THE OPERATIVE TREATMENT OF FRACTURES.

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PREFACE.

I have not attempted in these pages to consider the subject of the operative treatment of fractures in its entirety, but have confined myself more or less to dealing with general principles and with a sufficient number of examples to illustrate the views I have put forward. My thanks are due to Mr. Shenton and others for help in connection with the radiographs, and to the printers for the care they have bestowed upon the typography.

W. ARBUTHNOT LANE.

CAVENDISH SQUARE,
December, 1905.

THE OPERATIVE TREATMENT OF FRACTURES.

Thirteen 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 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 correspond-

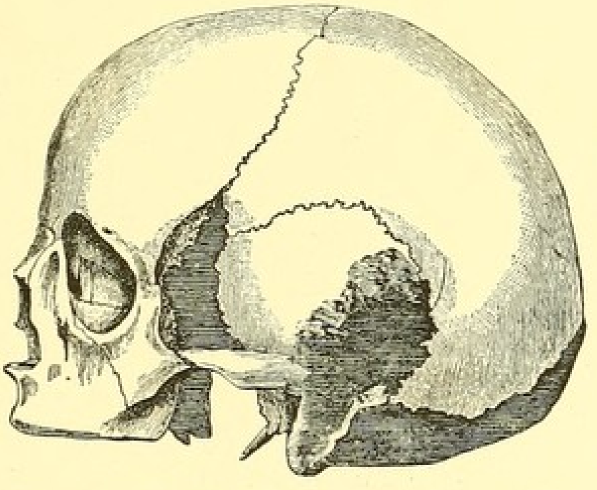


FIG. 1.—Skull of early mollities ossium.

ing 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.

Fig. 2.

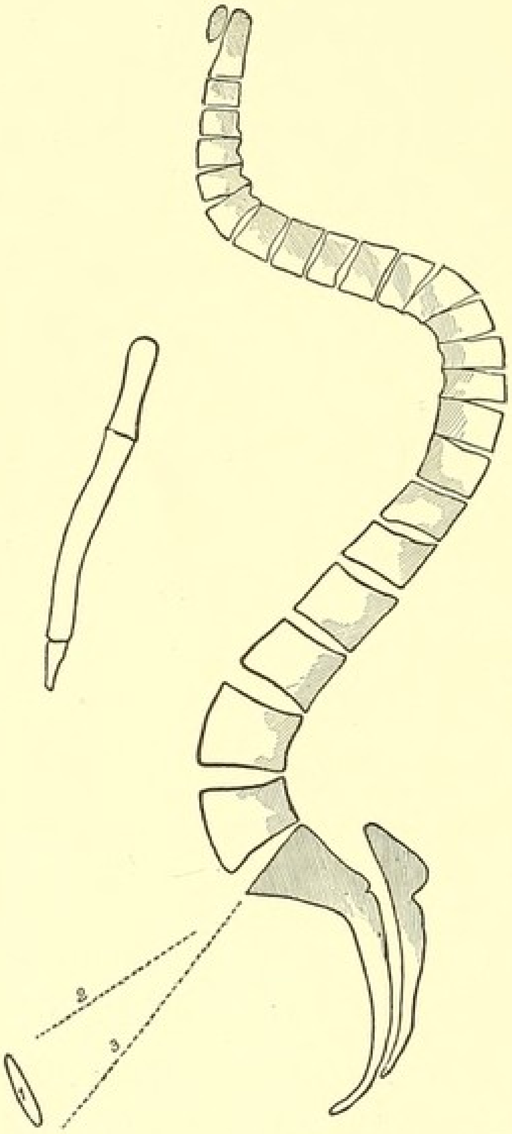


Fig. 3.

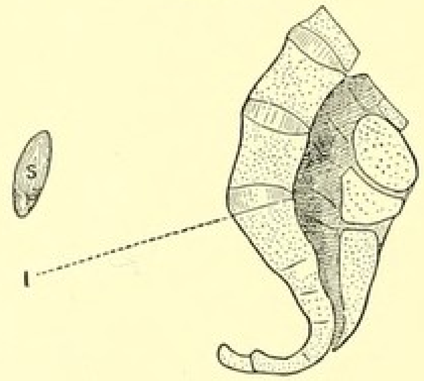


Fig. 2.—Spinal column of old woman.
Fig. 3.—Lower part of spine of feeble old subject.

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 intervertebral 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.

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

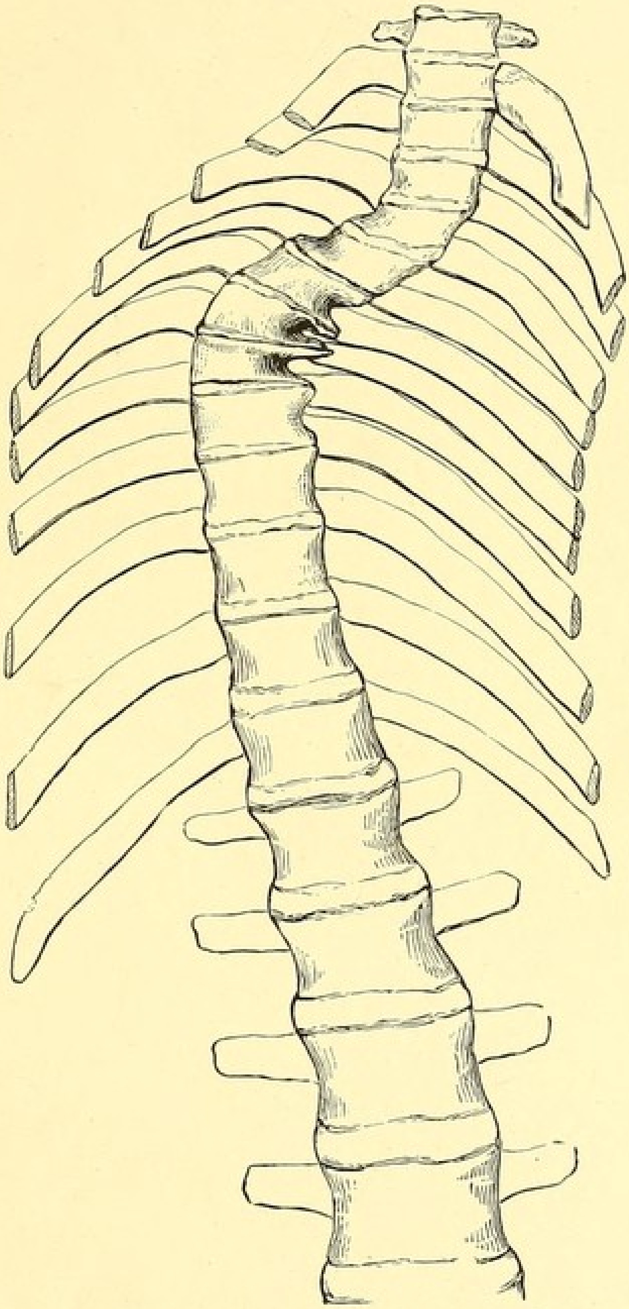


FIG. 4.—Spine and ribs of a brewer's drayman.

the weight can be transmitted with a minimum expenditure of muscular energy.

Fig. 5.

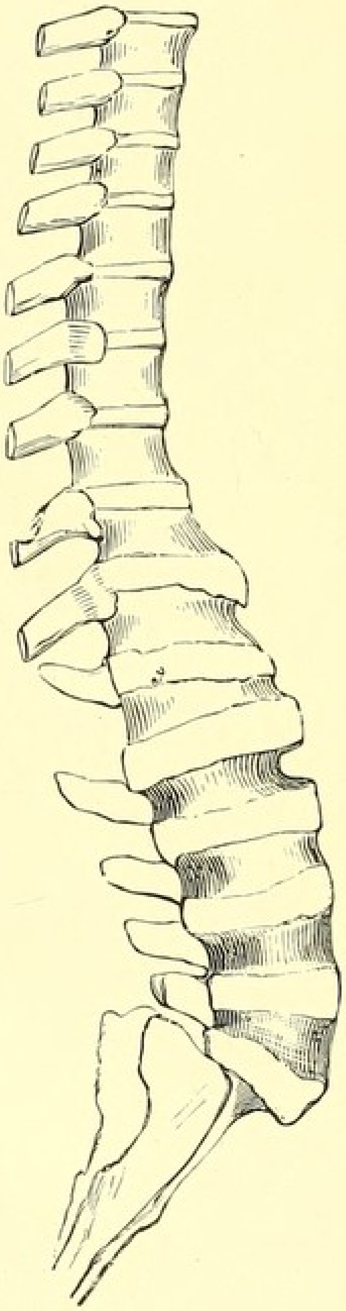
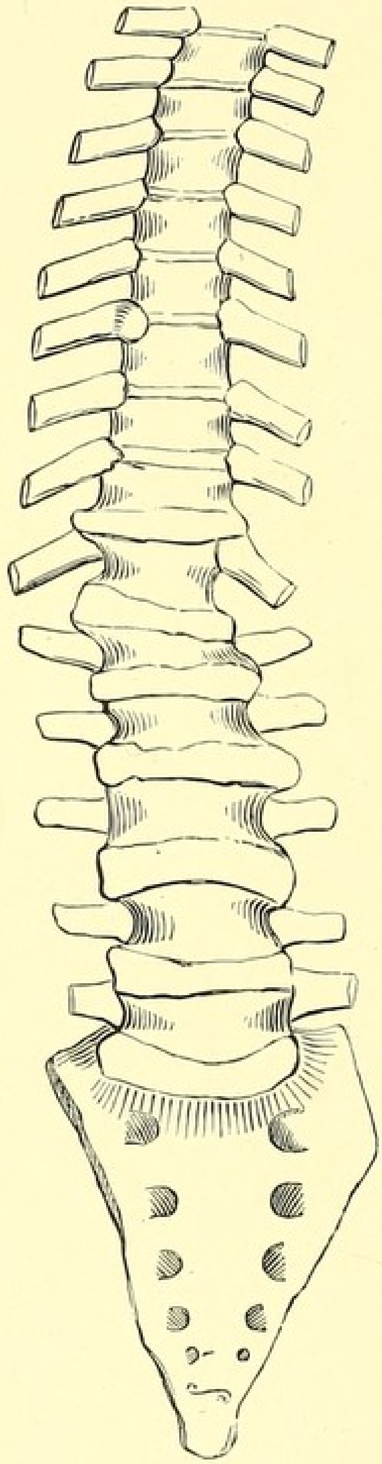


Fig. 6.



Figs. 5 and 6.—Spine of coal-heaver.

Figs. 5 and 6 represent the spine of a coal-heaver. They show much destruction of fibro-cartilages and the fixation of the margins of the vertebræ one to another by dense 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

Fig. 7.

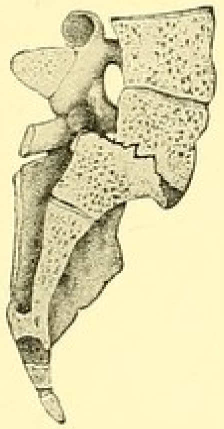


Fig. 8.

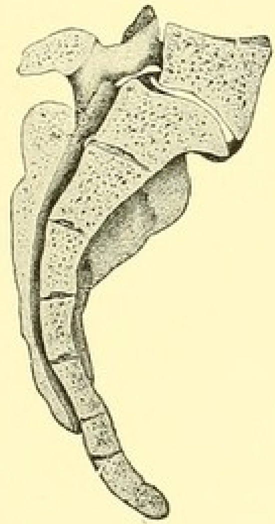


Fig. 7.—Fourth and fifth lumbar vertebræ and sacrum of coal-heaver.
Fig. 8.—Fifth lumbar vertebra and sacrum of deal-porter.

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 of a labourer whose business it was to carry loads, lifting 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. 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 of the spines of the lumbar vertebræ and sacrum, which articulated with one

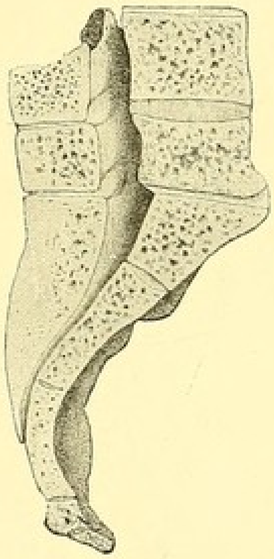


Fig. 9.—Fourth and fifth lumbar vertebræ and sacrum of labourer who carried loads in front of him.

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.

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

Fig. 10.

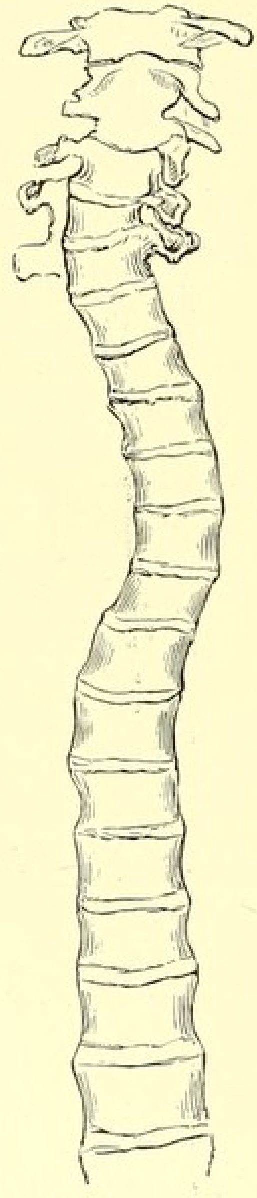
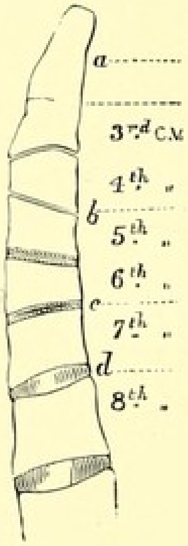


Fig. 11.



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

same specimen. The lateral curves should be noted, serving presumably to render the column less rigid.

Fig. 12.

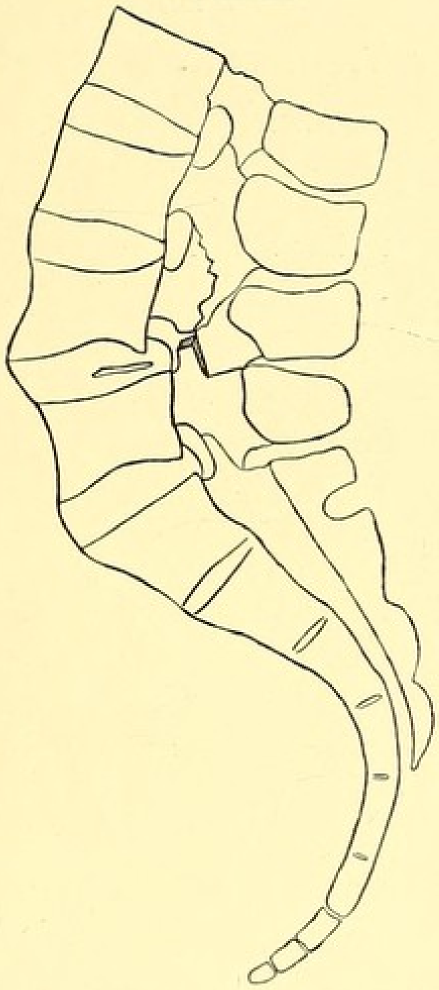


Fig. 14.

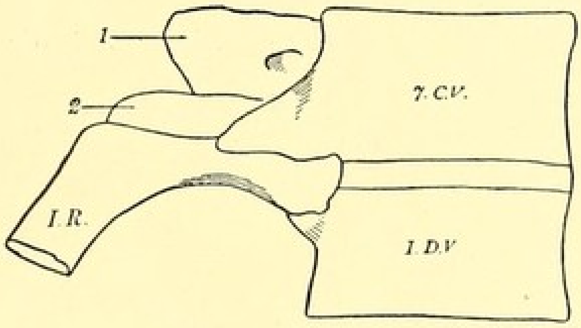


Fig. 13.

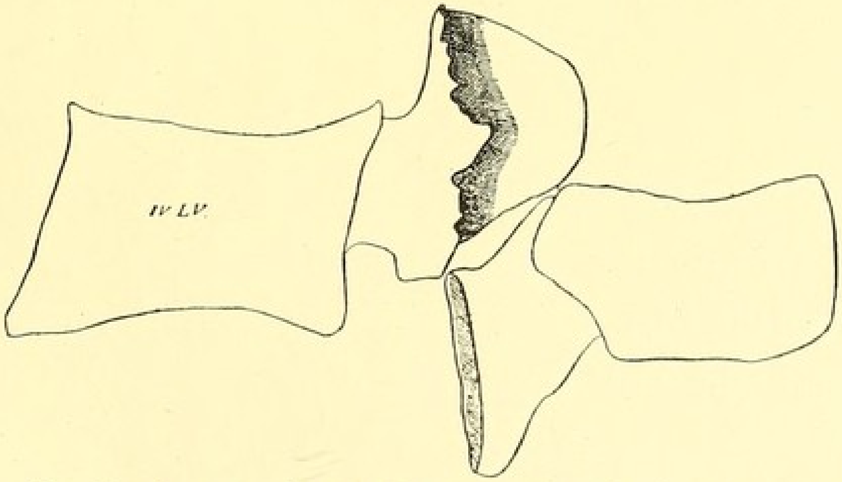


Fig. 12.—Lumbar vertebræ and sacrum of coal-trimmer.
Fig. 13.—Fourth lumbar vertebra of coal-trimmer.
Fig. 14.—Seventh cervical and first dorsal vertebræ of coal-trimmer.

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

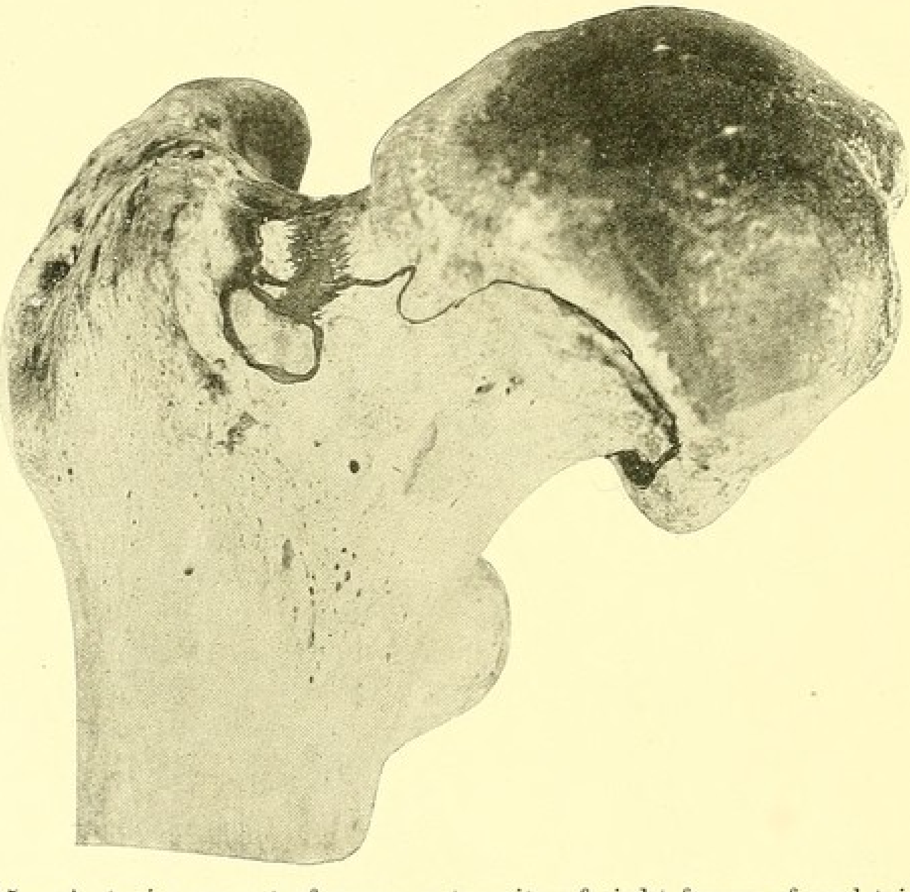


Fig. 15.—Anterior aspect of upper extremity of right femur of coal-trimmer.

lower 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 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 ver-

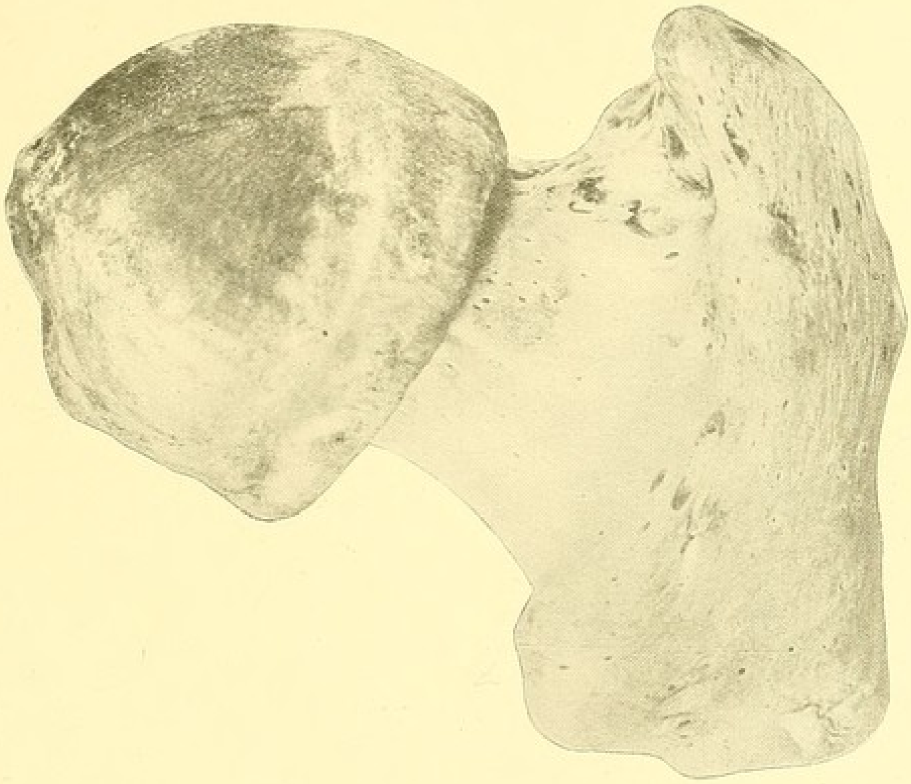


FIG. 16.—Posterior view of upper extremity of right femur of coal-trimmer.

tebræ 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 head and the extension of the articular surface outwards to the base of the

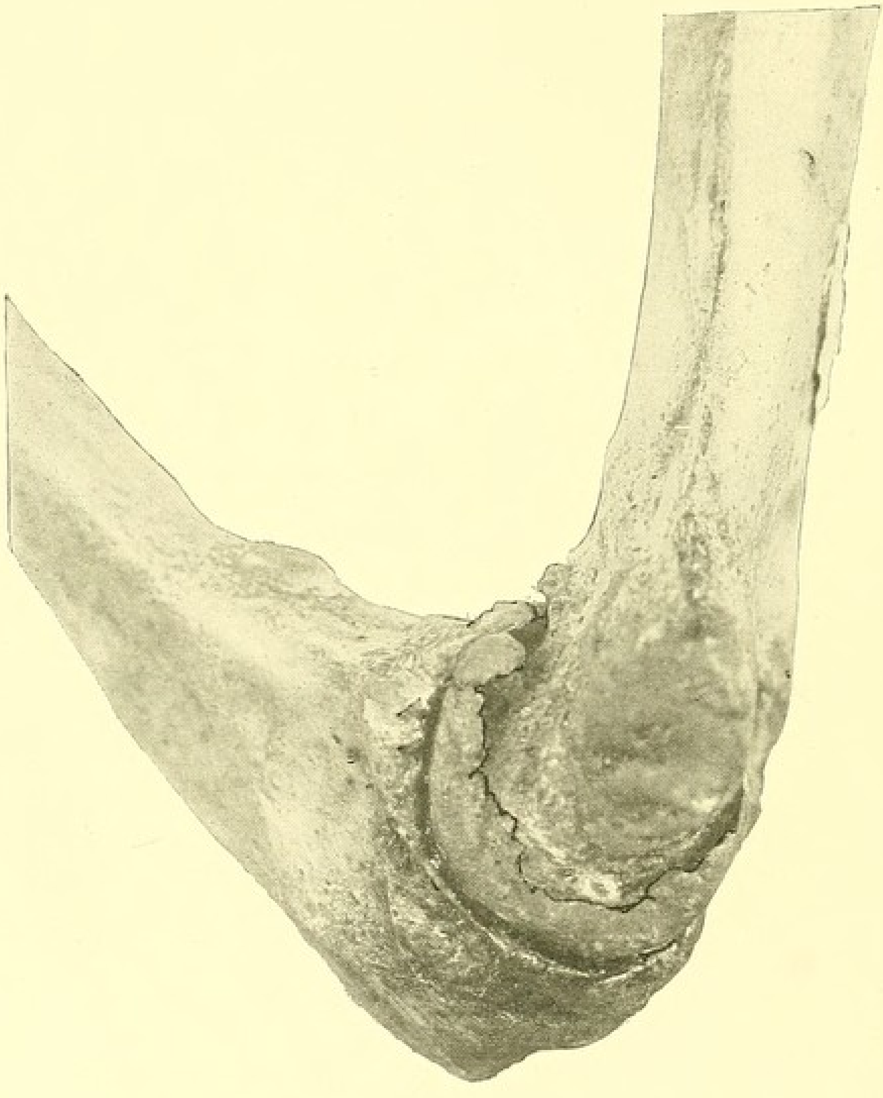


Fig. 17.—Right elbow-joint of coal-trimmer.

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

Fig. 18.

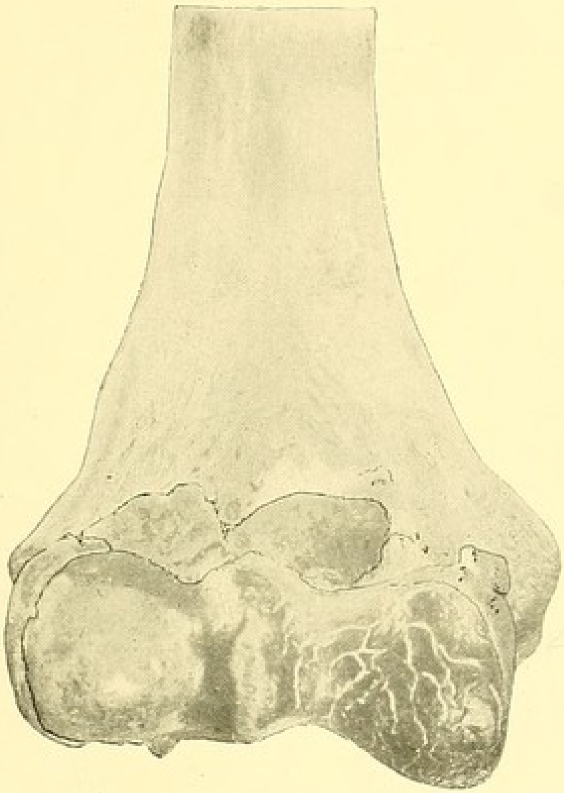


Fig. 19.

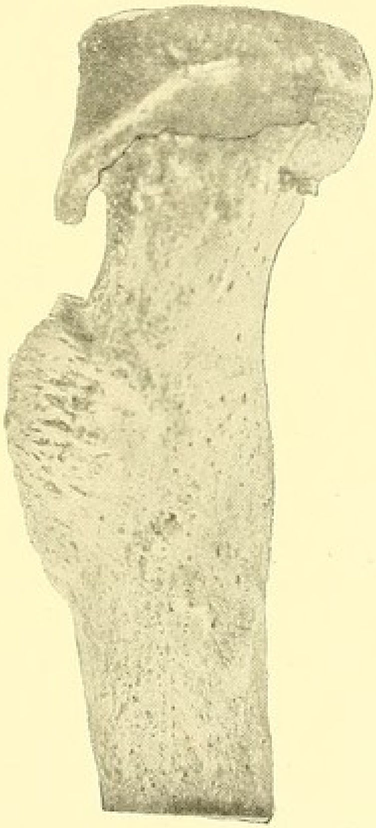


Fig. 18.—Lower end of right humerus of coal-trimmer.
Fig. 19.—Upper end of right radius of coal-trimmer.

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 formation 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

FIG. 20.—Right thumb of shoemaker.

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 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

Fig. 21.

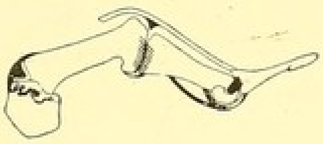


Fig. 22.

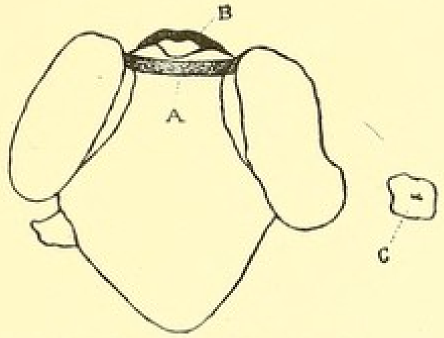


Fig. 21.—Tendons and ligaments in right thumb of shoemaker.
Fig. 22.—Occipital bone of shoemaker.

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 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

Fig. 23.

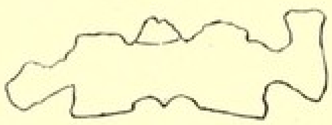


Fig. 24.

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

vertebra of the shoemaker, the prolongation upwards of the odontoid 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.

That the changes in the form of bones in labourers are not limited to the articular surfaces is shown

Fig. 25.

Fig. 26.

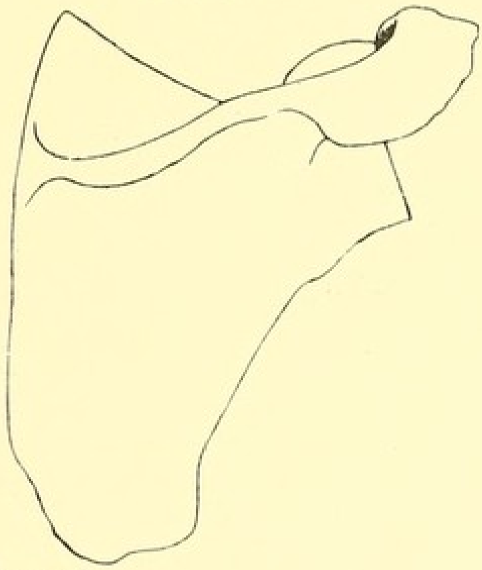


Fig. 25.—Scapula of shoemaker.
Fig. 26.—Scapula of deal-porter.

very well by Figs. 25 and 26. These two bones afford an excellent illustration of the mode in which the form of the several 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 supra-spinous fossa from that sustained by the supraspinatus muscle. The strain on the infra-spinatus 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.

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 deviations from the normal arise for which an abun-

Fig. 27.

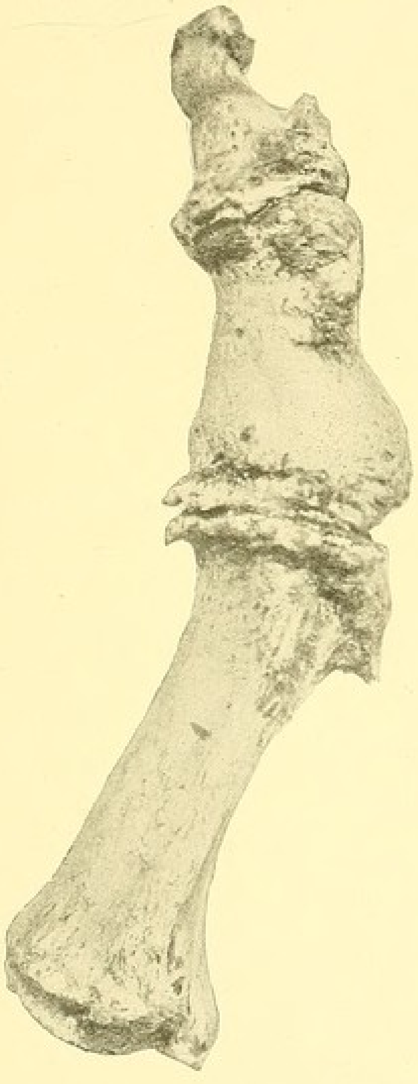
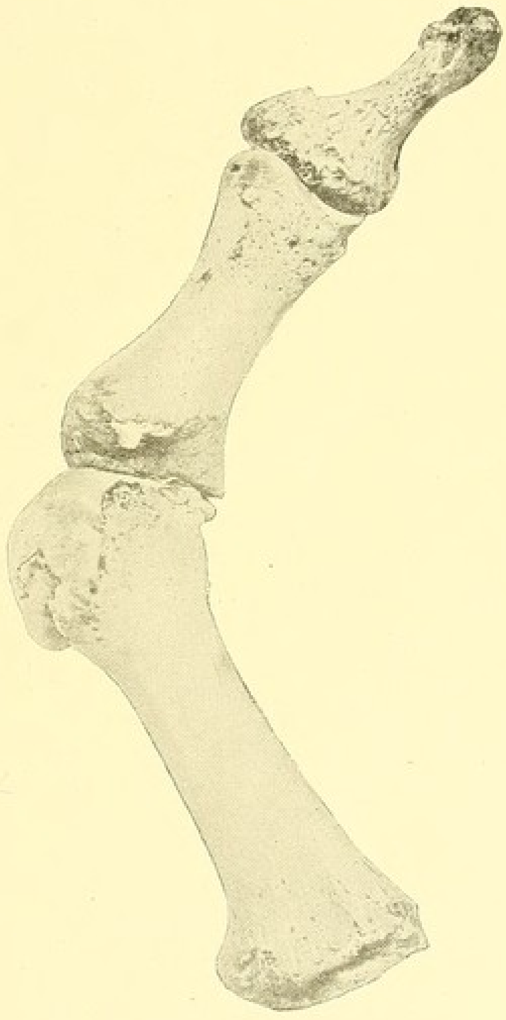


Fig. 28.



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

dant 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

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

of bone; asymmetry of both phalanges is also a consequence.

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

Fig. 30.

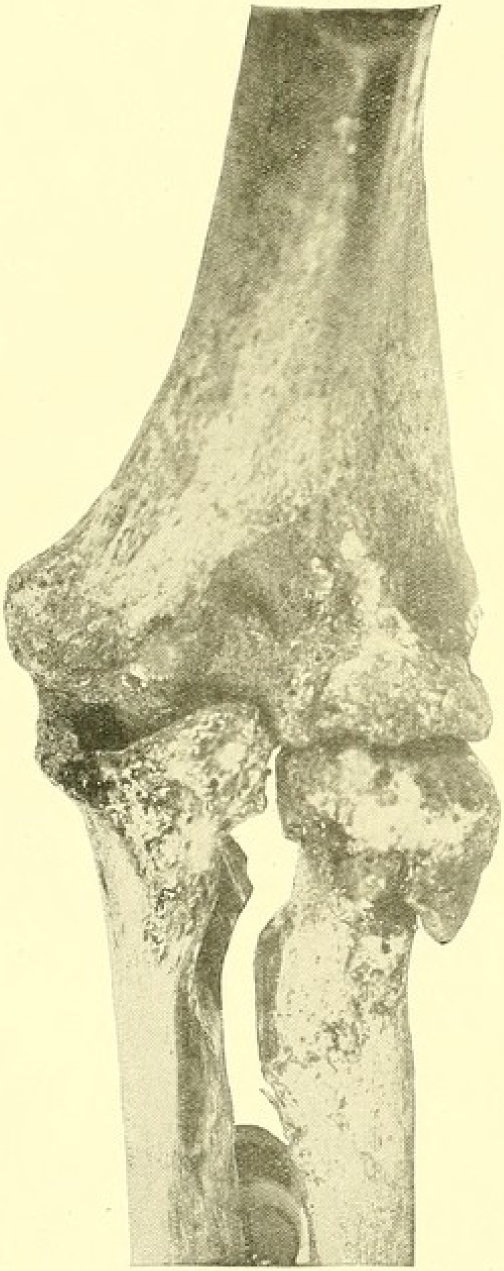
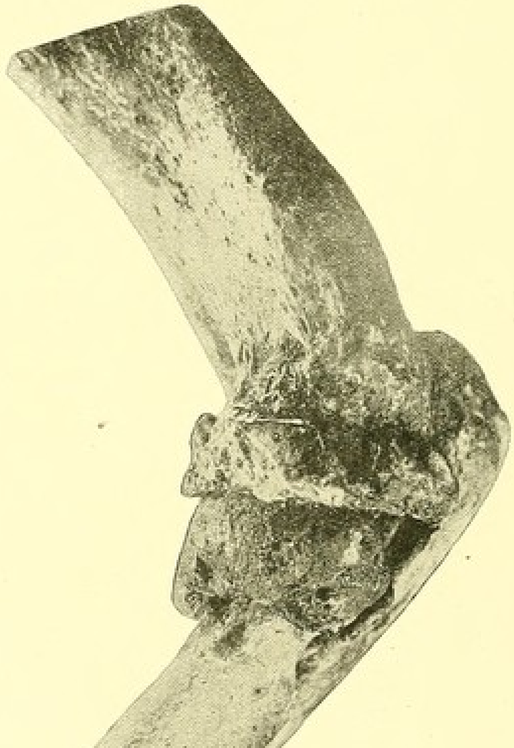


Fig. 31.



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

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 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 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

Fig. 32.

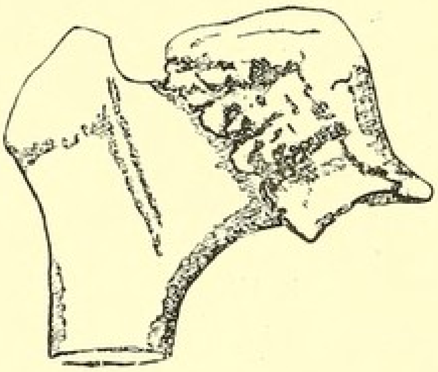
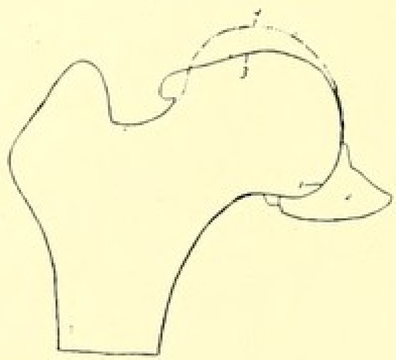


Fig. 33.



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

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

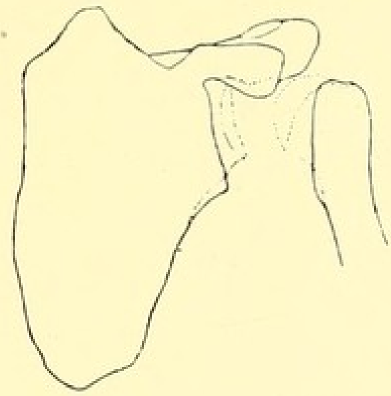


FIG. 34.—Pressure changes in shoulder-joint.

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 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.

Nature does what it can in all cases to restore the skeleton as far as possible to its normal form.

Fig. 35.—Old fracture of right femur.

The skeleton is best regarded as the crystallisation of lines of force. These when occupying the same direction 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

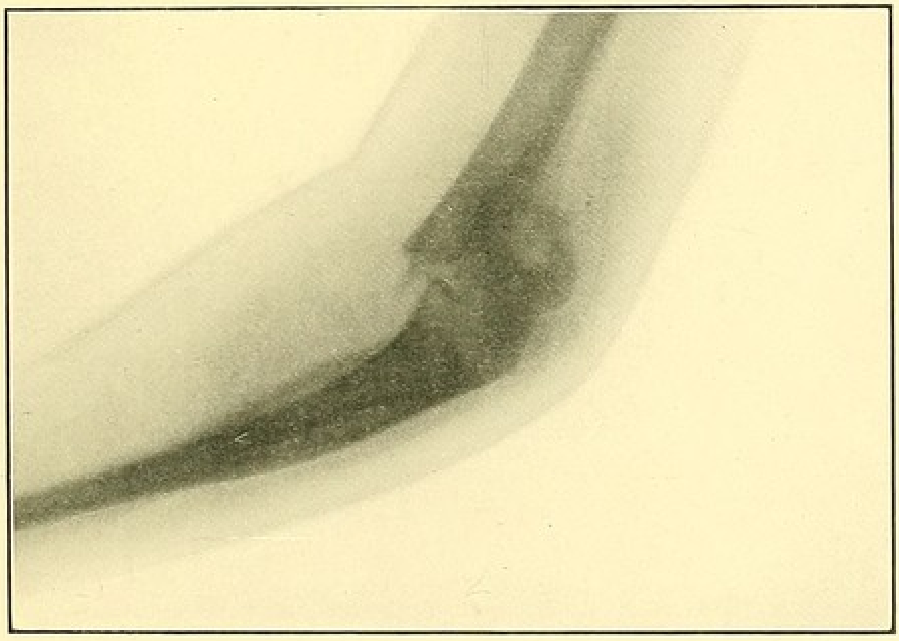


Fig. 36.—Fracture of lower end of humerus.

is laid down. The degree of restoration of form to that of the normal varies inversely with the age of the subject.

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

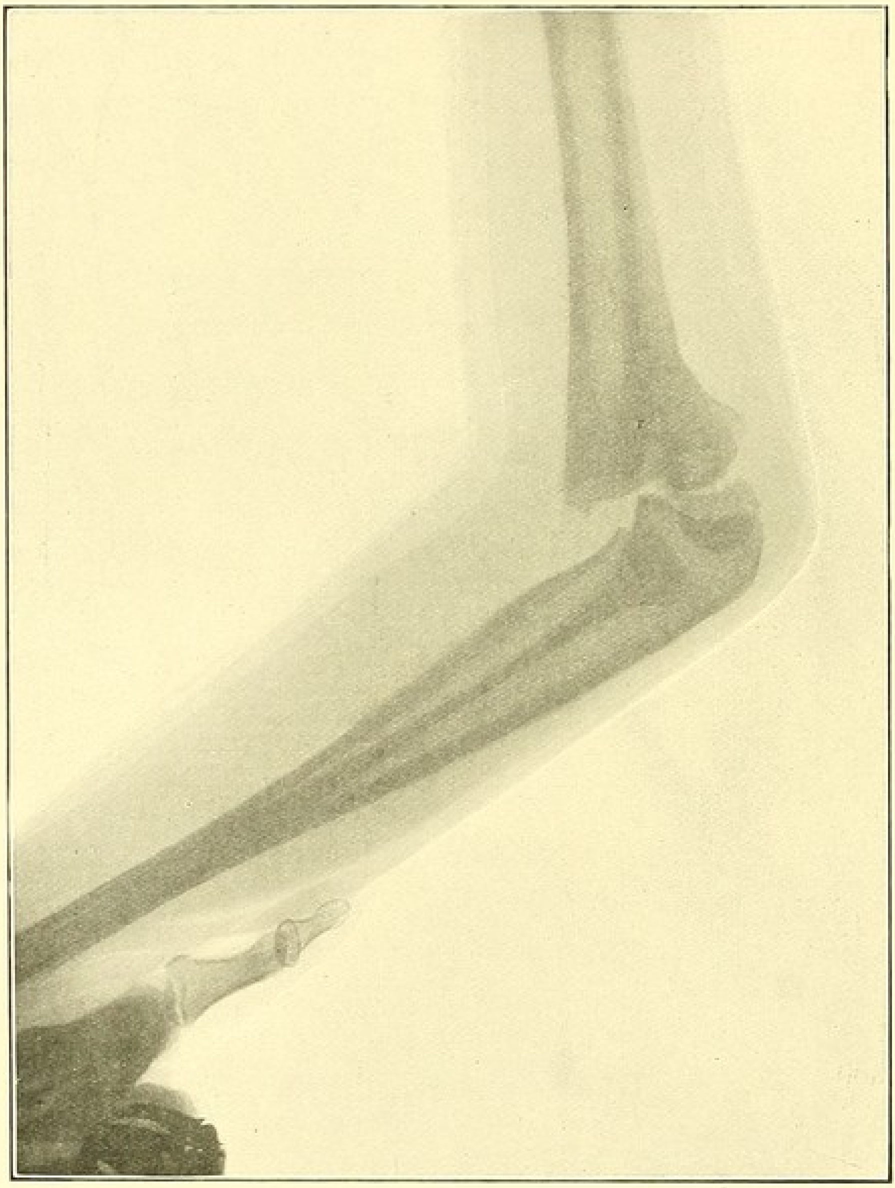


FIG. 37.—Fracture of lower end of humerus.

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 along the back of the shaft. This

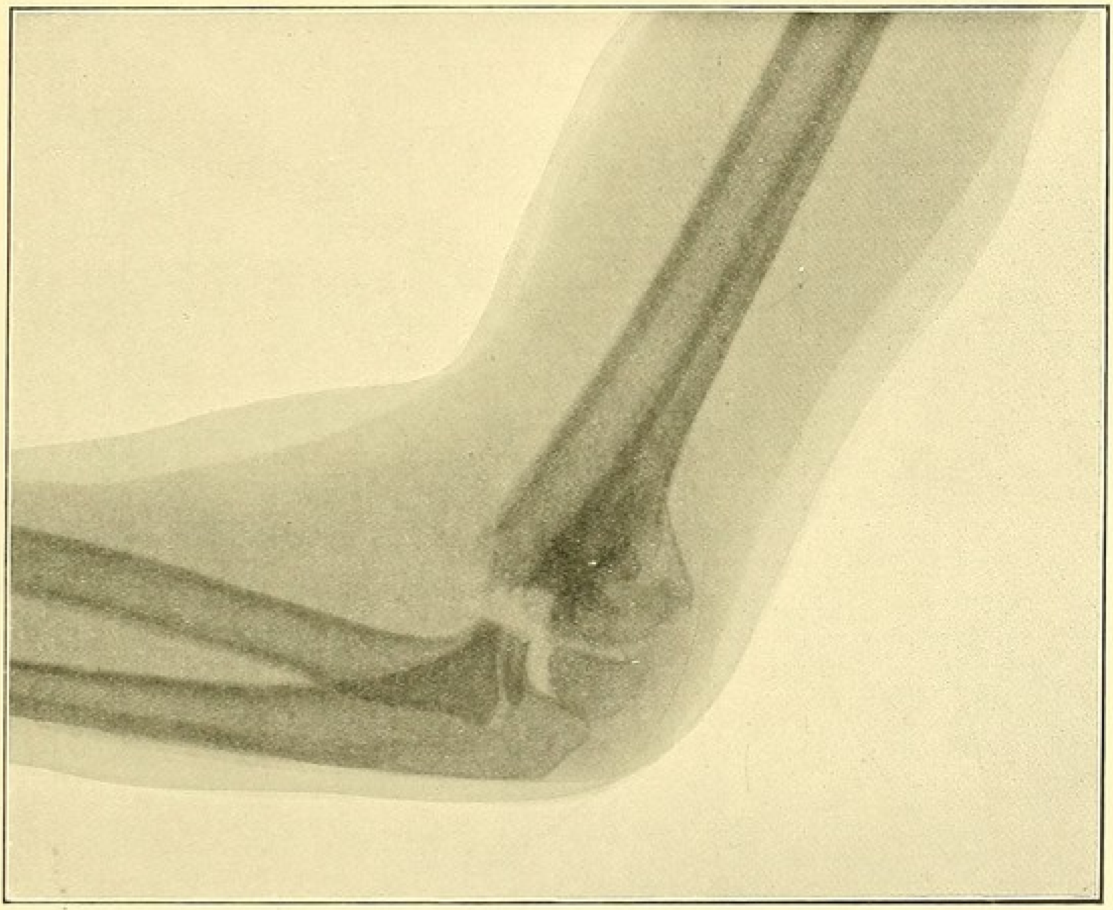


FIG. 38.—Fracture of lower end of humerus.

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 sub-

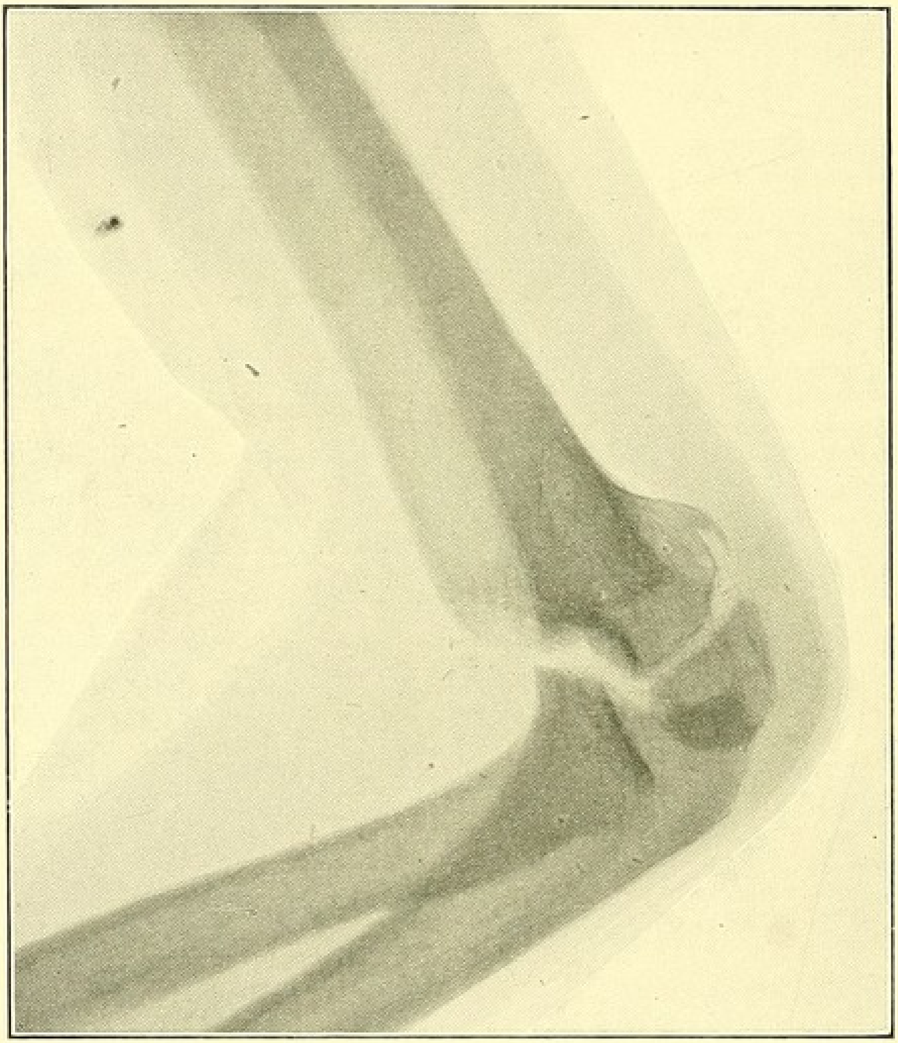


Fig. 39.—Fracture of lower end of humerus.

ject the 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

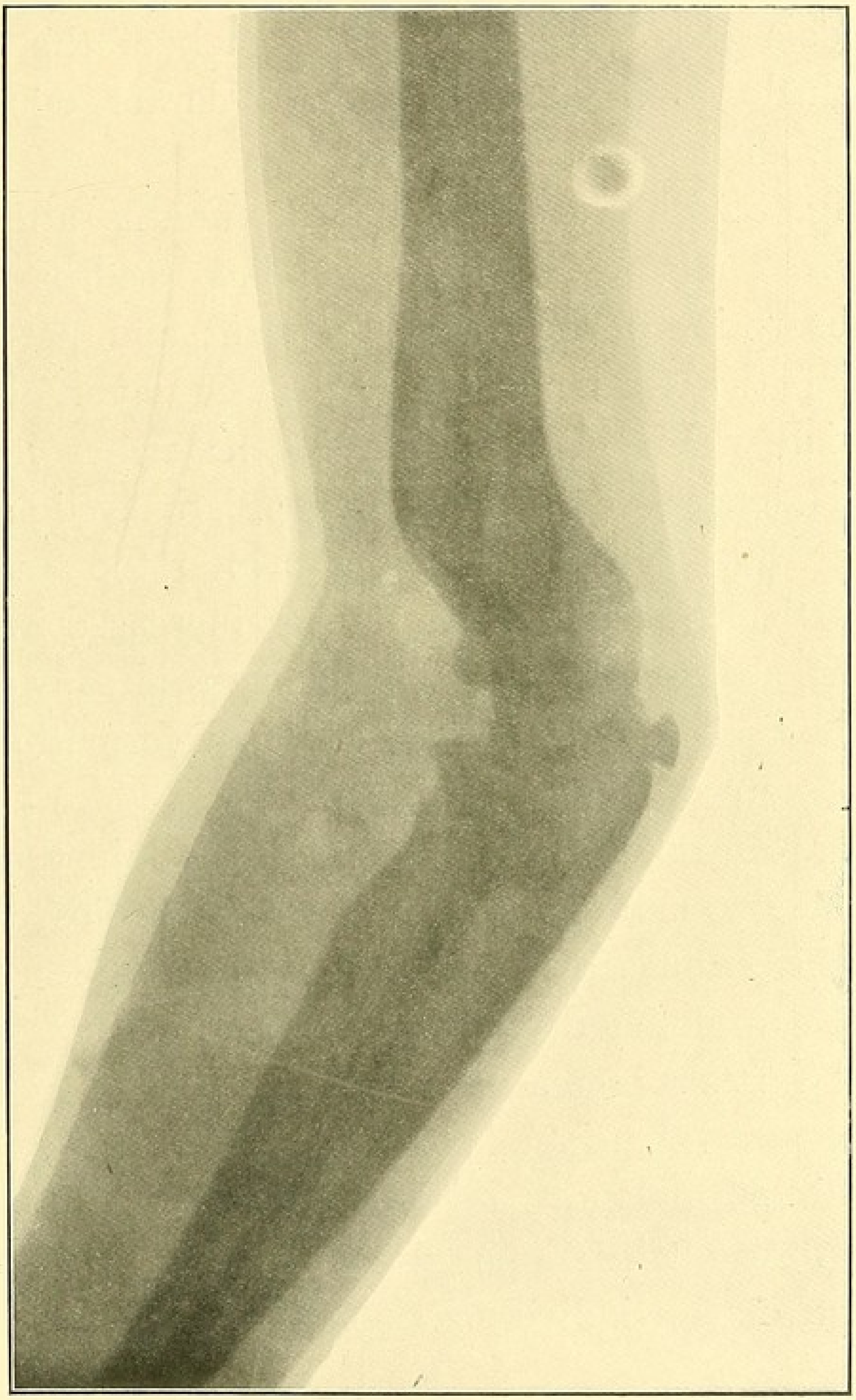


Fig. 40.—Fracture of lower end of humerus.

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. 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. 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 extract from the recent teachings of surgeons of the highest reputation in England their teaching on this subject.

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 halfway 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.

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. 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

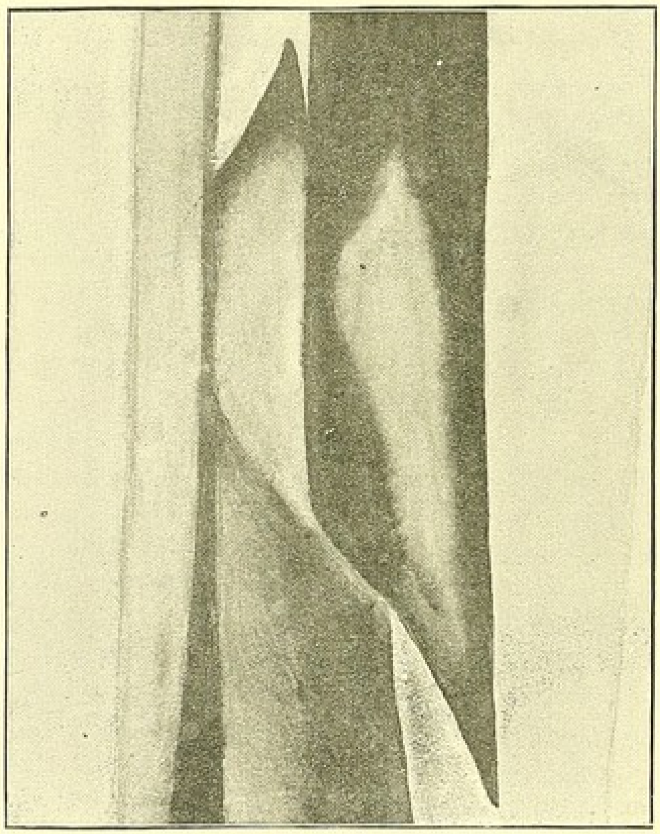


FIG. 41.—Spiral fracture of tibia.

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 around 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." 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

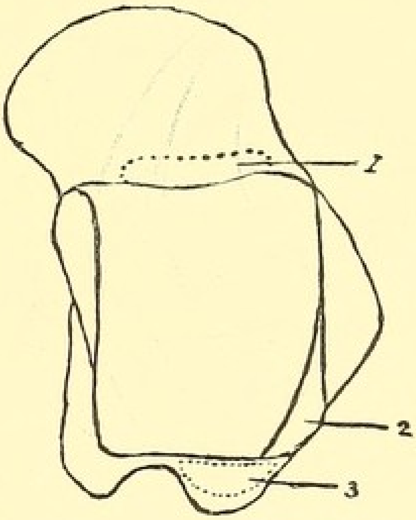


FIG. 42 represents the upper surface of the astragalus, 1 being the facet formed by the habitual impact of the anterior margin of the tibia in extreme flexion of the ankle-joint, 2 being the facet produced by the impact of the posterior margin of the tibia in habitual extreme extension, and 3 being that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

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.

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,

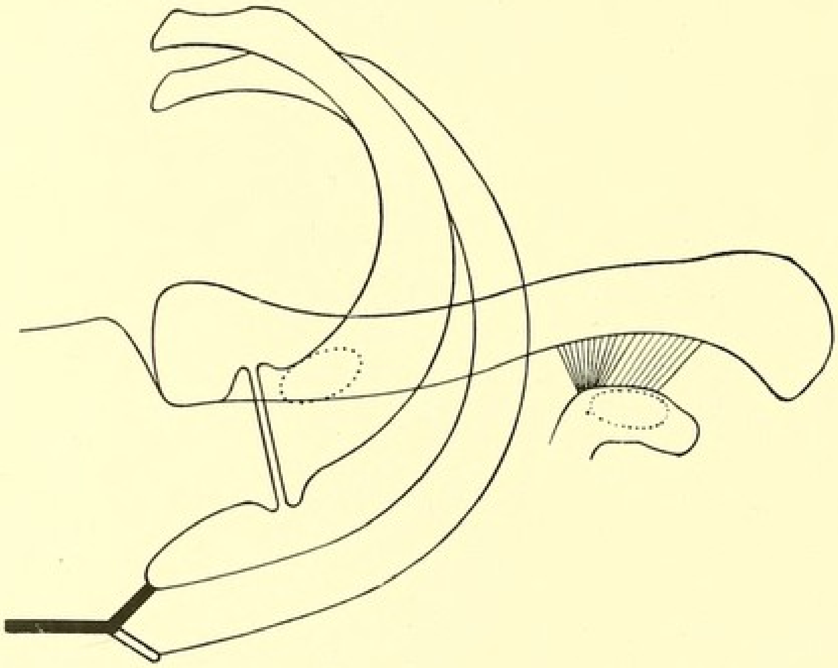


Fig. 43 represents the left first and second costal arches, with the manubrium, clavicle, and coracoid process, of a labourer. The manubrio-gladiolar joint is amphiarthrodial in character, while the joint which has developed in the ossified first costal cartilage is freely arthrodial. The position of 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.

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

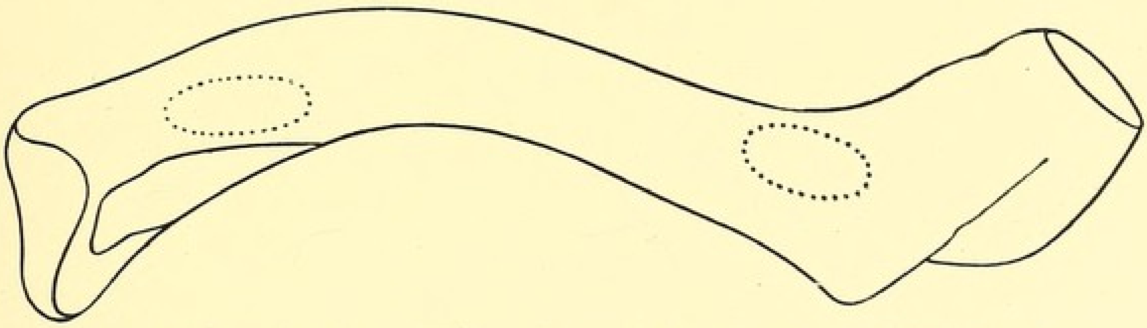
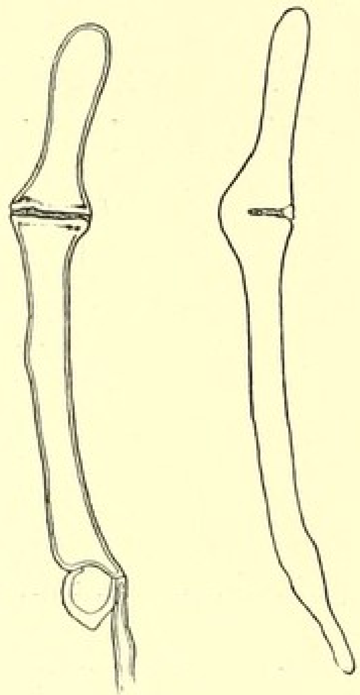


FIG. 44 represents the under surface of the clavicle with the articular facets which correspond with those on the costal arch and coracoid process.

scapula 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

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.

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 Fracture of the

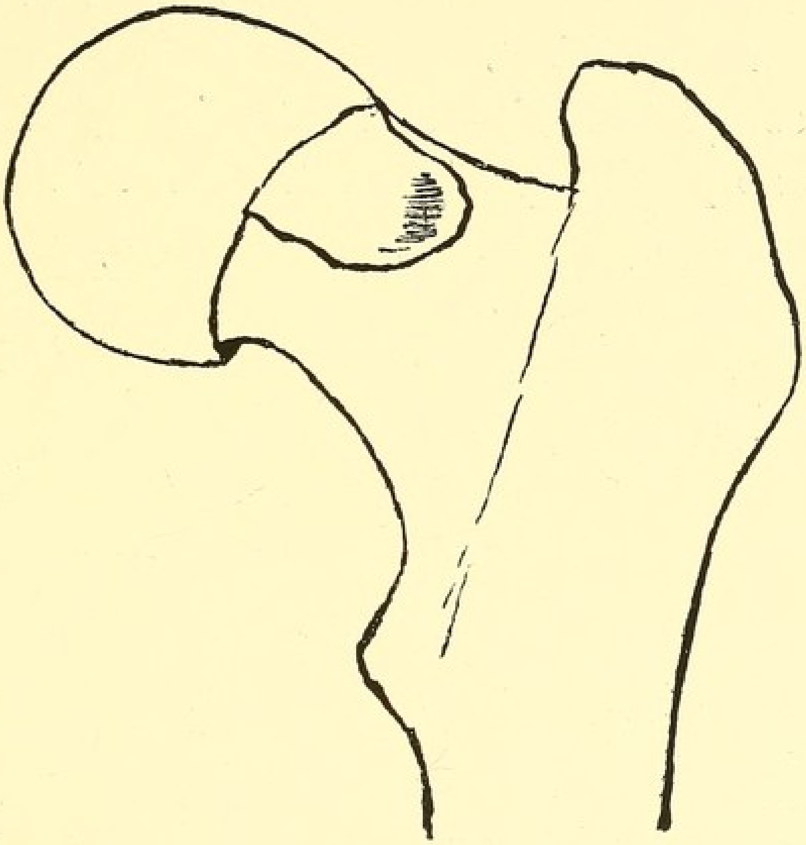


FIG. 47 represents diagrammatically the anterior surface of the femur of a man who has been engaged in carrying heavy loads upon his back. It shows an increase in the area of articular cartilage due to an extension outwards from its upper part on to the neck. Also the depression on the part of the neck 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.

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

Fig. 48.

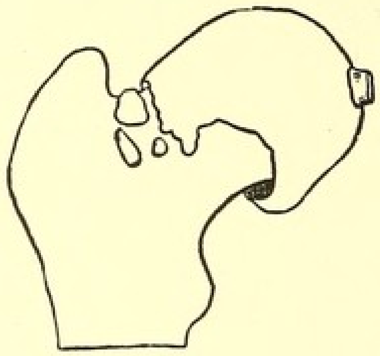
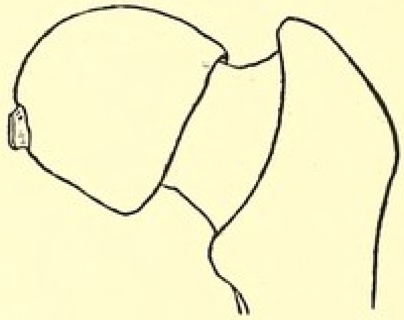


Fig. 49.



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.

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, 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 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 fibular 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.

If the foot be adducted by a force greater than it is able to bear, the head of the astragalus tends to become dislocated outwards. If, on the contrary, the foot be abducted excessively, the tendency to rotation of the fibula upon its own axis may be sufficient to break that bone; while if abduction be carried still further the astragalus and the rest of the foot are displaced backwards upon the tibia, when the internal lateral ligament or the internal malleolus may yield also. In extreme cases the back and outer portion of the lower end of the tibia sustains an enormous pressure and may be broken off. This fragment may be displaced upwards as well as backwards and prove a source of serious trouble, especially if the case is not operated on till after an interval of a few weeks. I am unaware that this not very infrequent complication has been recognised. This is well shown in Figs. 50 and 51. In Fig. 50, which is taken in an antero-posterior plane, the lateral margins of the fragments can be outlined, while in Fig. 51, taken laterally, the anterior and posterior limits of the displaced pieces of bone can be clearly defined.

The leverage which is exerted by the foot upon the ankle in abduction is very much greater than it is in adduction; for not only does the large broad grip of the ground by the sole of the abducted foot afford a much greater resistance than the narrow outer margin of the foot in extreme adduction, but the length of the arm of the lever in the former

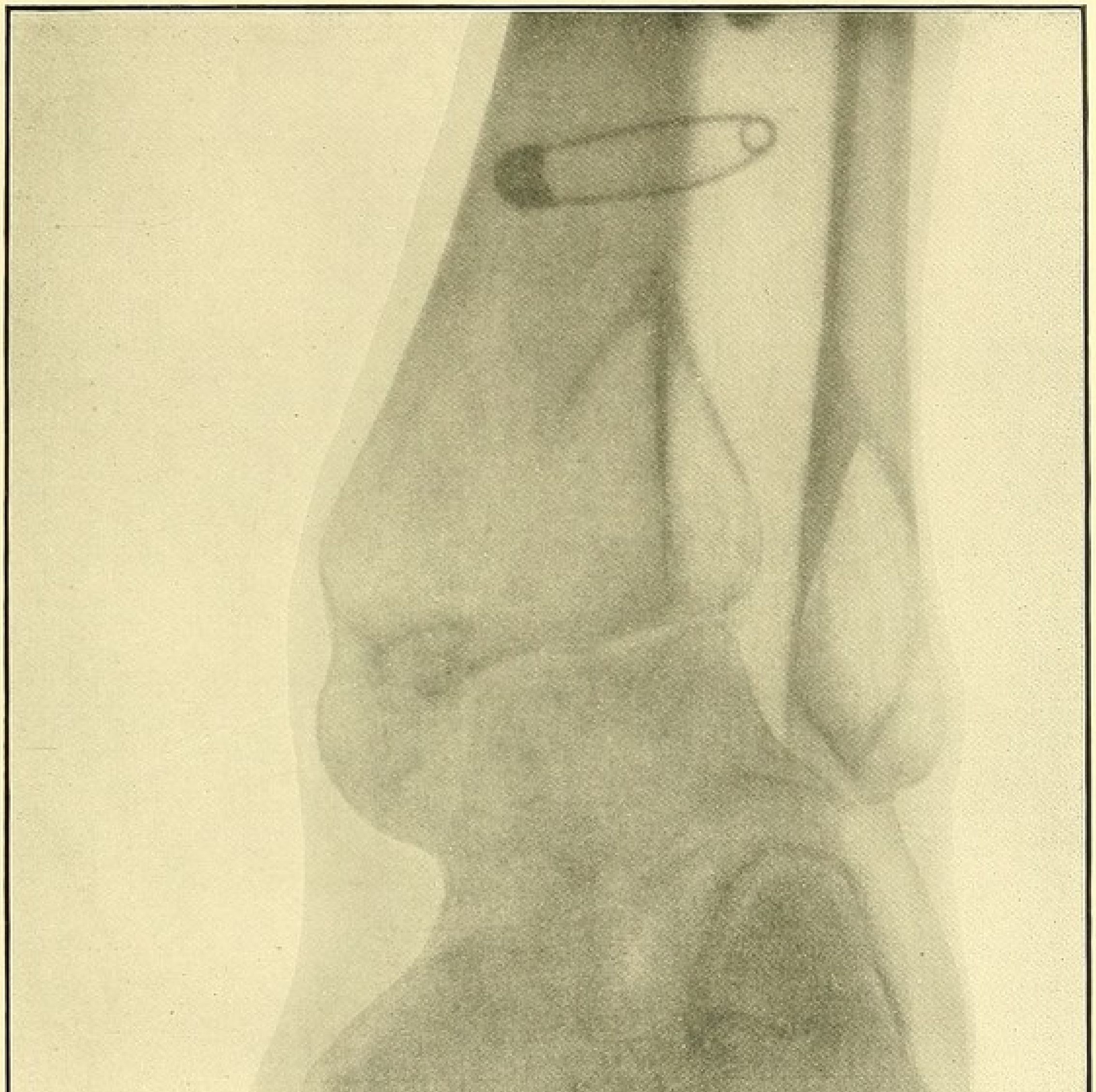


Fig. 50 represents a Pott's fracture taken in an antero-posterior plane, showing fracture of malleolus, lower end of tibia, and of fibula.

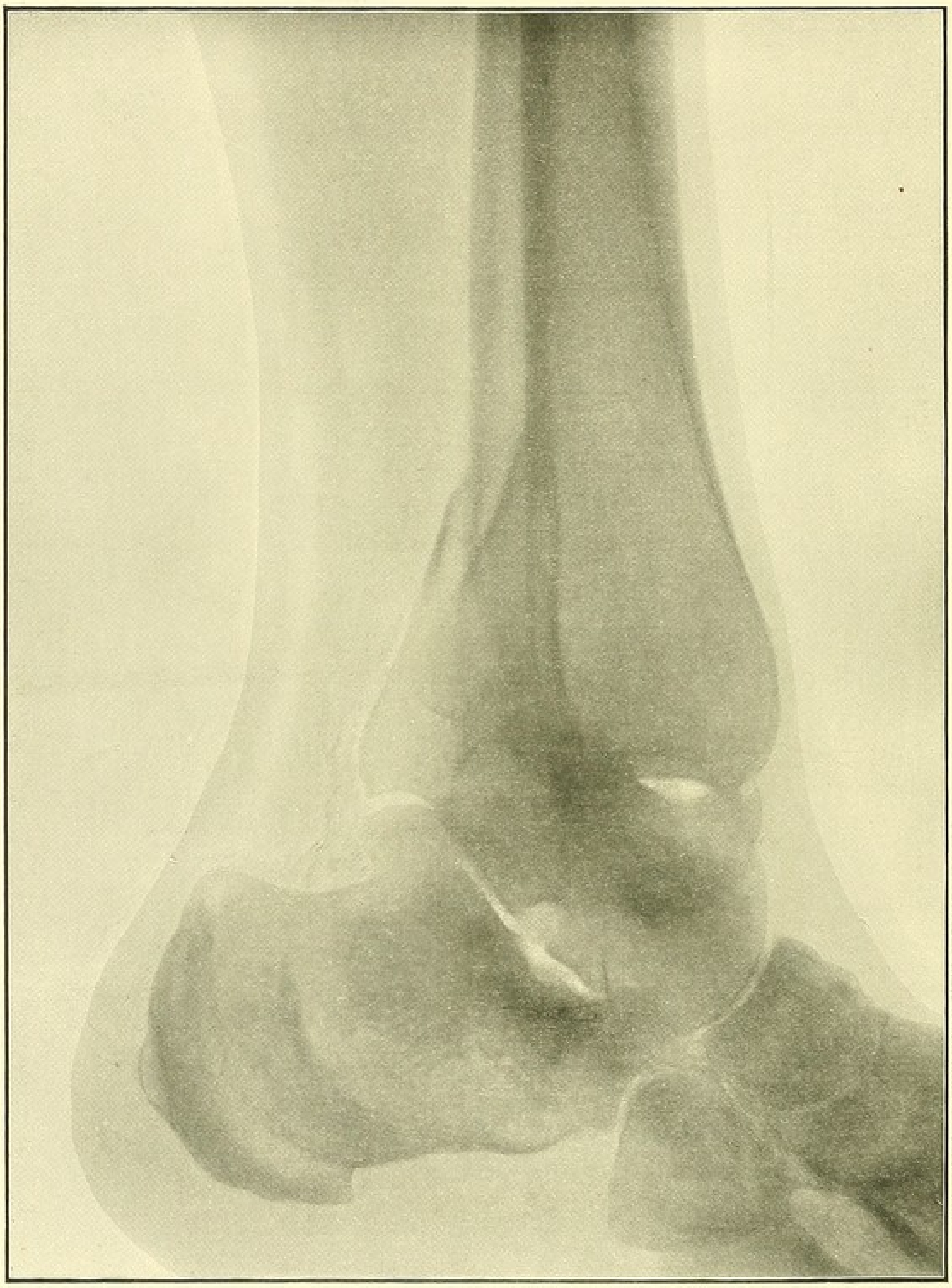


Fig. 51 represents a Pott's fracture, with considerable backward displacement of foot. The fracture of the lower end of the tibia and of the fibula is shown very clearly.

corresponds with the interval between the ankle-joint and the ball of the great toe in the foot elongated to its extreme limit, while in the latter the interval is between the ankle and the outer surface of the fifth metatarsal bone in the foot foreshortened as much as possible.

In consequence of excessive forcible abduction a vertical or spiral fracture of the fibula, with a displacement of the whole foot outwards and backwards upon the tibia, with or without damage to the internal malleolus or internal lateral ligament, may ensue. Fig. 52 represents the common type of Pott's fracture, and it also gives one a very good idea of the disability which results from the ordinary treatment, as in none of the radiographs which I have seen taken after convalescence under these circumstances did the displacement of the fragments appear to have been altered by the measures adopted. After a time, especially in the young subject, the irregularity in outline is reduced, but the mechanism of the joint is altered permanently.

Except in such circumstances as disease involving added risks, the surgeon has no possible excuse for not interfering here, as the disability resulting from any treatment other than operative is generally recognised; and a very moderate amount of skill and a reasonable familiarity with aseptic surgery should absolutely guarantee a restoration of the

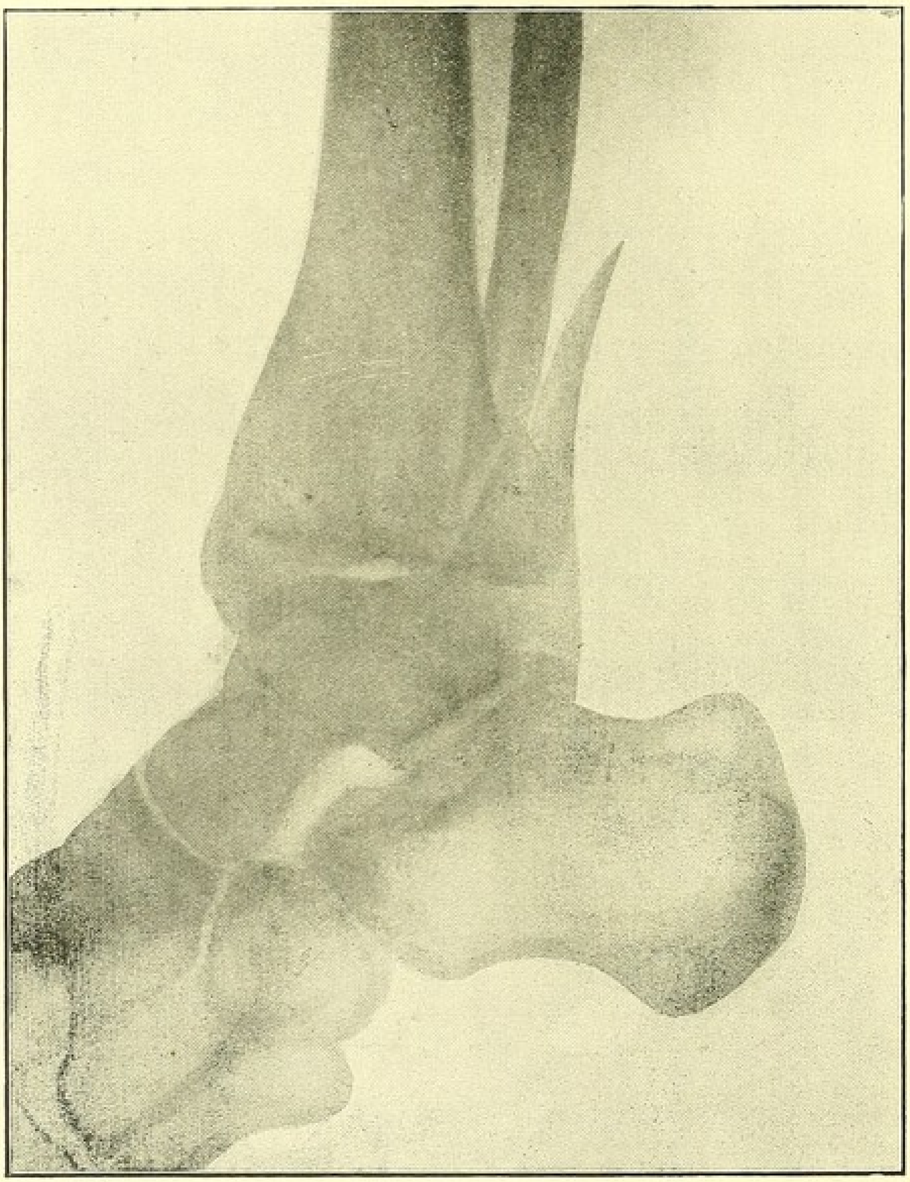


FIG. 52 shows the most common type of Pott's fracture of moderate severity, seen laterally.

normal use of the part, which should be as perfect anatomically and functionally as before the accident.

I could understand a nervous operator hesitating to operate on a fractured femur, but not on such a simple, but often more disastrously disabling, fracture as this.

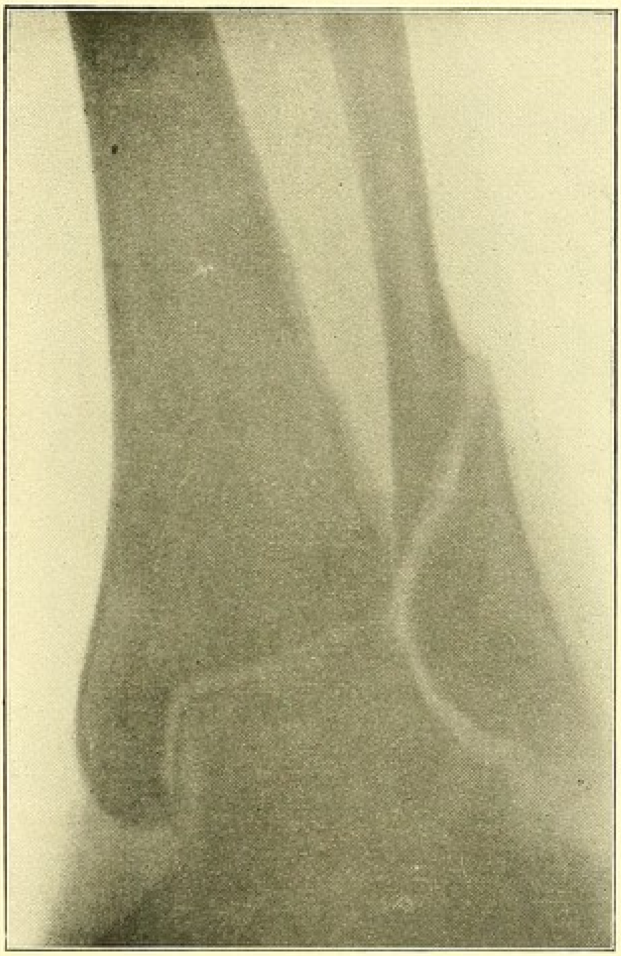


FIG. 53 represents a radiograph of the common variety of Pott's fracture, taken from before backwards. It also illustrates the necessity of taking skiagraphs of fractures in two planes crossing one another at right angles in order to ascertain the degree and character of the displacement of the fragments on one another.

Fig. 53 shows a Pott's fracture, seen from before backwards. Here I would take the opportunity of urging most strongly the importance of not trusting to a radiograph of a Pott's fracture taken in this plane. It never gives any idea of the extent of the displacement of the fragments of either bone.

Fig. 54 illustrates the condition of a bad Pott's fracture. In this, as in most severe cases, the foot

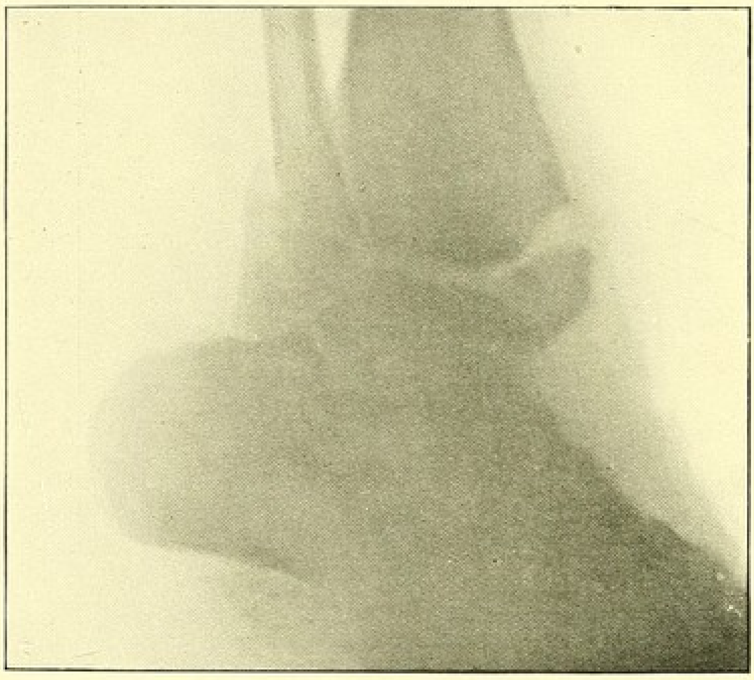


Fig. 54.—Pott's fracture of ankle.

was displaced backwards to a considerable extent. An oblique incision was made over the inner aspect of the ankle-joint, and through it the tibia was brought backwards till the broken fragment could be fitted accurately in position. A screw was driven through the inner malleolus into the lower end of the tibia, fixing the fragments securely in apposition, and restoring both the tibia and fibula to their normal form. The result was excellent (Fig. 55), the patient rapidly regaining the use of the limb.

Fig. 56 represents a case of Pott's fracture some time after the receipt of the injury, and illustrates the less common variety of this accident, namely

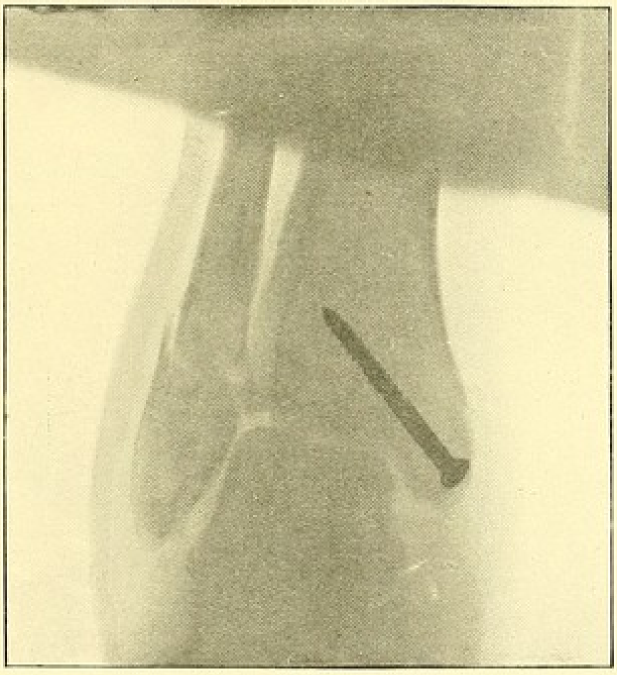


FIG. 55.—Same case as Fig. 54 after treatment.

fracture of the fibula at a distance from the malleolus. This case was treated by manipulation and splints, early movements being adopted. Owing to the complete disability which resulted, at the patient's urgent request I performed the operation the result of which is shown in Fig. 57. The patient obtained a considerable advantage from the altered relationship of the astragalus to the tibia. The degree of improvement can be readily gauged by prolonging the direction of the outer margin of the shaft of the

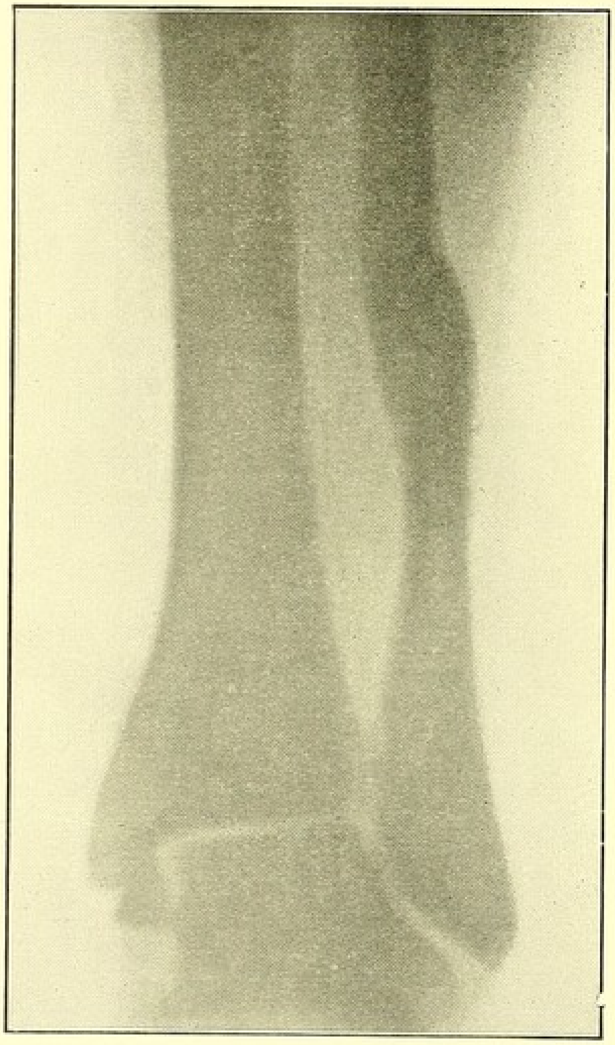


Fig. 56 shows the conditions present in a less common variety of Pott's fracture. The skiagram was taken long after the receipt of the injury. The man had been completely incapacitated, and begged that something should be done to remedy his pain and disability, failing which he wished the foot amputated.

tibia downwards in Figs. 56 and 57 respectively, and comparing the size of the areas of the astragalus external to that line. It is not quite as good as if the bones had been wired in the first instance; still, functionally, the patient was enormously benefited,

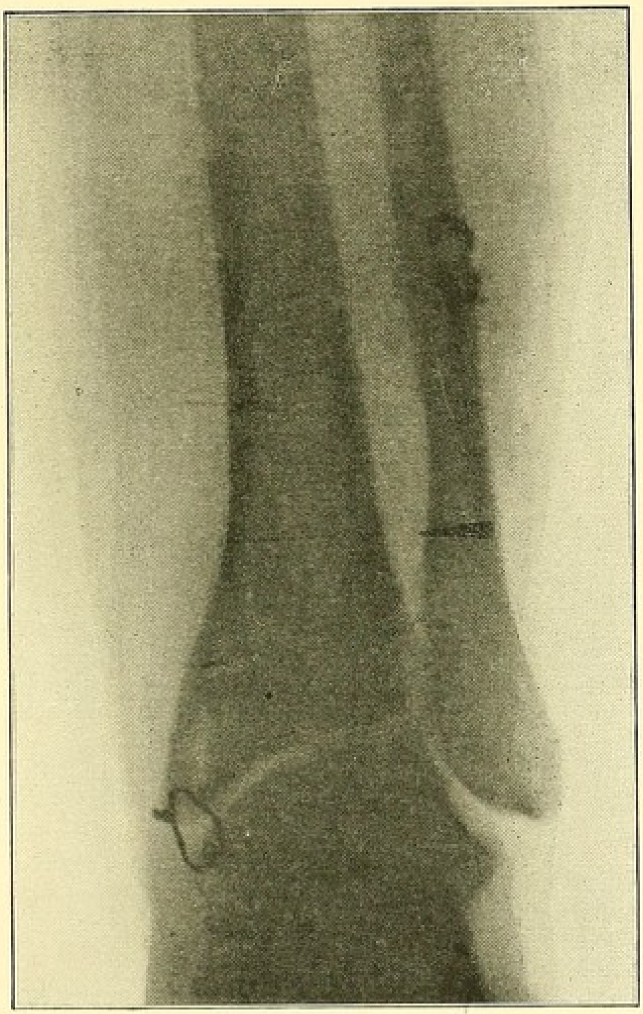


FIG. 57 represents the result of operative interference in the condition shown in Fig. 56.

though not by any means completely freed of his disability.

There is a remarkable similarity in the results of excessive abduction of the foot, the conditions varying with the degree of force exerted. Fig. 58 represents the fracture in its worst form with the displacement

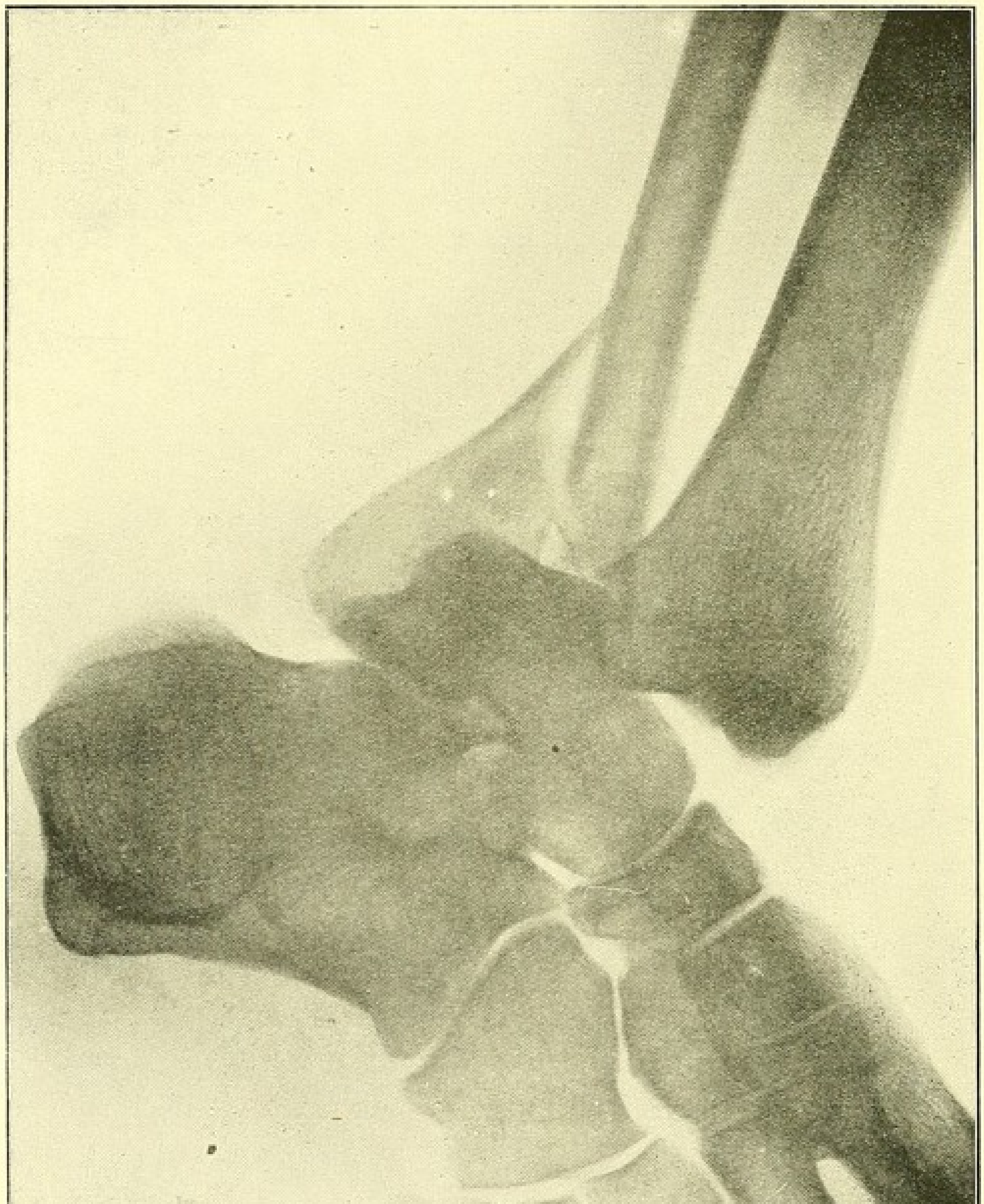


Fig. 58 shows the backward displacement of the foot in a bad case of Pott's fracture, the tibial facet on the astragalus being separated by a considerable interval from the corresponding surface on the tibia. The fibula was broken spirally, and its fragments were firmly united by bone, so that their axes included an angle of considerable size.

well illustrated in a marked degree. This skiagram was taken many months after the receipt of the injury, when it appeared that the patient, a lady, must continue to be a cripple for the rest of her life. By means

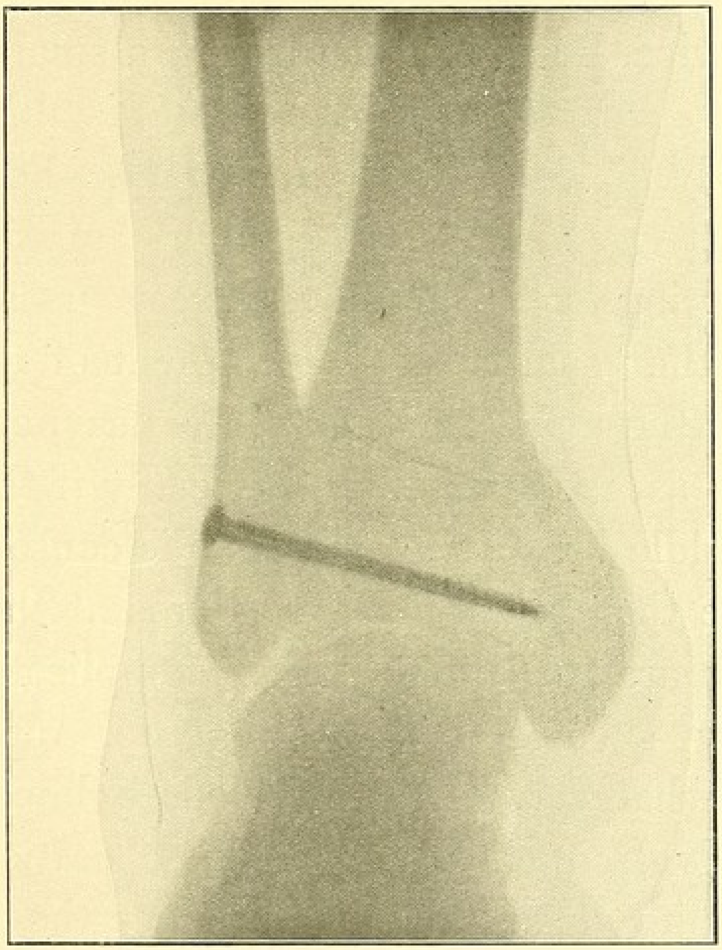


FIG. 59 shows the result of the operation in the case of Pott's fracture illustrated by Fig. 58.

of free incisions, and by removing from the surfaces of the fibular fragments the callus which had formed, these were retained in accurate apposition, and the tibia in its normal relationship to the astragalus, by a long steel screw which traversed the lower fragment of the fibula, and the lower end of the tibia. Fig. 59 represents the condition after she had recovered completely. Subsequently, to avoid any possible risk of the screw giving trouble, it being no longer of any service, I removed it through a small opening. She made an excellent recovery, and is able to walk comfortably for considerable distances. Fortunately, this patient was young and vigorous. My experience in attempting to remedy the very unsatisfactory results of the usual mode of treatment of these fractures after the lapse of much time has not been as successful as I should like, especially if the subject is past middle life. However, one is consoled by the knowledge that operative procedures at the time of the injury are, except in very complicated cases, completely successful and altogether obviate any disability whatever, and one is led to hope that an increasingly frequent recourse to operation at the time the injury is sustained will reduce the very large number of hopelessly unsatisfactory results which require some form of remedial surgical treatment.

In some cases, owing to the fracture passing through the fibula in the area of the attachment of the inferior interosseous ligament, there is no displacement of the fragments.

Indeed, in these circumstances the fracture often cannot be recognised even with the aid of the X rays, since, the fragments coapting perfectly, no evidence of the fracture can be obtained in a radiograph. This fact may have an important medico-legal bearing.

The vast majority of these fractures are spiral or almost vertical, the latter being the more common, since in the majority of cases the fracture traverses some part of the malleolus. Careful consideration of the anatomy of the part and of the mode of causation of this fracture, and experiments at manipulation of the foot made at the time of operation when the seat of fracture is fully and freely exposed, show how impossible it is to exert force upon the lower fragment of the fibula in a direction exactly the reverse of that by which the fracture was produced, and so effect accurate apposition of the fragments. This explains the well-known want of success that surgeons have always experienced in obtaining anything approaching a perfect result in this form of fracture. Indeed, in this fracture, as in those in the vicinity of other joints, their constantly repeated failures to restore to the parts their normal anatomy and physiology have driven them to attempt to effect a miserable and thoroughly unscientific compromise by commencing active and passive movements within a very short period of the receipt of the injury which caused the fracture, a method which cannot be too strongly condemned in the present day by competent operators, especially in patients who are no longer young or vigorous. The disabling mechanical conditions which I call mechanical or traumatic arthritis have been described very fully earlier under that heading. The importance to the surgeon of a thorough familiarity with the changes which develop in joints in the several decades of life, in consequence of such alterations in the lines of pressure through them as result from fracture of the bones taking part in the formation of these joints, cannot possibly be exaggerated. It was because surgeons were ignorant of these changes that they were, and may still be, satisfied to continue the barbarous indiscriminate treatment of fractures by means of manipulation, splints, massage, etc. A more careful study, however, of the mechanics of the normal skeleton, and of the conditions which result from any alteration in its form produced by injury, together with a larger experience in the application of the principles of aseptic surgery, will probably soon remove their conservatism in this direction.

The operative treatment of the results of excessive abduction of the foot, commonly called Pott's fracture, varies with the conditions present. In the majority of cases the accurate apposition of the fibular fragments by wire is sufficient even when the internal malleolus is fractured. In others it may be wise to unite the internal malleolar fragment also by wire or screw to the tibia, as in Fig. 57. In others, as in Figs. 54 and 55, the fixation of the internal malleolar fragment by means of a screw effects accurate apposition of the fibular fragments, and renders further measures unnecessary. In more severe cases, as in Figs. 58 and 59, the fixation of the fibular fragments in apposition by a screw which perforates the lower fragment of the fibula and the tibia is the most efficient treatment in my experience.

The next fracture we will consider is that of the tibia and fibula produced by indirect violence. It is brought about by the forcible rotation inwards of the leg upon the abducted foot, the superjacent weight of the trunk being transmitted vertically through the limb. The tibia breaks first, since it sustains by far the largest part of the strain. If sufficient force be exerted the fibula then yields also, usually at a much higher level. The continued transmission of the force applied vertically through the bones results in the upper fragment being driven downwards, forwards, and inwards, and the lower upwards, backwards, and outwards, into the surrounding soft parts,

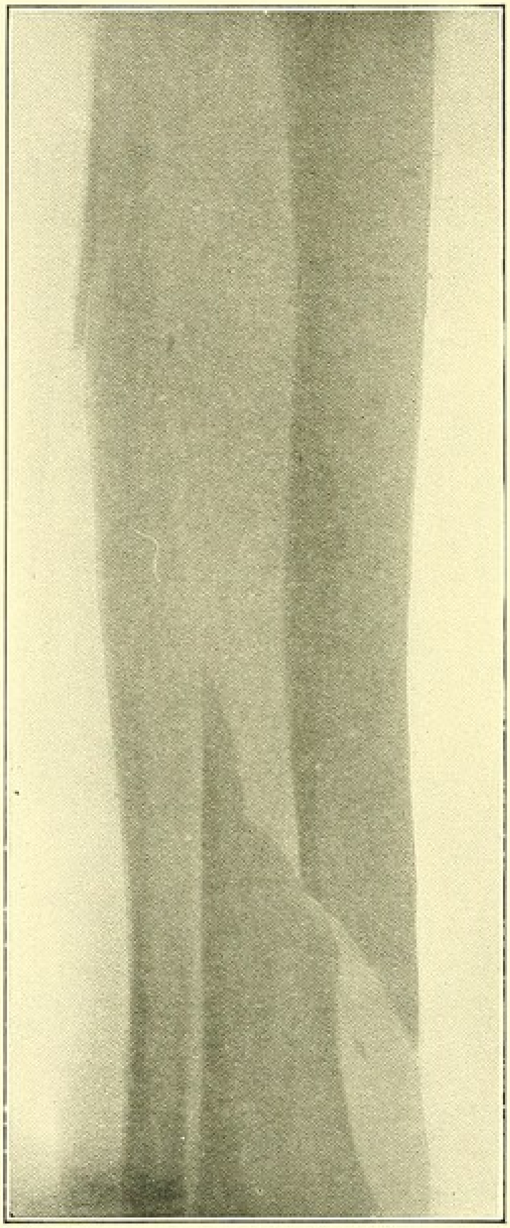


Fig. 60 is an example of the common type of spiral fracture of the tibia and fibula, the fracture of the latter being, as is always the case, at a level much above that of the tibia.

the chisel-shape of each fragment increasing the interval or separation between them in proportion to the degree of overlapping. The form of the fracture of the tibia is always spiral in character, each frag-

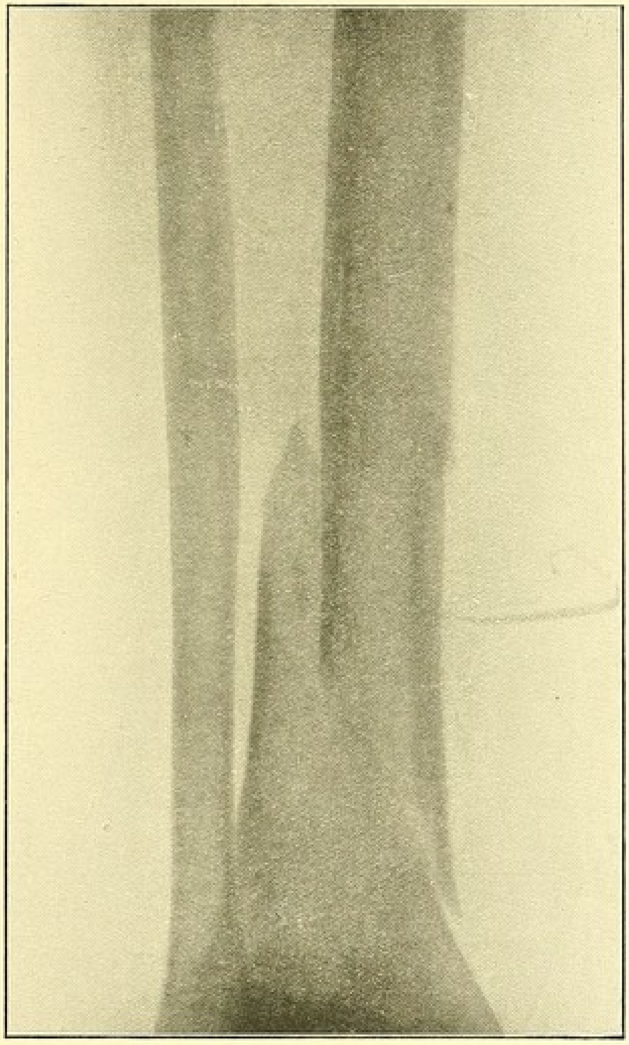


FIG. 61 represents a skiagram of a very common variety of spiral fracture of the tibia, taken from before backwards.

ment ending in a spike-like extremity, and their displacement is practically always identical. That of the fibula is very often spiral, but not with the same uniformity as in the case of the tibia.

Figs. 60, 61, 62, and 65 illustrate spiral fractures of the tibia and fibula. Though the fractures have

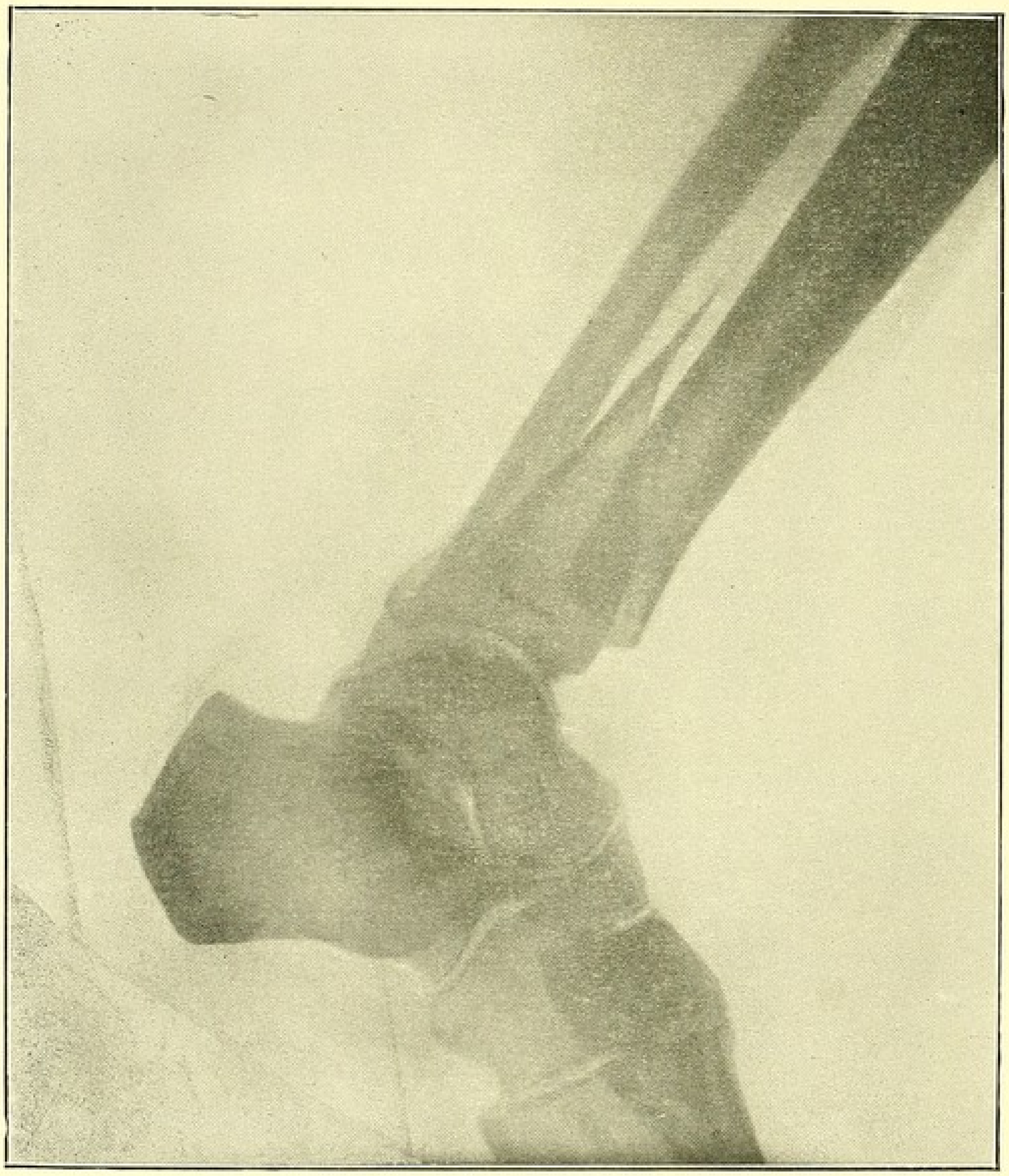


Fig. 62 shows a case similar to that illustrated in Fig. 61, seen laterally. This represents very well the degree of overlapping of the fragments in an antero-posterior plane, with the extent to which they overlap.

taken place at different levels the character of the

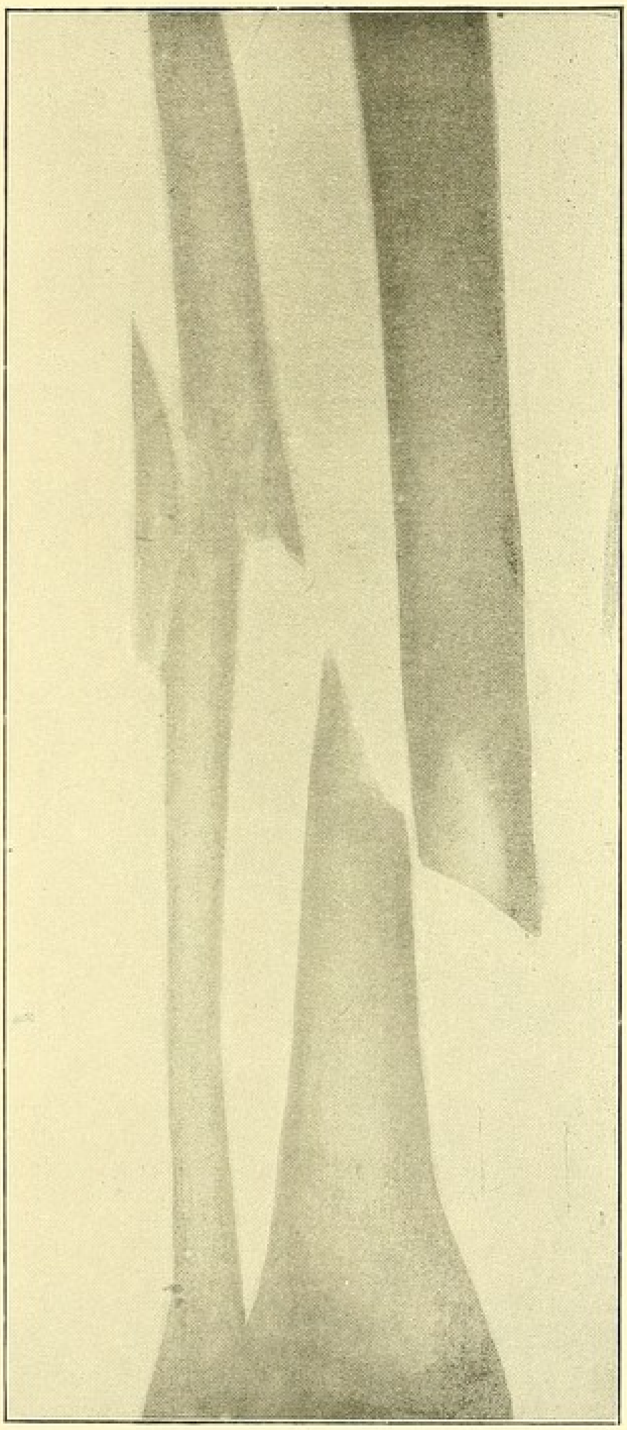


FIG. 63 represents the displacement of fragments in a case of complicated fracture of the tibia and fibula produced by both direct violence as well as by torsion.

fractures and the displacement of the fragments are

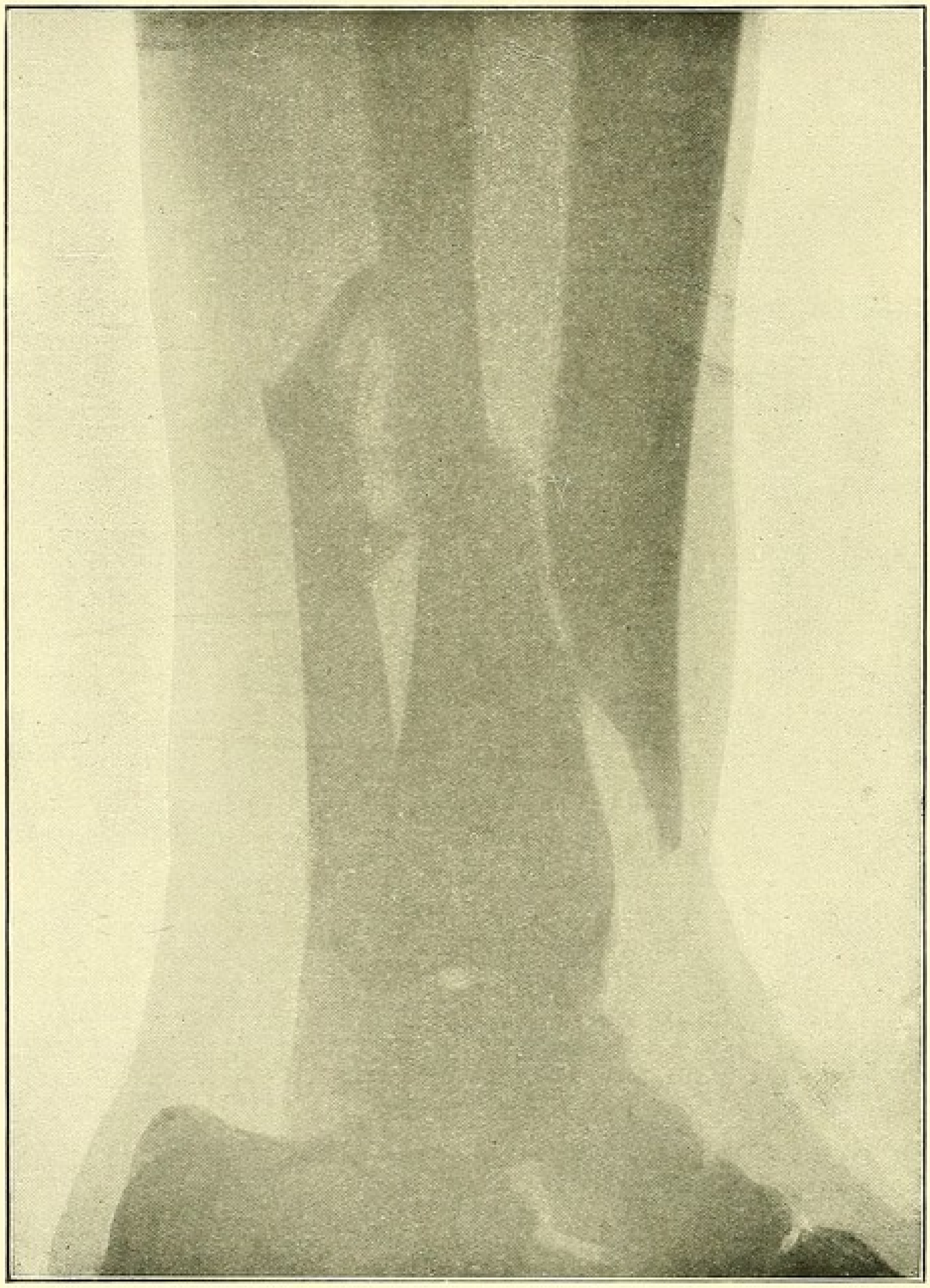


Fig. 64 shows the displacement in a fracture of the tibia and fibula produced partly by torsion and partly by direct violence.

practically identical in the four specimens. The fragments are radiographed in their best possible rela-

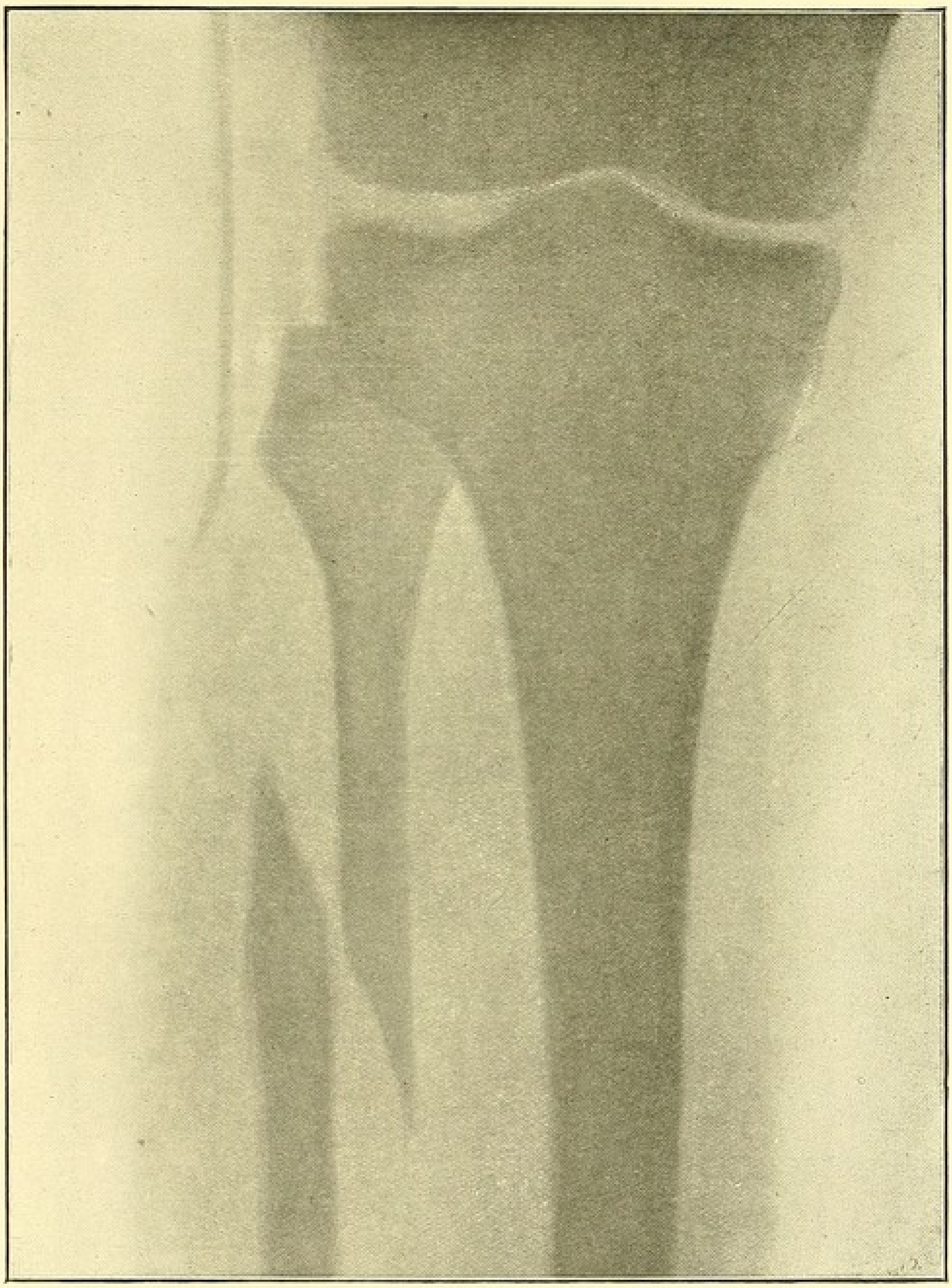


Fig. 65 is a skiagram of a spiral fracture of the fibula which was associated with the ordinary spiral fracture of the tibia in its lower third.

tionships to one another. The change of the form of

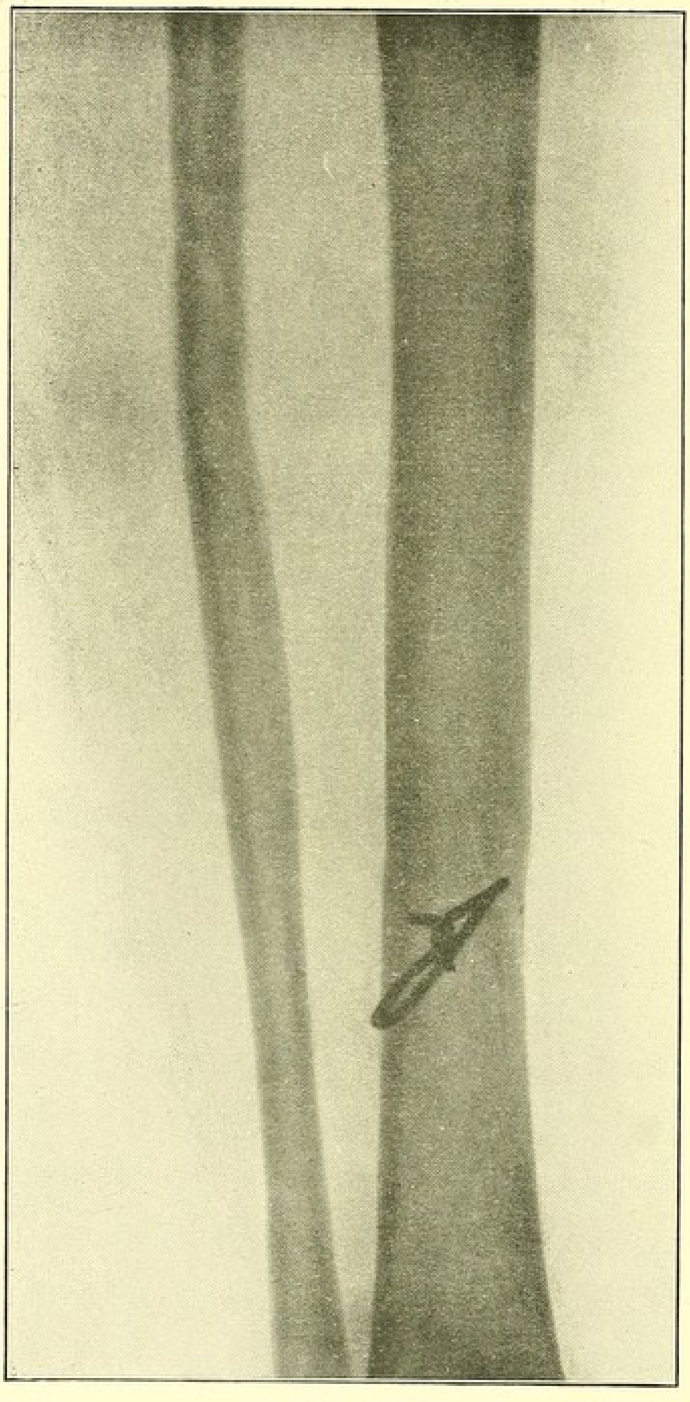


FIG. 66 is a skiagram of a spiral fracture of the tibia and fibula treated by operation shortly after the receipt of the injury. Owing to the apposition of the fractured surfaces produced by the wire being less perfect than that effected by the screw the line of fracture can be recognised in both bones.

the bone and of the mechanics of the joints influenced by it can be readily surmised.

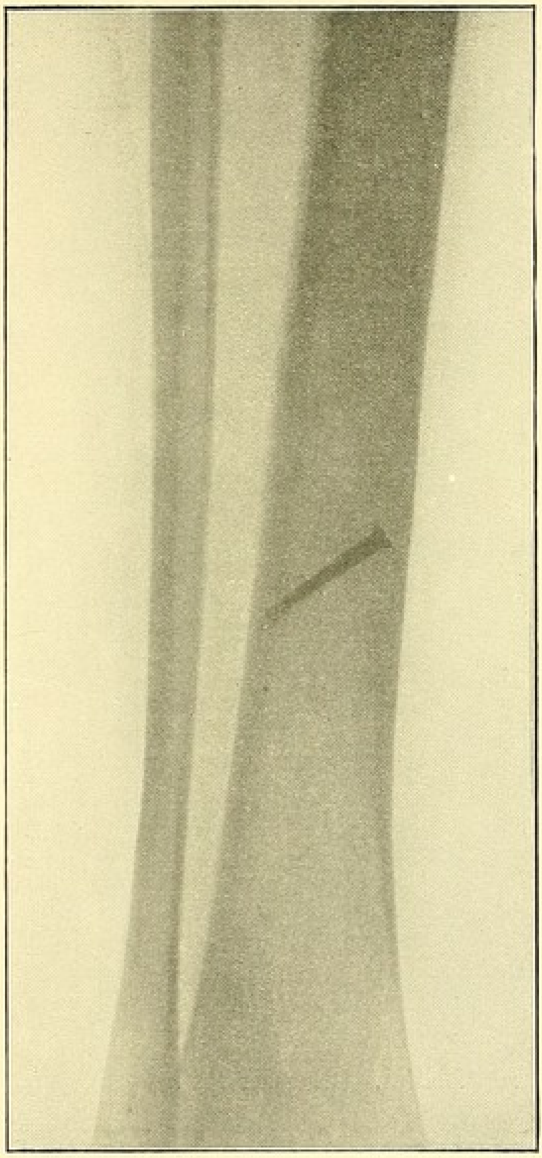


Fig. 67 represents a spiral fracture of the tibia in which the fragments were accurately united by a screw. Owing to the perfect apposition of fragments no evidence of its locality can be obtained from the radiograph.

Figs. 63 and 64 illustrate cases of fracture of both the tibia and fibula by both indirect and direct violence. The line of fracture and the displacement are identical in both cases, and the result of non-operative treatment unsatisfactory. Fig. 65 represents a spiral fracture of the fibula, which was associated

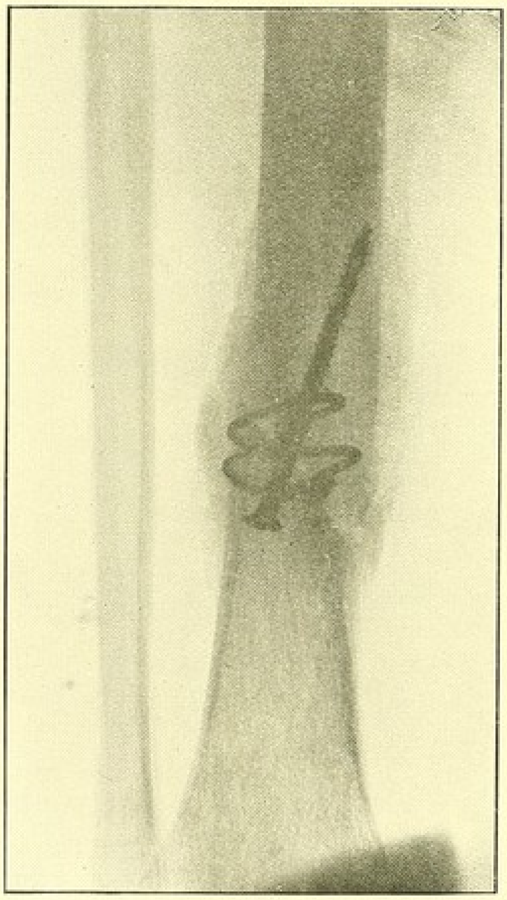


Fig. 68.—Fracture of tibia. Fragments united by screw and wires.

with a spiral fracture of the tibia in its lower third of a type identical with those already illustrated.

Excessive abduction of the foot results in a torsion of the fibula and its breakage in Pott's fracture, while excessive rotation inwards of the leg upon the abducted foot results in a spiral fracture of the tibia, which may or may not be associated with a fracture of the fibula at a higher level.

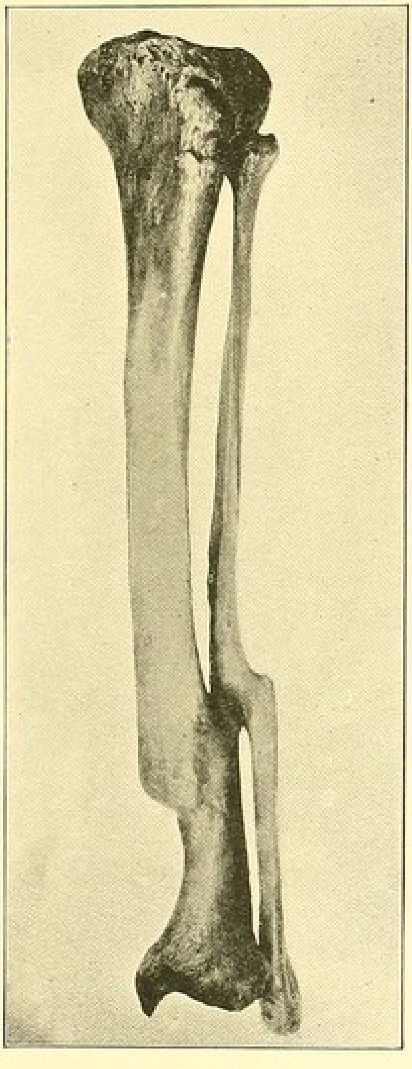


Fig. 69.—Fracture of tibia and fibula.

Figs. 66, 67, and 68 illustrate the only scientific method of treatment of these fractures. In Fig. 66 the fragments are held in intimate apposition by wire, in Fig. 67 by a screw, and in Fig. 68 by both screw and wires. In these cases the functions of the bones and joints were restored to the normal, and the patients suffered no permanent harm from the injury. These results form a striking contrast to those obtained by the usual modes of treatment, illustrated in Fig. 70, if that term can be fairly applied to them.

Fig. 69 illustrates a fracture of the tibia and fibula,

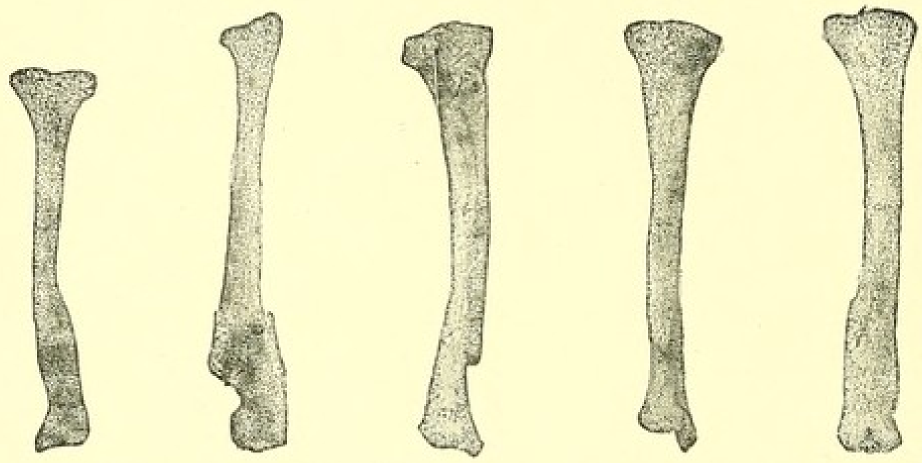


Fig. 70 shows the results of treatment of fractures of the tibia by splints, etc. A careful examination of each specimen shows that the deformity, with the consequent physical depreciation, could have been readily obviated at the time of the fracture by the simplest surgical procedures, it being hardly fair, perhaps, to signify the usual methods by such an attribute.

brought about probably by direct violence alone. The lower fragments have been so rotated upon the upper that their axes include between them an angle of about 45°. This is consequent upon the use of the ordinary vertical footpiece, 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 on the pelvis till the inner margin of the foot includes an angle of 45° with the vertical. The want of recognition of the principles involved I described fully long ago in a paper entitled "The Fallacy of the Vertical Footpiece," and published in the 'British Medical Journal.'

Spiral fracture of the femur is brought about in a similar manner, viz. by the forcible torsion of this bone during the transmission of an excessive vertical force through the lower extremity, which is fixed in a position of extreme external rotation at the hip-joint by means of the enormously powerful anterior portion of the capsule upon an abducted foot. Here we have two forces acting in opposite directions upon the axis of the femur; one extends from the front of the great toe to the axis of the tibia, and the other from the axis of the shaft of the femur through the neck of the femur and pelvis. Both form levers, the extremities of which move along arcs in opposite directions. When the knee is flexed, force may be exerted through the lower leg as the arm of the lever, the length of which varies with the degree of flexion and the interval between the point of application of the force to it, and the long axis of the femur. Again, the femur may be subjected to torsion in a reverse direction. The femur may be fixed on the pelvis in a position of flexion, accompanied or not by abduction, in the manner I have described in previous papers, the neck of the femur becoming impacted against the margin of the acetabulum. The leverage in the case of the abducted foot is less, but when the knee is flexed the leverage becomes the same as in rotation in a reverse direction In this case there is reasonable likelihood of the head of the bone becoming displaced and forming a dislocation, which cannot occur when the femur is rotated outwards ; or of the neck of the bone yielding at the point of impact, and intra-capsular fracture resulting. The form of fracture of the femur produced under these circumstances is always spiral in character, and takes place within a very limited portion of the shaft.

Here, as in the tibia and fibula, the spike-like extremity of the upper fragment is driven by its chisel-shaped form downwards, forwards, and inwards, while the upper spike of the lower fragment is for the same reason driven upwards, backwards, and outwards into the substance of the surrounding muscles. If, as much less frequently is the case, the femur is broken by rotation in a reverse direction, the lower fragment is driven upwards, backwards, and inwards.

Figs. 72, 73, 75, and 76 represent the ordinary form of spiral fracture of the femur produced by torsion. At the time the patient, whose fracture is shown in Fig. 72, came under my care an unsuccessful attempt had already been made to unite the fragments, and the wire loop which had been used for

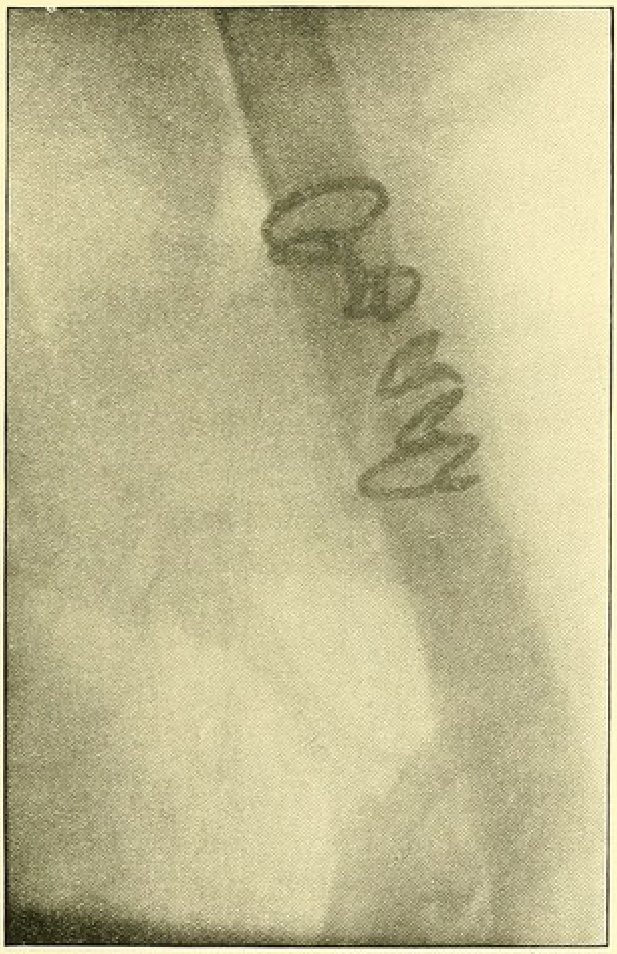


Fig. 71.—Femur four months after operation for comminuted spiral fracture.

the purpose is shown in the skiagram. In fracture of the femur it is important to employ screws or wire of sufficient strength, since the strain exerted on the fracture in the active and passive movements of the patient is very considerable indeed: further, it is

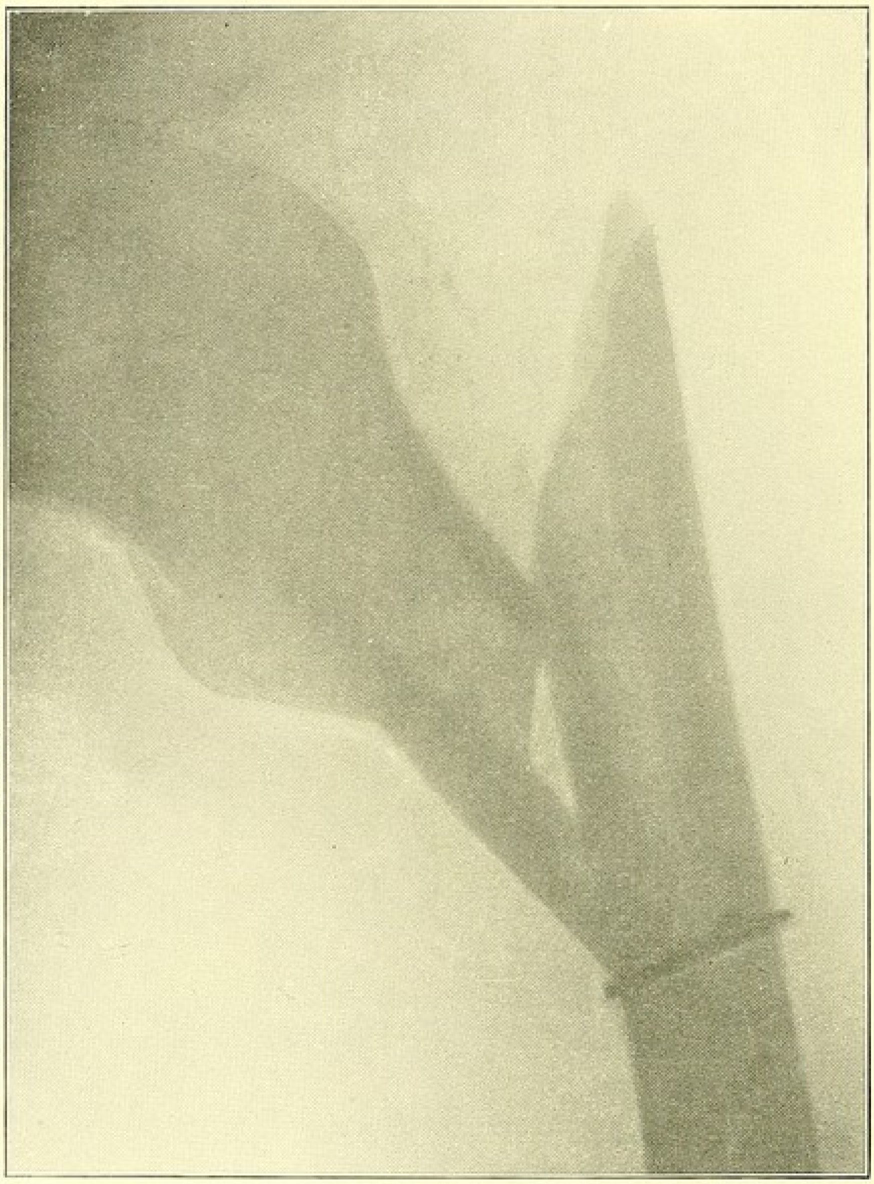


Fig. 72 shows the relative displacement in a transverse plane of the fragments of the femur in a case of spiral fracture. Their position differs somewhat from that which existed originally, since the lower end of the upper fragment is retained in contact with the lower by an encircling loop of wire which was used by the surgeon who had operated on it in the first instance.

necessary to perforate the fragments, as an encircling

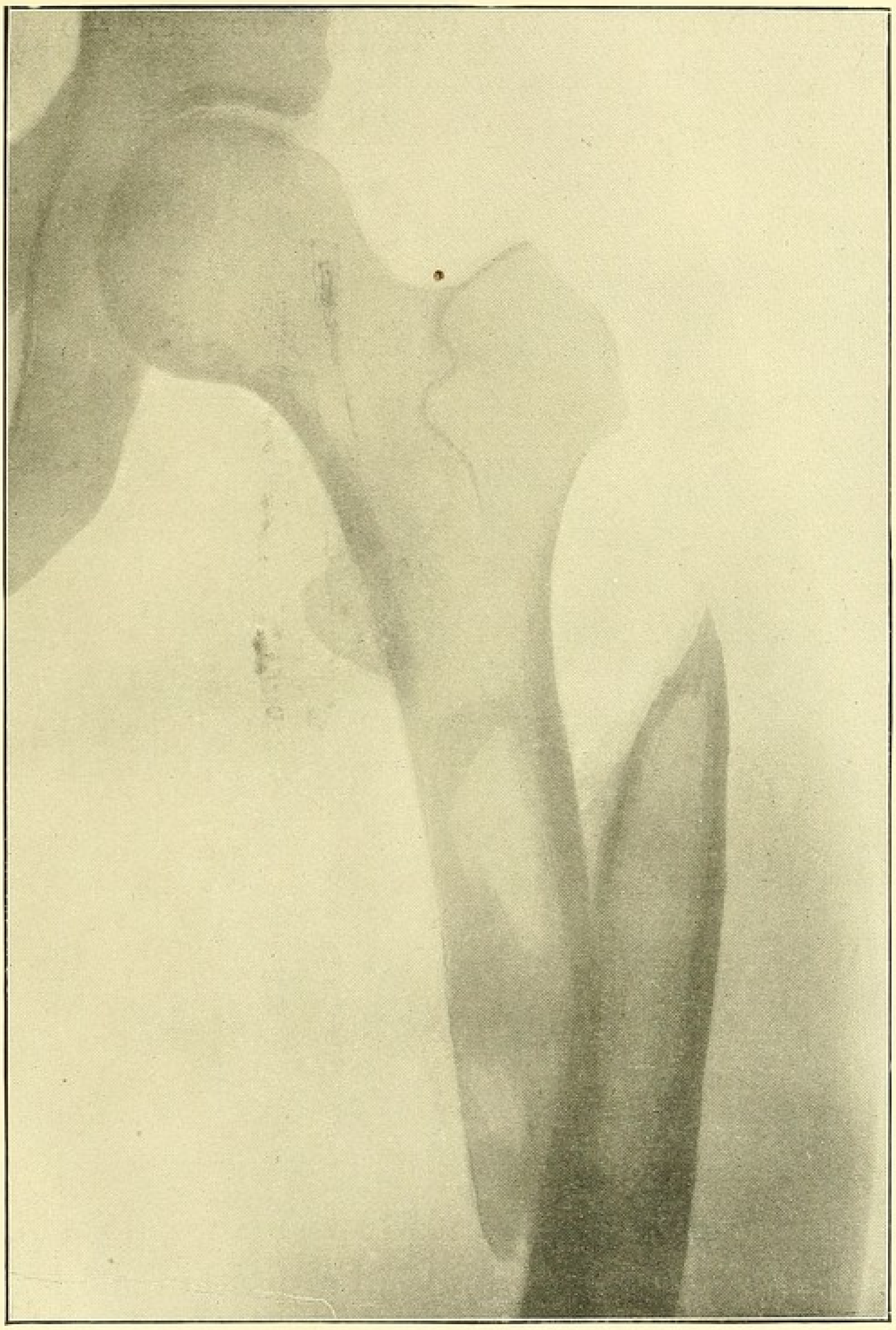


Fig. 73 shows the relative position of the fragments of the femur in a case of spiral fracture which had been treated by splints. The upper extremity of the lower fragment has lost through absorption a little of its original length.

wire alone affords no efficient obstacle to their separation from one another.

Fig. 71 represents a comminuted spiral fracture

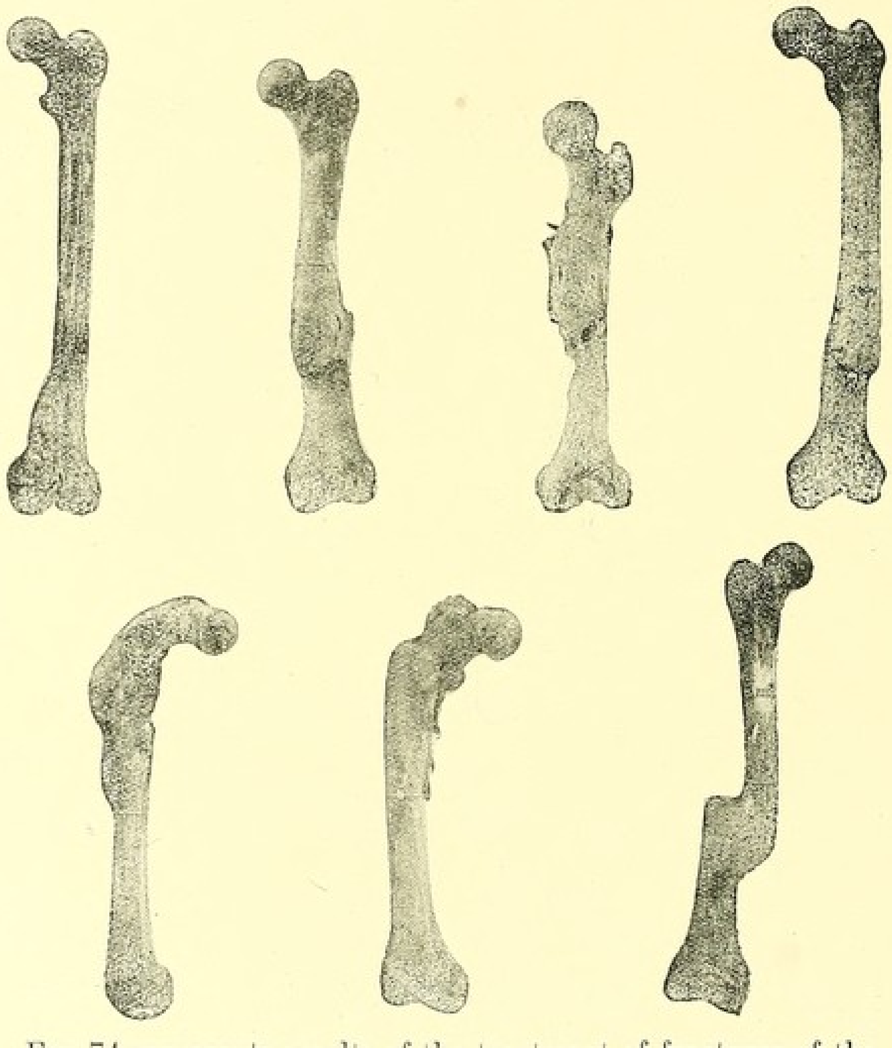


FIG. 74 represents results of the treatment of fractures of the femur with splints.

of the right femur of an elderly woman, whose right hip-joint had been ankylosed in a position of flexion and adduction since infancy. It was necessary to suture the several fragments together sufficiently

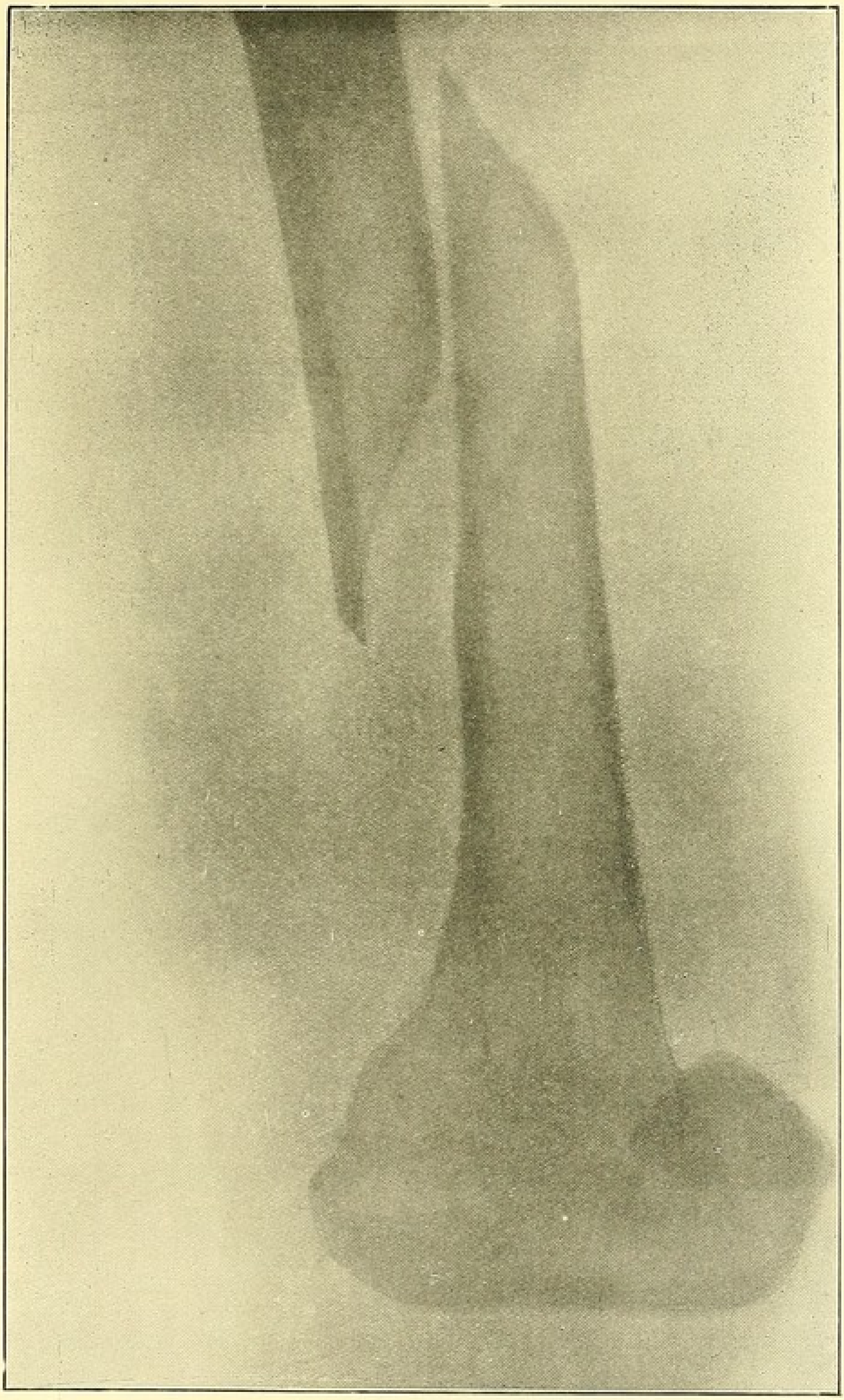


FIG. 75 shows the form of fracture and the displacement of fragments of a femur broken by indirect violence.

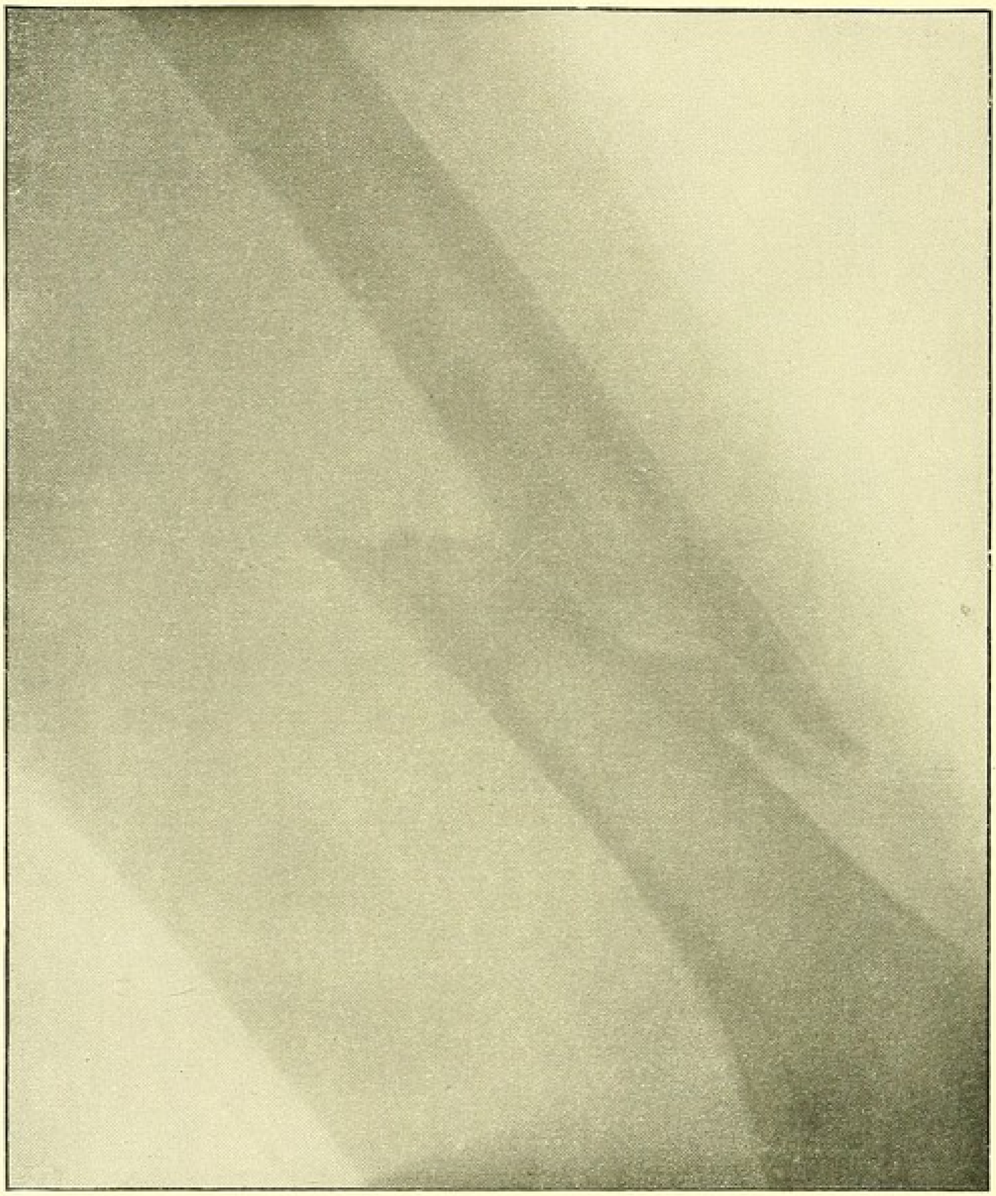


Fig. 76 shows the displacement of fragments in an antero-posterior plane. The influence of the malposition of the fragments on the functions of the knee-joint was disastrous, as one would naturally expect. The nearer the extremity of a long bone the fracture takes place, the greater is the alteration in the mechanics, and the consequent disability in the adjacent joint. Masses of bone or callus have formed in the interval between the fragments, the extremities and edges of which have been partly absorbed in the period following the injury.

securely and firmly to render a splint unnecessary, since, owing to the abnormal position of the leg, it was not possible to employ a splint advantageously. She kept the flexed leg supported on the left one.

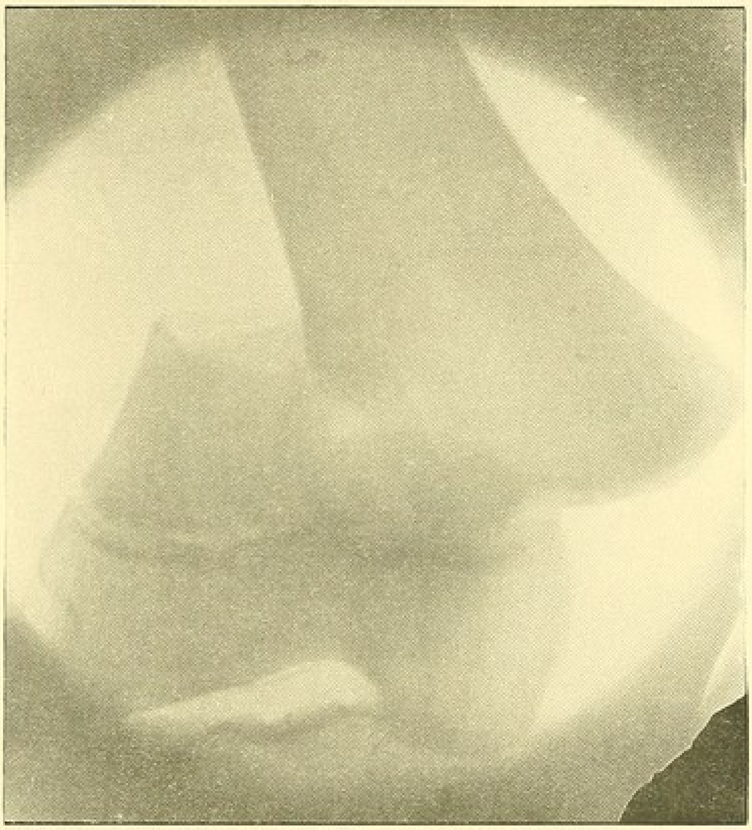


Fig. 77.—Fracture through lower epiphysial line of femur.

The mechanics of the patient were not affected by the injury after operative interference.

Fig. 77 shows a fracture through the greater part of the epiphysial line of the right femur of a boy æt. 15 years. A portion of the shaft was broken off and remained attached to the epiphysis, which was displaced outwards. The fragment was replaced with great difficulty, and was fixed immovably in position by three staples, which perforated the fragments in varying vertical planes. These staples are seen in

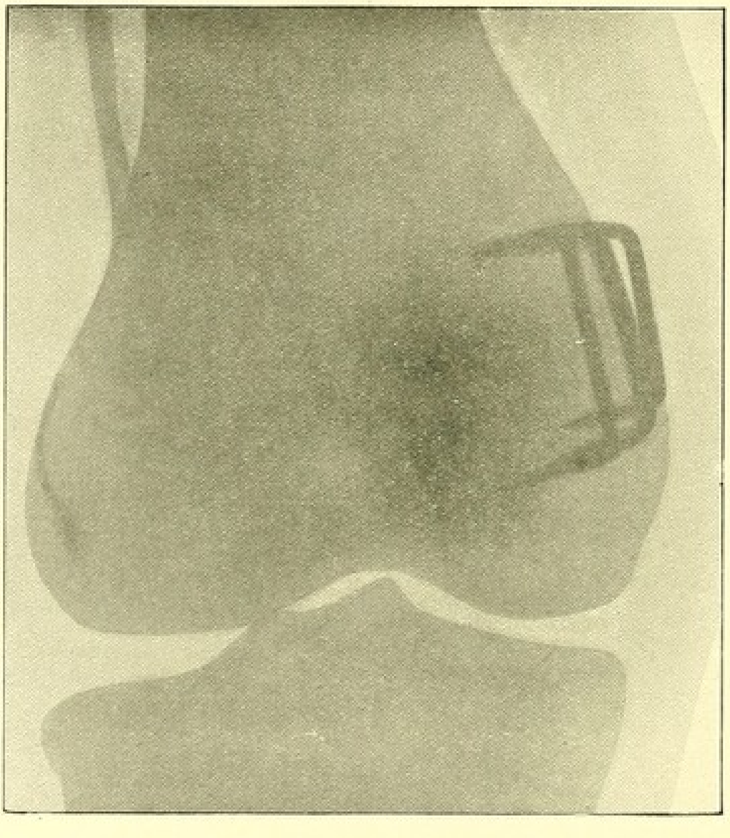


Fig. 78.—Fracture through lower epiphysial line of femur after operation.

Fig. 78. The periosteum displaced originally with the epiphysis and separated from the shaft by blood defines the limit of soft callus. The boy obtained a perfect limb.

In Fig. 74 some results of the non-operative treatment of fractures are illustrated. The hopelessness of any surgery other than operative is indicated by the illustrations, and they cast very natural doubts on the truth of the statements that are frequently made as to the results obtained by treatment of these conditions by means other than operative. A good deal more might be said about the accuracy or inaccuracy of many of these statements, but the skiagrams afford incontrovertible evidence, and speak for themselves.

It is hardly necessary to point out again that the muscles exert no active influence whatever upon the displacement of the fragment, though as swollen and shortened ties they oppose resistance to the replacement of the fragments, and this can only be overcome by operative measures. It seems a pity that anatomists, when writing text-books for students, do not confine themselves to improving on the existing, generally inaccurate, descriptions of the mechanics and functions of the skeleton, instead of attempting, under the title of Surgical Anatomy, to confuse the student by statements and illustrations which are usually extraordinarily incorrect in the face of our knowledge at the present day. Such inaccuracies are liable to impress themselves unduly on young minds at a time when their previous ill-designed method of education has led them to accept undoubtingly and without hesitation whatever they are taught. It is as well to leave surgeons to try to explain these matters as intelligently and correctly as they can in surgical text-books. By the time the student commences the study of surgery he may possibly have to some extent shaken himself free from that mental lethargy which results from an habitual excessive tax on the memory, the curse of a schoolboy's education, and having acquired a more critical and scientific habit of mind, have learnt to think a little for himself.

Fractures of the Upper Extremity.

In the upper extremity the mechanics are such that the bones are rarely exposed to excessive torsion, and spiral fractures are very uncommon. The transverse and oblique variety are those usually met with.

Fractures about the upper end of the humerus are not uncommon in adult life. It is sometimes impossible to treat them satisfactorily by means other than operative.

Fig. 79 illustrates such a fracture, in which the displacement was unusually great. Very fair apposition of the fragments was effected by operation.

The friability of the upper fragment with a certain amount of comminution of both fragments rendered it impossible to obtain accurate restoration. In dealing with fractures under such conditions staples

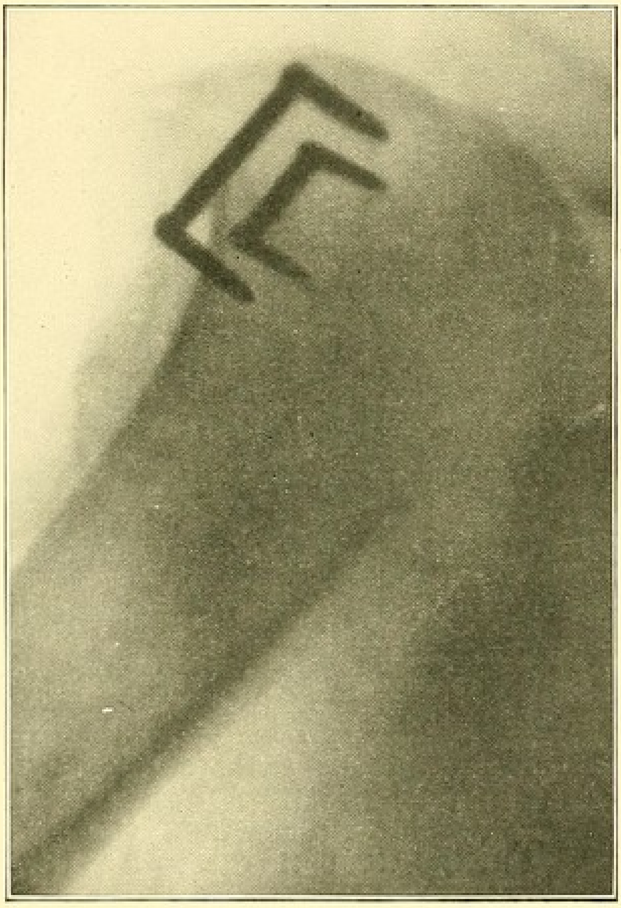


FIG. 79.—Use of staples in fracture of upper end of humerus.

are by far the best means by which a secure and perfect junction can be obtained, since the upper fragment does not offer facilities for carrying a wire, and it is too friable to hold a screw.

There is no class of fractures which I have found more difficult to operate on than those that come under the head of Separations of Epiphyses; and perhaps those which give most trouble are through or in the vicinity of the growing lines of the humerus.

Fortunately, fractures through the upper growing line of the humerus are of rare occurrence compared with those of its lower, which are fairly common. Fractures about epiphysial lines differ entirely from those of the long bones, where one knows that with a moderate amount of patience and skill a perfect result can almost always be obtained by operative measures, providing the comminution is not excessive. It often happens that some fracture of the shaft complicates that through the growing line, or the shaft may be broken in the immediate vicinity of the epiphysial line, rendering it exceedingly difficult, if not impossible, to restore the displaced fragment to or to retain it in its normal position except by operation. Take such a case as that illustrated by Fig. 80, which represents a fracture through the growing line of the upper end of the shaft, with considerable displacement of the epiphysis. The shoulder was much deformed, and the movements permitted in the joint were very limited. The displacement was so extensive that I feared that the limb would be permanently shortened.

Associated with this displacement the radiographs showed some comminution of the adjacent shaft. After forcible but useless manipulation I determined to attempt to obtain by operation a more useful arm.

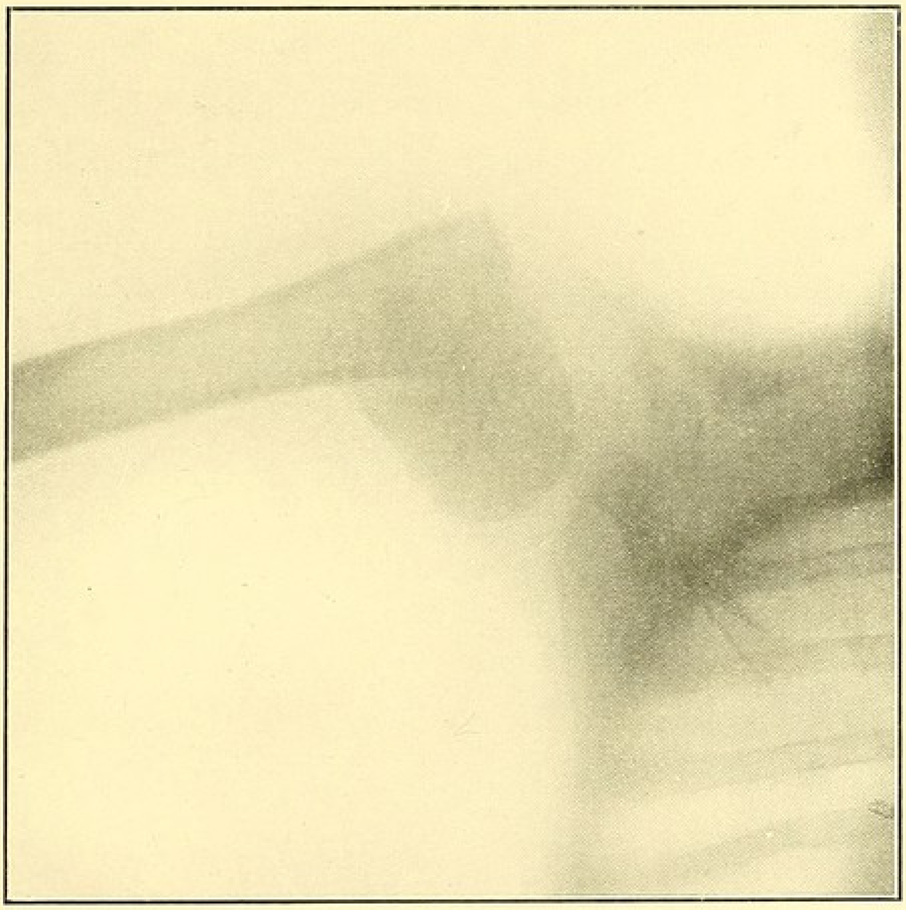


FIG. 80 represents a fracture through the upper epiphysial line of the humerus, with much displacement of the epiphysis. A portion of the shaft has been broken off and is attached to the epiphysis.

The seat of fracture was freely exposed by a vertical skin incision along the anterior part of the outer aspect of the shoulder. The deltoid was divided along the length of the incision, great care being taken that the circumflex nerve sustained no damage. By cutting through the deltoid transversely for some distance on either side just below its origin, and hooking aside the muscular flaps, the displaced epiphysis and the upper end of the shaft were exposed. A piece of bone measuring three quarters of an inch in length by half an inch in breadth lay loose in the wound, and was removed and put to one side. With great difficulty the epiphysis was elevated on to the end of the shaft, and the loose fragment of bone was restored to its place. The chief obstacle to effecting accurate apposition of the fragments was the friability of the crushed end of the shaft and of the epiphysis. The epiphysis showed no tendency to displacement once it had been put in position.

The progress of this case was perfect, the range of movement becoming perfectly normal. One must remember that the mechanical conditions which result from these fractures when the displaced fragments are not reduced have serious disadvantages. They are : deformity, abnormal range of movement, and a relatively short life of the joint. The last is more conspicuous if a laborious occupation is followed.

Force applied to the hand is transmitted upwards through the radius to the radial head of the humerus. A portion of this force is transmitted indirectly from the radius to the ulna along the obliquely placed fibres of the interosseous membrane and the ulna to the trochlear surface of the humerus.

If the arm be flexed, force exerted along the bones of the forearm towards the elbow-joint tends to break the lower end of the humerus and to displace it backwards. If sufficient force be exerted the humerus gives way, and the more nearly the angle of flexion approaches a right angle the less is the amount of force requisite to produce fracture. The lower fragment is displaced backwards behind and below the upper. The line of fracture is more or less transverse. Over-extension of the elbow-joint may produce a transverse fracture and displacement of the lower end of the humerus. Figs. 36 to 40 illustrate this form of injury.

If, however, in addition to the force exerted along the long bones of the forearm, force is exerted laterally also, the lower fragment of the humerus is displaced to one side as well as backwards, as in Fig. 81, producing a condition which may be very difficult to treat even by operation.

In this case the very considerable outward displacement associated with the backward displacement which rendered the mechanics of the elbow-joint hopeless, and a lapse of about sixteen days since the receipt of the injury, combined to increase the difficulties to be met by operative procedure much more than usual. The fracture was freely exposed, and the fragment was replaced in a position which was nearly perfect. It was then fixed in this relationship by a wire which passed through it and the inner limit of the shaft. The range of movement

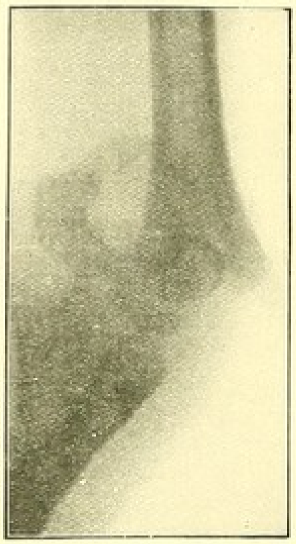


FIG. 81 represents displacement of the lower epiphysis of the humerus backwards and outwards.

in the elbow-joint and the relationship of the bones of the forearm to the humerus seemed excellent. The subsequent progress of the case was satisfactory.

As a rule, when the lower fragment is displaced backwards a good working result with but a slight amount of deformity is obtained, if the arm be put up at once in a position of extreme flexion. I mention this as operative interference is often very difficult and sometimes unsatisfactory in young children, because of the cartilaginous condition of the fragment, which renders it very difficult to secure it in position without leaving a foreign body projecting into the joint, and giving trouble later. It is the outward rather than the backward displacement that renders replacement difficult.

The sooner the condition is recognised and an attempt is made to restore the fragments to position, the better is the result. In fractures of the lower end of the humerus by direct force the bone may be comminuted, as in Fig. 82.

Fig. 82 represents a compound fracture of the lower end of the humerus, produced by a fall from a horse. The skin and soft parts over the fracture were lacerated and fouled, and the fragments of bone projected outwards. The patient came to me some days after the injury. The fracture was freely exposed. The comminuted fragments were much crushed and forced apart from one another by the violence of the injury, and great difficulty was experienced in bringing their surfaces into any sort of accurate apposition. The result is shown in Fig. 83. The range of flexion and extension was not complete, but the angle through which the forearm could be moved upon the humerus was quite sufficient to allow of the patient joining his regiment in South Africa.

Force applied to the region of the elbow may produce various injuries, some of which are treated with difficulty.

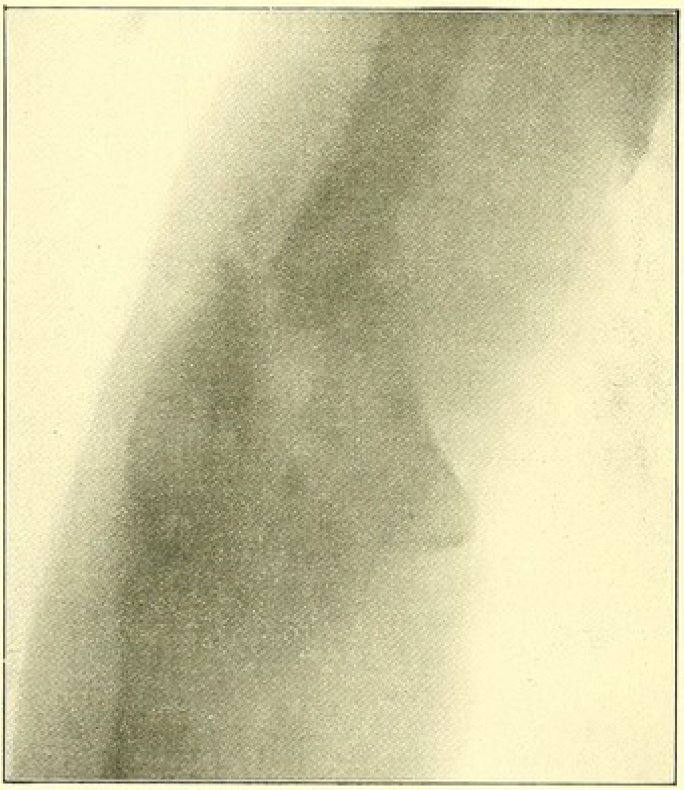


FIG. 82.—Comminuted fracture of lower end of humerus.

A gentleman was thrown from his horse, which trod on the outer aspect of the right elbow. Fortunately, the ground was very soft, so that the skin and subjacent tissues escaped laceration. The radiograph (Fig. 84) showed that a portion of the outer and anterior segment of the head of the radius had been broken off and displaced forwards. If the fragment had been left in this position, he would not have been able to flex or extend the arm beyond a very limited extent, and there might have been

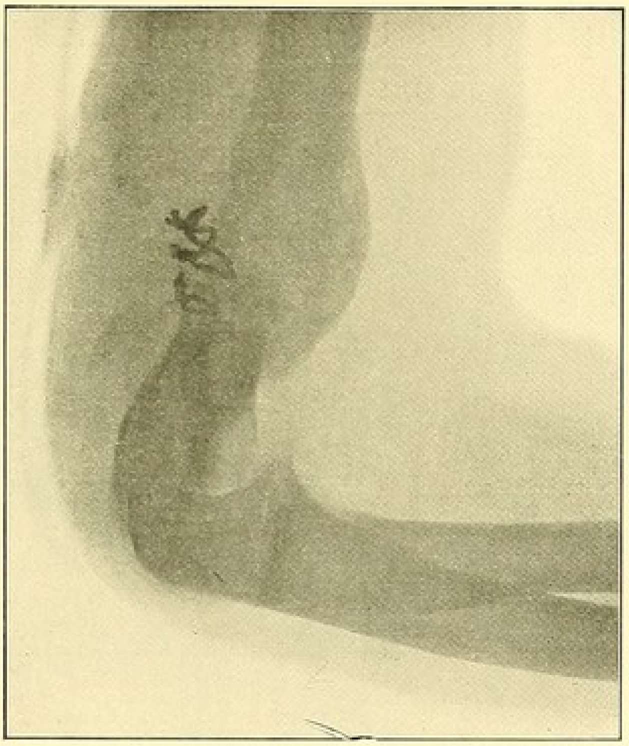


Fig. 83 represents the comminuted fracture of the humerus illustrated in Fig. 82, after operation.

no possibility of his regaining movements of pronation and supination. Besides this, he was anxious to have a thoroughly useful arm. I cut down on the radio-humeral joint and divided the orbicular ligament vertically, separating its segments widely. The loose fragment was then fitted accurately into the gap left in the head of the radius, and was fixed there by means of fine silver wire. The ends of the fixed ligament were sutured and the wound closed. He is now able to play cricket and shoot as well as before the accident.

A gentleman was thrown heavily off his bicycle. The radiograph (Fig. 85) showed that he had sus-

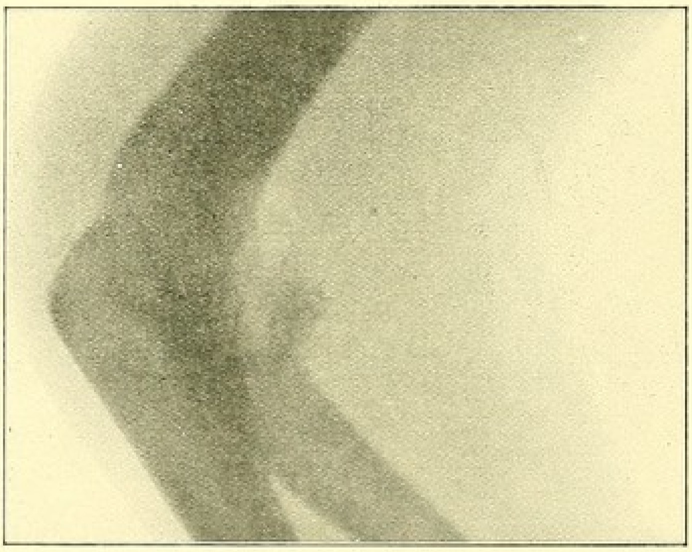


Fig. 84.—Fracture of head of radius.

tained a fracture of the head of the radius, the anterior half of which had been broken off vertically from the remainder of the head and horizontally from the upper limit of the neck. It had been displaced forwards in such a position as to render the arm quite useless unless some operative measure was resorted to.

Accordingly the seat of fracture was freely exposed, and an endeavour was made to fit the fragment accurately in position. I found I could not do this satisfactorily, and decided to remove the remainder of the head of the bone. This was done, and the wound closed. Recovery of movement was very much more slow and certainly more painful than in the last case. The result, after about two years, is that pronation and supination are almost

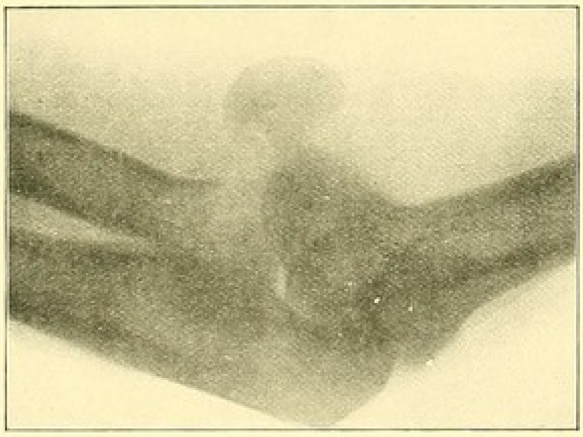


FIG. 85.—Fracture through neck of radius.

perfect and powerful. Extension is nearly complete, but flexion is limited to 90°. He plays golf, etc., with ease, and is quite satisfied with the articulation.

As the result is not so good as that obtained by restoring the head of the radius to its normal form, unless there is some obstacle I prefer if possible to wire on or otherwise secure the fragment.

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 a service. 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. Figs. 86 and 87 illustrate a case of fracture of the radius and ulna by direct violence, in which the displacement of fragments was very considerable. I was able to disengage the fragments and wire them together. An interval of over three weeks had elapsed since the receipt of the injury, and during this time changes had taken place in the

FIG. 86.

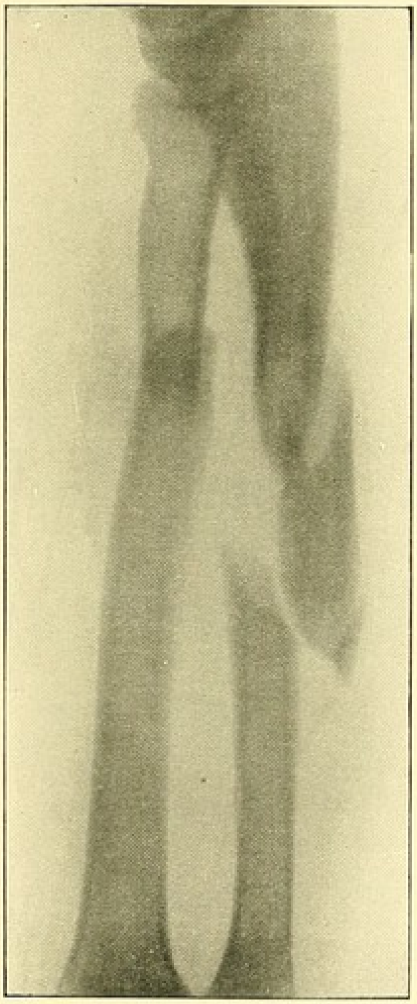


FIG. 87.

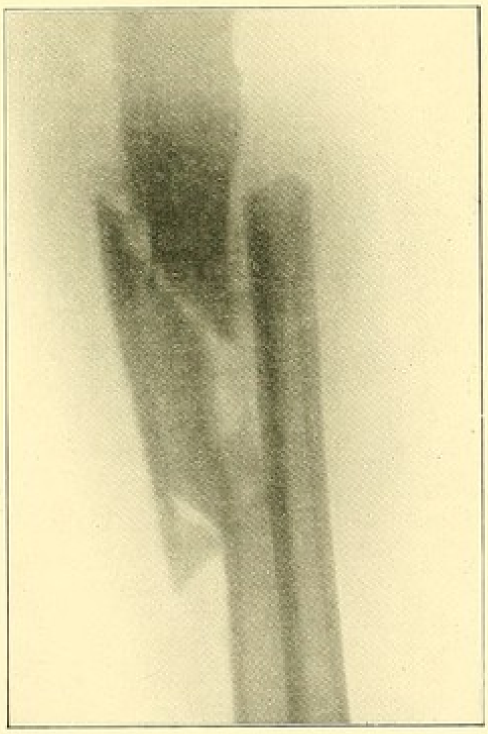


FIG. 86 shows fractures of radius and ulna in antero-posterior plane.
FIG. 87 shows the same in transverse plane.

soft parts that rendered the complete restoration of the bones to their original form and relationship impossible. Fig. 88 illustrates the condition some months after operation, when the normal functions were restored almost perfectly.

Fig. 89 shows a fracture which is by no means

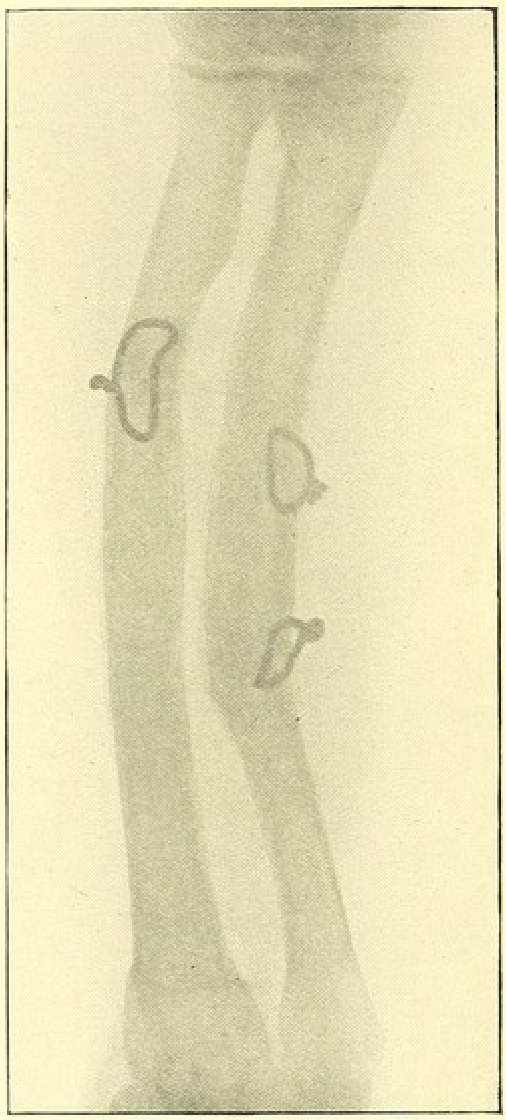


FIG. 88 shows condition after operation.

uncommon, though not often recognised. An officer was thrown off his horse, and dislocated both bones of the forearm 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.

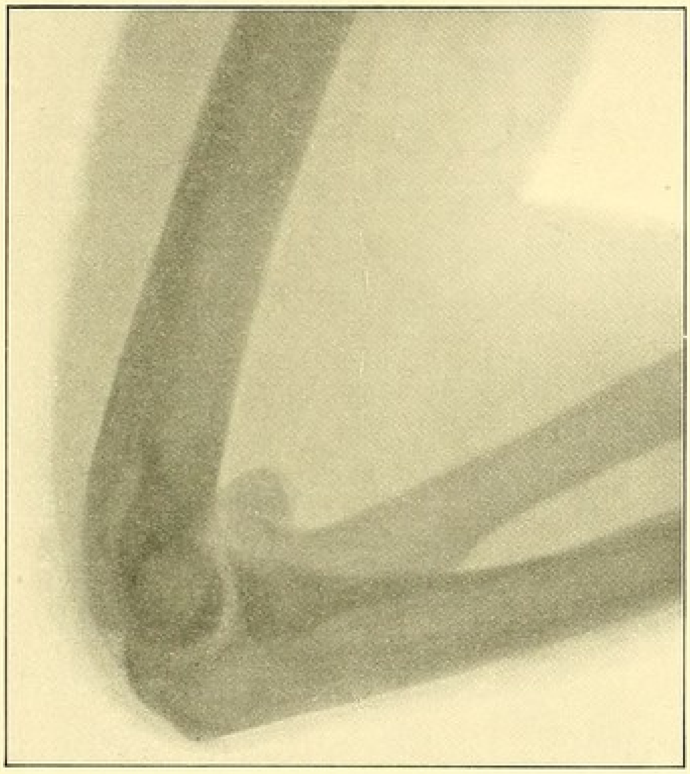


Fig. 89.—Old fracture of coronoid process.

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.

Operation on 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 in 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 incapacitated 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 a very 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 as rendered it 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 very bloody and difficult, and may be fraught with damage 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 in its axis through a sufficient angle, and uniting the fragments by staples, while if flexion be very limited, its range can be increased by cutting away the front of the stump of the neck of this 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 certain want of perception of the mechanics of the skeleton.

The second group of cases, namely those 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 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 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 employed by both. The probability is that earlier observers were less careful in the examination 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 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 which have come under my care.

Fig. 90 represents the result of an operation

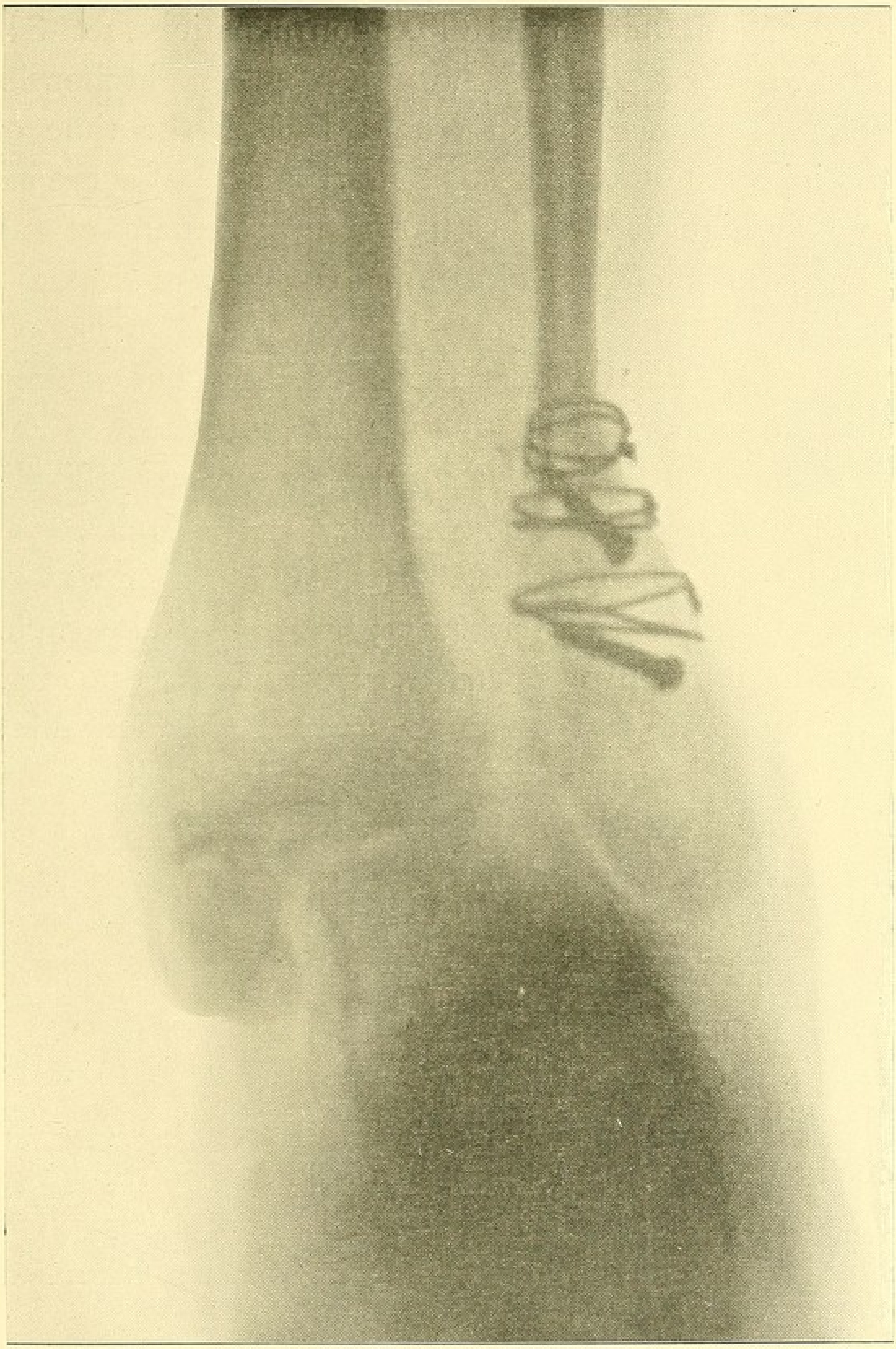


FIG. 90.—Case of malunited Pott's fracture treated by screws and wire.

performed in January, 1899, upon a patient, æt. 34, who was the matron of a hospital. She, eight months before, 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 levering 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

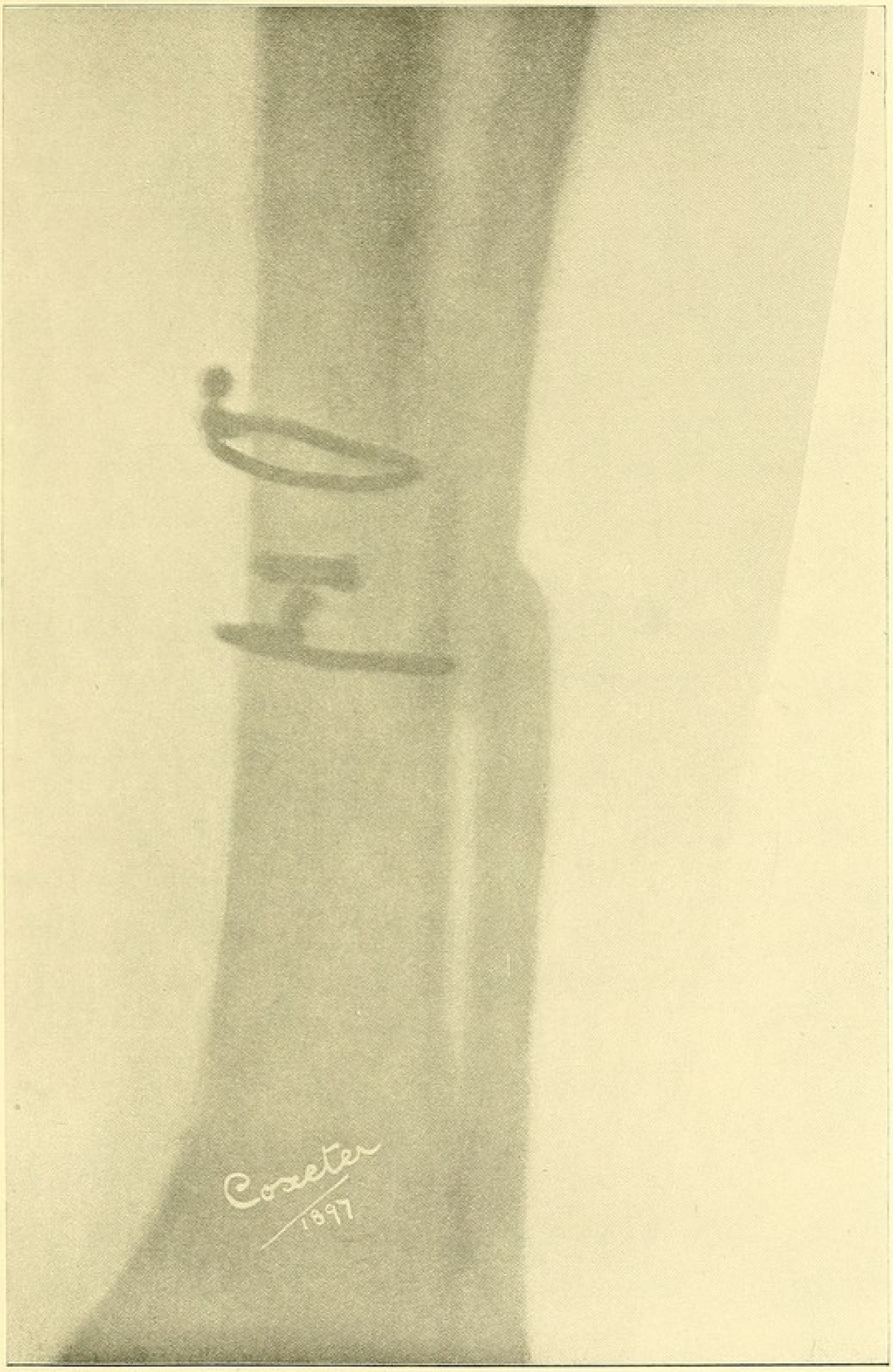


FIG. 91.—Malunited fracture of tibia and fibula treated by screw and wire.

relationship of the bony framework of the ankle-joint consequent on the displacement of the fragments of the fibula.

Fig. 91 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. Months and 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 at a mechanical disadvantage her weight, which was considerable, and which had increased in the long period during which she was unable to move about. As the fibular fractures were at a considerable distance from the ankle-joint, there seemed but little to be gained in 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

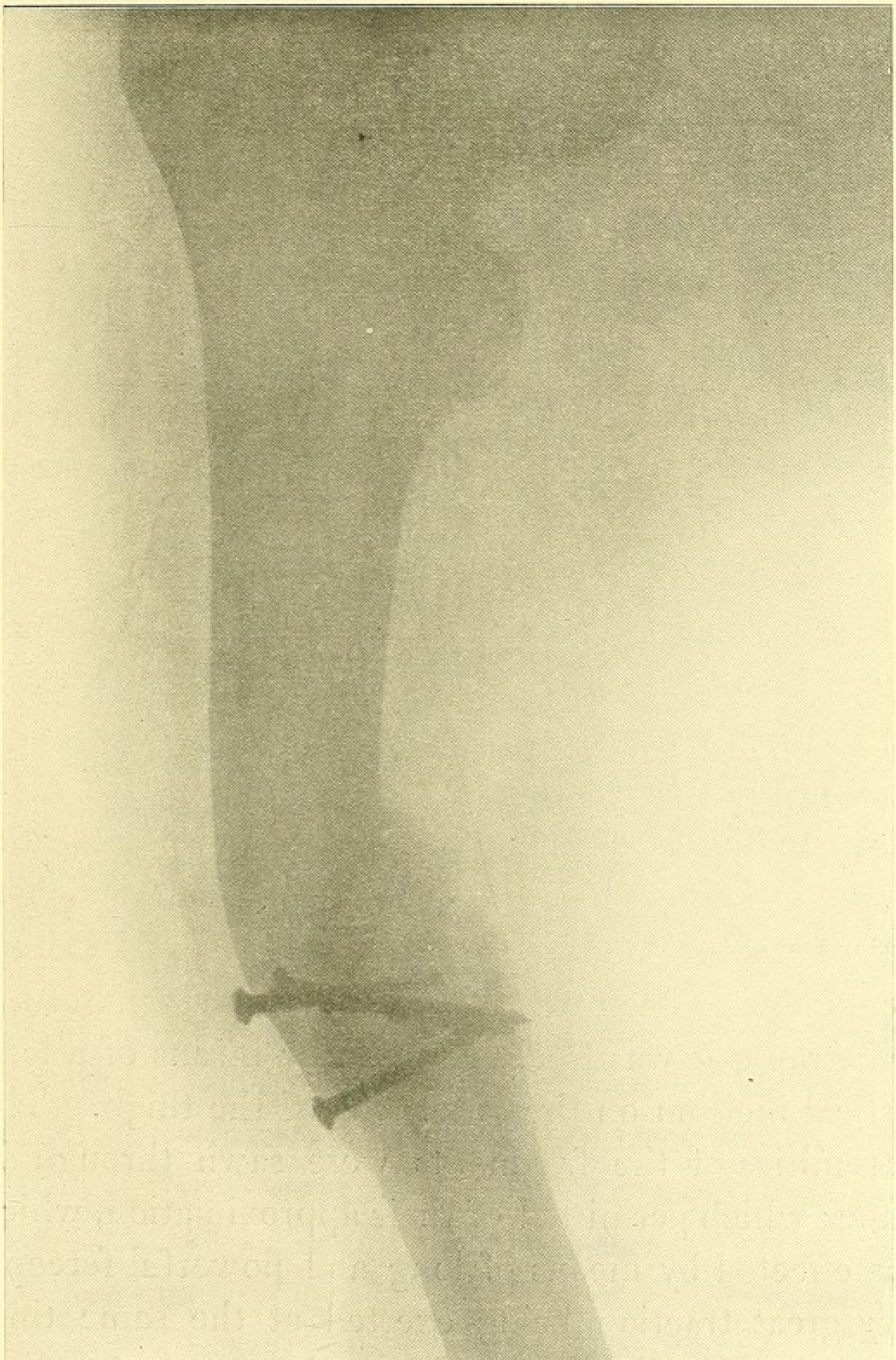


Fig. 92.—Malunited fracture of femur treated by screws.

amount of discomfort from the shortening and from the slight displacement of the fibular fragments.

Fig. 92 represents the femur of a governess, æt. 41, on whom I operated on 20th April, 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 during the whole of this time, she was quite unable to walk, because of great insecurity and of the pain she experienced in her hip- and knee-joints, as well as in 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

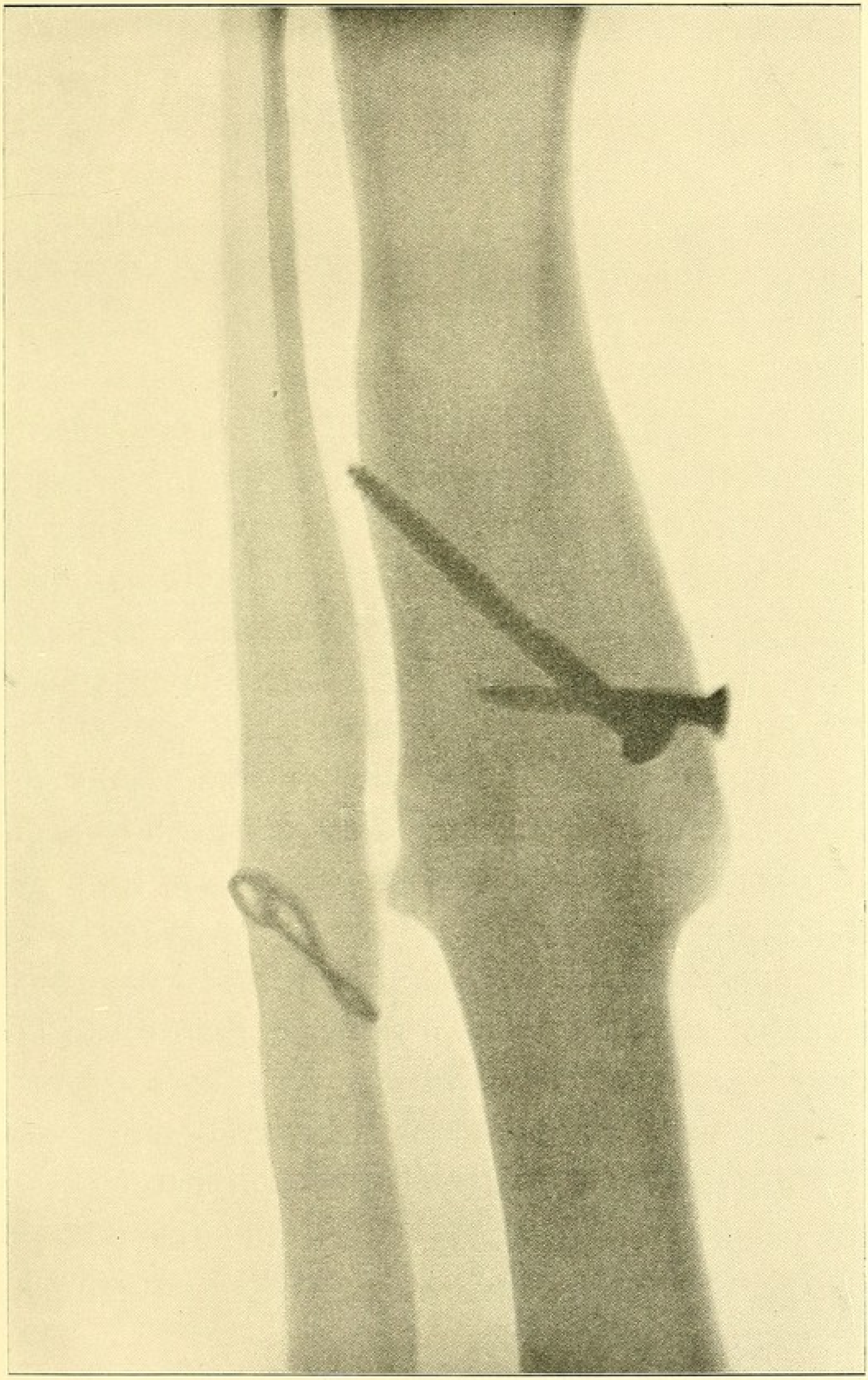


Fig. 93.—Malunited fracture of tibia and fibula treated by screws and wire.

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.

Fig. 93 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. He had every advantage that science and skill could offer; indeed, the surgeon under whose care he was placed is 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 an 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.

As there is nothing very novel in my methods of treating ununited fractures other than the use of the screw, I will confine myself to describing but one of the many operations I have performed for this condition. I would point out that success can

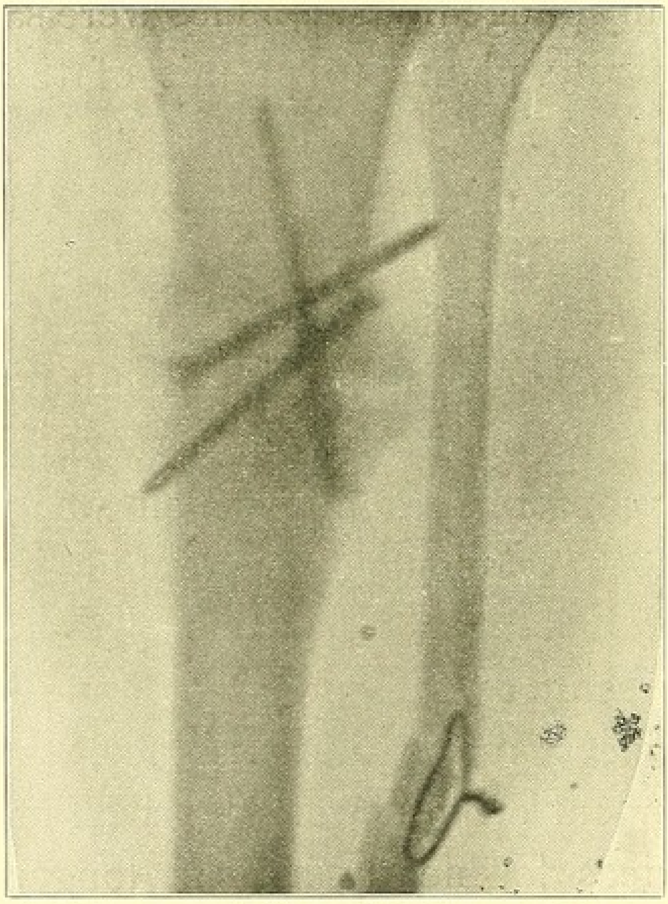


FIG. 94.—Ununited fracture of tibia and fibula treated by screws and wire.

only be insured by effecting firm and accurate apposition of fragments, and this can be brought about more perfectly by a screw than by any other mechanism.

An excellent illustration of the result of operative procedure in an ununited fracture of the tibia is shown in Fig. 94. The patient had previously undergone an unsuccessful operation for the relief of the mechanical disability resulting from the non-union. The man had broken his leg more than a year before. 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 the patient 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 immobility 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 is 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 being able to bear his weight securely on the damaged leg.

The Introduction of Bone Grafts.

In cases in which, through injury, infection, or congenital defect, part of a bone had been lost I expected and hoped to obtain a useful result by the implantation of a bone of one of the smaller animals into the interval, 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. 95) 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.

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. 96 represents the condition of the parts

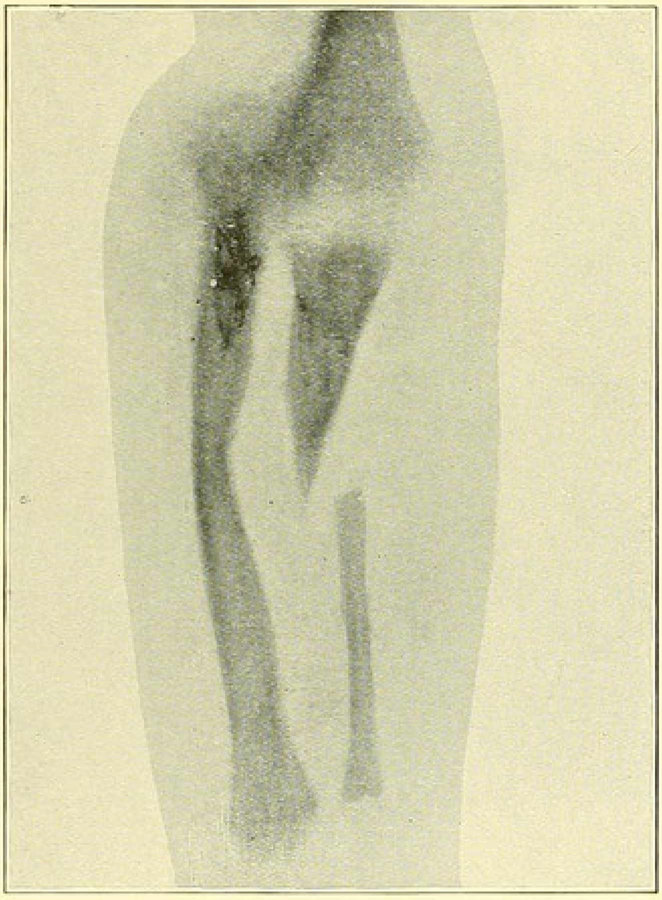


Fig. 95.—Before operation.

several 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.

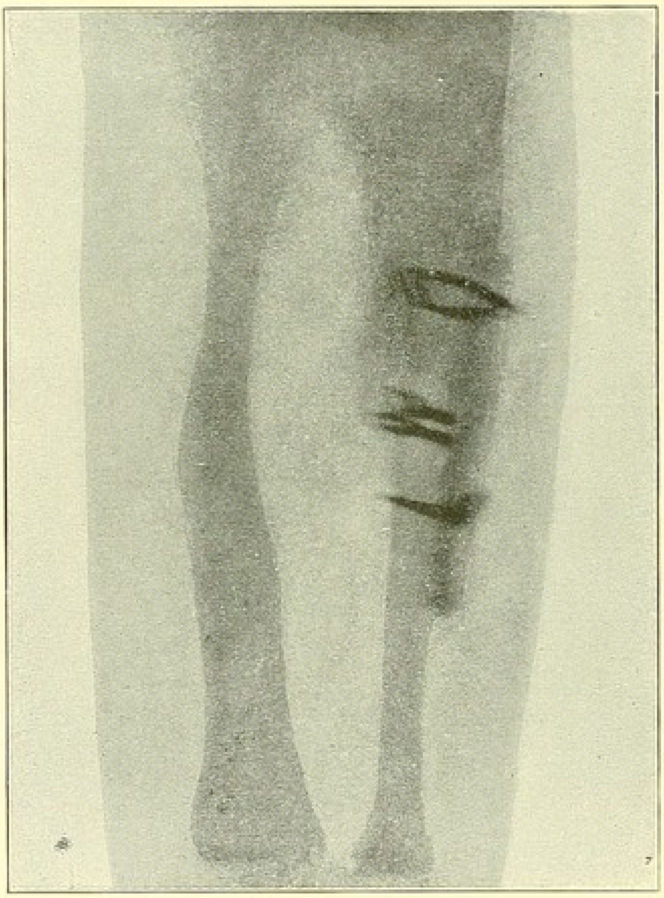


Fig. 96.—After operation.

It is easy to see, therefore, that in the event of considerable comminution of such a bone as the ulna, radius, 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. 97 represents the radiograph of a case very

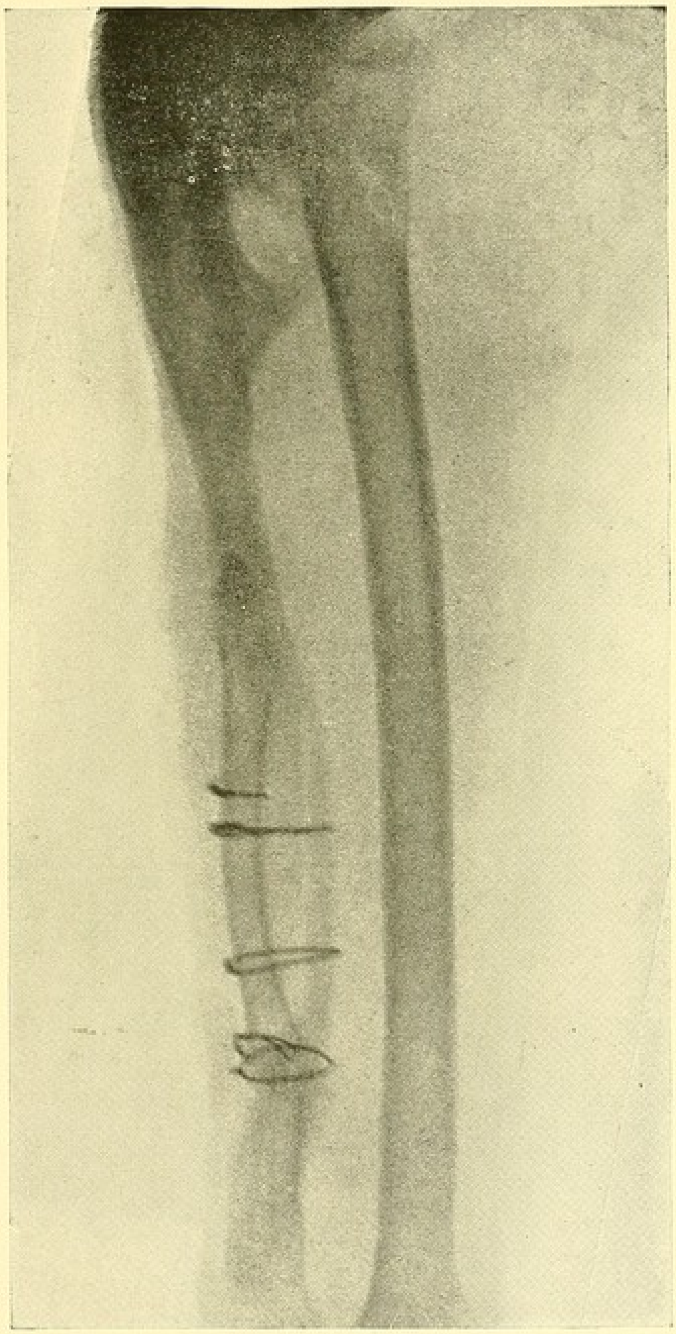


Fig. 97.

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 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.

I would impress on you the necessity of fixing such bones sufficiently firmly to prevent any movement in order to insure the graft living.

Methods of Procedure.

The operative treatment of simple fractures is comparatively easy in the majority of cases, and if due care be taken and reasonable skill be exercised the risk is practically *nil*.

In a certain small proportion of cases the bone may be too friable or too thin or too much broken up, and the surgeon may therefore be unable to restore it completely to its original form. Even in these circumstances he can almost always obtain a much better result by operating than by any other form of treatment

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.

Many complaints have been made by surgeons who have failed to obtain good results by operation. For example, some have said their screws would not hold and others that they could not obtain union. These failures are due to the fact that the very moderate cleanliness necessary to obtain a good result in ordinary operations is quite insufficient to meet that required when a large piece of metal, whether steel or silver, is left buried in the wound.

If the surgeon has not succeeded in such a simple operation as wiring fractures of the patella without killing or permanently disabling many of his patients, he had better bring himself to believe that the results of the generally accepted methods of treatment are excellent, and that any statements to the contrary are exaggerated or imaginary, and leave operations on recent fractures alone, since they may test the methods and skill of the operator to the utmost.

In performing these operations, not only must you not touch the interior of the wound with your hands nor permit the patient's skin to do so either, but you must never let any portion of an instrument which has been in contact with your skin or with that of the patient touch the raw surface. All swabs must be held in forceps and applied to the wound in that manner. They should not be handled in any way previous to being used.

After an instrument has been used for a length of time, or forcibly, it should be re-boiled or placed in a germicidal solution.

I have occasionally seen beginners employ the handle of a knife or dissecting forceps to separate adherent parts, or to displace some structure, instead of using the particular instrument made for that purpose. I need not remind you that this must not be done on any pretext whatever.

It is probably unnecessary to say that no germicidal or other liquid should be introduced into the wound.

The details of the operation are as follow :

Get the skin thoroughly clean. This may sometimes take several days, as the thick, indurated epidermis of the foot and knee is often difficult to remove. I find large moist compresses with careful scrapings most effective in enabling one to get rid of suspicious material. When this has been properly done a germicide should be applied to render the skin as clean as possible.

Choose a situation for your incision which involves a minimum chance of damage to important structures and a maximum advantage from the point of view of accessibility. Do not hesitate to make the incision of a length sufficient to enable you to deal effectually with the fragments. There is no greater mistake than to exaggerate the difficulties of the operation by employing an incision which is not sufficientlv long to permit of easy access to and ready manipulation of the fragments. Its length in no way increases the risk the patient runs, but usually adds to his safety, since it enables the surgeon to deal with the fragments more readily.

Fig. 98.

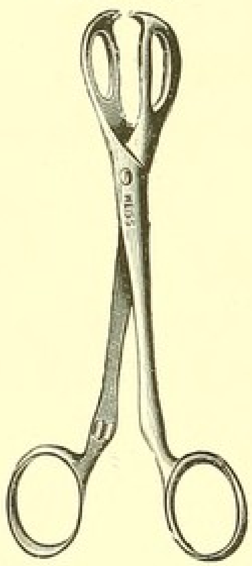


Fig. 99.

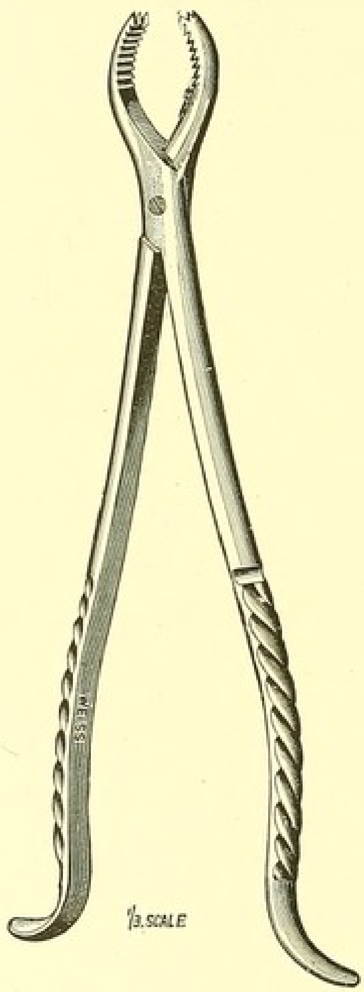
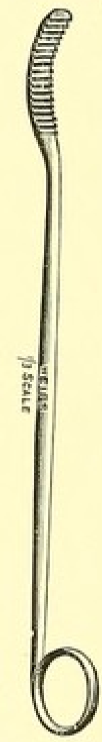


Fig. 100.



Having made the incision, exclude the skin of the patient from contact with the wound. This can be done effectually by attaching sterile cloths to the cutaneous margins of the incisions by forceps such as those illustrated in Fig. 98. These are made in several sizes.

The fragments are exposed and examined, and when all clot and material intervening between them have been removed they are brought into accurate apposition. To do this much traction may be necessary, combined with the leverage action of elevators and the approximating influence of powerful long-handled forceps. The long forceps I employ are very powerful and are made with a limited grasp to facilitate their use. The forceps are illustrated in Fig. 99, and a useful form of elevator and retractor in Fig. 100.

If there be any bleeding it is effectually dealt with by strong compression forceps long enough to allow that portion of the handles which has come into contact with the fingers to protrude beyond the area of the wound. Their grip is sufficiently firm to occlude the vessel if they are kept on for a short time, and so the necessity for a ligature is obviated. Fig. 101 represents this instrument. The head alone is drawn full size, and the handles are of various lengths.

Having obtained accurate apposition, screws, silver wire or staples are employed to retain the fragments in apposition. In some conditions one of these instruments is more serviceable than another, while in others they may all be used advantageously to obtain a perfectly firm, secure junction.

Generally speaking, the screw is by far the most efficient and most powerful means by which the

Fig. 101.

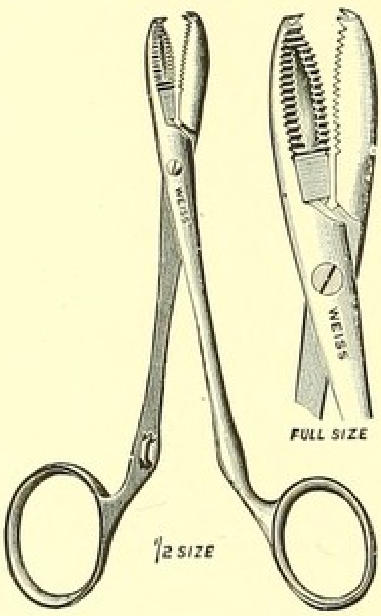
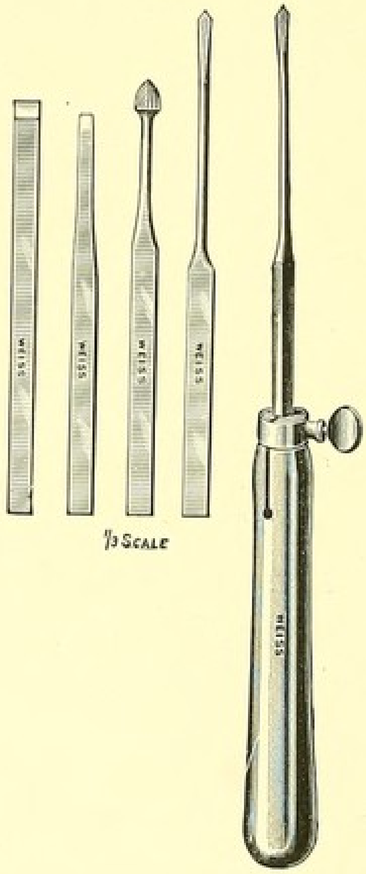


Fig. 102.



fragments can be retained immovably on one another. Remember in gauging the size of the drills you intend to employ in drilling the hole for any particular screw that the calibre of the barrel of the screw is much larger than that of the thread, and that an aperture in dense bone which readily admits the thread may be much too small for the barrel, and if the screw is driven into it the bone may be hopelessly comminuted.

The drills and screwdrivers should be of sufficient length to avoid any risk of the fingers touching the wound. Fig. 102 represents the handle and bits which I find most serviceable.

If silver wire be employed, it should be pure, and

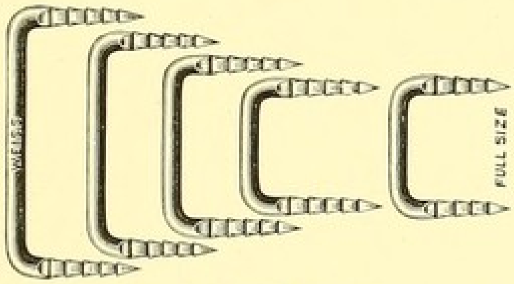


Fig. 103.—Staples.

before use it should be raised to a red heat in a flame and cooled slowly, by which its flexibility is increased very greatly.

The form of staple I employ resembles that ingeniously devised by Dr. A. Jacoel ("Une Agrafe pour Sutures Osseuses," 'La Presse Medicale,' December 25th, 1901), and slightly modified later by Dr. Dujarier. Fig. 103 shows the sizes most generally useful. The portions of the staple which penetrate the bone are serrated transversely to prevent their working out.

Too much care cannot be taken to bring the edges of the skin together with perfect accuracy, and in performing this part of the operation any infection of the wound by the dissecting forceps must be carefully avoided.

If much oozing is expected, drainage may be employed for a day or two with advantage.

Some form of splint, etc., is usually required after the operation, but occasionally, as in the case of fracture of the femur illustrated in Fig. 71, where the limb was ankylosed at the hip-joint in a position of considerable flexion and adduction, it may be impossible to employ any support. In such circumstances the surgeon should render the junction as secure as possible to meet any possible eventuality.

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