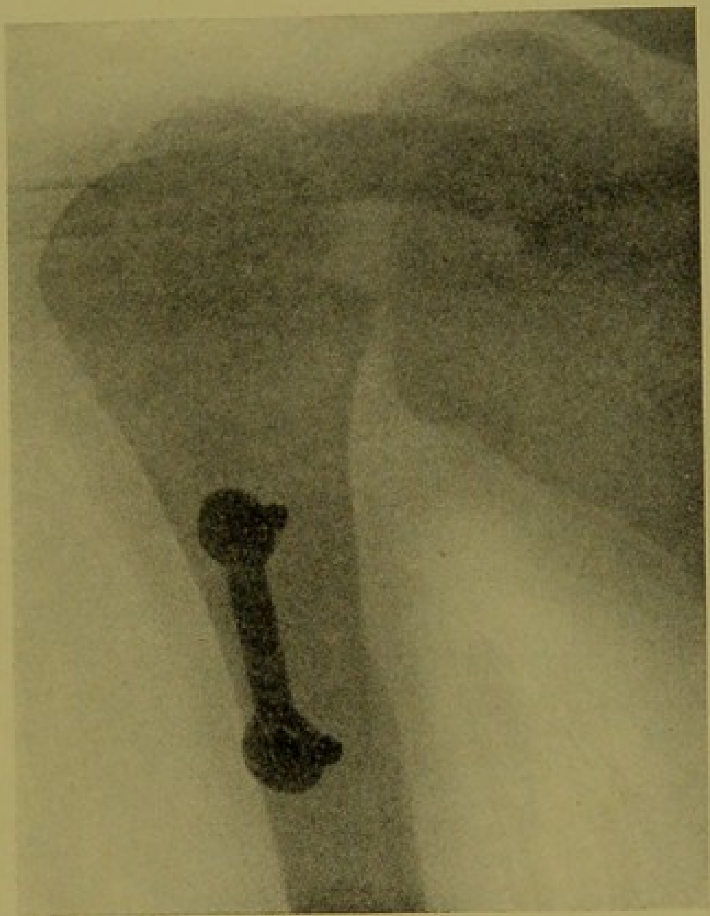


Fig. 127.

the humerus to permit of torsion acting efficiently.* The distinction between fractures produced by direct and indirect violence is of less moment than in the lower extremity since the ties in the length of the limb in the upper limb are much less taut, and apposition, whether of a spiral fracture

* On the mode of fixation of the scapula suggested by a study of the movements of that bone in extreme flexion of the shoulder-joint, and its bearing on fracture of the coracoid process ('Trans. Roy. Med.-Chir. Soc.,' 1888; also in 'Brit. Med. Journ.,' 1887, p. 1048).

or of the blunt ends of a direct fracture, is effected with very much less difficulty.

Fig. 126 illustrates a fracture of the upper part of the shaft of the humerus produced by direct injury and represents a common type of fracture. Its locality may vary, either approaching the head, or being placed somewhat

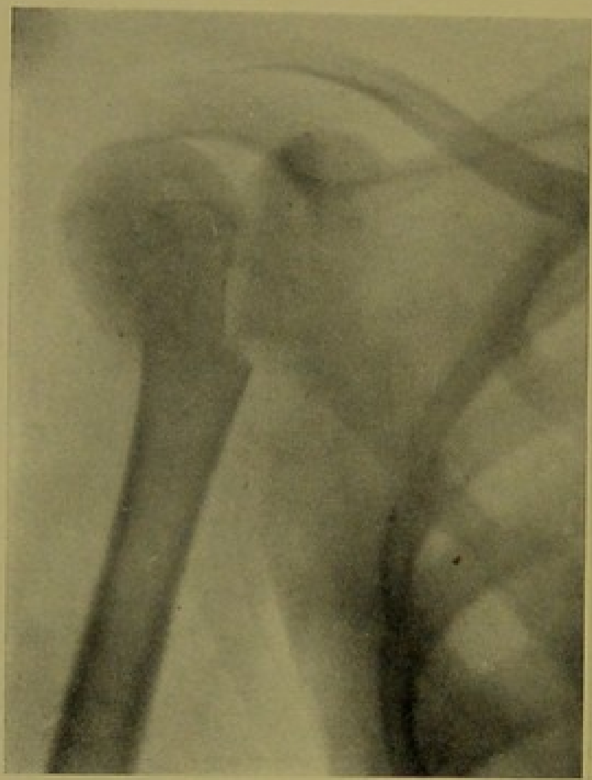


Fig. 128.

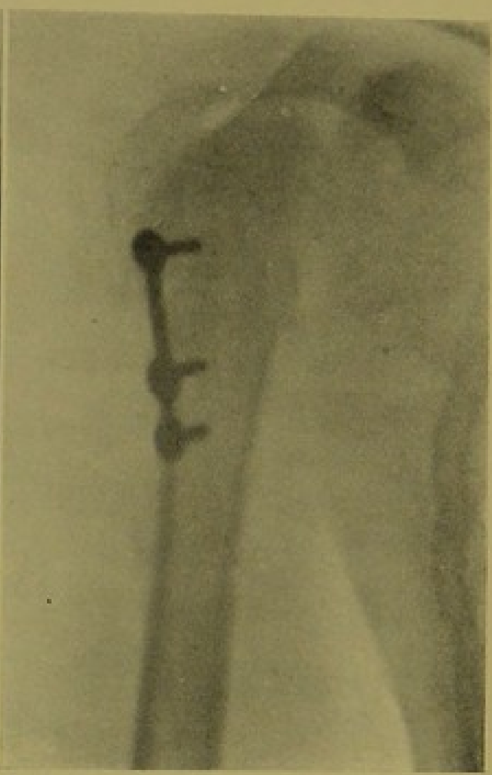


Fig. 129.

lower down than in this instance. The operative treatment is more difficult the higher the fracture.

Fig. 127 shows the fragments replaced in accurate apposition and retained by means of a steel plate.

The anatomical and functional results of the operation were perfect.

Fig. 128 shows a fracture of the upper part of the shaft of the humerus produced by direct violence. The upper end of the lower fragment was displaced inwards, forwards and upwards. It was impossible to place the fragments in apposition even with the help of X-rays.

The fracture was exposed by an incision through the anterior margin of the deltoid. The fragments were grasped with forceps and were placed in accurate apposition, and were secured by means of a plate and screws. The

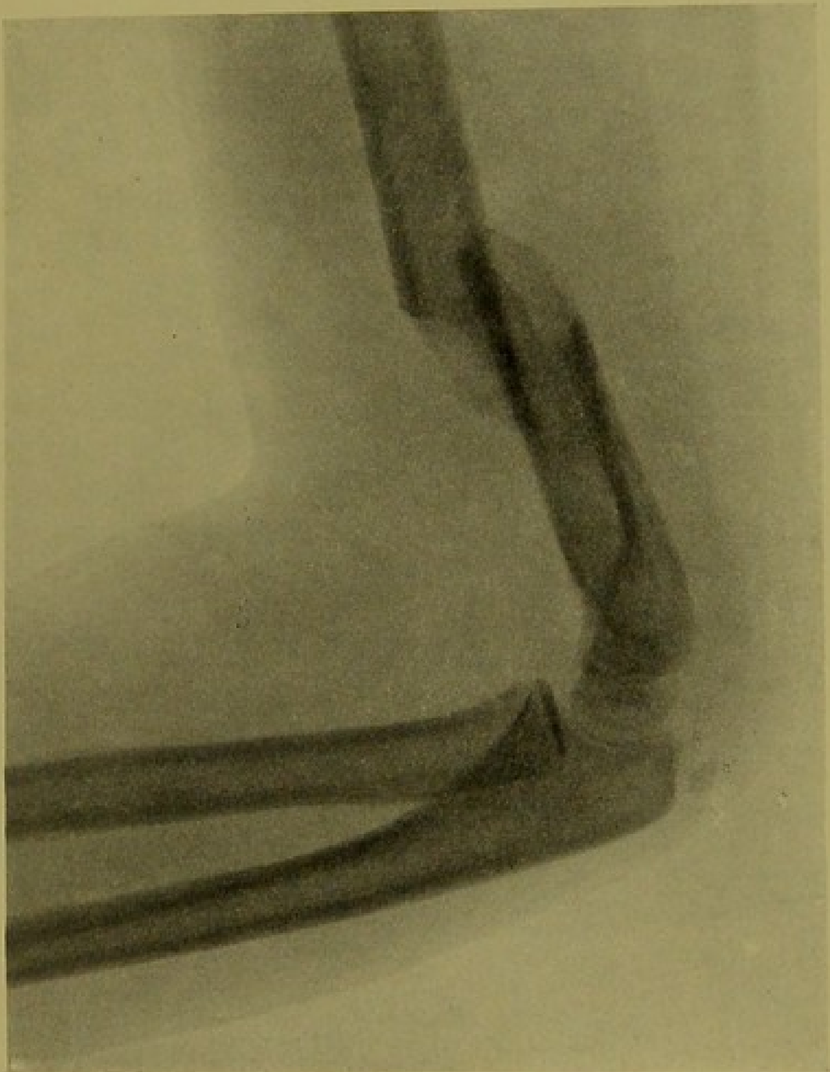


Fig. 130.

result was anatomically and functionally perfect as shown in Fig. 129.

Fig. 130 shows a fracture of the shaft of the humerus at the junction of the upper three-fourths with the lower fourth, as the result of direct violence. The fracture was exposed through a posterior median incision. The fragments were brought into accurate apposition, being held in powerful holding forceps, and were secured by means of a plate and screws with the result shown in Fig. 131.

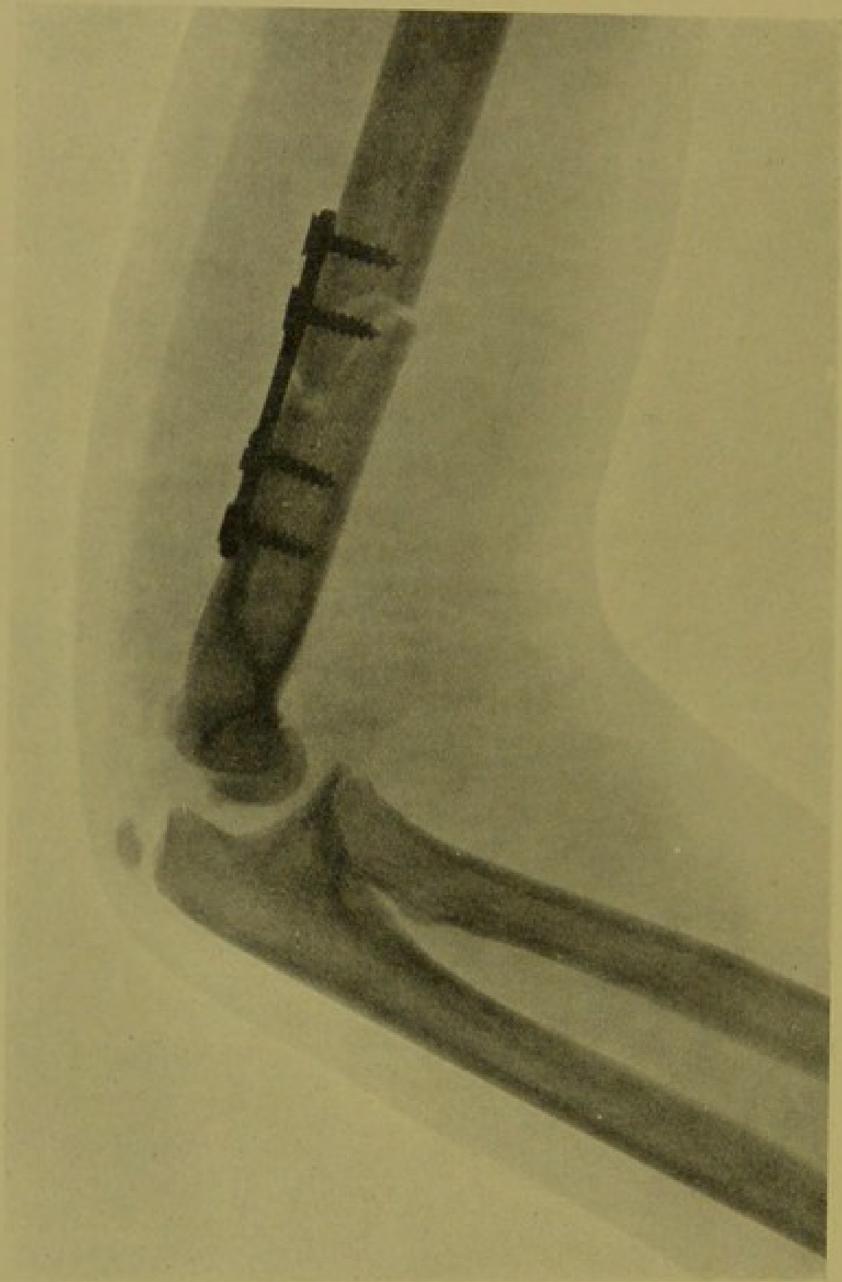


Fig. 131.

In fractures in the neighbourhood of the musculo-spiral groove non-operative treatment and its consequent callus formation may induce late involvement of the musculo-spiral nerve. Early operative replacement of fragments avoids callus formation and obviates this danger.

The greatest trouble in effecting apposition of fragments is experienced about joints, and this is particularly the case in the lower end of the humerus where the lower fragment may be split vertically. To bring the fragments of such a fracture into accurate apposition, and to secure them immov-

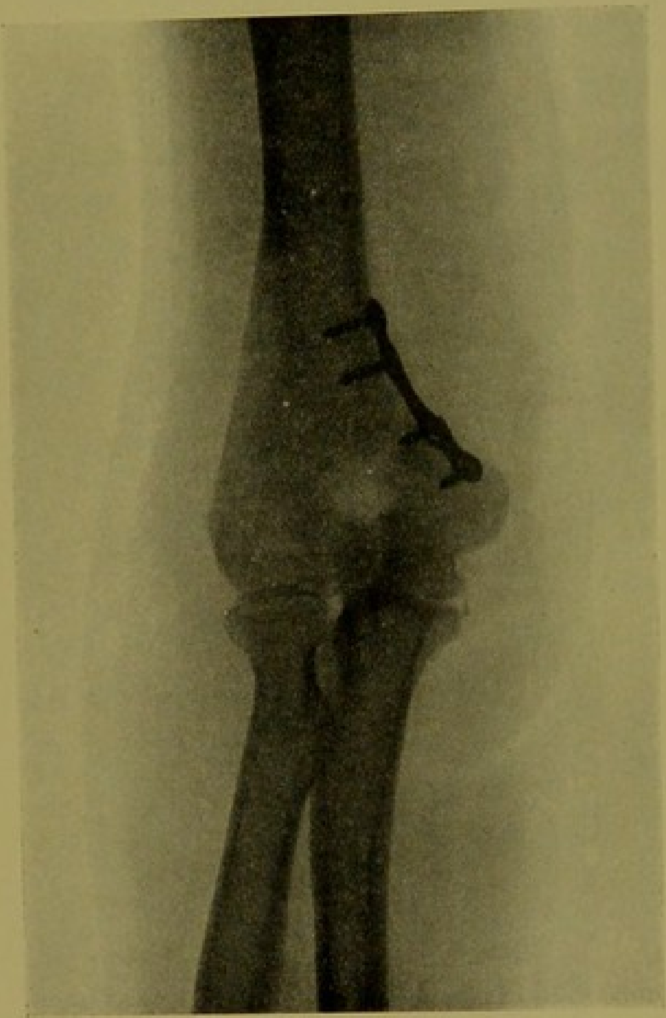


Fig. 132.

ably may be a very difficult operation, requiring much skill and expert assistance.

Fig. 132 shows a fracture running vertically through the inner portion of the lower end of the humerus traversing the coronoid and olecranon fossæ and the trochlea, the inner fragment being displaced forwards and upwards. It was exposed by an internal incision and was with difficulty restored to its normal position. It was secured by means of a plate and screws. The plate had to be bent in two planes in order to fit the surface of the fragments with accuracy, while it exerted a certain amount of approximating force upon the fragments.

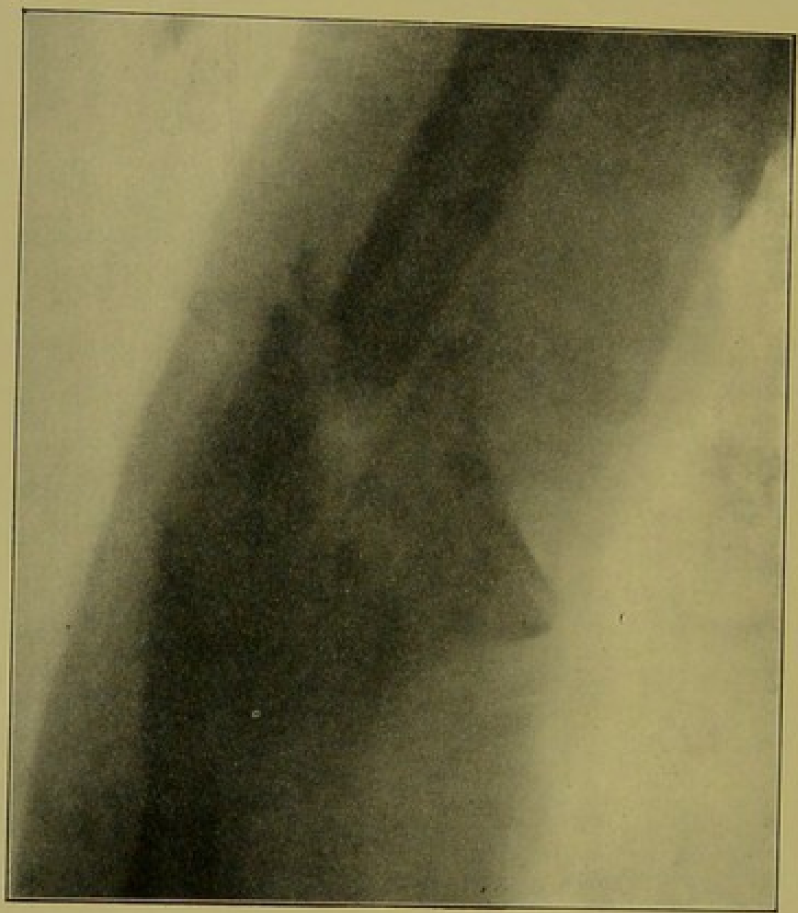


Fig. 133.

Fig. 133 represents a not uncommon type of fracture of the lower end of the humerus. It is obvious that no treatment that does not ensure the coaptation of the broken fragments is likely to be followed by a useful result. In this particular case the fracture was a compound one and was not aseptic. In these circumstances I preferred to retain the fragments by means of wire rather than plates, and the result obtained is shown in Fig. 134. The patient obtained almost perfect function of the elbow joint and arm.

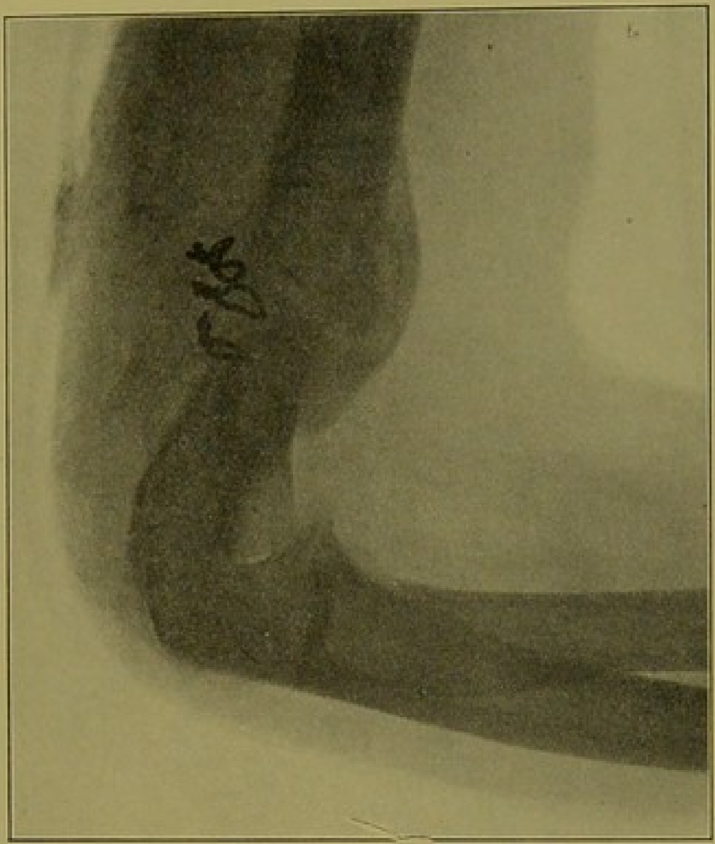


Fig. 134.

While in the operations on the lower extremity the surgeon runs no risk of damage to nerves, vessels, and

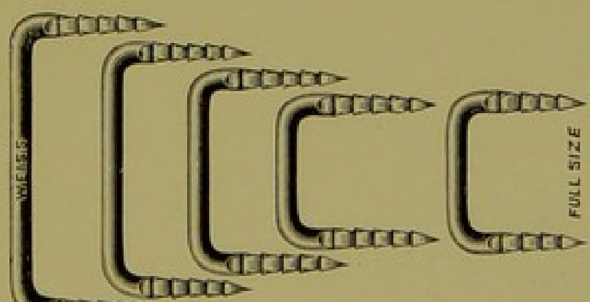


Fig. 135.

tendons, in the upper extremity these structures are exceedingly liable to injury, and may cause the operator much anxiety.

Plates and screws form as a general rule the most efficient means of retaining the fragments in apposition. Occasionally in fractures of the upper end of the humerus, staples (Fig. 135) may be of service as is shown in Fig. 136,

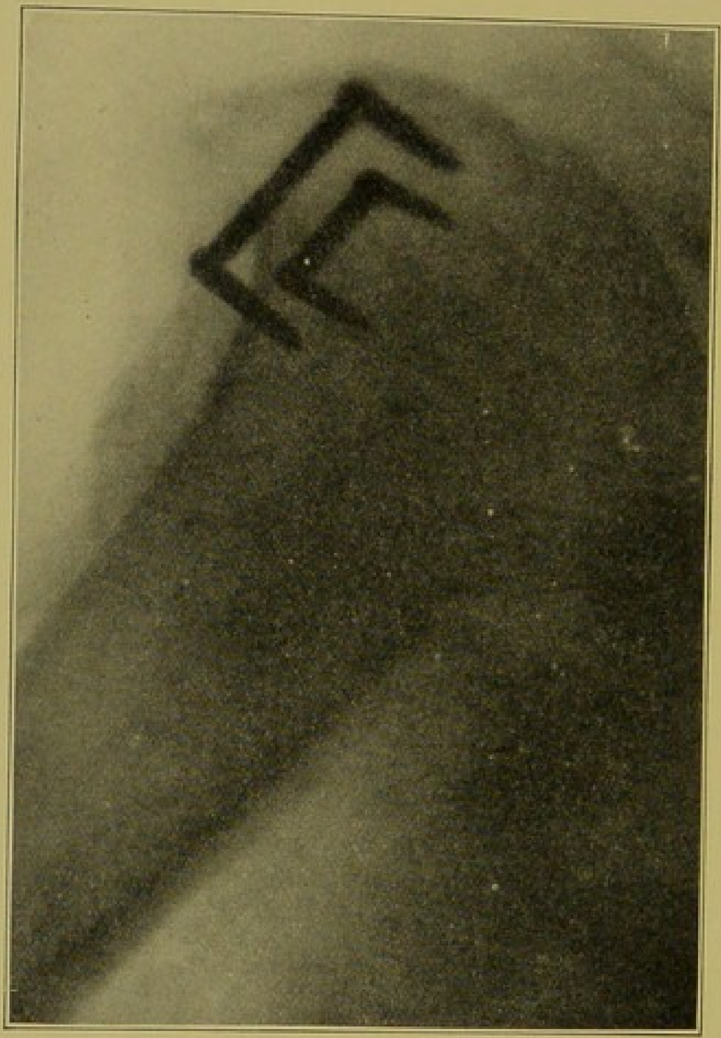


FIG. 136.

which illustrates the manner in which they can be employed with advantage in a fracture through the tuberosities and shaft of the humerus.

In fractures about the lower end of the humerus in young life, the surgeon may experience great difficulty in replacing the lower fragment in position with perfect accuracy. That a moderately useful, but ugly arm may be usually obtained by manipulation alone, I am not prepared to deny, but in doubtful cases I expose the fracture by a vertical incision through the triceps and make certain that

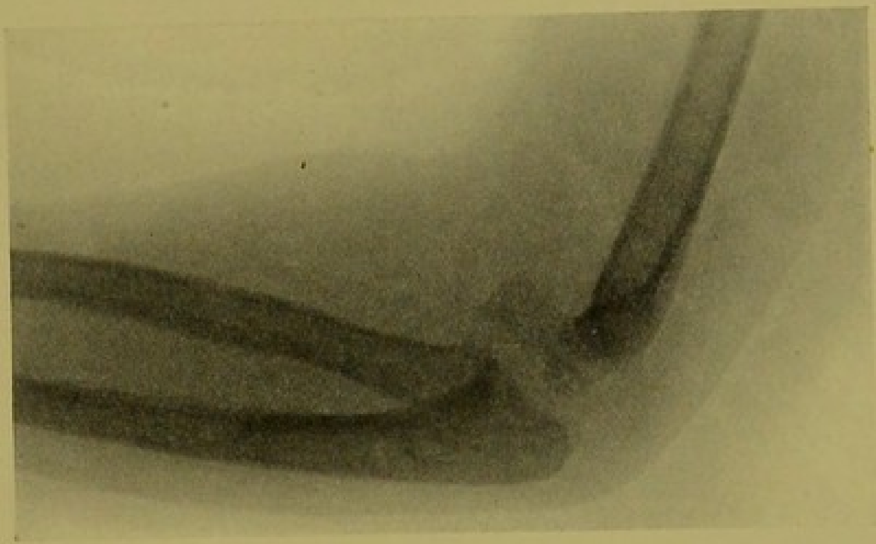


FIG. 137.

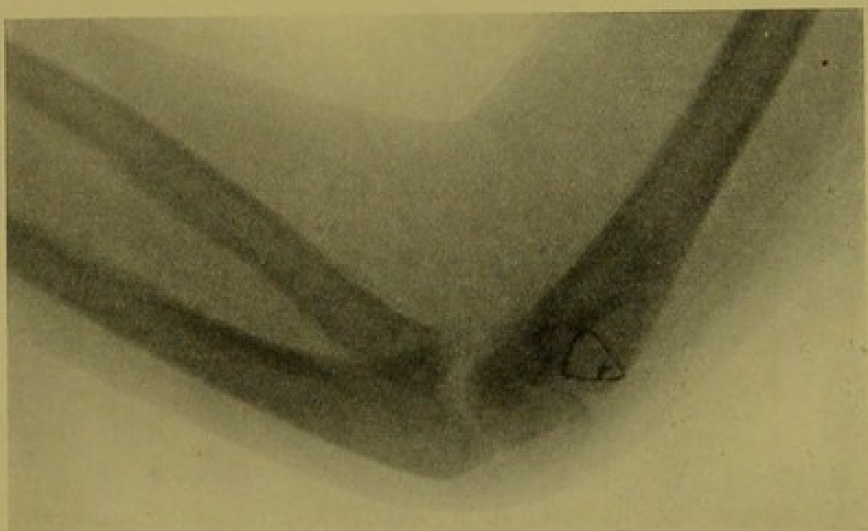


FIG. 138.

I have restored the outline of the bone perfectly. In fractures of portions of the lower epiphysis with displacement of the fragments it is often necessary to expose the fragment and to secure it in position by wire.

Fig. 137 illustrates a fracture of the lower epiphysis of the humerus, the radial portion of which had been broken off and had been displaced outwards and forwards. The joint was exposed by a posterior incision and the fragment was enucleated from the position into which it had been forced. It was then fitted accurately to the rest of the epiphysis and was secured in position by a loop of silver wire. The result of operation is shown in Fig. 138. The patient obtained an arm perfect in every detail, a result which would

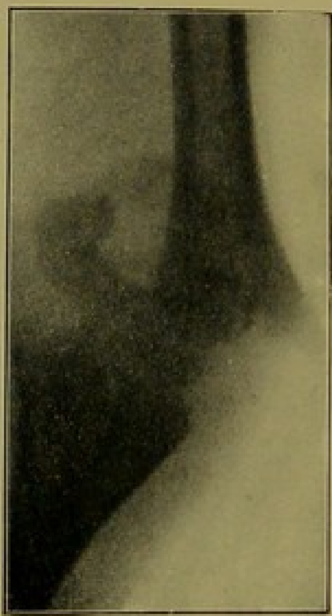


FIG. 139.

obviously have been impossible without operative interference.

Fig. 139 shows the displacement of the lower fragment backwards and outwards in a case of fracture through the lower epiphysial line of the humerus. In contrast to this Fig. 140 represents a fracture through the upper epiphysial line of the humerus with much displacement, and as is usual in fractures about epiphysial lines, a portion of the shaft was broken off and was attached to the epiphysis. In both these cases a perfect result was obtained by operation.

Fractures of the Radius and Ulna.

Fractures of the bones of the forearm occasionally present a considerable amount of displacement which cannot be

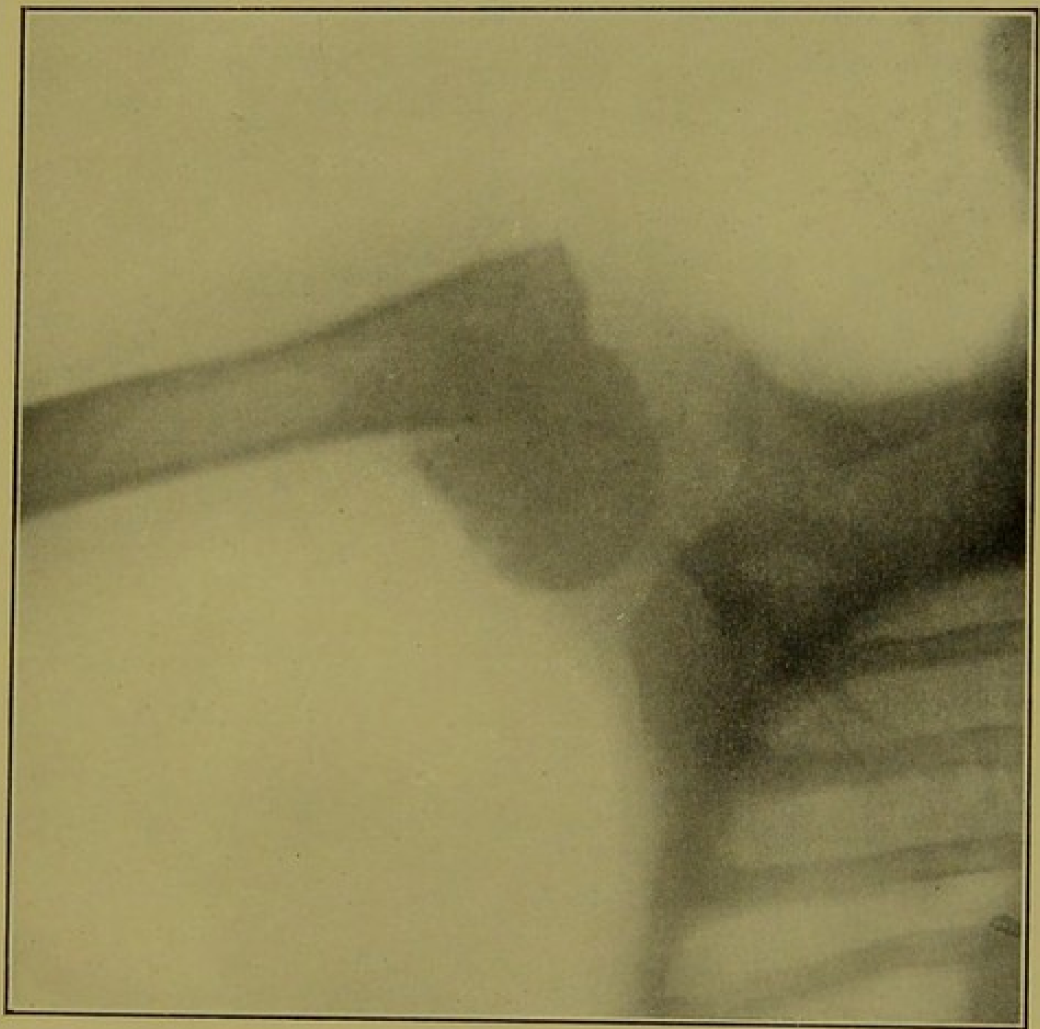


Fig. 140.

met by any form of manipulation. One of the most common fractures is that of the olecranon. This fracture is best treated by a plate and screws and with ordinary skill the continuity and function of the ulna may be restored with perfect accuracy. Fig. 141 represents a simple transverse fracture of the olecranon treated by means of a plate and two screws. The results of operation is shown in Fig. 142.

The Michel clips have not yet been removed. Fig. 143

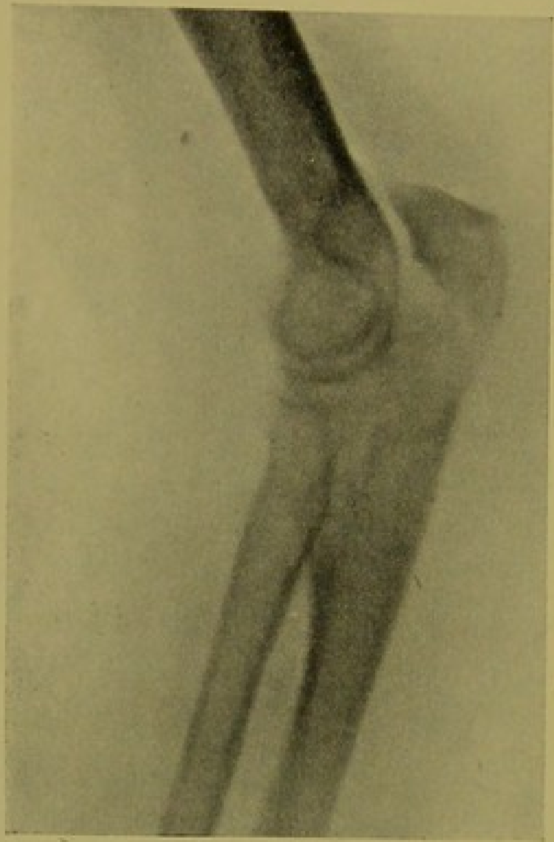


Fig. 141.

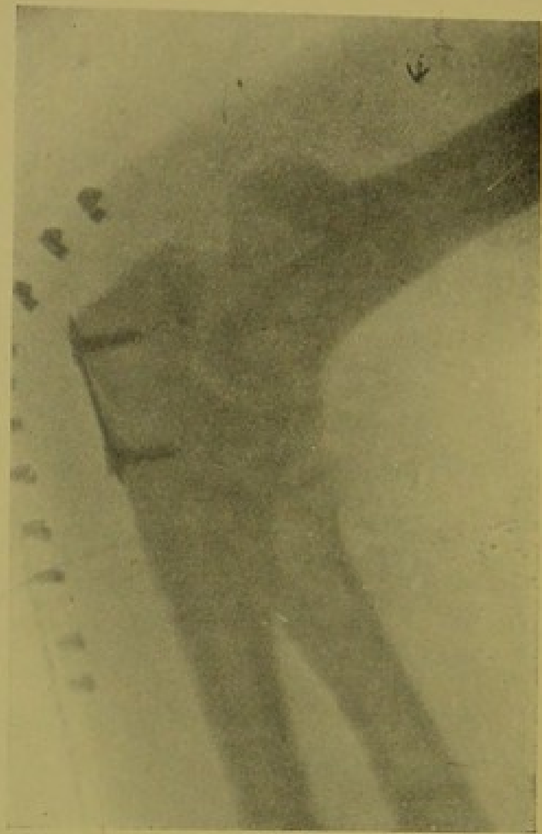


Fig. 142.

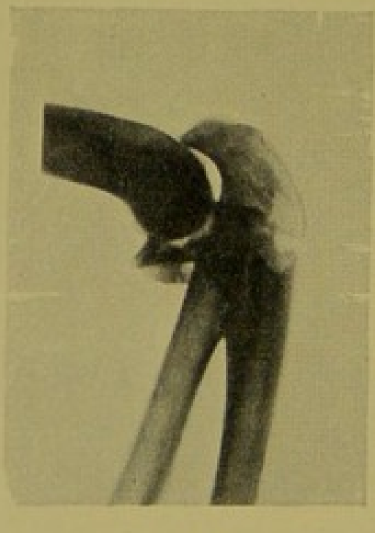


Fig. 143.

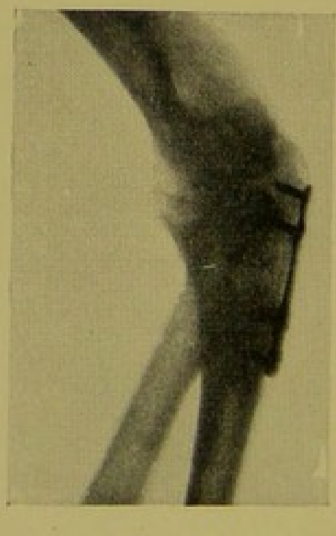


Fig. 144.

shows not only a fracture of the olecranon, but also a bad fracture of the coronoid process, the fragments of which came into perfect apposition when the olecranon had been secured in position by means of a plate and screw. (See Fig. 144.)

Fig. 145 shows a fracture of the olecranon with considerable displacement of the upper fragment. This was forced into apposition with the shaft and was firmly secured by means of a plate and screws. Fig. 146 illus-

Fig. 145.

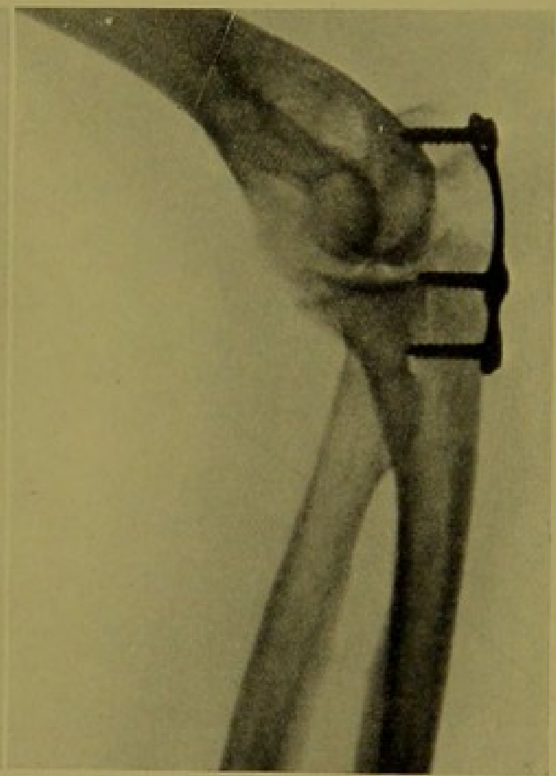


Fig. 146.

trates the result, the elbow-joint being perfectly normal in form and function.

Fig. 147 shows a fracture of the shaft in the radius beneath the attachment of the supinator brevis. Owing to the proximity of the branches of the musculo-spiral nerve great care is requisite in order to avoid damage to these very important structures.

Fig. 148 represents the condition some time after the operation when the arm was functionally perfect.

In fractures of both bones at the same level with dis-

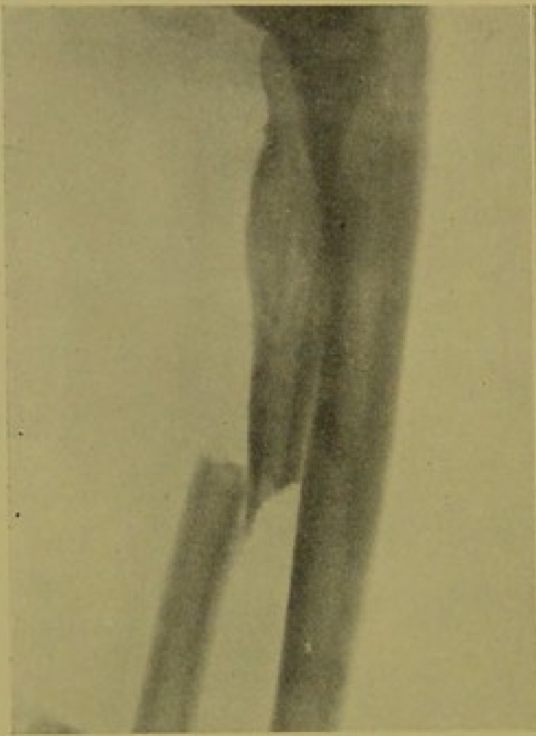


Fig. 147.

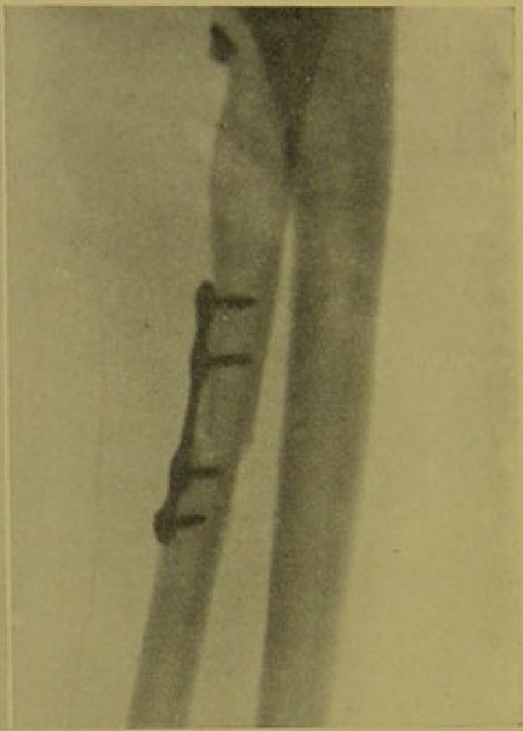


Fig. 148.

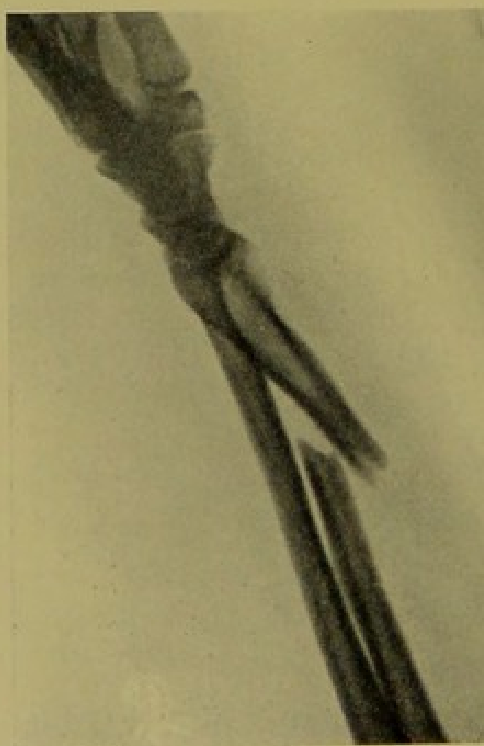


Fig. 149.

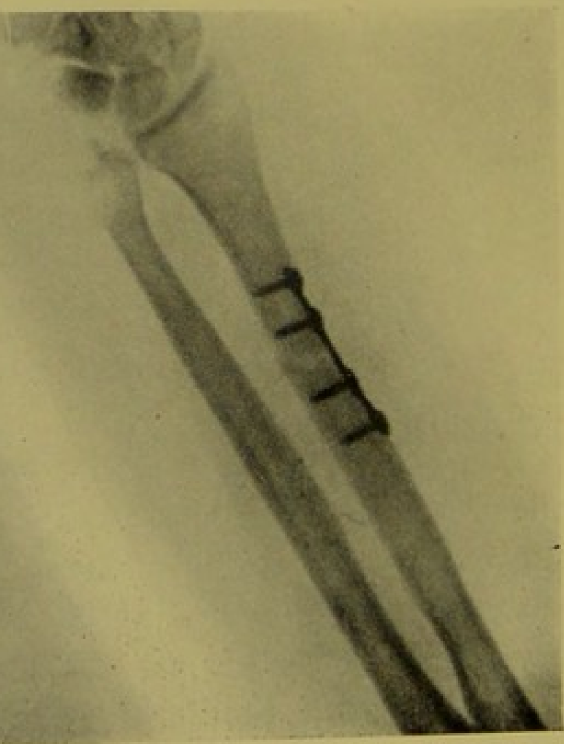


Fig. 150.

placement of fragments, and in fractures of the radius in its lower fourth with displacement of fragments it is practically always necessary to operate.

Fig. 149 represents a fracture of the radius in its lower third. Unless the fragments of this bone be placed in accurate apposition great physical disability may result,

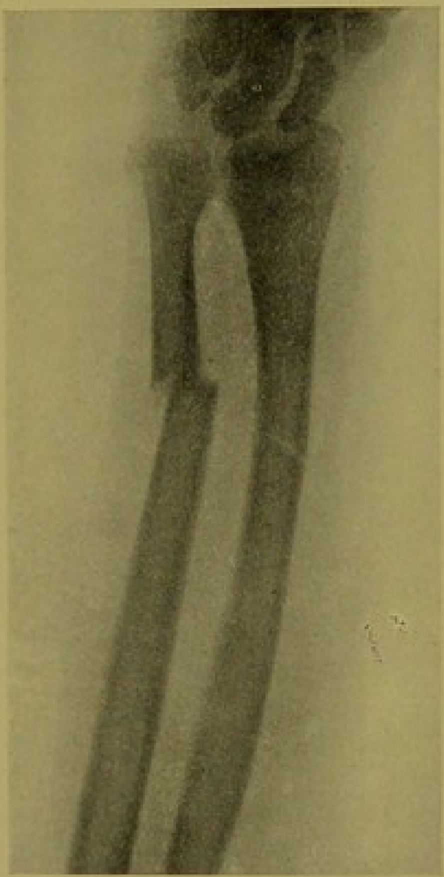


FIG. 151.

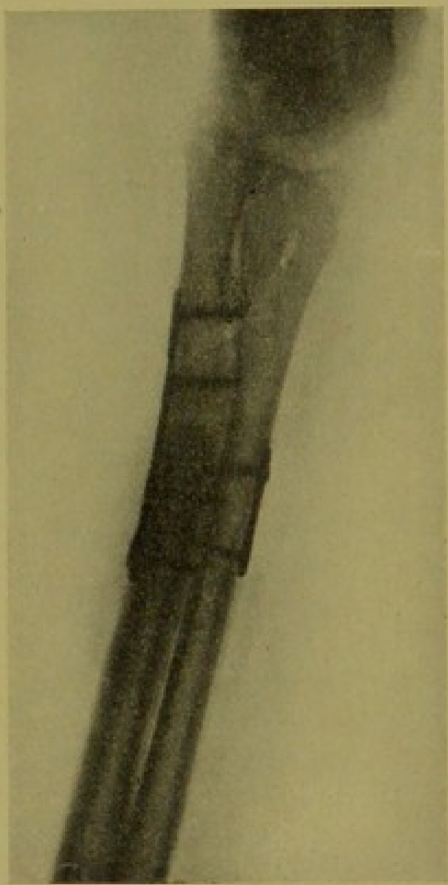


FIG. 152.

and occasionally non-union may ensue. In some cases of imperfect approximation I have seen the distal fragment waste with extraordinary rapidity. This is especially true in the young subject.

The fragments are easily accessible and are readily placed in accurate apposition, as is shown in Fig. 150, which was taken some weeks after the operation.

Fig. 151 represents a fracture of both bones at the same level. The photograph only shows the condition in one plane, and the displacement of fragments is much greater than would appear.

Fig. 152 shows the result of operation, the bones having been restored to their normal form and function.

Fig. 153 represents a fracture of the radius and ulna in their lower thirds. As already pointed out these fractures

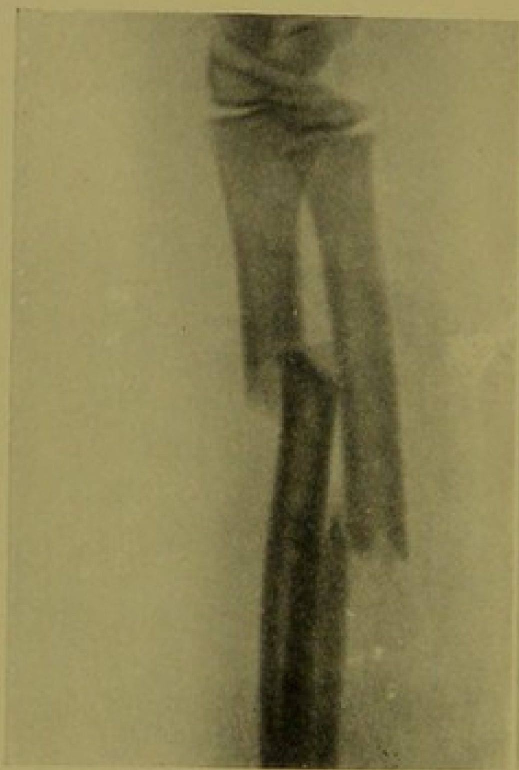


Fig. 153.

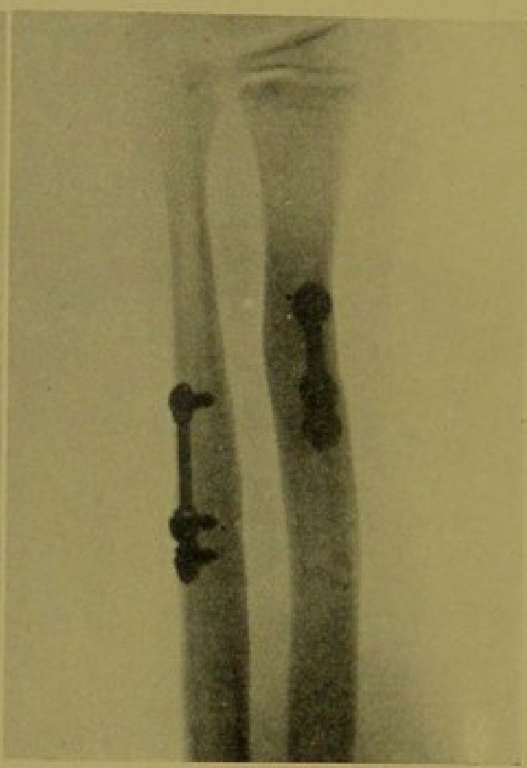


Fig. 154.

do exceedingly badly if treated in any way but by operation. The result of operation is shown in Fig. 154, in which the radius and ulna are seen to be normal in form and function.

Fig. 155 shows a fracture of the lower portions of the radius and ulna, the latter being much fissured and crushed. Both fractures were exposed and it was found that the fixation of the ulnar fragments enabled us to maintain the radial fragments in accurate apposition. This, without a

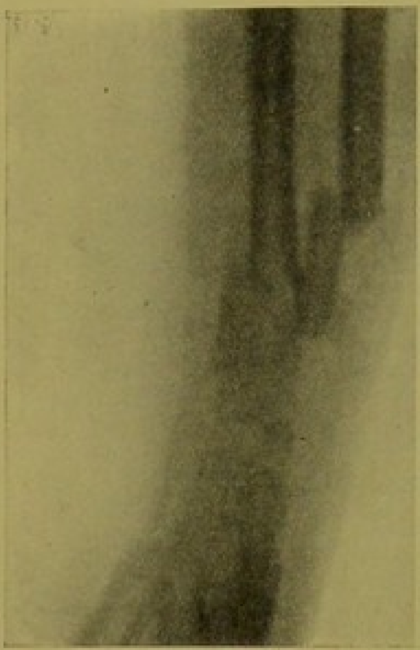


Fig. 155.

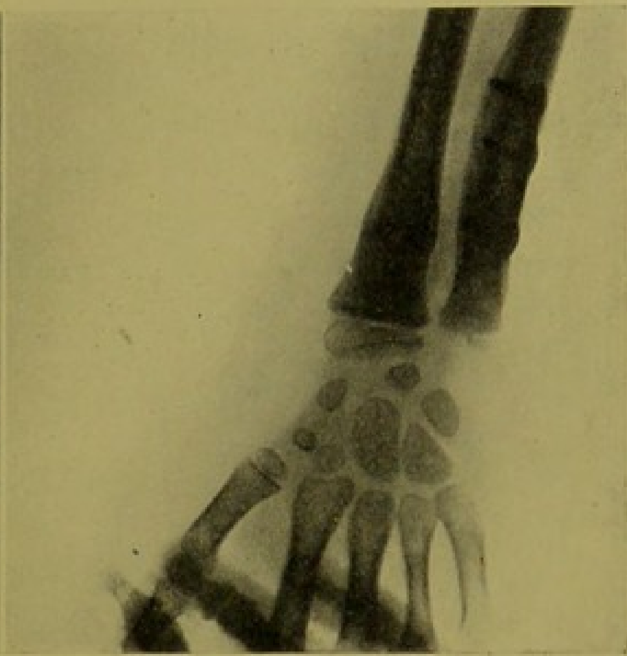


Fig. 156.

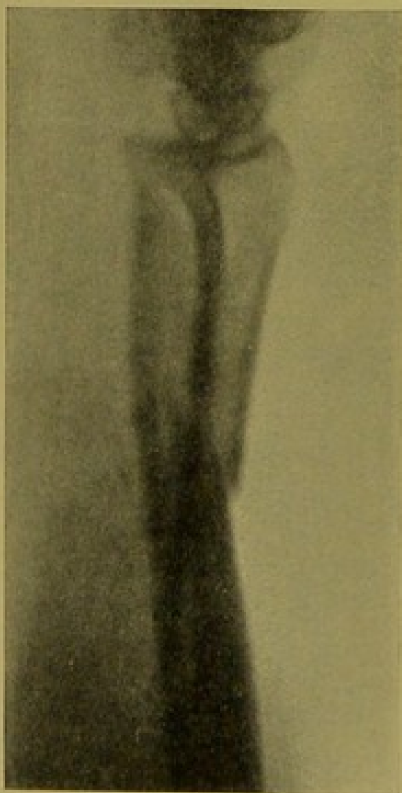


Fig. 157.

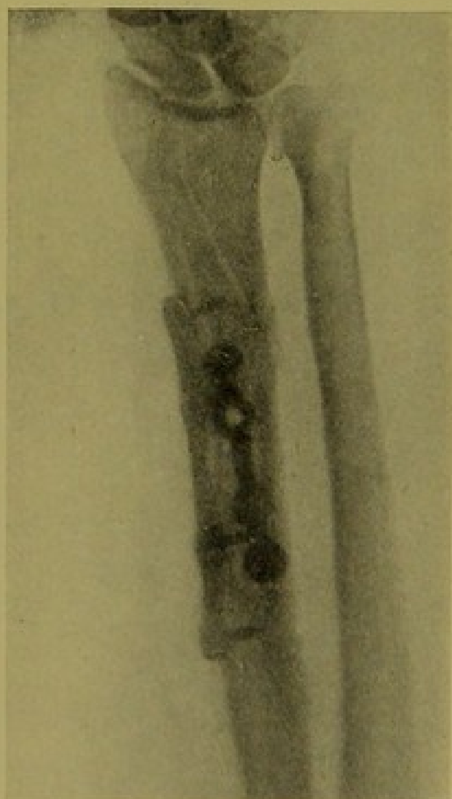


Fig. 158.

plate, was fortunate, as the boy was young and it was inadvisable to control the growing line.

Fig. 156 represents the condition six months after the operation.

Fig. 157 shows a very comminuted fracture of the lower fourth of the radius in which much difficulty was experienced in fitting and securing the fragments in accurate apposition. The result is shown in Fig. 158.

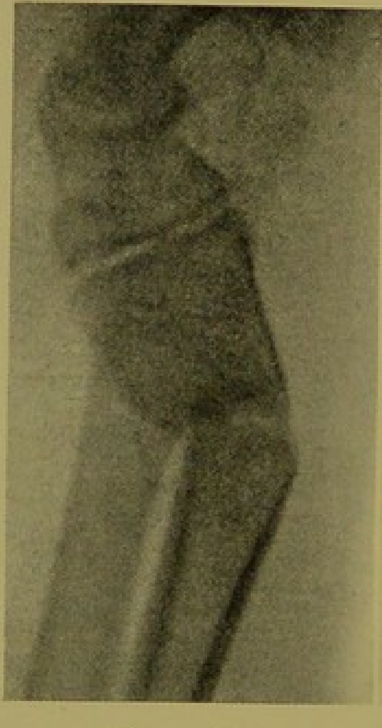


Fig. 159.

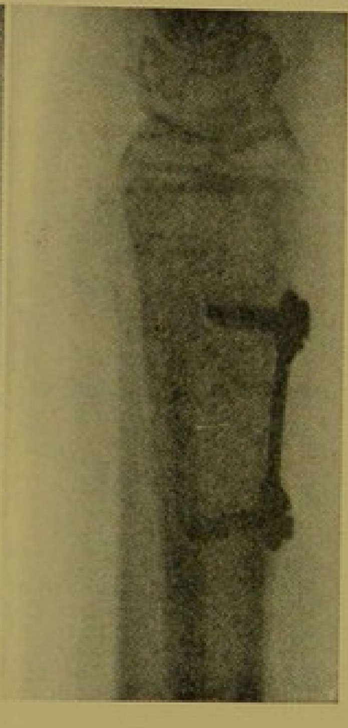


Fig. 160.

Fig. 159 shows a fracture of the radius in its lower fifth in a boy seen five weeks after the injury. The fracture was supposed to have been reduced under an anæsthetic and had been treated by splints.

The result was most unsatisfactory both from an anatomical and functional standpoint.

The fracture was exposed, the juncture divided, and the fragments were placed and secured in continuity by means of a plate so that the form and function of the bone was restored to the normal (see Fig. 160).

Another fracture about the elbow-joint that frequently calls for operative interference, especially in young life, is that of the radius in the upper part of its shaft. These cases are rarely operated on at the time the injury is sustained, but come first under the care of the operator when the splints have been removed. In the first instance the arm is generally put upon an internal angular splint, with the forearm in a semi-prone position, the hand being placed vertically, the thumb upwards. When this splint is taken off for the first time, it is found impossible to supinate or pronate the forearm. The patient is usually a child, and the mechanical depreciation, if at all marked, is sufficient to unfit him for many occupations, and especially for the Services. Such cases require very careful operative treatment, since to restore the axes of the bone to their normal relationship the radius has to be divided in two oblique planes, which usually cross each other at an angle of about 90°.

Such fractures when affecting the radius alone, may show little or nothing in a single radiograph, so that two, taken at angles of 90°, should always be obtained.

Roughly speaking, if a perfectly useful arm is required, it is always wise to operate when the form of the broken bone or bones cannot be accurately restored without having resort to operation. Some fractures call for very special care, such as those of the radius, in the area of attachment of the supinator brevis, where a perfect radius would be obtained at a serious cost if any of the extensor muscles were paralysed in the operation.

The so-called Colles's fracture rarely calls for operative interference if efficiently treated by manipulation at the time of the injury, yet in a certain proportion of cases it is impossible to replace the fragments in accurate apposition unless an incision is made and the fragments levered into position by means of an elevator. This occurs occasionally when the fracture is through the growing line as in Figs. 161 and 162, where such measures were adopted after manipulation under an anæsthetic had failed on three separate occasions. Note the small fragment of the shaft which is connected with the epiphysis.

The fractures that are sometimes very difficult to deal with are those of the coronoid process and of the head of

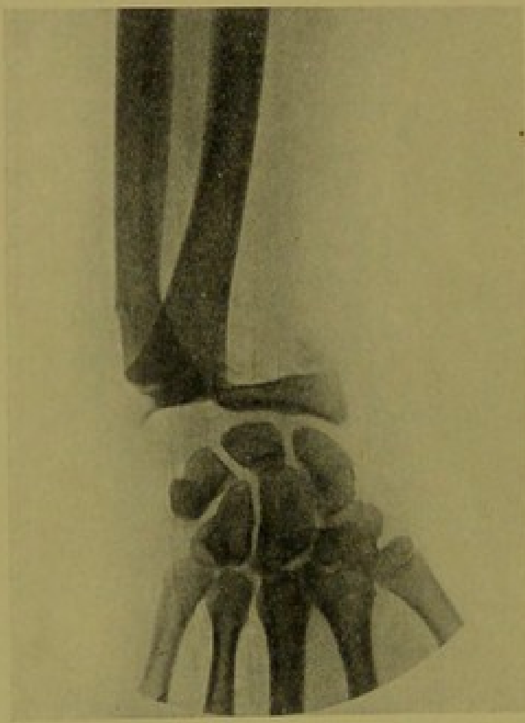


Fig. 161.

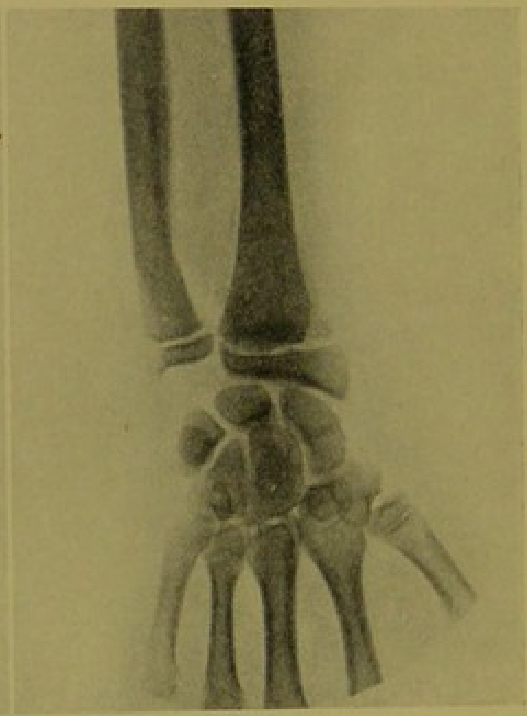


Fig. 162.

the radius. I have seen many joints hopelessly locked by abundant callus in these fractures owing to the early use of massage and forcible movement. In some of these cases the fragments have been removed, in some the head of the radius has been excised, while in others no operative procedure has been undertaken, and the fragment has remained displaced.

In a large proportion of cases, I believe, the wisest course is to keep the joint at rest at a right angle and watch the course of events, leaving any operation, should it seem necessary, to a later date. During this period the nutrition, function, and vitality of the tissues is maintained by electricity and gentle passive movements.

I cannot illustrate the bad effects of early movement in these fractures better than by relating the details of a case. A girl, aged 12 years, dislocated her left elbow. A radio-

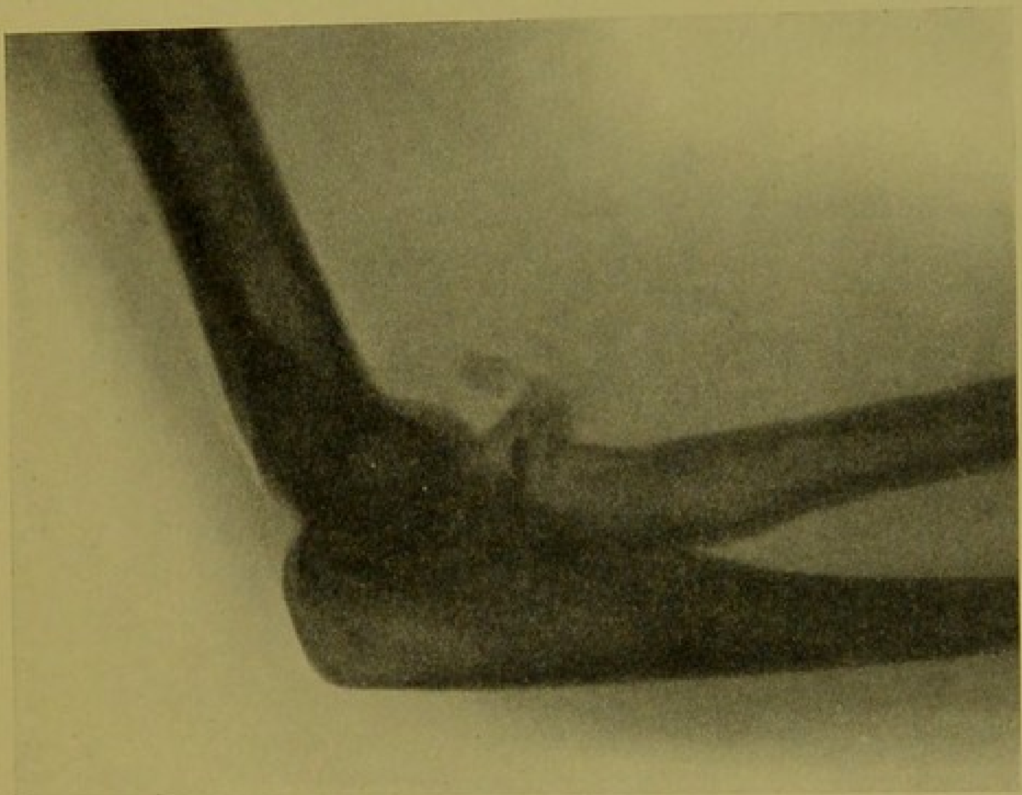


Fig. 163.

gram taken three days after the injury showed that the head of the radius had been broken off, comminuted and displaced. On the day that the dislocation was reduced passive movements of flexion and extension were commenced and were applied three times a day afterwards for twenty minutes at a time. The range of flexion and extension became more and more limited so that when she was seen thirty-three days after the injury the range did not exceed ten degrees. Pronation and supination were also very limited. Fig. 163 shows the condition three days after the

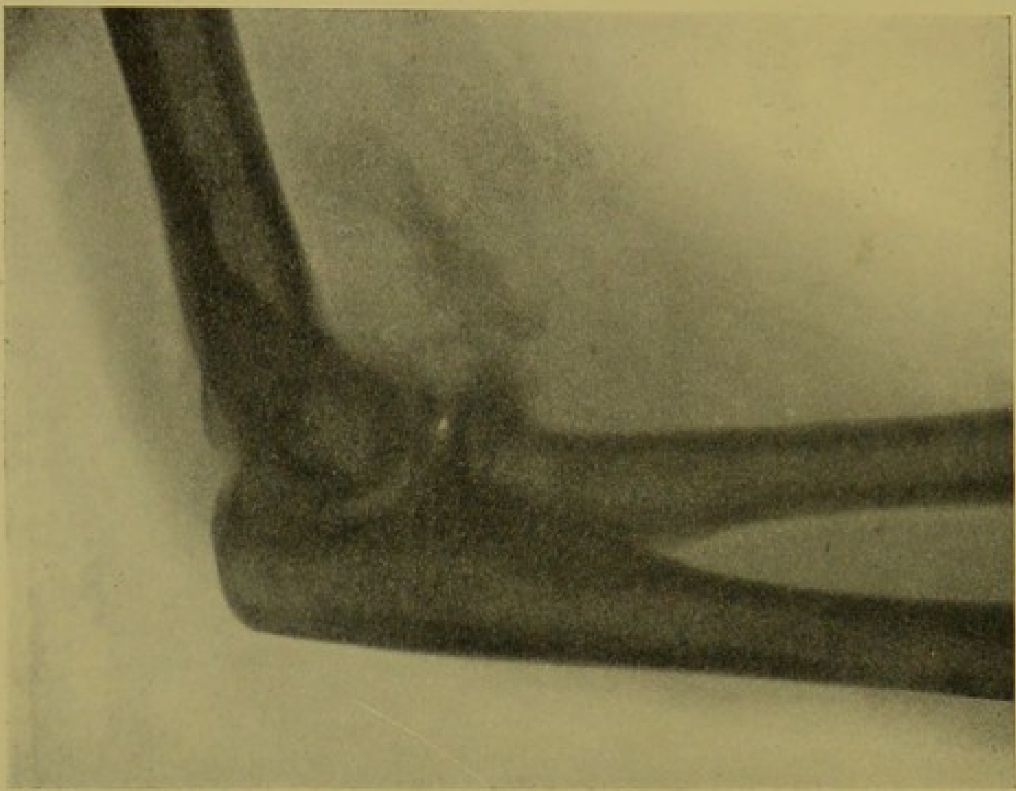


Fig. 164.

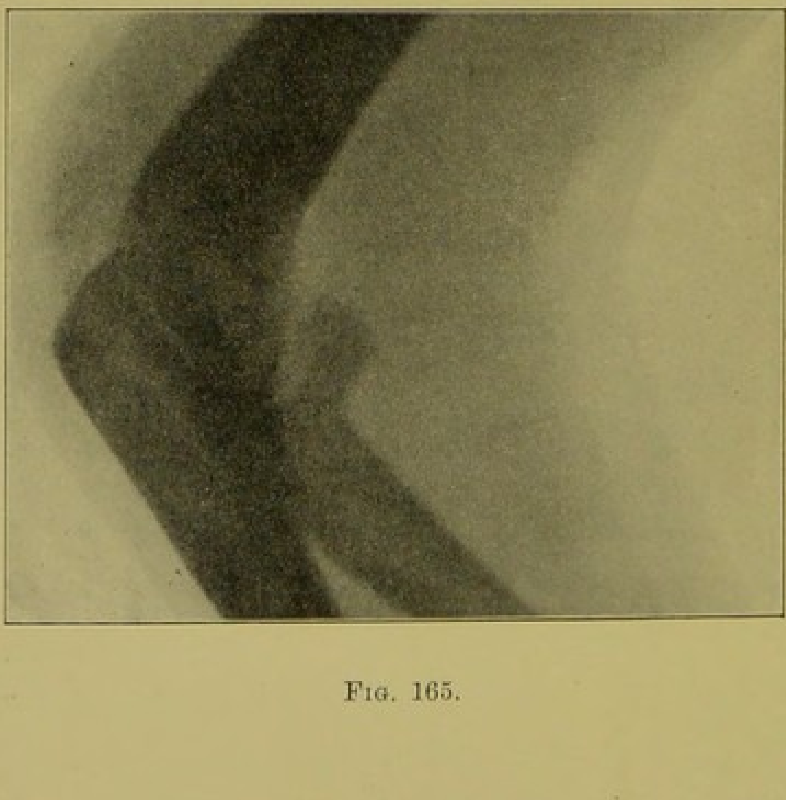


Fig. 165.

injury and Fig. 164 (which was taken twenty-four days later) the disastrous changes that had ensued in consequence of the systematic manipulation. Nature in these cases limits the mobility of the joint with relentless determination by the rapid and abundant formation of callus.

I have in some cases removed the broken bit of coronoid process, or the whole or part of the head of the radius, or I have secured them to the shaft with varying success.

Fig. 165 shows a fracture of portion of the head of the radius with displacement of the fragment. In this case

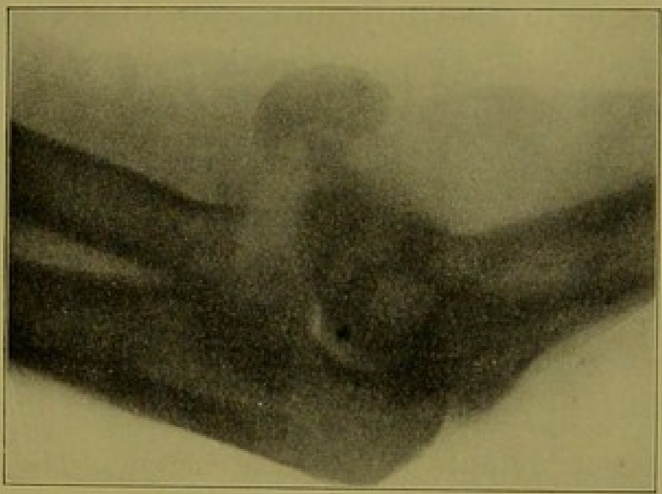


Fig. 166.

the fragment was secured in position by small screws and a good result was obtained.

Fig. 166 shows a fracture of the neck of the radius with displacement of the head of the bone. This case did not come under observation till some time had elapsed. The head of the bone was removed with the result that the patient got a very useful arm. At the end of two years pronation and supination were powerful and almost perfect. Extension was nearly complete and flexion was limited to 90°. It has improved considerably since.

I do not believe any general rule can be laid down for these fractures; each case must be treated on its merits.

Operative Technique.

I will now relate the several steps which are involved in an operation for simple fracture. I will do so in some detail, *as apart from manual dexterity and skill the whole secret of success in these operations depends on the most rigid asepsis.* The very moderate degree of cleanliness that is adopted in operations generally will not suffice when a large quantity of metal is left in a wound. To guarantee success in the performance of these operations the surgeon must not touch the interior of the wound even with his gloved hand, for gloves are frequently punctured, especially if it be necessary to use a moderate amount of force, and the introduction into the wound of fluid which may have been in contact with the skin for some time may render the wound septic. All swabs introduced into the wound should be held in long forceps and should not be handled in any way.

The operator must not let any portion of an instrument which has been in contact with a cutaneous surface or even with his glove enter the wound.

After an instrument has been used for any length of time or forcibly it should be re-sterilised.

No germicide or other fluid should be introduced into the wound.

The skin is prepared with ether or benzine, and tincture of iodine is applied freely at the time of the operation.

Choose a situation for the incision which involves a minimum risk of damage to important structures, and a maximum advantage from the point of view of accessibility to the seat of fracture.

There is no greater mistake than to add to the difficulties of the operation by making an incision which is not sufficiently long to permit of free access to, and ready manipulation of the fragments. Its length in no way increases the risk the patient runs, but usually minimises it, since it enables the surgeon to deal with the condition more rapidly and effectually.

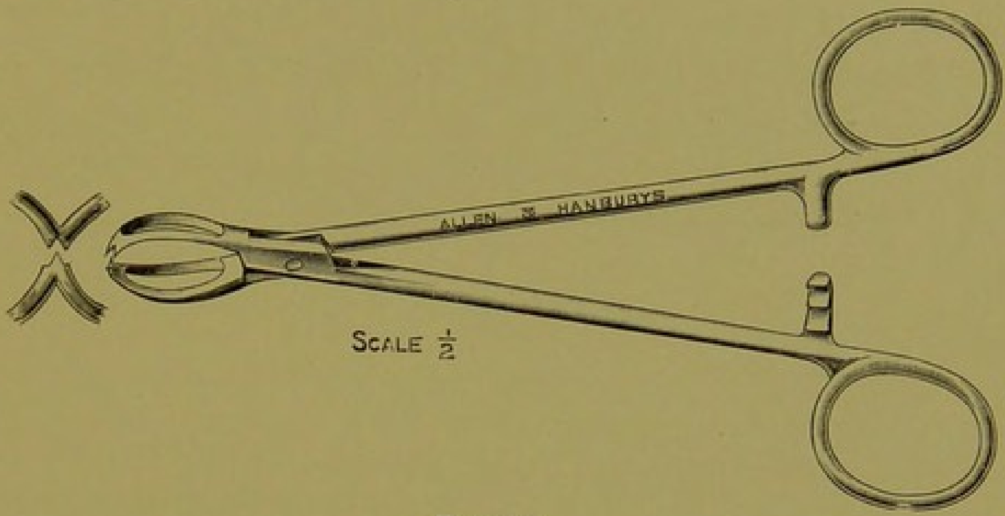


FIG. 167.

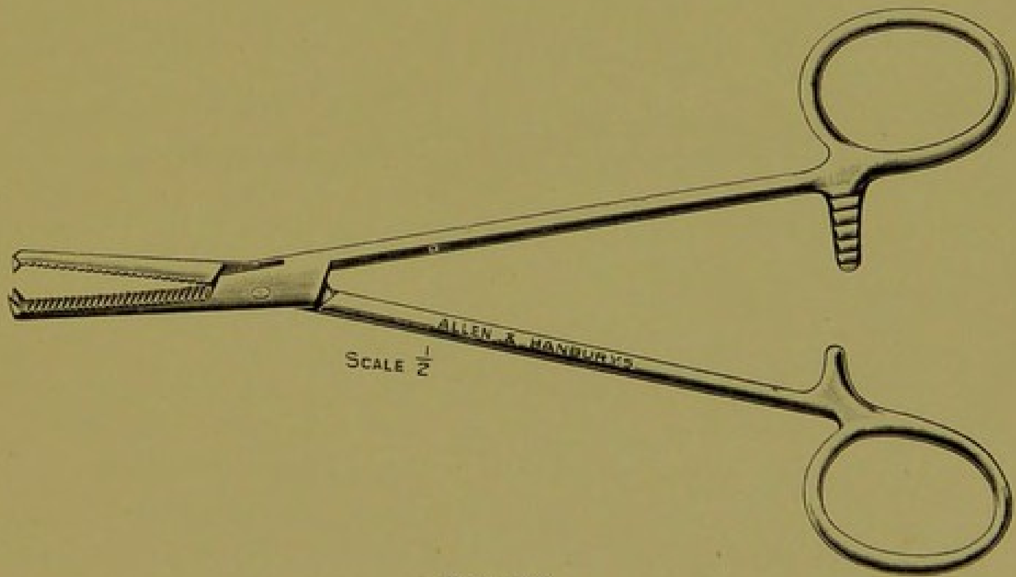


FIG. 168.

Having made the incision, the patient's skin is completely excluded from the wound by securing the margin of a sterile towel to each edge of the incision. This is done by means of tenaculum forceps with moderately heavy handles which fall away from the wound. (Fig. 167.)

The deep fascia and muscles are divided freely and the fragments are fully exposed. The periosteum is of no special importance, and it is stripped from the bone with the other soft parts if necessary. The nature of the fracture is accurately determined and all clots are removed. Should there be any hæmorrhage it is at once controlled by a very strong hæmostatic forceps of a type called Mayo-Ochsner's in the States (Fig. 168).

FIG. 169.

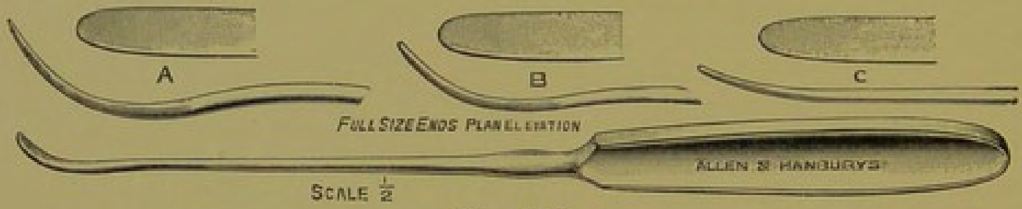


FIG. 170.

FIG. 171.

FIG. 172.

These are left on till the end of the operation, by which time they can be removed without fear of hæmorrhage. Ligatures or sutures are never used, so avoiding the risk of introducing the hand into the wound.

Elevators of various sorts and sizes are employed to enable the surgeon to obtain a good view of the fragments. Several forms are represented in Figs. 169, 170, 171, 172.

Figs. 173 and 174 illustrate the types of bone-holding forceps used for grasping and manipulating the fragments. They are made in various sizes.

A suitable plate is chosen and held by forceps. Figs. 175 and 176 represent the forceps and several sizes of plate.

Fig. 173.

Fig. 174.

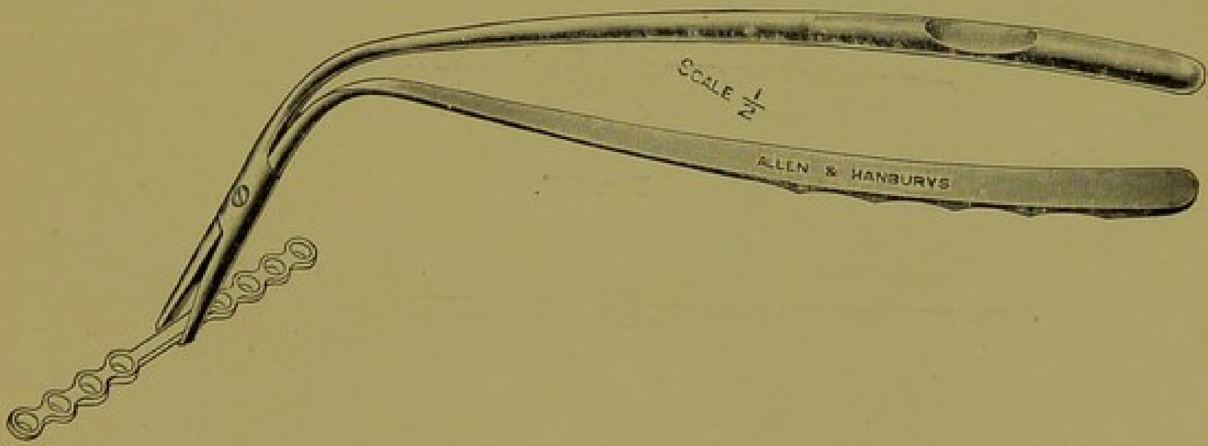


Fig. 175.

Fig. 177 shows the form of wrench suitable for bending plates in order that they may be accurately adapted to the surface of the bone. Drill holes are made with a drill corresponding in size to the screw which it is intended to use, except when the bone is softer than normal when a smaller drill is used. The screws are the ordinary "wood screw" of the trade except that the thread is cut up to the head, there being consequently no barrel. This is to enable the screw to hold the proximal layer of compact bone only,

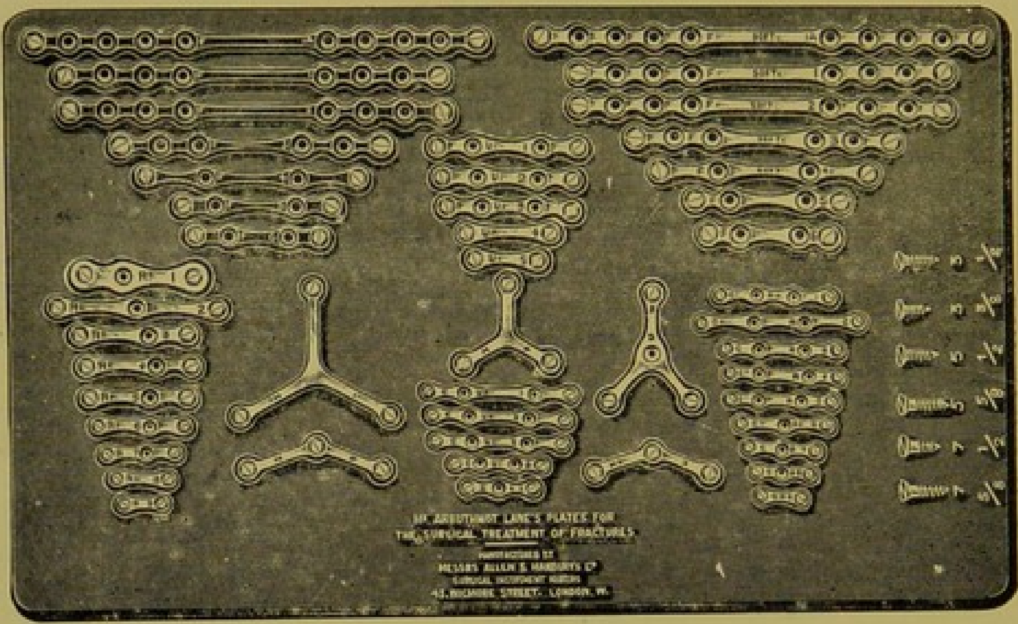


Fig. 176.

Fig. 177.

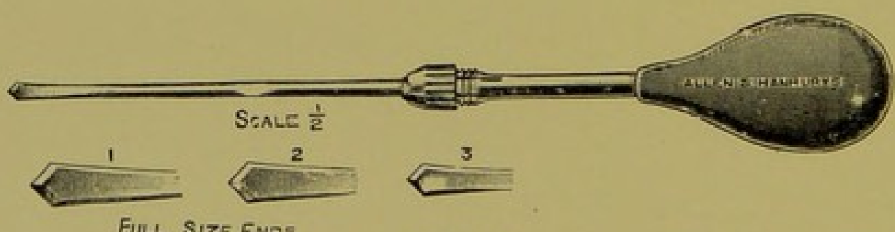


Fig. 178.

the screw not entering and gripping the distal compact tissue, except in the case of the young child.

Though the use of a hand drill entails the occasional expenditure of much energy, on the other hand it affords the surgeon a clearer idea of the density of the bone than he could obtain from the use of an electric drill and enables him to form a better opinion as to what gauge and length of screw he should employ.

The screws and drills are made up in three gauges for convenience. They are 3, 5, and 7. They are of various lengths varying between $\frac{3}{8}$ of an inch to $\frac{7}{8}$ of an inch. The drills and screws are indicated in Figs. 178 and 176. The screw is held in a convenient holder, Fig. 179, and is driven in firmly. Fig. 180 represents the form of driver usually employed for this purpose. The plate having been secured in position, the wound is wiped dry. Sutures are not introduced into the margins of the muscles and lasciæ, which

FIG. 179.

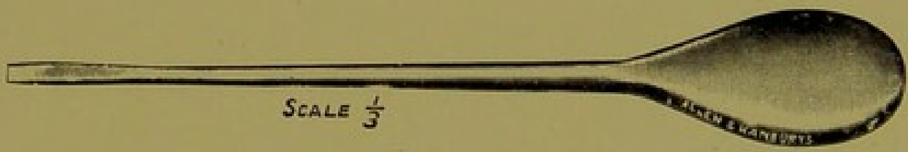


FIG. 180.

are left separate in order to allow any blood that may escape free access to the subcutaneous tissue from which it is readily absorbed. Blood dammed up beneath muscles may remain unchanged for a considerable period of time and become a source of danger.

The edges of the skin incision are brought accurately together by means of Michel's clips. When there is any fear of hæmorrhage, the clips are fastened very close to one another to prevent any escape of blood through the intervals between them.

The nature of the splint or fixation apparatus varies with the strength of the plate and with the security of its grip. If the plate is strong and has a secure hold upon the fragments of the broken bone no splint whatever is required. I have known a patient who had delirium tremens at the time of the operation kick a fractured femur, united securely by a stout steel plate, for many days without in any way endangering the junction. Some surgeons seem to have an erroneous idea that so-called rarefying ostitis may develop about screws and cause them to loosen. Rarefying ostitis, in plain English, means "dirty surgery," or such an insecure fixation of the fragments by wire or other connecting medium as allows of movement at the

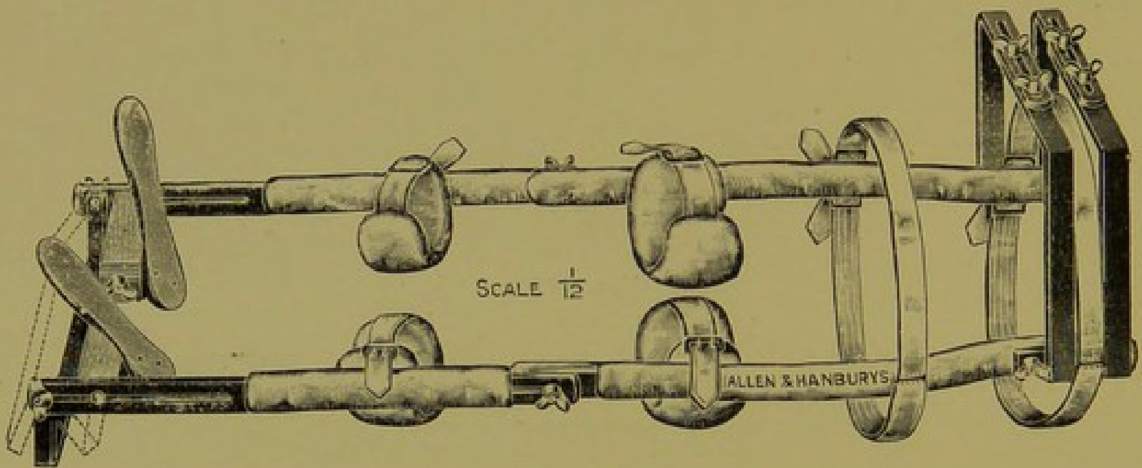


FIG. 181.

junction. Rarefying ostitis is consequent upon a "defective technique," and is a useful term to cover surgical incompetence.

A very useful splint for fractures of the lower extremity, and especially for fracture of the femur, is that devised by Mr. Harold Chapple, and to which I have already called attention. It permits of easy and early flexion of the knee-joint, and enables the nurse to keep the patient clean and comfortable. It is shown in Fig. 181.

The operative treatment of simple fractures was met with the most violent and virulent opposition for many years, the opponents of the suggested treatment not hesitating to employ any means, however unscrupulous, to prevent its becoming accepted. This continued till the meeting of the British Medical Association in London in 1910, when I had the honour of opening the discussion "On the Operative Treatment of Simple Fractures."

Following on this, a Committee was appointed by the Council of the British Medical Association in response to a recommendation to that effect by the Section of Surgery. The reference to the Committee was "To report on the ultimate results obtained in the treatment of fractures with or without operation." The members of the Committee were: Mr. W. J. Greer, Mr. J. Grant Andrew, Mr. C. W. Cathcart, Mr. H. S. Clogg, Mr. E. Deanesley, Mr. C. H. Fagge, Sir Victor Horsley, Prof. J. Rutherford Morison, Mr. Herbert J. Paterson, Mr. P. W. G. Sargent, Mr. W. Taylor, Mr. Wilfred Trotter, Mr. Richard Warren, Prof. Robert Saundby, Dr. Ewan J. Maclean, Dr. J. A. Macdonald, and Dr. Edwin Rayner. The report of this Committee was published in 1912, and in it are given at great length the means that were adopted to investigate cases of fracture and to separate out and classify results.

The Committee arrived at the following conclusions, which are put on the first page of their report.

REPORT OF THE COMMITTEE ON TREATMENT OF SIMPLE FRACTURES.

Conclusions.

The following are the main conclusions deduced from an analysis and full consideration by the Committee of the material collected by the Committee's Investigators:

"(1) The statistics relative to the non-operative treatment of fractures of the shafts of the long bones in children (under the age of fifteen years), with the exception of fractures of both bones of the forearm, show as a rule, a high percentage of good results. These are unlikely to be improved upon materially by any other method of treatment. Operative results in children, expressed in percentages, are approximately the same as non-operative. The relative figures are:

" *Non-Operative Cases* (Cases, 1,017) 90·5 per cent. good functional results. (*See* Table V, p. 1526)

" *Operative Cases* (Cases, 64) 93·6 per cent. good functional results. (*See* Table V, p. 1526.)

" (2) It is possible either by non-operative or by operative treatment to obtain a high percentage of good results in children.

" (3) In comparison with the non-operative results in children, the aggregate results of non-operative treatment in those past childhood (*i. e.* over the age of fifteen years), are not satisfactory. (*See* Table V, p. 1526.)

" (4) From the analysis of the age groups it is clear that there is a progressive depreciation of the functional result of non-operative treatment as age advances, that is to say, the older the patient the worse the result. (*See* Table VI, p. 1526.)

" (5) In cases treated by immediate operation, the deleterious influence of age upon the functional result is less marked.

" (6) In nearly all age groups, operative cases show a higher percentage of good results than non-operative cases. (*See* Table I, p. 1508).

" (7) Although the functional result may be good with an indifferent anatomical result, the most certain way to obtain a good functional result is to secure a good anatomical result. (*See* first paragraph, p. 1525).

" (8) No method, whether non-operative or operative, which does not definitely promise a good anatomical result, should be accepted as the method of choice. For this reason mobilisation and massage by themselves have not been found to secure a high percentage of good results. They are, however, valuable supplementary methods of treatment.

"Similarly, of operative methods, those which secure reposition and absolute fixation of the fragments yield better results than methods which fall short of this, imperfect fixation of the fragments by wire or other suture has been found to be an unsatisfactory procedure in the treatment of fractures of the long bones, with the exception of the olecranon process of the ulna.

"(9) Operative treatment should not be regarded as a method to be employed in consequence of the failure of non-operative measures, as the results of secondary operations (Classes B and C) compare very unfavourably with those of immediate operations. (Class A.) (*See* Table IV, p. 1525).

"In order to secure the most satisfactory results from operative treatment, it should be resorted to as soon after the accident as practicable.

"(10) It is necessary to insist that the operative treatment of fractures requires special skill and experience, and such facilities and surroundings as will ensure asepsis. It is, therefore, not a method to be undertaken except by those who have constant practice and experience in such surgical procedures.

"(11) A considerable proportion of the failures of operative treatment are due to infection of the wound, a possibility which may occur even with the best technique.

"(12) The mortality directly due to the operative treatment of simple fractures of the long bones has been found to be so small that it cannot be urged as a sufficient reason against operative treatment. (*See* Table X, p. 1528).

"(13) For surgeons and practitioners who are unable to avail themselves of the operative method, the non-operative procedures are likely to remain for some time yet the more safe and serviceable."

Though I would take some objection to (2), these conclusions bear out the statement I had put forward in relation to the operative treatment of simple fractures. As regards the statement that "it is possible either by non-operative or by operative treatment to obtain a high percentage of good results in children," all I would say here is that it is not borne out by the study of fractures in children during the last thirty years at the Hospital for Sick Children. I have operated on a large number of simple fractures at that institution without the slightest accident of any sort, in each case restoring the broken bone to its normal form. I would ask how it is possible to compare those results with those obtained by splints, etc., a very large number of which came under our observation because they were unsatisfactory. Mr. Sampson has published a very interesting paper on this subject in *The Lancet*, August 17th, 1912, reference to which will repay the reader. Conclusions (2) and (7) would appear to be rather contradictory. The accuracy of conclusion (7) is borne out most fully by my experience.

In the Report of the "Fractures Committee" are included papers by Mons. A. Lambotte, of Antwerp, who describes and figures his external protector; by myself; by the late Mons. J. Lucas-Championnière, who describes his method of treating fractures by massage and mobilisation; by Dr. F. Steinmann, who describes and illustrates his method of attempting restoration of the form of the bone by nail extension; by Geheimrath Prof. Dr. Bardenheuer and Stabsarzt Dr. Dräfsner, who describe their method of extension, and by Oberarzt Dr. Shrecker, who has introduced modifications of Dr. Bardenheuer's treatment. These treatments and results were considered very fully by the Committee, and I would strongly recommend to the reader the perusal of these several communications, in order that he may form an independent opinion as to the value of the several forms of treatment.

Like the Committee, I have not the slightest doubt as to the best method of dealing with simple fractures. The Committee is to be very much congratulated on the thoroughness of its work, and on the time and care it has devoted to the investigation of the treatment of simple fractures.

Operations for Malunited and Ununited Fractures.

I wish to call attention to two classes of cases. The first is the condition of mechanical disability which so often results from imperfect restoration of the broken bone to its normal form. The patient may require to be treated either for a more or less complete inability to perform his functions normally, or for pain, or for both conditions. The degree to which the above are present varies considerably with the displacement of the fragments and with the age and habits of the patient. They are generally very marked when they oblige the sufferer to submit to a serious operation. The second class is that of non-union of fragments, a so-called false joint being developed at the seat of fracture.

The first group is very rarely alluded to, and surgeons will always insist and affect to believe that such cases do not exist in their practice.

A very large number of these cases have come under my care, and have derived a varying amount of benefit from operations undertaken with the object of restoring the deformed bones as completely as possible to their original form. In the case of the upper extremity the patient usually suffered from such a limitation of the movements of the bones on one another as altogether to incapacitate him from following his employment. Occasionally the radius and ulna had united to one another. Sometimes also, in the case of female patients, deformity, rather than disability, induced them to undergo an operation. In the lower extremity pain, associated with a corresponding amount of mechanical disability, forces the sufferer to submit to any operation, however serious.

The number of cases operated on form but a small proportion of those who have applied for relief, and for many obvious reasons. For instance, to most of them I could promise but a slight prospect of improvement in their condition as the result of operative interference, because the displacement was of long standing, and such definite mechanical changes had taken place in the joints influenced by the deformity that it was unlikely that the patient would lose pain and disability when the fragments had been restored as nearly as possible to their normal relationship to one another. The operative measures necessary to dissociate fragments which have become firmly ankylosed together, and perhaps to adjacent bones as well, and to saw off sufficient bone from each fragment in such planes as will restore the outline of the necessarily shortened bone, are often bloody and difficult, and may be fraught with danger to important adjacent vessels and nerves. Such operations must not be undertaken unless the patient is likely to derive a freedom from pain and disability sufficient to compensate for the risk run. Sometimes it is absolutely impossible to restore the axes of fragments, however extensive the operation and however skilful the operator. It not uncommonly happens that in old-standing fractures the articular surfaces have been displaced from their normal relationship for too long a period to allow of their being replaced in their original position and restored to their previous functional activity. In separation of certain epiphyses, as, for instance, of the head of the femur, if even only very few weeks have elapsed since the injury, all hope of restoring the fragment to its normal position must be given up, and the surgeon is driven to make some more or less unsatisfactory compromise. In this particular injury a moderate amount of outward rotation of the femur can be controlled by stitching up the anterior ligament of the hip-joint, or in more advanced conditions by dividing the shaft of the femur transversely, rotating the lower fragment on its axis through a sufficient angle, and uniting the fragments by a stout steel plate; while if flexion be very limited, its range can be increased by cutting away the front of the stump of the neck of the bone, which by its early impact on the innominate bone produces this disability.

The frequent occurrence of these cases must be well known to surgeons generally, though I can readily understand any individual deluding himself into the idea that he has managed to avoid them in his practice by some skill peculiar to himself.

Considering the unfortunate physical condition of many of these patients, and the misery, distress, and financial loss they and those dependent on them have experienced through the gross inefficiency of the so-called science of which they are the victims, it seems little short of ridiculous to read the statements of surgeons that such mechanical disability is a rare sequence of fracture, and that it can usually be obviated by the use of massage and passive movements at an early date. That massage and passive movements serve to diminish the disability and pain which would otherwise ensue if these fractures were left for an indefinite period in rigid casings is quite familiar to me, but to regard such measures alone as being the best scientific treatment, and not merely adjuvant, suggests a want of perception of the mechanics of the skeleton.

The second group of cases, namely, that of ununited or imperfectly united fractures, is due also to the same unscientific treatment of fractures. Looking through the text-books, I find any number of reasons given for non-union of broken bones, the vast majority of which appear to be utterly without foundation in my experience. The surgeon is only too anxious to lay what blame he can upon the patient or his tissues, and seems inclined to regard as possible any factor other than the obvious inefficiency of his treatment. It may be that in some few cases of simple fracture non-union results from some cause which could not be obviated by proper treatment, but I have never come across one instance in which union would not have resulted in all probability if efficient operative measures had been adopted, though a very large number have come under my observation. I would also like to express an opinion on the frequency of ununited fractures, since my observation on the subject differs completely from that of those who have written about them. My experience and their statements are not to be reconciled, since I believe that ununited fracture is of comparatively common occurrence. I am not surprised at this divergence, as I frequently hear surgeons make assertions as to the results of their treatment of fractures which they would appear to believe to be accurate, and which I have reason to regard with suspicion. As to the published statistics of the frequency of non-union, Lonsdale ('Practical Treatise on Fractures,' London, 1838), found that out of 4000 fractures treated at the Middlesex Hospital, only four or five refused to unite; Norris ("On the Occurrence of Non-union after Fracture," 'Amer. Journ. Med. Sci.,' Philadelphia, January, 1842), did not meet with one case out of 946 fractures; Liston met with only one in his practice. Hamilton says they do not exceed one in 500 cases, and thinks that this is a high estimate. I do not like to think that surgeons of the present day are less successful than their predecessors in obtaining union, as precisely the same rude methods were invariably employed by both till quite recently. The probability is that earlier observers were less careful in the examination

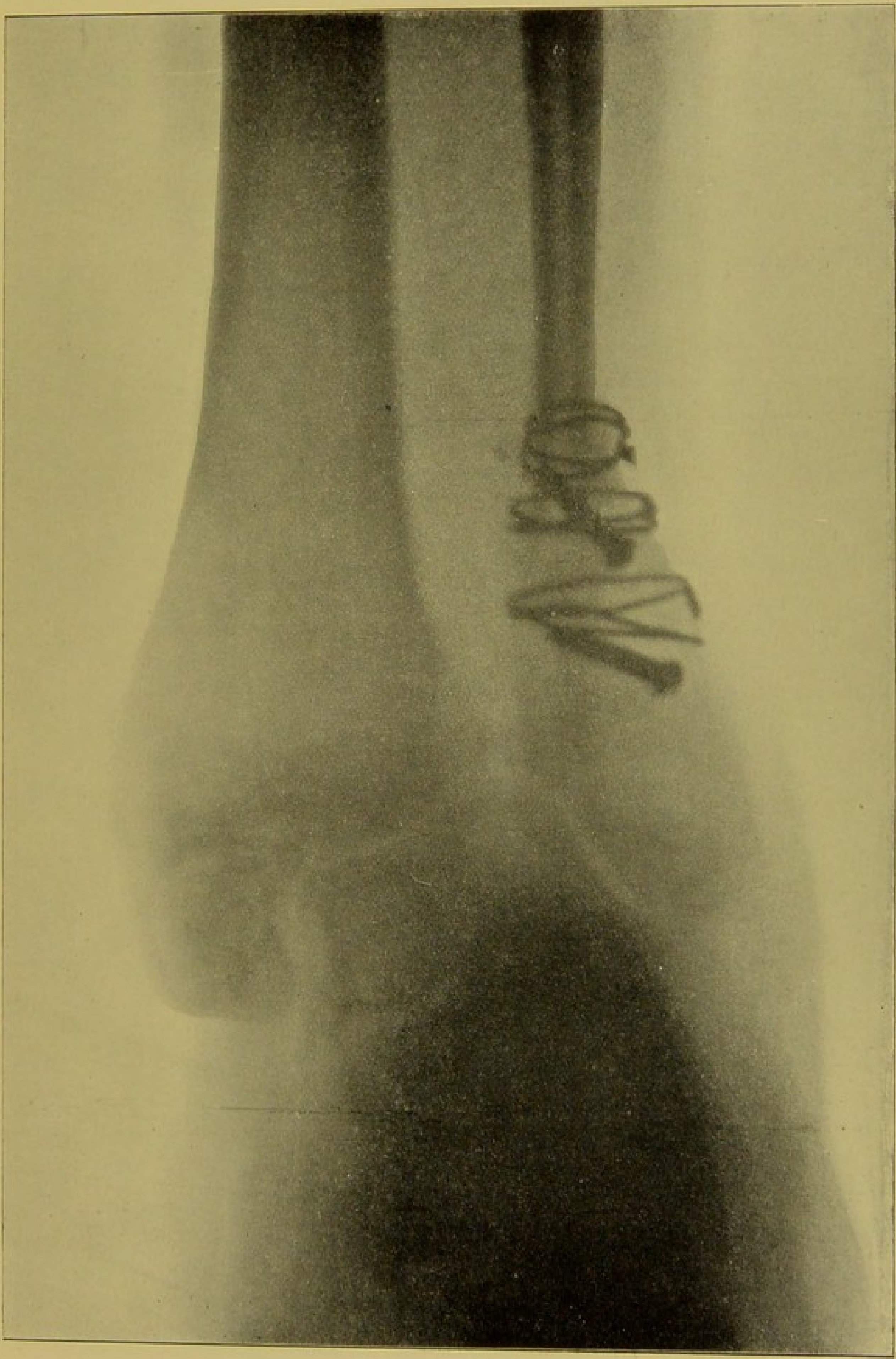


Fig. 182.—Case of malunited Pott's fracture treated by screws and wire.

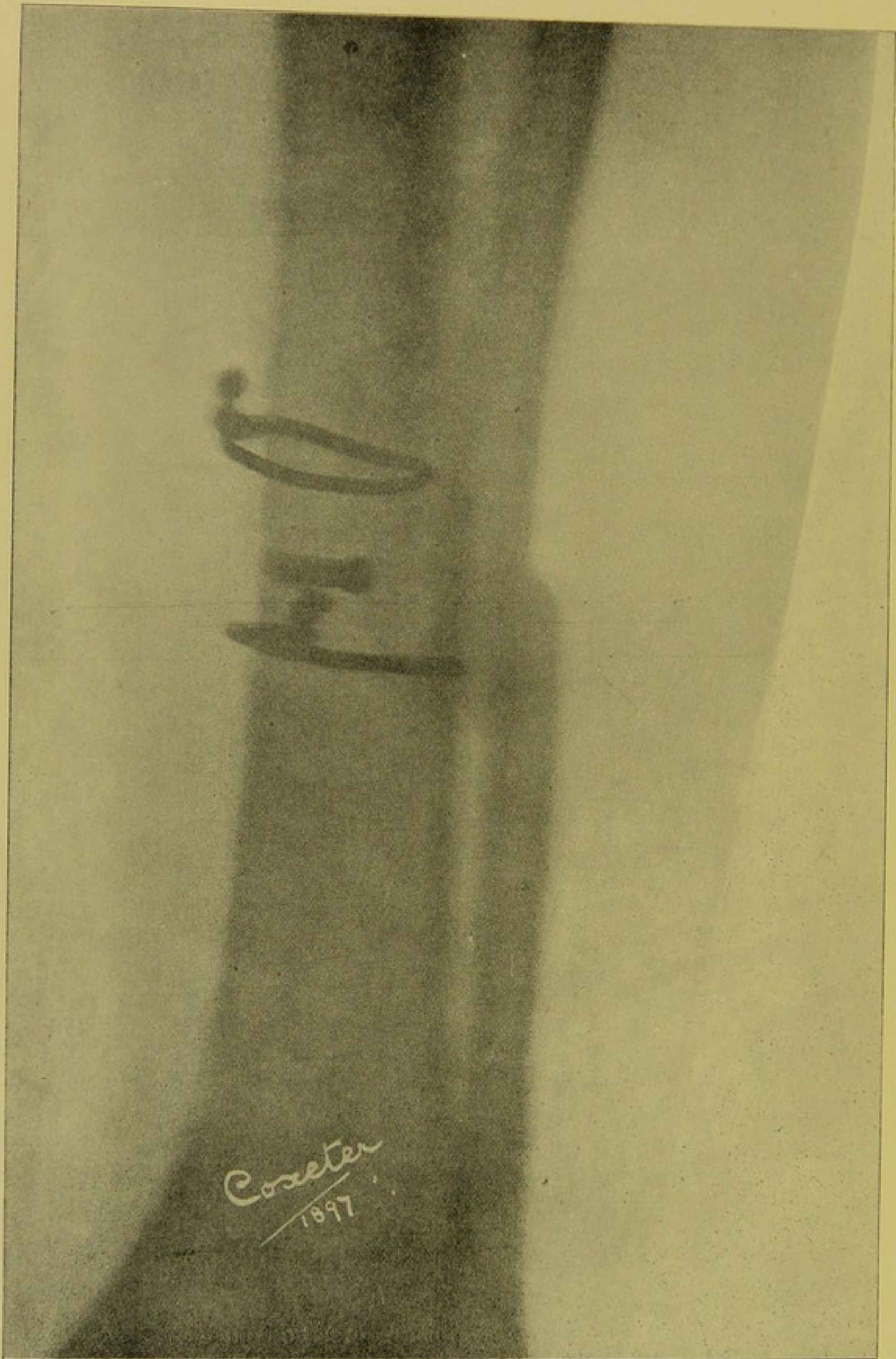


Fig. 183.—Malunited fracture of tibia and fibula treated by screw and wire.

of results, and this habit of regarding them through rose-coloured glasses still clings to the profession, particularly as regards the consequences of fractures.

If there were any truth in these published statistics, it would certainly be extremely difficult to account for the number of cases which I have treated. I find that other surgeons also seem to operate on a fair number of them. On these grounds I have no hesitation in assuming that the accepted statistics on this subject are, as usual, utterly false and misleading.*

I will proceed to give a brief account of a few typical cases from each group, and would call attention in the first instance to some treated by the means which I employed during the earlier years in operations on simple fractures. I do this to show that while I have succeeded in simplifying these procedures enormously by the use of steel plates and screws, so that the method is much more applicable to a greater number, very useful results can be obtained by other mechanisms.

Fig. 182 represents the result of an operation performed in January, 1899, upon a patient, æt. 34, who was the matron of a hospital. Eight months previously she had sustained a Pott's fracture. At the time of the injury she was placed under the care of surgeons of very high repute. Still the displacement of the fibular fragments remained, and, in spite of massage and the means usually adopted in these cases, she was unable to do more than hobble about. Even this caused her great pain. If she continued as she was, she must have given up her only means of livelihood, and settled down to the life of a cripple. As will be readily recognised by the number of screws and wires, shown very clearly in the radiograph, which I found it necessary to introduce, the difficulty experienced in lever-

* "Fact and Fiction, or the Prognosis in Cases of Fracture," 'Practitioner,' 1909, vol. lxxxii.

ing out the lower fragment after the lapse of many months was great, but, by carefully gauging the displacement, I was enabled, by means of two sections crossing the seat of fracture obliquely, to restore the fibula almost completely to its normal form and the foot to its original mechanical relationship with the leg. The result has proved most satisfactory. The patient is now able to walk for miles without pain, and has resumed her usual occupation. This shows clearly how entirely the incapacity of the patient in this fracture resulted simply and solely from the alteration in the mechanical relationship of the bony framework of the ankle-joint consequent on the displacement of the fragments of the fibula.

Fig. 183 represents the result of an operation on a lady who fell down a gangway and broke her tibia and fibula across at the same level, and the fibula a second time near its upper extremity. Many months passed, and she found herself unable to bear her weight upon the limb. She then came under my care. The radiograph showed very considerable overlapping of the tibial fragments. The material uniting them was dense and strong, but, owing to the alteration in the axes of the fragments, she was only able to transmit her weight, which was considerable, and which had increased in the long period during which she was unable to move about, at a mechanical disadvantage. As the fibular fractures were at a considerable distance from the ankle-joint, there seemed but little to be gained by dealing with them. I therefore exposed the tibial junction, and, gauging the displacement as accurately as possible, sawed off the ends of the bones obliquely, so as to bring the axes of the upper and lower fragments into the same line.

Firm union took place, and the patient resumed her usual occupation, suffering only a moderate amount of discomfort from the shortening and from the slight displacement of the fibular fragments.

Fig. 184 represents the femur of a governess, æt. 41, on whom I operated on April 20th, 1898. She sustained a fracture of this bone in June, 1897, less than a year before she came under my observation. Though she had been under skilful treatment the whole of this time, she was quite unable to bear her weight on the damaged limb, because of great insecurity and of the pain she experienced in her hip- and knee-joints, as well as at the seat of the fracture. The upper fragment ran outwards, forwards, and downwards, while the upper extremity of the lower fragment was united to its inner aspect. This is the most common arrangement of the fragments when the femur is broken in this situation. Besides, the deformity and the shortening of the limb were very considerable. The seat of fracture and the relative position of the fragments having been carefully defined by means of the radiograph, it was freely exposed by means of a long vertical incision on the outer side of the thigh. The extremities of the fragments were sawn through in planes which permitted of their approximation, which was effected by means of long and powerful forceps, very great traction being exerted at the same time upon them. They were fastened securely together by means of screws. The result was most satisfactory, the deformity being reduced to a minimum, while the shortening was considerably lessened, and the patient was able to walk with security and without anything more than discomfort in the joints, which was increased by much exercise. This was due to the fact that it was impossible to establish axial continuity of the fragments without sacrificing the length of the femur.

Fig. 185 represents the result of an operation for fracture of the tibia and fibula, the result of direct violence. In January, 1893, the patient, æt. 27, was treated in a large London hospital for simple fracture of the tibia and fibula.

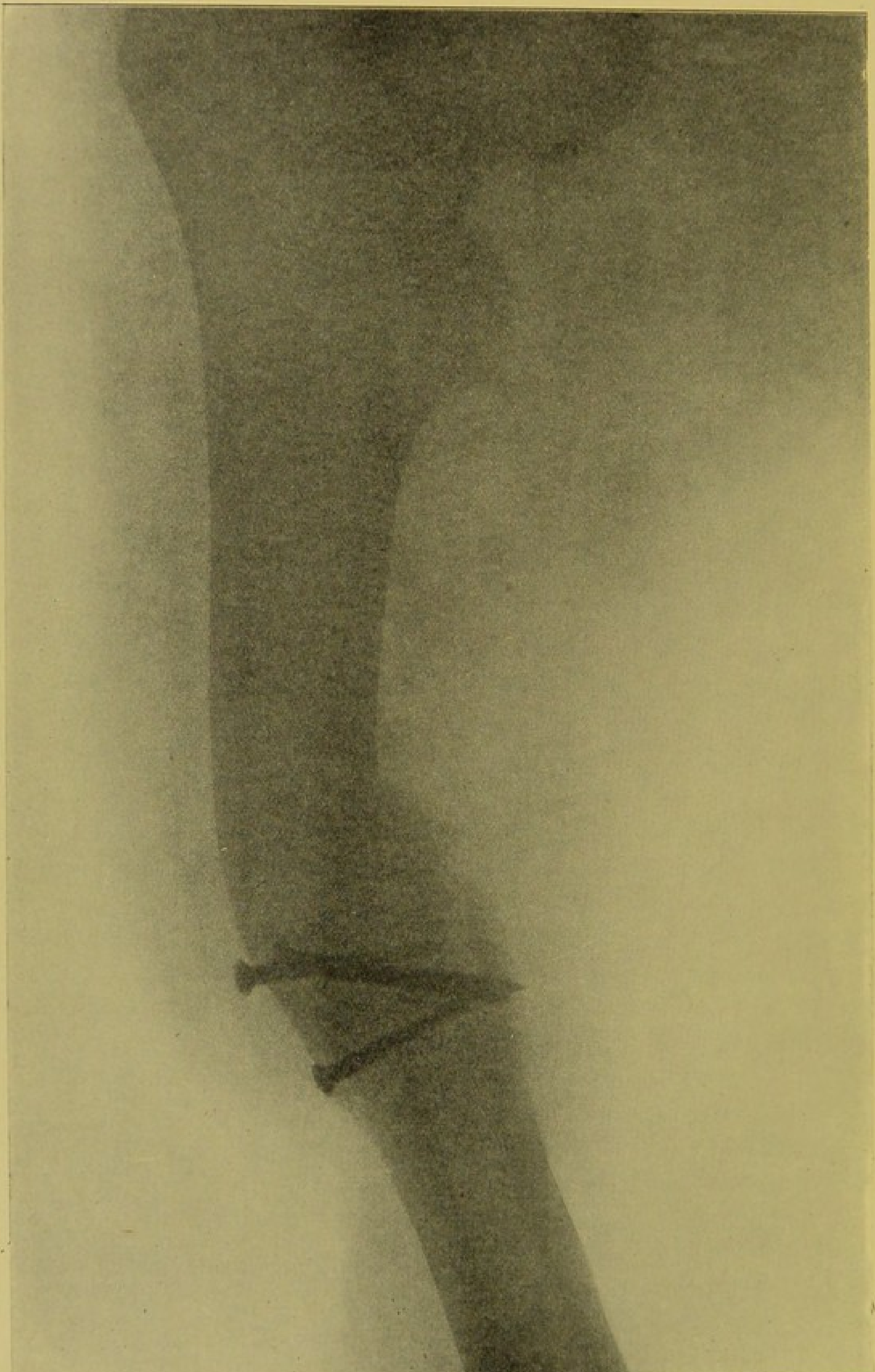


Fig. 184.—Malunited fracture of femur treated by screws.

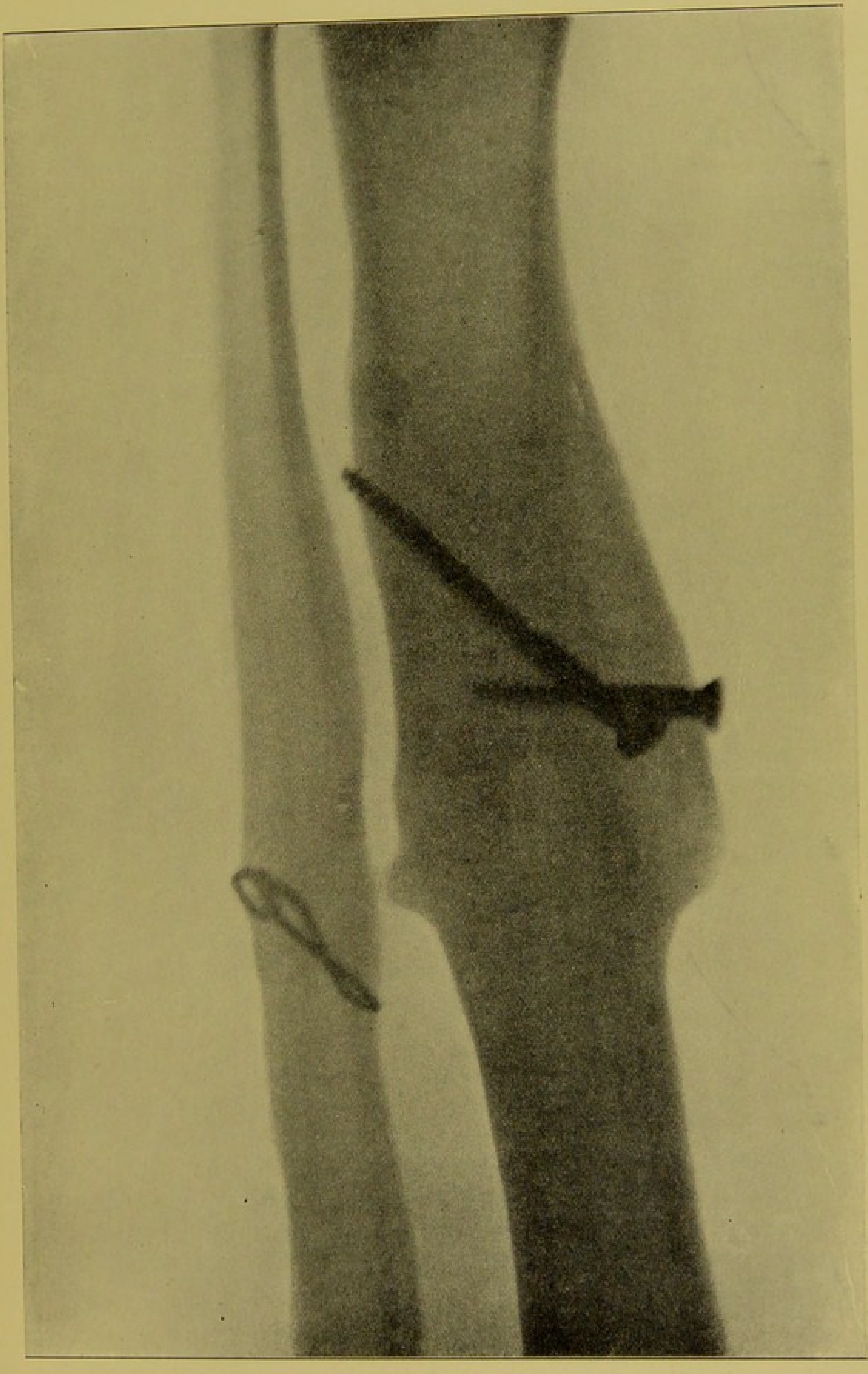


Fig. 185.—Malunited fracture of tibia and fibula treated by screws and wire.

He had every advantage that science and skill could offer; indeed, the surgeon under whose care he was placed was an acknowledged authority on fractures and their treatment. Manipulation and a plaster-case were the treatment adopted. The foot was forced inwards in such a manner that the ball of the great toe, centre of the patella, and the anterior-superior iliac spine occupied a straight line. This adhesion to a ridiculous and antiquated teaching had, combined with a want of recognition of the factors that resist the replacement of the fragments, brought about a disastrous result. He came into my hands many months after the injury with the fragments overlapping considerably. He could not bear his weight upon the limb, because of pain in the fracture and in the ankle-joint.

In October, 1893, both the fractures of the tibia and fibula were freely exposed, and the displacement of the fragments and the alteration in their axes were carefully gauged. The bones were sawn through in four separate planes to permit of the fragments being brought together so that their axes retained a normal relationship to one another. The tibial surfaces were then secured by two screws, and two loops of silver wire connected those of the fibula. The result of the operation was excellent. The only mechanical disability which he experienced was some shortening of the limb, which was unavoidable because of the prolonged overlapping of the fragments.

As the result of the imperfect apposition of the broken surfaces in the first instance, the man and those dependent on him were deprived of the benefit of his services for nearly a year longer than was necessary, and at the end of that time he was incapacitated to some extent by the shortening of the leg. I would point out that the patient, when he sustained the fracture, was a young and vigorous man in excellent health, and one in whom repair proceeded actively.

Another excellent illustration of the methods of operative procedure which I employed years ago is shown in the result of the treatment of an ununited fracture of the tibia (see Fig. 186). The patient, a man, had broken his

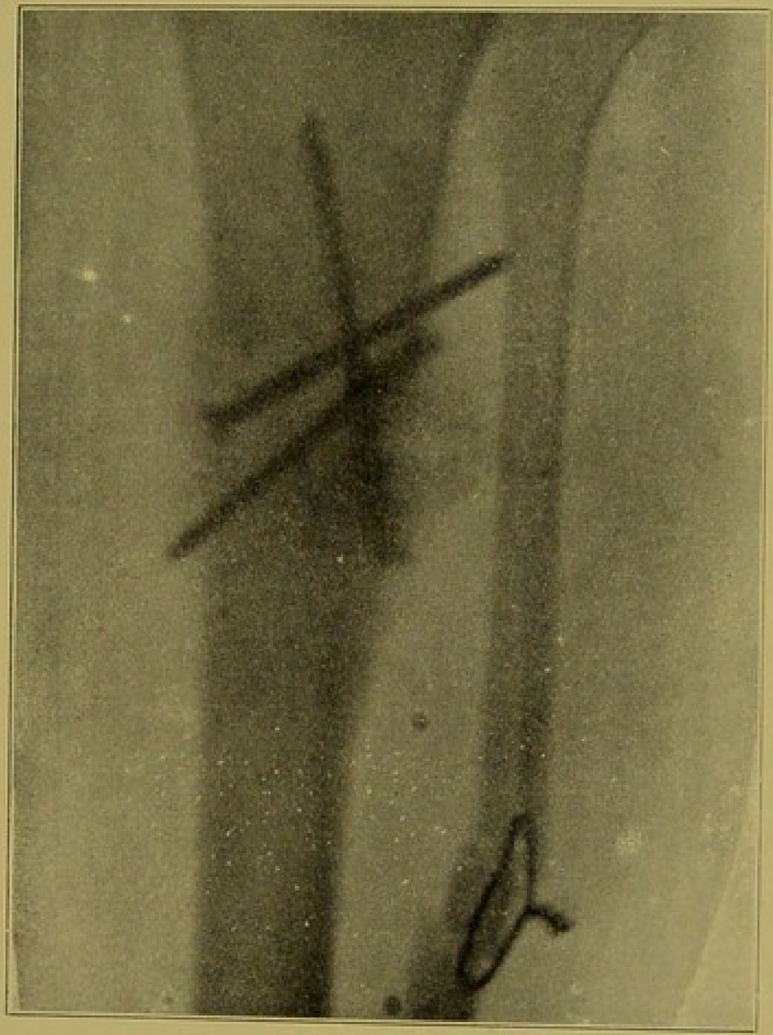


FIG. 186.—Ununited fracture of tibia and fibula treated by screws and wire.

leg more than a year before and had previously undergone an unsuccessful operation for the relief of the mechanical disability resulting from non-union. At the time he came under my care the tibial fragments moved freely on one another on an axis at right angles to the plane of the fracture, which was very oblique in direction, and he was altogether unable to bear his weight on the limb. In this case it was necessary, after excising the false joint, to use three long steel screws passed in different directions in order to secure perfect apposition and complete immo-

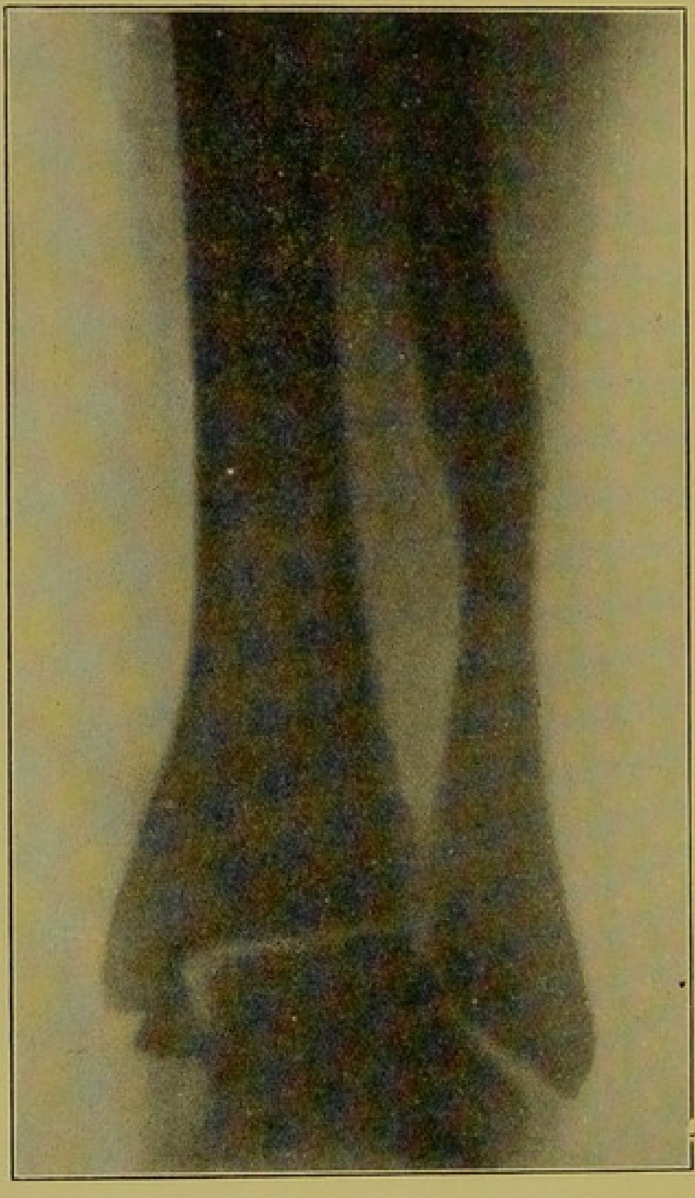


FIG. 187.

bility of the fragments. Two loops of silver wire were found lying loose in the bone, and afforded the only evidence of a previous operation. A little too much of the fibula was removed, and, as seen in the illustration, a portion of it was replaced. The radiograph was taken about three months after the operation, the result of which was perfect, the patient then being able to bear his weight securely on the damaged leg.

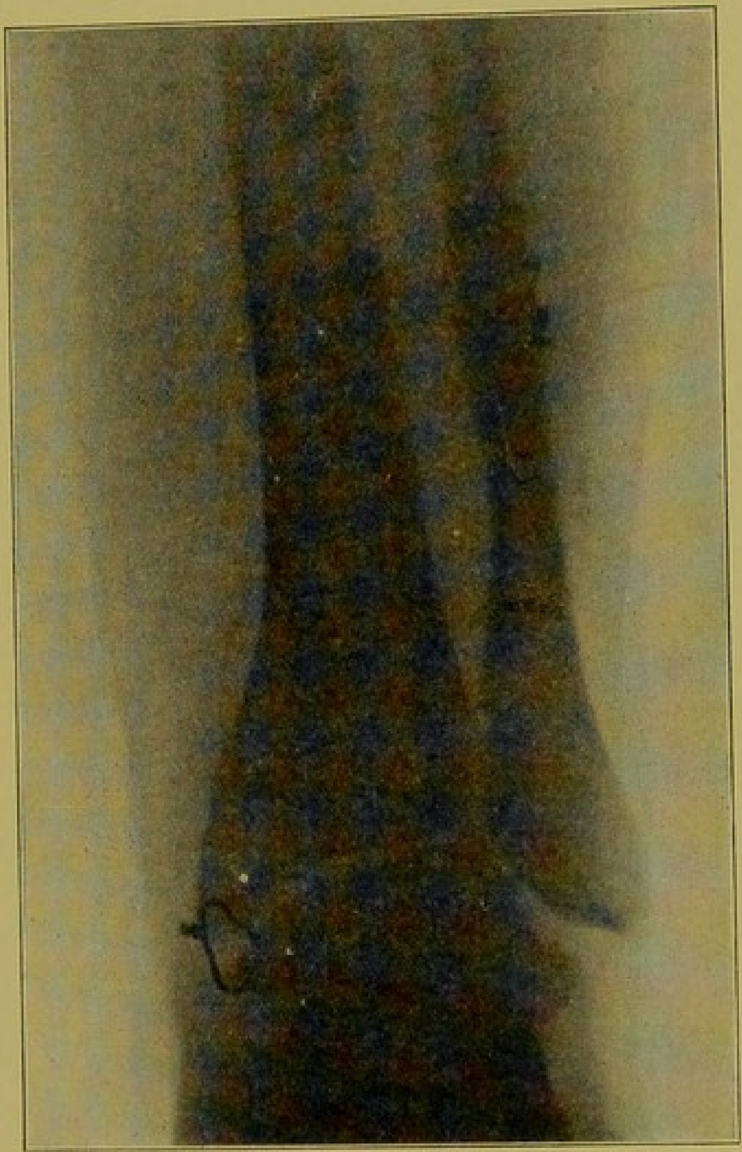


FIG. 188.

Fig. 187 represents the conditions present in an old case of abduction fracture of the ankle of the second degree. The fibular fragments are displaced upon one another, while the fragment of the inner malleolus is thrown outwards. In consequence the ankle-joint is fixed in a position of abduction.

The man, an artillery soldier, has been discharged as unfit from the Service.

Fig. 188 shows the result of operation. The fractures

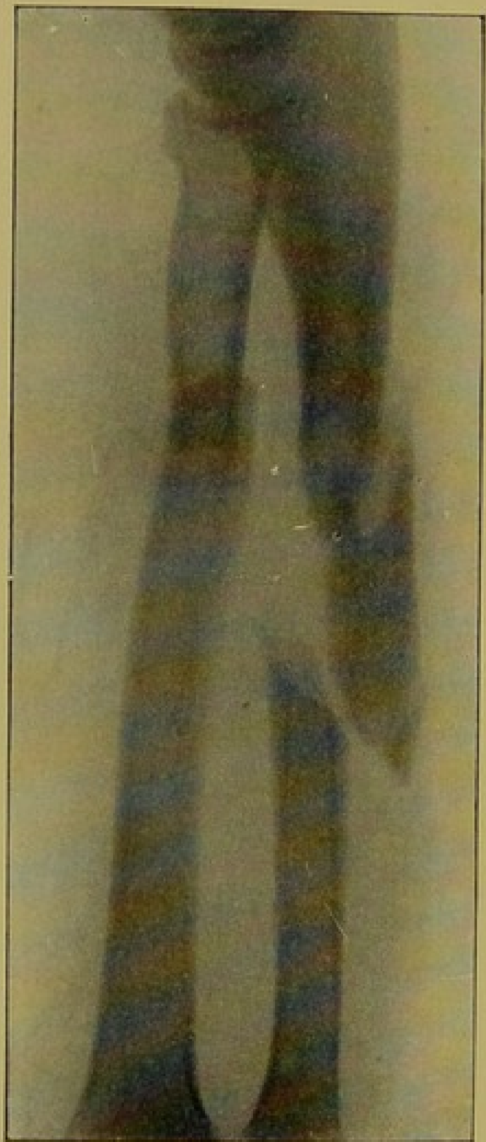


FIG. 189.

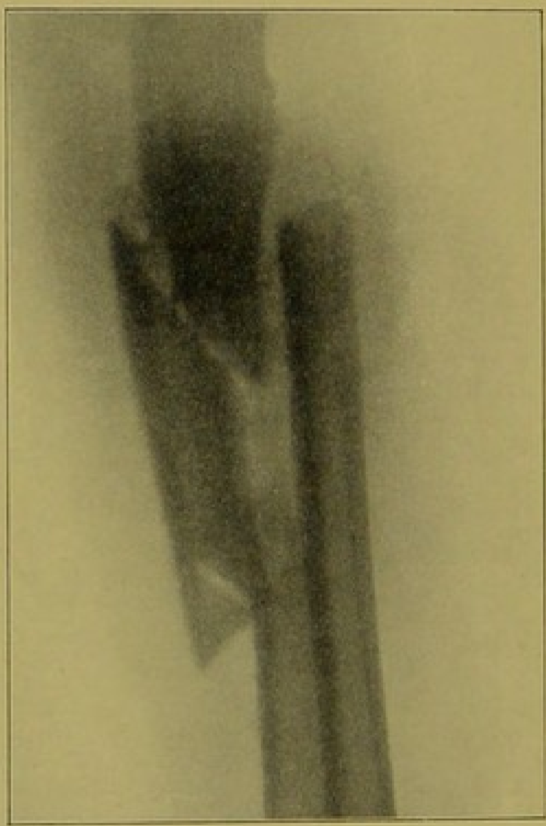


FIG. 190.

were cut up and the fragments secured in position by loops of silver wire. The man was enabled to earn his living, whereas previous to the operation he could only walk a few yards in great pain.

Figs. 189 and 190 show the conditions presented by an old extensively communited fracture of the bones of the forearm. The man had been completely incapacitated for months, and little or no callus had been formed between

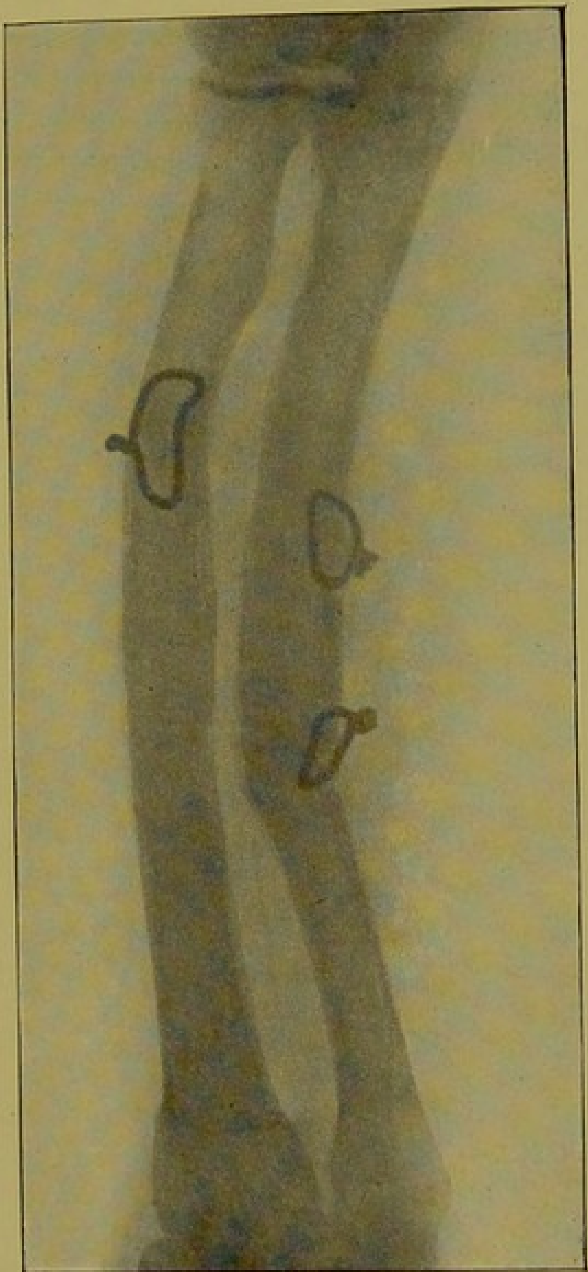


FIG. 191.

the bones. The several fragments were freed from the soft parts, placed in the best possible position, and were secured by loops of silver wire. The patient's capacity improved considerably after the operation, the result of which is shown in Fig. 191.

Fig. 189 shows fracture of radius and ulna in antero-posterior plane.

Fig. 190 shows the same in transverse plane.

Fig. 191 shows condition after operation.

Fig. 192 shows a fracture which is by no means uncommon, though not often recognised. An officer was

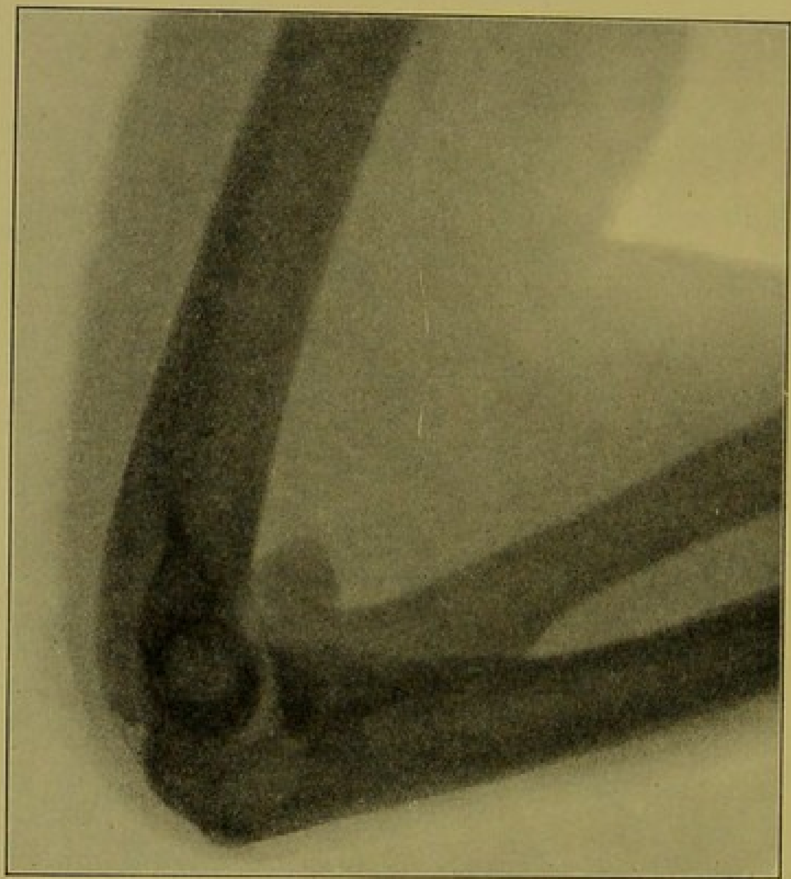


FIG. 192.—Old fracture of coronoid process.

thrown off his horse, and dislocated both bones of the fore-arm backwards. The dislocation was reduced, and he was directed to move the elbow-joint freely. He was quite unable to do so, the arm being kept rigidly flexed at a right angle. He was regarded as neurotic, and, being unfit to continue on active service, was invalided home from South Africa. The X rays showed that flexion was opposed by the presence of a hard bony mass, which could be felt projecting forwards in the situation of the coronoid process, and that the apex of the coronoid process had been broken off at the time of the injury. If this had been recognised at the time the injury was sustained, it could have been treated perfectly and simply by fixing the detached fragment to the remainder of the coronoid process. The fragment and callus being excised it was then possible to flex and extend the arm completely. Even then a very long time elapsed before the muscles and ligaments had become resilient enough for the patient to move his arm painlessly within a full range.

The case illustrates exceedingly well the advantages of a scientific operative treatment of fractures. If, in the first instance, this patient had been submitted to a simple operation, he would have been able to resume his duties in six weeks at the very outside, having had a painless convalescence, while, as it is, he has been lost to the Service for at least a year, and his health has been seriously affected by the pain he had to endure in the attempts made to obtain movement before the operation as well as after it.

Having related and illustrated some of my earlier cases of malunited or ununited fractures, I shall now describe two typical examples treated by the most recent methods.

I choose them as they illustrate some difficulties which may at first sight seem insuperable, and the methods by which these difficulties can be overcome.

One represents a badly comminuted fracture of the femur which was operated on five months after the bone had been broken, and the other multiple fractures of the tibia and fibula operated on twelve weeks after the injury. Both cases had been under the care of very eminent surgeons, and in neither, apart from operation, was there the slightest prospect of restoring the patient to active usefulness. Both cases are illustrated by radiograms taken at intervals. They are of particular interest since they show the manner in which callus serves to render secure the junction of a broken and deformed bone in which it has been impossible to obtain any large area of bone apposition without shortening the limb very materially and so reducing its usefulness and the symmetry of the individual in a corresponding degree. They also show that the crystallisation of lines of force, which I showed to be a striking feature in the fractures of young life, takes places progressively in a marked manner later in life and for a long period after the union of the fractured ends has been effected. This entails the careful retention of the leg for a considerable time in an apparatus by means of which the weight of the body is transmitted from the tuberosity of the ischium to the boot. Such an apparatus enables the patient to get about at an early stage of convalescence, while the gorging of the limb with blood consequent upon the dependent position of the leg during locomotion assists very materially in the formation of callus. Great care should be taken to encourage this engorgement within reasonable limits and to avoid any direct pressure on the seat of fracture which is likely to reduce its blood-supply. Such a splint was made for me in both these cases by Mr. A. Hoefftcke, and it served its purpose perfectly.

The first case was that of a man, æt. 46. On February 1st, 1910, he fell in an aeroplane accident and sustained a very severe comminuted fracture of the upper part of the shaft of the right femur. Everything that was possible was done by means of splints, etc., but he was left with a useless and deformed limb. Fig. 193 shows the condition of the bone when he came under my care five months after the receipt of the injury. It is apparent from an examination of the radiogram that the junction was unsatisfactory in the extreme. The comminuted fragments were united by callus at a very bad angle, the union being scanty and imperfect. It also shows that, owing to the splitting of the shaft vertically and to the comminution of the fragments, in order to restore the limb to anything approaching its normal length only a portion of the

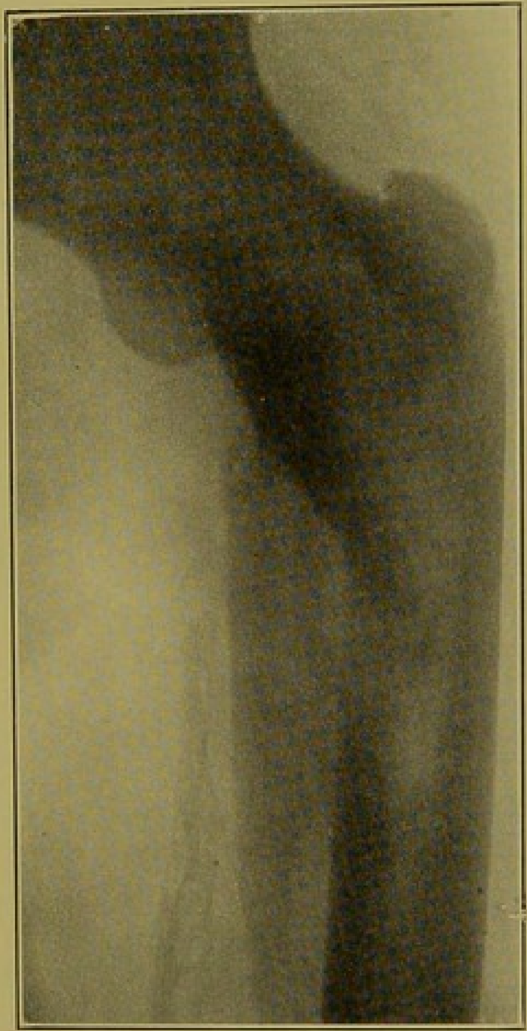


FIG. 193.—Skiagram taken July 4th, 1910, showing condition of femur before operation.

segment of each bone could be employed to effect a junction, and that some delay must necessarily take place before the interval that would remain between the broken spikes could be filled in with new bone in sufficient quantity to make the femur perfectly secure functionally. On July 13th, 1910, the operation was performed. As was expected, it was only possible to utilise the blunt end and side of a spike of the lower fragment, which was placed in contact with a similar spike and blunt surface on the upper fragment. In this manner the length of the shaft was reduced

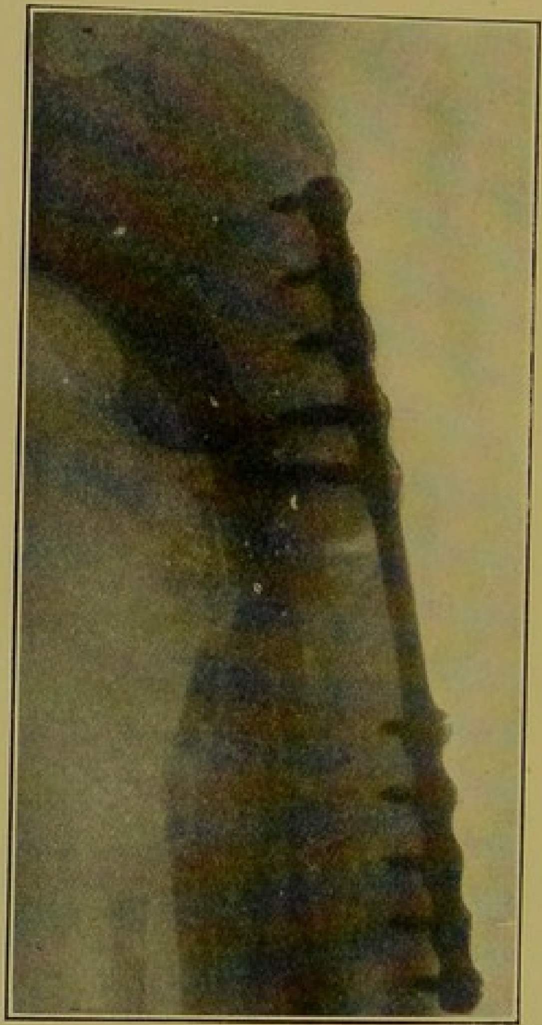


FIG. 194.—Skiagram taken August 22nd, 1910, showing early results of operation.

by only half an inch. A very stout steel plate, secured by means of eight No. 7 screws, three quarters of an inch in length and threaded up to the head, was placed in position so as to retain the fragments immovably and firmly together. Fortunately the bone was very dense and strong. The patient made an uninterrupted recovery. On September 13th, Mr. Hoefftcke fitted him with his splint and the patient gradually got about with increasing comfort and facility. He was finally able to discard the splint after wearing it for some months. He now gets about easily and leads a very active life. Figs. 194 and 195 show

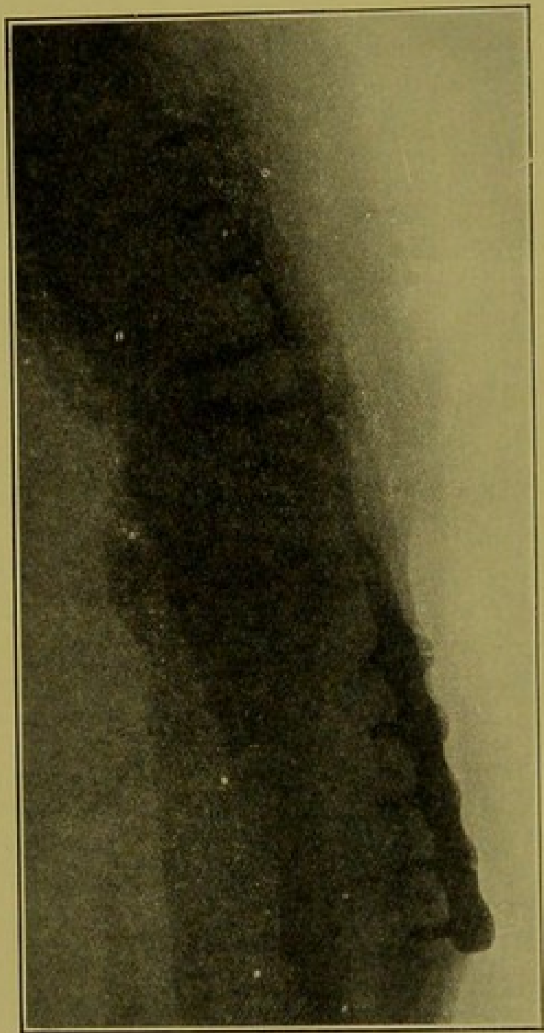


FIG. 195.—Skiagram taken May 25th, 1911, showing firm bony union.

the condition of the bone at intervals. Fig. 194 was taken in August, 1910, a little more than one month after the operation, and Fig. 195 in May, 1911, nine months later. They speak for themselves and hardly need any description. The amount of callus which was formed, and filled in the interval which existed between the fragments after the operation, has increased considerably and now exists in sufficient quantity to render the bone perfectly strong and efficient.

The second case was that of a powerfully-built man, æt. 56, under the care of Dr. Henry Menzies. He had

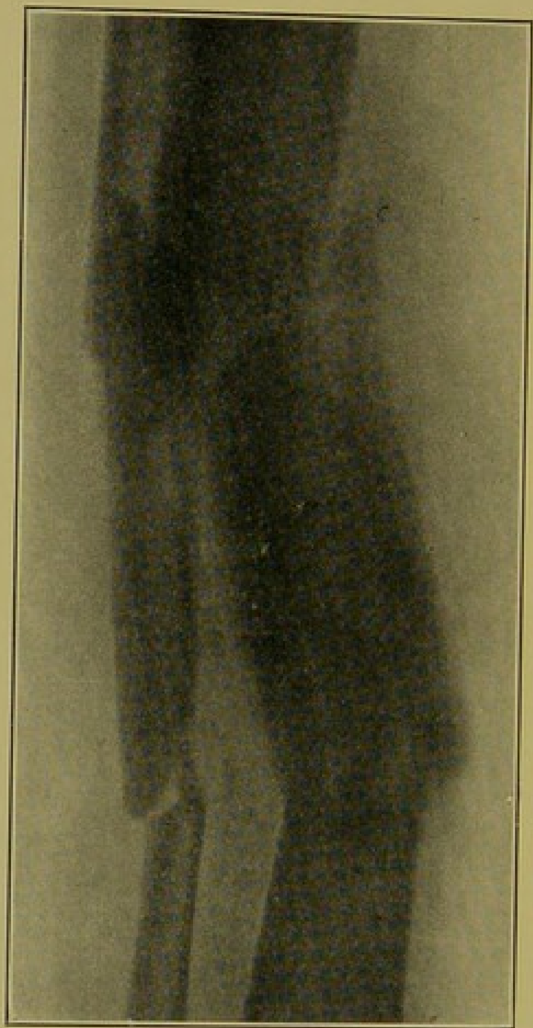


Fig. 196.—Skiagram taken February 5th, 1911, showing condition of tibia and fibula before operation.

sustained a severe comminuted fracture of the left tibia and fibula in December, 1910. The fractures were produced by direct injury, and there was much damage to the soft parts. The tibia and fibula were each broken in two places, so that there were six separate large fragments of bone (Fig. 196). Besides this there were smaller pieces.

The fragments had been so displaced that their several axes differed very greatly in direction and there was much overlapping, so that at none of the four fractures was there anything approaching apposition of the broken parts. The

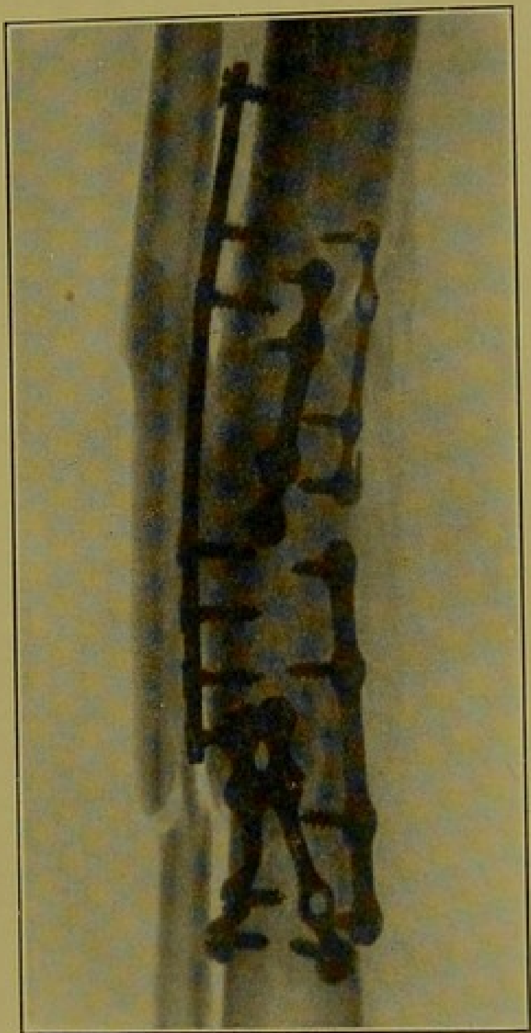


Fig. 197.—Skiagram taken April 26th, 1911, showing reposition of parts two months after operation. The formation of new bone is indicated but faintly.

operation was performed on February 19th. The imperfect junctions between the tibial fragments were cleared, and their opposing surfaces were sawn so as to enable us to restore the bone to its original form ; the cut surfaces were placed and secured in accurate apposition. To retain the fragments in position it was necessary to use six steel plates of varying sizes and strengths. No attempt was made to unite the fibular fragments. This would have increased the risks of the operation very much, while it would have afforded no sufficient compensation, as the

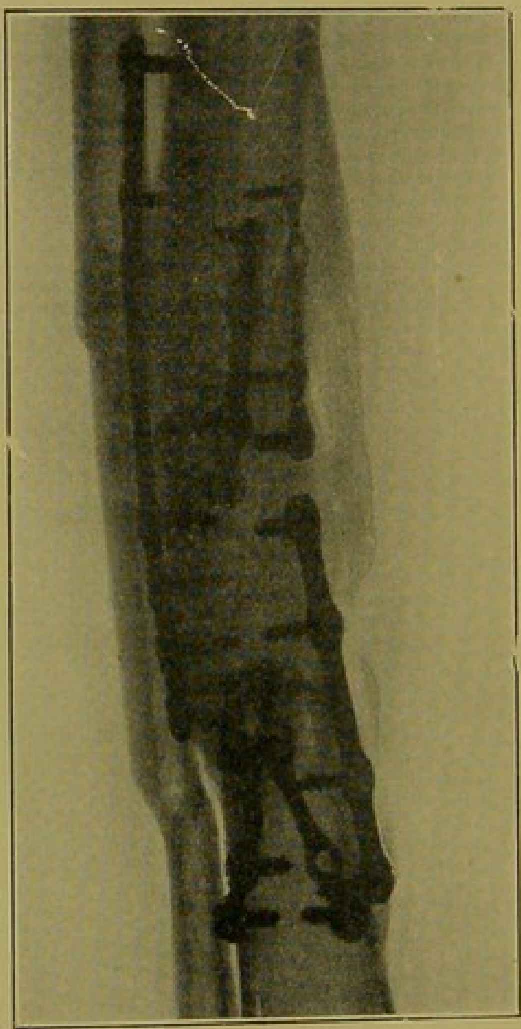


Fig. 198.—Skiagram taken September 11th, 1911, showing later results of operation and the further deposit of bone along the line of pressure.

fibular fragments would unite as soon as the tibia was functionally secure. As in the first case, the successful result was chiefly due to the skill and care of my assistants—most important factors in the performance of these operations. The patient made an uninterrupted recovery. Mr. Hoefftcke fitted a splint on May 8th, 1911, and the patient soon learnt to use it. Figs. 197 and 198 show the condition of the bone at intervals of about two and seven months after the operation. The amount of new bone that continued to form even after the fragments of the tibia had apparently become firmly united was considerable. Fig. 199

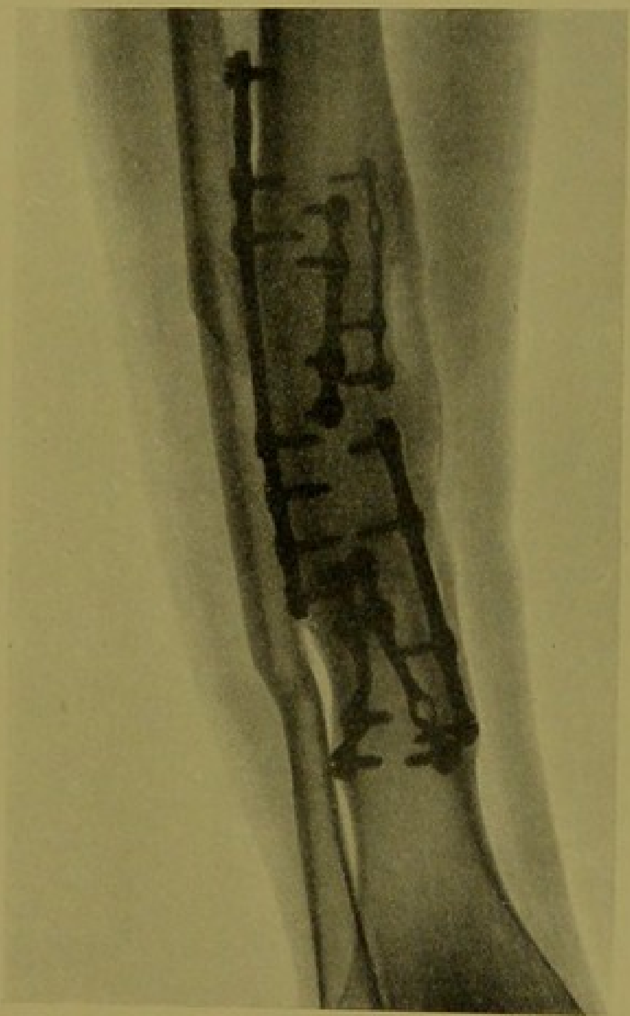


FIG. 199.—Skiagram taken June, 1914, showing still further crystallization of the lines of force.

showed that union is perfect between all the fragments of the tibia and fibula. The radiograms illustrated in Figs. 196 and 197 were taken by Mr. A. H. Greg, the others by Mr. W. A. Coldwell. They show very clearly how comparatively late in life the lines of force may be crystallised by gorging the limb with blood. This is indicated in progressive stages in Figs. 197 and 198, and is much more marked in Fig. 199, which was taken in June, 1914, three years and four months after the operation.

I would illustrate the treatment of ununited fracture of the neck of the femur by the skiagrams of a patient who was a vigorous, strong man. He was thrown from his

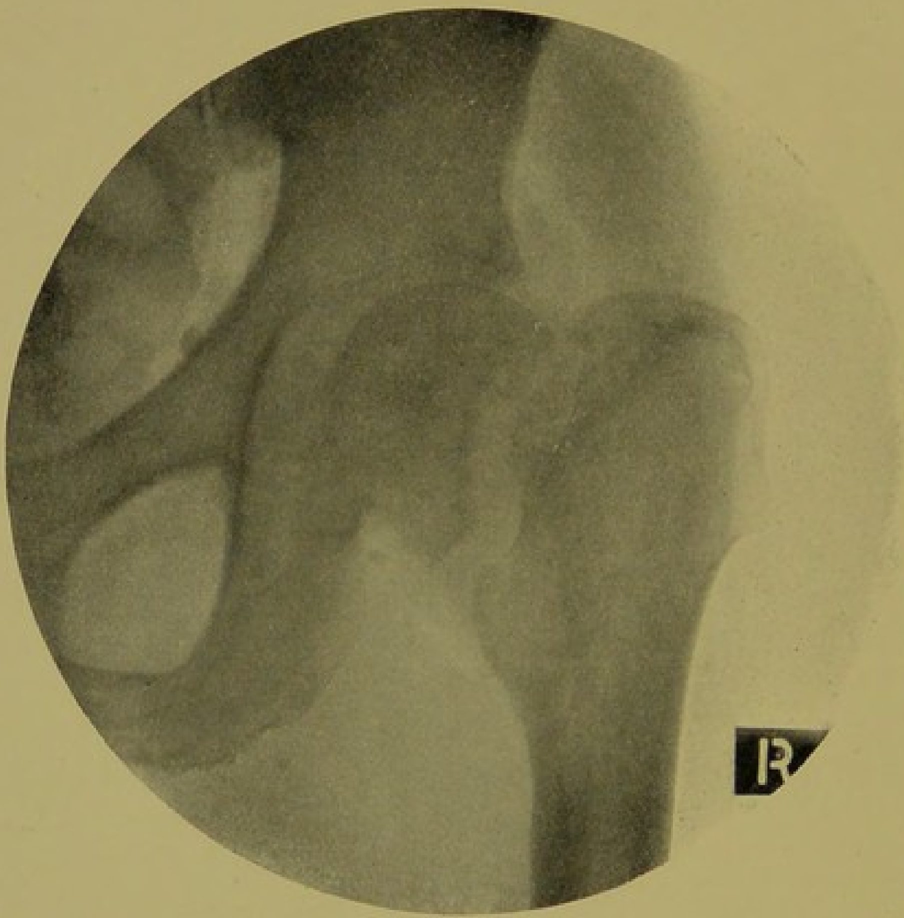


Fig. 200.

horse, breaking the neck of his femur. He was treated in the usual manner by splints and extension, with the result that he developed an ununited fracture. His disability was such that he was to be invalided out of the Service unless the fragments could be united. As a considerable interval had elapsed since the receipt of the injury, much wasting of the fragments of the neck of the bone had ensued. This is shown clearly in Fig. 200.

The joint was exposed, the adjacent surfaces of the neck were sawn off, and the head was fastened securely to the stump of the neck by two long screws. The patient made an uninterrupted recovery. The range of movement in the hip-joint is limited by the shortening of the neck,

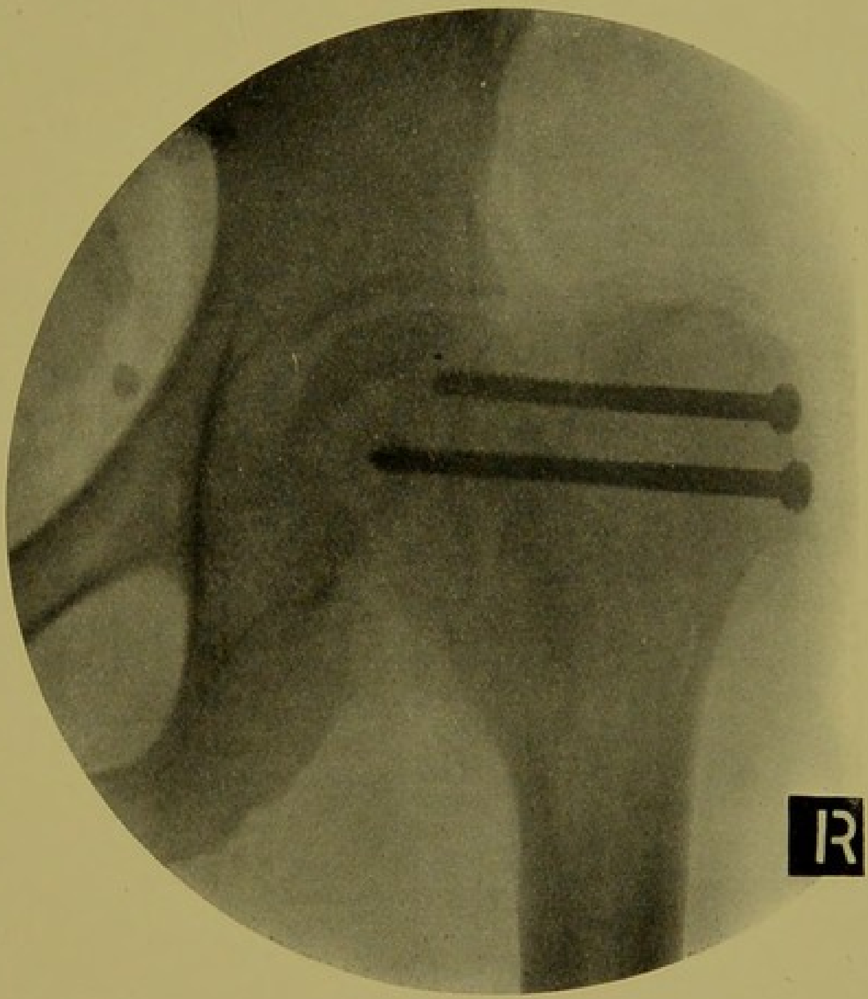


Fig. 201.

but his activity is such that he is able to walk and ride comfortably and is still in the Service. Fig. 201 shows the result of operation.

Fig. 202 shows an ununited fracture of the neck of the femur, which, on account of the free mobility between the fragments, totally disabled the patient from following his occupation.

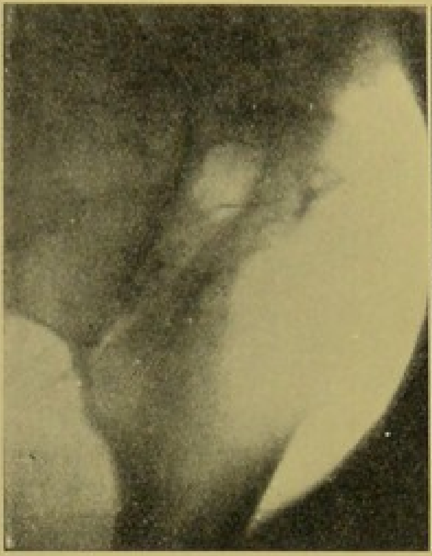


Fig. 202.

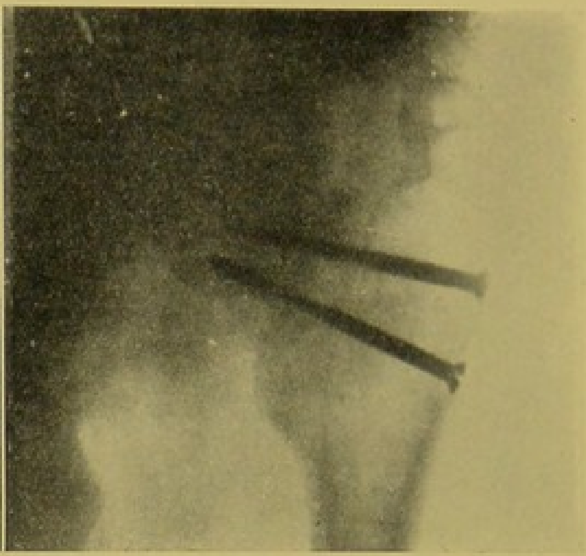


Fig. 203.

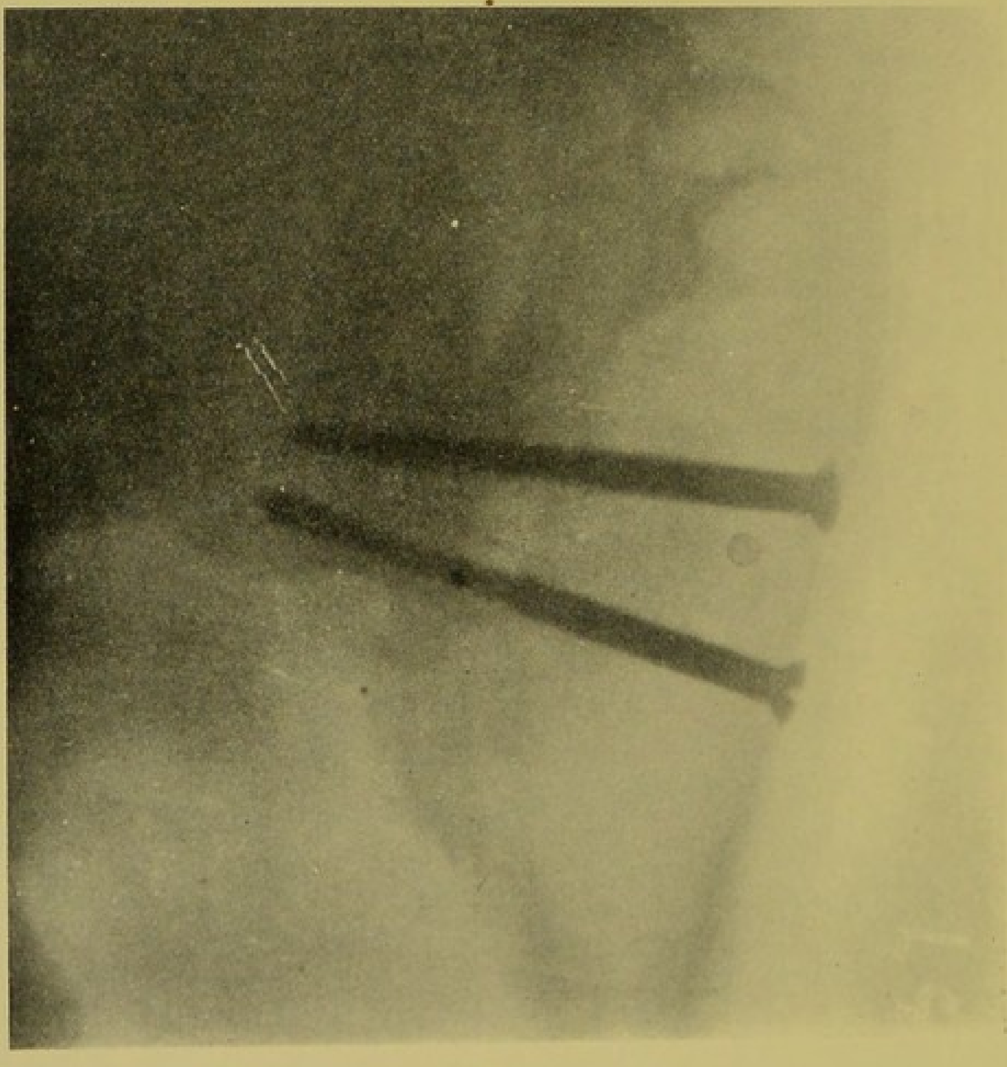


Fig. 204.

The false joint which had formed was freely exposed, its surfaces removed and the fragments firmly united to one another by two long screws. An excellent result was obtained, the patient being able to follow his employment with comfort.

The result is shown in Fig. 203.

Fig. 204 shows the condition which obtained after an

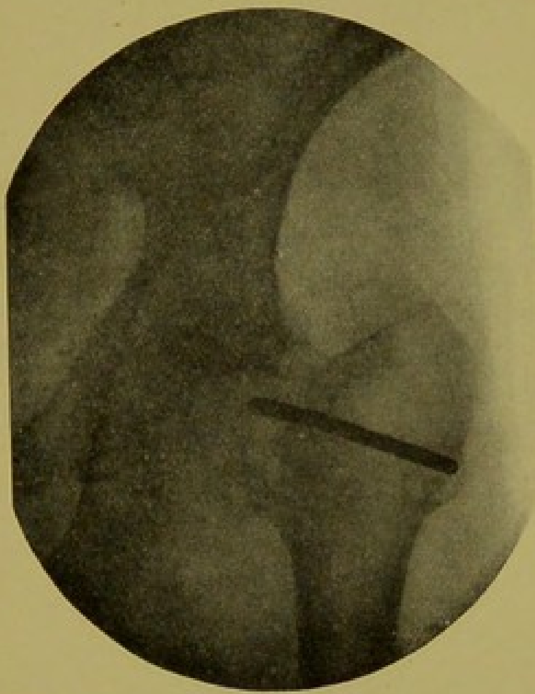


Fig. 205.

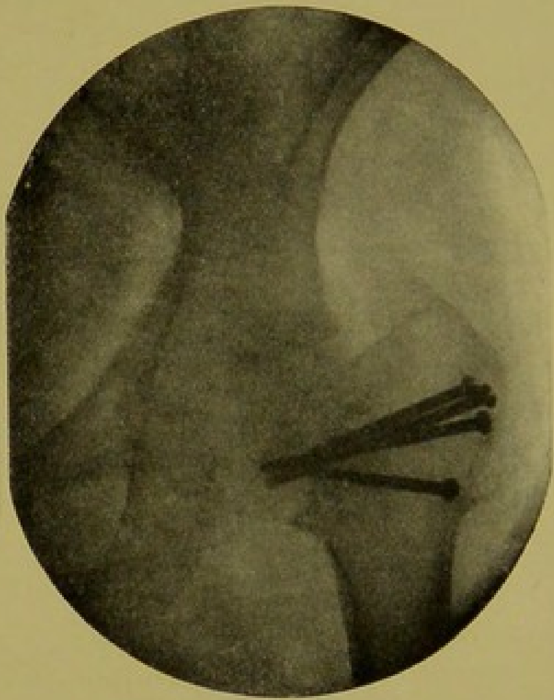


Fig. 206.

operation in a similar case of ununited fracture of the neck of the femur.

I have treated many of these cases in this way, mostly with similar success. In some the operation has been only partly successful, because of ankylosis of the head of the bone to the acetabulum previous to the operation.

In a fair proportion of the cases that have come under my care a futile attempt had been made to establish union of the fragments by the introduction of ivory pegs or of round nails or steel rods. In no case have I ever seen any benefit result from this rather useless means. On the other hand much rarefaction of the bone and often ankylosis of the head of the femur to the acetabular cavity has ensued from movement upon their unsuitable mechanical appliances.

Fig. 205 shows such a mode of treatment, while Fig. 206 illustrates the result obtained by the removal of the

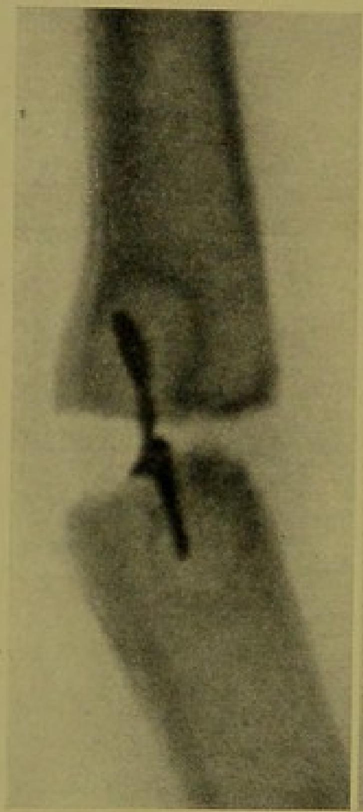


FIG. 207.

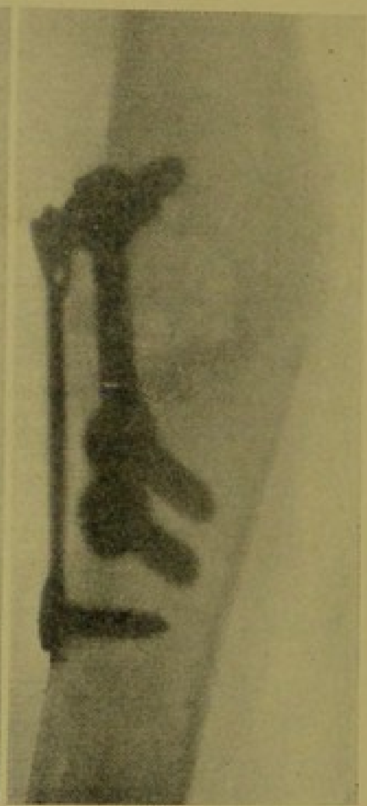


FIG. 208.

useless steel rod, the freshening of the opposing surfaces and their accurate approximation by means of four screws.

The following cases illustrate three operations for ununited fractures of the humerus, all of which had been previously operated on, one for malunion.

Fig. 207 shows the radiogram of an ununited fracture of the humerus, which had been originally broken by indirect violence. The surgeon under whose care she was cut down in the fragments and fastened them together with a loop of silver wire, which is shown. As the result of imperfect apposition, the fragments moved on one another and the bone about the wire was absorbed. The failure to unite was attributed to some fault or peculiarity of the patient which was called rarefying ostitis. The fracture was exposed and the wire was removed. A thin shaving of bone was sawn off the opposing surfaces, the area of

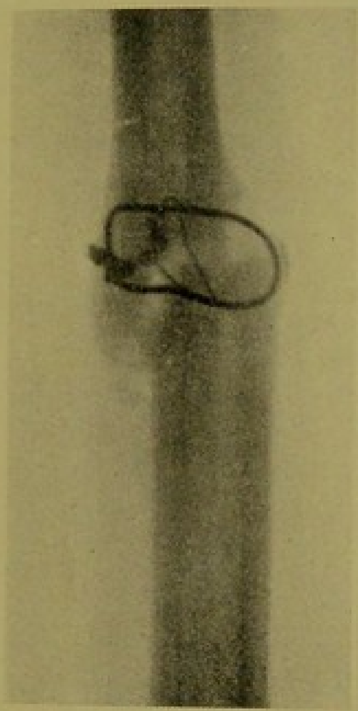


Fig. 209.

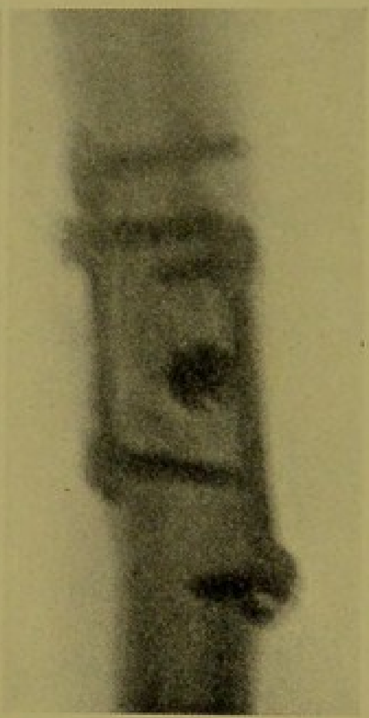


Fig. 210.

rarefaction being left intact. The fragments were placed in apposition, being secured by two steel plates and screws.

A perfectly useful arm was obtained, union taking place normally. Here the original failure was clearly due to defective technique and not to any peculiarity in the osseous system of the patient.

Fig. 209 is a radiogram of an ununited fracture of the humerus of a young lady. As in the last there is a loop of thin wire which perforated the adjacent fragments. The patient was treated in the first instance by plaster, etc. As the fragments showed no sign of union after some months had elapsed, the surgeon cut down upon the fracture and attempted to retain the fragments in apposition by means that seem singularly frail and inefficient. Unfortunately he included the musculo-spiral nerve in the wire, so that the

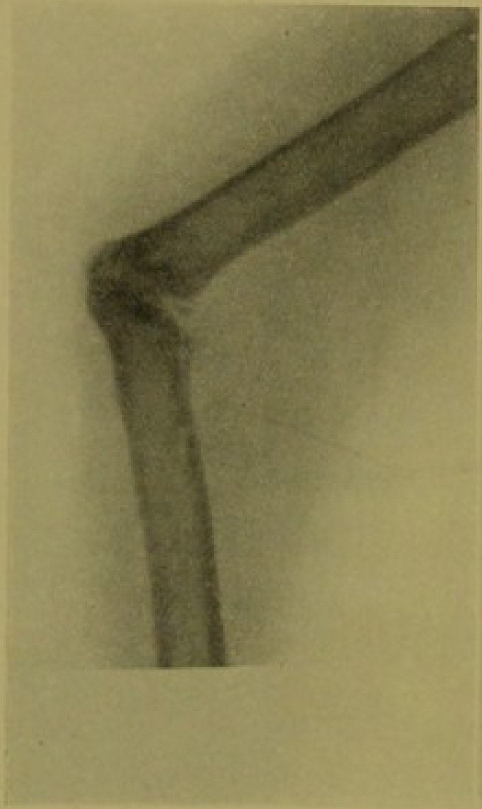


Fig. 211.

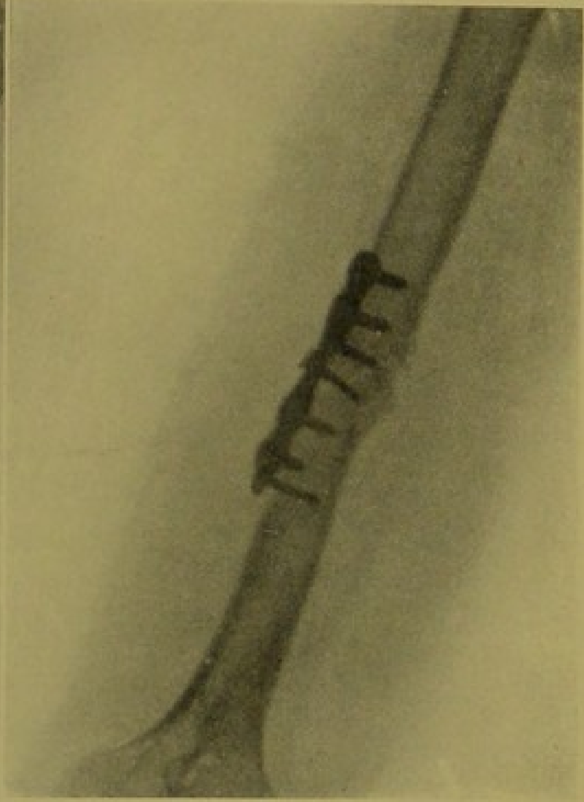


Fig. 212.

patient had, in addition to the non-union, paralysis of the muscles supplied by this nerve.

The seat of fracture was freely exposed, the musculo-spiral traced and freed from the wire, which was removed.

The apposing surfaces of bone were freshened and were secured immovably in position by means of two plates and screws as shown in Fig. 210.

Union took place normally and the paralysis of the musculo-spiral disappeared.

Fig. 211 represents an ununited fracture of the right humerus which had been treated in the first instance by splints. An attempt had been made to unite the fragments subsequently by operation, but the bone remaining ununited the wire which had been employed was removed.

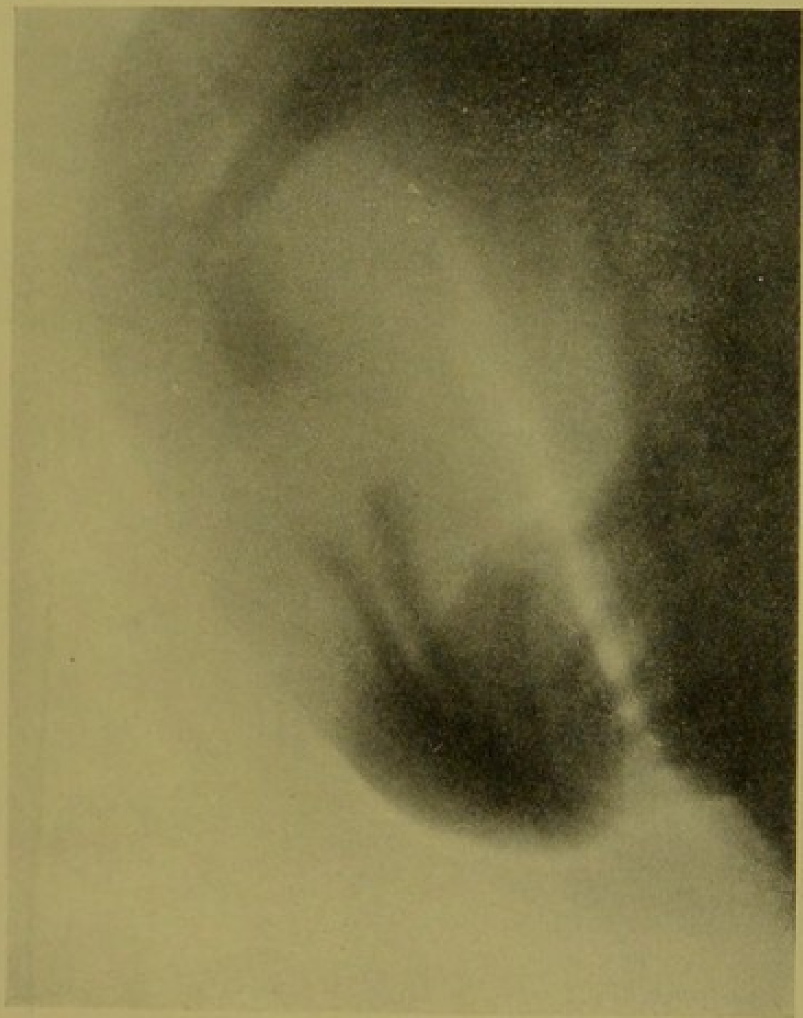


Fig. 213.

Fig. 212 shows the result of operation, the fragments having been securely united by means of plates and screws.

In ununited fractures alone, and then only on rare occasions, have I found it necessary to introduce portions of the other bones of the patient. At the same time I always utilise any fragment of bone which I saw off, using it to fill any gap or strengthen any weak spots in the junction.

The fourth case is illustrated by Fig. 213, which shows a humerus whose fragments were united at a right angle. The baby sustained a fracture of the humerus at birth. This was treated by splints and bandages. When she was admitted into the Hospital for Sick Children the muscles supplied by the musculo-spiral nerve were found to be completely paralysed.

Fig. 214.

The seat of the fracture was exposed, the musculo-spiral nerve was dissected out of the callus, the bone was divided at its junction in such a way that the axis was restored to the normal, and the fragments were retained securely in apposition by means of a plate and screws.

Much difficulty was experienced in securing the distal fragment, because of the softening which it had undergone. Union of the fragments took place perfectly and the paralysis of the muscles disappeared (see Fig. 214).

I would like to call attention to the importance of operating on fractures as soon as possible after the receipt of the injury. This is of vital importance in young life when the softening of the distal fragments, which takes place in a diminishing degree as age advances, develops at a remarkable rate. The difference of a few days in young

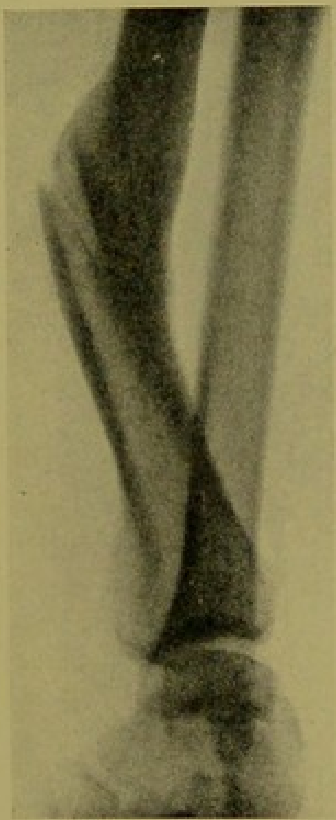


Fig. 215.

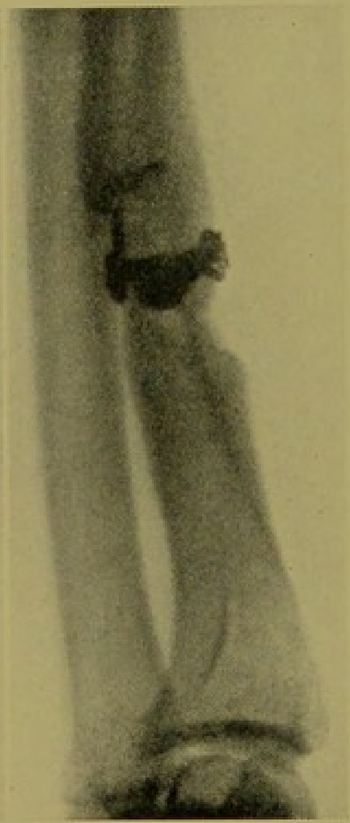


Fig. 216.

infants may mean the difference between a comparatively easy and a comparatively difficult operation.

Fig. 215 is a radiogram of a fracture of the radius showing much displacement of fragments. The end of the ulna projected, while the hand was considerably disabled because of the shortening of the radius. The bone had been broken on two occasions in the same situation, and had been treated with splints, massage, etc.

Fig. 216 shows the result obtained by operation. The junction was sawn through in such a manner as to obtain as much length as possible, the fragments being secured by means of a plate and screws.

There are few fractures that call more urgently for

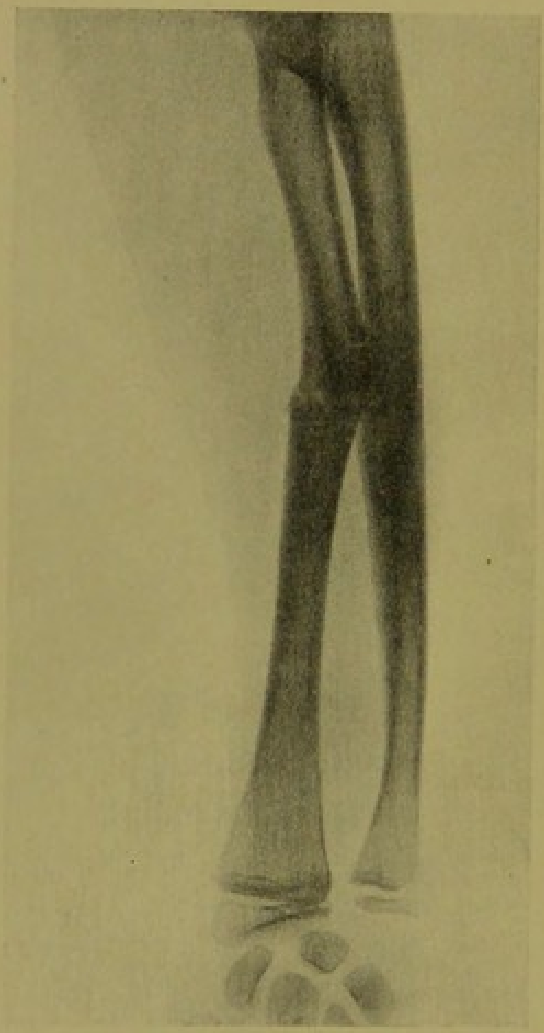


Fig. 217.

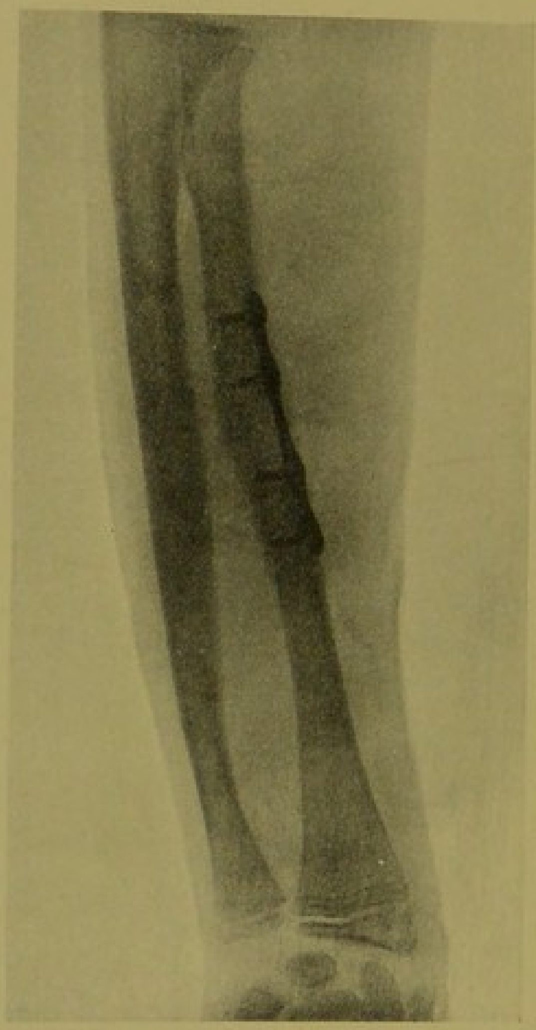


Fig. 218.

operative interference than do those of the lower third or fourth of the shaft of the radius.

Fig. 217 is of interest since it illustrates the remarkable disability that may follow a fracture of the radius in childhood treated by manipulation and splints, and shows also how fallacious was the conclusion of the Committee on Fractures that equally good results can be obtained in young life by operative interference or by manipulation and splints.

It also demonstrates the manner in which Nature crystallises the lines of force continuing the direction of the lower fragment upwards.

As is shown in Fig. 218 all this new material had to be carefully shelled off both fragments before they could be so

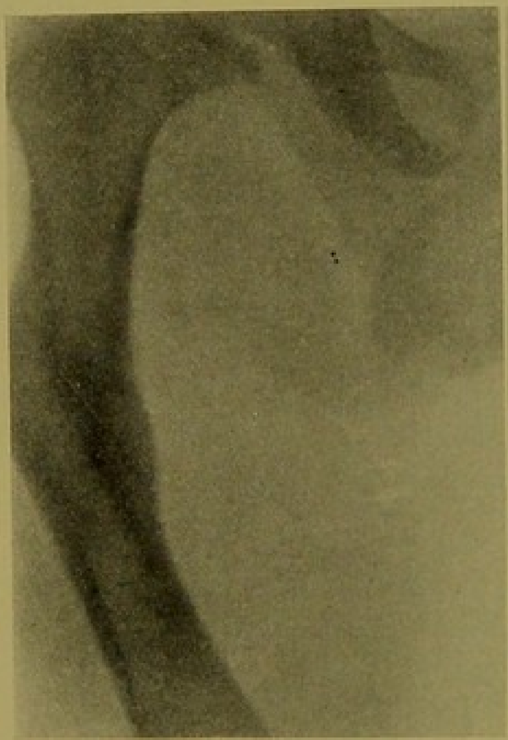


Fig. 219.

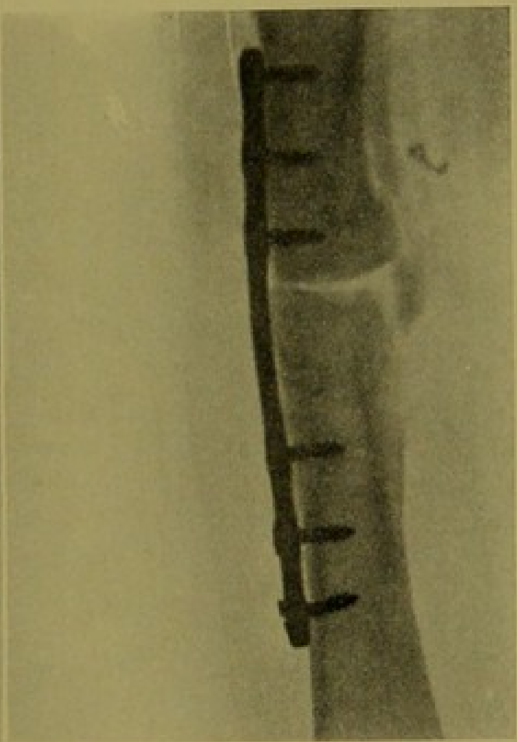


Fig. 220.

adapted to one another as to restore the bone to its normal form and functions, and the arm to its original usefulness.

Fig. 219 is a radiogram of a fracture of the femur. The result of the treatment adopted had been to leave the patient a helpless cripple, totally unable to follow his employment. By thoroughly freeing the fragments it was possible to so employ the abundant callus as to restore the leg to its original length and usefulness.

Fig. 220 represents the result of operative treatment.

Fig. 221 shows a fracture of the femur which had been treated by the usual methods. The leg was absolutely useless to the patient. By cutting the fragments in two oblique planes their axes were made to correspond, the femur was reconstituted as shown in Fig. 222.

Fig. 223 shows the result of operative interference in a case of fracture of the femur in a youug officer and on whom I operated eight months after the injury had been sustained.

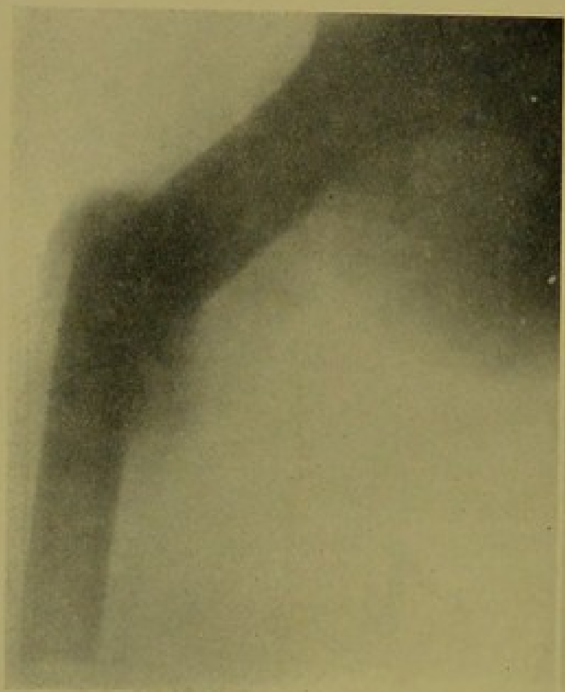


Fig. 221.

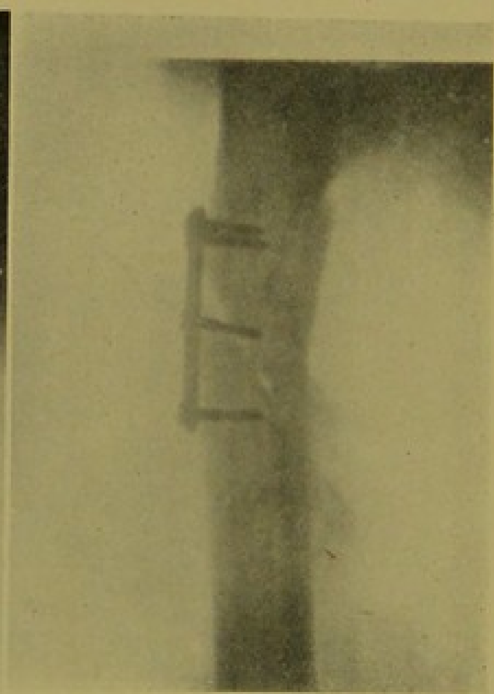


Fig. 222.

He was treated by surgeons of very great experience by means of a long Liston's splint and extension.

Less than three months after the accident he was sent home on a splint with supposed union of fragments.

Five months after the original accident the junction gave way. A radiogram showed that the fragments had overlapped considerably and that they had formed an angle with one another.

We operated on the fracture with the result shown in the illustration. As soon as the junction was fairly secure a Hoefftcke's splint was applied. The patient is now able to use his leg as well as ever and there is no perceptible shortening.

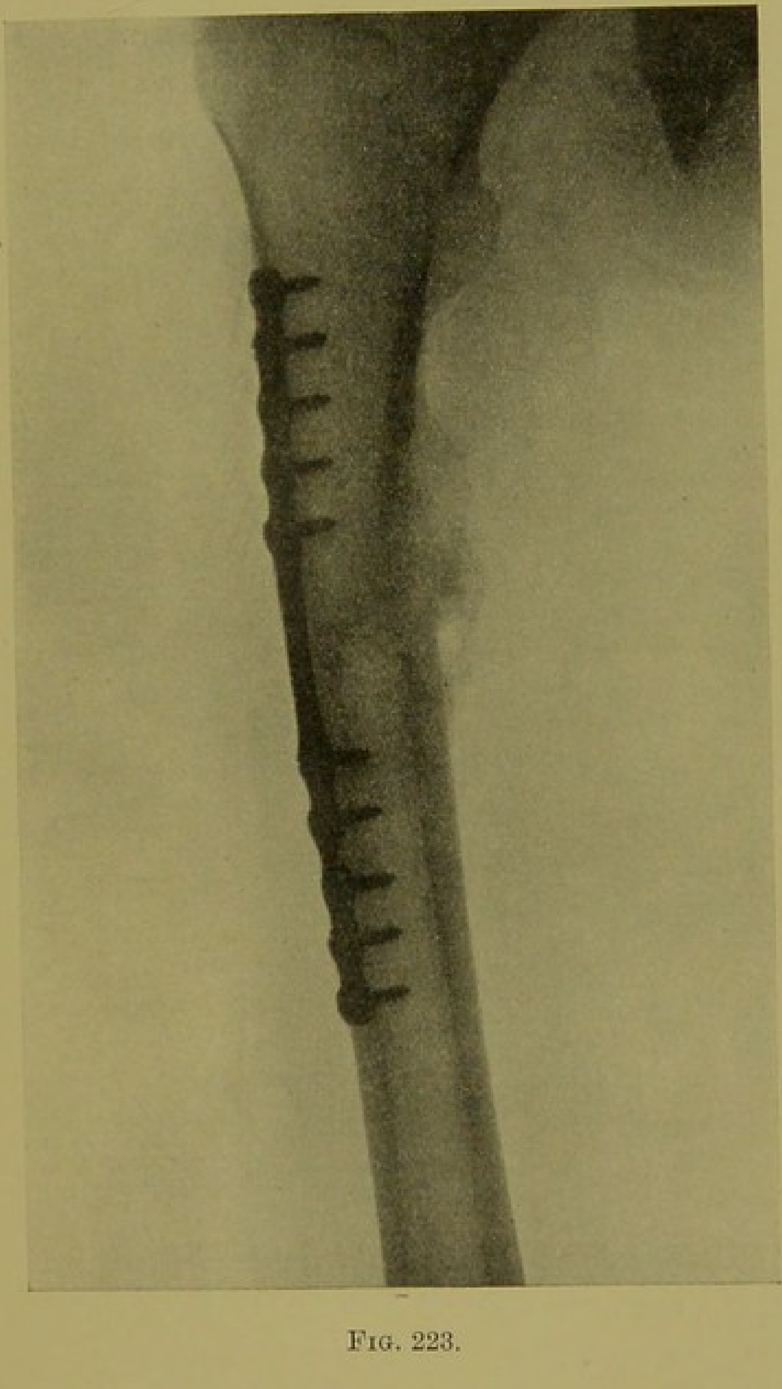


FIG. 223.

I have described these badly united fractures of the femur to show how useless and inefficient are the usual methods of treatment of these injuries even in the hands of the most skilled and competent surgeons.

The Treatment of Compound Fractures.

This is a matter of much greater difficulty than that involved in the case of the simple fracture. In the latter one knows that if the bone is not too fragile and is not too comminuted that a perfect result may be obtained if the surgeon possesses a certain amount of skill and familiarity with the operations, and if his aseptic technique is perfect, except in such rare cases of infection which takes place from within, as, for instance, gonococcal.

In the case of the compound fracture the problem is by no means so simple, nor can the surgeon guarantee success with the same certainty as he can in an operation on a simple fracture.

Here we have to deal with a wound which may be infected to a varying extent with organisms of varying virulence.

Some surgeons, who seem to have very little familiarity with the principles that govern the technique of the operative treatment of fractures, see no objection whatever to the introduction of a metal plate and screws into a compound fracture where the wound is probably septic, while they are very reluctant to, or would in no circumstances, deal with a simple fracture in the same manner. With such it is of no service to discuss the matter.

Personally I am very reluctant to introduce a plate into a wound which I think is septic, or which I know has been infected at a recent date.

If one sees a compound fracture soon after the receipt of the injury the skin should be efficiently cleansed, and the wound opened up and swabbed out thoroughly with tincture of iodine. This drug seems to exert a maximum amount of damage to any organisms that may be present, while it does a minimum amount of harm to the tissues. In most cases it is well to wait till the wound has healed before any attempt is made to secure the fragments together by plates and screws.

Should it be advisable to secure the fragments in apposition while the wound is doubtfully or certainly septic, I employ a long plate, and secure it by screws inserted into each fragment at as great a distance as possible from the seat of fracture. By this means, even if the screws are infected, the damage done by the inflammatory process is separated by a considerable interval from the opposing surfaces of the fragments, and so it does not interfere with the union of the bones to one another.

The screws, even though infected, will retain the plate in position for a length of time sufficient to ensure union. Then they can be removed with the plate. For this reason in an infected wound, or in a wound that may be infected, it is wise to place the plates in such a situation that they can be removed easily should this necessity arise. When there is any evidence or suspicion of infection some arrangement should be made for drainage, which is never called for in the case of simple fractures.

If there is suppuration, vaccines of the organisms should be employed by an expert bacteriologist. I have found them of the greatest service on many occasions, and I would attribute the failures in this method of treatment to the incompetence of the person who employs it and not to the principle involved.

I am sorry to say that the most disastrous cases of septic infection of fractures which I have had to treat have resulted from the fouling of simple fractures during the introduction of a plate.

It is well to remember that it is never perfectly safe to operate on a compound fracture, even though the wound has been healed for months, and there be no evidence whatever of the presence of any inflammatory process about the fracture. It would seem possible for organisms introduced at the time of the injury to remain latent for long periods of time, and to light up into activity when a large foreign body is introduced. Sir Almroth Wright tells me that this is a well recognised fact not only in the bones, but in the other tissues of the body. The surgeon should bear this fact in mind in arranging the details of his operative procedure, and in giving a prognosis as to the probable result of his treatment.

Several years ago I had hoped to obtain a useful result by the implantation of a bone of one of the smaller animals into bad cases of ununited fractures, the ends being wired firmly in position. Though the result of this operation was excellent in certain cases I gave it up for two reasons. One was the danger of a sarcoma developing about the foreign bone, and the other was the bone that was introduced did not increase in thickness and was not usually strong enough to perform the functions expected of it. The following case,* though not one of fracture, illustrates very well the advantages which such a bony support affords:

A child had suffered from birth from a progressive deformity, with loss of power of the forearm, apparently consequent on an undeveloped condition of the ulna. This bone consisted (see Fig. 224) of two parts, which were not continuous in direction with one another. The ulna was in consequence shorter than the radius, the head of which was being displaced outwards and upwards, while its lower extremity projected beyond the ulna to an abnormal amount. I cut down on the shaft of the ulna, freed the fragments for a considerable distance, and brought their axes into continuity with one another. By exerting traction on them I was enabled to lengthen the bone to what appeared to be its normal extent.

* "Two cases of deficiency of the shaft of the ulna treated successfully by the insertion of a rabbit's femur," 'Trans. Clin. Soc.,' London, 1899, vol. xxxii, p. 44.

In order to retain the fragments in this position a rabbit's femur was split in two and laced with wire to the fragments. The whole arm was then fixed immovably.

Fig. 225 represents the condition of the parts several

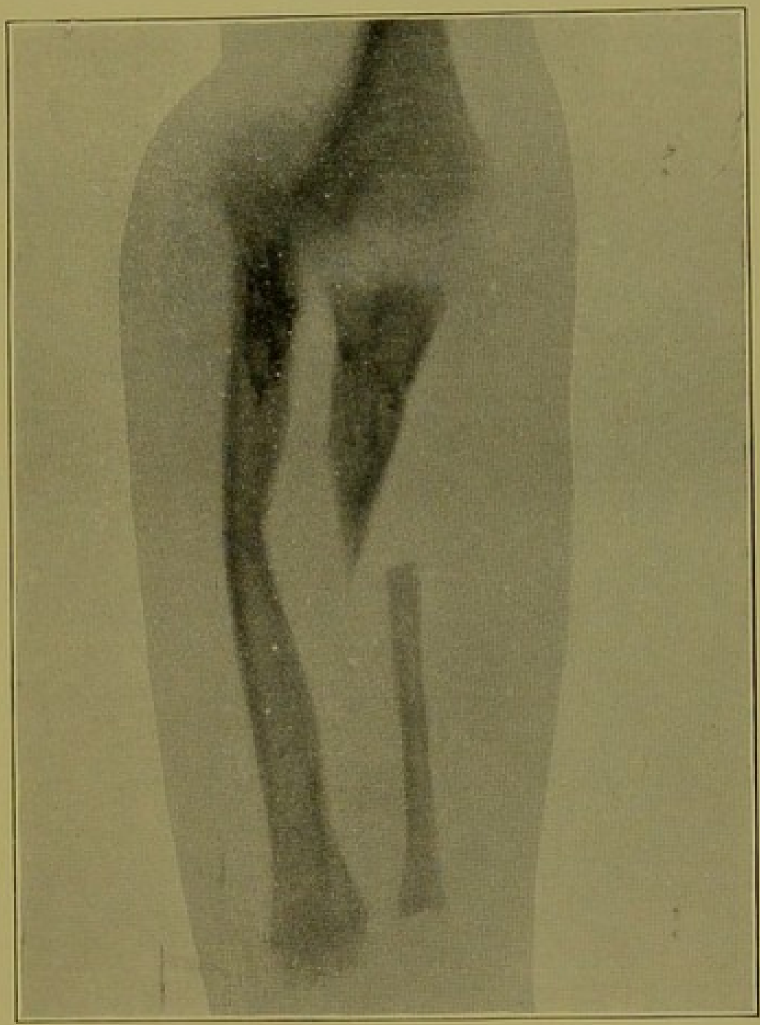


FIG. 224.—Before operation.

months afterwards. It requires no explanation. The advantages which the patient gained from this operation were very considerable, both in the functional capacity and appearance of the part, the parents being delighted with the result.

Unfortunately, some two years later the child developed a slow-growing tumour in the situation of the operation.

I amputated the arm and found a sarcoma surrounding the foreign bone. It was of remarkable density.

It is easy to see, therefore, that in the event of considerable comminution of such a bone as the ulna, radius,

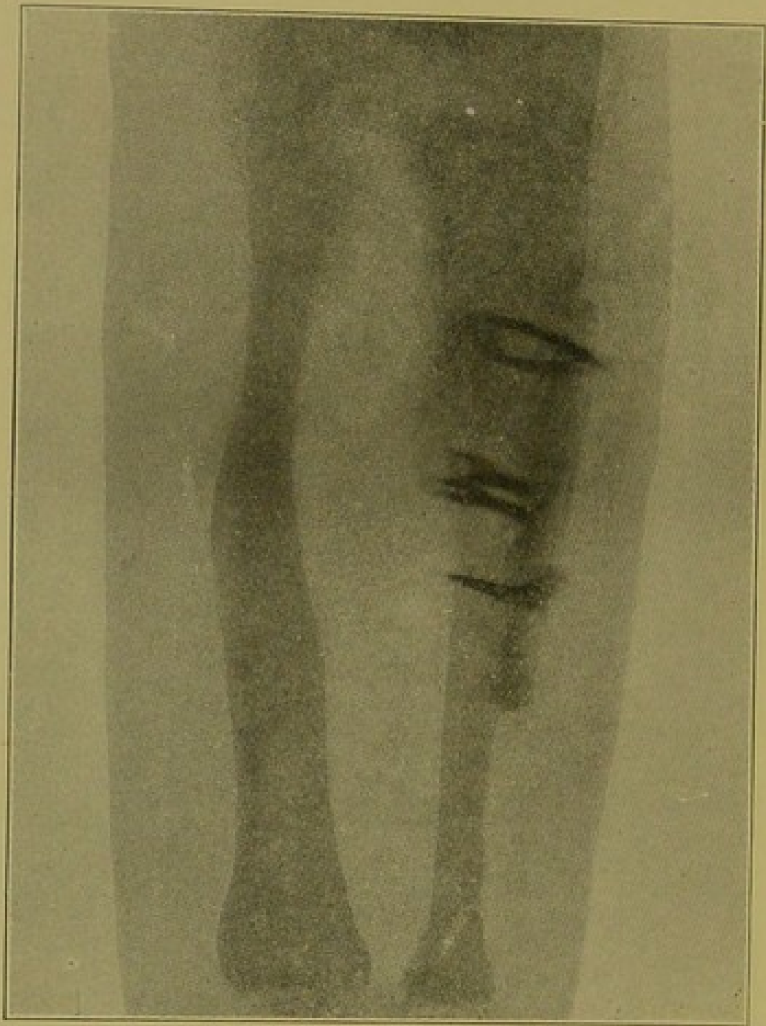


FIG. 225.—After operation.

or fibula, the additional security which the use of such bony supports can afford may possibly make all the difference between a good and a bad result.

Fig. 226 represents the radiograph of a case very similar in character to the last. It was taken many months after the operation. The shaft of the ulna had necrosed in consequence of an acute infective process. Though every means was employed to obtain a sheath of callus in its

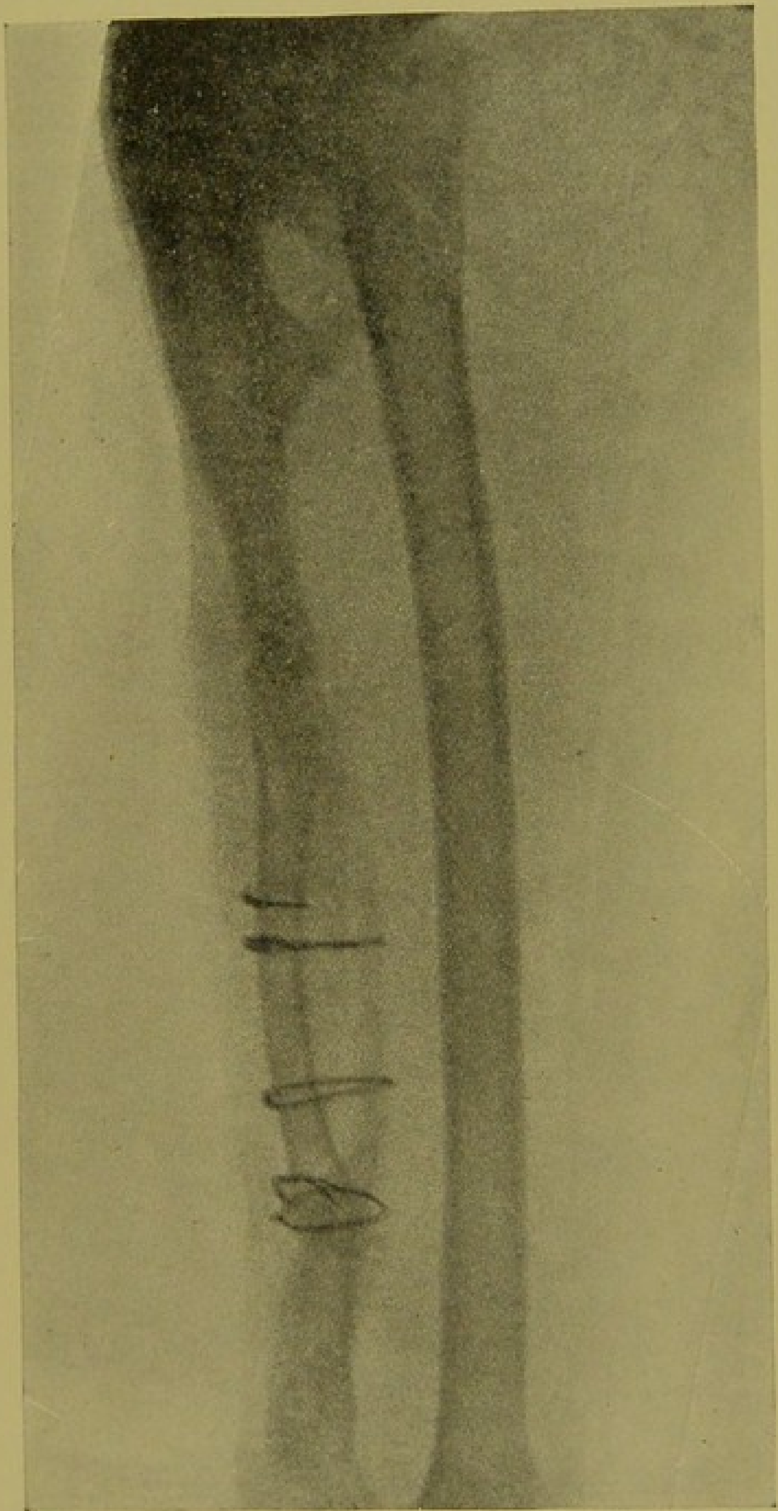


Fig. 226.

place, the fragments ended in two delicate spikes of bone, separated by a considerable interval. The femur of a large rabbit was introduced and fixed in position by loops of silver wire, its extremities having been filed down to fit the surfaces of bone to which they were attached. An excellent result was obtained, and the whole shaft of the ulna is now firm, strong, and efficient.

For some time I have discarded the use of bones of the lower animals, and have employed portions of some other bone of the patient as a graft.

In my experience it is very rarely necessary to employ bone grafts in the operative treatment of ununited fractures, since the metal bone plate is in the vast majority of cases the best and most efficient means of establishing union.

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