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ATLAS AND EPITOME
OF TRAUMATIC
Fractures and Dislocations

BY

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AUTHORIZED TRANSLATION FROM THE GERMAN

EDITED BY

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Fifth Edition, Revised and Enlarged

With 216 Colored Illustrations on 64 Lithographic Plates, and 190 Figures in the Text

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EDITORIAL NOTE

An American edition of this "Atlas of Fractures and Dislocations," translated from the fifth German edition, is needed and will be welcomed by both students and practitioners.

Fractures and dislocations cannot be properly taught nor understood without illustrations showing the visible external deformity, the X-ray shadow, the anatomic preparation, and the method of dressing. These are as necessary here as with anatomy.

The book of Professor Helferich, better than any yet published, answers the requirements for illustrations. We have much to thank the author for. Such a splendid collection of illustrations is possible only in a very large clinic, and represents time, labor, and great care. The work has been reviewed with pleasure and profit.

Jos. C. Bloodgood.

Baltimore, *June, 1902.*

PREFACE TO THE FIFTH EDITION

THE present edition has been enriched by the addition of nine skiagraphs and twenty-one text figures. The text of the epitome has been enlarged and corrected. The original intention of retaining the character of an epitome, and describing important matters more fully at the expense of questions of great rarity, has been adhered to. Accordingly, I refrained from inserting, from the wealth of my skiagraphs, reproductions of rare conditions. On the other hand, the reader will find many new Röntgen-ray pictures illustrating the commoner fractures. To assist in the understanding of the Röntgen-ray plates,—and I have no doubt many think this a very difficult matter,—I have taken skiagraphs of normal joints and added an explanatory outline sketch carefully prepared by Dr. Werner. It is to be regretted that we do not as yet possess any method of reproduction which would enable us to present pictures approaching in excellence the Röntgen-ray plates. Many of the Röntgen-ray pictures were reproduced directly from original plates of larger size (as, for instance, the nine plates representing normal structures, Plate 6, and text-figures 97, 105, 106, 156, 157, and 158). Others were reproduced from drawings by Dr. Werner, copied from original plates and photographs. These are Plate 7, and the text-figures 2, 3, 66, 76, 80, 82, 87, 90, and others.

I trust the book will be found useful in the study of fractures. I earnestly request the reader not to neglect either the text or the explanations of the plates, and to read with the corresponding parts of the skeleton in his hand. Both in the general and in the special portion of the book I have endeavored to present as complete a view of each case as possible, and to equip the physician for the manifold appearances that he will meet with in practice.

DR. HELFERICH.

EXTRACT FROM THE PREFACE TO THE FIRST EDITION

THIS "Atlas and Epitome" is intended to facilitate the student's introduction to the important department of fractures and dislocations, and to serve as a ready reference-book for the use of physicians in general practice. I have endeavored to make the book one of practical utility, and at the same time to elucidate some of the more important questions, especially those connected with the anatomy of fractures.

The first suggestion for the book came through the publisher, and I was glad to agree to his proposition. I welcomed the opportunity to use the specimens and drawings which I had collected in the course of years, and I was glad also of the chance to contribute something to the general diffusion of useful knowledge in a department of medicine in which much harm can be done, and which has of recent years acquired great importance for the entire body of physicians.

It is distinctly emphasized that this book is in no sense intended as a substitute for clinical studies or special courses, and can only serve to complete and illustrate the demonstrations and explanations of the clinical teacher.

Part of the specimens were artificially produced and prepared. It has been my custom for some years, in connection with my course of operative surgery, to produce the more important injuries on the cadaver. Many of the plates and figures represent specimens which I had occasion to study when I acted as assistant to Herr Geheimrat Thiersch in the Leipziger Klinik, and later in Munich and at this place; others belong to the pathologic anatomic collections in Munich and Greifswald, and were kindly placed at my disposal by Professor Bollinger during his incumbency, and more recently by my colleague, Professor Grawitz.

The present epitome arose out of my desire to perfect the explanations accompanying the plates, which did not seem to me quite sufficient. The various divisions of the Atlas are immediately followed by corresponding portions of the epitome. Injuries of common occurrence and practical importance are described in detail, while rare ones are described with a few words.

DR. HELFERICH.

CONTENTS

DESCRIPTION OF PLATES

FRACTURES AND DISLOCATIONS

I. GENERAL CONSIDERATIONS

FRACTURES

FRACTURES may be divided into *traumatic fractures*, or those produced by external violence, and *spontaneous fractures*, or those in which the degree of external force that produced them would not be sufficient to cause a fracture in a healthy bone.

Spontaneous fractures are attributable to a brittle condition of the bones, due, as a rule, to neoplasms, such as sarcoma, metastatic carcinomata, or echinococcus cysts; to inflammatory disease of the bones, as osteomyelitis with insufficient osteosclerosis (involucra), bone abscess, tubercular caries, syphilis [gumma], rachitis [rare], or osteomalacia; to nutritive disturbances of the bone in diseases of the spinal cord, such as tabes and syringomyelia; or to grave disturbances of metabolism, such as osteopsathyrosis (fragility of bone) in gout. The discussion of this class of fractures will not find a place in this work, which deals exclusively with traumatic fractures occurring in healthy bones.

[Attention should be called here to the fact that not infrequently a fracture, usually associated with but slight trauma, may be the first sign of a medullary sarcoma. For this reason one should be very suspicious, especially in an adult, of a fracture following an unusually slight trauma. The question of diagnosis could probably be settled by an examination with the Röntgen ray. It is also to be borne in mind that a fracture at the site of a medullary sarcoma may unite (Koenig). Personally I have never observed this to take place.

Fractures in healed cases of osteomyelitis are not unusual. In such instances the bone is weakened by the great increase of fibrous tissue, a condition called *ostitis fibrosa* (von Recklinghausen). Instead of a fracture there may be a bending of the bone. With proper treatment we may, however, expect firm union, although it is usually delayed, and for this reason the fracture dressing should be maintained for a longer period.

The relation of contusion of the bone as an etiologic factor in pyogenic and tubercular osteomyelitis and primary sarcoma is a very interesting one. Observation has demonstrated that these diseases very rarely follow a complete fracture, but are frequently associated with contusion of the bone with or without splintering. For this reason if the induration and swelling following a trauma of the bone do not disappear in the usual time, we should be suspicious of the onset of one of these diseases, and institute an early investigation.—Ed.]

Fractures are divided into *compound* [open] and *simple* or *subcutaneous fractures.* A compound fracture is one in which there is a simultaneous injury of the skin and soft parts at the seat of fracture. As a rule, this involves exposure of the seat of fracture to the air and to infection reaching it from without; but even when the injury to the skin and soft parts is slight and does not communicate with the fractured bone, it is still spoken of as a compound fracture. In the treatment of such cases the strictest antisepsis or asepsis is to be observed in accordance with the accepted principles of surgery; this offers the only prospect of a favorable course in compound fractures, which were formerly considered so dangerous. In other respects the treatment does not differ from that of simple fractures, having for its aim the firm union of the fractured bone with the least possible amount of displacement. This is, of course, a more difficult task in compound fractures, and the surgeon is often forced to be content with a more or less imperfect result.

As we shall not return to the subject of compound fractures in this work, a few remarks on the treatment will be in order. If the compound fracture is not so severe as to require primary amputation of the limb, conservative treatment may be instituted. The first and most important indication in that case is to employ every means to render the wound aseptic. To this end the primary dressing should be applied as after an operation (even under full anesthesia if necessary). If the skin has merely been injured by a sharp fragment of bone piercing it from within, the case is much simpler, and a good result will usually be obtained by disinfecting the wound and surrounding skin, replacing the fragments of bone, and applying splints. Later a well-fitting plaster dressing may be substituted, if necessary, under anesthesia. If, however, the skin has been injured by the external force which caused the fracture, with the production of an extensive contused and contaminated wound, all sinuses and pockets must be carefully laid open with the knife and, after thorough cleansing, packed with aseptic gauze; the mechanical treatment of such a fracture, which must be applied at the same time, is often very difficult.

[The term compound or open fracture, I believe, should be strictly confined to one in which the skin wound communicates with the seat of the fracture. Amputation should be the last resort. Every attempt should be made to save the limb. It should be decided at once whether an operation is indicated. In the treatment of compound fracture in which amputation is not indicated one should either do very little, or, if it is considered best to operate, the operation should be most carefully performed, with the most thorough surgical technic. In the first instance we decide against operative interference, because the wound is small, the laceration of the soft parts not extensive; there is no nerve injured, no large hematoma. The fracture can be easily reduced, and there are no comminuted fragments which cannot be replaced, and we judge from the history of the accident and nature of the external wound that the degree of the infection has been slight. Here it is only necessary to disinfect the external wound, irrigating it with a solution of 1 : 1000 bichlorid, or to swab it out with pure carbolic acid (Lister's method).[1] It is probably best not to completely close the external wound of the skin, because if there is much hemorrhage from the fracture the wound will act as a safety-valve, and there will be no distention of the tissues with blood which lowers their resistance to infection. In these cases if there is much discharge of blood, the dressing should be frequently changed, and the external surface of the wound and the skin redisinfected. The blood-clot, however, which will be found filling the external wound at the first dressing, should never be disturbed. These cases of compound fracture should run an almost afebrile course with less elevation of temperature than in a simple fracture, because in the latter the blood has no exit, and there is fever (100° to 102° F.) from the absorption of fibrin ferment, but associated with this fever no leucocytosis. Elevation of temperature and leucocytosis in a compound fracture should be considered an indication to open and disinfect the wound. In the second instance the indications for operative interference in a compound fracture are numerous, the most important being thorough disinfection; the next, better reduction and fixation of the fragments. Either should be considered a sufficient indication. Great laceration of the soft parts, excessive hemorrhagic exudate or a hematoma, nerve or tendon injury, are other indications. When we operate, it should be done with the most careful technic and the best possible surroundings. In the majority of instances a patient with a compound fracture would have a better chance of recovery without operation

[1] See Progressive Medicine for December, 1901, p. 271.

if the operation could not be done in a proper and thorough manner. In the operation, after the thorough disinfection of the skin and external wound, the wound should be enlarged, disinfecting as we proceed. In approaching the bone, the greatest care should be taken not to disturb the periosteal attachments of the fragments. Only those fragments should be removed which have no periosteal attachments. In the majority of instances it is better to approximate the fragments with silver wire, disturbing the periosteum as little as possible. If the approximated bone cannot be covered with periosteum nor healthy skin, it should be covered with a muscle-flap. Every effort should be made to cover the bone at the seat of the fracture. If possible, the skin opening should be closed. The indications for drainage—which is best accomplished by rubber tissue, never a drainage-tube—are excessive hemorrhage from the bone and laceration or contusion of the soft parts which threatens their circulation. If this is excessive, the skin wound should be left wide open. In such instances frequent dressings are indicated to prevent or inhibit secondary infection. It is remarkable what excellent results can be obtained in the most grave cases of compound fracture by early and proper operative interference, proper drainage, and the most careful after-treatment.—ED.]

Varieties of Fracture

According to the degree of separation of the fragments, fractures are divided into *complete* and *incomplete*. The latter class includes *fissures*, traversing the bone without producing any alteration in its outward form; *infractions* ("greenstick" fractures), which occur most commonly in children, particularly in the bow-legs of rachitic children, although occasionally also in the long bones of adults; and *depressed fractures*, which occur chiefly in flat bones.

In a *complete fracture* the line may assume various forms; hence we distinguish *transverse, oblique, longitud-*

PLATE 1.

Bending Fractures (Greenstick Fractures).—Fig. 1 *a* and *b*. —Tibia and fibula of the left lower extremity. From a boy, fourteen years old, who was caught between the cogwheels of a threshing-machine. The outer surface of the two bones is shown; the epiphyseal lines are still visible. The fracture of the fibula appears about 2 inches higher than that of the tibia. Both bones are bent at the seat of fracture, forming on the outer surface a projecting, and on the inner surface a receding, angle. The bending first produced a solution of continuity on the convex surface, the fracture being completed by the formation of the characteristic wedge, which, however, has not completely separated, and is still held in place by a bridge of bone, at the lower border in the case of the tibia, at the upper border in the case of the fibula. (From the author's collection.)

Fig. 2 *a* and *b*.—Tibia and fibula from the skeleton of an adult after a fracture had been produced artificially with the aid of Rizzoli's osteoclast. It is seen at a glance that the fracture was produced by bending the bone. The tibia shows an excellent sample of oblique fracture. (From the author's collection.)

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inal, and *spiral fractures*. If the bone is broken into a number of small fragments, which may or may not be held together by periosteum, we speak of a *comminuted* or *splintered fracture*. There may be *multiple* fracture of the same bone, as fracture through the upper, lower, and intermediate portions; and *simultaneous fractures* of several bones, as, for example, fracture of both bones of the forearm or leg, or of various bones situated at some distance from one another.

It is not without importance to determine whether a fracture is *direct* or *indirect*. These terms are used to indicate the seat of fracture in relation to the point of impact of the breaking force. If the seat of fracture corresponds with that of the injury,—as, for example, fracture of the ulna sustained in warding off a blow ("parrying fracture"),—the fracture is said to be *direct*. But when a child falls on its outstretched hand and sustains a fracture of the clavicle or of the lower end of the humerus,

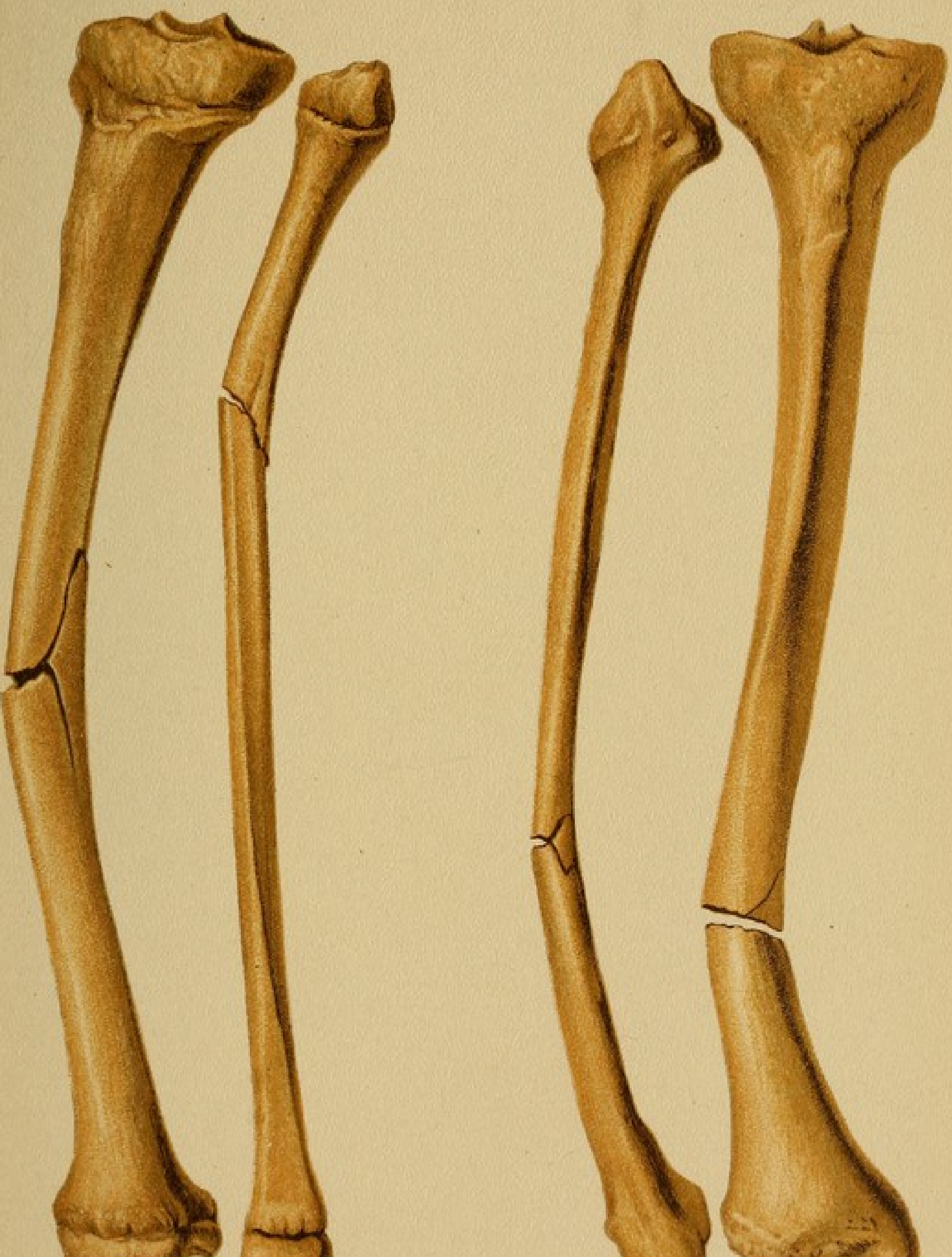


Fig. 1 a Fig. 1 b Fig. 2 a Fig. 2 b

Lith. Anst. F. Reichhold, München.

it is called an *indirect* fracture. Since the effects of the insult, consisting in contusion and subcutaneous hemorrhage, occupy the seat of the fracture itself in direct fractures, the latter are generally considered more serious than indirect fractures.

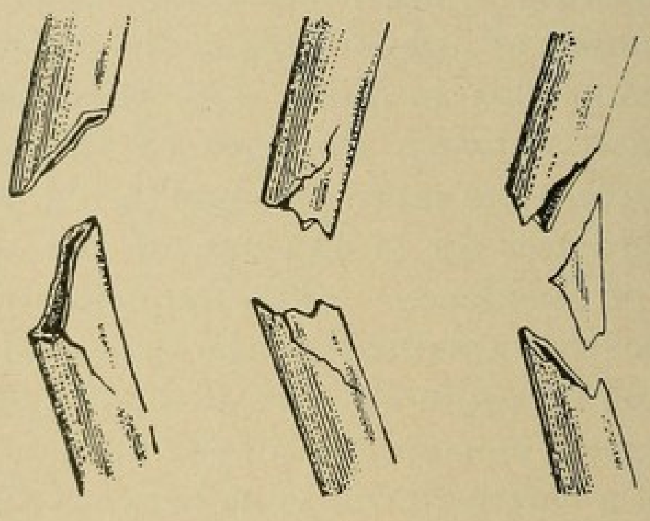
Another important point is the incidence of certain forms of fracture according to age. That the greatest number of fractures occur among adults is easily understood, since this class is most engaged in heavy labor, and accordingly exposed to the dangers and accidents incident thereto. To obtain a correct idea of the significance of statistics it is necessary, however, to remember the relation of the total number of inhabitants to the different periods of life. Keeping this in mind, it is found that fractures are most frequent between the ages of thirty and forty (15.4%); fractures are more common in old persons than in children, the latter up to the age of ten representing the minimum of incidence. The frequency of fractures in old age is partly explained by the increased brittleness of the bones due to senile atrophy of the bony tissue (diminution of organic constituents in the bones). In youth the presence of a cartilaginous joint between diaphysis and epiphysis plays an important rôle in the etiology; instead of actual fracture of the long bones, *epiphyseal separations* are more likely to take place, similar to those which occur spontaneously in inflammatory processes, such as syphilis and, especially, acute osteomyelitis.

The degree of force necessary to produce a fracture varies greatly. As has been said, a comparatively slight force suffices in the case of children (epiphyseal separation) and old persons (senile atrophy). In a healthy adult the resistance of individual bones varies; thus, the following widely differing results were obtained by actual tests:

Female clavicle	126 kg.
Female humerus	600 "
Male radius	334 "
Neck of femur in a man	815 "
Tibia	450–650 "

In rare instances fractures have occurred, without any accident, while the individual was engaged in ordinary work, such as climbing a ladder with a load on his back. These are the so-called occupation or work fractures.[1]

Our knowledge of the *mechanism of fractures* is obtained from a study of specimens that happen to present a fracture and of fractures produced artificially on the cadaver. The results obtained in these two different ways are found to agree. Most forms of fracture can be produced with very little trouble; and a little experience and careful observa-



a *b* *c*

Fig. 1.—Various forms of typical bending or greenstick fractures: *a*, Oblique fracture; *b*, transverse fracture with fissures; *c*, oblique fracture with separation of a wedge-shaped piece.

tion will enable one in most cases to determine, by an examination of the specimen, the mechanism of the fracture—*i. e.*, the way in which it occurred. Such knowledge may be useful in medicolegal cases.

A **bending** (or **greenstick**) **fracture** (Plate 1) is produced by bending the bone beyond the limits of its elasticity. The so-called *relative* or *bending* resistance of the bone is overcome by a force acting from without in a

[1] Golebiewski, "Atlas and Epitome of Diseases Caused by Accidents," W. B. Saunders & Co., 1900.

direction perpendicular to the long axis of the bone. When a stick is bent and finally broken across the knee, the convex side is the first to yield, and precisely the same thing occurs in a long bone that is broken in the

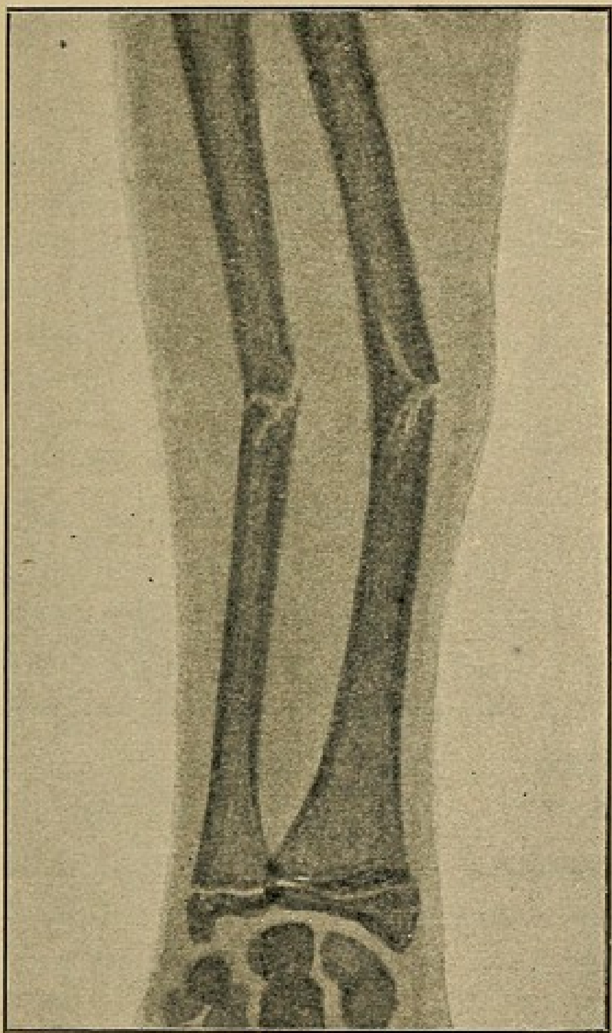


Fig. 2.—Characteristic bending or greenstick fracture of the forearm, especially the radius. Skiagraph. In both bones the fracture is incomplete. The boy had been injured by a machinery belt. In reducing the fracture it was rendered complete, but without any additional displacement. Good recovery.

same way. In actual practice such a fracture may be produced in various ways; as, for example, by an overload applied to the unsupported middle portion of the bone, or by bending the bone while one extremity is fixed. This variety of fracture results when the osteoclast is used

PLATE 2.

Torsion-fractures.—Fig. 1 *a* and *b*.—Torsion fracture of the upper half of the shaft of the femur in a woman eighty years of age. The fracture was produced by rotation of the body while the foot remained fixed. The illustration shows the anterior aspect of the (left) thigh bone with a beautiful spiral line of fracture. Figure 1 *b* shows the two fragments separately (opened like valves, as it were). The spiral form, the acutely oblique fracture, and the longitudinal portion of the line of fracture are readily recognized. (Author's observation.)

Fig. 2 *a* and *b*.—Artificial fracture of the femur by torsion. The illustration shows the spiral line passing upward and to the right. In figure 2 *b* the rhomboidal fragment is shown, turned back like the lid of a box; it was produced by two longitudinal lines of fracture running into the spiral line. (From author's collection.)

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or when one of the weaker bones is broken over the edge of a table. A bending fracture results also when the rigidity of a long bone is overtaxed; the bone at the same time sustains a bending and a compressing force in its longitudinal direction and fracture results at the weakest point, where the bending is greatest, as soon as the limit of perfect elasticity is overstepped. A practical illustration of this mechanism may be observed when, after gunshot-fracture or fracture by torsion of the tibia, the individual attempts to get up and the fibula is snapped in two by the weight of the body (see Plate 65, Fig. 1).

It is important for medicolegal purposes to remember that a greenstick fracture has a very characteristic appearance and is easily recognized in the anatomic specimen. The convex side presents a fissure or crack which is usually converted into a complete fracture by the sudden separation of a wedge of bone. The base of this wedge, which may be partially or completely separated, or only outlined by fissures in the bone, always corresponds to the concave side of the broken bone. It is evident that the bending of the bone may result in a *fissure*, an *infraction* (incomplete fracture), or a *complete fracture*, accompanied

Fig. 1 a

Fig. 1 b

Fig. 2 a

Fig. 2 b

Lith. Anst. F. Reichhold, München.

sometimes by separation of a fragment. Depending on the shape, size, and direction of the wedge of bone, the fracture will be either *transverse* or *oblique.*

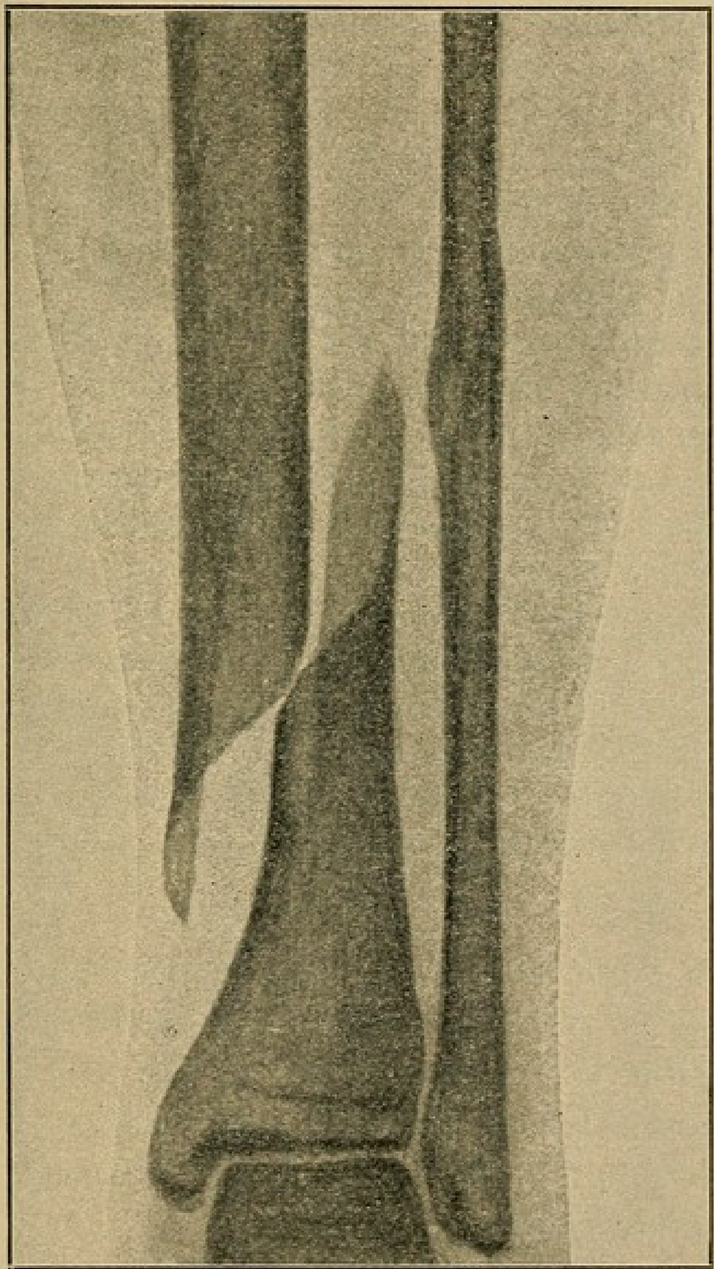

Fig. 3.—Typical torsion-fracture of the tibia. Skiagraph. A laborer twenty-seven years of age fell on the street and sustained a fracture of the leg. The clinical diagnosis of supramalleolar torsion-fracture of the tibia was confirmed by the Röntgen-ray picture. Even under anesthesia it was found impossible to replace the fragments ; the fracture was accordingly laid open and the fragments adjusted and fixed with silver wire. The patient made a perfect recovery.

PLATE 3.

Fractures Produced by Compression, Tearing, and Crushing.—Fig. 1 *a* and *b*.—Impacted fracture of the upper end of the tibia, which is wedged in between the remaining fragments. This is the famous specimen in the collection of the Pathologic Institute at Giessen. Figure 1 *a* presents an anterior view of the bone, figure 1 *b* a longitudinal (coronal) section. One illustration supplements the other, and together they show the effect of force applied at the upper border of the tibia, driving the bone in between the condyles of the femur. The diaphysis of the tibia has been wedged into its epiphyseal fragments, which have spread out in all directions.

Fig. 2.—Fracture by muscular action of the distal extremity of the bones of the forearm. The two styloid processes are broken off, the lines of fracture being serrated. The fracture occurred in a machine-accident and was produced by a sudden pull transmitted through the lateral ligaments. The fracture of the ulnar styloid process is incomplete. That of the radius complete.

Fig. 3.—Comminuted fracture of the bones of the forearm at their distal extremities by a machine-accident. Male, aged fifty, while tending a steam-engine, slipped and caught his arm in the drum. Immediate amputation was performed, as the soft parts were badly contused. There was also a fracture of the humerus. Recovery from the operation with good union of the humeral fracture. (Author's collection.)

Finally, we may distinguish one more variety of fracture by bending or crushing produced by direct lateral pressure against the extremity of a bone in fixation, without actual bending at the seat of fracture; as, for example, fracture of the fibula by the pressure of the astragalus in a typical fracture of the ankle. In this accident the pushing or gliding resistance of the bone is overcome.

Fracture by torsion (Plate 2) is produced by a rotatory force overcoming the rotatory resistance or resistance to torsion of a long bone. Rotation of the bone eventuating in fracture is possible whenever one segment of the bone is fixed while the remaining segments are rotated. Thus, a torsion-fracture may be produced either by rotating the distal portion of the limb while the body remains fixed,

Tab. 3.

Fig. 1 a

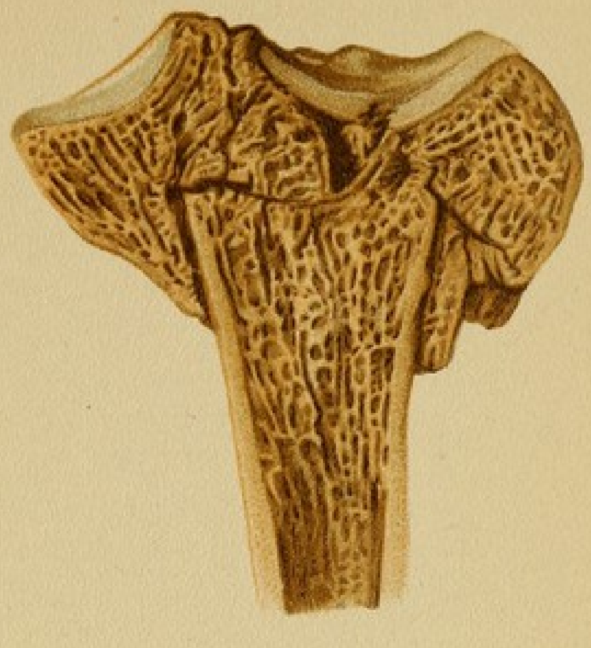

Fig. 1 b

Fig. 2.

Fig. 3.

Lith. Anst. F. Reichhold, München.

or, inversely, by rotating the body while the extremity is fixed. The latter is the more frequent accident; thus fracture of the femur by rotation of the body during a fall, the foot and leg remaining fixed, not infrequently occurs. The former mechanism is imitated when by an artificial torsion a fracture is produced on the cadaver; it must be, however, supplemented by a sharp blow with a hammer on the desired seat of fracture. The line of fracture thus produced is usually distinctly spiral. The spiral line in this so-called fracture by torsion, or **spiral fracture,** is, as a rule, readily recognized. If the bone has been rotated to the right,—that is to say, in the same direction as an ordinary right screw when it is being screwed home,—the resulting line of fracture will represent a spiral wound to the right. As, in addition to the spiral line, a double longitudinal fracture is produced, there is always a partially or completely separated rhomboidal fragment which is characteristic of torsion-fractures. The short sides of this rhomboidal fragment are formed by sections of the spiral line. Thus we have acute-angled oblique fractures or longitudinal fractures, and, occasionally, oblique fractures with longitudinal fissures. Fracture by torsion is by no means a rare occurrence (humerus, femur, tibia). Although it is probably always due to indirect violence, the prognosis is unfavorable because of the jagged fragments, which tend to become displaced and perforate the skin, rendering the fracture compound, and because of the great extravasation of blood.

[The subject of torsion-fractures has recently been thoroughly considered by Zuppinger.[1]—Ed.]

Compression-fractures (Plate 3), or **contusion-fractures,** are produced by external violence causing a sudden compression of the bone. The compressing force is usually transmitted by a contiguous bone of greater density. Compression of a long bone in the direction of its long

[1] Beiträge zur klin. Chirurgie, 1900, vol. XXVII, p. 735, with eight X-ray photographs.

PLATE 4.

Gunshot-fractures.—*Effects of the German army rifle, model 88, with a projectile of 7.9 mm. diameter, propelled by a full charge of powder at actual distances.*

Fig. 1.—Gunshot wound of the shaft of the femur. Distance 600 meters. Wound of entrance on the anterior aspect of the bone, surrounded by radiating lines of fracture forming a number of splinters of various sizes. The splinters have been replaced like the parts of a mosaic, and the continuity of the macerated bone restored by inserting a wooden rod into the medullary cavity. (From author's collection.)

Fig. 2.—Gunshot wound of the shaft of the tibia. Distance 50 meters. The illustration shows the wound of entrance on the anterior surface of the tibia. The splinters have been restored to their original positions so that the characteristic stellate appearance of the fracture with the loss of substance in the center is shown.

Fig. 3 *a* and *b*.—Perforating ("button-hole") gunshot-fracture of the upper end of the humerus. Distance 1500 meters. In the recent state the specimen presented a clean perforation with smooth edges through the soft parts, periosteum, and bone. The projectile, which is shown in figure 3 *b* entered the anterior surface of the arm and, after producing the perforation shown in the illustration, lodged beneath the skin of the posterior surface. The macerated specimen shows a fissured fracture beginning at the point of entrance and running upward and outward through the tuberosities, almost completely encircling the anatomic neck. The wound of exit on the posterior surface of the humerus is somewhat smaller than the wound of entrance, and presents a circular outline. (From author's collection.)

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axis by a sprain (or contusion) results in a characteristic partial fracture—*infraction*—of the spongy tissue in the extremity of the bone, or in impaction of the fragments,—*impacted fracture*,—the narrower and more compact diaphyseal fragment being driven like a wedge into the more voluminous and spongy epiphyseal extremity; or, rarely, it may result in complete shattering of the bone. The following are examples of compression-fractures: Fracture of the upper end of the humerus (Plate 33, Fig. 3); fracture of the neck of the femur by a fall on the trochan-

Tab. 4.

Fig. 1.

Fig. 3 a

Fig. 3 b

Fig. 2.

Lith. Anst. F. Reichhold, München.

ter (Plate 54); fracture with contusion of the calcaneum, resulting from a fall on the feet; fracture of the upper end of the tibia (Plate 63, Fig. 3, *a* and *b*; Plate 3, Fig. 1, *a* and *b*). This class also includes cases in which a small plate of bone becomes separated from the margin of a joint (true "sprain-fracture").

In the production of an impacted fracture the so-called *retroacting resistance* or *resistance to pressure* of the bone must be overcome.

Fracture by muscular action is produced by the sudden pull of muscles or ligaments in forcible movements of joints (distortion), and, rarely, by external violence (machinery belts). Typical examples of this class are found in fracture of the patella, of the olecranon, of the ankle, of the lower radial epiphysis, etc. In this variety the so-called *absolute resistance* or *resistance to traction* of the bone must be overcome.

Comminuted fractures (Plate 3, Fig. 3) are produced in various ways by powerful external violence (machine injuries). The bone may be broken into a number of pieces or completely pulverized.

Gunshot-fracture (Plate 4) is produced by gunshot wound of a bone. A full charge of shot discharged at short range may produce an extensive comminuted fracture such as a rifle-ball inflicts. A gunshot wound by a modern weapon, such as the German army rifle, model 88, discharged at a distance of 800 meters or less usually results in extensive shattering of the shaft of a long bone. This powerful effect was also observed in 1870 in the case of Chassepot rifles when discharged at very short range, and the explanation then given was that the French used explosive bullets. This assumption was later found to be erroneous, nor is the theory of hydrostatic pressure within the bone (marrow) tenable. At the present day the phenomenon is explained by the sudden and violent displacement of the molecules of the bone, the effect of which extends some distance beyond the point of impact.

If the range exceeds 700 or 800 meters, the resultant wound may be a perforation even in the diaphysis of a bone, and the wound tends to heal kindly. In the spongy portions of the bone (epiphysis) perforations are observed at distances of 600 meters and over.

Symptoms of a Recent Fracture

In the examination of a patient suffering from an injury it is advisable to gain a general impression of his condition before examining by manipulation the painful part. The character of the functional disturbance—the way in which a patient supports the injured arm, for instance—often points to the correct diagnosis. A complete examination is particularly important if the patient is unconscious, since he cannot call attention to the injured part and shows no sign of pain; in such a case the entire body must be gone over and every swelling and ecchymosis conscientiously examined.

The characteristic features of a fracture depend on the solution of continuity in the bone. This solution of continuity and its mechanical consequences constitute the most important symptoms of fracture.

1. **Abnormal mobility** is the most important symptom. It is more or less pronounced in most cases of fracture and can usually be demonstrated. It is absent in incomplete fractures—fissured fractures—and in impacted fractures. In the latter the dense narrow fragment of the shaft is driven into the softer, spongy portion of the epiphysis and becomes mechanically fixed, so that the two fragments practically form a *single* bone. While this variety is most frequent in fracture of the neck of the femur, it also occurs in fractures of the articular extremities of other long bones. In some cases, such as fracture of short bones like the ribs, etc., it is often impossible to demonstrate abnormal mobility.

2. **Crepitus** or crepitation is the grating sensation pro-

&K

duced by rubbing together the broken surfaces, and may be elicited when there is displacement of the fragments. It is usually detected by the sense of touch, but may also be heard. Abnormal mobility is a necessary condition for the production of crepitus; if it is absent and the ends of the fragments are not displaced, crepitus cannot be produced. Hence crepitus cannot be elicited in fissured fractures and in incomplete and impacted fractures. In some cases in which no abnormal mobility can be demonstrated, crepitation, or at least a gentle rubbing noise, may sometimes be elicited by appropriate manipulation, and thus determine the diagnosis of fracture.

But a typical abnormal mobility may in some cases be quite clearly recognized and yet no crepitus elicited. Hence the second condition for the production of crepitus is that the ends of the fragments be in contact. Crepitus is therefore absent when the displacement of the fragments is such that the ends are not in contact (*dislocatio ad longitudinem*), either because they are separated (diastasis), as, for instance, in fracture of the patella, or because there is marked longitudinal displacement with great shortening of the entire bone (overriding).

Crepitus is also absent when the ends of the fragments are prevented from coming into contact with one another by the presence of soft parts; in other words, when there is an *interposition of soft parts* (usually parts of fasciæ or muscles). This occurs when there is great displacement of the roughened ends of the fragments so that they penetrate the surrounding soft parts, from which they are not entirely freed when the fracture is reduced. The intervening tissue acts like a cushion and prevents contact between the ends of the fragments. [In fractures of the neck of the femur no attempt should be made to elicit crepitus for diagnosis. Such an attempt would break up an impaction, if present, and an impaction is the best thing that can happen in a fracture of the neck of the femur. Here the diagnosis should and can be made by the inspec-

PLATE 5.

Displacement of Fragments.—Figures 1 and 2 present different views of the same specimen, being that of a fracture of the femur. It shows all the different forms of displacement.

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tion of the deformity and by measurements. Unnecessary manipulation is frequently employed in the diagnosis of injuries about the hip-joint.—Ed.]

3. **Deformity.**—This is another very important symptom which can usually be both seen and felt. It is absent only in fissured fractures and in those rare complete fractures in which there is no displacement of the fragments. The finding of this symptom clinches the diagnosis. In certain cases fracture of some hidden portion of the bone can only be inferred by finding displacement of certain accessible bony points, as, for instance, in fracture of the neck of the femur. Careful inspection and palpation (digital examination) of the injured part should never be neglected, the findings being, if possible, controlled by comparison with symmetric parts of the sound side. Shortening of the fractured bone is rarely absent.

The deformity is due to the displacement of the fragments. It has long been customary to describe various forms of displacement (compare Plate 5)—namely (see Fig. 4):

(*a*) *Lateral displacement* (*dislocatio ad latus*); (*b*) *angular displacement* of the fragments (*dislocatio ad axin*); (*c* and *d*) *longitudinal displacement* (*dislocatio ad longitudinem*). This variety is further divided into *separation* of the fragments (diastasis; *dislocatio ad longitudinem cum distractione*), where the fragments are drawn apart, as in fracture of the olecranon and patella, and into so-called "*overriding*" of the fragments (*dislocatio ad longitudinem cum contractione*), in which the fragments are displaced laterally and the ends by one another, so that the entire bone becomes shortened; this frequently occurs in fracture of the long bones. (*d* and *e*) *Rotatory displacement* of one or both

Fig. 1.

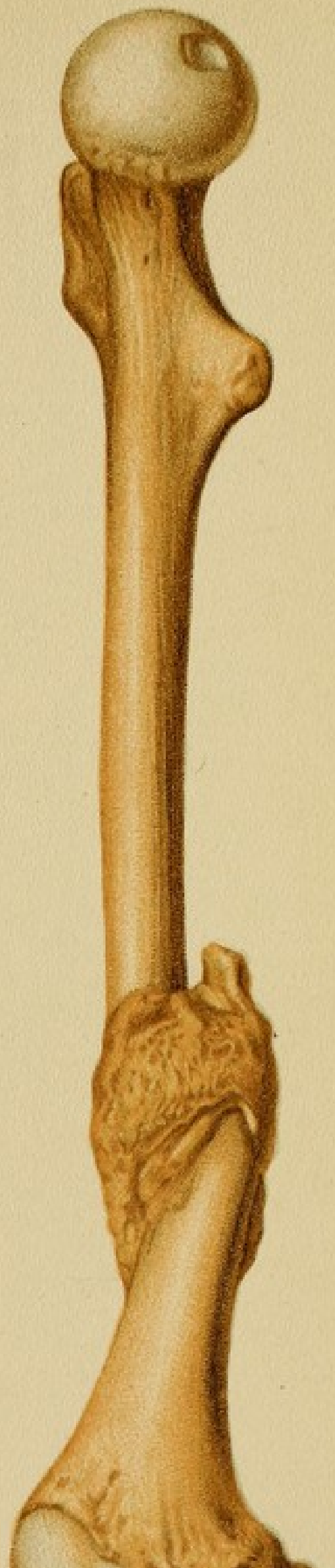
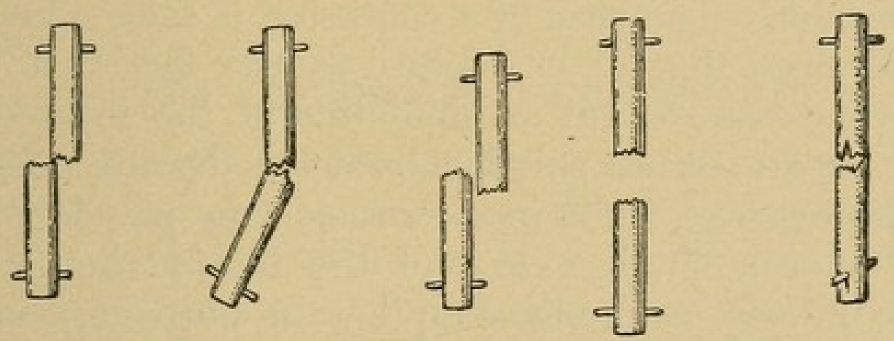


Fig. 2.

Lith. Anst. F. Reichhold, München.

fragments about the long axis of the bone (*dislocatio ad peripheriam*). This is not infrequently present in a slight degree. The deformity occurs in a pronounced form in fracture of the neck of the femur and in fractures of the shaft of the femur and radius, the distal fragment undergoing rotation when the rest of the limb is in its normal position.

Causes of the Deformity.—In very many cases it is the continued action of the trauma after the fracture has taken place that produces the displacement of one or both fragments. In another class of cases the unopposed pull of the muscles, acting on one or both fragments, produces displacements;



a *b* *c* *d* *e*

Fig. 4.—Schematic illustration of various forms of displacement: *a*, Lateral; *b*, angular; *c*, overriding; *d*, separation; *e*, rotatory.

for example, the action of the iliopsoas muscle on the upper fragment in fracture of the femur, causing flexion of the thigh; the action of the masseter, temporal, digastric, and other muscles in fracture of the lower jaw; action of the quadriceps in fracture of the patella; of the triceps in fracture of the olecranon. Finally, we have as a third cause of the deformity, the effect of gravity on the injured part. Thus, for instance, in fracture of the middle third of the clavicle the outer fragment is displaced downward by the weight of the arm.

4. **Extravasation of blood** and other phenomena in the external soft parts are, as a rule, more pronounced in direct fractures. In these the bone is injured at the point

where the *crushing force* is applied. Extravasation into the tissues is never absent; in articular fractures it takes the form of a hemarthrosis. *Excoriations* are not infrequently present, more rarely subcutaneous perforation of the skin from within by a sharp fragment, as, for instance, in fracture of the upper end of the humerus (see Fig. 55). If the extravasation is profuse, it may seriously interfere with digital examination of the fracture. [Localized ecchymosis, especially if the trauma has been an indirect one, is a very important point in the diagnosis of an obscure fracture.—Ed.]

5. **Pain** as a symptom of ordinary fracture loses much of its value from the fact that it is a purely subjective phenomenon. The pain of a contusion is said to be differentiated from that of a fracture by the fact that in the latter condition careful manipulation of the injured limb brings out an intense pain localized to a definite point (like pain on pressure), while in a contusion the pain is felt uniformly over a larger extent of the injured bone. Pain may be a very valuable symptom in indirect fractures; that is, when the crushing force was applied at some point distant from the seat of injury. Occasionally, particularly in fracture of the bony prominences situated on the articular extremities of bones and in incomplete fracture, the pain produced by certain movements and during the action of certain muscles that have their origin or insertion at these points is a symptom of some value (pain on motion). In doubtful cases of suspected fissured, incomplete, or impacted fractures, the attempt to produce pain at the suspected point by sudden compression of the bone or limb in its long axis, without directly touching the injured spot, is often of material aid in the diagnosis.

[Pain and tenderness at the site of the supposed fracture are important points in diagnosis only when the trauma has been an indirect one. In direct trauma the pain and tenderness from a contusion of the periosteum cannot always be differentiated from that of a fracture.—Ed.]

6. **Disturbance of Function.**—This symptom obviously depends to a large extent on the individual's disposition. There are on record undoubted cases of patients who have walked after a recent impacted fracture of the neck of the femur or after fracture of the fibula alone, and of others who used the arm after fracture of the ulna or continued standing at their work after a compression-fracture of the vertebral column.

Finally, it must not be forgotten that the history,—that is, information in regard to the manner in which the injury occurred, and its subsequent course,—the manner in which the individual was struck or the way in which he fell, are all important points in the diagnosis.

The Examination of a Fracture

The first requisites are gentleness and dispatch. Inspection will often give all the necessary information, leaving only certain special questions to be decided by manual examination of the seat of fracture. In examining a fracture the surgeon must always aim at obtaining an accurate knowledge of the nature of the fracture and of the shape and position of the fragments. To do this it is often necessary to resort to anesthesia, especially in so-called joint fractures. One who in doubtful cases makes it a practice to examine under anesthesia (chloroform, ether, or bromid of ethyl) with all due precautions will never regret it. The accurate and correct idea of the state of affairs which is thus obtained will be of the greatest value in the course of the treatment, and, besides, the fragments can at once be replaced while the patient is still under the influence of the anesthetic. While it is perfectly true that an experienced surgeon can usually manage to arrive at a diagnosis and reduce the fracture without resorting to anesthesia, I nevertheless believe I am justified in recommending to physicians in general practice a more frequent use of narcosis as the best means of perfecting themselves in this important and often very difficult subject. The examination under anesthesia need not necessarily be made while the fracture is recent; barring exceptional cases, there is no harm done by putting it off, providing it is done within a week.

The difficulty and responsibility of the first examination are especially great when the subject is unconscious. The surgeon must not forget that the finding of one fracture does not necessarily exclude the presence of others,—*i. e.*, multiple injuries and dislocations,—and that a careful examination of all the bones and joints is the only sure way to avoid fatal mistakes.

A very important procedure in the examination of a fracture is mensuration; as there is nearly always shortening of the broken bones, the finding of a difference in the length of the two limbs is very significant. One should not at once proceed to use the tape-measure; on the contrary, the proper thing to do is to place the injured limb in symmetric position with respect to the sound side, and subject it to an accurate comparison by inspection from a certain distance. One who has diligently trained himself will often be better able to detect slight differences by the eye than by means of the tape-measure, though one should also practise actual mensuration.

Ultimate Result in Fracture.—The examination of cases of long standing such as frequently present themselves nowadays requires the utmost care in order to decide the degree of disability. In the great majority of such cases *deformity* is found to be the cause of the *permanent disability*. In these, as in all other cases, the objective changes and subjective symptoms should be susceptible of being brought into a certain harmony. The surgeon must be on the lookout for any alteration in form and evidence of displacement at the seat of fracture, the presence of edema, injury of a neighboring nerve-trunk (radial nerve, external popliteal nerve), atrophy of the muscles, etc. It requires no small measure of experience and shrewdness to convict a man of exaggeration or malingering even after a thorough examination. If positive evidences of an abnormal condition are found, it must be remembered that the alterations in the external form frequently do not correspond with the degree and extent of destruction of the bone,—as, for instance, in fracture of the metatarsus,—and that it would be unjust to the patient to judge of his condition merely by the external objective changes.

[The estimation of the disability in old fractures is frequently a difficult one. We may speak of a perfect *anatomic result* and a perfect *functional result*. With rare exceptions a perfect anatomic result is always associated with a perfect functional result. By a perfect anatomic result we mean that the fracture has healed without deformity and without shortening. Nevertheless in some instances the patients suffer pain and discomfort, and the function of the limb is not perfectly restored. This is usually due to more or less ankylosis of a neighboring joint caused either by some injury to the joint at the time of the fracture, or a fracture into the joint, or improper and prolonged fixation of the limb. On the other hand, the functional disability may be due to the involvement of a nerve in the scar tissue.

An imperfect anatomic result is by no means always associated with impaired function, and it is this fact that complicates the estimation of the disability of an individual case. Nor is there a definite relation between the defective anatomic result and the use of the limb. This fact we frequently observe in fractures of the neck of the femur, Colles' fracture, and Pott's fracture. In the three fractures mentioned the good function of the limb, notwithstanding a very bad anatomic result, is frequently remarkable. We must also remember that there is not uncommonly a marked neurasthenic condition associated with fractures which may or may not be good anatomic results.—Ed.]

Examination by Means of Röntgen Rays.—The use of the Röntgen rays in the examination of fractures has justly become a universal practice. No surgical hospital is complete without a Röntgen-ray apparatus. Many practising physicians, even in the country, resort to its use, and many patients resort to the skiagraph behind the doctor's back to obtain their desired information. The practical value of the Röntgen rays in the examination of fractures is no doubt sometimes overestimated, but the method unquestionably possesses very great value—a much greater value than many skeptics are willing to accord it. One thing, however, is important. The examination with the Röntgen rays is a method that requires for its proper application special study and training, if correct and trustworthy results are to be obtained. There are, of course, many text-books on this subject and space forbids a full treatment here. I will only bring out a few practical points that have occurred to me during a somewhat extended use of the method.

In examining a fracture of a long bone by means of the Röntgen rays two skiagraphs should always be made: an anterior (or posterior) view, and a lateral view. This is absolutely necessary to obtain a clear idea of the displacement at the seat of fracture, and it may even be necessary in certain cases to prove the very existence of a fracture (compare Plate 6).

For purposes of comparison the Röntgen-ray examination should not be confined to the fractured bone, but a skiagraph should also be made of the corresponding bone on the sound side. It is, of course, indispensable for the correctness of the comparison that the two skiagraphs be taken under exactly similar conditions. Hence the Röntgen tube and the limbs to be photographed must be symmetrically arranged.

In exceptional cases the deformity of a fracture may appear greater and more marked in the skiagraph than it is in reality.

[The exaggeration of the deformity in the skiagraph should be constantly borne in mind. I have observed this quite frequently in the X-ray negative taken of a Colles' fracture after reduction. A careful external examination demonstrated apparently a perfect anatomic result, yet the X-ray negative showed a considerable separation between the fragments. Yet in these cases the ultimate result was apparently a perfect one.

The length of exposure is important, since certain conditions, such as beginning callus-formation and fissured fractures, are brought out by a short exposure, but do not appear in the photographic plate if the time of exposure is too long.

A knowledge of the normal shape of the bones, both in nature and in the Röntgen-ray image, is indispensable in interpreting the skiagraph of a fracture; otherwise, the picture of an epiphysis or of accidental indentations or dark lines might be mistaken for a fissure or the line of a fracture. For this reason a thorough knowledge of the articular ends of bones as seen in the Röntgen image is peculiarly important, and it demands a great deal of study. It must not be forgotten that the Röntgen-ray picture is nothing but a shadow picture which by means of light and heavy shading reproduces the density of tissues, especially of bone.

[A special knowledge of the time of the ossification of the epiphyses is required to properly interpret the X-ray fractures near the epiphysis. This subject has recently been fully discussed by Wolff.[1]—ED.]

The usefulness of the Röntgen-ray picture is not confined to the recognition of a fracture and of the individual conditions of the case; it is also valuable during the treatment, enabling the surgeon to determine whether reduction has been successful and the fragments are in good position.

[1] Deut. Zeitschr. f. Chir., 1900, Bd. LIV, p. 287, reviewed in Progressive Medicine, December, 1900, p. 135.

PLATE 6.

Fracture of the Fibula as shown by a Skiagraph.—Fig. 1.—Anterior view. Fig. 2.—Lateral view. The patient, a man forty-four years of age, fell on the ice and with difficulty managed to get home. Pain on pressure was elicited in the fibula, but there was no deformity. The anterior view does not show the fracture, which is distinctly seen in the picture taken from the side.

The Diagnosis of Fracture

The diagnosis of a fracture ought not to be difficult in most cases, if all that has been said in regard to the symptoms and the examination is carefully borne in mind. If, however, displacement is altogether absent or barely perceptible, owing to impaction of the fragments or because one has to deal with a simple infraction or a fissured fracture, it is sometimes impossible to make a positive diagnosis. The clinical appearances in contusion or distortion are frequently indistinguishable from those observed in fissure or infraction, and the diagnosis of a fracture may remain in doubt until the formation of callus and pronounced disturbance of function clear up the situation.

The diagnosis includes, besides the determination of the presence of a fracture, the recognition of its details: displacement of fragments, the presence of splinters and of soft parts between the ends of the bones, etc.

Special methods of diagnosis, such as acupuncture and percussion (osteophony), are of little practical value and have failed to become popular. On the other hand, the use of the Röntgen rays is, as has been stated, a diagnostic method of the utmost importance. It is by means of this method that the knowledge of fractures and dislocations has been materially enriched in a comparatively short space of time by the discovery of hitherto unknown facts and by the recognition of errors that had obtained up to the time of its advent. It is to be distinctly remembered,

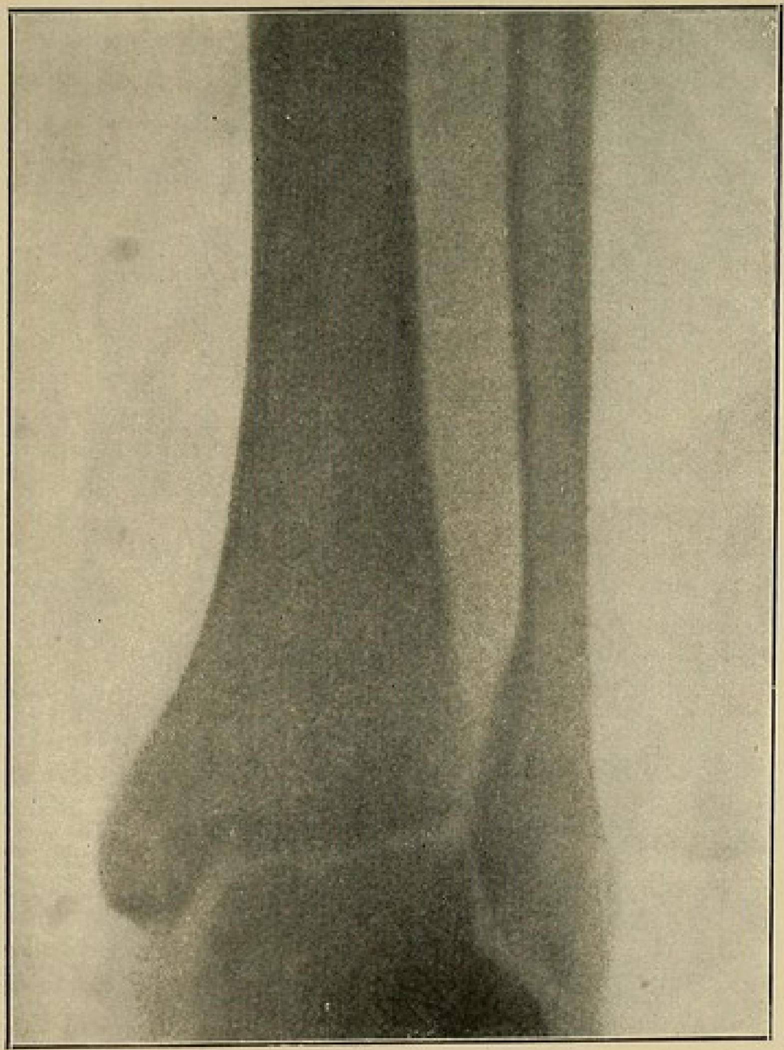


Fig. 1.

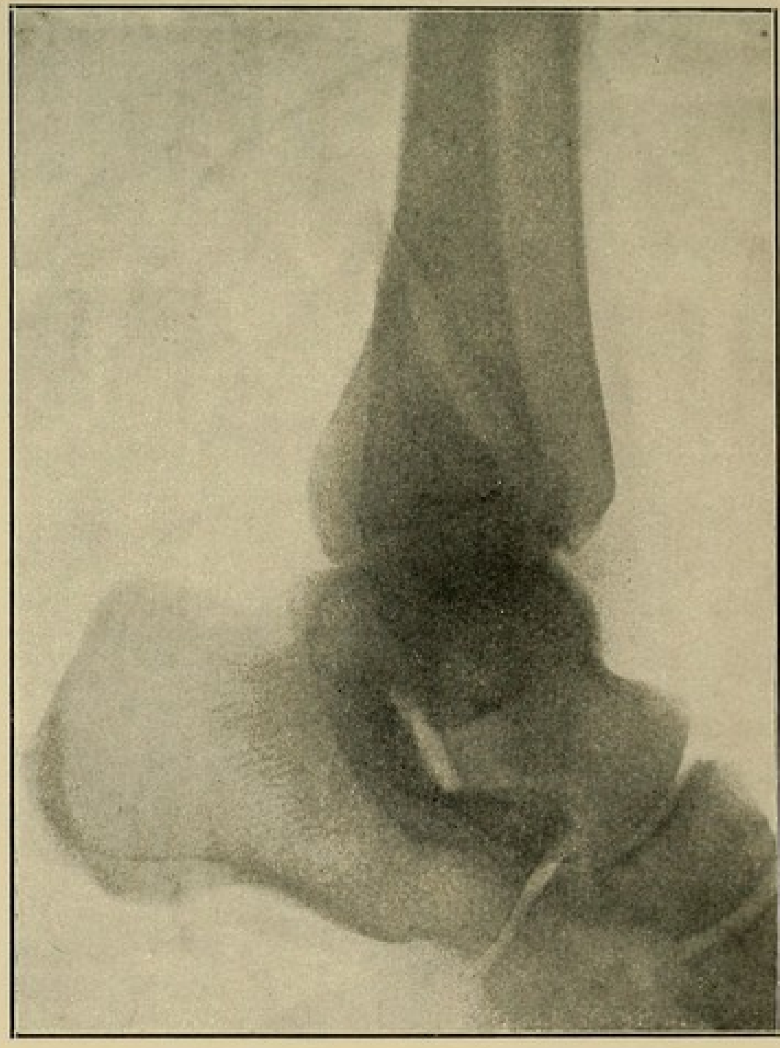


Fig. 2.

however, that careful examination usually suffices to make the diagnosis and determine the treatment of a fracture, and should always precede the employment of the Röntgen-ray apparatus. The latter, however, in most cases supplies us with more detailed information in regard to the displacement of fragments which is of great value at the very beginning of treatment.

[One should never hesitate, if in doubt with regard to diagnosis of a fracture, to treat the injury as a fracture, and, if there is a deformity which cannot be reduced under anesthesia, to operate. This is especially true in partial epiphyseal separation. I believe many of the recorded bad results could have been prevented by operation, which allows not only a better recognition of the injury, but a more perfect reduction of the deformity.—Ed.]

Clinical Course and Repair of Fractures

The production of a fracture is followed by swelling of the surrounding soft parts, due in part to the outpouring of blood, in part to infiltration of the tissues. The swelling is proportional to the severity of the injury, the amount of hemorrhage, and the length of time that intervenes between the injury and the proper replacement of the fragments. These conditions do not, of course, fail to affect the organism as a whole. In addition to blood, the seat of fracture contains lacerated bone-marrow and other tissue elements. This explains why a recent subcutaneous fracture in a healthy individual is frequently followed by the occurrence of fever. The explanation of the phenomenon may be found in the resorption of minute decomposing tissue elements at the seat of fracture, but it is probably more correct to assume that the rise in temperature is produced by the action of the blood ferment which is absorbed from the extravasated blood. That resorption of blood ferment may produce fever has been proved experimentally by Angerer.

[So far observations have demonstrated that there is no leucocytosis associated with the fever frequently present in simple fractures.—ED.]

The laceration of the bone-marrow may permit the escape into the circulation of larger or smaller masses of fat (for Fat Embolism see page 50), which is in part excreted by the kidneys; accordingly, fat and sometimes albumin and casts may be found in the urine after fracture.

[Death from fat embolism following fracture is very rare. It has been more frequently recorded after fracture of the shaft of the femur.—ED.]

The early and softer tumefaction about the seat of fracture is due partly to the extravasation of blood and partly to a form of inflammatory exudate (edema), and may persist for several days. Under proper treatment, however, it usually begins to subside toward the end of the first week. The ecchymosis thereupon leaves its usual mark in the skin in the form of well-known color changes, and the tension of the skin relaxes. If the swelling is very great, the skin over the seat of fracture sometimes presents vesicles and blebs filled with serum, which, however, do not affect the normal course if the fracture is properly treated and no further complications declare themselves. Nevertheless they call for careful disinfection of the skin and an aseptic dressing.

[Secondary infection of a simple or closed fracture is a very rare observation, even in those cases associated with extensive blood extravasation. When an anesthetic has been given to reduce the fracture, the possibility of a post-anesthetic pneumonia must be borne in mind. With the first rise of the temperature and accompanying leucocytosis the signs of lung involvement may be so obscure that there will be difficulty in excluding the fracture as the cause. In some instances it might be safer to explore the fracture under cocain anesthesia, because the early incision, if the fracture is infected, is the most important one in the ultimate result. It can do no harm if the fracture is not infected. I have had one such experience. Later in the progress of a simple fracture pyogenic osteomyelitis is very rare. In my observations it has usually been associated with comminuted fractures in which one of the fragments has become completely separated from the periosteum, with death from lack of blood-supply. This fragment undoubtedly has acted as a foreign body and lowered the resistance of the surrounding tissues. In every case observed the infection has taken place after complete healing of the fracture, and with timely and proper operative interference the ultimate result has not been affected by this late complication.—Ed.]

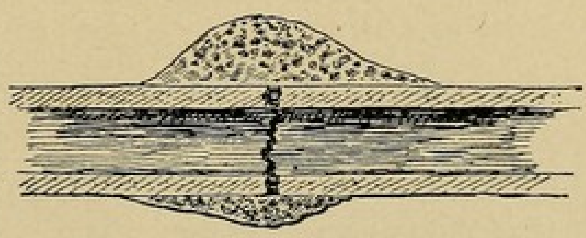


Fig. 5.—Callus-formation in a recent fracture of the ribs, without displacement.

The disappearance of this early and softer swelling is followed by the formation and appearance at the seat of fracture of a harder spherical or spindle-shaped tumor, which soon becomes almost cartilaginous. This swelling gradually fades away in either direction into the normal outline of the bone; it is the so-called *callus.* As it increases in density, the abnormal mobility at the seat of fracture diminishes. Finally, the fragments become actually fixed by the callus, and the fracture is said to be consolidated or united.

It is a rather remarkable fact that this normal course is the rule. In new-born children, as well as in persons of advanced age, consolidation of the fracture by means of callus takes place. The new tissue is almost exclusively a product of the periosteum. The irregular laceration of the periosteum at the seat of fracture, with the presence of minute shreds of the membrane in the immediate neighborhood, probably leads to the production of a periosteal

PLATE 7.

Observation of the Repair of a Severe Fracture of the Leg by Means of the Röntgen Rays.—Male, thirty-three years old, laborer, sustained a fracture of the lower half of the leg. The diagnosis was certain, the displacement of fragments marked, and the Röntgen rays confirmed the presence of a multiple fracture of the tibia. Even under anesthesia the fragments could not be accurately replaced (Fig. 1). Operation was accordingly resorted to, the fragment was exposed, and both ends secured with silver wire sutures (Fig. 2). The wires were later removed and excellent union resulted (Fig. 3).

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proliferation partaking of the character of an ossifying periostitis. In this process the bone-marrow is not altogether passive; it also exhibits some degree of callus-formation (pin callus). In an ordinary fracture without marked displacement of the fragments we may suppose this callus-formation to take place about as follows: The outer or periosteal callus (ring callus) surrounds the ends of the fragments like a ferrule (ring-shaped mass of mortar), the inner or pin callus occludes the medullary cavity at the seat of fracture, while between the two, and uniting them, is the so-called intermediary callus formed by the bone tissue itself.

In marked displacement of the fragments callus-formation is, of course, much more abundant. Considerable masses of callus are often built in, as it were, like masonry between the ends of the fragments. In the case of children callus-formation is least marked, the periosteum, as a rule, is not torn, and forms a sheath about the seat of fracture, at the same time guarding the fragments from displacement.

[It is to be remembered that callus-formation is very slight in some fractures; for example, the olecranon, the patella, and the neck of the femur. For this reason in fractures of the patella and olecranon, unless we can get absolute approximation we resort to an early perfect approximation of the fragments with some form of suture;

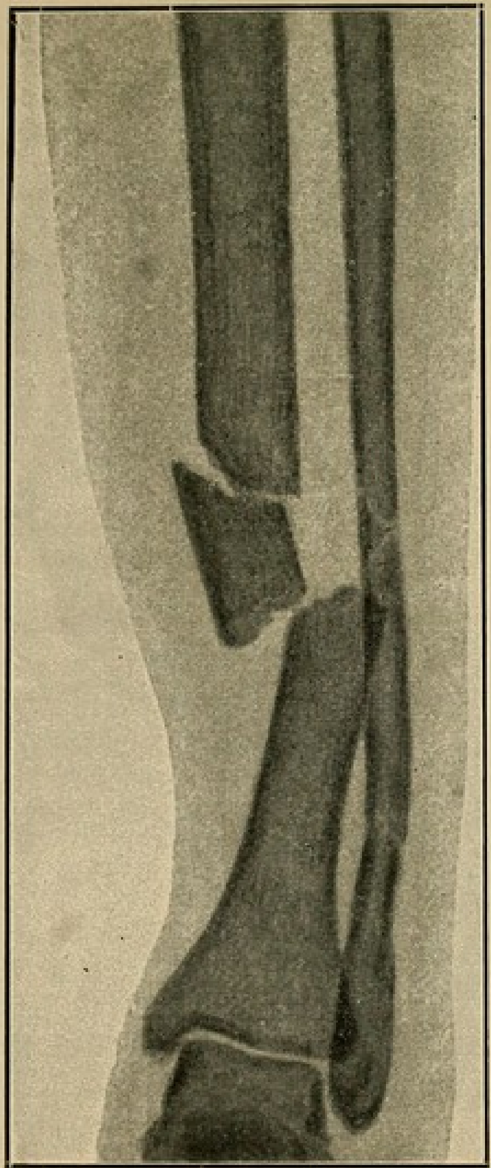

Fig. 1.

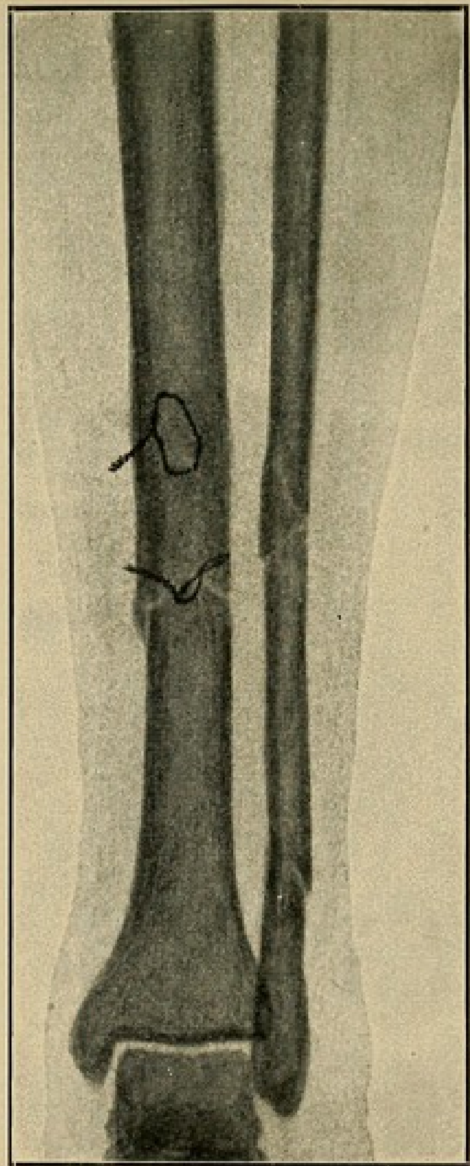

Fig. 2.

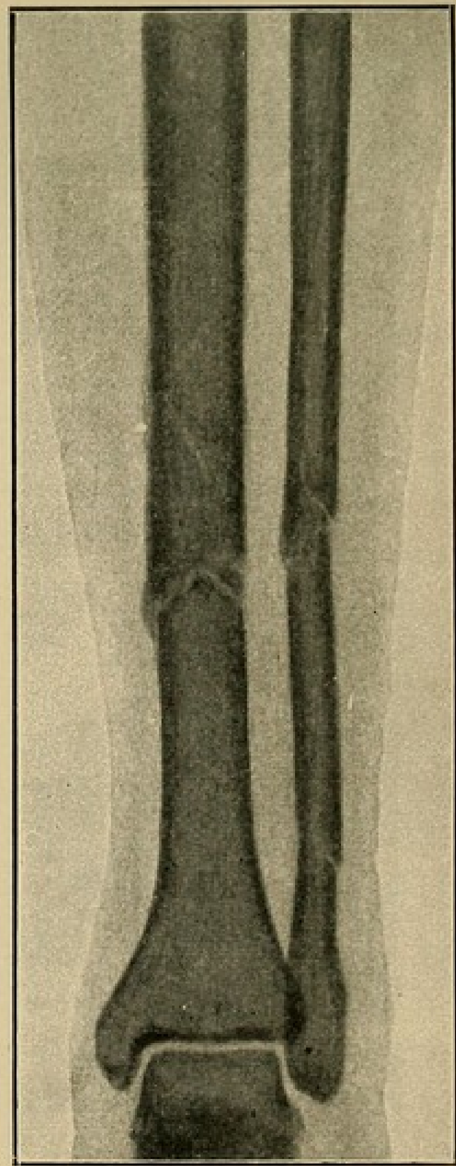

Fig. 3.

silver wire is preferred. For the same reason one should never interfere with the impaction in a fracture of the neck of the femur.—ED.]

In compound fractures *necrosis* of one or both ends of the fragments sometimes takes place. In this traumatic form of necrosis, as in osteomyelitis, a line of demarcation appears between the dead and the living bone. The living portion becomes the seat of rarefying osteitis which after a variable period of time, ranging from two to six months according to the age of the patient and the bone involved, leads to complete separation of the dead bone, the so-called *sequestrum*. Meanwhile an ossifying periostitis is manufacturing new bone, and as a rule in sufficient abundance to bring about consolidation of the fracture by union of the newly formed bone tissue from either side, so that complete recovery finally ensues after separation of the sequestrum.

[Osteomyelitis with its accompanying necrosis in compound fracture can usually be prevented or inhibited by early and proper operative intervention and the intelligent treatment of the wound. At the operation the two most important points are: first, the disinfection; second, care in preserving the circulation of the bone. Completely separated fragments of the bone should be removed. Every effort should be made to preserve the periosteal attachment of the remaining bone. In the treatment of the wound we must make the proper decision whether it should be treated as an open or as a closed wound. If we feel that there is no infection and no necrosis of tissue, we should close the wound, but when it is necessary to leave the wound open, it is remarkable how infection can be combated and osteomyelitis and necrosis inhibited by the subsequent open treatment of the wound. Union is always delayed, and the case demands long fixation. I have observed a few cases in which the open fracture healed under direct observation by granulation without any gross necrosis; osseous union resulted.—ED.]

PLATE 8.

Repair of Fractures; Callus-formation.—Fig. 1.—Cross-section of the humerus, showing a fracture. Slight angular displacement. At the seat of fracture we see the old compact bone of the fragments connected by a scanty mass of callus which has again assumed the character of compact bone. The medullary cavity is patulous, though somewhat encroached upon by a few plates of spongy bone at the seat of fracture. (From the Pathologic Institute at Griefswald.)

Fig. 2.—Cross-section of the tibia showing an angular fracture. The marked displacement and lateral apposition of the fragments is recognized. The original compact bone of the cortex has assumed a more spongy character, the medullary cavity is interrupted by the cortical portions of both fragments, and a thick mass of new bone is interposed between them. (From the Pathologic Institute at Greifswald.)

Fig. 3.—Specimen from a severe compound fracture of the thigh. The infection of the wound has led to necrosis of the ends of the fragments in their entire cross-section, followed by the formation of sequestra which separated after months. The limb was finally amputated because firm union of the bone was despaired of.

In figure 3 *a* one of the fragments is represented in section, affording a good view of the deposits, the beginning resorption in the compact bone, and the occlusion of the medullary cavity by masses of spongy tissue.

Figure 3 *b* shows a complete section of the fragment and the sequestrum belonging to it. The sequestrum appears like a piece of macerated bone with jagged projections. The other end is surrounded by the contiguous piece of bone; the normal appearance of the latter is altered by delicate deposits on its surface which become more abundant toward the sequestrum and take on the character of stalactites.

Figure 3 *c* shows on one side the sequestrum with the fractured surface, and on the other side the jagged projections formed during the slow inflammatory processes ending in separation. (From the author's collection.)

It was formerly customary to distinguish between provisional and permanent callus-formation (Dupuytren), but in the light of our present knowledge we can only speak

Tab. 8.

Fig. 3 a

Fig. 3 b

Fig. 3 c

Fig. 1.

Fig. 2.

Lith. Anst. F. Reichhold, München.

of provisional and permanent conditions in the repair of fractures in so far as, after the repair of a fracture in the ordinary sense, various changes continue to take place for an indefinite period of time, lending a more permanent character to the anatomic appearance of the seat of fracture. In other words, the seat of fracture continues to undergo change even after firm union of the bone has taken place. The callus, which at first is abundant and spongy in character, becomes reduced in quantity and its density increases until it gradually assumes the character of a compact mass of bone. Those portions of the callus and of the fragments that have not been utilized in the mechanical repair of the fracture undergo gradual resorption, the bone retaining only as much as it needs for the performance of its mechanical function. Even the medullary canal may regain its integrity. These processes of absorption and ossification require a great deal of time. The illustrations found on Plate 8 show the outer callus, the occlusion of the medullary cavity by the inner callus, callus-tissue of a spongy and compact character, and the resorption of old compact masses of bone.

Complications of Fractures and Their Treatment

Fat embolism has already been mentioned. While the resorption of small masses is not attended by danger, the absorption of large masses of fat may be a very serious matter; even fatal. The fat is derived from the lacerated bone-marrow and possibly from the injured adipose tissue at the seat of fracture. Fat, which at body-temperature is fluid, may enter directly into the lacerated veins of the bone and thus reach the circulation, or it may be absorbed and carried away by the lymphatic channels. The fat thus enters the circulation and leads to fat embolism in the capillaries of the lungs. If the fat passes through the pulmonary capillaries, it enters the arterial circulation and may lead to embolism in the various organs (general fat embolism). In fatal cases extensive fat embolism in the lungs, in the central nervous system, and in the capillaries of the greater circulation has been demonstrated. The treatment consists in stimulating the action of the heart so as to facilitate the excretion of the fat by the kidneys.

Thrombosis of a vein and **embolism,** though rare, constitute a very dangerous complication of subcutaneous fractures. Cases have been reported in which the repair of a fracture was suddenly interrupted by the occurrence of sudden death with symptoms of asphyxia. At the necropsy embolism of an artery derived from a thrombus at the seat of fracture was found. In other cases which ended in recovery the diagnosis of embolism of the pulmonary artery was made from the clinical symptoms. Thrombosis in the region of fracture often produces an edematous swelling of the injured extremity. This accident has been observed most frequently in fractures of the lower extremity, usually in the third week. It occurs sometimes in relatively mild cases, as instanced recently in the case of a fracture of the patella.

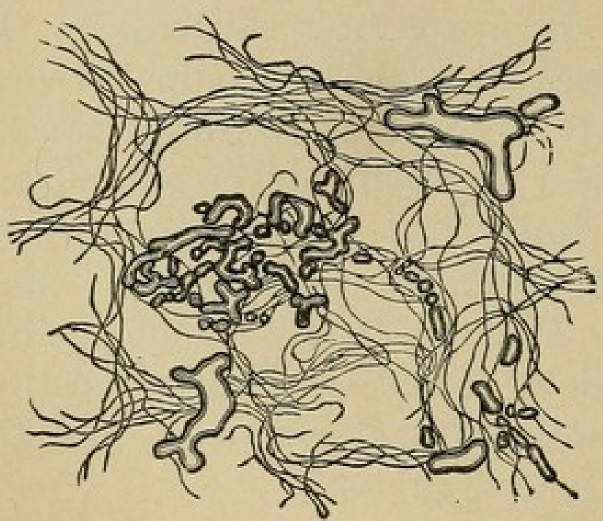

Fig. 6.—Fat emboli in the pulmonary tissue. Recent preparation treated with a solution of caustic soda. The fat is seen within the capillaries and in free globules.

[As yet we have discovered no preventive treatment for thrombosis and phlebitis. It is usually not a fatal or serious complication, but it is a very uncomfortable one, and interferes with the function of the limb for many months. The diagnosis should not be difficult. It is a late complication, associated with great pain and swelling of the limb, and not infrequently with some fever. If the patient is out of bed, the reclining position should immediately be resumed; the limb should be elevated; the dressing should be frequently changed and applied with great care and less snugly than usual; later, about the second week, gentle massage should be instituted, and passive motion of the joints. Involvement of the joint in the general phlebitis is not uncommon, even with resulting ankylosis, if not properly treated.—ED.]

Injuries to blood-vessels are not so very uncommon; they may lead to extensive hemorrhages if the artery has been injured, or to the formation of aneurysm or to gangrene. The anterior and posterior tibial arteries are the ones most commonly injured. The subject of gangrene from tight bandaging will be discussed later.

[The possibility of vessel injury in fracture is a complication most frequently overlooked. Gangrene of the limb much more often follows this complication than tight bandaging, although in many instances the bandage and the surgeon have borne the odium of the result. It is especially important to bear this in mind in a suit for malpractice. The subject has recently been fully discussed by Hertzog,[1] Schultz,[2] Boetticher,[3] and Bloodgood.[4]—ED.]

Injuries to nerves may occur in fractures from a variety of causes. A nerve-trunk, such as the ulnar or external popliteal, for example, being closely applied to the bone may be injured in direct fractures by the same force that produces the insult; or a nerve-trunk may be injured by the displaced fragments (interposition); or, finally, the nerve may be compressed by, or actually included in, the callus-formation. The symptoms obviously depend on the cause and the distribution of the injured nerve. Operative intervention, consisting in freeing the injured

[1] Beiträge zur klin. Chirurgie, 1899, Bd. XXIII, p. 643.

[2] Deutsche Zeitschrift für Chirurgie, 1897, Bd. XLVI.

[3] Ibid., 1898, Bd. XLIX, p. 297.

[4] Maryland Medical Journal, September, 1900; and Progressive Medicine, December, 1899, p. 190.

nerve from the surrounding mass of callus, may be considered and has often been followed by complete recovery.

[Operative intervention for nerve injury associated with fracture is unfortunately frequently delayed. At the first examination we should always search for nerve injury. If the nerve is severed, it should at once be found and the ends reunited. When later, in the healing of the fracture the nerve becomes compressed by the scar tissue or the callus, the indications for operation are not so clear, because observations have demonstrated that nerve function is restored later when the scar tissue and callus are absorbed. This, however, does not always take place, and surgeons are frequently called upon to operate. Without much doubt a more careful study of the cases would in many instances lead us to an earlier operation. The prognosis for the restoration of the function of the nerve after suture or after its separation from its surrounding and compressing scar tissue or callus is always good, though the restoration of complete function does not usually take place for a year. We should perform the operation even in those cases when the interval of time since the injury is a long one, even a number of years. In these cases of long duration the prognosis is less favorable, but there is always a possibility that the nerve will regenerate.—Ed.]

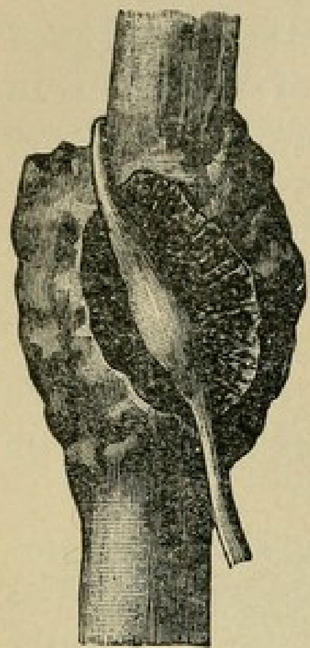

Fig. 7.—Club-shaped enlargement of the musculospiral nerve, surrounded by an abundant mass of callus, in fracture of the humerus. The nerve has been exposed by chiseling away the edge of the bone. The paralysis ultimately disappeared. (After Ollier, supplemented by the author's own observation.)

Delayed Callus-formation (Delayed Union).—Although excessive development of callus and, rarely, actual tumors, such as osteomata, enchondromata, and sarcomata, are observed, the process of callus-formation is occasionally much delayed. The cause of this is rarely ascertainable. From a practical standpoint it is important to know that in such cases conservative expectant treatment, supplemented by the use of suitable auxiliary procedures, will as a rule be followed by firm union, thus avoiding the production of a false joint. These auxiliary procedures include general tonics, regulation of the diet, exercise, and the application of suitable dressings allowing the broken limb to hang free. Good results are often obtained by inducing venous hyperemia at the seat of fracture by means of a moderately tight rubber bandage applied above the fracture, the limb below the seat of fracture being at the same time protected by means of a bandage (Fig. 8). As the author has shown, the venous hyperemia can in this way be easily confined to a definite point, and by regulating the compression of the elastic bandage the dosage, so to speak, can be controlled.[1] This procedure has been especially recommended by Bier in the treatment of tubercular affections of the extremities by means of venous hyperemia, and has been commented upon by various authors. In fractures showing delayed or insufficient callus-formation it works very well, and can

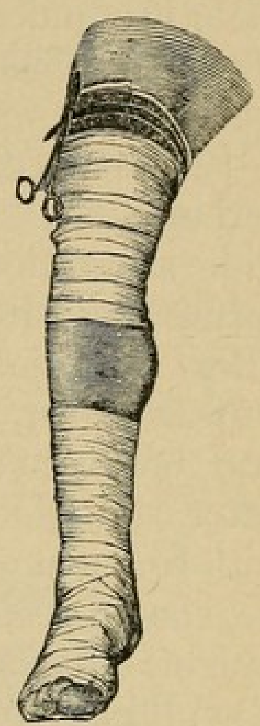

Fig. 8.—Author's method of inducing venous hyperemia at the seat of fracture. A strip of felt is interposed between the skin and the rubber band which is fastened by means of an artery forceps. The lower part of the leg is protected by a bandage, so that the effect of the hyperemia is entirely confined to the seat of fracture.

[1] Compare Helferich, Ueber künstliche Vermehrung der Knochenneubildung, Archiv f. klin. Chir., 1887, vol. XXXVI.

of course be combined with the various methods of immobilization. A more energetic operative manipulation consists in rubbing the fragments of the bone one against the other under anesthesia or in driving nails into the ends of the fragments to set up irritation and more energetic reaction.

[The subject of delayed union in fracture is a very important one. As a rule, it is due to faulty position, wide separation of fragments, or the interposition of soft parts, very rarely to new-growth formation in the callus. These conditions demand immediate operative interference. Now and then, when the fragments are in perfect apposition, firm union may be delayed. The best treatment in the latter is undoubtedly the so-called ambulatory combined with frequent change of dressing and massage ; in addition, we should seek for the cause in the general health of the patient. If anemic, they should be given iron and tonics ; if syphilitic, the proper therapeutic remedies. They should be encouraged to live outdoors as much as possible. In the case of a syphilitic man with a fracture of the shaft of the tibia in the middle third, and a second similar case with a fracture of the shaft of the femur, upper third, solid bony union did not take place for a year, but our persistence in the ambulatory treatment with proper fixation was followed by a perfect result in each instance. Such observations are rare. We more frequently observe delayed union after operation for badly united fractures or in cases of non-union because of the overriding of fragments or the interposition of soft parts. The danger of delayed union increases with the interval of time since the original injury. This seems to be due to a process of osteosclerosis usually combined with an anemic condition of the ends of the bone in which the marrow spaces between the sclerotic areas become very fatty, a condition called lipomasia. The osteosclerosis is probably a secondary condition to the callus-formation, and the lipomasia is the result of the poor circulation which is always present in unused extremities.

Both conditions inhibit callus-formation and its proper ossification, so that after the operation the properly approximated fragments very slowly throw out callus, and the firm ossification of this new callus may be delayed for months, even a year, and in some few instances firm bony union is never accomplished. Nevertheless, bearing these possibilities in mind, we should persistently continue the proper treatment. In the majority of instances a good result will be obtained.—ED.]

The term **pseudarthrosis** or **false joint** is employed to describe the formation of a new joint which occurs when firm union fails to take place. Further details in regard to the subject will be found under the head of Treatment. It may here be briefly stated that we dis-

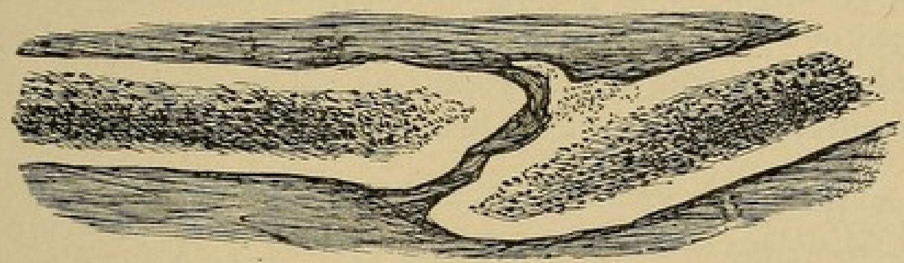

Fig. 9.—Fibrous pseudarthrosis of the ulna (after Bruns). The fragments are connected only by bands of connective tissue.

tinguish two forms of false joint, a *fibrous pseudarthrosis*, and a "*true*" *pseudarthrosis; i. e.*, the formation of a joint with articular cleft and a capsule.

The formation of a false joint may be due to general or to local causes. Among general causes syphilis, general debility, etc., are the most important. Various circumstances operating at the seat of fracture itself may lead to the formation of a false joint. Thus, for example, severe contusion at the seat of fracture, such as occurs in grave direct fractures, especially if they are compound.

In other cases a false joint may result in spite of normal or even exaggerated callus-formation, either because of the interposition of soft parts or marked overriding of the fragments.

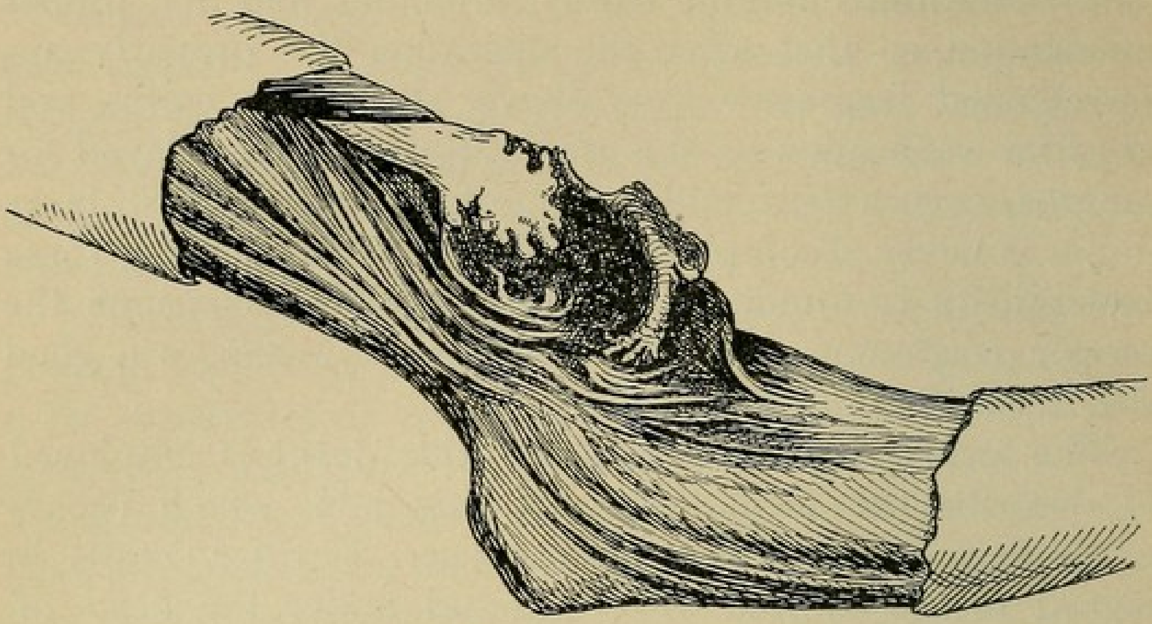

Fig. 10.—False joint after fracture of the humerus. The extremity of one of the fragments is slightly club-shaped, while that of the other is flattened out in the shape of a shallow cup. The two fragments articulate within a true capsule showing a villous formation (specimen from the cadaver ; author's own observation). (Compare Fig. 11.)

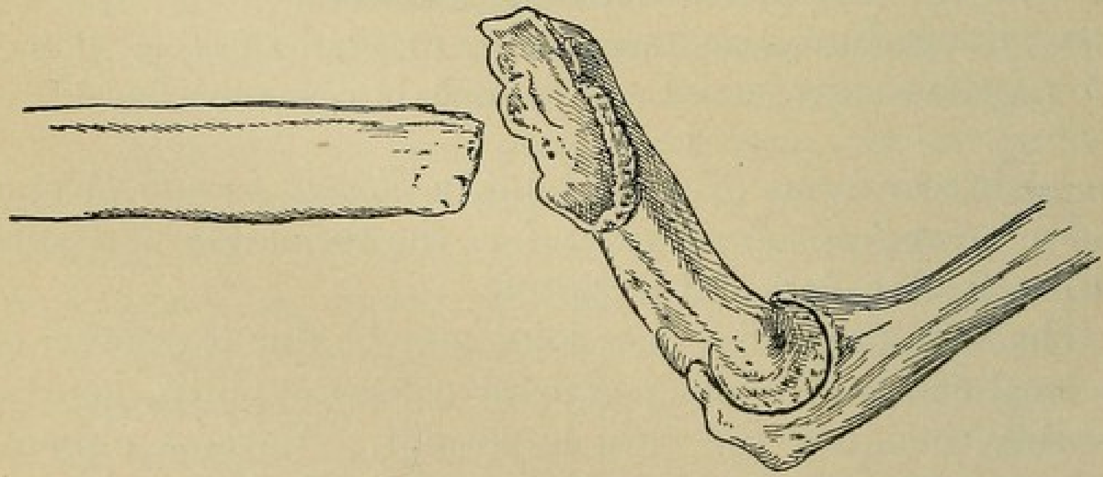

Fig. 11.—Specimen of a well-developed false joint. Specimen shown in figure 10 after maceration. On the posterior aspect of the lower fragment of the humerus a kind of cup-shaped expansion is seen which articulates with the extremity of the upper fragment ; the latter has undergone but slight alteration. The cup-shaped expansion is formed entirely by periosteal deposit, the medullary cavity is almost completely occluded at the extremities of both fragments, including the free lower extremity of the lower fragment.

The *interposition of soft tissue,* especially of muscle-fibers, forms an absolute obstacle to firm union, and

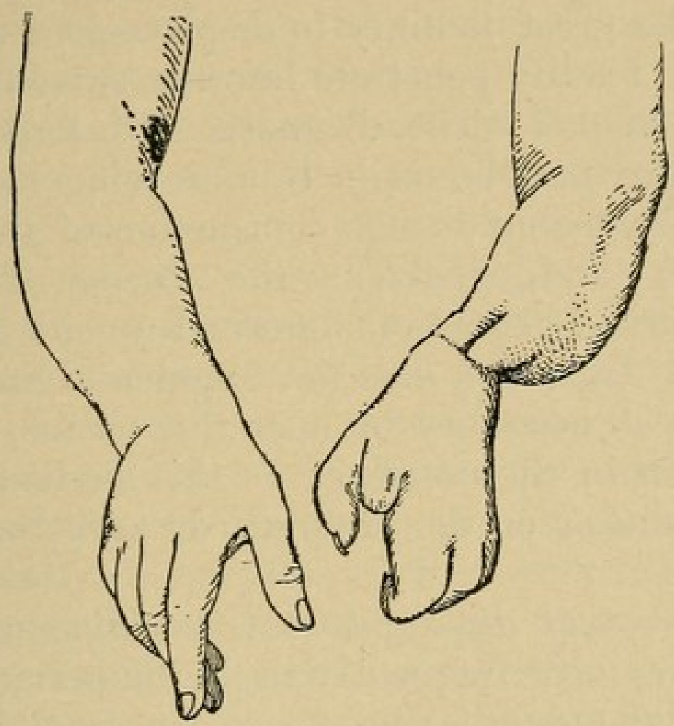

Fig. 12.—False joint of many years' standing, in the left forearm, from loss of bone tissue. Caused by severe fracture sustained in early life. Male, forty-four years of age, had a severe fall at the age of eight and sustained a multiple fracture of the left forearm. Several pieces of bone were removed. The patient was treated in clinic for nine months, but the arm remained practically useless. At present there is an obtuse-angled ankylosis of the left elbow, and the fingers of the left hand are undeveloped, flexed, and immovable. The left forearm is 11 cm. shorter than the right, and shows a false joint at the junction of the middle with the lower third. In the peripheral segment the radius is preserved, while the ulna is completely wanting. There is an absolute want of control at the false joint, the peripheral segment falling down with the hand unless it is supported. The patient improvised a splint which enables him partially to oppose the thumb against the fingers, which are immovable. Cicatricial contractions are seen at the seat of fracture and at the elbow. It is probable that the fracture was compound, that the wound became infected, and that suppuration followed. Resection of the lower segment of the ulna ; ultimate healing of the wound with the production of a false joint in the radius, loss of the ulna, and ankylosis of nearly all the joints and tendons involved.

always leads to pseudarthrosis. Interposition of muscular fibers is most frequently observed in fractures of the humerus and femur, and is explained by the length of these bones and the great liability to displacement of the fragments which readily penetrate into the surrounding mass of muscular tissue. The diagnosis of interposition in a recent fracture may be made by observing movement of one of the fragments during contraction of the lacerated muscle (rare); and, chiefly, by the absence of crepitus in spite of a marked degree of abnormal mobility at the seat of fracture. In such a case the fragments must be forcibly replaced, if necessary by operative means, until crepitation is elicited; the usefulness of this method is vouched for by the author on the strength of numerous observations.

High degrees of displacement—overriding of the fragments—occurs most frequently in the humerus and femur. In spite of abundant callus-formation from both of the overriding fragments ossification fails, and a pseudarthrosis results.

Finally, it goes without saying that insufficient immobilization of the fracture greatly favors the production of a false joint.

The *correction of a pseudarthrosis* may be achieved by such minor interventions as rubbing the ends of the fragments together, or driving steel or iron nails into the bone, but only when the condition is due either to the absence of callus-formation or to insufficient immobilization. If the case is one of interposition, with marked displacement at the seat of fracture and the formation of a false joint, the only hope of recovery lies in operative removal of the interposed tissues, resection of the ends of the bones, and proper fixation. If there has been much loss of bone tissue at the seat of fracture, the interposition of a piece of bone between the ends of the fragments by means of transplantation may prove successful.

[Bone transplantation is an uncertain procedure. The bone flap should be taken from one or both of the fragments. Its periosteal attachments should always be preserved, and if possible some muscles. The details of this procedure belong to the special surgery of bone operations rather than to a treatise on fractures.—Ed.]

Suppuration in a subcutaneous fracture (closed), that is to say, suppuration of the extravasated mass of blood, may be the result of infection derived from some distant point (angina, furuncles, etc.), although not the slightest injury of the skin is present at the seat of fracture. In such cases early and thorough incision and drainage are indicated ; as a precautionary measure any inflammatory area in the body should be carefully treated.

Delirium tremens is a grave complication. Its occurrence, especially in fractures of the lower extremity, calls for the application of heavy plaster casts reinforced by iron splints, and for constant supervision to prevent the patient, who is insensible to pain, from getting out of bed. Great care is necessary in the administration of anesthetics if delirium is present. As a prophylactic measure alcohol should be given from the beginning and insomnia combated by the administration of hypnotics, chloral hydrate being preferable to morphin.

[In this country it is the usual practice to place the fractured limb in a pillow splint when the patient is suffering from delirium tremens. Properly applied, it holds the fracture in good position, it allows frequent inspection, and is more comfortable. The extreme restlessness of the patient increases the danger of some injury if the leg is incased in plaster-of-Paris.—Ed.]

Prognosis of Fractures

The prognosis in a simple, subcutaneous fracture is, generally speaking, favorable so far as life is concerned. The prognosis may be unfavorably influenced by grave accidents, such as those that have been described above, and by old age or debility of the injured person. A considerable proportion of the cases of fracture of the lower extremity occurring in old persons end fatally from hypostatic pneumonia. [In any patient in whom we fear lung complications some form of ambulatory splint should be used, and the patient at least should be allowed to sit up. —Ed.]

Our knowledge of the factors influencing repair of a broken bone, both as regards its form and restoration of function, has received many additions in recent times. This is derived from two sources. The development of legislation in regard to accidents has produced valuable statistical information in regard to the effect of individual fractures on the subsequent ability of the injured person to earn a living. Our knowledge prior to this time has been summarized in the following generally accepted truths:

Firm union is facilitated and hastened by vigorous health in the person affected; slight degree of dislocation, permitting perfect reduction; a method of treatment which leaves the seat of fracture itself free and allows a fuller hyperemia to take place (treatment by extension). The prognosis in spiral fractures, owing to extensive injury to the bone-marrow, and in direct fractures, on account of the accompanying contusion of the soft parts, is more unfavorable than that of transverse fractures and indirect fractures. *Prolonged disuse of an extremity is followed by atrophy of the muscles and rigidity and other changes in the articulations.*

As the result of recent accident legislation many details are now more accurately known. A man who has sustained a fracture is not considered cured until he is able to work, hence a fracture very frequently produces permanent disability. A valuable paper on these questions, with numerous statistics, was contributed by Hänel,[1] after analyzing material obtained from labor unions. Of a total of 121 fractures of the shaft of the femur, 34% ended in

[1] Deutsche Zeitschrift für Chirurgie, vol. XXXVIII, page 129.

perfect recovery, 66 % in permanent disability; the average duration of treatment was 13.5 months. Of 19 cases of fracture of the neck of the femur, 12 % proved fatal, 12 % ended in recovery, and 76 % in permanent disability. Of 148 fractures of the leg, 78 % ended in recovery, 21 % in permanent disability. Of 32 fractures of the arm, 72 % resulted in recovery; of 67 fractures of the forearm, 89 % ended in recovery.

Somewhat better results have been reported by Loew [1] and Bliesener.[2] The former's investigations concerned 167 fractures of the leg; the latter's, a large number of fractures of the lower extremity, treated in the Kölner Hospital by Bardenheuer's extension method. Jottkowitz furnished a statistical illustration of the favorable influence of *mechanical after-treatment* after firm union of the fracture, his figures being based on the abundant material, consisting especially of fractures of the leg, supplied by the Königshütte Knappschaftslazarett.[3] With only a slight increase in the duration of treatment more recoveries were recorded; and during the period of thirteen weeks allowed for recovery, 49 % of all the cases were cured, as against 36 % under the old system.

The chief causes of unfavorable results and unduly delayed recovery observed in many cases are displacement of the fragments, rigidity of the immobilized joints, hypertrophy of the callus, delayed consolidation (ossification), pressure on nerves, pain, and edema at the seat of fracture. The lesson to be learned from these observations is that the kind of treatment instituted has an important influence on the result.

Our second source of information is one which has recently produced a revolution in surgical lore. It is the use of the *Röntgen rays.* By the aid of this discovery it has been proved that even when firm union, with perfect

[1] Deut. Zeitschr. f. Chir., vol. XLIV, p. 462.

[2] Ibid., vol. LV, p. 277.

[3] Deut. Zeitschr. f. Chir., vol. XLII, p. 610.

restoration of function, takes place, the shape of the bone is not by any means always perfect; in other words, a deformity remains. Interference with function, therefore, is not always due to deformity at the seat of fracture, although the deformity is a factor of some moment. The value of the Röntgen rays as an aid to treatment lies chiefly in the fact that they enable us to determine the kind of displacement present and to control its development during the period of treatment. The method should, therefore, always be resorted to. I consider it indispensable in a large number of fractures to examine the seat of fracture with the Röntgen rays, both before and after replacement of the fragments; in this way there is no possibility of deformity appearing unexpectedly. Even in subcutaneous fractures the fate of the injured person is in the hands of the physician. Perfect restoration of the shape of the bone must be achieved early, either by bloodless methods or by replacing the fragments under anesthesia and, if necessary, by wiring the fragments together.

Treatment of Fractures

The object is to obtain *firm union of the fragments without displacement and without loss of function.* To accomplish this, two things are necessary: accurate replacement of the fragments and a suitable dressing.

Reduction almost always necessitates the presence of one or two assistants who exert extension and counter-extension while the surgeon replaces the fragments by appropriate manipulations, such as lateral pressure and flexion or extension of the limb. Speed and accuracy in reduction depend on the surgeon's general knowledge of the typical displacement occurring in the fracture, and his special knowledge previously obtained by examining the position of the fragments. In reducing an incomplete fracture with angulation of the fragments, the fracture is often converted into a complete one. Sometimes reduction is exceedingly difficult and cannot be effected without anesthesia. The special obstacles to reduction are: excessive displacement of the fragments, especially of bony prominences that have been broken off; interposition of soft parts; fixation of the sharp ends of the bone in the soft parts (perforation of the skin from within); impaction of the fragments, *in which case it is not always proper to separate them;* and certain unusual complications, such as shattering of the bone, a complicating luxation, etc.

Too much stress cannot be laid on the importance of perfect reduction; it is often the deciding factor in the prognosis, and as it cannot always be effected even under anesthesia, it is justifiable with our present aseptic methods to cut down on the bone even in a subcutaneous fracture for the purpose of obtaining complete reduction, and, if necessary, wiring the fragments in their corrected position.

Dressing.—Since the object of the dressing is to place the fragments at rest, it must include the broken bone and the *two contiguous joints.* The materials used are pillows, splints, wire gutter-splints, and more complicated apparatus. In a case of emergency, and during the first transportation of the patient, a broken arm may be bound fast to the thorax; in a case of fracture of the lower extremity the sound limb may be used as a temporary splint. The commonest surgical dressings at present in use are those that harden after their application, especially plaster-of-Paris bandages. Splints or extension by means of weights are also employed.

While it is undoubtedly true that good results may be obtained in the treatment of fractures in a variety of different ways or by the exclusive use of any one of the various methods of dressing, provided the surgeon possesses some measure of skill and experience, there are nevertheless certain fundamental principles that should be observed in order to avoid unpleasant consequences.

The choice of the method in the beginning is determined by the position of the fragments after reduction.

If reduction has been correctly carried out and the resulting position can be maintained, the subsequent treatment consists solely in retaining the fragments in good position. This may be done by means of any firm bandage, such as splints, plaster bandages, etc., and is usually quite easy in transverse fractures and in many oblique fractures. If, however, the fragments have not been successfully replaced and there is more or less tendency to secondary dislocation; if, for instance, one or the other fragment is subject to the unopposed action of a muscle, especially in oblique fractures, the aim of the treatment should be to bring about, if possible, a permanent condition like that which is produced temporarily when a fracture is properly reduced by traction and countertraction; in such cases an extension apparatus is indicated. Extension is almost always effected by means of weights permanently attached to the limb and varying in size with each individual case, or by means of the tension exerted by elastic bands. The extension treatment is, of course, applicable to the first group of cases as well, and has the advantage of allowing free access to the seat of fracture; but it requires more constant supervision on the part of the surgeon and, as a rule, keeps the patient in bed longer than any other method of treatment.

The treatment by means of splints and plaster-of-Paris also requires careful attention and the strict observance of certain rules. The older physicians not infrequently applied a plaster bandage to a recent fracture at their first visit and left the bandage in place for weeks until union was supposed to have taken place. *This procedure is to be condemned absolutely*, for it necessarily results in more or less deformity. In applying the primary dressing the surgeon must keep in mind that the limb will be enlarged at the seat of fracture by swelling of the soft parts which is often considerable; hence, to allow room for this swelling to take place, the first dressing must contain plenty of padding. It must, of course, be properly applied, and must include the contiguous joints, but it should consist largely of loose material such as cotton-wool, so as to allow for the expected increase in size. [Pieces of blanket properly folded undoubtedly make the very best padding material, not only to pad splints, but in the form of a roller bandage beneath the plaster cast (Halsted).—Ed.]

In the absence of special indications the first change of

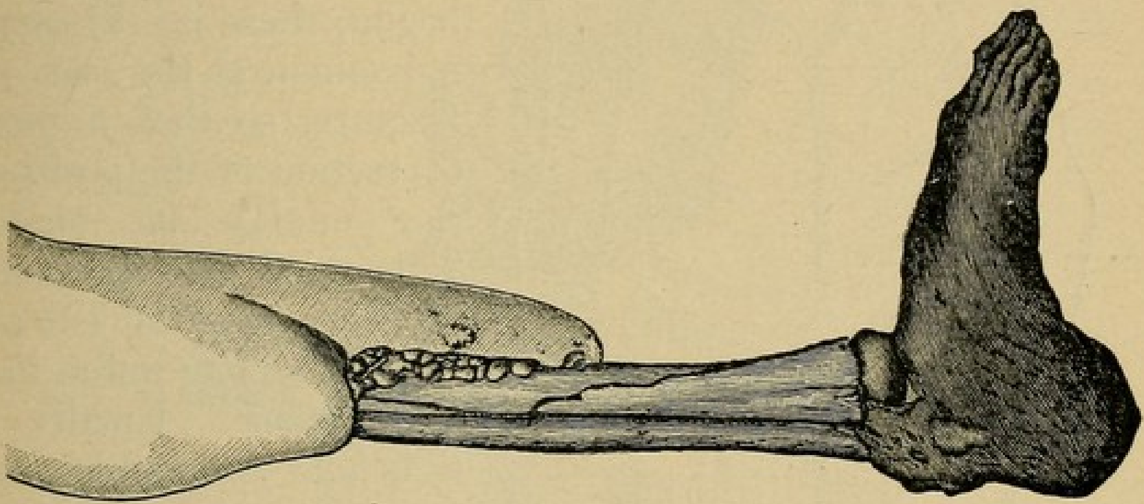

Fig. 13.—Gangrene after simple fracture of the leg, due to tight bandaging. The primary dressing with splints was left in place for twenty-three days in spite of bluish-red and, later, black discoloration of the toes, and violent pain. The bones of the leg below the line of demarcation are seen to be macerated. The foot is mummified and held together by the desiccated ligaments. This is the condition found fourteen months after the injury (after Bruns). [Gangrene is less frequently caused by tight bandages than by an overlooked injury to the arteries with rupture or thrombosis.—Ed.]

dressing should take place on the eighth day. By that time the swelling will have at least partially subsided and the dressing, becoming looser, might permit displacement of the fragments. The second dressing is then applied over the seat of fracture with little or no padding, after the position of the fragments has been carefully ascertained. I prefer the wood-felt (Holzfilz) manufactured by Hermann in Heidenheim, as it is both soft and firm and keeps the skin dry. This second dressing should again be changed about a week later; that is to say, the second change of dressing should take place about two weeks after the injury. By that time the swelling has disappeared completely, and although callus-formation has begun, there is still some movement at the seat of fracture, so that a final correction of the position can easily be made. This third dressing may in some cases be left on until complete union has taken place. Finally a light and removable protective bandage should be worn as long as may be necessary in the individual case. It should consist preferably of light splints or a cut plaster-of-Paris or silicate of lime cast.

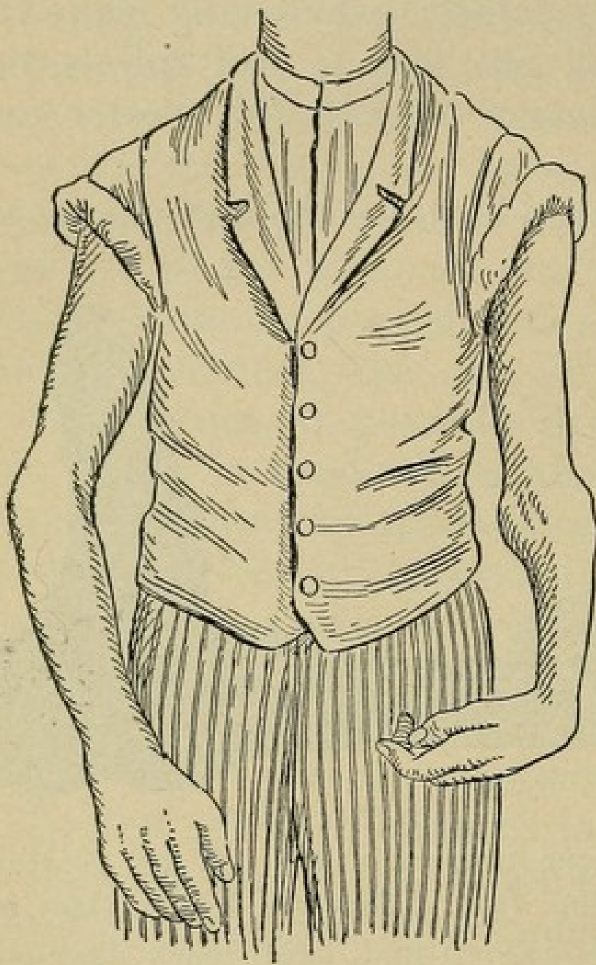

Fig. 14.—Paralysis and contracture of the muscles of the forearm due to ischemia, in a young man seventeen years of age, following fracture of the lower end of the humerus ten years before. The primary dressing consisted of a closely fitting plaster-of-Paris cast. [The cause of the muscular contraction in this case was probably due to an interstitial myositis (Tillman), in which the muscle is replaced by scar tissue.—Ed.]

Unless it is especially indicated and the patient can be examined daily, the first dressing of a recently injured limb should *not* consist of a circular plaster-of-Paris bandage. Splints are very much to be preferred. Failure to observe this rule is responsible for many disastrous results. A tight plaster-of-Paris bandage has in a number of cases led to compression at the seat of fracture, producing ischemia, paralysis, and contracture or even gangrene of the entire extremity, and many a surgeon has been held responsible for such results and gotten himself into serious trouble.

All the cases of ischemic paralysis and contracture

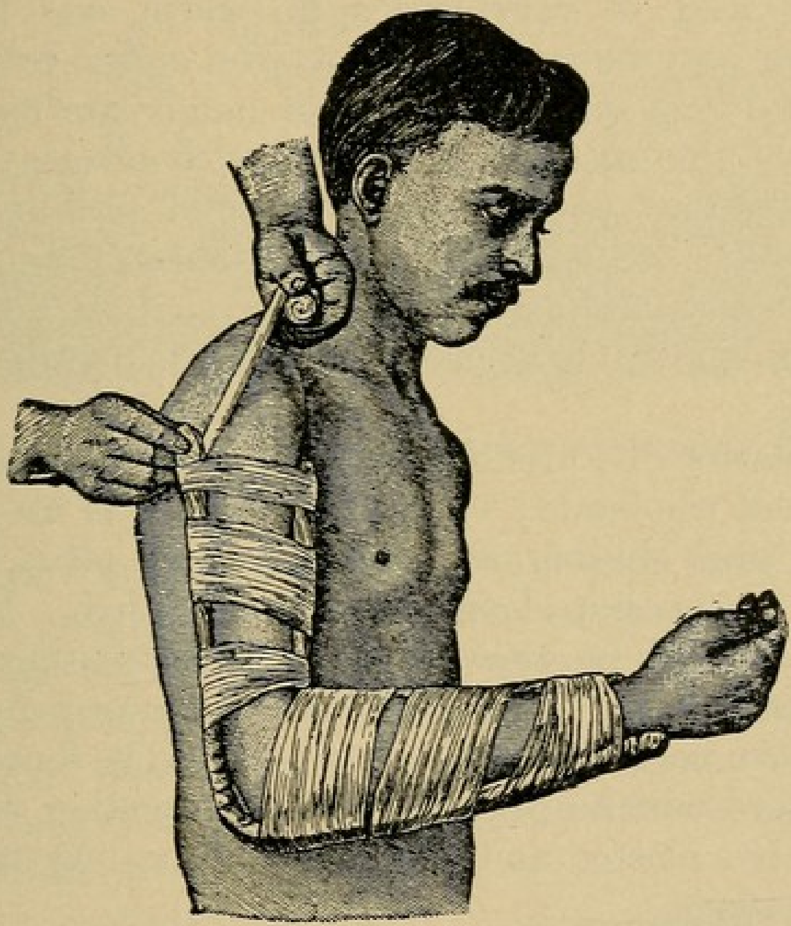

Fig. 15.—Fixation bandage with two padded strips of lead, bent so as to conform accurately to the shape of the arm flexed at a right angle at the elbow. The illustration shows the upper extremity of the posterior splint being fixed by the bandage.

(Volkmann) that I have seen were due to this practice of dressing a recent fracture with plaster-of-Paris. The prolonged interference with the blood-supply of the muscle leads to disintegration of its elements, the muscle loses its elasticity and becomes shortened and rigid (contracture). The irritability of the nerves remains intact, while that of the muscle-fibers disappears more or less completely, depending on the severity of the case.

The best splints for use in the treatment of fractures are flexible metal splints, or plaster-of-Paris splints prepared for each case (Beely's combination splints of plaster-of-Paris and hemp). Of the former, I prefer either the wire splints proposed by Dr. Cramer, or narrow padded strips of lead of varying length, width, and thickness. The latter may be padded with cotton and a covering of gauze, and kept on hand ready for immediate use. With the aid of two such strips and a few bandages a broken limb can at once be fixed in any desired position. These strips, which are used in the Münchener Poliklinik and in Greifswald, and have recently come into vogue here, are, as I know, being used daily by many of my own students.

The plaster-of-Paris dressing is not by any means to be condemned wholesale; on the contrary, it is an excellent bandage for holding the fragments in place after the swelling at the seat of fracture has subsided. It is particularly useful in view of the modern treatment by frequent massage of the seat of fracture, especially when it is cut down each side with a saw so as to be separated into two gutters which are easily fastened together with strips of adhesive plaster and secured with a few turns of a roller bandage.

[This criticism of plaster-of-Paris as a primary dressing in fractures is a very just one. One inexperienced in the treatment of fractures and in the use of plaster-of-Paris should never use this as a first dressing. On the other hand, as we become more experienced we use plaster-of-Paris more frequently as a primary dressing.

I believe most surgeons and practitioners err on the side of too infrequent rather than too frequent dressings in fractures. The second dressing should always be made within the first six to ten days, because within this time it will be possible to correct any displacement. The advantages of more frequent dressings are: It allows the bathing and rubbing of the skin, so important in maintaining a better circulation; it decreases the danger of atrophy or inflammation of the muscles from continuous pressure, and the danger of pressure necrosis of the skin over the more ex-

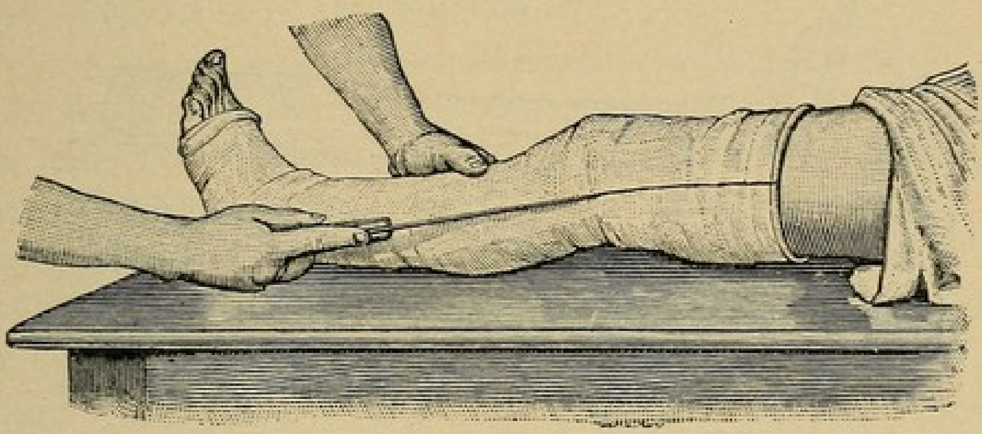

Fig. 16.—Plaster-of-Paris dressing cut down the side with a saw.

posed bony prominences, and where pads have been used to exert pressure in certain forms of fractures. In fracture of the leg the possibility of pressure necrosis over the tendo Achillis, over the malleoli, and across the dorsum of the foot must always be borne in mind. This is frequently neglected, especially in inexperienced hands. Not only should these points be carefully protected by padding, but they should be frequently inspected. The pressure spots at the position of the pads in Colles' fracture are also frequently observed in the hands of inexperienced practitioners. Until one's experience in the dressing of fractures has become large, and until one is quite familiar with the application of the different dressings, early inspection after the first dressing (two to four days) and more frequent subsequent dressings will practically eliminate the dangers and com-

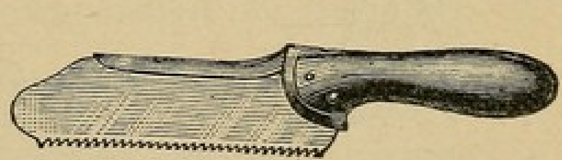

Fig. 17.—Saw for cutting plaster-of-Paris dressings.

plications just mentioned. Eternal vigilance is a good rule in fracture dressings.—Ed.]

For the padding of a plaster-of-Paris dressing I use only the tricot sleeve-bandage, which can be made to lie perfectly smooth over the extremity. This sleeve-bandage

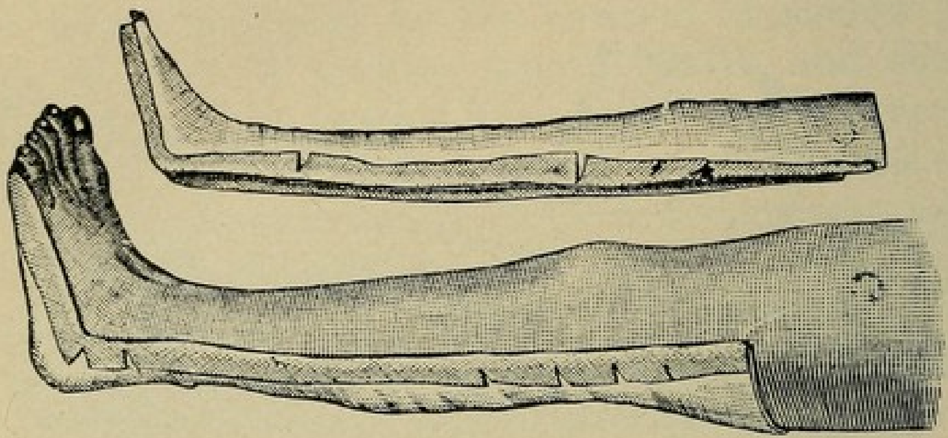

Fig. 18.—Plaster-of-Paris dressing, converted into two accurately fitting gutters by cutting it down the side. The cut edges are bound with adhesive plaster.

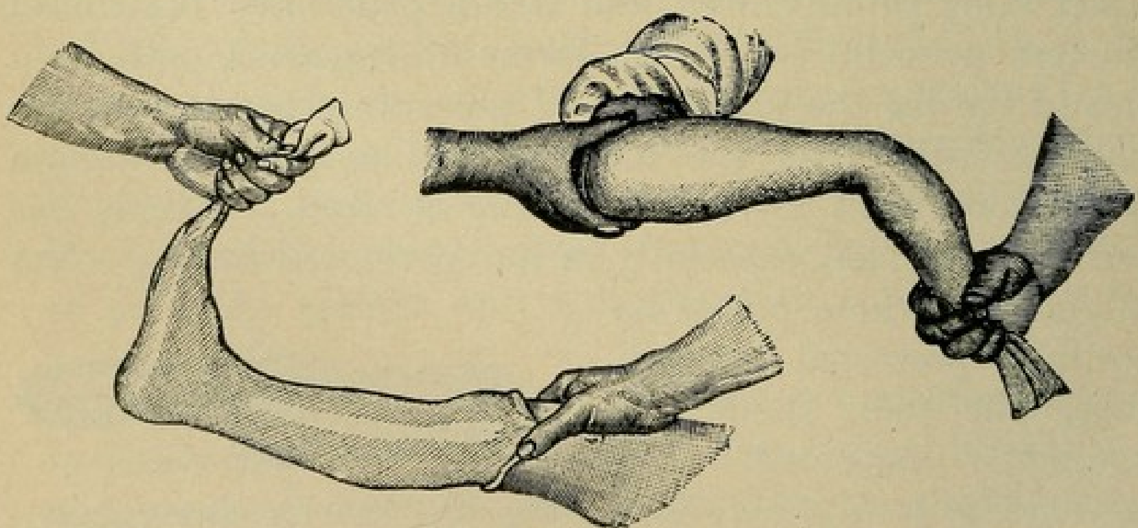

Fig. 19.—Showing how the hand and foot are held in the desired position by the tricot sleeve-bandage, while the plaster-of-Paris dressing is applied.

has the additional advantage that the overhanging ends can be utilized to hold the end of the extremity,—hand or foot,—while the plaster-of-Paris dressing is applied, thus taking the place of the loops ordinarily used.

In applying a fixation bandage direct pressure on the seat of fracture must always be avoided. Fixation is obtained not by direct pressure, but indirectly, so to speak, by placing the contiguous fragments in the proper position. Incidentally, it hardly needs to be mentioned that any other prominences must also be protected against pressure and the formation of pressure-sores.

The use of an extension apparatus with permanent extension by means of weights is not confined to fractures of the thigh. They may quite properly be employed in the treatment of fractures of the upper extremity, as, for example, fracture of the neck of the humerus or of the elbow-joint, and in fractures of the vertebral column, etc. The technic of these dressings must be learned by actual practice, which can readily be obtained in any surgical clinic.

Adhesive plaster is now chiefly used for extension dressings, the American elastic plaster, if necessary on a foundation of sail-cloth, being preferred, as it is strong enough to bear considerable weights. To avoid irritation of the skin I sometimes find it advisable, especially in summer, to reinforce—double, as it were—the long strip of adhesive plaster by interposing a strip of zinc plaster mull, so that the latter alone comes into immediate contact with the skin, while traction is accomplished by the strip of adhesive plaster.

Strips of buckskin have also been used quite recently in extension dressings (Heusner). The adhesive material is made according to the following formula :

℞. Ceræ flavæ.		
Resinæ Damarah.		
Colophon..	āā	10.0
Terebinth.		1.0
Æther.		
Spirit.		
Ol. terebinth.	āā	55.0
Filter.		

This mixture, which can be kept as long as desired in a well-stoppered bottle, is not to be smeared on the strip of cloth, as might be supposed, but is to be applied with an insufflator so as to form a thin layer on the part of the body which is to receive the dressing. The two strips of cloth, which should be about 3.5 inches wide, are then applied along the limb, the ends being allowed to hang over for the attachment of the pulley rope. The strips are held in place by wrapping the limb first with mull and then with a gauze bandage. If the part is one that cannot be bandaged in this way, the method cannot be used. A very considerable degree of traction can be applied to the limb by this method, which has the advantage that the strips of cloth can be readily removed, after the outer ban-

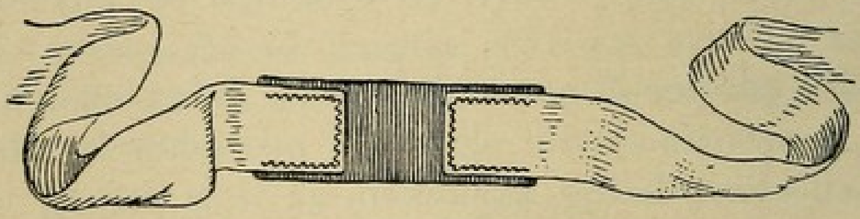

Fig. 20.—Adhesive strips and elastic cloth (congress) with which extension of any desired strength can be effected.

dages have been cut, and used a second time. The skin must be carefully washed with soap.

In addition, some practical arrangement is needed for attaching the weights, such, for example, as a ring tied to the end of the strips, into which may be inserted the ring or hook attached to the cord that supports the weights (sandbag, bricks, etc.). Chafing of the limb must be avoided as much as possible by the use of a sliding footrest, etc., and by placing a tightly wound roller bandage or small wooden rollers under the limb.

The extension method is used in the treatment of fractures of the long bones. It is especially recommended by Bardenheuer. This surgeon uses lateral as well as longitudinal traction, and gets very good results (see page 61).

Many other surgeons, to my personal knowledge, have worked up the technic of the extension method and prefer it in the treatment of fractures of the extremities. Bliesener's article [1] contains detailed descriptions of all the extension dressings used by Bardenheuer.

The effect of traction or pressure can also be obtained with the aid of pieces of elastic bandage, rings, etc., inserted in the dressing. A combination of adhesive strips and a piece of elastic cloth, as suggested by Thiersch, is both convenient and effective, and is being employed quite extensively. I frequently use elastic strips of this kind, especially in the treatment of fracture of the clavicle.

Other methods are now in vogue for the treatment of certain fractures; but while they may give excellent results in the hands of specialists, they are hardly to be recommended to the general practitioner. There is no doubt that primary bloody suture of the fragments in fracture of the patella gives excellent results in the hands of a trained surgeon; or that the treatment of fractures of the lower extremities by the ambulatory method is frequently successful; and it is true that in the treatment of typical fractures of the lower radial epiphysis it is recommended to discard bandages altogether and treat the fracture by simple position in a mitella; but in general practice these and other similar methods are, in my judgment, out of place.

The so-called *ambulatory method* has recently gained a great number of adherents. For my part, I still adhere to the principles that I have just now outlined: The ambulatory method may yield very good results in important fractures of the lower extremities, but the technic of applying the cast is difficult and the dressing requires constant, careful supervision as long as it is worn; in other words, the danger of complication interrupting the course of recovery is greater in the ambulatory than in any of the other methods in ordinary use.

[1] Deutsche Zeitschr. f. Chir., vol. LV, p. 277.

On the other hand, the ambulatory method has the following advantages: Inflammatory diseases of the respiratory organs, such as bronchitis or hypostatic pneumonia, are rarer even in old subjects; delirium tremens even is said to be less likely to develop; it is the best means of avoiding atrophy of the muscles and rigidity of the joints; the callus-formation is abundant, and it is said that insufficient callus-formation is very rare when this method is employed. While some authorities reject the ambulatory method altogether, and others use it as soon as possible after the injury, I often follow a middle course in my clinic. After the swelling has subsided and the fragments are in good position, a firm bandage is applied and the patients are allowed to walk about at the end of the second or third week. At the beginning the pain of putting the foot to the ground will be materially lessened if some form of walking apparatus, like the "walking chairs" of children, is employed.

After the fracture has become firmly united, the **after-treatment** is of the greatest importance for restoring the function of the injured extremity. In this respect there has been a marked improvement in recent times and much more is done to achieve a good result. Massage and passive movement to combat the stiffness of the joints due to prolonged fixation may, with proper care, be begun as early as the date of the first change of dressing. After the fracture has become united, both these procedures assume a very important rôle. At the same time warm baths, needle douches, the use of certain kinds of bandages, and especially medico-mechanical apparatus, are of the greatest value.

The treatment of **joint fractures** calls for special consideration. In a joint fracture the injury to the articular process of the bone leads to grave injuries of the joint itself, the capsule of which becomes filled with extravasated blood. This class includes the typical fractures of the radius, fracture of the ankle (Pott's fracture), and fracture of the surgical neck of the humerus. It is in these cases that it is most difficult to get firm union of the bone with a good movable joint. The dressing in these injuries must be changed every second or third day for the first two weeks, and later every day. To facilitate the resorption of the blood, if it has not been removed by puncture, moderate pressure and massage with passive movements at each change of dressing are advisable from the very beginning. The extremity must be fixed in various positions; active movements should be encouraged as early as possible, and mechanical apparatus may be employed. A treatment of this kind gives the physician a great deal of trouble, for which, however, he is amply rewarded if he can achieve union of such a fracture with a good movable joint.

A similar mode of treatment has been recently recommended by many physicians for all kinds of fractures. It is, however, unnecessary and cannot be carried out, especially in large practice.

[Wolff[1] recommends extension in fractures about the elbow-joint, and gives an illustration of an apparatus which not only produces extension, but allows frequent changes in the position at the elbow-joint. Similar mechanical devices have been devised for fractures about the knee and ankle. The apparatus is expensive; one must have a large assortment, or they must be made for each case. I agree with the author that the results obtained are no better than those in which simpler methods have been employed.—Ed.]

In conclusion, a few words in regard to *badly united* or, better, *unfavorably united* fractures. Notwithstanding the exercise of the greatest care, it may occasionally happen that the physician is not quite satisfied with the result of his treatment; besides, many cases of deformity due to an old fracture have to be treated, partly because of the folly and disobedience of patients, and partly because of the

[1] Deutsche Zeitschrift für Chirurgie, 1900, Bd. LIV, p 287.

bungling work of quacks. In all such cases no time should be lost in correcting the deformity, by violent means if necessary. To accomplish this the bone may have to be broken artificially with the aid of an osteoclast, or osteotomy may be required. After the operation a correct position of the fragments is secured by manipulation and maintained by permanent extension by means of weights. The proper position is to be maintained until firm union again takes place. Operative intervention is distinctly indicated also in badly united joint fractures.

It has been pointed out repeatedly that the position of the fragment can be constantly controlled by means of X-ray pictures during the course of treatment. Accordingly, I find that I now resort to operation much earlier than formerly, either in order to replace the fragments more accurately or for the purpose of wiring the fragments together. The success I have had in such cases impels me to resort to operative intervention more and more. Such operations are to be carried out according to generally accepted rules, and their description does not belong to the scope of this work. It is important, however, that every physician who treats patients with fractures should realize his responsibility from the beginning, and should remember that with our present knowledge of diagnosis and therapeutic methods a good result can and must, as a rule, be obtained in the treatment of fractures. [With the present

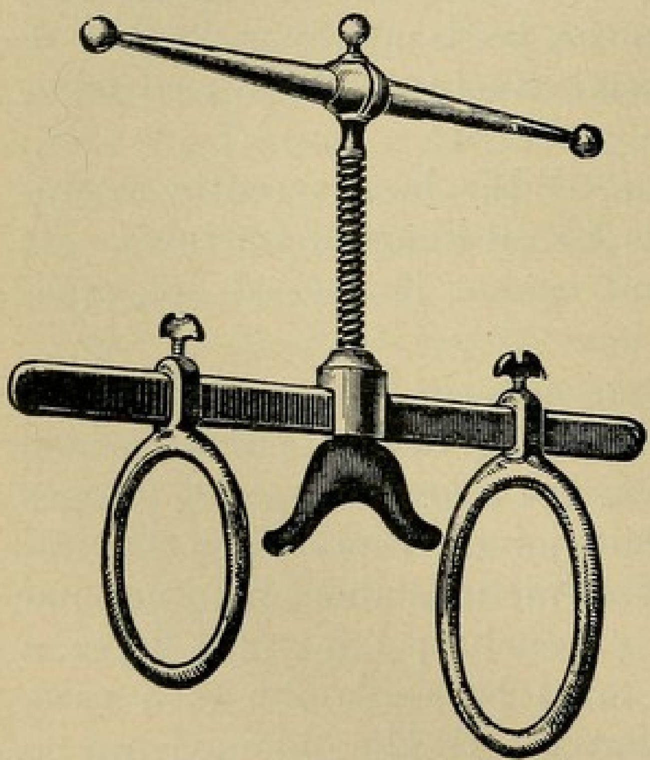

Fig. 21.—Rizzoli's osteoclast.

more perfect technic a surgeon should never hesitate to operate in a case of fracture. In badly united fractures it is much better to operate than to use great force in an attempt to refracture. If the badly united fragments cannot be broken with the use of moderate force, it is a much wiser and safer procedure to expose the bone by incision and separate the fragments with a chisel, because it allows us to control absolutely the line of fracture. The use of greater force by means of an osteoclast (Fig. 21) is not free from danger, and we cannot always control the line of fracture.—Ed.]

DISLOCATIONS

The extent of the movements in normal joints is in many cases limited. In every joint there is some provision which prevents the movement from going beyond a certain definite limit. In some of the joints this inhibition is effected by the shape of the bones, in others by the action of ligaments, and in a third class by the action of muscles. We therefore speak of muscular, ligamentous, and bony inhibition of joints. Bony inhibition is absolute, while muscular inhibition varies according to the elasticity and extensibility of the muscles concerned. As examples may be mentioned the great mobility of the wrist in piano performers, and the contortions of so-called india-rubber men, which can only be achieved by exercise directed toward the diminution of muscular inhibition.

There is a limit to the motion of any joint, beyond which, if motion is continued, injury to the articular apparatus, a laceration of the capsule or other ligaments, takes place; such an injury we designate by the term *sprain* (*distorsio*). If the injury to the articular apparatus is severe enough, a *dislocation* (*luxatio*) is produced, in which the normal contact between the articular extremities of the two bones is completely abolished, one of the extremities with few exceptions being thrust more or less completely through the tear in the capsule. As in the case of fractures, we have *traumatic*, *pathologic*, and *congenital* dislocations. The latter depend on true developmental errors or on displacement occurring *in utero*. Pathologic [spontaneous] dislocations occur only after marked alteration of the joint by pathologic processes, especially pyogenic and tubercular osteomyelitis and chronic hydrarthrosis with extreme distention of the capsule and ligaments.

[In dislocations from slight injury, especially recurrent ones, the possibility of syringomyelia as the cause of the joint changes allowing the easy dislocation should always be borne in mind. This is most frequently observed at the shoulder.—Ed.]

Traumatic dislocations, which are the only ones that we shall speak of here, are produced by injuries affecting the joint directly or indirectly. Luxations may even be produced by intense muscular action in sudden violent movements.

Dislocations are, of course, more frequent in men than in women, and in adults up to beginning old age than in children. In children under ten years of age dislocations are extremely rare. It is worth noting that out of 100 luxations collected by Krönlein, 92.2 were in the upper, 5 in the lower extremity, and 2.8 in the trunk.

Dislocations due to direct violence are rare. In this class the traumatism acts at the region of the joint and produces a dislocation; just as a fracture is produced in a bone by direct violence. In the production of an indirect dislocation the movement of the joint is carried beyond the utmost limit of physiologic excursion, the normal inhibition being overcome by the leverage of the long fragment of the shaft. The short arm of the lever (head or articular extremity of the bone that becomes dislocated) is forced outward in a certain direction, gaining a purchase on the edge of the articular cavity, the capsule, a ligament, or a neighboring bony process, and its contact with the opposed articular surface is abolished. The capsule, after suffering enormous distention, gives way and the head of the bone escapes through the laceration, assuming a definite position which is determined by the shape of the bone and of the surrounding soft parts, and by the action of the ligaments and muscles,—the dislocation is complete.

A dislocation is always described in terms of the peripheral part of the skeleton. Thus, for example, a dislocation of the shoulder-joint is spoken of as a luxation of the humerus. The direction is also described according to that taken by the peripheral bone; thus, for example, luxation of the humerus in front of the glenoid fossa when the head of the humerus lies in front of the articular cavity.

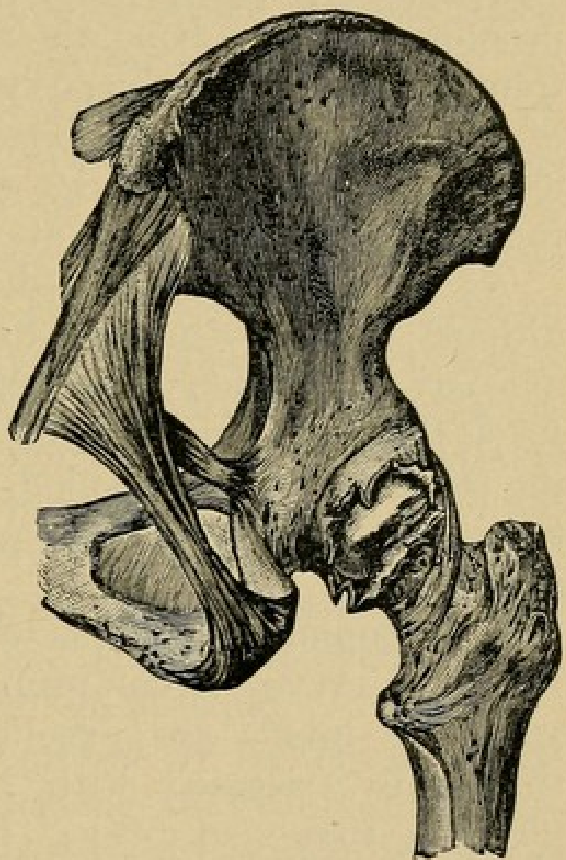

Fig. 22.—Laceration in the capsule on the posterior aspect of the hip-joint.

The *symptoms* of a recent dislocation are, as a rule, very striking. The absence of the articular end of the bone from its normal position and its presence in an abnormal position produce a very distinct deformity which could be disguised only by a very great extravasation of blood. The position of the dislocated limb is almost always quite characteristic, and it is frequently possible to make the diagnosis by inspection alone; besides, the position is, as a rule, typical in each form of luxation, because it depends on the action of certain portions of the capsule and ligaments which remain intact in regular forms of luxation. The dislocated limb persistently assumes its new position; that is to say, while it may be forced to perform the normal excursion (destroyed by the luxation) by means of external pressure and traction, it immediately returns to its abnormal position as soon as the pressure is removed. The last-mentioned symptom is the most important one in the differential diagnosis between dislocation and fracture, as this tendency to return to the abnormal position is *absent* in fracture of a joint. There are other important symptoms in dislocation, such as the absence of the normal prominence of the bone, the ability to feel the articular extremity in an abnormal position, and the altered direction of the long axis of the bone. Mensuration is sometimes useful, as some dislocations are characterized by lengthening instead of shortening of the affected extremity.

As in fractures, so in dislocations, there may be additional injuries—injuries to nerves and blood-vessels, or extensive laceration of the soft parts surrounding the joint. Even the outer skin may be injured, lending to the injury the character of a compound dislocation; in such cases the treatment must be carried out according to strict aseptic principles.

[Compound dislocations without fracture are rare. The results, however, from proper treatment instituted early after the injury are excellent. The wound should be thoroughly irrigated with 1 : 1000 bichlorid, and loose pieces of tissue cut away. In many instances the capsule of the joint can be sutured and the wound closed without drainage. If later the joint becomes distended with effusion it should be aspirated. The introduction of gauze and drainage-tubes into the joint should be condemned. They irritate the synovial sac and increase the danger of subsequent ankylosis. If drainage is indicated, a small piece of rubber tissue answers the purpose best. In the majority of cases it is better, however, to close the joint capsule at once, and if indicated drain only the superficial wound. I believe that improper drainage in joint injuries is more frequently the cause of secondary infection and restricted motion than the injury itself.—Ed.]

The diagnosis is sometimes very difficult when the dislocation is complicated by a fracture. This rare complication is usually produced by the external force continuing to act after the luxation has been produced.

The treatment has for its object the restoration or replacement of the dislocated bone (reduction). While it was formerly customary to employ great force in the reduction of a dislocation,—a proceeding which was not infrequently followed by grave consequences, such as the laceration of large vessels and nerves and the fracture of bones,—the general practice nowadays is to effect reduction by manipulations based on a careful study of the anatomic relations and without the use of great force—generally under anesthesia. The rule that the reduction must be accomplished by forcing the dislocated extremity over the same path which it followed in the production of the dislocation is in the main correct. The manipulations should not be determined by thumb rule, but by accurate knowledge of the position of the articular head, of the tear in the capsule, and of the surrounding soft parts. "Our therapeutic actions nowadays are determined primarily by the anatomy of the dislocation" (Krönlein).

Successful reduction is recognized by feeling the bone glide back into place, and observing that the normal outline of the articular region and the normal mobility of the joint have been restored, while the tendency to return to the abnormal position has disappeared.

With regard to the subsequent course, after reduction, the following points may be of some importance. Under normal conditions, if rest has been secured by appropriate dressings, the tear in the capsule heals, the extravasation of blood disappears, and the slight synovitis which is the expression of irritation in the joint subsides in from one to two weeks. As soon as possible, even before the end of this period, massage and careful passive movements can and ought to be instituted. If, as occasionally happens, pain and symptoms of articular irritation return, massage must be discontinued or at least performed with great gentleness. After the third week the excursions are to be increased and active exercises with the use of apparatus indicated. Eventually a complete restoration of function should be aimed at.

[The after-treatment of a dislocation is quite as important as that of a fracture. It must be remembered that besides the tear in the capsule other important ligaments may be stretched or torn. The proper healing of these fibrous structures takes a number of weeks, and during this time the joint, although it may be used to a certain extent, should have some form of support. If this is neglected, a permanent disability in the form of a weak joint or a tendency to recurrent dislocations from slight trauma may result. Hasevroek [1] has called attention to the necessity of this longer support, and describes and illustrates a number of simple apparatus which not only give support, but allow certain motions of the joint.—Ed.]

The term *habitual dislocation* is used to designate the frequent recurrence of a dislocation, often under the influence of quite inconsiderable force. The patients are perfectly aware of their condition and usually have their diagnosis ready when they consult the physician ; not a few are able to reduce the dislocation themselves. The cause of habitual dislocation is usually to be sought in extensive injury of the joint leaving an abnormally broad insertion of the capsule. For the treatment, such measures as prolonged immobilization and the injection of alcohol to produce shrinking of the tissues have been recommended. In very bad cases resection has been performed. It might be wise to try arthrotomy and partial extirpation of the capsule.

[I do not believe that injections of alcohol or any other substance should be used. Prolonged fixation should be first given a trial with the form of apparatus recom-

[1] Münchener med. Wochenschrift, 1899, vol. XLVI, p. 93; reviewed in Progressive Medicine, December, 1900, p. 168.

mended by Hasevroek, which allows some joint motion. If this fails, exploratory arthrotomy should be performed. In some cases the cause will be found to be quite simple, such as a loose cartilage, or a stretched or torn ligament. The cartilage should be removed and the ligament fixed by suture. Other cases will be more complicated. The condition, however, must be rare, because there is little in the literature on the subject, and even in a large surgical experience one observes these cases very infrequently.—Ed.]

Under certain circumstances a dislocation may be irreducible. It may happen that, in spite of persistent efforts at reduction under anesthesia, it is found impossible to put the bones in place. Failure may be due to the small size of the tear in the capsule, but, as a rule, it is due to the interposition of soft parts. If the edge of the articular surface was broken by the injury, it is evident that reduction may be impossible. In all such cases bloody reduction of the dislocation ought to be resorted to as early as possible. The joint must be opened as much as may be necessary to effect reduction.

[In experienced hands, when reduction of a dislocation fails after the proper trial of the usual methods one should never hesitate to operate at once. Prolonged and forcible attempts at reduction are dangerous. With proper technic the operation is a very simple matter, and seldom fails to reduce a recent dislocation. In the majority of instances one will find a sufficient cause which prevented the usual easy reduction of the dislocation; for example, a small fragment of bone, or an interposed tendon or muscle. —Ed.]

If a dislocation is not reduced, there results the condition known as an "*old dislocation*," complicated frequently by the formation of a new joint (a nearthrosis). Therapeutic measures in such cases will be determined by the conditions found on careful examination. If the function of the new joint is satisfactory, as happens in very rare cases, no interference is indicated, and the surgeon should confine his efforts to enhancing the mobility of the new joint by means of passive exercises, etc.; but if the opposite is the case, there is nothing left but resection or arthrotomy, followed by the replacement of the dislocated articular head in the original cavity. The latter should be the usual procedure, if for no other reason, because these cases of unreduced luxations are presenting themselves for treatment earlier than they used to, and because the results obtained by replacement are, as a rule, much better than anything that can be hoped from resection. It is always more desirable, however, that reduction be effected as early as possible.

[There is really no necessity for an old dislocation. In the recent state reduction is always possible. Nevertheless many cases come to the surgeon. The same rules should be followed in the reduction as those advised for recent dislocations: first, an attempt at reduction without operation, always under anesthesia; if this fails, an immediate operation, so that the patient is subjected to only one narcosis. In some cases of old dislocations resection gives much better results than reduction; this is especially true at the shoulder and elbow. The functional result of a proper excision of these joints is always excellent. On the other hand, in cases in which perfect reduction is possible, the joint changes from the old injury are so advanced that marked restriction of motion is always present, and the function of the arm is never as good as after a resection. Experience and the study of the soft parts around the joint will usually indicate the better procedure.—Ed.]

II. FRACTURES OF THE SKULL

In the study of fractures of the skull it is of interest to know that the doctrine of a certain elasticity of the skull promulgated by Bruns has been confirmed by recent investigations carried out with the best instruments and under the observance of all necessary precautions. The skull, in fact, possesses a certain elasticity; and a force acting on it from without must overcome the limit of its elasticity before producing a fracture. This is equally true of fractures of the base of the skull.

(A) FRACTURES OF THE SKULLCAP

In fractures of the vault of the cranium it is noticeable that the inner table suffers more extensively and exhibits

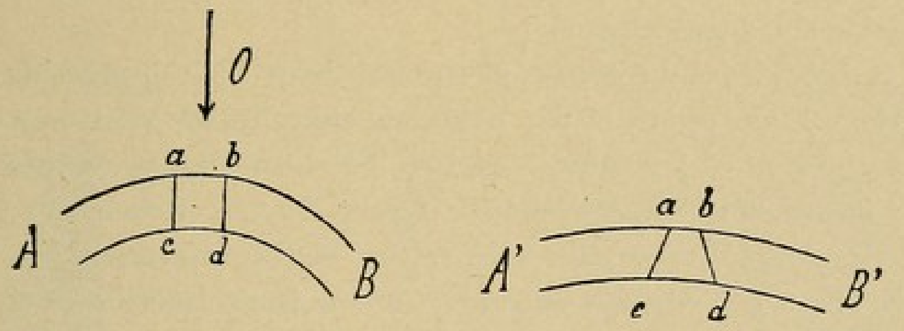

Fig. 23.—*A B* represents the segment of a skull, *a b* showing the points of impact of an external force. The first effect of the force is to produce a certain flattening of the skull, as at *A′ B′*; at the same time the point of impact at *a b* is compressed and the corresponding portions of the internal table are stretched, the particles of bone being pulled apart to the point of bursting. This is readily understood by comparing the quadrilateral *a b c d* in the two figures. (After Teevan.)

greater dislocation of its fragments than the outer table. This phenomenon was formerly explained by assuming a greater brittleness for the inner table, which was accordingly named *tabula vitrea*. In recent times it has been found that the phenomenon depends on certain simple mechanical laws, and that in any injury of the vault that table which is furthest removed from the injuring force suffers the most extensive fracture. A glance at the illustration on Plate 9 suffices to show the important fact that an injury of the vault of the cranium from within—that is, from the cavity of the skull—produces the same appear-

PLATE 9.

Fractures of the Vault.—Fig. 1.—Gunshot wound from without and from within. Fragment of the skullcap of a cadaver showing the marks of two bullets fired with a small charge of powder, one bullet striking from without, the other from within. The direction of the bullets is indicated by arrows. The section shows that the point of entrance represents a round hole, while the point of exit is marked by a larger and more irregular loss of substance. (Author's collection.)

Fig. 2.—Effect of a projectile with low velocity discharged from without (artificial). The force was not sufficient to perforate the skull; the point of impact on the skull is marked only by a slight depression, while the internal table shows extensive shattering of the bone. (Author's collection.)

Figs. 3 *a*, *b*, *c*.—Old fracture of the skullcap with depression of the fragments. Firm union of the bone had taken place with some thickening at the seat of fracture. Figure 3 *a* shows the preparation from within; figure 3 *b*, from without; figure 3 *c*, in transverse section. In this preparation also the splintering of the internal table is more extensive than that of the external. (From the collection of the Path. Anat. Institute at Greifswald.)

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ance of more extensive shattering on the outer table as is usually seen on the inner table under ordinary circumstances, when the injuring force is applied to the skullcap from without. According to Teevan, it appears that the effect of a force acting from without, such as a spent ball, a small stone, or a stick, is to induce a certain bending of the skullcap at the point of impact. This bending process, as long as it is confined within the limits of elasticity, produces only a slight flattening of the normal curve of the bone. The particles of bone in the external table are compressed, while those in the internal table are distended; *i. e.*, forced apart. Just as when a stick is broken over the knee the fracture begins on the convex side,—that is, the side on which distention and separation of the particles take place,—so in the same way the fracture begins and becomes most extensive on the distended side of the skull

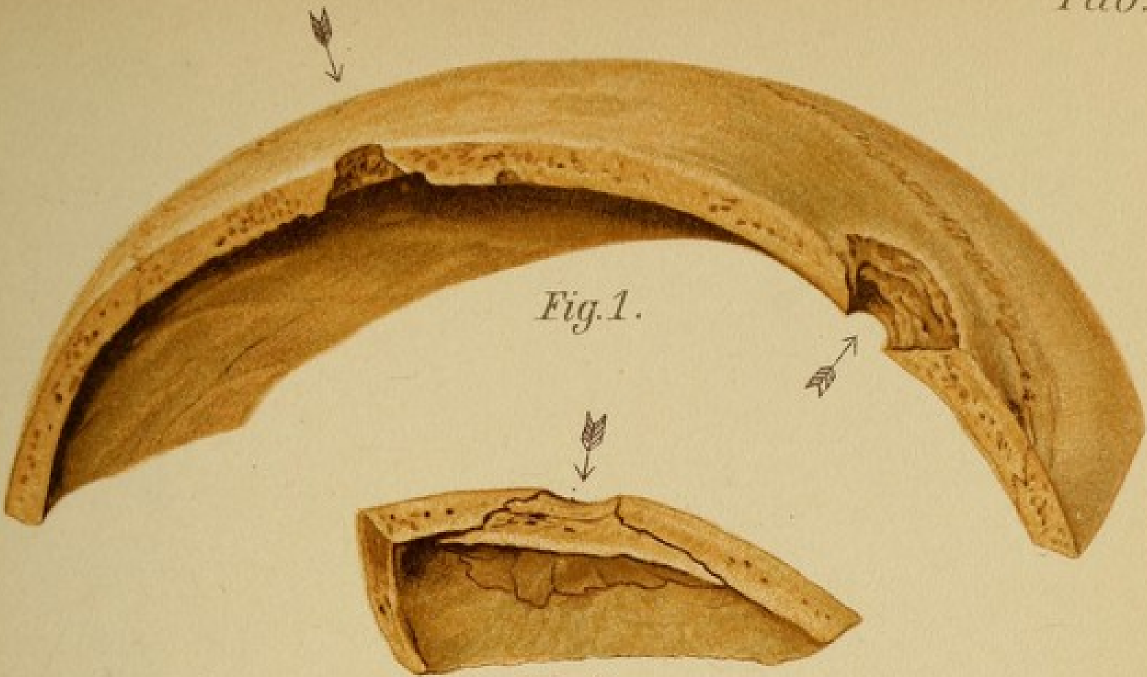

Fig. 1.

Fig. 2.

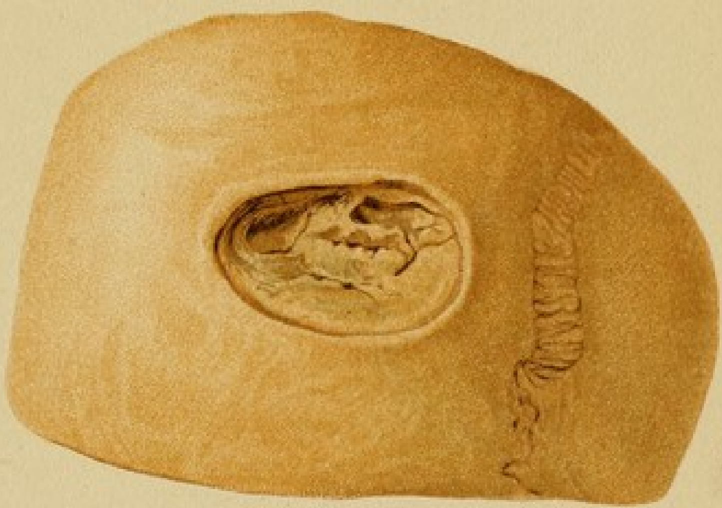

Fig. 3 b

Fig. 3 c

Fig. 3 a

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which is furthest removed from the injuring force. This explanation is confirmed by numerous preparations as well as by experiments, and is now generally accepted.[1]

The correctness of this theoretic view is proved by a few preparations obtained from the skulls of suicides who ended their lives by shooting themselves through the mouth. In these cases the fracture of the so-called vitreous table is slight, while that of the external table is quite extensive.

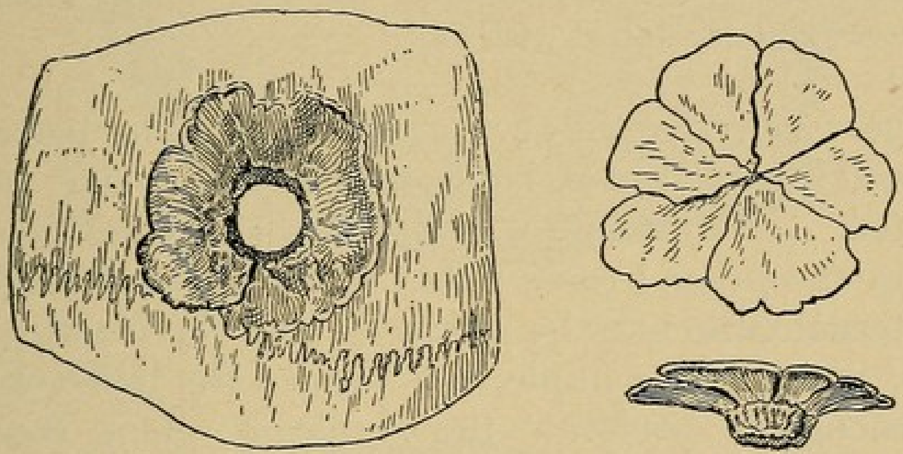

Fig. 24.—Bullet mark in a fragment of the skullcap of a male cadaver; the bullet struck the inner table of the skull. The point of entrance on the inner table is marked by a round hole, while the point of exit in the external table shows a more extensive loss of substance. The fragment when removed presents the form of a mushroom seen from the side; seen from above or without, it has a peculiar rosette-like appearance, being composed of several pieces loosely held together. The author has observed this condition repeatedly.

We can, therefore, readily understand that under certain conditions—that is, when the force is slight—a blow delivered with a blunt instrument on the outside of the skull may produce an isolated fissure of the internal table, unmistakable cases of which have been observed (see Plate 9, Fig. 2). In such a case the effect of the injuring force must have ceased to act as soon as the continuity of

[1] Bony tissue offers greater resistance to a rending than to a compressing force (Rauber).

PLATE 10.

Gunshot Wound of the Skull.—Figs. 1 and 2 show the anterior and posterior sides of a skull which was struck at a distance of 200 meters with the projectile of a German infantry rifle (model 88) ; a full charge of powder was used.

The illustration shows the small round hole at the point of entrance and the large ragged hole at the point of exit. It was impossible to replace the mass of minute fragments at the point of exit. The skull was broken into a number of variously sized pieces separated by numerous approximately radiating lines of fracture, and grouped more or less concentrically about the points of exit and entrance. The fragments were carefully united with wire.

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the bone was destroyed on the distended side, before the compressed particles of bone on the other side became separated. In the same way the opposite condition may occur in exceptional cases ; that is, an isolated fissure of the external table may be produced by a force acting from within, when, for example, the force of the bullet was not great enough to perforate the skullcap. This condition has also been observed in preparations. Under certain circumstances—for instance, when the direction is oblique —a force acting from without may injure the outer table, while the inner table remains intact. While this condition is rare as the result of a blow with a blunt instrument, it is frequently observed in sabre wounds.

Somewhat more frequent than isolated fractures of the inner table are those cases in which the outer table presents only a slight injury, as a depression or a fissure, while the inner table is completely shattered, the splinters being forced into the cavity of the skull like the rafters of a roof. Then there are the severe forms of fracture of the skull (piece fractures) in which an extensive area of the cranium suffers complete fracture with depression of the splinters which are attached around the margin of the fracture at the normal level. In this variety also the destruction and displacement of fragments is more extensive on the inner table (compare Plate 9, Fig. 3).

Tab. 10.

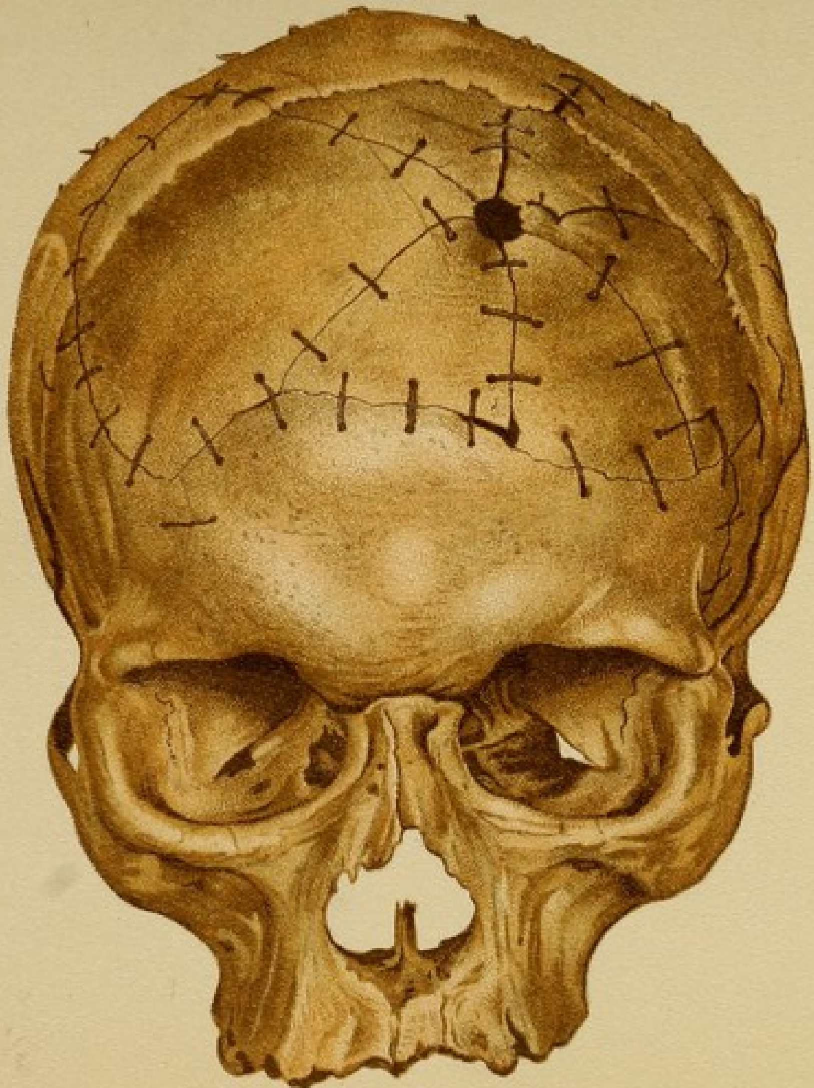

Fig. 1.

Fig. 2.

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For the sake of completeness it should be mentioned that a solution of continuity in the vault of the cranium may coincide with a suture (diastasis), and from such fractures radiating fissures often extend to some distance (Plate 13, Fig. 1; Plate 11, Fig. 1 *b*).

Gunshot wounds of the skull at short range as a rule produce a general shattering, which is explained, according to the most recent views, as the result of hydrodynamic pressure transmitted by the cerebral mass.

In examining severe compound fractures of the vault of the skull it is always to be remembered that the fragmentation of the bone is much more extensive on the inner table than on the surface. In the treatment of these compound fractures of the skull the most careful cleansing of the external soft parts, which are frequently very much polluted, should be the surgeon's first care. This is best accomplished by removing the contused and polluted masses of tissue with a knife and scissors. The next step should be to raise the depressed fragments; this requires trephining at the margin of the fracture (or, better, chiseling). In most cases complete asepsis cannot be attained without removing all the splinters of bone and exposing the dura, which shows the typical cerebral pulsations. For the rest, the treatment of the wound should follow general surgical rules. The loss of substance may at some later time be repaired by an osteoplastic operation, either by taking a plate of bone from the immediate surroundings or in some other similar way.

The reason for this radical procedure and the removal of all splinters of bone is the possibility, or rather probability, that polluted particles of matter from the outside have become lodged between the fragments of the fracture. In specimens showing fracture of the skull hairs are often found wedged in between the fragments. This I have repeatedly observed in macerated specimens from the Pathologic Institute at Leipzig and the one at München. The obvious explanation is that there is a greater interval between the fragments at the time the fracture is produced than later, and during the instant when their separation is greatest hair may be forced into the wound by the external violence. When the edges of the fracture come together after the force has ceased to act, the hairs may become so firmly caught between them that they even resist maceration of the bones. Hence we can readily understand that infective material, possibly along with hair, may equally well be carried from without into the depths of the wound, and, if the wound is not sufficiently opened, may lead to meningitis.

In recent subcutaneous fractures operative interference, such as trephining, is much more rarely indicated. Our former views on this question have been revised, and we now know that moderate grades of compression are not necessarily followed by grave consequences to the brain. A slight diminution of the capacity of the skull is of no particular significance. It is true that disturbances may manifest themselves later on in such cases, so-called Jacksonian epilepsy, for example, and may call for operative interference.

[The operative procedure for a fracture of the skull (the vault) is so simple and so free from danger that surgeons, in this country at least, believe that no exception should be made in a depressed fracture, or in any fracture of the vault in which there is a possibility of depression. To elevate such fractures it is seldom, if ever, necessary to use the trephine. The elevated or overriding edge should be chiseled until the edge of the depressed fragment is free; now it can be easily lifted in place. In the procedure one should remove as little bone as possible.—ED.]

(B) FRACTURES OF THE BASE OF THE SKULL

It is readily seen that fractures of the base of the skull are chiefly produced by indirect violence. Direct injury of the base of the skull is possible only by way of the orbital or nasal cavity, and such injuries are exceedingly rare. A bullet may, of course, strike the base of the skull from any direction. The occurrence of fracture of the base was formerly explained by the idea of contrecoup or counterstroke. By this was meant that the mechanical effect of an external force applied to the roof of the skull was to produce a certain wave-like movement in the adjacent portions of the bone, and that the vibrations thus produced became collected on the side opposite to that which was exposed to the injuring force by a process of summation, and thus produced a fracture of that side—so-called fracture by counterstroke. With the increase in surgical knowledge the doctrine of contrecoup has lost much of its importance. A large proportion of the forms of fracture of the base about to be described were formerly described by this doctrine of counterstroke. A force acting at more than one point (double-acting force) may simulate so-called fracture by counterstroke; as, for instance, a blow on the forehead followed by a fall on the occiput, where the autopsy may show, in addition to a fracture in the frontal, a second one in the occipital bone. Nowadays the doctrine of contrecoup in the sense just given is hardly tenable.

Careful examination of fractures of the base at the autopsy and numerous experiments demonstrate that many indirect fractures of the base present a certain regularity of form and permit a definite explanation. This, of course, applies only to fractures produced by a moderate degree of force; when the force has been great enough to produce general destruction, there is no regularity whatever in the lines of fracture.

The following points are of importance in explaining the **shape and direction of fractures of the base:**

1. *The base of the skull is regarded as the weakest portion of the skull.* This statement is only partially true; for connecting the thinner and partly translucent portions —which, in addition, are perforated by large openings for

PLATE 11.

Fracture of the Skullcap Continued to the Base.—The patient was struck in the parietal and temporal region by a falling roof-tile and sustained a compound fracture with depression of the fragments and a wide crack in the bone, followed by extradural hemorrhage from the middle meningeal artery. The patient recovered.

By combining this case with a specimen in the collection of the Path.-Anat. Institute at Greifswald, the figures on Plate 11 were obtained.

Fig. 1 *a* shows the skull with the calvarium removed, and the brain within the uninjured dura. A large hemorrhage from the middle meningeal artery, two branches of which are visible, is seen at the typical site. The crack in the bone extends down to the base of the skull.

Fig. 1 *b* shows the calvarium. The fracture in part follows the suture, and ends as a fissure in the parietal bone.

Fig. 1 *c*.—Base of the skull belonging to the specimen; seen from within. The fracture traverses the middle fossa of the skull.

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the passage of nerves and vessels—are firmer and in part extremely robust sections of bone which act as a kind of buttress. Thus a lateral support is supplied by the petrous portion of the temporal bone and the junction of the edges of the wings of the sphenoid; behind the skull is braced by the occipital crest, and in front by the frontal crest. These structures converge toward the clivus and the anterior margin of the foramen magnum. It has been learned by observation that fractures of the skull preferably follow the intervals between these supporting buttresses (Felizet). It is not to be denied, however, that the petrous portion of the temporal bone is often involved.

2. *By far the greater portion of fractures of the base have their beginnings in severe fractures of the vault.* Such are the so-called "continued fractures" (*fractures par irradiation*). They begin on the convexity of the skull, at the point of impact of the injuring force, and in many cases *follow the shortest route from that point to the base of the skull* (*Aran's law*). If the position of the buttresses

Fig. 1 b

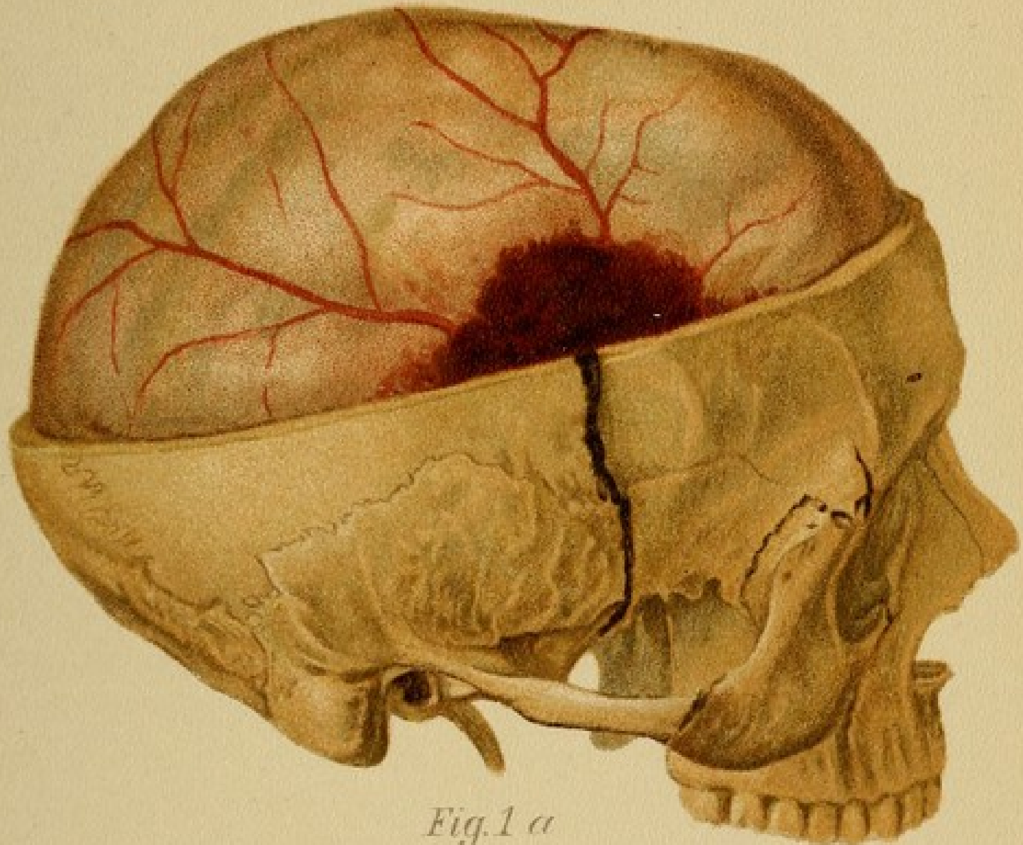

Fig. 1 a

Fig. 1 c

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mentioned in (1) is borne in mind, an explanation is at once obtained for these fractures of the base that traverse the anterior fossa of the skull and take their origin in an injury to the forehead; for those that pass from the parietal or temporal region to the middle fossa of the skull between the wings of the sphenoid and the petrous portion of the temporal; or for those that follow a fall on the occiput and occur between the petrous portion of the temporal bone and the occipital crest. This is the mechanism in about 40% of fractures of the base belonging to this class. In the majority of such fractures the force of the blow is such as to produce irregular lines of fracture and often an injury of the buttresses themselves. The middle fossa of the skull contributes by far the greatest number of fractures of the skull. They are usually transverse; frequently the line of fracture unites the middle fossæ of the skull; more rarely they follow an oblique course into the anterior fossa of the other side.

3. Another class of fractures of the base are produced by indirect violence, parts of the facial bones or the vertebral column being actually driven into the base of the skull. If an individual should fall on his head without suffering direct injury to the roof of the skull, the weight of the after-coming vertebral column might nevertheless produce pressure on the base of the skull in the vicinity of the foramen magnum after the head has struck the ground. In such a case the skull would be crushed as by a direct force. The same thing is possible if the trunk or the legs are the first to strike the ground and the skull, so to speak, presses itself against the vertebral column, the direction of which is perpendicular to the base of the skull. These fractures present very characteristic appearances (Plate 12), and can also be produced experimentally.

A fracture of the base may also result from a force transmitted by the bones of the face in a manner similar to that produced by the vertebral column, but such accidents are much less frequent. Plate 13 shows a specimen

PLATE 12.

Various Fractures of the Vault and Base of the Skull.— Fig. 1.—Vault of the skull with a fissure in the left parietal bone and separation (diastasis) of the right half of the lambdoid suture. The fissure is directly continuous with the separation of the suture. (Path.-Anat. Institute, Greifswald.)

Fig. 2.—Fracture of the base of the skull by pressure of the after-coming vertebral column in a fall on the head. The bones about the foramen magnum are fractured and in the macerated specimen have partly come away. (Author's observation; also artificial, and after Baum, Arch. für klin. Chir., vol. XIX, p. 381.)

Fig. 3.—Sagittal section of the base of the skull at the articulation of the left lower jaw. The picture shows the relations about the articulations of the jaw, and especially the extreme thinness of the skull bone at this point.

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in which a blow in the region of the nose forced the bony portion of the nose into the anterior fossa of the skull and brought about a most characteristic displacement of the crista galli. Plate 12 represents the base of the skull in sagittal section through the articulation of the jaw, and serves to remind us that this is the thinnest portion of the base of the skull, which at this point is often translucent. A force applied to the lower jaw, if transmitted to the ascending ramus, and especially to the articular processes (fall on the chin while the mouth is open), may produce fracture of the base of the skull. An actual forcing through of the articular process into the cranial cavity through a wide crack at this point has even been described. Accidents of this kind are extremely rare, however, because the lower jaw itself in this mechanism usually becomes fractured and because the thin spot is protected by robust bony margins in its immediate vicinity.

4. In extremely rare cases a fracture of the base may be produced by *compression of the skull as a whole.* Such an effect would have to overcome the natural elasticity of the skull; but if the compressing force is prolonged, a fracture will be produced. It has been shown experimentally

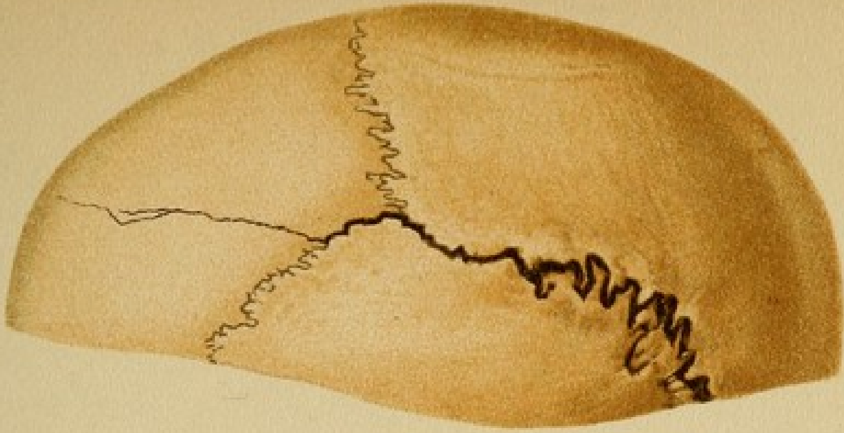

Fig.1.

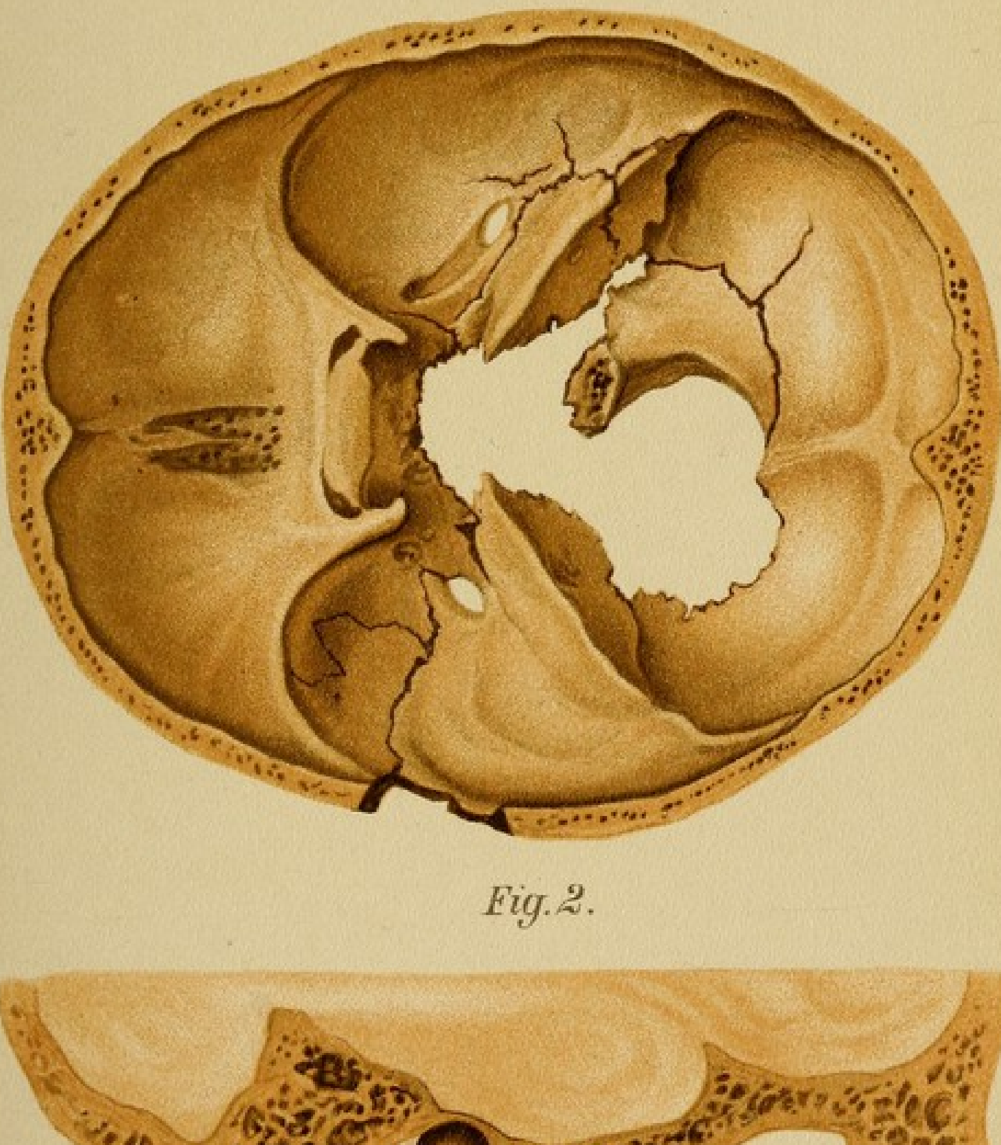

Fig.2.

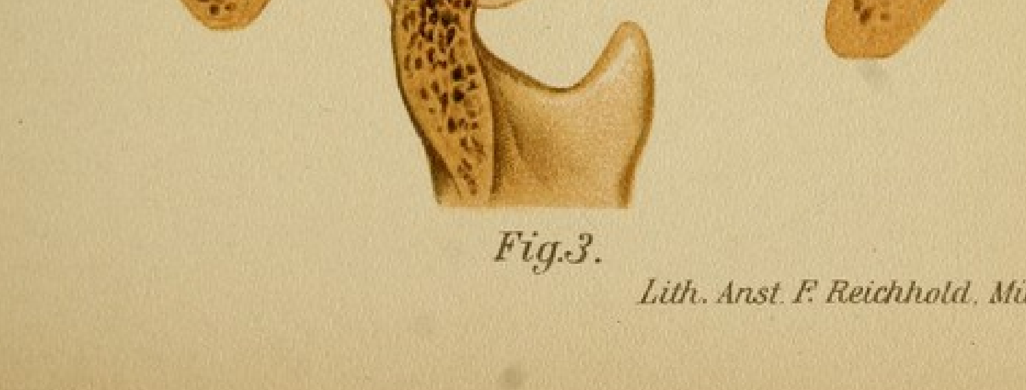

Fig.3.

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that these fractures followed the long axis of the skull when the compression took place in the long axis, and traversed the base of the skull transversely when the compression took place in a transverse direction. The lines of fracture are, of course, not the same in every instance, but in a general way they present the same character (compare Plate 14). A transverse fracture may traverse either the middle fossa of the skull or the petrous portion of the temporal bone.

This disposes of all but the rare isolated fractures, especially of the orbit, and fissured fractures of the base in gunshot injuries. In the production of the latter the action of hydrostatic pressure, with the consequent effect of a vacuum, is now conceded to play the most important part. It need not be a matter for astonishment that in such injuries, which affect the skull as a whole, the weakest portion should present the fracture or fissure. Further theoretic discussions of these questions will be found in the larger text-books devoted to the subject.

The **symptoms of fracture of the base** vary greatly according to the seat of the fracture and the fossa of the skull involved. The following symptoms are most important for the diagnosis:

1. **Hemorrhage.**—This may take the form of a suggillation under the skin. It is, however, of importance only when it appears at some distance from the point of injury. Extravasation of blood in the region of the eyes is more or less significant of fracture of the anterior fossa. There is no doubt that nearly all fractures of the orbital roof present hemorrhage into the orbital fat, and as the hemorrhage becomes more and more extensive it gradually leads to suffusion of the bulbar conjunctiva, and finally of the lids. Exophthalmos does not occur unless the collection of blood is very great; it is of importance only when the frontal region is absolutely uninjured. Suggillation in the pharyngeal mucous membrane is rarely observed. Hemorrhage from the nose is more frequent. When the patient is in

PLATE 13.

Fracture of the Base of the Skull by an Injury to the Nasal Region.—Figs. 1 and 2.—Section and anterior view of a skull in which fracture of the base was produced by a compression-injury to the nasal and superior maxillary region.

The specimen was prepared from the cadaver of a man twenty-eight years of age who had been admitted to the Leipziger Krankenhaus with the diagnosis of fracture of the nose, and died of meningitis on the 12th of April, 1876. At the autopsy there was found this remarkable condition, which was immediately photographed.

The section shows the dislocation of the nasal and ethmoid bones, which was in the main upward, so that the crista galli was thrust into the interior of the cranial cavity. The anterior view also shows the dislocation of the nasal bones and numerous lines of fracture at the orbital margin on both sides. (Author's observation.)

[Meningitis is not an uncommon complication of fractures of the nose associated with fracture of the base of the skull communicating with the nasal cavity. The complication is fatal. I do not believe it can be prevented by an attempt to disinfect the nasal cavity. In fact, I think it is better to let the nose alone and not disturb the blood-clot. Perhaps future experience will teach us that an operation should be performed the moment the symptoms of meningitis begin. The base of the skull should be exposed through an opening in the frontal bone and drainage instituted. I have observed one case in which this procedure at least should have been attempted.—Ed.]

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the dorsal position, or if the posterior portion of the nose has been injured, the blood may flow down into the pharynx and be swallowed, and later give rise to hematemesis. In fractures involving the middle fossa of the skull and of the petrous portion of the temporal bone hemorrhages from the ear (external meatus) are frequently observed. In the differential diagnosis it is necessary to exclude the entrance of blood into the auditory canal from without; simple rupture of the drumhead; fracture of the anterior wall through the articular prominence of the lower jaw in a fall on the chin; and fracture of the posterior wall and of the mastoid process. For the production of hemorrhage from the ear

Fig. 1.

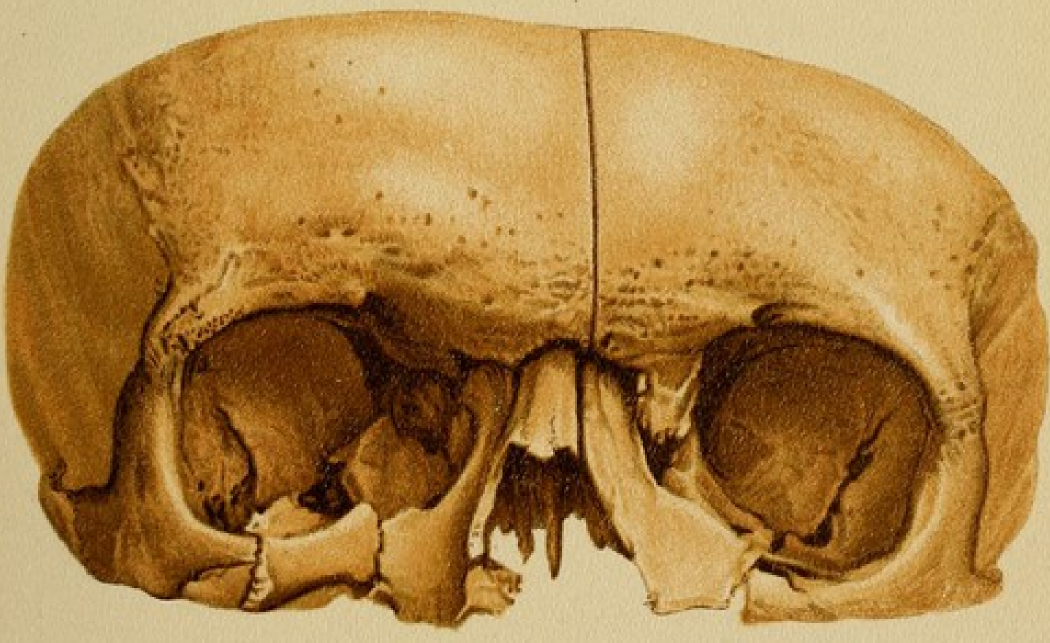

Fig. 2.

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it is obvious that the fracture of the base must be complicated by laceration of the drumhead. Suggillation at the mastoid process developing several days after the accident appears to possess some diagnostic significance pointing to fracture of the posterior fossa of the skull.

2. **Escape of brain-matter** is a rare occurrence, observed only in the most severe forms of fracture. It is a positive sign of fracture of the base, with accompanying concussion of the brain and laceration of the meninges. Escape of brain-matter into the ear and into the external auditory meatus is relatively the most frequent form of the accident. **Escape of cerebrospinal fluid,** on the other hand, is much more frequent. It is observed after the hemorrhage from the ear has ceased, sometimes twenty-four hours after the injury. The amount of serous fluid discharged is usually quite considerable; the drops follow each other in rapid succession and can be collected in a test-tube. The fluid is clear unless mixed with blood, of alkaline reaction, and shows only a trace of turbidity on boiling; it is, therefore, free from albumin, but contains a little sugar and an abundance of sodium chlorid. Escape of a serous fluid of this character is a positive sign of fracture of the base with laceration of the meninges, but the symptom is much less frequent than hemorrhage from the ear.

3. **Injury to the Nerves at the Base of the Brain.**— If this symptom makes its appearance at once or very soon after the injury, it is a sign of laceration or contusion of the nerves within their bony canals, which have therefore been included in the line of fracture. If a paralysis in the distribution of one or more of the cranial nerves occurs late in the course of the disease, it is to be referred to an inflammatory process extending from without inward, which may end in fatal basilar meningitis. The cranial nerves that most frequently suffer primary injury in fractures of the base are the facial and auditory. This is explained by the greater frequency of fractures in the middle fossa of the skull and the course of these nerves in

PLATE 14.

Fractures of the Base by Compression of the Skull.—Fig. 1.—Transverse fracture of the base artificially produced by transverse compression of an unopened and uninjured skull from a recent cadaver.

Fig. 2.—Fracture of the base due to compression of the skull in its long axis from sinciput to occiput. The patient, a man thirty-five years old, was injured by a fall on the head from a height of 10 feet. At the autopsy it was found that the fracture had traversed the foramen magnum.[1] Similar appearances are observed in artificially produced simple compression fractures.

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the petrous portion of the temporal bone. The other nerves are much less frequently involved.

In 48 fractures of the base Köhler observed 22 cases of facial paralysis, and only 2 of paralysis of the abducens. Battle, in an analysis of 168 fractures of the base, reports 2 cases of laceration of the olfactory nerves, a very few cases of paralysis of the oculomotor, 5 palsies of the abducens, 15 facial palsies, 14 cases of isolated deafness, and 8 cases of blindness due to hemorrhage into the sheath of the optic nerve; the latter was confirmed by autopsy.

Clinical Course and Prognosis of Fractures of the Base.—It was formerly held that a fracture of the base was necessarily a fatal injury. We now know, however, from clinical and postmortem observation, that recovery is possible after fracture of the base unless the force has been so great as to produce lesions of the brain and of the large nerve-trunks, or a fatal hematoma within the cranium.

Cerebral symptoms are rarely absent in cases of fracture of the base. The mildest injury with which we have to deal in this connection is **concussion** (*commotio cerebri*), a condition characterized by unconsciousness [not always], vomiting, disturbance of cardiac action, and, usually, retardation of the pulse [brachycardia]. The symptoms

[1] Hutchinson, Illustrations of Clinical Surgery, vol. I, Plate 30.

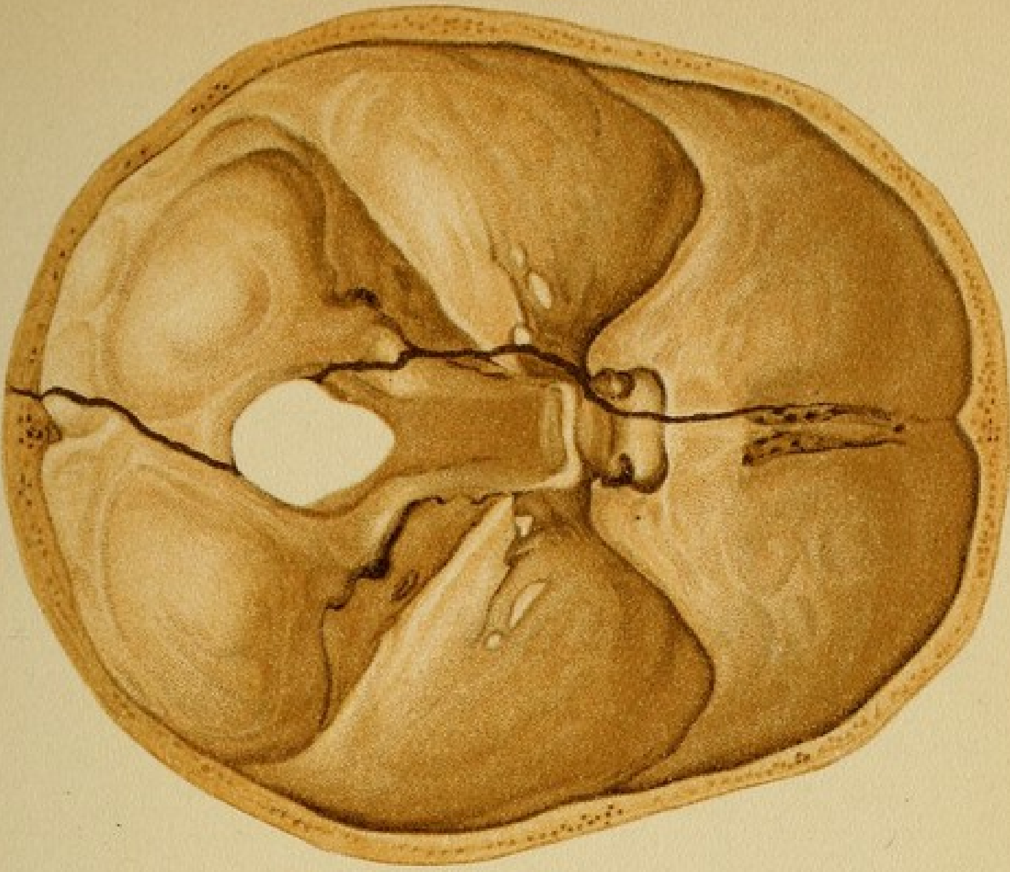

Fig. 2.

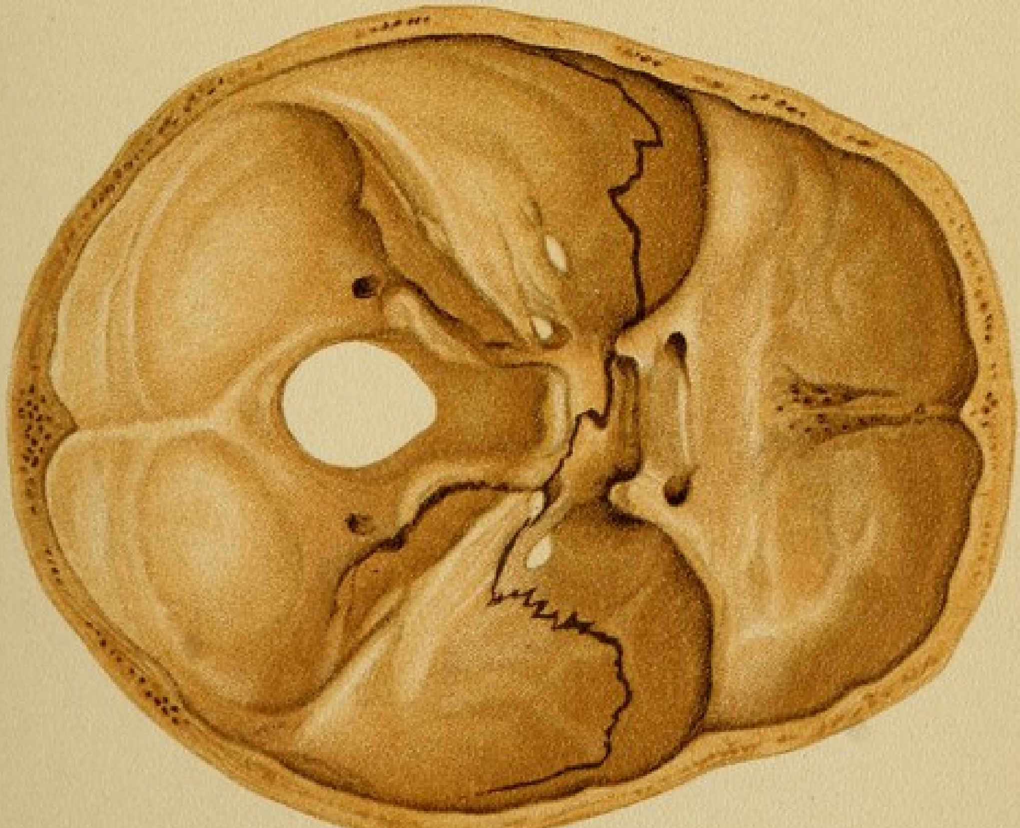

Fig. 1.

Lith. Anst. F. Reichhold, München.

are transient; if the loss of consciousness lasts longer than a few hours, or at most from twenty-four to thirty-six hours, a severe injury of the skull should be suspected. In some cases the patient loses all recollection of the occurrence. As a rule, the symptoms disappear completely and recovery results.

Simple cases of concussion are less frequent than was formerly supposed. The theory of an agitation of the cerebral mass by an oscillating motion, which was formerly held, is hardly to be accepted, as it seems probable that in any violent injury to the skull there is always a displacement of the brain as a whole. If the force has been sufficient to crack the skull, **contusion of the brain-matter** (*contusio cerebri*) may be assumed to be present at the seat of the injury, and not infrequently a similar contusion of the opposite side is produced by the dislocation of the brain just referred to. This occurs particularly in fractures of the occiput. The contused area presents grave anatomic alterations, hemorrhages into the brain, and, not infrequently, laceration of the brain-substance. The nervous symptoms are due to loss of certain brain-centers, and their character accordingly depends on the part of the cortex affected. In addition to *general*, we then also have *focal*, symptoms. Marked elevations of temperature have recently been observed in cases of contusion of the brain and intradural hemorrhage at the base of the frontal and temporal lobes, meningitis being excluded by the autopsy.

Under certain conditions a **compression of the brain** (*compressio cerebri*) may result. It is established, both by clinical observations and by experiments, that a relatively large diminution of the cranial cavity must take place before the phenomena of compression are produced. Small extravasations and depressed fractures, unless they are of unusual extent, do not produce the symptoms of compression. This is probably to be explained by escape of cerebrospinal fluid. Pressure symptoms are produced in fracture of the skull principally by injury to the middle

PLATE 15.

Fracture of the Skull with Laceration of the Middle Meningeal Artery, the Line of Fracture Extending to the Base of the Skull.

Fig. 1.—Hemisection of a skull, on the inner surface of which the direction and extent of a fracture, observed by the author, have been outlined. The details were obtained by actual measuring, and the drawing was at the autopsy. The case was that of a laborer twenty years of age who had fallen from the fourth story of a building. On admission to the clinic an extravasation was found in the region of the left temple ; fracture of the left squama was detected by palpation. There followed hemorrhage ; later, discharge of cerebrospinal fluid from the left ear ; and paresis of the left half of the face and of the extremities on the right side of the body. The patient died of tetanus contracted through a contused wound in the region of the trochanter. The illustration shows the seat of the hemorrhage in the distribution of the posterior branch of the middle meningeal artery. It also shows the ramifications of the artery, the line of fracture, and the suture between the left parietal and frontal bones. (Author's observation.)

Fig. 2.—Horizontal section through the skull and its contents. A copious hemorrhage from the middle meningeal artery is found at the seat of fracture between the skull and the dura. The brain is compressed and displaced. (After Hutchinson, Illustrations of Clinical Surgery, vol. II, Plate 54.)

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meningeal artery and consequent hemorrhage between the dura mater and surface of the bone which lessens the convexity of the brain (see Plate 9). In typical cases of this kind the initial symptoms of concussion soon disappear, the patient regains consciousness, and appears to be on the road to recovery; soon, however, the symptoms reappear, first irritation and later paralysis and mental depression, ending in loss of consciousness, retardation of the pulse, and finally profound coma. In such a case the only hope lies in trephining the skull over the hemorrhage, turning out the blood-clot, and, if necessary, ligating the middle meningeal artery.

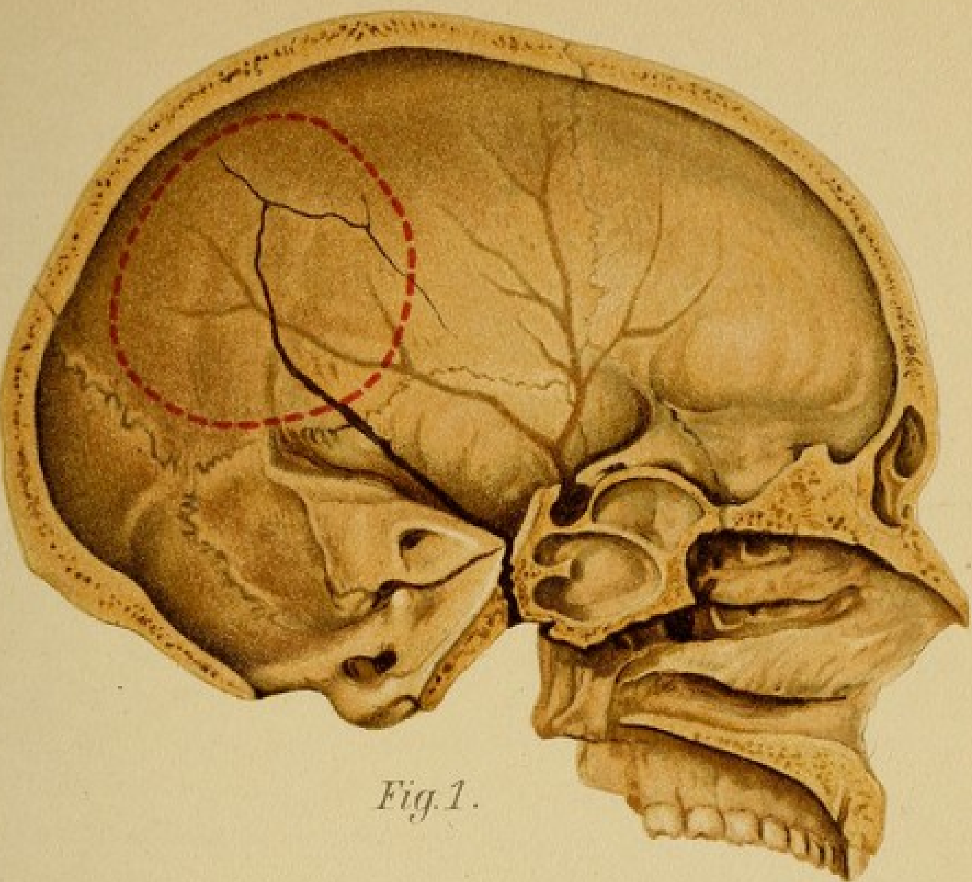

Fig. 1.

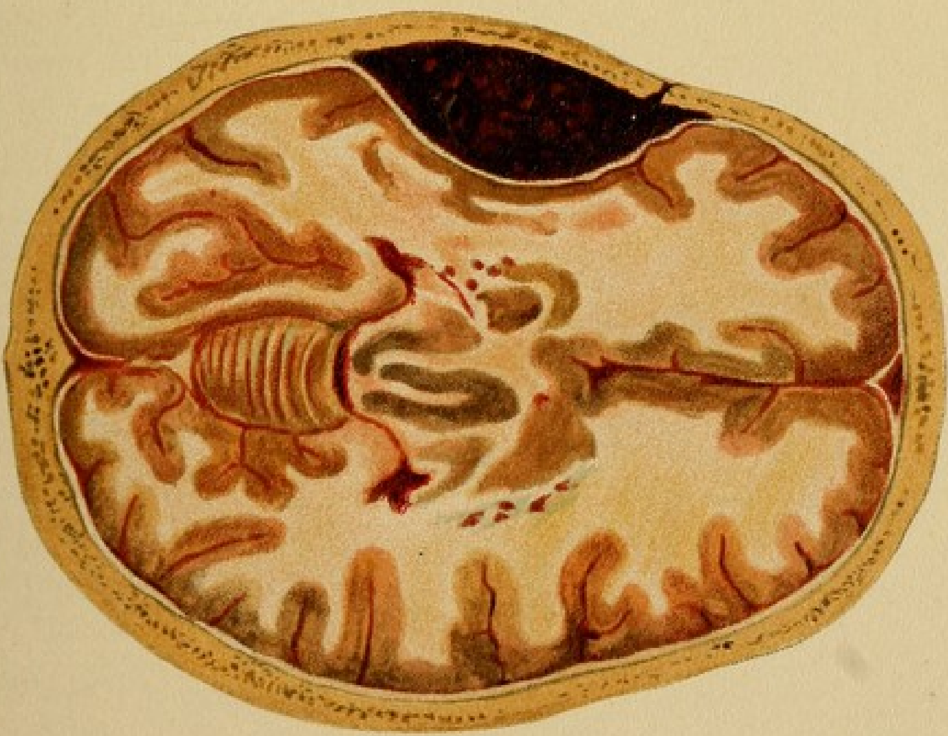

Fig. 2.

Lith. Anst. F. Reichhold, München.

It appears, therefore, that fracture of the base, even excluding rare complications, presents many dangers ; the mortality is great, and depends of course on the severity of the injury and the presence or absence of complications. Fractures through the middle fossa of the skull are by far the most frequent, but fractures through the posterior fossa have the greatest mortality.

The **treatment** of uncomplicated fractures of the skull is in the main expectant: rest, good nursing, if necessary esophageal feeding, and the local application of cold. Great care must be exercised to guard the patient against any additional injury.

It is an open question whether the external auditory meatus should be cleansed with a disinfecting solution when there is hemorrhage from the ear. Personally I consider it impossible to achieve complete disinfection in this way, and only allow the outer portion of the meatus to be carefully wiped out. On the other hand, the ear itself and the surrounding skin are thoroughly disinfected and dressed with sterile cotton. The objection to using a syringe is that there is danger of carrying infection to the deeper portion of the wound and thus bringing on meningitis.

As the pressure of the hemorrhage on the surface of the brain rather than the contusion of the brain-substance is regarded as the cause of death, it follows logically that trephining is greatly to be recommended. Some very satisfactory results have been obtained by this operation in recent times.

Fractures of the skull heal by bony union with an astonishingly small amount of callus-formation, which is owing to the slight degree of dislocation, to the fact that the fragments are completely put at rest, and to the fact that the capacity of the dura mater for producing bone is less than that of the periosteum of the long bones. In rare cases loss of substance remains after fracture of the roof of the skull, especially in small children ; it is sometimes accompanied by meningocele.

III. INJURIES OF THE FACIAL BONES

The bones of the face are accessible to examination either from without or by way of the nasal and aural cavities, so that fracture of these bones rarely presents diagnostic difficulties. Fractures of the nasal bones are always to be regarded as compound, since there is necessarily an open communication between the seat of fracture and the nasal or oral cavity. It is remarkable that notwithstanding this condition recovery usually takes place without any special complications or dangers due to infection. **Injuries of the nasal bones** are always due to direct violence by a blow or a fall. Fracture of the nasal bones and parts of the bony septum behind them usually produces distinct, and sometimes excessive, deformity (traumatic saddle-nose); the displacement may be reduced in recent cases by means of a forceps introduced through the nasal cavity. The obvious symptoms are suggillation, and hemorrhage from the nose; a slight degree of cutaneous emphysema may be produced by entrance of air-bubbles

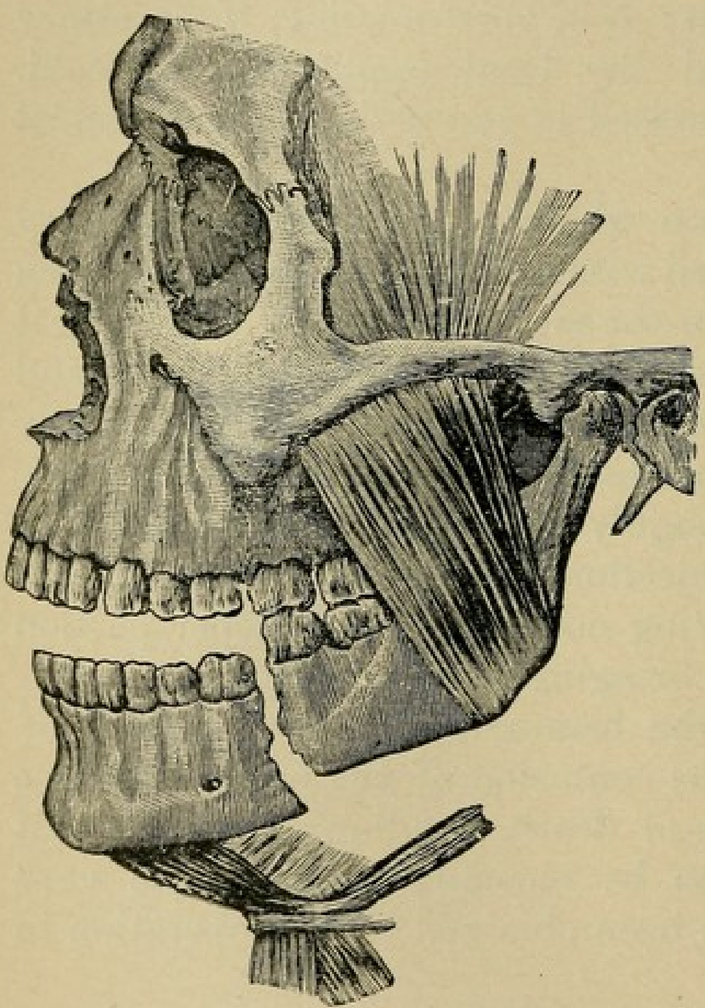

Fig. 25.—Showing the action of the muscles in displacing the fragments in fracture of the lower jaw.

through the opening in the mucous membrane into the cellular tissue about the seat of fracture. [This is rare.—Ed.]

Fractures of the malar and superior maxillary bones result from direct injuries, mostly the kick of a horse; they are, therefore, very frequently compound. The diagnosis presents no difficulties. The treatment demands reduction and fixation of the displaced fragments. This should be done by proper operation. This part of the treatment should be properly intrusted to a dentist, who may be able to save some of the teeth that have become loosened. I have sometimes obtained a good result by simply securing a fragment with a nail. The mouth must be kept clean with a 3% boric acid solution, and the patient put on liquid diet.

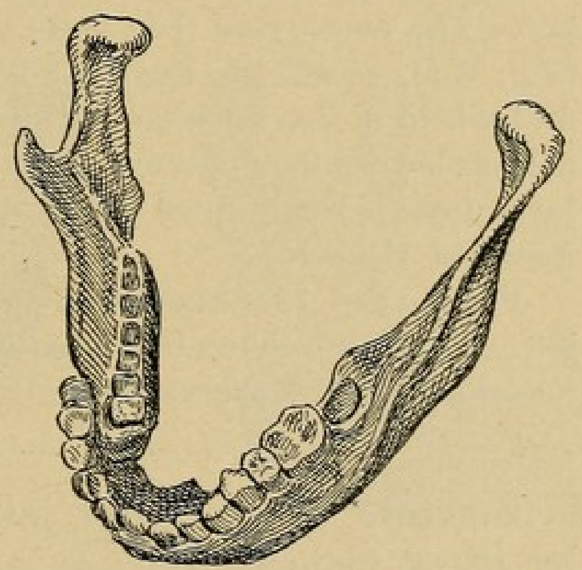

Fig. 26.—Specimen of fracture of the lower jaw with lateral displacement.

Fracture of the lower jaw is a more frequent accident. The condition is easily recognized, either from without or through the mouth, so very little needs to be said about the diagnosis. In fractures of the body or arch of the lower jaw a typical dislocation is observed, the posterior fragment being drawn upward by the masseter, while the anterior fragment is displaced downward by the action of the digastric and other muscles attached to the chin.

In the great majority of cases there is also a certain lateral dislocation by virtue of which the two fragments override each other so that the arch of the bone becomes shorter and narrower. Double fracture of the lower jaw is occasionally met with, and comminuted fractures are not so very rare.

PLATE 16.

Fractures of the Lower Jaw.—Fig. 1.—Recent fracture of the body of the lower jaw. The line of fracture is oblique and corresponds with the region of the molar teeth which have disappeared. (Path.-Anat. Institute, Munich.)

Fig. 2.—Interesting oblique fracture of the body of the lower jaw, involving both articular processes; recent. The preparation is evidently the product of a very severe injury, probably a fall on the chin (see Fig. 3, Plate 12, including the description). (Pathol.-Anat. Institute, Munich.)

Figs. 3 *a* and 3 *b*.—Fracture of the articular process of the lower jaw. The outer view (Fig. 3 *a*), and even more so the inner view (Fig. 3 *b*), shows the fragment which was diplaced downward and firmly held in that position. On the injured side the coronoid process projects beyond the upper extremity of the condyloid process; the semilunar fossa is partly filled by the dislocated fragment. (Path.-Anat. Institute, Munich.)

Fig. 4 *a* and 4 *b*.—Hammond's wire splint for fracture of the lower jaw. Figure 4 *a* shows it in position on the jaw. (After Rose, Ueber Kieferbüche and Kieferverbände.)

Fracture of the lower jaw is almost always produced by *direct* violence, such as a blow, the kick of a horse, or a gunshot wound from without or through the oral cavity in suicidal attempts. *Indirect* fractures may, however, be met with after a fall on the chin or lateral compression of the bone. Fracture of the alveolar process and complete separation of a fragment are relatively frequent accidents following unskilful or violent extraction of the teeth, especially with the forceps.

With respect to the *treatment*, it must be remembered that fractures of the body of the lower jaw are always accompanied by a wound of the gums. They are, therefore, to be regarded as compound fractures even when there is no injury to the skin. For this reason the oral cavity must be kept scrupulously clean by brushing the teeth and using a disinfecting mouth-wash, especially after eating. If the gum wound is extensive, it may be dressed with

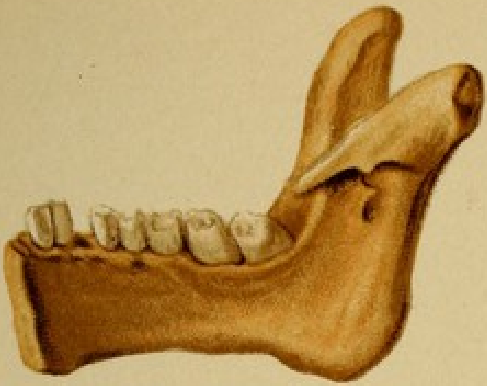

Fig. 3 b

Fig. 3 a

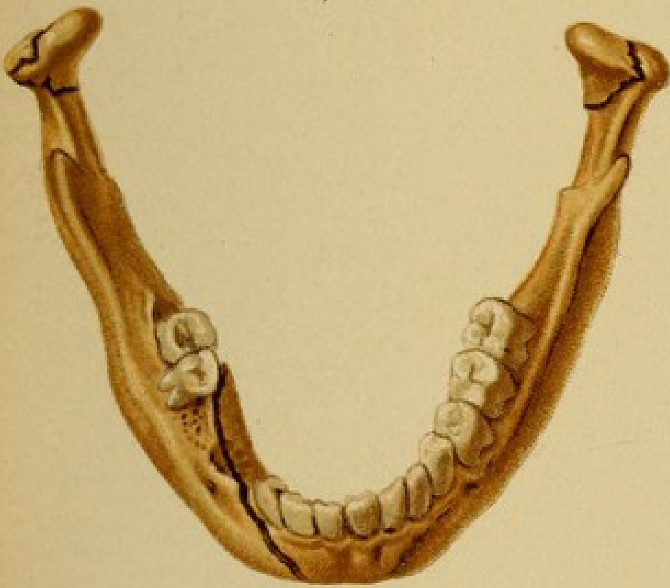

Fig. 2.

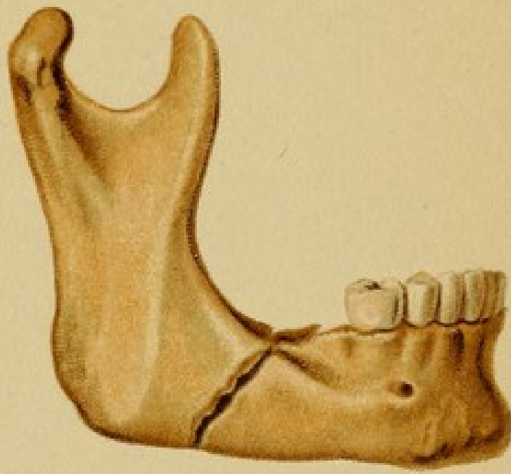

Fig. 1.

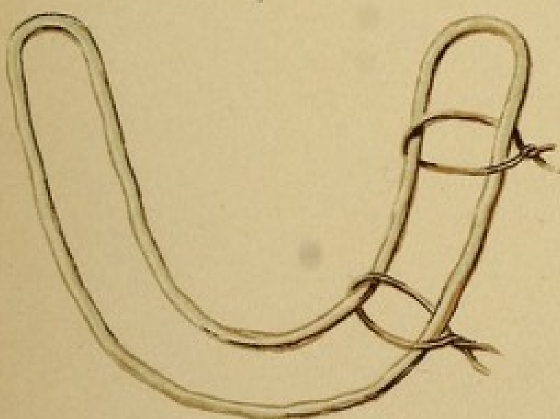

Fig. 4 b

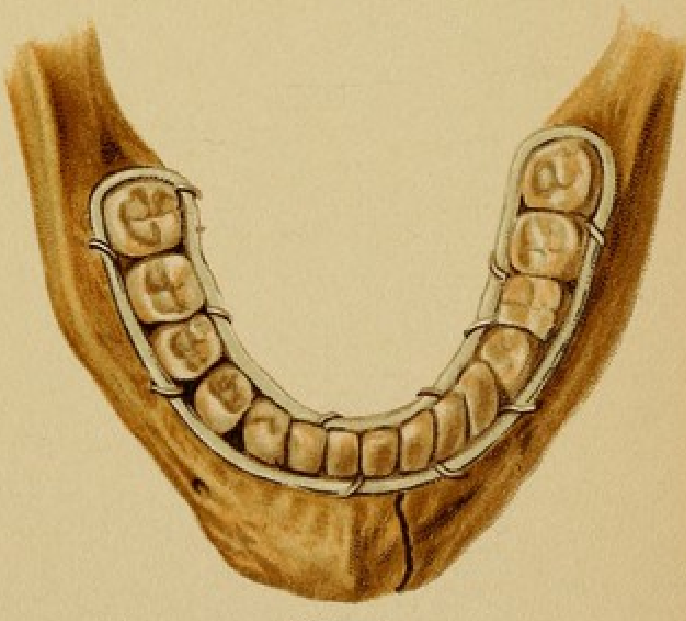

Fig. 4 a

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iodoform gauze, which may, if necessary, be secured in place with sutures. [Pure carbolic acid is one of the best disinfectants to use in wounds about the gums and jaw. It should be applied with a cotton swab and followed at once with alcohol.—Ed.]

Displaced fragments can, as a rule, be readily reduced by direct pressure, but permanent retention often presents considerable difficulties on account of the action of the muscles. Fortunately, we now have other means besides splints and other apparatus applied to the outside of the jaw and chin, and held in place by a roller bandage. With the help of a dentist, fixation of the fragments may be achieved by means of splints secured to the teeth of both fragments. Sometimes the simple procedure of tying together the teeth by means of silver wire wrapped around the crown suffices. It is only in cases where the teeth are lost, or under unusual conditions, that we are forced to resort to the older methods or to the use of a bone suture; for the latter, thick silver wire is used, the necessary holes being first made with a drill. If the holes are correctly placed, dislocation may, as a rule, be avoided. Suturing a bone in this way does not require anesthesia.

Among the rarer fractures occurring in the lower jaw may be mentioned fracture of the articular process (Plate 16), and the rare accident of fracture by muscular action (temporal muscle) of the coronoid process. Such a fracture usually leaves considerable separation of the fragments after union has taken place.

DISLOCATIONS OF THE LOWER JAW

(A) Forward Dislocation

Bilateral anterior dislocation of the lower jaw is a very common accident; it occurs when the mouth is widely opened, as in yawning, vomiting, etc. Every physiologic movement of the lower jaw is associated with displacement

PLATE 17.

Anterior Dislocation of the Lower Jaw.—Fig. 1.—Double dislocation of the lower jaw, artificially produced and prepared in the cadaver. The mouth is wide open and the chin is displaced forward. The articular process of the lower jaw is in front of the articular tubercle. Behind the latter is the empty glenoid fossa. The capsule is greatly distended but uninjured. The temporal muscle is in extreme tension, as there is a marked dislocation forward of its point of insertion, the coronoid process. Thus the action of the temporal muscle causes an actual buckling of the articular process against the anterior surface of the articular tubercle. (Author's preparation.)

Fig. 2.—Normal condition of the articulation of the jaw when the mouth is open. The articular process lies on the articular tubercle.

Fig. 3.—Normal relations of the articulation of the jaw when the mouth is closed. The temporal muscle is relaxed.

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of the articular extremity. When the mouth is open, the head of the bone emerges from the glenoid fossa and rests on the articular tubercle. The axis for this movement—*i. e.*, the line of least movement in the lower jaw during this act—corresponds approximately with the beginning of the inferior dental canal at the lingula. In forced movements the articular extremity may be pushed beyond the articular tubercle and glide into another depression, where it then becomes firmly lodged; in other words, a dislocation is produced. The accident is more frequent in women than in men. The fixation of the head of the bone is enhanced by the vigorous contraction of the muscles, especially the temporal.

The **symptoms** of dislocation of the jaw are extremely simple. The mouth is widely opened; the alveolar process of the lower jaw projects far beyond that of the upper jaw; the patient is utterly unable to close the mouth; and the absence of the prominence of the condyloid process from its normal position and its presence further forward are readily detected. In unilateral anterior dislocation the mouth is also wide open and the chin is slightly displaced

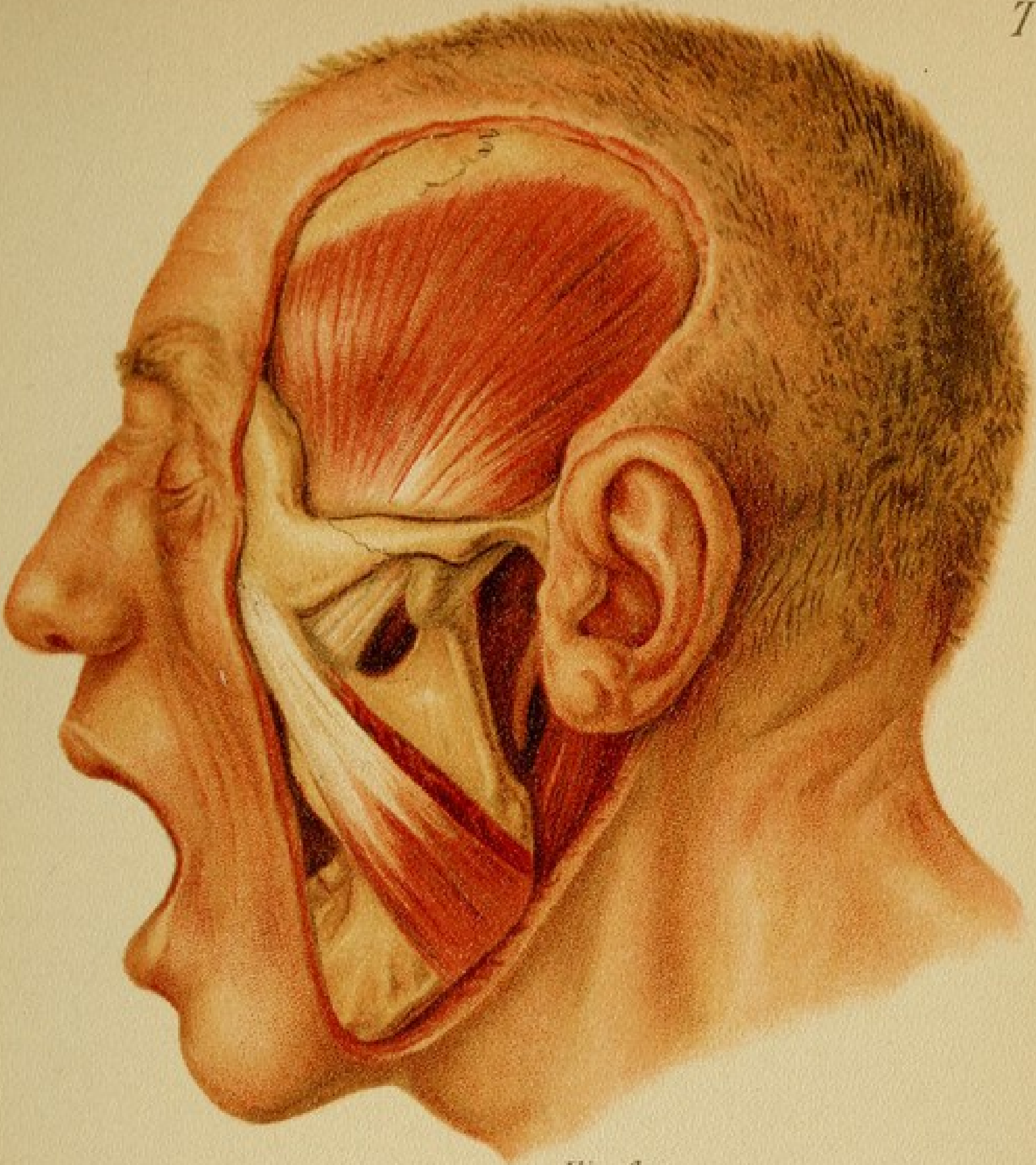

Fig. 1.

Fig. 3.

Fig. 2.

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toward the uninjured side. The capsule of the joint, as a rule, is not torn, but becomes greatly distended (Plate 17). This dislocation does not occur in children. The prognosis is favorable, although a marked tendency to recurrence is frequently observed. It is termed habitual dislocation of the lower jaw.

It follows from what has been said that a special manipulation is necessary to effect reduction. The surgeon inserts his two thumbs into the mouth and lays them on the alveolar processes of the lower jaw; the bone is then pressed first downward and then somewhat backward. In this way the articular extremity is pushed back until it rests on the articular tubercle, and finally into the glenoid fossa, and the dislocation is reduced. The sudden disappearance of the muscular resistance, which produces the fixation of the head of the bone, is plainly felt as the luxation is reduced.

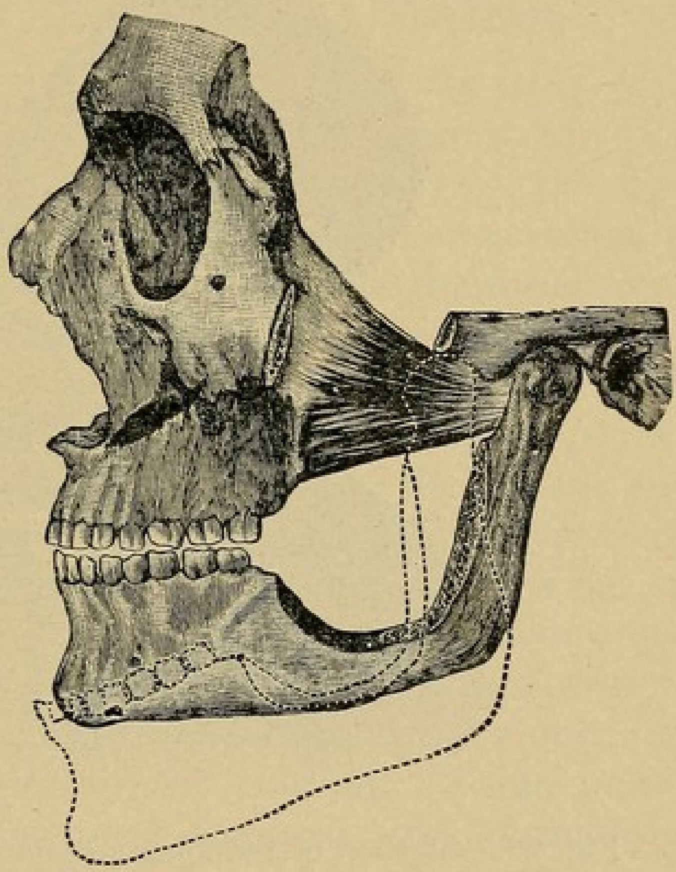

Fig. 27.—Action of the external pterygoid muscle in dislocation of the lower jaw.

(B) Backward Dislocation

Backward dislocation of the lower jaw is an extremely rare occurrence, and is observed almost exclusively in women. The accident occurs after yawning or spasmodic contraction, during a fall, etc. The condyloid process is forced behind the small tympanic tubercle which forms the posterior boundary of the glenoid fossa and enters the tympanico-stylo-mastoid fossa. The mouth is tightly closed ; the teeth of the lower jaw are behind those of the

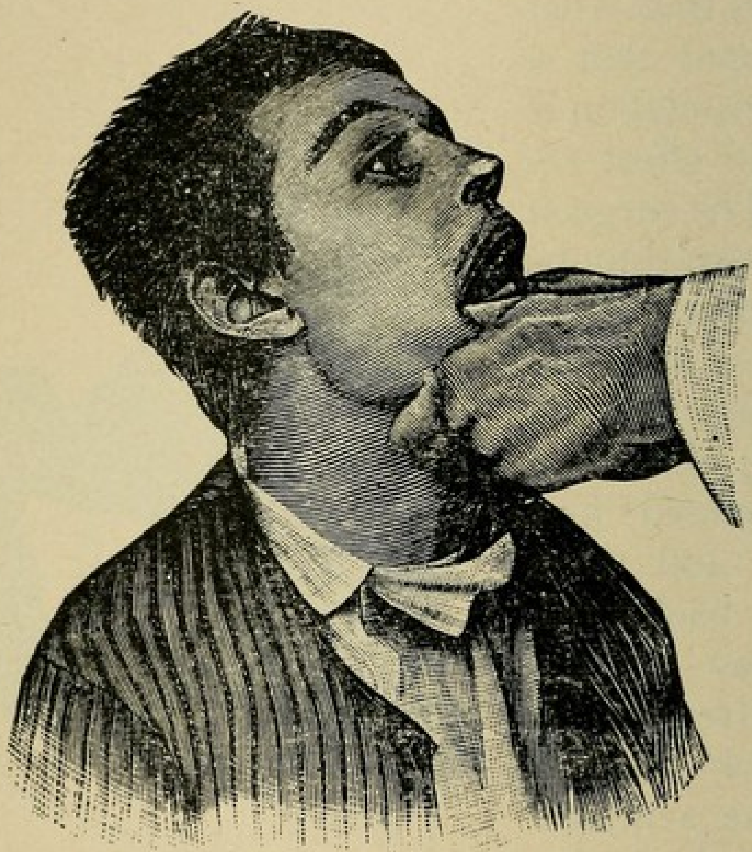

Fig. 28.—Method of reducing a dislocation of the lower jaw.

upper jaw and tightly clenched. The articular process is found beneath the external auditory meatus in front of the mastoid process. Reduction is effected by pressing the jaw backward, and then downward and forward, or the teeth may be forcibly separated with any suitable instrument. [Anesthesia is usually necessary.—Ed.]

IV. FRACTURES AND DISLOCATIONS OF THE VERTEBRAL COLUMN

(A) FRACTURES OF THE VERTEBRAL COLUMN

1. Fracture of the Body of a Vertebra

We may speak of a typical fracture of the body of a vertebra, such as that occurring in the region of the fifth and sixth cervical, of the last thoracic, and of the first lumbar, these being the most frequent. The accident is always produced by great violence. That the force must be great is readily understood when we consider that the vertebral column, in addition to a considerable degree of rigidity, possesses marked elasticity and mobility, since one-fourth of its entire length consists of the elastic and extremely movable intervertebral discs. The degree of mobility that can be attained by exercise is shown by the astonishing performances of so-called india-rubber men, who are able to bend almost double in the cervical region, at the junction between the thoracic and lumbar portions, and in the lumbar region of the column. These points also correspond with the most frequent sites of fracture, evidently because a bending force here finds the most favorable point of attack. This may be further illustrated by the fact that a rod of variable flexibility, like the vertebral column, when subjected to a breaking strain, usually breaks at a point where one of the more flexible segments joins a more rigid one; *i. e.*, in the region of the twelfth thoracic and first lumbar, and particularly in the region of the lower cervical vertebræ.

Direct fracture of the body of a vertebra is extremely rare. In all such cases of fracture of a vertebra by a violent blow or a wagonwheel, *indirect* violence is always a causal factor.

Indirect fractures very commonly affect the bodies of the

PLATE 18.

Fracture of the Cervical Portion of the Column with Contusions of the Cord.—Fracture in the region of the sixth and seventh cervical vertebræ. From a woman thirty-three years old, admitted to the Greifswalder Klinik on June 28, 1893; died on July 5th. At the autopsy a complete transverse contusion of the cord was found. During life consciousness was preserved and there were sensory and motor paralyses of the trunk and lower extremities, with partial paralysis of the upper extremities. The limits of sensation were found, in front, at the level of the third rib on both sides. There was also retention of urine. In the region of the sixth cervical vertebra a distinct prominence was felt which could be reduced under anesthesia. The injury was treated by the extension method, weights being attached to the head by means of a jury-mast (Glisson's sling). The patient was kept on a surgical bed provided with a water-mattress and a contrivance for raising and lowering. Death from paralysis of respiration.

The illustration shows the fracture of the two vertebræ and the dislocation backward and upward of the seventh, which encroached on the spinal canal and pressed upon the cord. (Author's observation.)

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vertebræ and are produced by excessive flexion or extension, by compression, or by a dislocating force—usually by a combination of all these factors. The accident is always produced by an overwhelming force, such as a fall on the back, the head, the buttocks, or the feet, or a cave-in, etc. In some cases it occurs while the vertebral column as a whole is fixed by the action of the muscles. Indirect fractures of the vertebræ by compression are comparatively frequent among coal-miners. The injury is usually produced while the miner is bent over in a sitting posture, with the buttocks resting on the heels, by a mass of stones or coal falling on his head and neck from an inconsiderable height. Thus he is gradually bent over forward and compressed, excessive forward flexion of the vertebral column takes place until the head comes in contact with the knees, and a fracture is produced.

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Various forms of fracture of the body of a vertebra are distinguished:

Oblique fractures are the most common, and show a tendency to marked dislocation (compare Plate 18). The line of fracture is usually directed from above and behind, forward and downward.

Longitudinal fractures are extremely rare.

Transverse fractures are observed in so-called contusion-fractures or compression-fractures of the vertebral column; they occur when the column is subjected to extreme flexion and simultaneous compression in its long axis. The least resistant vertebra is compressed by its neighbors on either side; its transverse diameter is increased while its vertical diameter is shortened. True impacted fractures and fissured fractures also occur. Although the outer contour of the vertebral column is, as a rule, but slightly altered in these compression-fractures, a marked narrowing of the spinal canal and contusion of the cord may nevertheless take place, as shown on Plate 19. Fissures and partial or even complete separation of the intervertebral discs have been observed.

Symptoms.—A significant phenomenon in fracture of the vertebræ, besides the shock with which such a serious injury is often attended, is the *traumatic kyphosis* at the seat of fracture. It is the outward expression of displacement of the fragments with shortening of the entire vertebral column, and is produced partly by the injuring force and partly by the contraction of the powerful longitudinal muscles and by secondary movements. An angulation on the posterior aspect of the vertebral column is thus produced which is recognized by the characteristic prominence of the affected spinous process. If the fracture is oblique instead of transverse, a lateral dislocation may also take place, corresponding with the direction of the fracture.

A slight grade of kyphosis is often difficult to recognize. Sometimes there is an absence of prominence, and the

PLATE 19.

Double Compression-fracture of the Vertebral Column.—The specimen was taken from the cadaver of a roofer, thirty years of age, who fell from a height of about 60 feet on the 28th of May, 1894. It was said that he first struck with his back against a ladder and then fell on his feet on the gravel beneath. The patient did not recover consciousness until the following day (in the clinic). On admission, there was pain in the upper and lower segments of the thoracic portion of the column; there was no motor paralysis, but sensation was lost on the posterior aspect of the thighs, on the perineum, genitalia, and buttocks. After the second day urine and feces were discharged involuntarily. The case was complicated by a typical compression-fracture of the os calcis on the left side, a deep wound of the soft parts on the posterior portion of the sole of the right foot, and fracture of the right ankle. The subsequent course was marked by decubitus, erysipelas, and amputation of the leg, etc. Death supervened on November 11, 1894. (See Enderlen, in Deutsche Zeitschr. f. Chir., vol. XLIII, p. 329.)

The picture gives a faithful reproduction of the double compression-fracture; the anterior border of the fifth thoracic vertebra is pressed into the sixth; the vertebral canal at this point is intact (Fig. 1 *a*). The body of the first lumbar vertebra appears completely crushed, the lines of fracture running in all directions. This has produced a marked narrowing of the vertebral canal, which at this point measures only 4 mm. in the sagittal diameter. The cauda equina and its covering are involved at this point (adhesions) (Fig. 1 *b*).

The fractures were produced by longitudinal compression of the vertebral column in marked anteroflexion. (Author's observation.)

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kyphosis can only be recognized by the diminution of the normal lordosis or normal curve of the back. The diagnosis in such cases may be indicated by localized pain on pressure, or transmitted pain by pressure or a blow on the head or shoulder, while the patient is sitting or standing. Abnormal mobility is, of course, never present and crepitus very rarely.

Accessory injuries of the *spinal cord* or of the *nerves* that make their exit through the intervertebral foramina may be present in spite of the fact that the spinal cord is

Fig. 1 a

Fig. 1 b

Fig. 1.

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securely incased in its canal formed by the bony arches and stout ligaments of the vertebræ and further protected by its covering of dura mater and free suspension within the cerebrospinal fluid. Fracture of a vertebral body with displacement of the fragments frequently produces more or less contusion of the cord. If the contusion involves the entire thickness of the cord, the most prominent symptom will be loss of motion and sensation in the region over which the injured segment presides, and we have: Paralysis of the rectum and bladder; paraplegia of the lower extremities if the injury is in the thoracic portion above the lumbar enlargement; motor and sensory paralysis of the trunk and upper extremities, marked disturbance of the respiration, sometimes excessive elevation of the body-temperature, if the injury is in the lower cervical portion; early death from injury to the respiratory center, if the lesion occupies the upper cervical portion.

In addition, motor paralysis in the distribution of the sciatic nerve is observed in injuries involving the lumbar enlargement (at the level of the spinous process of the twelfth thoracic vertebra); paralysis of rectum and bladder; impairment of sexual power; local anesthesia of the anal and perineal region, of the genitalia, and of the posterior aspect of the thigh, when the lesion is below the third lumbar vertebra. In this localization the cauda equina alone is affected. The condition of the reflexes is variable; as a rule, they are obliterated when the entire cord is injured by contusion or other analogous compression. If the injury is slight, they may be unchanged or even exaggerated.[1]

The **diagnosis** of fracture of the body of a vertebra in very severe cases can hardly be mistaken. If the degree of injury is known, if the kyphosis is readily recognizable and the symptoms of transverse lesion of the cord are present, the diagnosis is assured. But nervous phenomena

[1] For further details see the instructive monograph of Trapp (Deutsche Zeitschr. f. Chir., vol. XLV, p. 434).

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need not necessarily be present in fracture of the body of a vertebra, and we must insist that the spinal cord and nerve-trunks escape injury in many cases. A glance at the fracture in the upper thoracic portion of the vertebral column represented on Plate 19 (Fig. 1 *a*) shows that the cord at this point is quite intact. In these cases the force is only a moderate one and the kyphosis is less distinctly marked. To detect the latter, careful examination, especially by inspection, is necessary; the least deviations from the normal curvature of the vertebral column, such as accentuation of the curve, the presence of a prominence at the seat of injury, and flattening of the adjacent portion, must be looked for. If the examination is made some little time after the injury, functional disturbances, local pain on pressure, and pain elicited at the suspected spot by sudden pressure on the head in the direction of the vertebral column, are valuable diagnostic data. Ability to stand or walk, or even to do light work, does not absolutely exclude fracture of the vertebra, especially a compression-fracture. If grave symptoms develop later on, they are due to loosening of the impaction at the seat of fracture and to alterations in the fragments, such as occur in every variety of fracture.

The **prognosis** depends on the character of the accessory injuries and their consequences. As far as the fracture itself is concerned, it may heal by bony union, and many patients live on undisturbed and are able to do more or less work, provided only the spinal cord has not been injured. If, on the other hand, the symptoms of cord-lesion are present, the case immediately becomes very grave. Even if myelitis is warded off, other dangers threaten. Bladder paralysis, as a rule, calls for the use of the catheter several times a day, and while perfect asepsis should always be insisted upon and is not impossible of attainment, there is nevertheless great danger in actual practice of cystitis developing through infection by the catheter and resulting in septic pyelonephritis which eventually ends the patient's life.

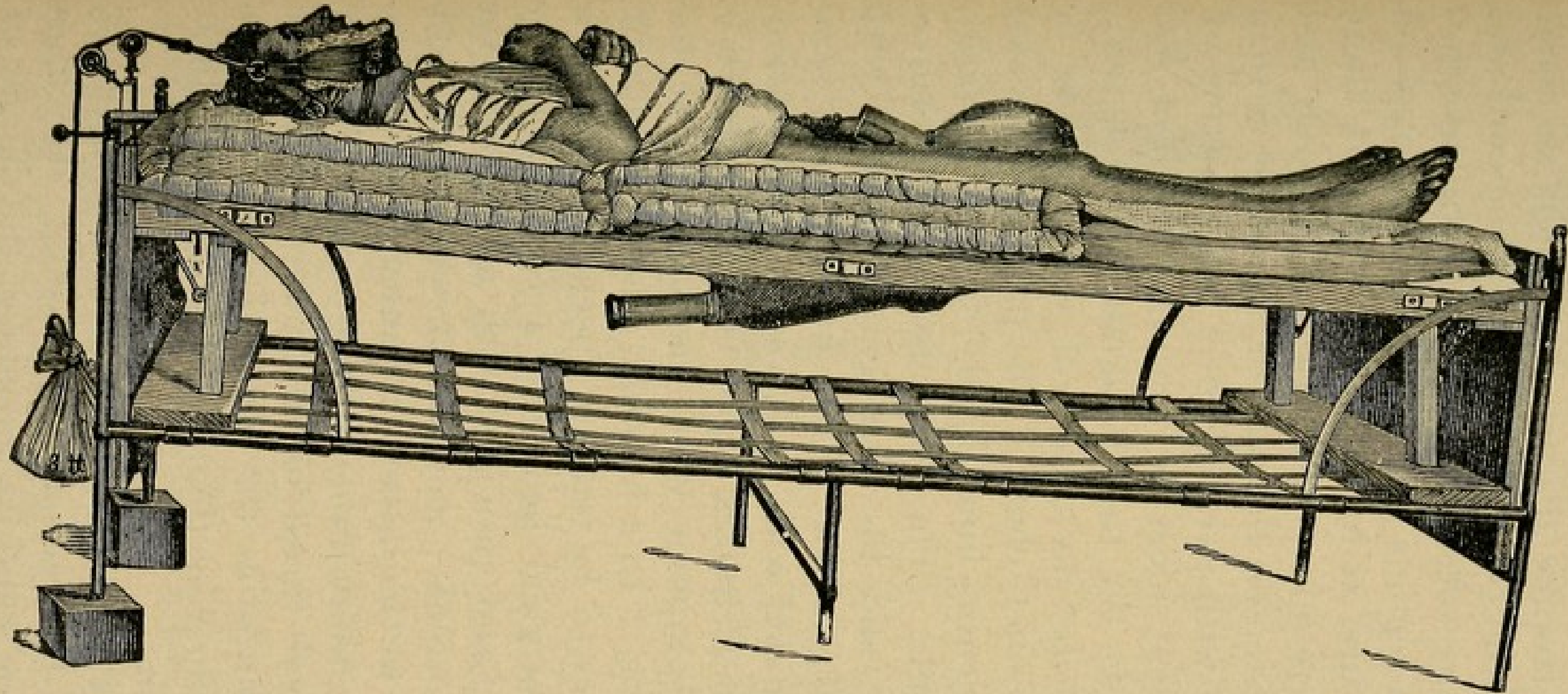

Fig. 29.—Patient with fracture of a cervical vertebra as he lies on the surgical bed. Glisson's sling (jury-mast) is attached to the head.

Otto Knüppel, twenty years of age, was severely injured on the 5th of August, 1895, by a fall on the head from a horizontal bar. He was admitted to the clinic on the same day with a fracture of the sixth and seventh cervical vertebræ. There were pain on pressure and ecchymosis at the seat of fracture. At first the upper extremities were not involved, but motor, sensory, and reflex paralysis was present from the level of the fourth rib downward. Retention of urine and feces; marked and persistent priapism; pulse 60; temperature 39.9° C. (104° F.); sensorium not involved. Later partial motor and sensory paralysis appeared in the upper extremities. The catheter had to be used regularly. Soon cystitis developed and the patient was threatened with bed-sores. Death from pyelonephritis on the 1st of October, 1895.

Another danger lurks in the *anesthesia of the paralyzed portions of the body.* Pressure gangrene may result not only from the grave trophic disturbances, such as occur especially in lesions of the cervical portion of the cord and rapidly produce pressure sores, but also from the anesthesia itself, especially in regions that are constantly exposed to pressure and moisture, as in the sacral region. There is no condition that requires more careful nursing and more constant supervision on the part of the surgeon than fracture of a vertebra with paralysis of a large portion of the body. The patient must be provided with a soft mattress free from folds, the sacral region, the heels, etc., being especially protected by means of water-pillows or cushions filled with millet chaff. The patient's position must be changed by turning him slightly, first on the right, and then on the left side. The bed must be kept scrupulously clean and dry, and the skin gently washed with alcohol, bichlorid solutions, etc. The urine, as has been stated, must be evacuated with every aseptic precaution. The state of the bowels requires supervision. Diarrhea is a most unfavorable symptom when incontinence of the alvine discharges exists. In a hospital, where patients of this class ought always to be treated, special apparatus is at hand, such as a surgical bed with a contrivance for raising and lowering, and provided with an opening for the discharge of the stools; permanent water-bath, etc. The nearer the lesion to the upper extremity of the vertebral column, the more unfavorable is the prognosis, because the injury at this level threatens interference with vital organs. Hence fractures in the cervical portion are in general much more dangerous than those in the lower thoracic and lumbar regions.

Treatment.—Intelligent treatment should be instituted from the moment of the patient's admission. He must not be allowed to sit or stand on account of the danger of secondary displacement of the fragments and injury of the as yet uninjured cord, especially if the fracture is oblique

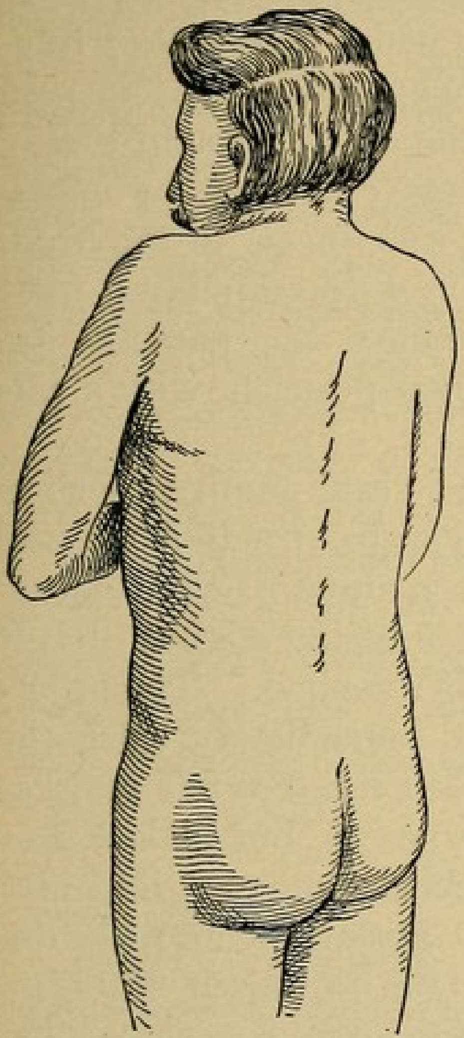

Fig. 30.—Angular kyphosis in the region of the eighth and ninth thoracic vertebræ after a fall on the back (on May 24, 1894) from a height of 5 meters. The man landed on a pile of bricks. After the primary loss of consciousness cleared up, the patient was able, with the assistance of his companions, to walk to his home, which was in the neighborhood. On May 30th the man, who was thirty-eight years of age, was admitted to the clinic. There was pain at the seat of fracture; no nervous symptoms.

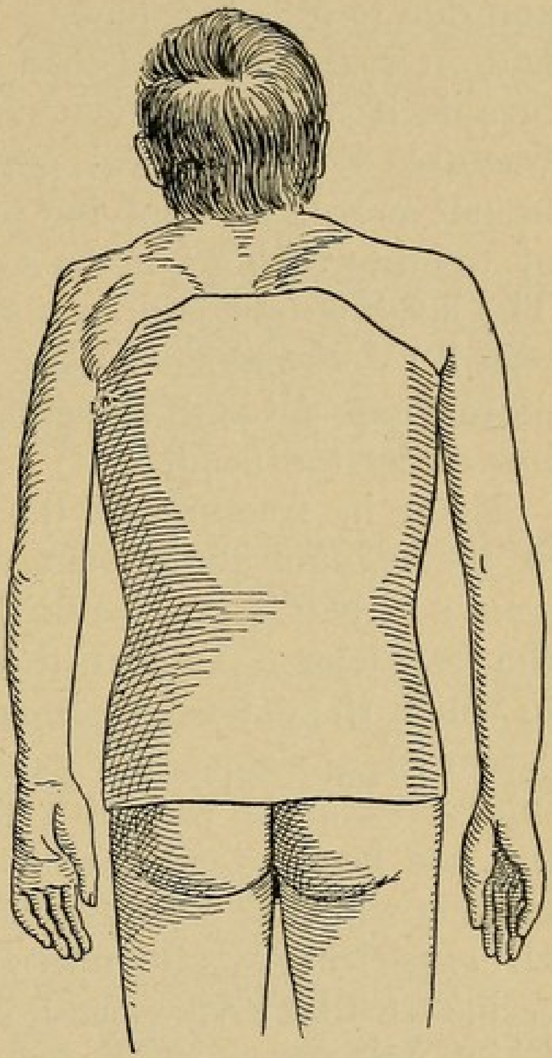

Fig. 31.—Showing the same patient with a plaster-of-Paris jacket which somewhat relieved the strain on the seat of fracture. If the fracture is located in the region of the last thoracic, or lumbar vertebra, the jacket must reach further down on the pelvis; *i. e.*, have more of a hold on the pelvis.

and due to direct violence. The patient must be carefully laid on a stretcher and then put to bed. The seat of fracture itself does not always require special attention. In fractures of the cervical portion the seat of fracture may be put at rest by applying permanent extension by means of weights with a Glisson's sling (jury-mast) to the head. The head is best laid on a sliding rest like a sliding foot-board (Volkmann's rest). Sometimes the patients are more comfortable in the simple dorsal position, with a pillow under the head.

Even in fractures of the thoracic and lumbar portion of the column permanent extension by traction on the head and pelvis may be utilized to maintain separation of the fragments. I am in the habit of using a kind of belt to which the extension apparatus is attached. The application of a plaster-of-Paris jacket immediately after the injury, while the patient is suspended in a Sayre's apparatus, has been attended with good success, but it is a proceeding which is not altogether without danger. Recently an experienced and trustworthy authority (Poller describes Füller's views and methods in the Arch. für klin. Chir., vol. LIV, p. 289) has recommended forcible reduction of the displaced fragments, by means of forced extension of the vertebral column and pressure with the hand on the kyphosis, in all cases of fracture from compression characterized by marked kyphosis at the seat of fracture. The procedure requires full anesthesia. It is better at first merely to place the patient in the proper posture and apply extension by means of weights; after a time, rigidity of the head and back may be secured by means of a heavy plaster-of-Paris gutter fitted on while the patient lies on his face. Later, a suitable supporting apparatus, such as a plaster-of-Paris jacket, is necessary. Surgical intervention to relieve the pressure on the cord (laminectomy) is indicated only in very rare cases, as when fragments of the vertebral arch have entered the cord from behind, provided the condition can be diagnosed. (Goldschneider.)

Even in milder cases, in which there is no injury of the cord, such as contusion or ecchymosis near the nerves that make their exit from the vertebral canal, the treatment should be carried out with the minutest care. To bring about bony union of the fragments and avoid secondary displacement requires a long period of rest in the proper posture and the wearing of well-fitting supportive apparatus for an indefinite time afterward. The strain on the body of the vertebra in the erect posture and in doing work is enormous, while the formation of new bone is not very abundant. We know from recently reported cases

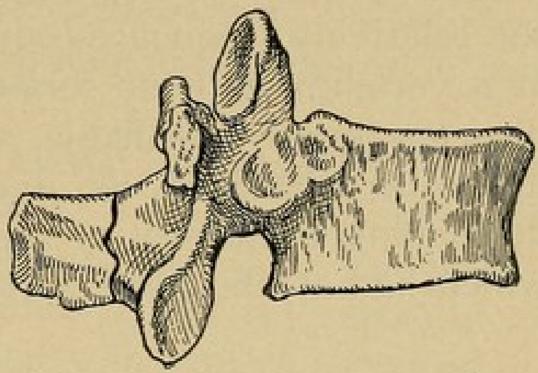

Fig. 32.—Fracture of a spinous process.

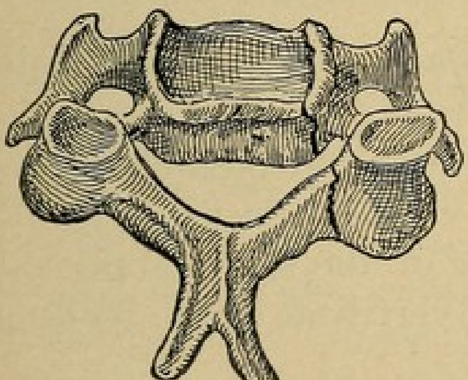

Fig. 33.—Fracture of the arch of the fifth cervical vertebra by a wagonwheel. The body of the vertebra is intact. (Pathol.-Anat. Institute at Greifswald.)

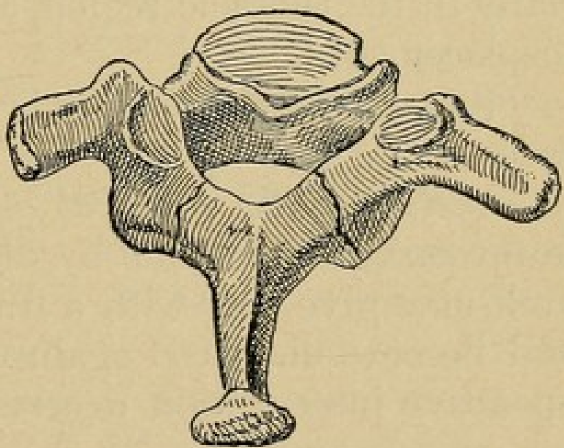

Fig. 34.—Seventh cervical vertebra; fracture of the arch and spinous process.

that a relatively slight injury of the vertebral column may be followed by secondary changes with grave symptoms and functional disturbances. To explain this phenomenon the occurrence of inflammatory changes at the seat of fracture—*i. e.*, a traumatic spondylitis (Kümmell)—has been assumed; but in view of the occurrence of analogous processes in other fractures, and especially in view of the relatively frequent occurrence of fracture of the body of a vertebra without serious symptoms, this assumption does not appear justifiable. In these cases the symptoms must be regarded as due to secondary disturbances developing at the seat of a slight fracture of the vertebra which had at first been overlooked.

2. Fractures of the Vertebral Column or Spinous Processes

These fractures are rare, and when they do occur, are usually combined with fracture of the body of the vertebra. We distinguish:

Fracture of the spinous process by direct violence, especially in the thoracic region, attended usually with marked displacement.

Fracture of the transverse or oblique processes—extremely rare.

Fracture of the vertebral arch—rare, but possible in the lower cervical vertebræ by direct violence; a piece of the arch may give way with a fracture of the spinous process and become displaced against the vertebral canal, making operative intervention necessary.

(B) DISLOCATIONS OF THE VERTEBRAL COLUMN

The anatomic relations are such that dislocations of the vertebral column in the thoracic and lumbar regions are exceedingly rare. In the cervical region, on the other hand, dislocation is more common and is of great practical significance.

If the cervical vertebræ of the skeleton are arranged in their proper order, and a heavy rubber tube is drawn through the vertebral canal so as to bring the individual vertebræ into contact with one another, it is quite easy, by stretching the rubber tube, to produce first a separation and then a luxation of two of the vertebræ. There is no better way of learning the pathologic anatomy of a luxation.

We distinguish between *flexion-* and *rotatory luxations* of the cervical vertebræ (Hueter). In the first class the dislocation is produced by forced flexion of the head on the chest. The posterior borders of the vertebræ are thus forced apart; the ligaments, including those on the articular processes, are stretched and finally torn; and by a simultaneous forward displacement of the upper vertebræ luxation is produced (Plate 20, Fig. 2). Rotatory luxation may be described as a unilateral flexion-luxation, although it is not produced by flexion, but by abduction toward the side which remains uninjured and anterior rotation of the upper border (Plate 20, Fig. 1).

The **symptoms** are often quite characteristic: In *flexion-luxations* there is a characteristic interruption of the line of the spinous processes, and occasionally, it is said, the projecting body of the vertebra can be felt by introducing the finger in the mouth; there is always marked flexion of the neck forward, with vertical position of the head. In *rotatory luxations* the head is inclined and slightly rotated toward the unaffected side; the interruption in the line of the bodies of the vertebræ and of the spinous processes is much less marked. Injury to the cord is possible in these dislocations; their consequences are the same as those that attend fractures of the vertebræ, and have already been discussed. Injury to the phrenic nerve does not occur when the dislocation is below the fourth cervical vertebra.

The **prognosis** depends on accessory injuries and on the completeness with which reduction has been effected. In rotatory luxations accessory injuries may be absent.

Treatment.—The dislocation must be reduced under

PLATE 20.

Dislocation in the Cervical Portion of the Column.—These illustrations were made from specimens in which the dislocation had been produced artificially.

Fig. 1 *a* and *b*.—Unilateral dislocation (rotatory luxation) in the cervical portion of the column, seen from the side and from behind. The fourth cervical vertebra is dislocated in such a manner that the articular process, on the left side, overrides and projects in front of that of the fifth. The luxation was produced by abduction; *i. e.*, movement to the right, or anterior rotation. The two processes became firmly locked. The prominence of the body of the fourth vertebra is seen (lateral view), and the inclination of the upper vertebra and of the head to the right (posterior view).

Fig. 2 *a* and *b*.—Bilateral dislocation in the cervical portion of the column (flexion-dislocation), seen from the side and from behind. The body of the fourth vertebra projects some distance in front of the fifth; the line of the vertebral column is perpendicular. (Author's preparation.)

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full anesthesia. In rotatory luxation reduction is effected by means of abduction toward the uninjured side so as to overcome the locking of the processes, followed by backward rotation of the head on the injured side. In performing abduction not only the head, but all that portion of the neck above the dislocated joint, must be firmly held and properly supported. In a flexion-luxation the two sides are successively treated and reduced as in a rotatory luxation. After the dislocation has been reduced the parts must be kept rigid for several weeks by means of some appropriate dressing, such as a stiff collar.

Of the remaining dislocations occurring in the cervical portion of the cord, luxation of the head (between the atlas and the occiput) by excessive flexion or extension of the head, and luxation of the atlas (between the atlas and axis) may be mentioned; in both these luxations death usually results from accessory injuries.

Dislocations in the thoracic and lumbar regions are extremely rare. Their occurrence has, however, been

Fig. 1 a

Fig. 1 b

Fig. 2 a

Fig. 2 b

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unmistakably proved in the postmortem room. During life they cannot be recognized; that is to say, it is hardly possible to exclude fracture. Anterior, posterior, and so-called abduction-luxations have been observed.

The **prognosis** is unfavorable owing to injury of the cord. Attempts at reduction should be made by extension and counterextension and direct pressure.

V. FRACTURES OF THE THORAX

(A) FRACTURES OF THE RIBS. (Plates 21 and 22.)

Owing to the great mobility of the lowest ribs and the position of the upper ones, protected as they are by the overlying muscles and clavicle, fractures in these two divisions are comparatively rare. Excluding these, however, fracture of the ribs is a very common accident, and constitutes about 15 % of all fractures. In children, owing to the exceeding elasticity of the ribs, fractures are very rare.

Fractures of the ribs are produced by direct and by indirect violence when the thorax is compressed either in its transverse or in its antero-posterior diameter. Multiple fractures occur chiefly in the axillary line and at the angles of the ribs.

The **diagnosis** is based not so much on the displacement of the fragments as on the presence of pain and crepitus on pressure which is frequently audible. The lung is often injured. It may be directly perforated by a sharp fragment at the time of the fracture; and as the costal and pulmonary pleuræ are injured at the same time, hemothorax and pneumothorax may take place. Traumatic cutaneous emphysema is frequently present, beginning at the seat of fracture, and, in severe cases, extending to the cellular tissue of the entire body. The air escapes into the pleural cavity from the alveoli and tertiary bronchi of the injured

PLATE 21.

Fractures of Ribs.—Fig. 1.—Fracture involving the third to the tenth ribs on the right side. This beautiful preparation, which was taken from a man fifty-three years of age, shows numerous fractures. The right half of the thorax sustained a linear fracture involving the above-named ribs, corresponding approximately to the middle of the affected ribs not counting the costal cartilage ; or, in other words, to the axillary line. In all but the eighth and tenth ribs the fracture is found in this line. In addition, the four lower ribs of the preparation —*i. e.*, the seventh, eighth, ninth, and tenth—were fractured at the angle, with considerable displacement ; the two upper ones show the traces of an infraction at the same point.

The case, therefore, is one of multiple fracture of the affected ribs. The fractures coincide with the axillary line and with the line of the angle of the ribs. It is evident at a glance that in the three lowest ribs of the preparation (eighth, ninth, tenth) the fractures in the axillary line have united without displacement, while those at the angle present marked displacement. The fourth, fifth, sixth, and seventh ribs present marked deformity (there had been overriding of the fragments in the axillary line), while at the angle no deformity is apparent. The third rib was broken only in the axillary line and shows good union.

Fig. 1 *a.*—Horizontal section of the fourth rib (axillary) of the same preparation, showing the displacement and firm union.

Fig. 2.—Recently united fracture of the ribs without displacement, shown in horizontal section. Callus-formation is well shown.

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portion of the lung, during both inspiration and expiration, and spreads from there in all directions. Unless the cutaneous emphysema is universal and becomes dangerous by reason of its extent, it is not a serious symptom. As a rule, it disappears by absorption within a few days. Hemothorax may require aspiration.

Treatment.—Complications must be treated as they arise. The region of the fracture is supported with strips of adhesive plaster. Bony union takes place, usually without marked displacement, and in almost every case with only temporary disability. After a fracture of the upper ribs the carrying of heavy burdens on the shoulder

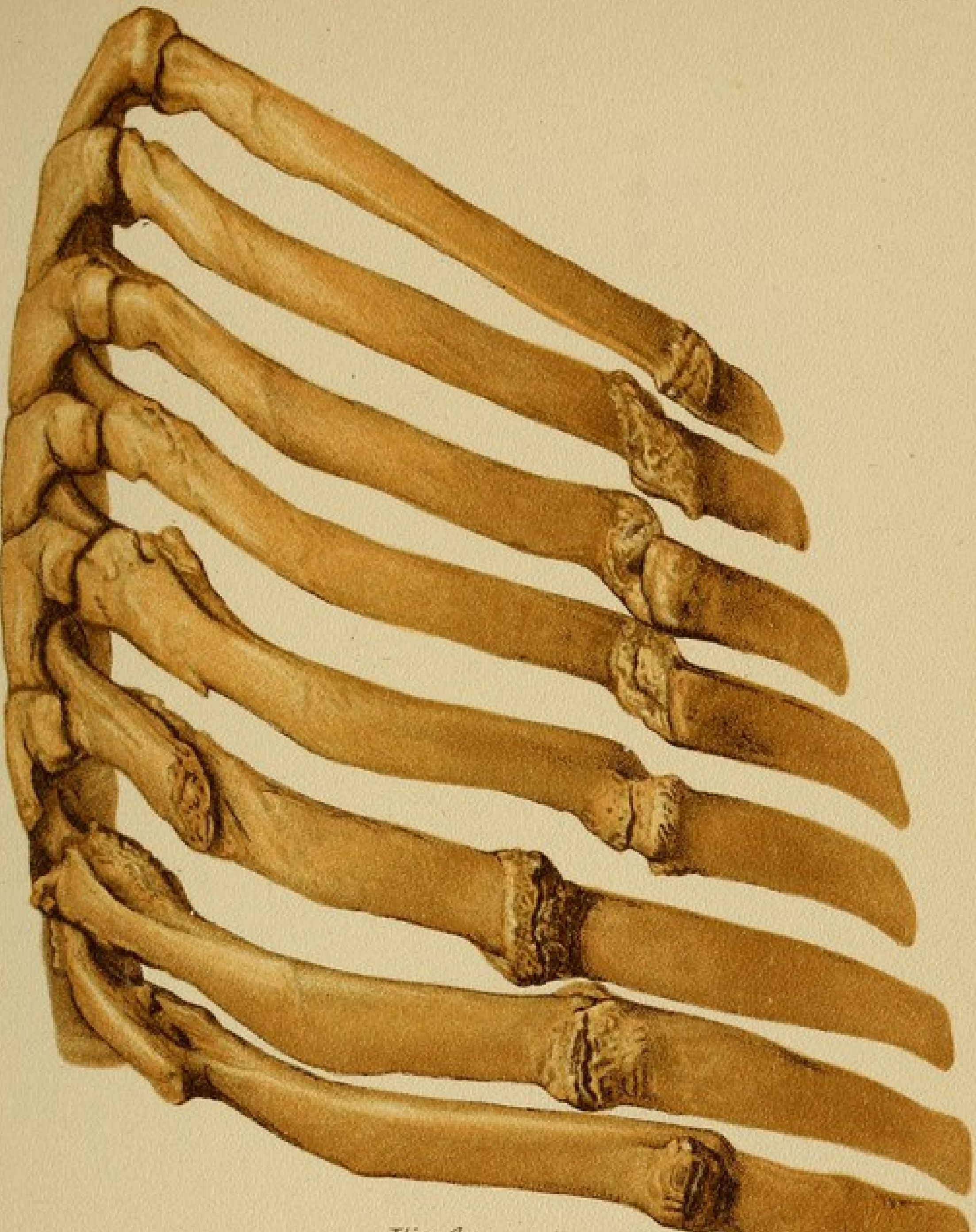

Fig. 1.

Fig. 1 a

Fig. 2.

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may continue to cause great distress for an indefinite period.

Fractures of the costal cartilages are not as rare as might be supposed. The fracture occurs at the junction between the cartilage and the rib (see Plate 22, Fig. 2), or in the body of the cartilage itself (Plate 22, Fig. 1). The latter specimen demonstrates that a fracture of this kind may leave considerable deformity and unite with a scanty formation of callus. The fracture is predisposed to by diminished elasticity of the cartilage, due to senile changes, and is usually produced by direct violence; it occurs most frequently in those cartilages which are most exposed—namely, the fifth to the eighth.

The symptoms are the same as in fracture of the ribs, except that crepitus is of a softer character.

DISLOCATION OF THE RIBS

This extremely rare injury needs only a passing reference. It may occur in the form of a luxation of the costal cartilages at the sternal extremity or of the costo-vertebral articulations, or, finally, as a dislocation at the junction of two costal cartilages. Reduction is effected by direct pressure or movement, as, for instance, deep inspiration.

(B) FRACTURES OF THE STERNUM. (Plate 22.)

They are produced by direct violence, and are then dangerous on account of injury to the internal organs, or by indirect violence in flexion of the vertebral column or of the head so that the chin presses against the upper edge of the sternum. In the latter variety the sternum is compressed in its longitudinal axis until it snaps. Sometimes the combination of fracture of the cervical portion of the vertebral column and fracture of the sternum is produced in this way. Fracture of the sternum has also been known to occur after overextension of the trunk; that is

PLATE 22.

Fracture of the Costal Cartilages and of the Sternum.—Fig. 1.—Fracture of the costal cartilages; horizontal section; marked displacement of the fragments, which are united by a scanty formation of bone. (Path.-Anat. Inst., Greifswald.)

Fig. 2.—Fracture of the costal cartilages at the bony portion of the fifth rib; horizontal section; no displacement. The union is not bony; it rather resembles a false joint. (Path.-Anat. Inst., Greifswald.)

Fig. 3.—Recent fracture of the sternum, artificially produced in the cadaver in imitation of a similar fracture observed by the author.

Fig. 4. Fracture between the manubrium and gladiolus; union with displacement of the fragments. (After Gurlt.)

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to say, by muscular action. Owing to the superficial position of the bone, the **diagnosis** presents no difficulties, especially when there is anterior or posterior displacement of the fragments.

Treatment.—In two recent cases under my care I was able to reduce the displacement of the fragments, as is shown in the picture, by extension applied to the head with Glisson's sling; extension was maintained by supporting the thorax on a wedge-shaped cushion and the head was placed in slight overextension.

VI. FRACTURES AND DISLOCATIONS OF THE UPPER EXTREMITY

Injuries to the upper extremity are either direct or indirect. Injuries due to *direct* violence present certain definite characteristics, and their presence can often be recognized by a knowledge of the cause alone; on the other hand, injuries due to *indirect* violence, even when produced by the same cause, present a great variety of forms. Thus, a fall on the hand may be followed by a typical fracture of the lower extremity of the radius, by an injury to the elbow-joint, the upper end of the humerus, or the

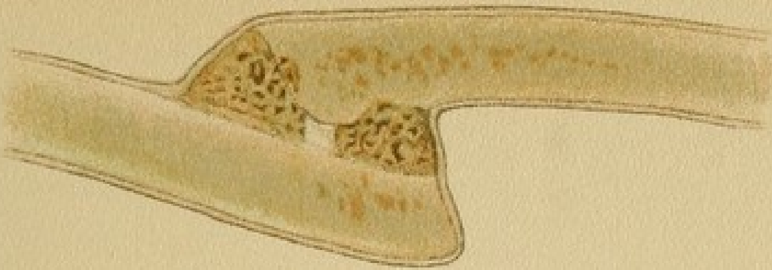

Fig. 1.

Fig. 2.

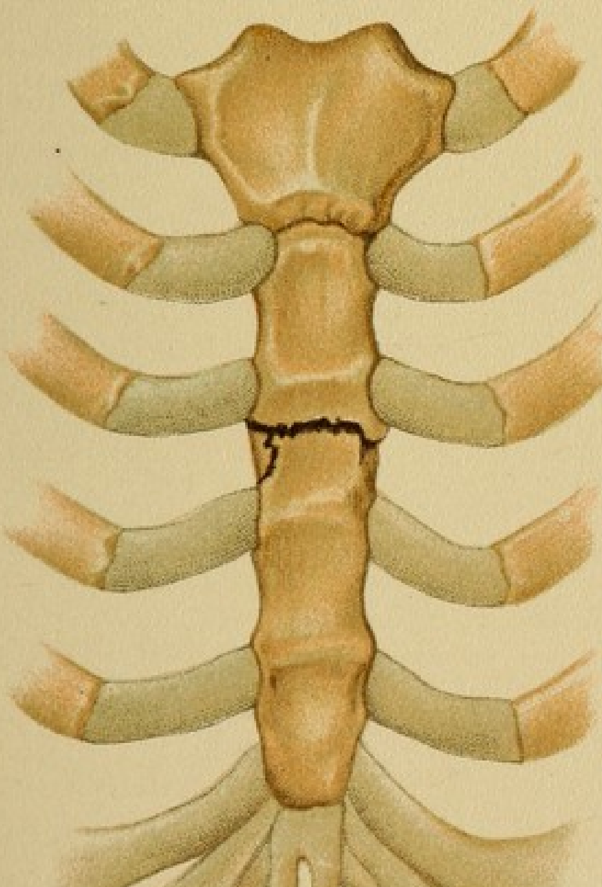

Fig. 3.

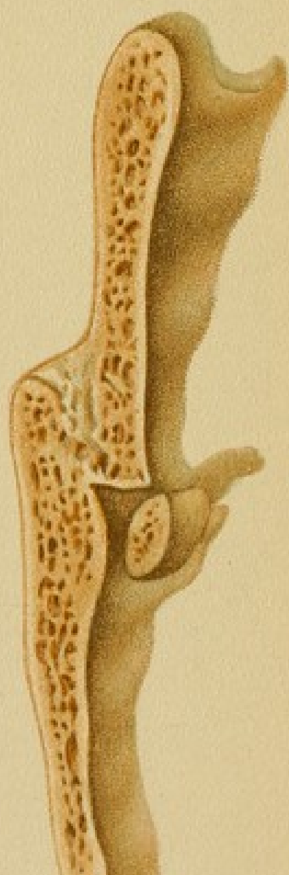

Fig. 4.

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shoulder-joint; in children the accident may even produce a fracture of the clavicle.

1. CLAVICLE

(A) Fracture of the Clavicle

is a common accident, constituting about 15% of all fractures. The fracture may occupy any portion of the bone, but is most frequent at about the middle, usually a little nearer the sternal extremity. Fracture of the clavicle is, as a rule, produced by indirect violence, by a fall on the hand while the elbow- and shoulder-joints are fixed, or by a fall on the shoulder, the bone being bent until it breaks. Owing to the fact that the clavicle comes in contact with the first rib when the shoulder is strongly depressed, fracture of the bone at this point is said to be produced by the downward pull on the arm in lifting heavy weights. Incomplete fractures (infractions) are frequently observed at this point, particularly in children.

The **symptoms** of a typical fracture of the clavicle are, as a rule, very characteristic. The displacement of the fragments depends both on the action of the muscles and on the weight of the arm. The sternal fragment is acted on by the sternocleidomastoid muscle and usually suffers some degree of upward displacement. The pull exerted by the powerful muscles that connect the thorax with the arm causes a secondary approximation of the outer fragment and of the entire arm toward the thorax, for under normal conditions the clavicle acts as a brace maintaining the shoulder at the proper distance from the thorax. Hence in a typical fracture of the clavicle the arm hangs lower than on the sound side. Furthermore, the arm as a whole is brought nearer to the thorax, so that the axillary space is not as accessible as under normal conditions; and, finally, there is a forward and median inward displacement of the arm—a

PLATE 22 a.

Normal Shoulder-joint of an Adult. Skiagraph.—The picture is explained by figure 35.

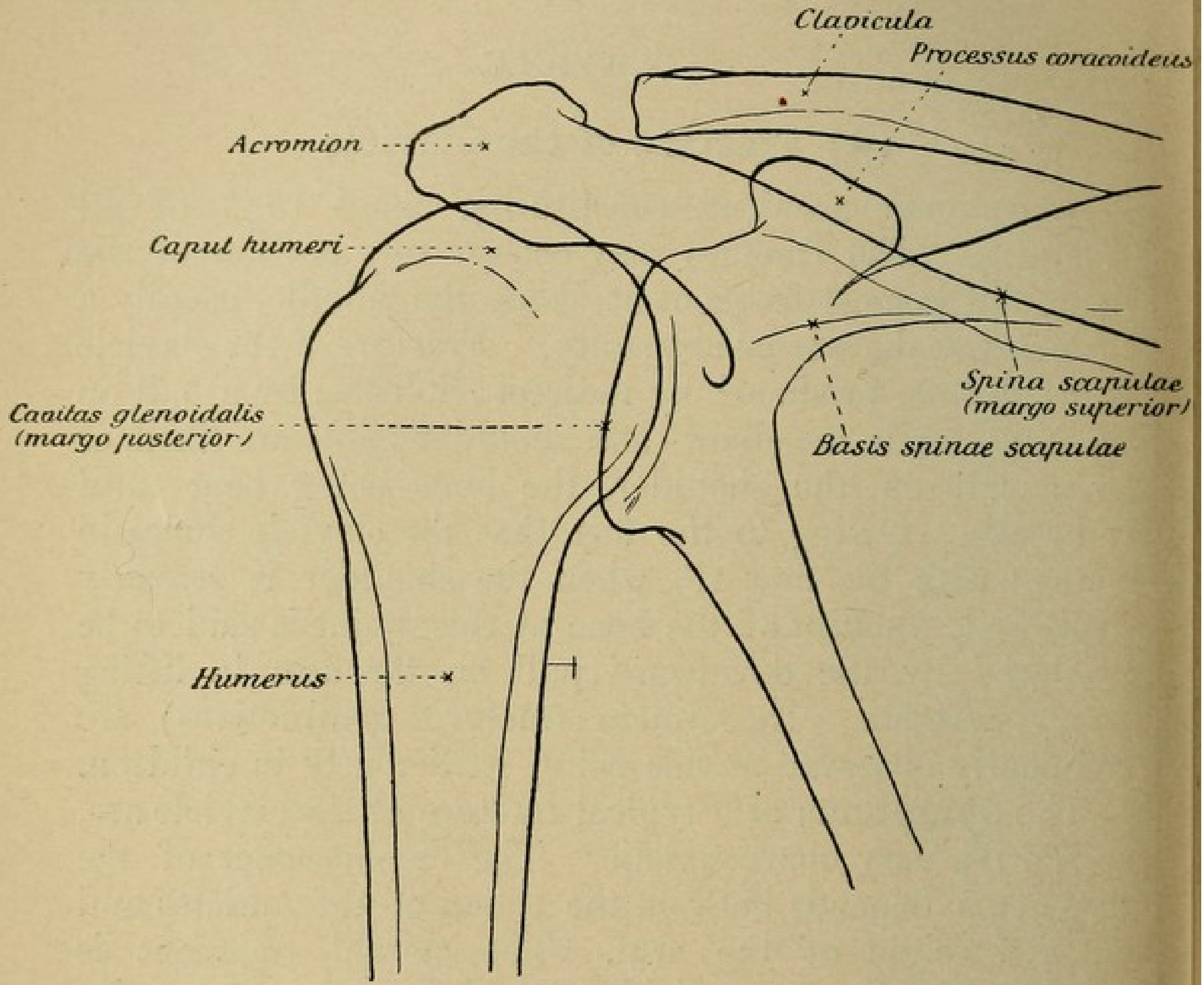

Fig. 35.

kind of internal rotation, due evidently to the unopposed pull of the thoracic muscles.

The **diagnosis** of a fully developed fracture of the clavicle is very simple, and is usually made by inspection. The displacement, the attitude of the arm, and the swelling at the seat of fracture are recognized at a glance. As the bone is very accessible, the displaced fragments can readily be palpated, and, in addition, the pain and functional disturbance usually point to the seat of injury. If the fracture is incomplete (infraction and fissure-fracture), displacement may be slight or entirely wanting.

Tab. 22a.

The **treatment** of these typical fractures of the clavicle demands, in the first place, accurate reduction, and, in the second place, a dressing that will counteract the

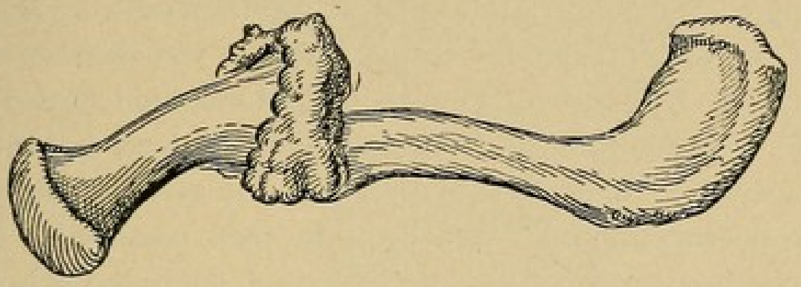

Fig. 36.—United fracture of the right clavicle in a man thirty years of age. Seen from above and behind. There is an abundance of callus; the inner fragment is displaced forward and upward, and overrides the outer fragment considerably. (Berliner Anat. Museum; after Gurlt.)

causes that produce the displacement. It is well known that union of a broken clavicle without deformity was formerly considered one of the greatest rarities and a most difficult problem to solve.

We now have means at our disposal which enable us, even in the severest cases, to secure union in a favorable position.

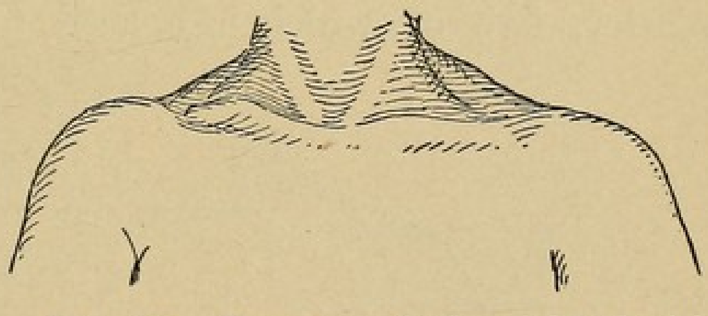

Fig. 37.—Fracture of the right clavicle with displacement. The sternal fragment projects slightly upward and distinctly forward (Müller, female, nineteen years old). The shortening of the right clavicle is recognized by the diminished width of the shoulder on that side, measured to the median line. (Author's observation.)

To effect reduction and maintain the fragments in position while the bandage is applied (Fig. 39), an assistant should stand behind the patient, who is seated in a chair, and forcibly draw the shoulders backward, helping himself if necessary by bracing his knee against the patient's back. An

PLATE 23.

Fracture of the Clavicle with Typical Displacement of the Fragments.—The seat of fracture is at the junction between the sternal and middle third of the bone. The fragments present marked "overriding." The sternal fragment is displaced upward by the pressure of the outer fragment and the pull of the sternocleidomastoid muscle. In the illustration the sternocleidomastoid muscle is readily recognized; behind, the outer boundary of the neck is formed by the trapezius muscle; the deltoid is dissected out and the clavicular portion of the pectoralis major has been in part removed. Within the fenestra thus produced we see the fractured clavicle with the subclavian muscle hugging its lower surface and the first rib. Behind the clavicle the large vessels and nerves are shown. As a result of the fracture the arm is brought nearer to the trunk, and the axillary cavity therefore contracted; the arm hangs down, the right elbow being lower than the left.

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appropriate dressing is the adhesive plaster dressing devised by Sayre; it consists of three strips of adhesive plaster, two of which are used to correct the above-

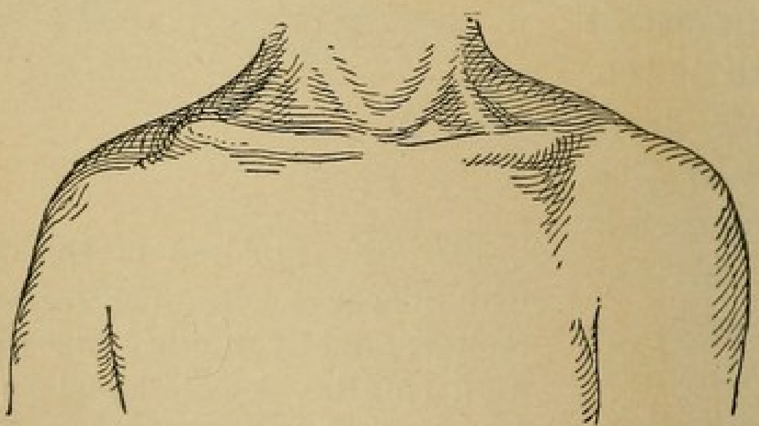
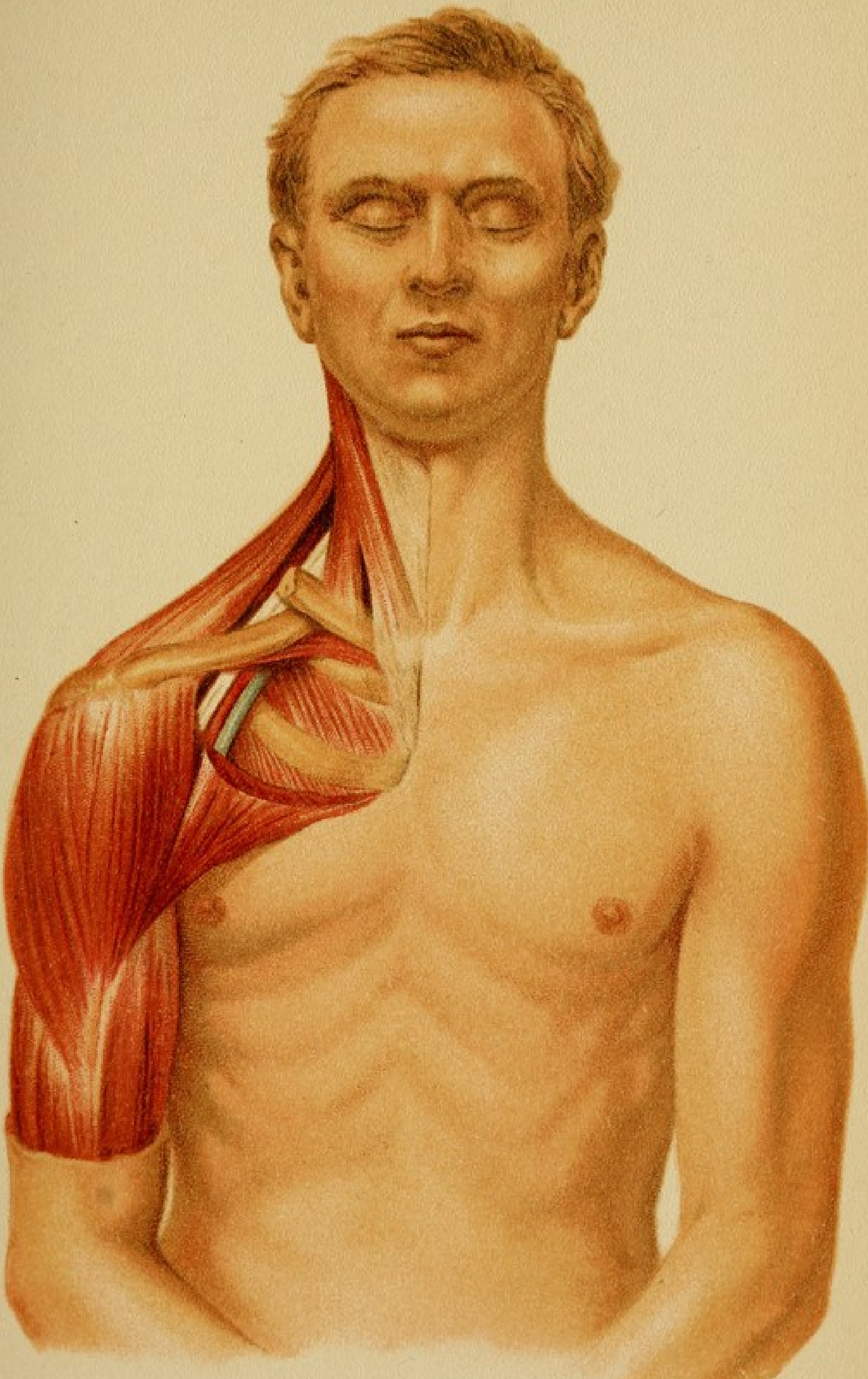


Fig. 38.—Recent fracture of the outer half of the right clavicle (Schröder, male, sixty years old). Marked deformity; the larger, median fragment projects upward; the outer fragment is depressed along with the entire shoulder. The width of the shoulder is distinctly diminished. (Author's observation.)

described displacement. The first strip corrects the internal rotation of the arm. It is wrapped around the upper extremity of the arm from the inner to the outer



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side and passes over the shoulder to the back. The second strip is wrapped around the elbow and passed over the shoulder of the sound side so as to support the injured arm. The third strip acts merely as a sling to support the hand, being passed over the injured shoulder. Incidentally it exerts moderate pressure on the fragments from above and in front. One indication which is not met by this method is the restoration of the axillary space; *i. e.*, of the normal distance between the shoulder and thorax. For this purpose a pad of some soft material, covered with gauze, should be placed in the axilla and fixed in some simple way. The dressing may be advantageously reinforced by a few turns of a roller bandage in order to enhance its effectiveness. At the same time a small pad may be fixed over the seat of fracture so as to produce a slight downward pressure on the sternal fragment. In the summer-time it is well to dust the area covered by the dressing, especially the axillary space, with toilet powder.

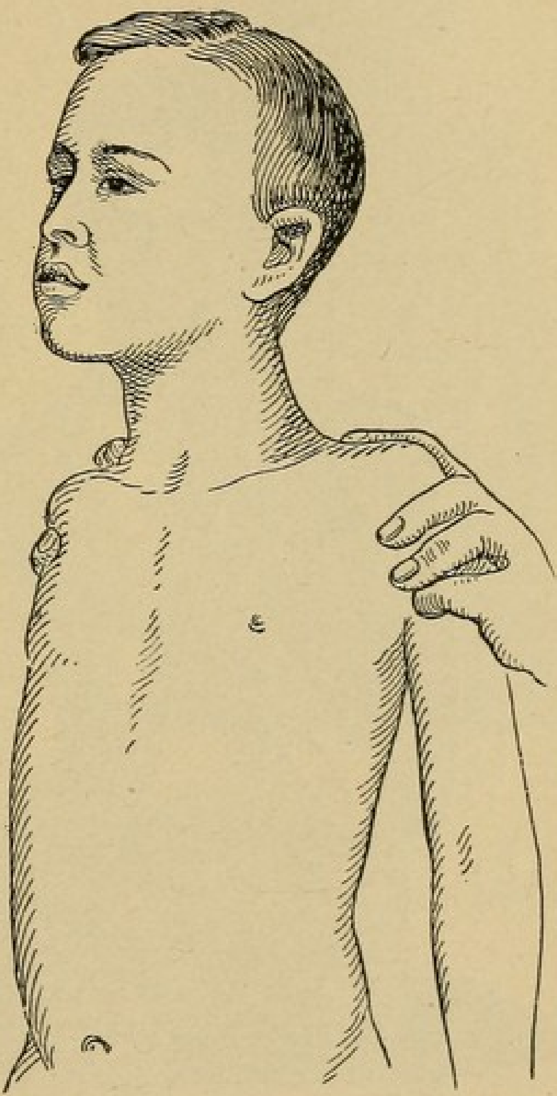

Fig. 39.—Method of reducing a fracture of the clavicle and maintaining the fragments in place while the dressing is applied.

The effectiveness of the adhesive-plaster dressing may be increased by incorporating two pieces of rubber bandage in the strips of adhesive plaster, and by exerting the proper tension while they are being applied so as to produce a continuous elastic pressure which prevents recurrence of the displacement. The same thing may be accomplished by means of pieces of rubber tubing. With proper supervision of the patient these simple means will suffice to obtain satisfactory results, provided the surgeon possesses the necessary technical skill. It is much to be regretted that we still see a good many badly united fractures of the clavicle. Cases of multiple fracture and infraction should be treated on the same principles.

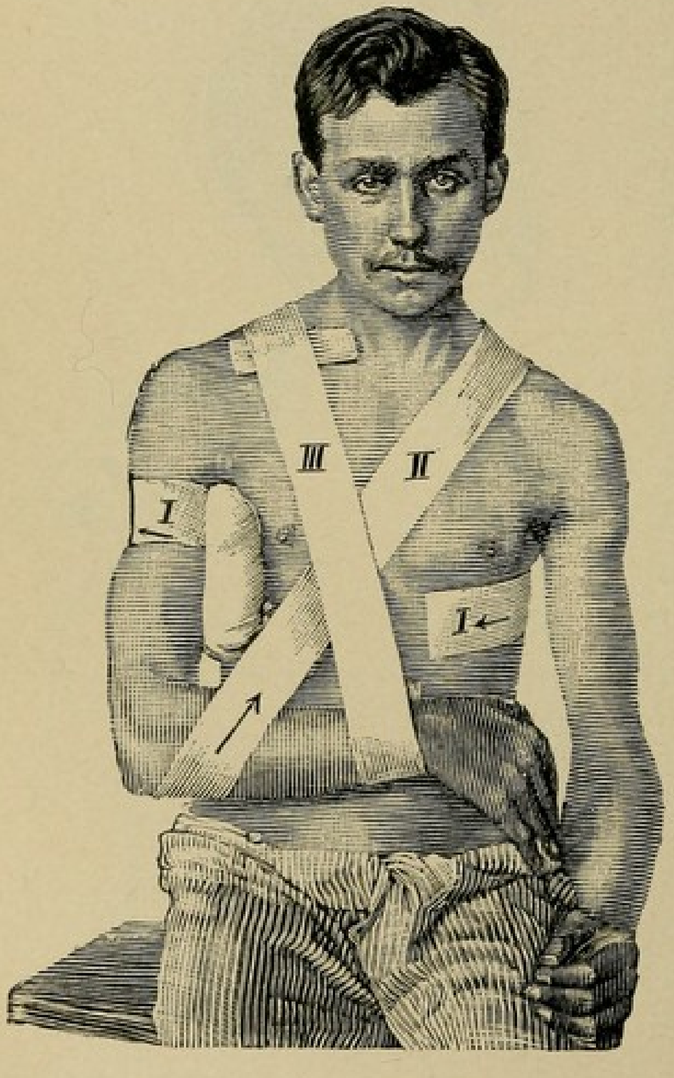

Fig. 40.—Sayre's adhesive-plaster dressing for fracture of the clavicle.

[The most important point in the treatment of fractures of the clavicle is to prevent the usual deformity—lowering and falling forward and slightly inward of the shoulder. Surgeons in this country prefer a somewhat more simple method of dressing than the one illustrated here (see Scudder's recent text-book). They also prefer the Velpeau position of the forearm. Personally, I prefer a plaster dressing with the arm in the Velpeau position, the hand out of the dressing. A properly fitted axillary pad is most important. This plaster dressing holds the shoulder in its corrected position perfectly. A window can be cut over the site of the fracture to allow inspection.

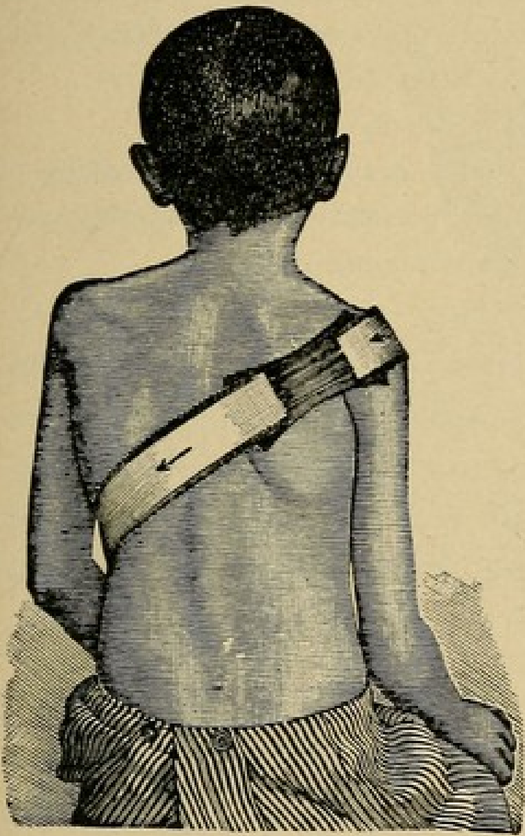

Fig. 41.

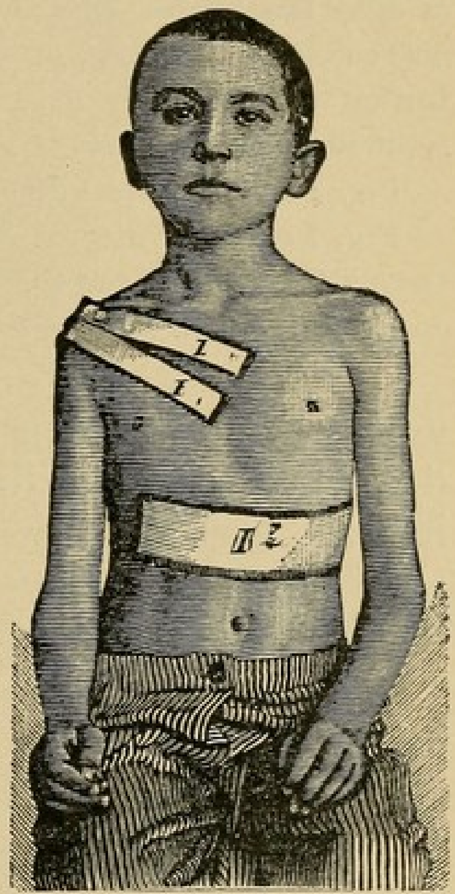

Fig. 42.

Figs. 41 and 42.—Adhesive-plaster dressing for fracture of the clavicle (first strip of Sayre's dressing) with interposed zinc plaster-mull, and intercalated strip of rubber bandage.

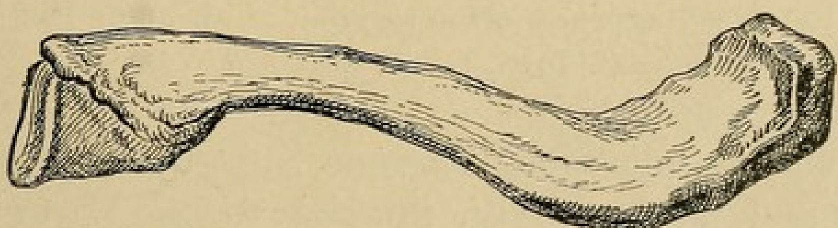

Fig. 43.—United fracture in the sternal third of the right clavicle, seen from above and behind. The oblique fracture is firmly united by callus. (Anat. Museum, Breslau; after Gurlt.)

When properly applied over skin well dusted with magnesium powder, the dressing is worn with comfort for two

PLATE 24.

Dislocation of the Sternal Extremity of the Clavicle.—Fig. 1.—Presternal luxation of the right clavicle, in a man fifty-seven years of age (Brackhahn, 1894–95, No. 1160); anterior view. There was also compound fracture of the forearm on the same side. In the illustration the prominence of the dislocated clavicle is well shown; the right shoulder is nearer the median line than the left.

Fig. 1 *a*.—The same dislocation shown in the skeleton.

Fig. 1 *b*.—Retrosternal dislocation of the clavicle. A dislocation of the clavicle behind the sternum produces pressure on the trachea and esophagus, which may be followed by grave consequences.

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weeks. It has been my experience, especially in children, that only the plaster dressing remains fixed; other dressings are very apt to work loose, and adhesive plaster applied to large areas of skin in warm weather produces much more discomfort than the plaster dressing.—Ed.]

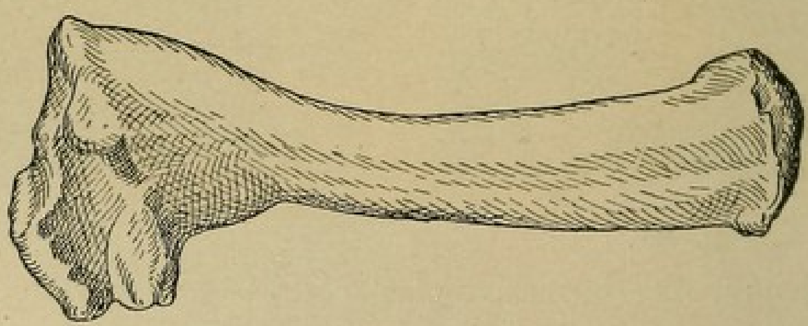

Fig. 44.—United fracture of the acromial end of the right clavicle; seen from above and in front. The outer fragment is placed obliquely on end; the two fragments come together at an angle like the rafters of a roof. (Path.-Anat. Inst., Greifswald.)

Among complications there are injuries to the brachial plexus and, more rarely, injuries to the large vessels. Secondary injuries to the plexus may result from pressure of the callus; because, owing to its position on the first rib, the plexus is unable to get out of the way. It very rarely happens in fracture of the clavicle that the dome of the pleura and apex of the lung become injured by a sharp fragment.

Fig. 1.

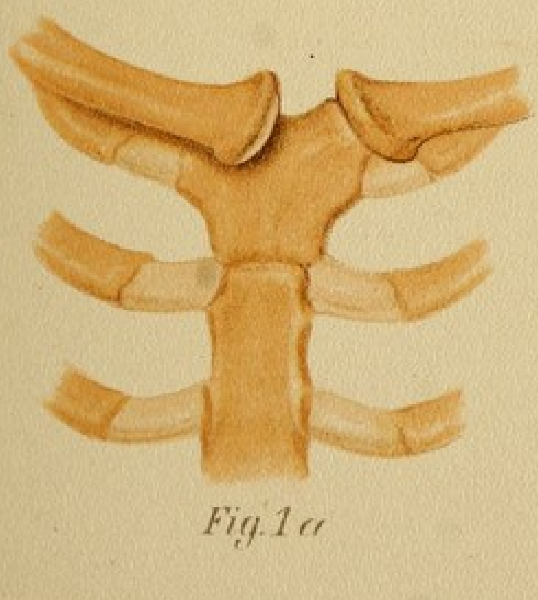

Fig. 1 a

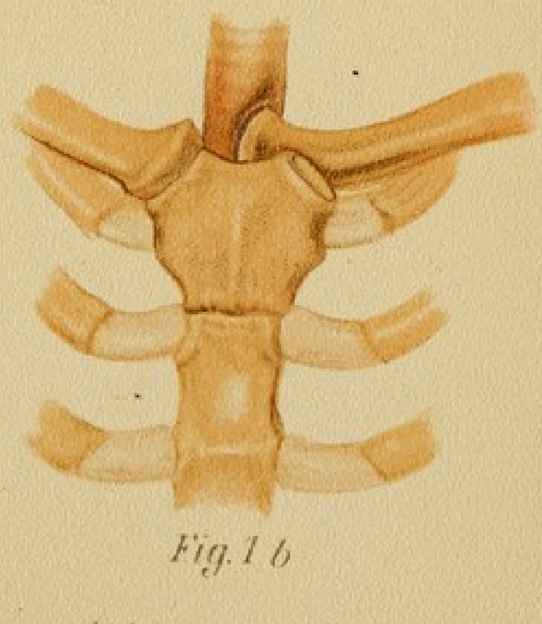

Fig. 1 b

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Fracture of the sternal segment of the clavicle is rare, and does not, as a rule, produce any deformity.

Fracture of the acromial end of the clavicle sometimes produces marked deformity, the outer fragment being almost placed on end. It may be difficult to apply the bandage so as to keep both fragments in position, but good reduction and an elastic bandage are required.

(B) Dislocations of the Clavicle

(a) Sternal dislocation of the clavicle—*i. e.*, dislocation of the sternal end of the clavicle—presents various forms:

Anterior dislocation (*luxatio præsternalis*).

Upward dislocation (*luxatio suprasternalis*).

Both these varieties are produced indirectly by leverage, the first rib acting as a fulcrum; or they may be produced by a force acting from without, depending on the position of the clavicle, whether it is directed backward or downward. In anterior dislocation secondary displacement may take place.

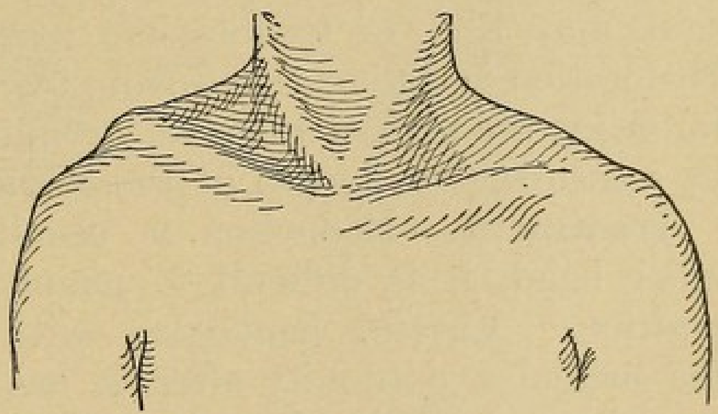

Fig. 45.—Recent fracture in the acromial third of the clavicle. The normal clavicle on the sound side measures 18 cm. in length. The inner fragment measures 16 cm., leaving 2 cm. for the acromial fragment. The median extremity of the latter is distinctly raised and partially connected with the inner fragment, which is also displaced upward and can be distinctly felt under the skin. The patient's name was Warnke, sixty-eight years of age. (Author's observation in the surgical clinic at Greifswald, 1896.)

Posterior dislocation (*luxatio retrosternalis*). This is very rare; it is produced by direct violence.

PLATE 25.

Upward Dislocation of the Acromial End of the Clavicle.—Fig. 1.—The abnormal prominence of the clavicle is very conspicuous. To the outer side and below we see the normal rotundity of the shoulder with the acromion. The dislocation is seen even more plainly in the posterior view shown in figure 1 *b*. The line of the spine of the scapula is directed toward the acromion. The right shoulder is nearer the median line than the left, because the bracing action of the clavicle is lost. The right axillary space is contracted.

Fig. 1 *a* shows an anterior view of the dislocation in the skeleton. (Author's specimens.)

The **diagnosis** is always easy, because all the conditions can be readily palpated. In the backward dislocation (Plate 24, Fig. 1 *b*) the pressure on the trachea and esophagus may lead to troublesome dyspnea and dysphagia. Dislocation is differentiated from fracture near the joint by following the normal spherical prominence of the bone and by measuring the length of the clavicle.

Treatment.—Reduction is usually easy, but, on the other hand, it is difficult to maintain the fragments in position. Careful bandaging with direct pressure on the articular extremity after it has been replaced, and sometimes elastic bandages, as referred to under treatment of fracture of the clavicle, are indicated. In some cases the fragments may have to be fixed by means of a suture through the skin (percutaneous suture). [It is surely a better surgical procedure, when a bone is to be fixed by suture, to make a skin incision and approximate the fragments with a subcutaneous suture. The danger of infection is less, and with the open wound one can be more certain of the perfect approximation.—ED.]

(b) Acromial Dislocation of the Clavicle.—To be exact, this condition should be called dislocation of the scapula. The clavicle may be dislocated:

Upward (*luxatio supra-acromialis*), or

Downward (*luxatio infra-acromialis*).

Fig. 1.

Fig. 1 a

Fig. 1 b

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The latter is a very rare accident. The first variety is often produced by direct violence acting on the acromion while the clavicle is fixed. It is really a downward dislocation of the scapula. If after the coraco-clavicular ligament is torn a marked displacement exists, the dislocation is *complete.*

The **diagnosis** is easy, as the parts can be accurately palpated; nevertheless, this dislocation is often confounded with dislocation of the humerus. Great care in the examination is necessary to distinguish this dislocation from a fracture of the clavicle close to the acromial extremity. To establish the diagnosis between these conditions, the length of the clavicle must be accurately measured. To distinguish it from a typical dislocation of the shoulder a single manipulation by the surgeon seated in front of the patient suffices. If both hands are passed along the scapular spines from behind, they will, without fail, come upon the point of the acromion (Plate 25, Fig. 1 *b*); the position of the latter in relation to the abnormal prominence of the clavicle will at once clear up the doubt.

Treatment.—In this form reduction is easy, but it is often difficult to keep the fragments in position. Several turns of a roller bandage are applied in such a way as to elevate the arm and at the same time press the clavicle downward. Elastic bandages or percutaneous suture of the ligaments may be necessary (Baum).

2. SCAPULA

Fractures of the scapula are rare (about 1%), and present several varieties.

Fractures of the body and spine of the scapula are produced by direct violence; the line of fracture may be multiple or stellate, but the fragments show little tendency to displacement. Crepitus and abnormal mobility may often be elicited, especially if the arm is put in an appropriate position. The *treatment* consists in placing the arm at rest and applying a bandage with slight pressure.

PLATE 26.

Fractures of the Scapula.—Fig. 1.—Specimen of fracture of the neck of the scapula. The fragment comprising the articular cavity and the coracoid process is depressed.

Fig. 1 *a*.—The same in the living subject. The prominence of the acromion is recognized ; the shoulder is somewhat depressed. (Author's observation.)

Figs. 2 and 2 *a* —Specimen of multiple fracture of the body and spine of the scapula. The lines of fracture are united by callus. (Author's collection.)

Fractures of the neck of the scapula are extremely rare and occur only at the so-called surgical neck ; *i. e.*, in such a way that the coracoid process remains attached to the articular fragment. In other words, the line of fracture runs from the notch of the scapula downward (see Plate 26). The differential diagnosis of fracture of the neck of the scapula is important, because it is apt to be confounded with subcoracoid dislocation of the humerus.

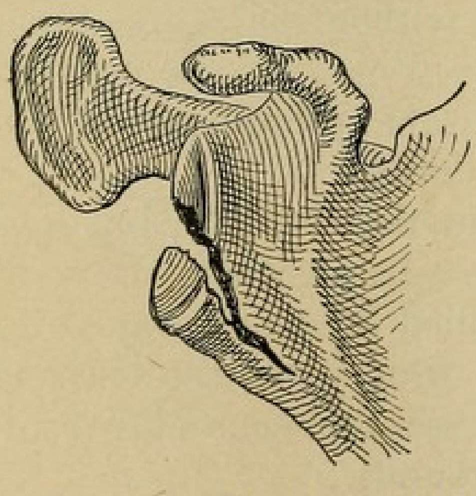

Fig. 46.—Fracture at the lower border of the articular surface.

The *symptoms* of the fracture are : depression and some degree of abduction of the arm with prominence of the acromion ; if the arm is raised, crepitus is elicited and the deformity disappears, but returns as soon as the support is removed from the arm. Sometimes the edge of the fractured surface of the scapula can be felt through the axilla. The fracture unites readily if the bandage is applied in such a way as to place the arm and the scapula at rest. The indications are to keep the arm permanently elevated, abducted, and in a slightly posterior position. An axillary pad should be used.

Fracture of the edge of the articular surface, espe-

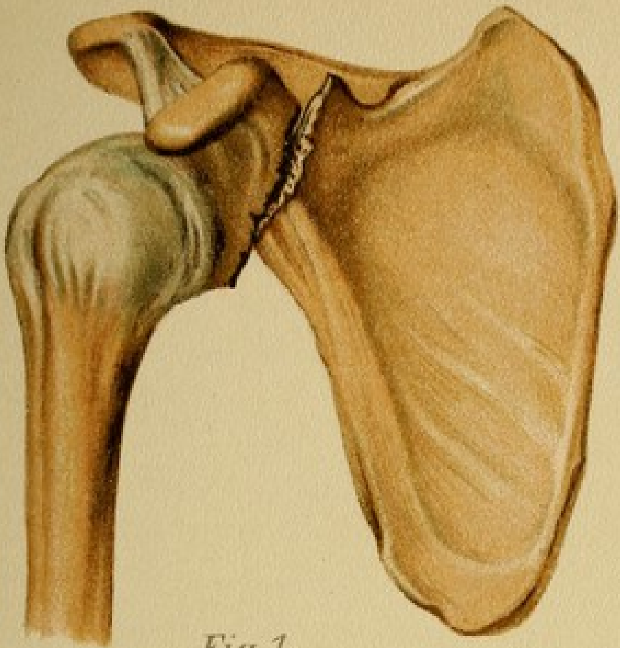

Fig. 1.

Fig. 1 a

Fig. 2.

Fig. 2 a

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cially the lower border, is rare; being an intra-articular injury, it can be recognized only when the arm is placed in a certain position. The symptoms are, slight depression of the head of the humerus when the arm is held out at right angles to the side of the body; and, sometimes, crepitus when the head of the humerus is made to move from before backward.

Isolated **fracture of the coracoid process** by direct violence is extremely rare. A similar fracture of the **acromion** is somewhat more frequent, and is recognized by direct palpation and by the presence of abnormal mobility and crepitus. Sometimes the crack in the bone can be felt in marked adduction of the arm. Union may be obtained by slightly elevating the arm and placing it at rest.

3. SHOULDER-JOINT

Dislocation of the shoulder-joint is one of the most important, as it is one of the most frequent, injuries. Although its recognition presents no peculiar difficulties, many cases are overlooked. In a normal shoulder we can easily feel the acromion at the outer extremity of the spine of the scapula and its connection with the clavicle; the coracoid process; and the head of the humerus beneath the deltoid muscle. The head of the humerus is so plainly felt that, by rotating the arm, even the tuberosities and the groove between them can be made out. Through the axilla the head of the humerus and the edge of the glenoid fossa are felt. As we all know, contact in this very movable joint is not maintained by the capsule and ligaments, but by the muscles and atmospheric pressure. In paralysis of the deltoid muscle the head of the humerus is always somewhat depressed; and there are cases of idiopathic palsy in children in which the soft parts are so thin that the downward displacement of the head of the humerus is visible.

(a) Forward dislocation of the humerus (preglen-

PLATE 27.

Subcoracoid Dislocation of the Humerus.—The patient, a man of sixty-four, was injured about three weeks before the skiagraph was taken. In the interim the swelling subsided, so that the relations at the shoulder-joint are easily recognized. The prominence of the acromion is almost angular. The arm is abducted and the outer boundary forms an obtuse angle with the vertex directed inward. The long axis of the humerus is directed toward the coracoid process instead of toward the acromion, and underneath the coracoid process is an ill-defined prominence; the arm appears to be lengthened. The diagnosis of subcoracoid dislocation is unmistakable.

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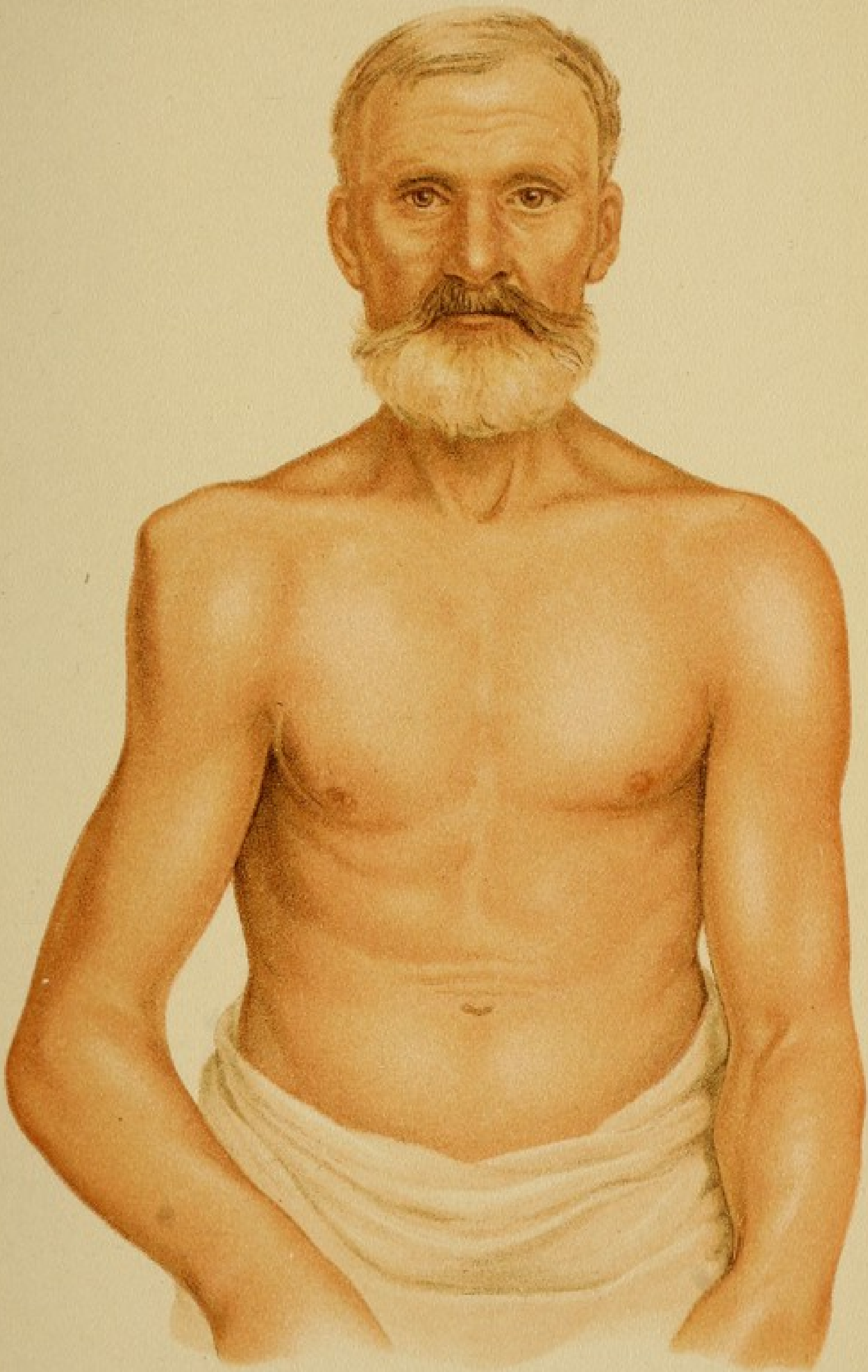
oidal, also called subcoracoid, or subclavicular, depending on whether the head of the bone is found under the coracoid process or under the clavicle). This is the most frequent dislocation at the shoulder-joint. It can be produced artificially without difficulty by placing the cadaver in the dorsal position, abducting and elevating the arm to its full extent, and gradually forcing it backward. During this procedure the anterior portion of the capsule (the thinnest portion) is greatly stretched by the head of the humerus, and a tear is produced. The head escapes through the rent in front and below the coracoid process —the dislocation is complete. As soon as the arm is replaced in a more normal position, all the objective symptoms of this luxation, except the ecchymosis, make their appearance.

In the living subject subcoracoid dislocation is produced sometimes *directly* by a blow on the humerus from behind, or from the side; or, more frequently, *indirectly* by a fall on the side while the arm is elevated and abducted, or by a fall on the outstretched hand, or on the elbow, especially when the arm is directed backward. The accident has also been observed after violent movements of the arm, as in throwing. When the dislocation is produced by indirect violence,—that is, by excessive abduction,—the mechanism is as follows : the humerus comes in contact laterally



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with the scapula; the region corresponding to the tuberosities and the surgical neck (if the force continues to act) are pressed against the upper border of the glenoid fossa and the acromion. These constitute a fulcrum, and the short arm of the lever—*i. e.*, the head of the humerus—is pried out of its normal position, tearing the capsule. A dislocation produced in this way generally presents the character of a downward or infraglenoid dislocation, which by a secondary displacement of the humerus under the action of the muscles is converted into a subcoracoid dislocation. As regards the anatomic relations in a subcoracoid dislocation, the head of the humerus is found in close contact with the edge of the glenoid cavity, between it and the thorax (see Fig. 47), and may exert pressure on the large vessels and nerves.

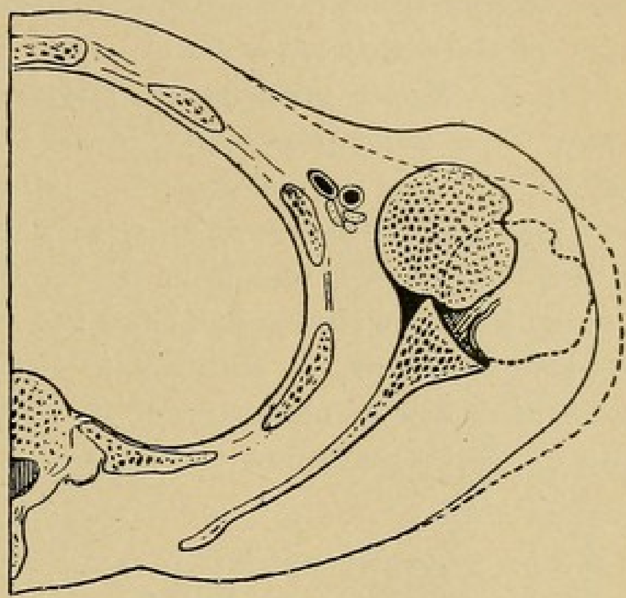

Fig. 47.—Horizontal section through the shoulder region and adjacent half of the thorax in a subcoracoid dislocation of the shoulder on the right side. The abnormal position of the head of the humerus and of the shoulder is indicated by solid lines, the normal position of these parts by dotted lines. The cross-section of the vessels and nerves is also shown. The tuberosities and the groove between them can be recognized on the head of the humerus. (After Anger.)

The **symptoms** of a typical subcoracoid luxation are very characteristic (see Plate 27). They are due to the fact that the head of the humerus is absent from its normal position and occupies an abnormal position. The examination is always begun by inspection, as this alone often suffices for the diagnosis, palpation being desirable

PLATE 28.

Subcoracoid Dislocation of the Humerus; Anatomic Specimen.—Fig. 1.—From the skeleton, showing the abnormal position of the head of the humerus. What is seen more particularly is that the head occupies a lower position than normal, explaining the "lengthening" of the dislocated arm.

Fig. 2.—Muscle preparation. The characteristic position is also recognized, the angular prominence of the acromion and the deltoid muscle are particularly well shown; the latter is tightly drawn downward and meets the humerus at an acute angle. The characteristic outline of the dislocation is seen to be produced by the outer border of the dislocated humerus (lower half) and the edge of the deltoid muscle. The illustration shows, in addition to the deltoid muscle, the pectoralis major, the biceps, alongside of the latter a section of the brachialis anticus, and a portion of the triceps.

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only as a confirmatory procedure. It is best to have the patient sitting on a chair with the back unsupported. The clothing should be removed down to the waist so as to enable the surgeon, who sits opposite, to inspect and compare both sides. This is best done by placing the sound arm in approximately the same position as that of the injured arm.

The rotundity of the shoulder has disappeared and the acromion forms an angular prominence. The normal rotundity of the shoulder is formed by the head of the humerus and the deltoid muscle. If the latter is very atrophic, the acromion projects; and if the head of the humerus is in an abnormal position, the acromion forms an angular prominence, even when the deltoid is well developed, and in spite of the presence of considerable extravasation. That the prominence is due to the acromion is readily determined by following the course of the spine of the scapula, which ends in the acromion.

In the region of the coracoid process and beneath it there is an abnormal prominence which is both visible and palpable, the latter especially when the humerus is rotated slightly backward and forward. This manœuver proves

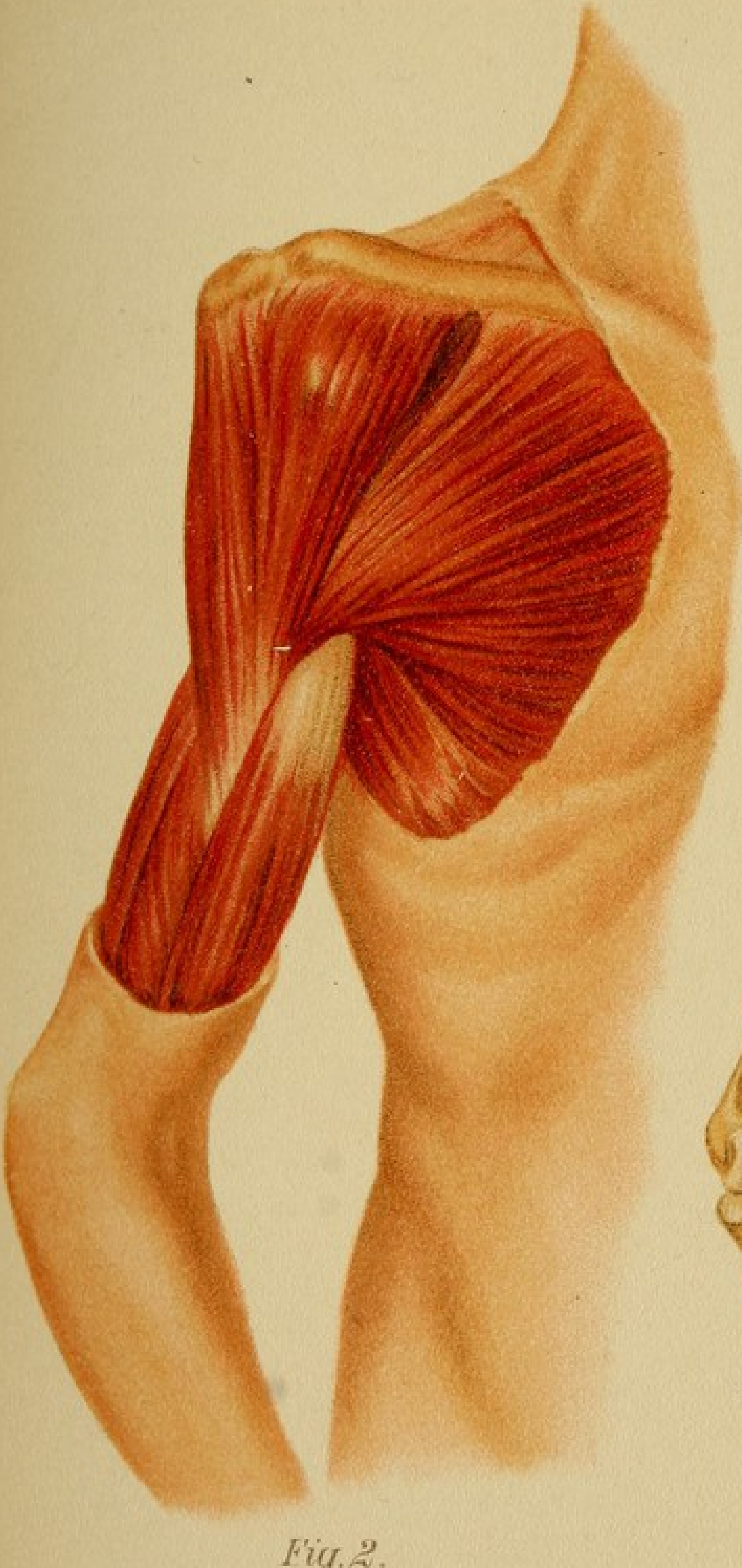

Fig. 2.

Fig. 1.

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that the prominence belongs to the humerus, and by its spherical form it is recognized as the head of that bone.

The arm is in abduction, and immediately returns to that position when the reducing force is removed; *i. e.*, by the exertion of a moderate force it can be adducted until it comes in contact with the thorax, but as soon as the pressure is removed, it immediately returns to an abducted position. This position is due to the tension of certain ligaments—the coraco-humeral ligaments and the ligaments attached to the tuberosities.

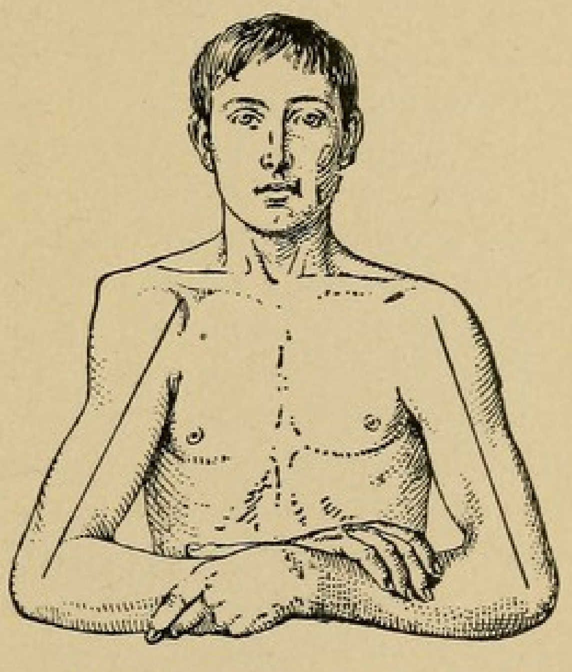

Fig. 48.—Showing a young man with a subcoracoid dislocation of the humerus on the right side. The long axis of the humerus is indicated on both sides by solid lines.

The long axis of the humerus is directed toward the coracoid process or toward a point below the clavicle, instead of toward the acromion, as under normal conditions. This is readily determined by comparing the injured with the sound side.

The outer border of the upper arm appears bent and forms an angle with the vertex directed inward, whereas the sound arm presents an almost rectilinear border. This abnormality is caused by the arm being in abduction, producing the lower half of the line, and by the stretching of the fibers of the deltoid between the acromion and the humerus, representing the upper segment (or upper side of the angle) of this broken line.

The *humerus appears to be lengthened* and the distance between the acromion and a point on the elbow, such as

PLATE 29.

Subcoracoid Dislocation of the Humerus; Anatomic Preparation.—This illustration represents a later stage in the dissection of the specimen shown in the preceding plate. The deltoid muscle has been separated from the clavicle and reflected outward so that the distended acromial portion of the muscle is seen from within. The pectoralis major has also been separated at its upper border and hangs down, supported by its costo-sternal origin and its insertion in the humerus. The pectoralis minor has been divided at the coracoid process and lies against the inner surface of the greater pectoral. The coracoid process is readily recognized by the two short muscular insertions, that of the pectoralis minor on the inner side and that of the coraco-brachialis, with the short head of the biceps, on the outer side. The coraco-acromial ligament runs from the coracoid process outward to the acromion. Underneath the coracoid process is seen the head of the humerus, and a little nearer the median line we see the cartilaginous articulating surface through a rent in the capsule. The muscles inserted on the tuberosities are also discernible on the median side, as is also the subscapular muscle inserted on the lesser tuberosity. Between the two tuberosities the long tendon of the biceps comes into view as it crosses downward in the direction of the belly of the biceps muscle, which has been completely dissected out (below the insertion of the pectoralis major). Between the wall of the thorax, of which the second, third, and fourth ribs are visible, and the humerus lies the brachial plexus, which obviously is exposed to injury by the head of the humerus in this dislocation. Between the humerus and the edge of the deltoid muscle is an empty space from which the adipose and connective tissue have been removed. This space, under normal conditions, is of course filled by the humerus. The circumflex nerve, which supplies the deltoid muscle, is seen crossing this space in an oblique direction from the plexus.

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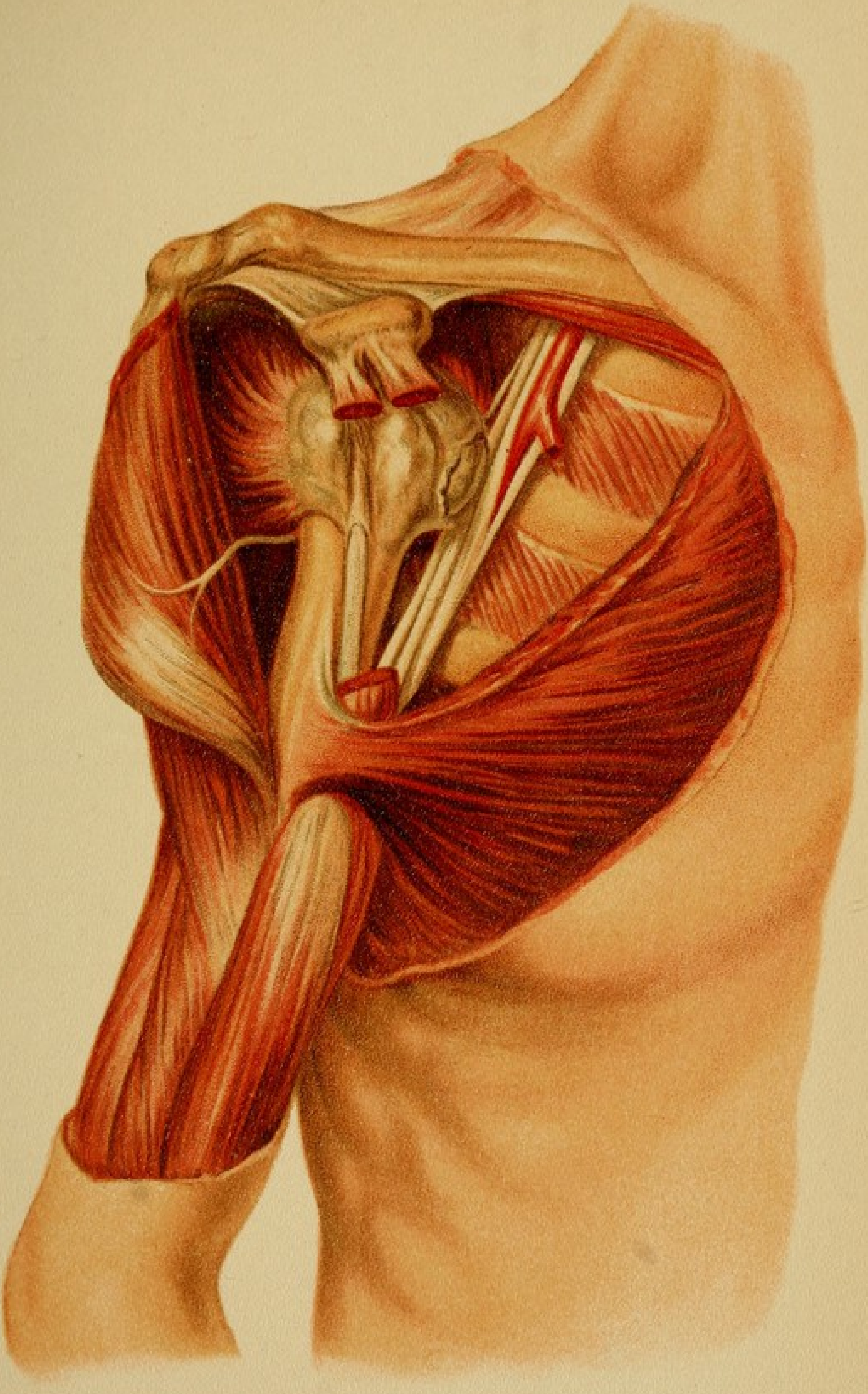
the external condyle of the humerus, is actually lengthened in many cases—certainly never shortened. This can also be seen when the patient is inspected from behind. The explanation of this lengthening is readily seen when the dislocation is produced in the skeleton; the head of the humerus being actually found at a somewhat lower point than its normal position in the articular cavity.



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Finally, the head of the humerus can be palpated more or less distinctly in its abnormal position through the

Figs. 49–52.—Illustrating the differential diagnosis of subcoracoid dislocation of the humerus. In the figures *a* stands for acromion.

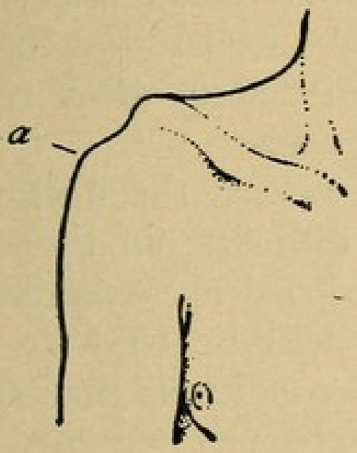

Fig. 49.—Upward dislocation of the acromial end of the clavicle.

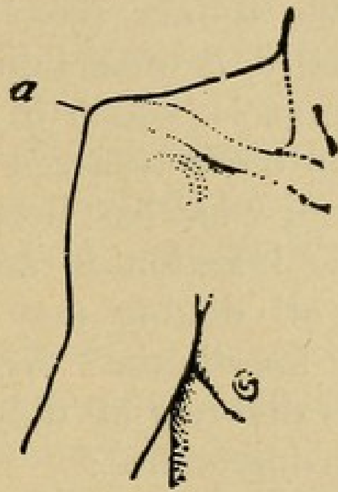

Fig. 50.—Typical subcoracoid dislocation of the humerus.

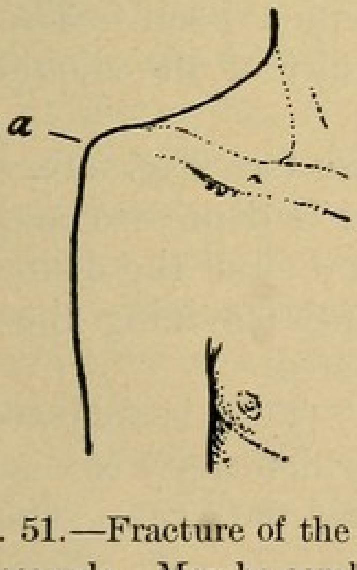

Fig. 51.—Fracture of the neck of the scapula. May be combined with sinking of the shoulder if the deltoid is paralyzed.

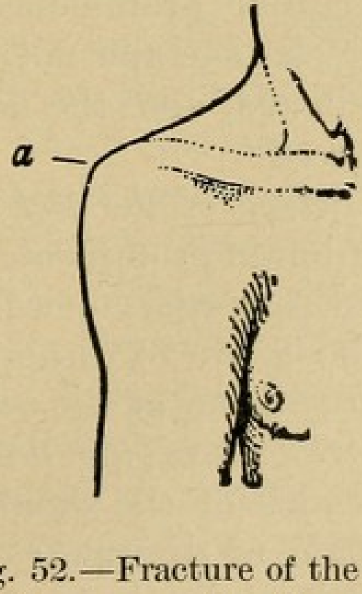

Fig. 52.—Fracture of the neck of the humerus with the arm in abduction.

axilla. Passive movement is exceedingly painful and limited; active movements are even more restricted.

Among the **accessory injuries** are separation of a plate of bone at the greater tuberosity; rarely injuries to the vessels; more frequently injuries to the nerves. The nerves in this dislocation are always exposed to great tension; sometimes they suffer from contusion by pressure of the head of the humerus or by being caught between it and the thorax (see Plate 29). The circumflex nerve, especially, is often injured; hence it is well to test the deltoid muscle, which it supplies, immediately after reduction, in order to avoid error in prognosis.

From what has been said it follows that the **diagnosis** of this luxation is not, as a rule, difficult; in the worst cases all doubts may be dissipated by an examination under anesthesia. Nevertheless it will be well to refer to the differential diagnosis. The conditions that are to be considered are:

Contusion of the shoulder and distortion of the shoulder-joint; in these injuries there is no displacement.

Supra-acromial dislocation of the clavicle; in this injury the angular prominence is produced by the acromial end of the clavicle and not by the acromion itself. The arm is abducted, and the normal rotundity of the shoulder is preserved.

Fracture of the neck of the scapula (see Fig. 51). The acromion is prominent, the shoulder is depressed and displaced somewhat forward and inward; but the dislocation can be made to disappear by simply elevating the arm, crepitus being at the same time elicited.

Paralysis of the deltoid muscle. This is followed by depression of the shoulder, but the deformity can at once be made to disappear by supporting the arm. The arm is not in abduction.

Fracture of the acromion, with great displacement of the fragments; the anatomic relation between the acromion and the head of the humerus is unaltered.

Fracture of the surgical neck of the humerus (see Fig. 52); the rotundity of the shoulder is preserved even when the lower fragment is displaced inward, and the arm rests in abduction. Abduction does not tend to return after reduction, and the arm is never lengthened; on the contrary, shortening is present in almost every case.

Treatment.—The dislocation must be reduced as early as possible. If the surgeon possesses some degree of skill, reduction can be effected without anesthesia, and the head may sometimes be pushed back into place under the pretense of making an accurate examination. In other cases, however, this cannot be done, and anesthesia must be at once resorted to. Among the many methods of reduction which have been devised and carried out, we shall recommend the following:

1. *Moderate Abduction with Extension.*—The patient is placed on his back. An assistant abducts the arm slightly and applies extension, while counterextension is maintained by a broad strip of cloth passed around the thorax. At the same time the surgeon applies direct pressure to the outside of the head of the bone in the direction of the articular cavity.

The well-known *method of Cooper* consists in making traction on the arm in the long axis of the body with the foot in the axilla, thus exerting direct pressure on the head of the bone. The surgeon should remove his shoe.

Extension by hyperabduction: The assistant sits behind the patient, who lies on the ground. The surgeon exerts direct pressure against the head of the bone through the axilla while the arm is being abducted. In this method several assistants may be employed, the patient lying on a table.

2. *Kocher's Method.*—This consists in several distinct steps or positions which must be accurately carried out (see Plate 30). They are:

I. *Adduction of the arm,* until it touches the trunk.

II. *Outward rotation,* until the flexed forearm approximately occupies the frontal plane; great care is required to avoid producing a fracture. During this phase the head of the humerus is displaced outward, away from the cora-

PLATE 30.

Method of Reducing Subcoracoid Dislocation of the Humerus.—In this plate Kocher's method is represented anatomically in its various phases. The specimen shown on Plate 29 was used for the purpose, each step being at once photographed, after which the illustrations here reproduced were copied from nature.

Fig. 1.—Adduction of the arm until the region of the elbow comes in contact with the trunk, which is in a straight position (step I). No material change in the position of the head of the humerus is produced by this step.

Fig. 2.—Outward rotation of the adducted arm by means of the forearm flexed at right angles (step II), until the forearm approximately occupies the frontal plane of the body. The opening in the capsule is plainly visible ; the head has moved nearer the acromion and further away from the brachial plexus.

Fig. 3.—Elevation of the arm held in adduction and outward rotation (step III); in other words, the arm is raised and directed forward. This partially reduces the dislocation.

Fig. 4.—Inward rotation completing the act of reduction (step IV).

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coid process and toward the acromion. This is recognized in figure 2 of Plate 30, by the increased distance of the head of the humerus from the brachial plexus.

III. The arm is held *in adduction and outward rotation and pushed upward and slightly forward.* The head of the humerus now begins to slip through the opening in the capsule and moves toward its normal position in the glenoid fossa.

IV. *Inward rotation:* This completes the reduction. The movement must be performed gently and without jar, so that often the bone is not felt slipping back into position, and the fact that reduction has been successful is only determined afterward by examination.

By this method more than by any other the dislocation can often be reduced without anesthesia and with a minimum amount of injury to the parts. By adducting the arm the upper wall of the capsule is stretched and the head firmly held at the edge of the glenoid fossa, so that,

Tab. 30.

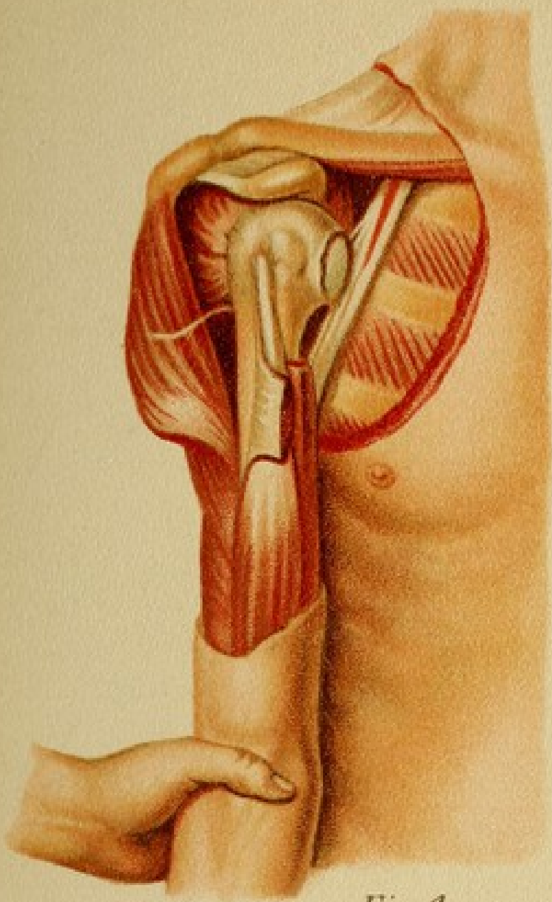

Fig. 1.

Fig. 2.

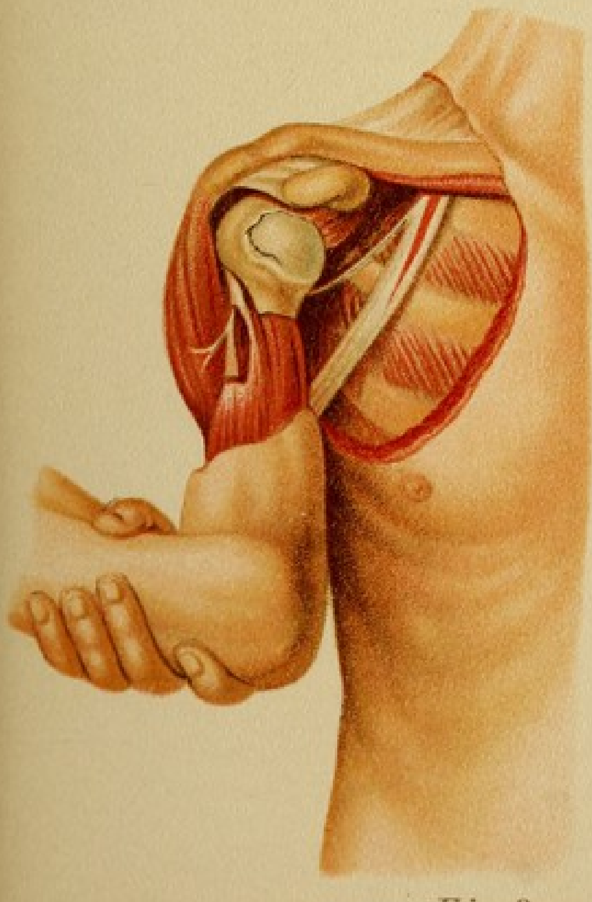

Fig. 3.

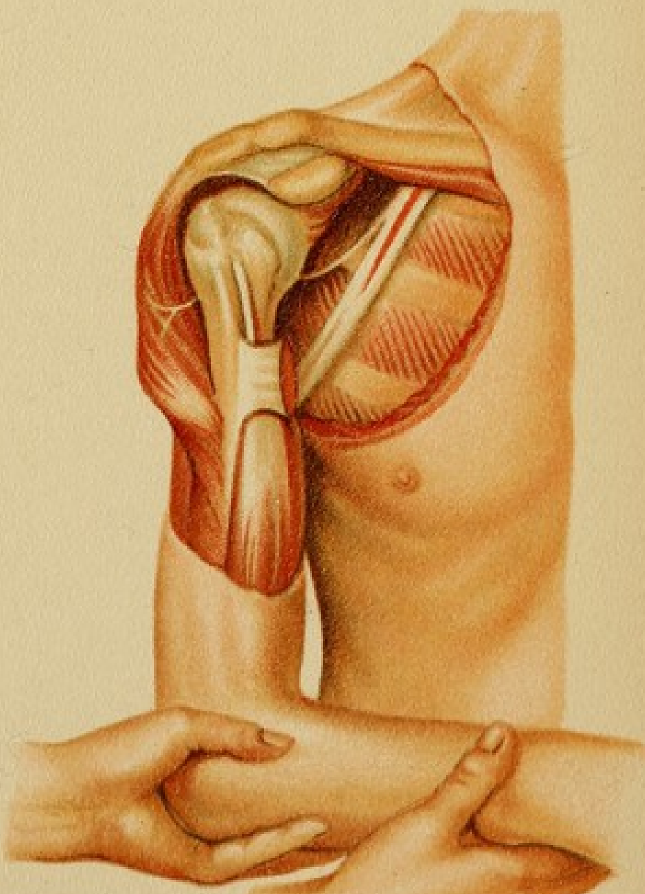

Fig. 4.

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when the arm is rotated, the edge of the cavity acts as a fulcrum and the bone does not rotate about its own axis. The subsequent elevation has for its object to relax the coraco-humeral ligament.

Reduction is recognized by more or less distinctly feeling the head slip into place, and especially by observing that the normal mobility and outline have been restored.

[The results of reduction of recent dislocation of the shoulder by Kocher's method of manipulation when properly performed are marvelous. The manipulation, however, is frequently misunderstood and often misquoted in text-books. The most frequent mistake is to hold the arm in abduction during the external rotation rather than adduction. This improper position is illustrated in Treves' recent "System of Surgery." It is incorrectly translated in the American edition of Tillmann's "Surgery." Kocher's publication appeared in 1870.[1] The outward rotation, however, seems to be the most important part of the manipulation. Reduction seems to have been accomplished in many cases with the arm held away from the body (abduction) instead of against the chest (adduction). Theoretically, adduction is the proper position, and practically, in my own experience, the better position. In a recent case I failed to reduce the dislocation with outward rotation and abduction, but at the second trial succeeded without any force with outward rotation and adduction. Great force is not necessary in this manipulation.—Ed.]

In the *after-treatment* the arm must be fixed to the body with the hand of the injured side on the sound shoulder, handkerchiefs, roller bandages, or adhesive strips being used. After a week, passive movements should be begun, and a little later supplemented by active movements. The entire duration of the treatment, from the time of the injury until the patient is able to return to his duties, comprises about four to five weeks.

[1] Berliner klin. Wochenschr., 1870, No. 9, and Volkmann's Sammlung klin. Vorträge, No. 83, p. 611.

PLATE 31.

Old Subcoracoid Dislocations with the Formation of a New Articular Surface on the Scapula, and Wearing Away of the Humerus. (Compare Fig. 44, p. 134).

Fig. 1.—Anterior view of the two bones in dislocation. The head of the humerus conceals the region of the glenoid fossa, as it lies in apposition with the anterior surface of the neck of the scapula below the coracoid process. We see the free anterior surface of the head of the humerus covered with cartilage, and the edge of the callus-formation on the neck of the scapula which surrounds the new articular surface. The humerus is slightly abducted. The amount of movement afforded by this abnormal joint is extremely limited, the reason of which is readily understood after a careful inspection of the bones where they come in contact with one another.

Fig. 2.—Anterior view of the scapula as in figure 1. The humerus has been rotated through about 180 degrees, bringing into view its posterior surface, which is turned toward the scapula. On the scapula we see the glenoid fossa from the side, hence it appears greatly shortened. Its anterior border is much diminished by the wearing away of the bone, and is joined at this point by the new articular surface, surrounded by a somewhat irregular wall of bone. The humerus also shows a depression, due to attrition with the edge of the glenoid fossa ; and, at the anatomic neck, an overgrowth of bone like that which is characteristic of arthritis deformans. Unfortunately, the eburnations that are found at the points of contact of the two bones where they have been rubbed together could not well be represented. (Author's preparation.)

If it should be found impossible to effect reduction, another attempt should be made under full anesthesia, after enlarging the capsular opening by free movement of the arm. If even under anesthesia the attempt does not prove successful, and the dislocations cannot be reduced even with assistance, surgical interference must be resorted to in order to restore the normal relations of the parts as early as possible. The operation is readily performed through an incision from the coracoid process downward.

[The usual mistake made in the attempt at reduction of

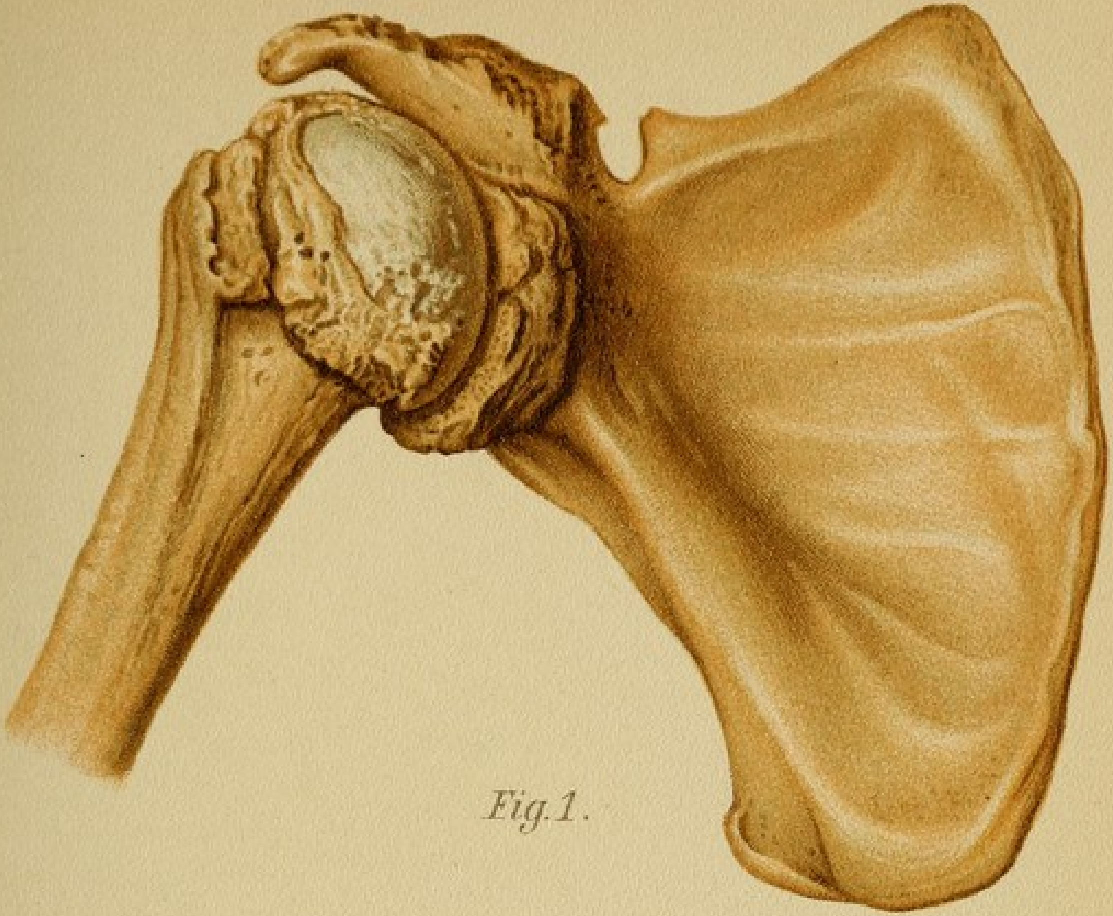

Fig. 1.

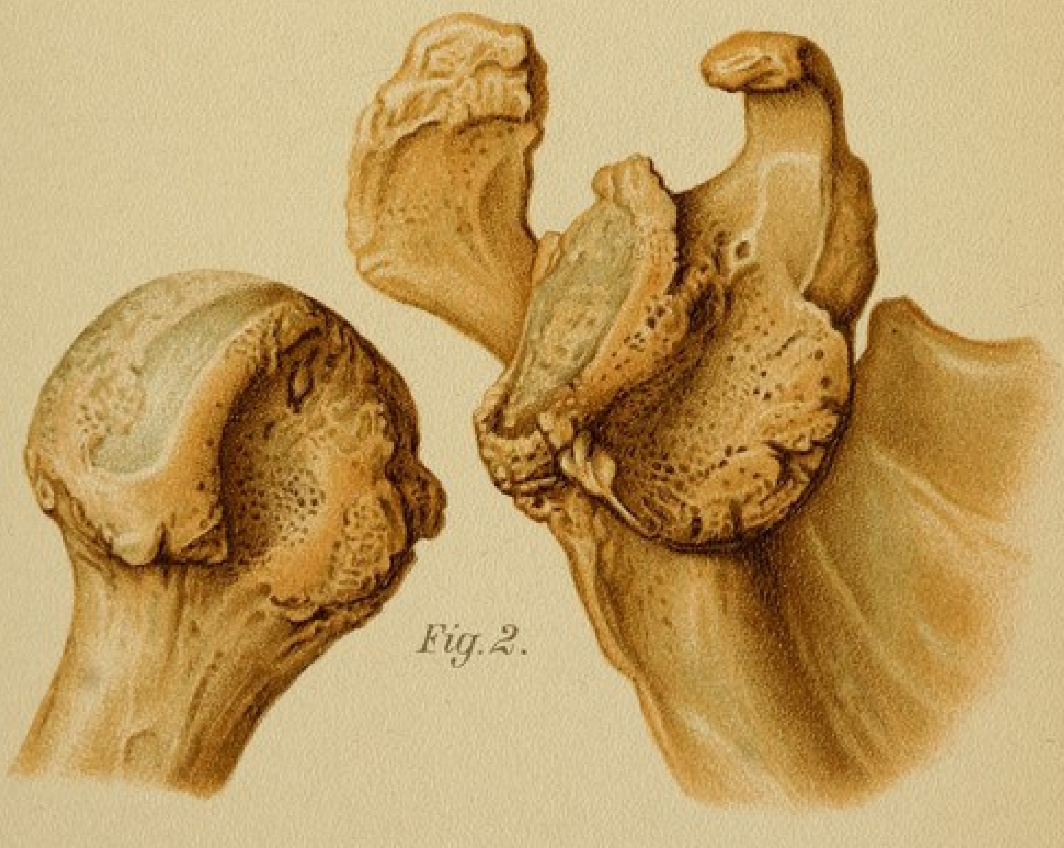

Fig. 2.

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a dislocation is too great force and the repetition of manipulations. In the majority of instances reduction should not be attempted without anesthesia. This attempt should be made in only those few dislocations which experience has taught us can be reduced by simple manipulation without great force, as in Kocher's method for shoulder dislocation. When the proper methods have been carefully tried without reduction under anesthesia, the probabilities are that there is some obstacle; and in such an event further and more forcible attempts at reduction only increase the danger of injury. The surgeon should immediately expose the dislocation by an open incision, when in the majority of instances the obstacle can be removed and the bone easily replaced.—ED.]

Fig. 53.—Simple dressing, by means of a gauze bandage stuffed with cotton, that may be used after reduction of a dislocation of the humerus.

If reduction is neglected, there usually results a very serious condition known as an "*old luxation.*" It is rare that a new joint with any degree of mobility is formed; as a rule, the shoulder-joint continues to cause the patient pain, and movement is reduced to a minimum. But even in these cases a surgical operation effecting reduction after removal of obstructions or resection of the head of the humerus may be followed by considerable improvement. [As discussed on page 147, resection of the head of the humerus as a rule gives a much more serviceable arm than reduction of an old dislocation.—ED.]

In rare cases *habitual luxation* results; the only successful method of treating it is a surgical operation consisting in resecting portions of the capsule for the purpose of shortening it.

Modifications and Complications of Preglenoid Dislocation.—If the head of the humerus escapes from the glenoid fossa in a direct line forward, it sometimes lies so close to the fossa, between the scapula and the subscapular muscle, that the articular surface of the head still remains in relation with the edge of the glenoid fossa. In these cases, which are produced chiefly by direct violence, a groove is formed in both bones by attrition within a few weeks. In old cases of this kind the wearing away may be very considerable, forming a deep groove on the head of the humerus and completely wearing away the anterior half of the glenoid fossa. At the same time the usual periosteal proliferation takes place, forming a kind of new joint for the head in its abnormal position (see Plate 31). Reduction in such cases is, as a rule, extremely difficult, and often impossible without arthrotomy.

Supracoracoid dislocations are extremely rare, and always combined with fracture of the coracoid process.

Dislocation with simultaneous fracture of the neck of the humerus: This constitutes a very grave injury. If the attempts at reduction by abduction and extension, supplemented by direct manipulations, fail even under full anesthesia, arthrotomy is indicated for the purpose of forcing the bones into place, or, if necessary, removing the fragment, especially if it is small and principally intra-articular. The treatment formerly recommended was to aim at producing a false joint at the seat of fracture without attempting to correct the position of the head of the bone. [Without much doubt, in this injury the seat of fracture should be explored by an open incision, and if the fragment cannot be properly fixed with a fair hope of its union with good function of the joint, the head of the bone should be removed.—Ed.]

(b) **Downward or subglenoid dislocation of the humerus** (*luxatio infraglenoidalis* or *axillaris*). In this [rare.—Ed.] dislocation the head is often found at the lower border of the glenoid fossa, and is accordingly felt through the axilla. The appearance of the patient is most characteristic when he stands with his hands extended from the body, as in this position the line of the shoulder resembles a bayonet in shape. In this variety also there are: prominence of the acromion; absence of the head from the glenoid fossa; and functional disturbances. Sometimes the arm is elevated (*luxatio erecta*), or in horizontal extension. Reduction is effected by extension and direct pressure against the head through the axilla, with the thumb pressed against the acromion.

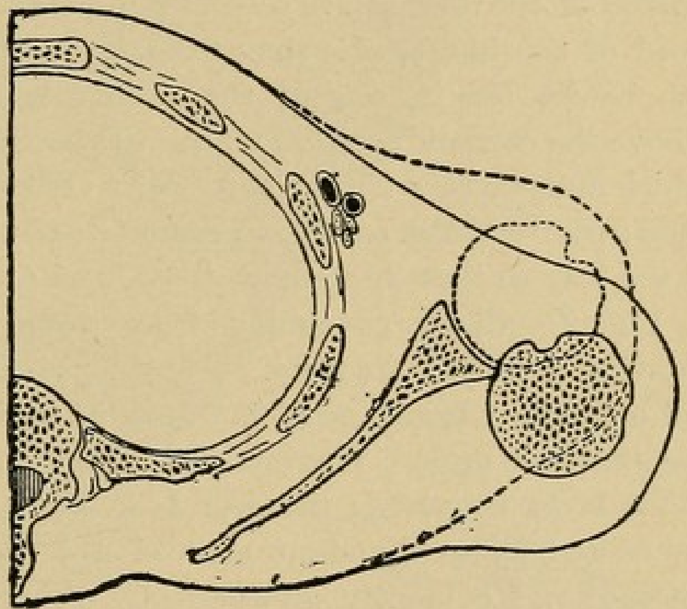

Fig. 54.—Horizontal section through the shoulder-joint and adjacent half of the thorax in retroglenoid dislocation. (Compare Fig. 47, p. 141, after Anger.)

(c) **Backward or subacromial dislocation of the humerus** (*luxatio retroglenoidalis, subacromialis, infraspinata*). This form is rarely met with and is mostly produced by direct violence. The head is readily seen and felt in its abnormal position. The coracoid process forms a distinct prominence. Reduction is effected by extension, with the arm in abduction, and by direct pressure.

PLATE 32.

Fracture of the Surgical Neck of the Humerus, with Marked Displacement of the Fragments and Abduction of the Arm.

Fig. 1.—The specimen represents the anatomic conditions most faithfully. We see the head of the humerus with its tuberosities in the normal position. The end of the lower fragment is displaced inward as in a subcoracoid luxation. The possibility of injury to the plexus and the large vessels, and the strain and displacement of the tendon of the biceps, are seen at a glance. Above and medial to the head of the humerus is the coracoid process, where the short head of the biceps has its origin; the pectoralis minor has been removed. Above the coracoid process we see the clavicle, the outer extremity of which articulates with the acromion. Parts of the deltoid and pectoralis major muscles have been removed; the latter has been pushed out of the way so that the second, third, and fourth ribs are exposed.

Fig. 2.—Upper extremity of the humerus, from the right side, showing a united fracture. Anterior view. The fracture included not only the surgical neck, but also the region of the tuberosities and the anatomic neck. There is great inward and upward displacement of the lower fragment; the arm is in abduction. The two fragments are united by an abundant mass of not very condensed callus. The fracture was evidently produced by great violence; it presents the appearance of a compression-fracture. (Author's collection.)

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4. HUMERUS

(A) Fractures of the Upper End of the Humerus

The upper extremity of the humerus presents the following parts: the anatomic neck; the region of the tuberosities; and, below the latter, the surgical neck. Fracture may take place in any one of these regions; as a rule, the line of fracture is not confined to one, but extends more or less into neighboring parts.

Fracture of the upper end of the humerus may be due to direct or to indirect violence. *Indirect* violence may produce it by compressing the bone in its long axis against the glenoid fossa or the arch of the acromion, as in a fall

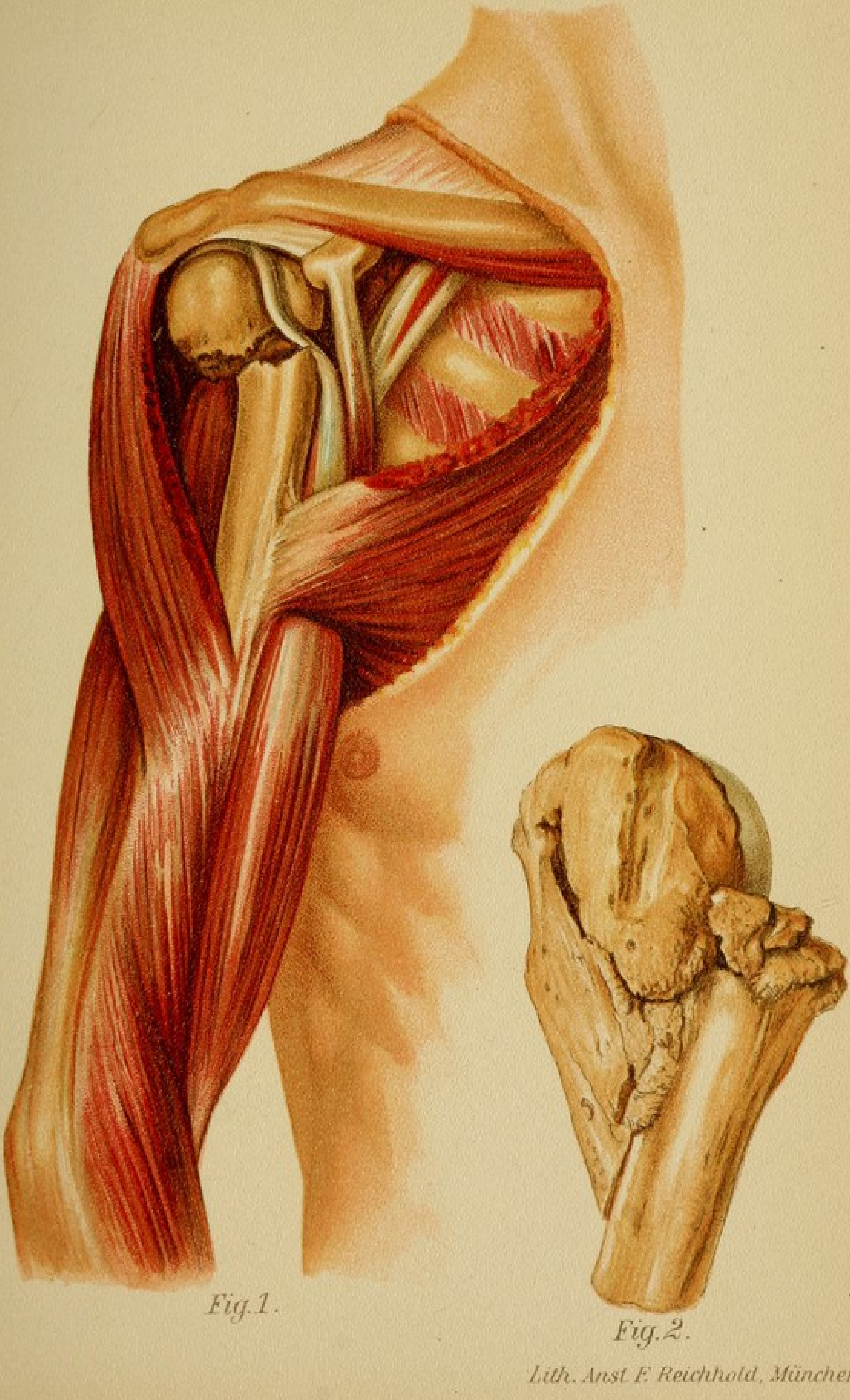

Fig. 1.

Fig. 2.

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on the elbow. *Direct* violence may consist in a blow or a fall on the outer side of the shoulder.

Examination in these cases always presents some difficulties, and if the extravasation of blood is profuse, the diagnosis may be exceedingly difficult. After inspection, by which we determine the direction of the shaft of the bone and the alteration in the outline of the shoulder, we proceed to palpation, which is equally important. The tuberosities, the groove between them, and the region of the surgical neck can be directly palpated under normal conditions; not so, however, the region of the anatomic neck and head of the bone. The parts should be felt from the outside; from in front; if necessary, from behind; and last, but not least, through the axilla.

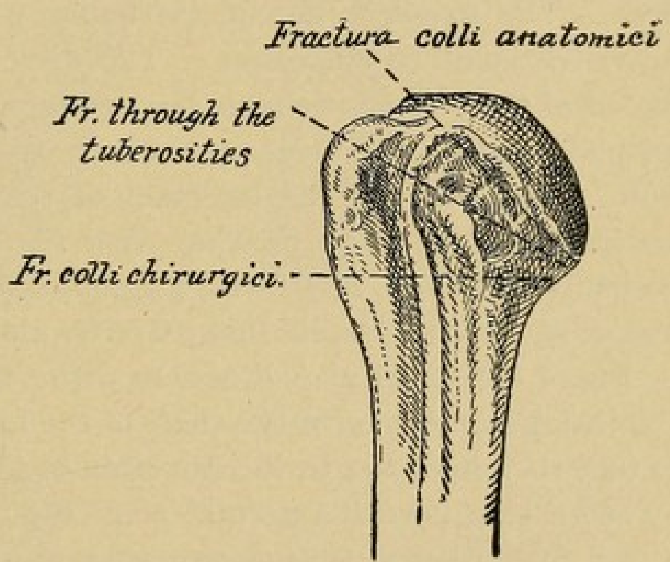

Fig. 55.—Upper extremity of the humerus, showing the possible lines of fracture.

(a) Fracture of the anatomic neck alone is a very rare accident. If only the articular head with its articular cartilage should break off,—in other words, a purely intracapsular fracture,—the vitality of the fragment would probably be endangered. It would act like any fragment consisting of bone and cartilage, as, for example, in the knee-joint. As a rule, however, the fracture is not altogether intracapsular; the fragment is attached by portions of the capsule which convey the blood-supply, and the line of fracture includes neighboring portions of the tuberosities, of the shaft, or of the head.

The injury is produced by severe external violence to

PLATE 33.

Fractures of the Upper End of the Humerus.—Fig. 1.—Normal specimen showing the course of the epiphyseal line in a frontal section.

Fig. 2.—Specimen showing fracture of the surgical neck with typical displacement. Right shoulder-joint seen partly from the side and partly from behind. The displacement of the humerus forward and inward is recognized.

Fig. 3.—Specimen of a united fracture of the left humerus. Anterior view. On the outer side, the line of fracture runs through and below the tuberosities and then curves inward toward the anatomic neck. The upper fragment (articular process) is in abduction, the lower fragment in adduction. The direction of the humerus in the region of the tuberosities can be recognized in spite of the abundant callus-formation, which is particularly marked in the diaphyseal portion. Owing to the displacement of the fragments, the base of the articular surface is in relation with the seat of fracture, which was probably impacted, and forms a right angle with the long axis of the humerus. (Path.-Anat. Inst., Greifswald.)

Fig. 4.—Lateral view of a man with a fracture of the surgical neck. Typical displacement of the shaft of the humerus forward and inward, so that the alteration in the direction of the axis is at once perceptible by comparing it with a normal arm (Fig. 4 *a*). (The patient's name was J. Wendigorra, twenty-two years of age. July, 1895.)

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the outside of the shoulder or by compression of the humerus in its long axis. The fragment from the head may be firmly *impacted* between the tuberosities or in the space above the lower fragment. The *deformity* is often very slight; but sometimes the head has been found completely turned around, so that the broken surface presented toward the glenoid fossa, and the cartilaginous surface toward the upper end of the shaft of the humerus.

The **symptoms** are those of a severe intra-articular injury. Direct palpation of the seat of fracture is out of the question, even under anesthesia; all that can be determined is that a fracture above the tuberosities exists. Abnormal mobility of the upper end of the humerus and

Fig. 3.

Fig. 2.

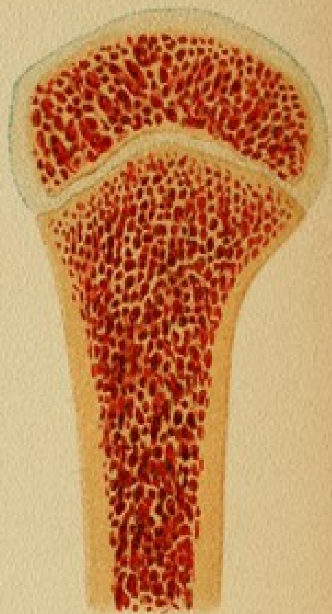

Fig. 1.

Fig. 4 a

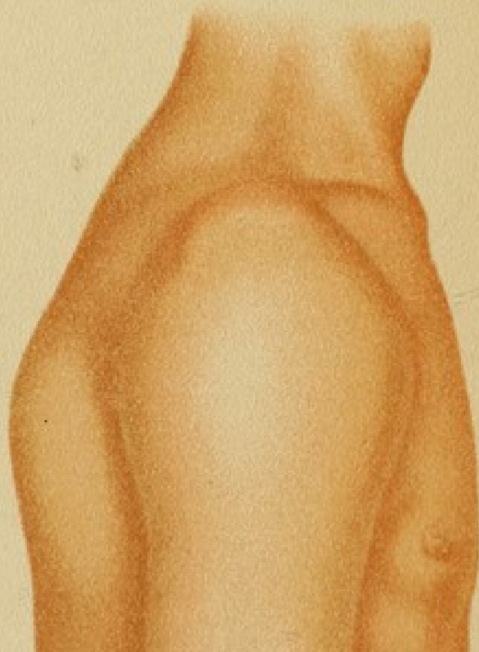

Fig. 4.

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crepitation, especially during rotation, are observed. There is marked functional disturbance, and pain is elicited by compressing the bone in its long axis.

Treatment.—Rest in bed with extension by means of weights; pad in the axilla; movements should be begun early. [In two cases which I have observed and diagnosed as fracture of the anatomic neck, this method of treatment by extension was most satisfactory.—Ed.]

(b) **Fracture of the Surgical Neck** (Plate 32, Fig. 2). —This is quite common. The line of fracture is below the tuberosities or may even include them. The upper fragment is therefore partly under the influence of the muscles which are inserted in the tuberosities. The fracture occurs usually in older individuals and is produced by *direct* violence, as by fall on the shoulder; or *indirect* violence by a fall on the hand or elbow. The fragments may become impacted or they may unite with marked deformity.

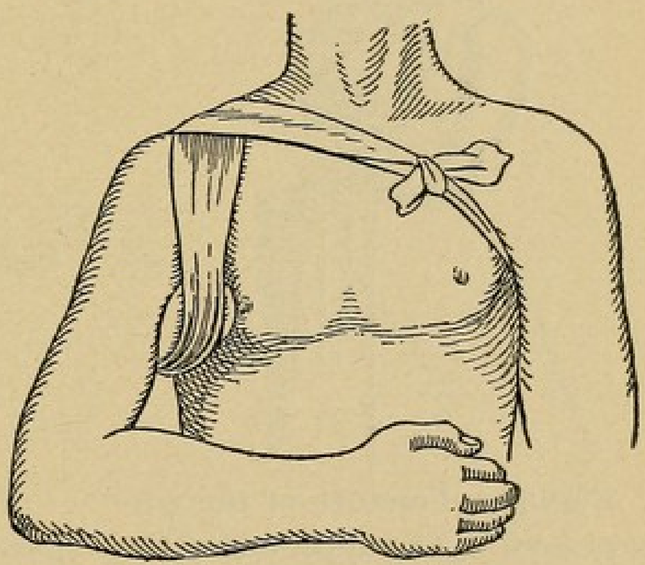

Fig. 56.—Axillary pad, held in place by a short bandage to prevent slipping.

The following considerations are of prime importance both for a clear conception of the mechanism and for the treatment of these fractures: The upper end of the shaft of the humerus may be displaced inward or outward at the seat of fracture. If it is displaced inward, the arm is in abduction, but does not tend to return when the reducing force is removed; the long axis of the humerus points toward the coracoid process or the clavicle. If the shaft is displaced outward, the arm is in adduction. This position of adduction is rare, and is usually produced by indirect force. The abduction—*i. e.*, inward displacement of the end of the shaft at the seat of fracture—is much more frequent, and is produced, as a rule, by the continued action of the injuring force in a fall on the outer and posterior portions of the shoulder (compare Figs. 57 and 58).

Symptoms.—In palpating the lateral outline of the shoulder the convexity of the head of the humerus is felt

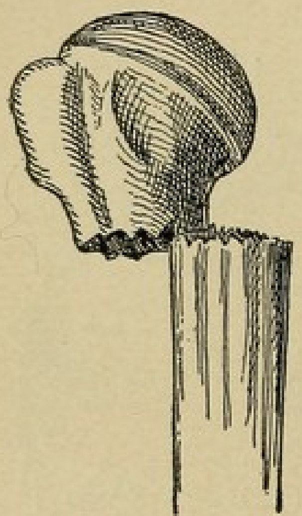

Fig. 57.—Fracture of the surgical neck. The upper end of the lower fragment is displaced inward. The arm is in abduction.

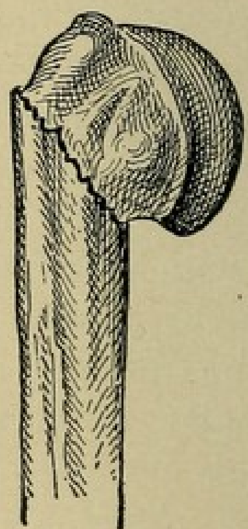

Fig. 58.—Fracture of the surgical neck. The upper end of the shaft is displaced outward and wedged into the bone; hence the arm is in adduction.

in its normal position under the acromion. The injured arm is either in abduction or in adduction, but does not tend to return to its position after the reducing force is removed. In many cases there is shortening of the arm, a point of distinction from subcoracoid luxation. As a rule, abnormal mobility may be detected if the head is firmly fixed and crepitation is elicited during rotation of the arm. Occasionally displacement of the upper end of the shaft forward, inward, and upward can be demonstrated. In such a case the fragment is forced into the soft parts, especially into the pectoralis major muscle, and may even appear close under the skin (see Fig. 59). A case of this kind presents some similarity to subcoracoid dislocation; the diagnosis will be determined by the presence or absence of shortening and the other above-mentioned symptoms. Impaction of the fragments

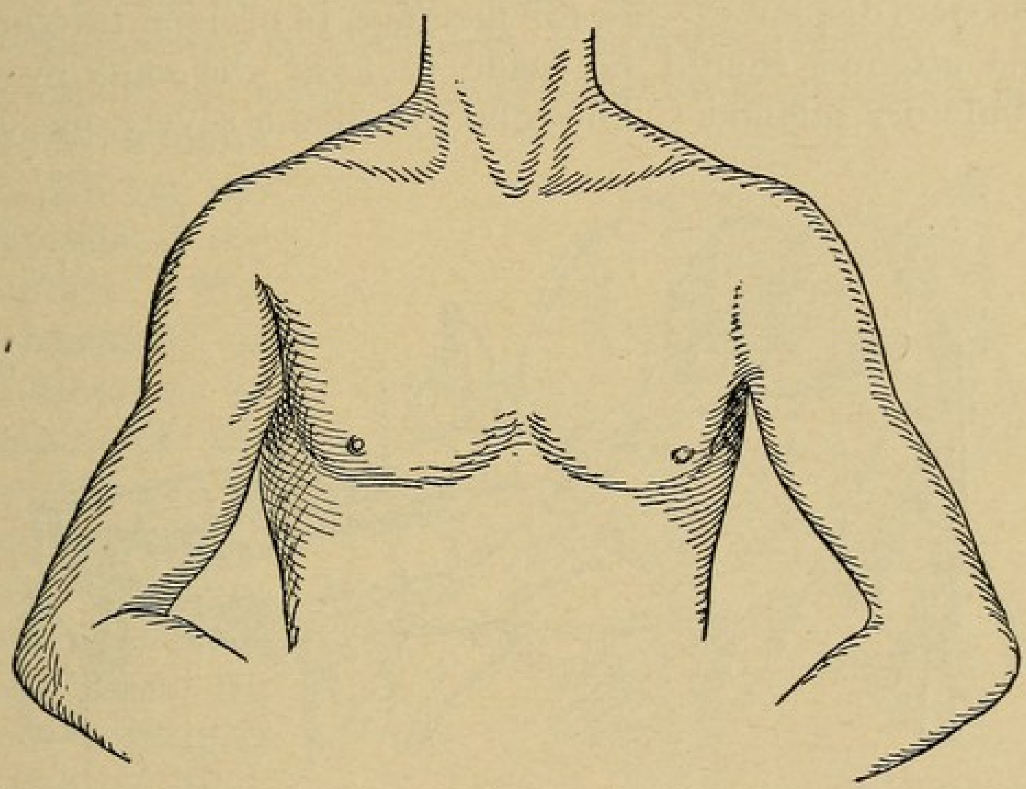

Fig. 59.—Fracture of the surgical neck. On the anterior surface of the right shoulder region the sharp end of the fractured shaft of the humerus is seen pushing against the skin. The arm is in abduction, but does not tend to return when reduced. There is also some shortening. (The patient was a man, twenty years of age.) The fragment was withdrawn from the soft parts and the fracture reduced under anesthesia. 1896.

may complicate the diagnosis, but it should always be possible to exclude a dislocation. The combination of fracture and dislocation has already been discussed.

Treatment.—If there is distinct displacement of the fragments, they should be replaced with great care; as a rule, an anesthetic is desirable. For the subsequent treatment, fixation of the entire arm, including the shoulder (see Fig. 60), by means of splints and a pad in the axilla (see Fig. 56), will suffice if there is no tendency to secondary displacement of the fragments and the end of the shaft is displaced inward. If the end of the shaft is displaced outward, constituting the so-called adduction-fracture of Kocher, no axillary pad is used. If the fragments tend to become displaced,—as, for instance, in oblique fractures, —no attempt should be made to treat the case by the ambulatory method. The injury is then a severe one, and

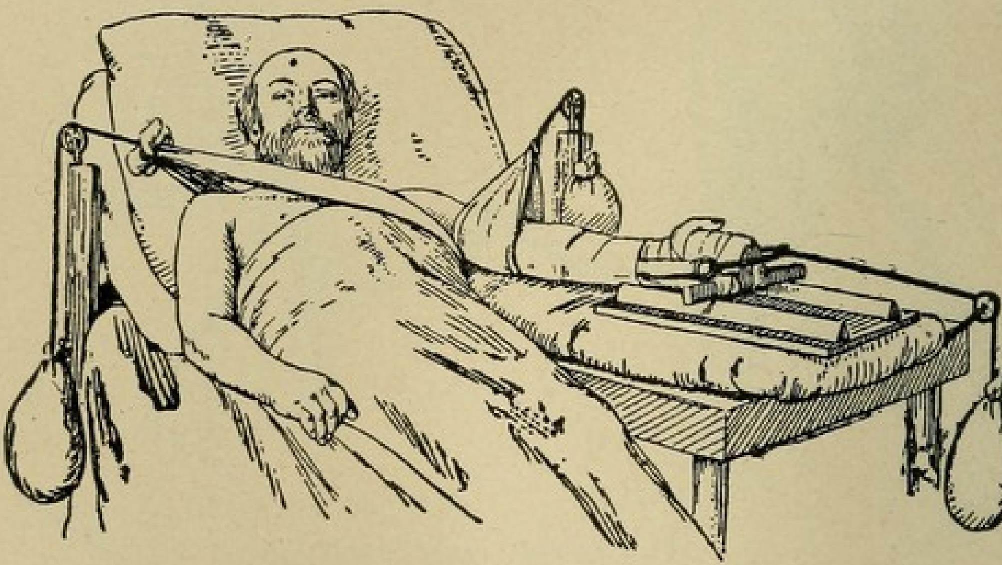

Fig. 60.—Showing a patient in bed with extension applied to the arm on a sliding hand-rest; counterextension across the breast and by lateral traction on the upper arm.

fraught with great functional disturbance and possibly grave injury to surrounding parts. The proper treatment is rest in bed and permanent extension in the long axis of the arm by means of weights, with a pad in the axilla, or, better, an additional loop to effect counterextension. By this means the shoulder-joint is freely accessible and under constant supervision, so that even during the first few days massage can be resorted to and the weights temporarily removed for the purpose of performing gentle passive movements. After a time the extension apparatus may be arranged so as to allow the patient to carry his forearm in a sling, the dressing being confined to the upper arm and the weight hanging free during the daytime when the patient is allowed to be out of bed (Fig. 62). At night the extension apparatus is again applied as usual over a pulley fixed to the foot of the bed (Fig. 61).

(c) **Fracture through the Tuberosities** (*Fractura pertubercularis*, Kocher).—A transverse fracture of the humerus at the level of the tuberosities is produced, as a rule, by a blow or a fall on the outer side of the shoulder. The displacement is the same as in fracture of the surgical neck. Impaction has been observed. The treatment is based on the same principles as that of fracture of the surgical neck, taking due account of the injury to the muscular insertions, which is apt to be severe.

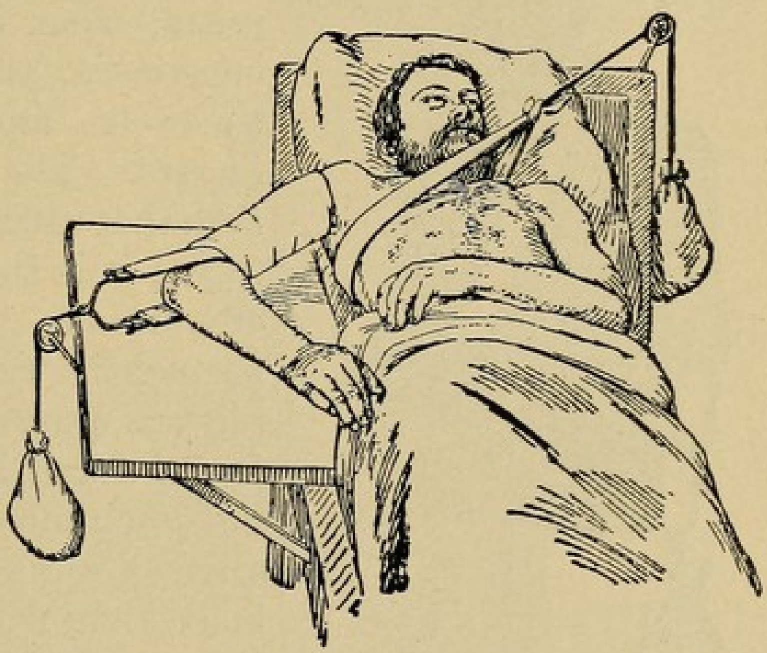

Fig. 61.—Showing the patient in bed. Extension with the elbow flexed; counterextension across the chest.

(d) **Traumatic Epiphyseal Separation at the Upper End of the Humerus** (Plates 33 and 34).—This injury, owing to its relative frequency, is of the greatest practical importance. It is, of course, only possible before ossification of the so-called epiphyseal cartilage, or, better, intermediary cartilage, has taken place,—*i. e.*, in young persons,—and is produced by a fall on the shoulder or the arm. To understand its mechanism it is necessary to know the anatomic details of the epiphyseal line (see Plate

33, Fig. 1, and Toldt, Anatomischer Atlas, Figs. 250–254).

The symptoms are often quite characteristic; they point to a separation of the bone similar to that which occurs in fracture of the surgical neck. The outline of the shoulder is preserved as the head of the bone is in its normal position. In moderate displacement abnormal mobility and crepitation may sometimes be made out below the upper fragment; when the patient is under anesthesia, the head can sometimes be fixed firmly with the fingers. The crepitation is softer than that usually observed in fractures; it is the so-called cartilage crepitation. The displacement is frequently well marked, the diaphyseal extremity being displaced forward and inward and producing a circumscribed, almost angular prominence, best seen by inspection from the side or from above, the surgeon standing behind the patient. The arm is therefore in abduction. Some rare cases present a displacement that is almost equivalent to dislocation of the end of the shaft inward and upward. In such a case *reduction* may be extremely difficult, if not impossible, even under anesthesia. If it is successful, the rest of the treatment is the same as for fracture of the surgical neck. If, however, reduction cannot be effected, the parts must be exposed by free incision, the line of separation cleared of interposed tissues, and the two parts forcibly brought into apposition. The author knows of a number of successful

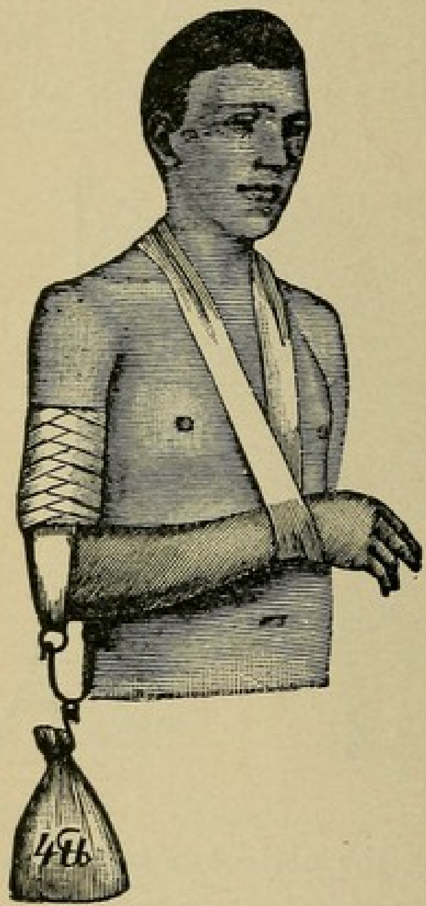

Fig. 62.—Extension apparatus for fracture of the humerus, to be worn during the day (compare Fig. 61).

cases in which reduction was thus effected and the fragments kept permanently in position by inserting a long steel needle.

Fig. 63.—Traumatic epiphyseal separation at the upper end of the humerus, with typical displacement of the diaphyseal fragment forward and inward. We see that the axis of the arm is directed toward a point considerably in advance of the prominence of the acromion. The patient, fifteen years of age, had fallen from a high stack of straw directly on the left shoulder, and was admitted to the clinic two weeks after the injury. Through an incision in front of the shoulder the completely dislocated diaphyseal extremity was replaced and fixed by means of a steel needle. Recovery with good function.

Accurate reduction is necessary to save the youthful patient from a deformity and loss of function which

PLATE 34.

Traumatic Epiphyseal Separation at the Upper End of the Humerus.—Fig. 1.—Specimen of a juvenile shoulder-joint. The connection between the humeral epiphysis and the scapula is preserved by the capsule and ligaments and by the muscles that insert at the tuberosities. The diaphyseal segment is completely separated. A few tags of periosteum cling to the epiphysis. The union between the coracoid process and the scapula has not as yet become ossified.

Fig. 2.—A young man with marked arrest of development of the right arm due to early traumatic lesion of the epiphyseal cartilage. The patient (Bertram, 1878) sustained an injury at the upper end of the humerus in early childhood. (Author's observation.)

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will be noticeable throughout life. Besides, if reduction has been incomplete after this injury, the development of the epiphyseal cartilage is retarded, the humerus fails to grow and remains shorter than that of the sound side (Plate 34, Fig. 2).

An appropriate extension dressing, and particularly a

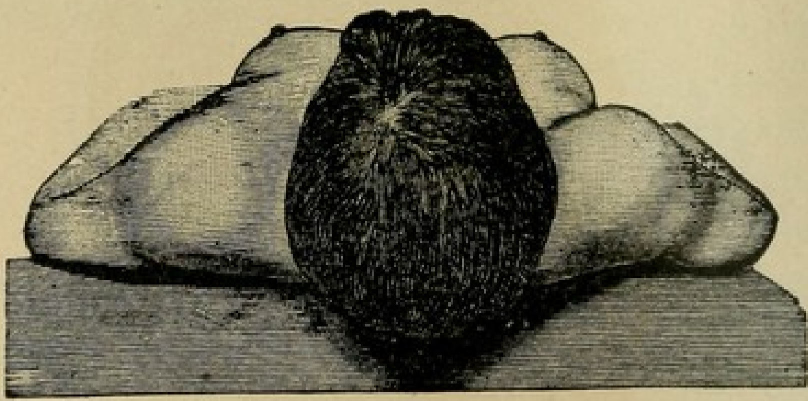

Fig. 64.—Showing the same girl represented in figure 63, from above. We see the enlargement of the pectoral portion of the left shoulder region, due to the dislocation of the diaphysis.

good axillary pad (Fig. 56), may be required to keep the parts in good position.

In the new-born, epiphyseal separations sometimes result from injuries sustained during delivery. The epiphy-

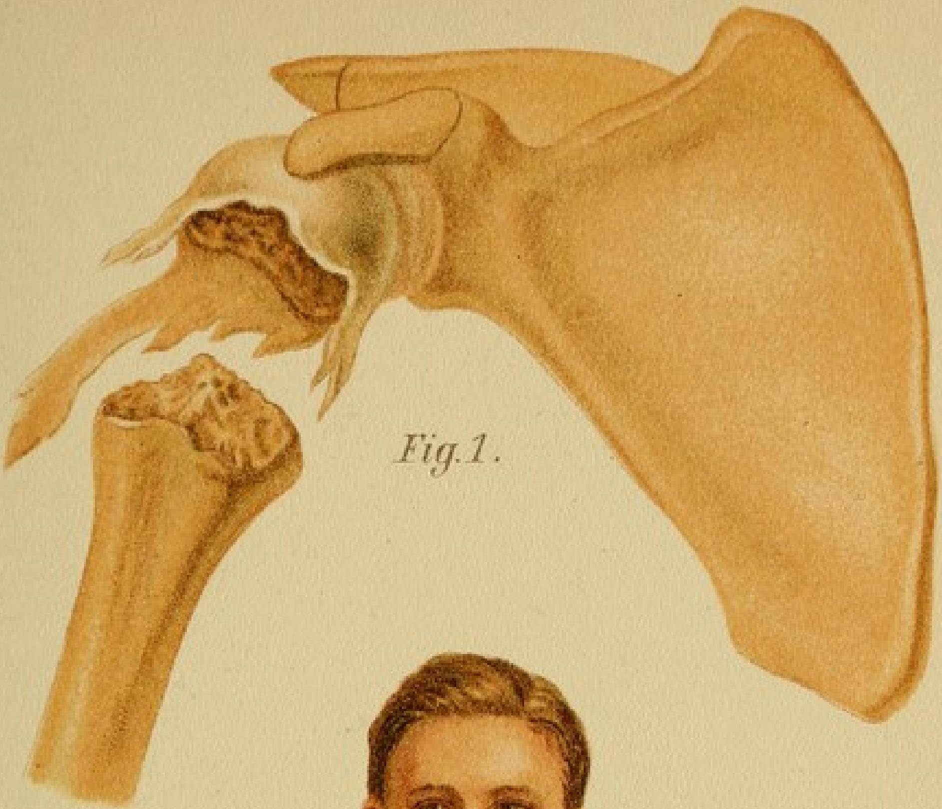

Fig. 1.

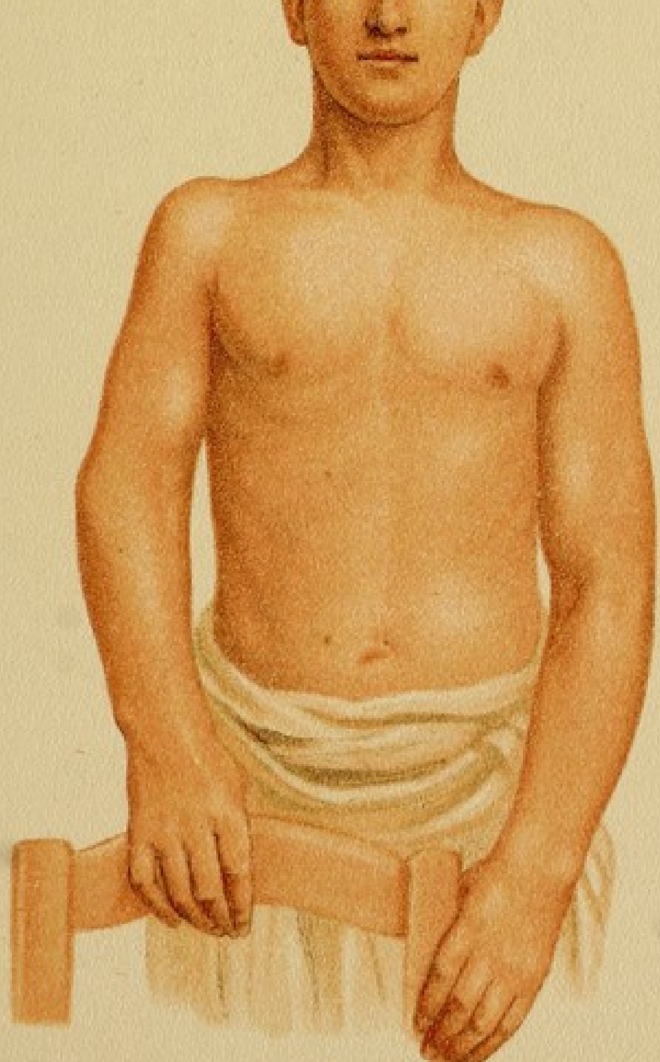

Fig. 2.

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sis (the head plus the tuberosities) occasionally shows marked outward rotation; the shaft is rotated inward, so that after union takes place the function is greatly interfered with.

(e) Isolated Fracture of the Greater or Lesser Tuberosity.—Fracture, or splitting off, of the greater tuberosity is sometimes met with in connection with dislocation of the humerus. It may also be produced by rotation in violent efforts at reduction. Isolated fracture of the lesser tuberosity is much more rare. The symptoms are: pain on pressure, functional disturbance, and separation at the seat of fracture. The **treatment** consists in relaxing the muscles that have their origin at the lesser tuberosity by appropriate movements, in prolonged rest, etc.

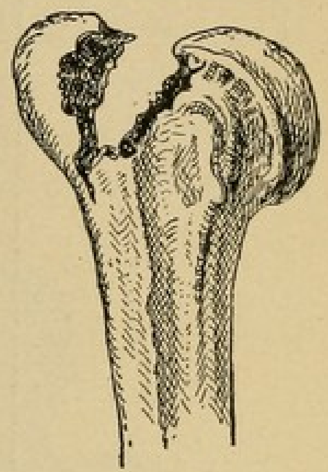

Fig. 65.—Right humerus; splitting [sprain fracture—Ed.] off of the greater tuberosity.

(B) Fractures of the Shaft of the Humerus.

(Plate 35.)

These fractures are produced by direct or indirect violence and present the general symptoms of fracture in a pronounced form: abnormal mobility, crepitation, and varying degrees of deformity. When the seat of fracture is below the insertion of the deltoid muscle, the upper fragment may be drawn upward and outward (*dislocatio ad axin*). In fractures occupying the junction between the middle and lower thirds of the humerus the musculospiral nerve is often injured, either primarily at the time of injury, or secondarily by pressure of the callus in which it is often embedded.

This complication should receive careful attention from the very outset. It is recognized by paralysis of the extensor muscles of the hand, making it impossible to extend

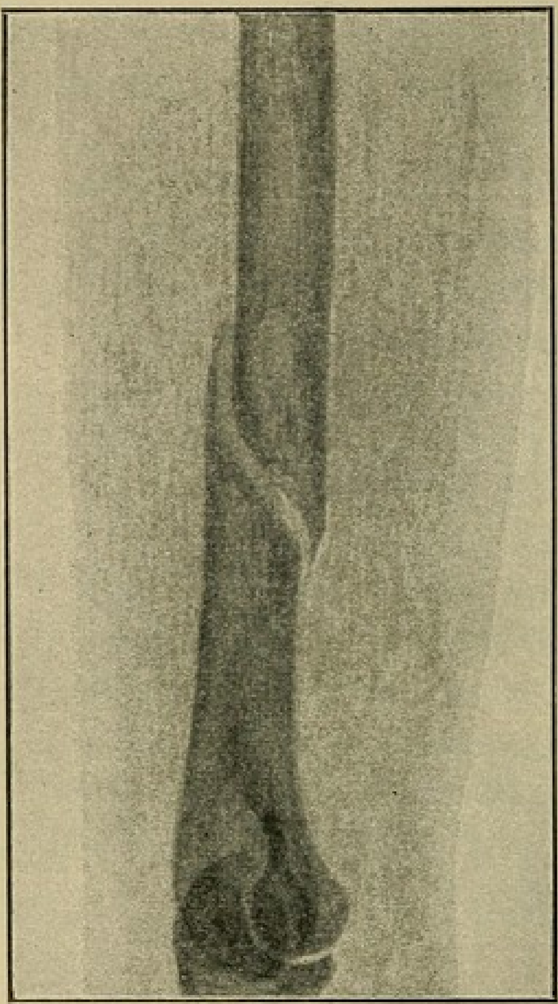

Fig. 66.—Torsion-fracture of the humerus. Skiagraph. Hellmund, thirty-three years of age, sustained a fracture of the humerus by falling on the arm in a wrestling bout. In addition to the fracture, there was paralysis of the musculospiral nerve (compare Fig. 79). As the paralysis was not improved by an extension bandage, such as shown in figure 60, the nerve was exposed by an incision over the seat of fracture, twelve days after the injury; no injury of the nerve could, however, be detected. The wound was therefore closed, after interposing a soft pad, consisting of a layer of muscular tissue, between the nerve and the fragments, which were found in good position. The paralysis gradually disappeared, and the patient recovered with good functional result. [This observation of paralysis following a contusion of the nerve is a very interesting one, and the possibility should be borne in mind. Nevertheless it seems a safer plan to expose the nerve by incision if function is not restored in a few days.—Ed.]

the fingers. By this means a bad error in prognosis may be avoided. Injuries to the vessels are less frequent.

With appropriate treatment good union takes place. Nevertheless the formation of a false joint is relatively more frequent after fractures of the humerus than after fractures of the other bones of the extremity, partly because of the greater difficulty of immobilizing the part, and partly on account of the displacement, which is often considerable, and may be complicated by the interposition of soft parts between the ends of the fragments.

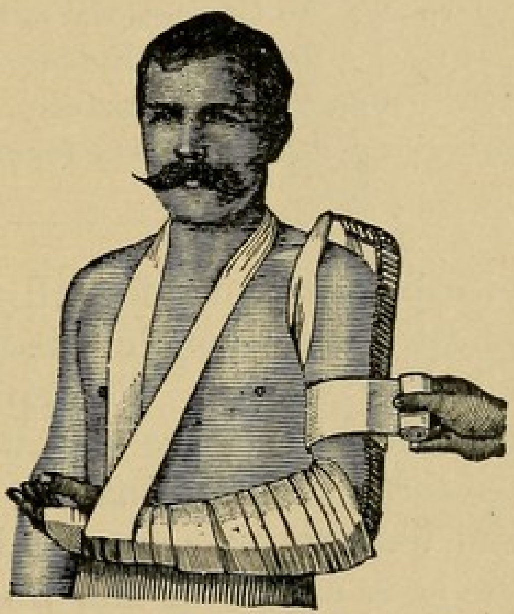

Fig. 67. — Simple splint-dressing with elastic traction for fracture of the humerus.

Treatment.—By incasing the upper arm, including the shoulder- and elbow-joints, in a circular bandage, the axillary space is protected against dangerous pressure. We may use plaster-of-Paris, wire, or padded tin splints. If the latter are used, a long splint should be applied to the outer side of the entire arm and a shorter one to the inner side of the upper arm. The wire splints may readily be applied in such a way as to exert permanent traction in the long axis of the humerus. The splint is simply bent at the proper angle and firmly bandaged to the forearm flexed at a right angle. The upper extremity is bent over in such a way as to leave a space above the shoulder. Then a short loop, well padded with cotton, is passed around the axilla and attached to the projecting end of the splint with moderate tension, so as to produce permanent traction. The tension may be regulated by occasionally changing the length of the axillary loop. This dressing may be used in fractures of the upper, as well as of the lower, end of the humerus. A very ser-

PLATE 35.

Fractures of the Humerus.—Fig. 1.—Anatomic preparation of the humeral region. Lateral view, showing the relation of the musculospiral nerve to the bone. The nerve lies directly upon the bone at the site of an artificial fracture. In front of it are recognized the brachialis anticus and the biceps; behind, the triceps; and above, the deltoid. The point where the nerve comes in contact with the bone corresponds approximately to the junction between the middle and lower thirds of the arm.

Fig. 2.—United fracture of the shaft of the humerus, with moderate deformity. In this case the musculospiral might have been injured.

Fig. 3.—Fracture of the lower end of the humerus above the condyles (supracondylar fracture), with typical deformity simulating a posterior dislocation of the forearm. (See Plate 38.)

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viceable appliance for all fractures of the humerus is the so-called collar-splint made of plaster-of-Paris strips, devised by Albers. The splint covers the entire outer and posterior side of the arm, which is flexed at the elbow with the forearm in supination, from the wrist to the shoulder, and extends up over the lateral and posterior region of the neck as far as the line of the hair. The plaster-of-Paris strips are applied directly to the skin, which has previously been well oiled. The plaster dressing is then covered with a soft roller bandage, and a well-fitting gutter is obtained, which assures complete fixation of the arm and shoulder region (Fig. 68). While the bandage is being applied, one assistant should hold the head while a second applies extension to the elbow.

If there is much tendency to secondary displacement after the fracture has been correctly reduced, good permanent extension becomes necessary. The counterextension in that case may not be applied in the axilla; or, when the fracture is to be treated with splints without rest in bed, the arm must be brought into greater abduction, so that the entire lateral surface of the thorax may be utilized for counterextension.

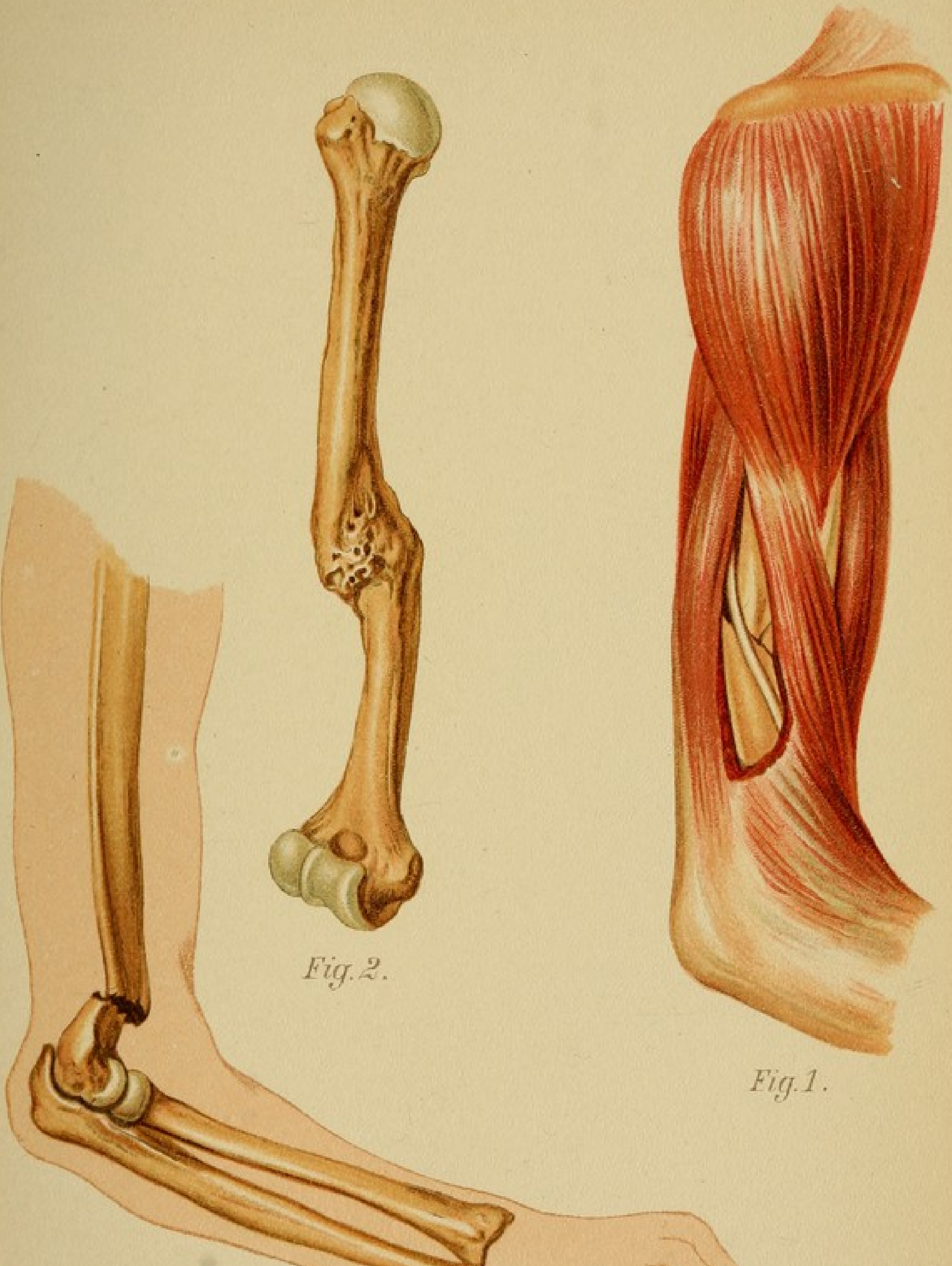

Fig.2.

Fig.1.

Fig.3.

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It is a better plan in such cases to give up ambulatory treatment altogether and apply permanent extension to the forearm and lower part of the upper arm by means of weights and a sliding hand-rest. The arm may be slightly abducted and supported on a table of suitable height placed by the side of the bed. This has the advantage that a counterextending loop can be applied on the thoracic portion of the axilla, thus avoiding dangerous pressure on the nerves and vessels in the axillary space. Heavier weights can thus be used on the extension apparatus, a distinct factor in obtaining a good result.

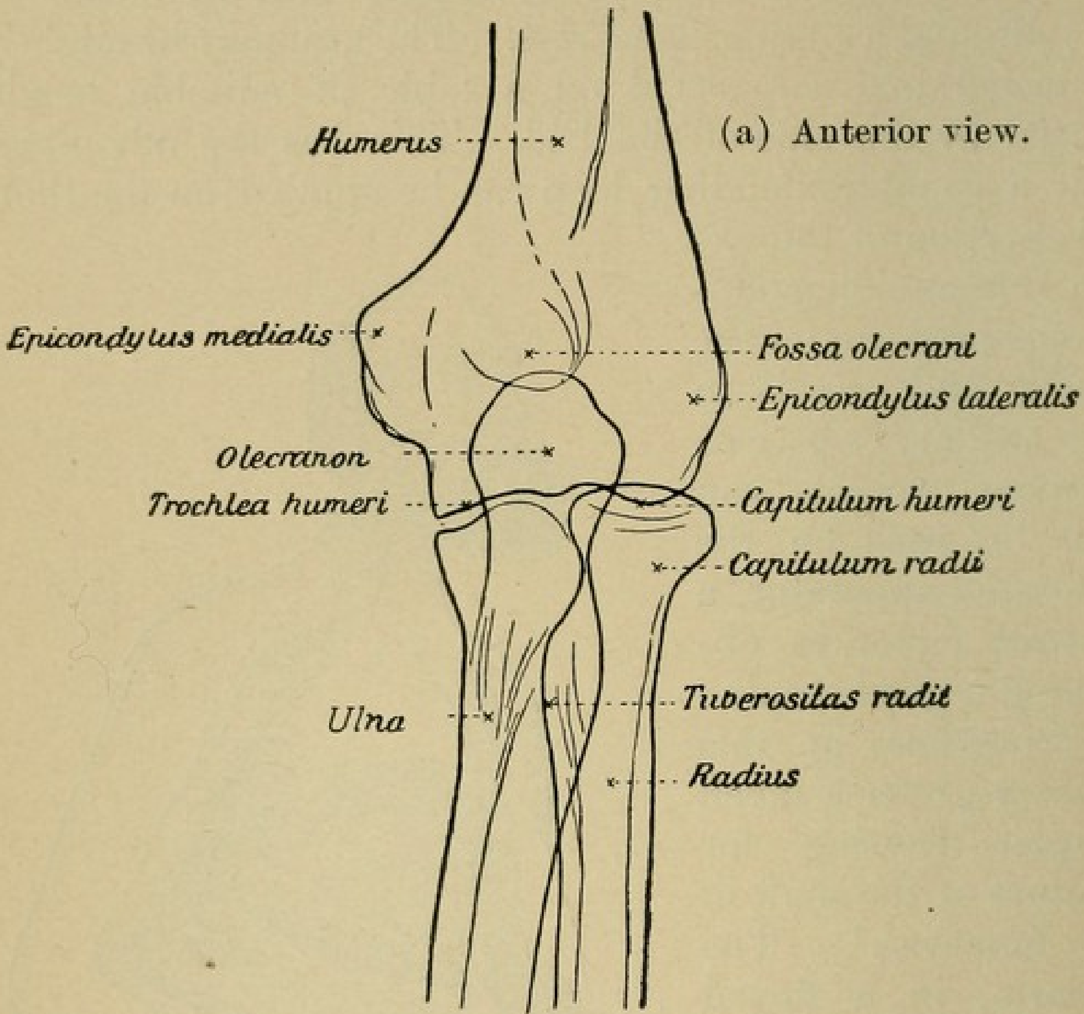
Fig. 68.—Albers' collar splint.

[Surgeons in this country prefer a much simpler dressing for fracture of the shaft in the humerus.[1] The forearm, in a flexed (right angle) position, and arm are first lightly bandaged. The arm from elbow to shoulder is then fixed with well-padded splints. The arm is then fixed to the chest with a pad in the axilla. This pad is very important. It should extend the full length of the arm to the elbow ; if too short, it will act as a fulcrum, and the lower fragment will be bent toward the side of the body. The dressing of this fracture with an anterior right-angled splint should be condemned.

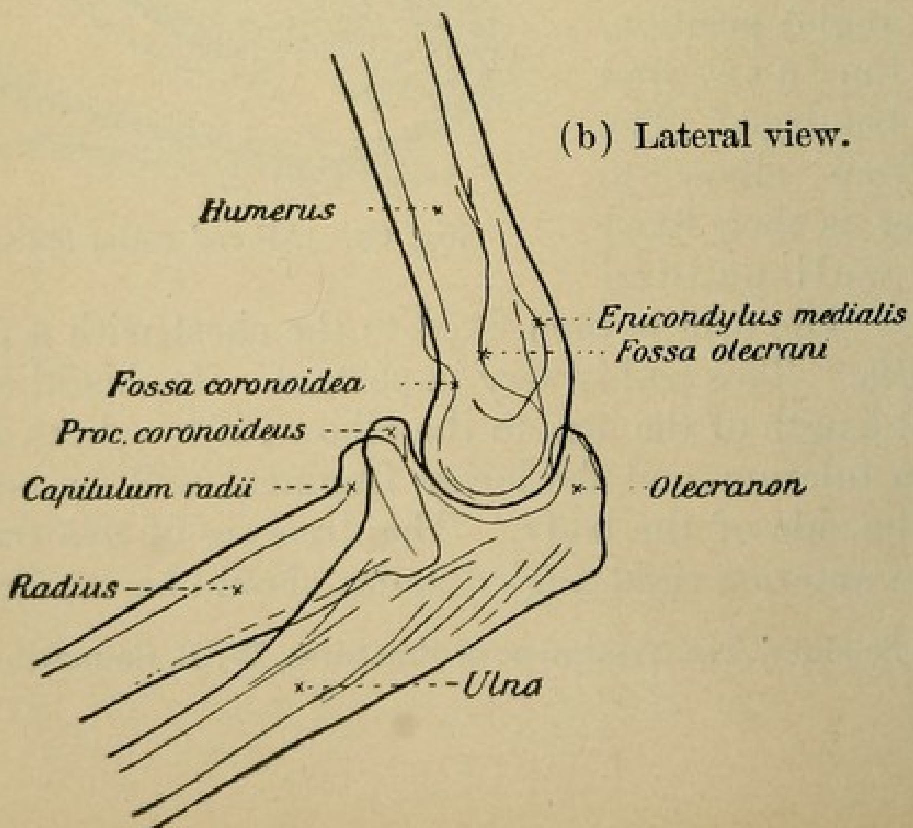
[1] See Scudder, The Treatment of Fractures, W. B. Saunders & Co., 1900.

PLATE 35 a.

Explanation: Normal Elbow of an Adult as seen in the Skiagraph. [Note in the skiagraph the light shadow in the area of the fossa olecrani. This is normal, and should be remembered in the diagnosis of diseases of bone which diminish the density of the bone shadow. In this photograph the medial (inner) part of the lower end of the humerus shows much lighter than usual, also the shadow of the radius and ulna in the lower skiagraph.—ED.]

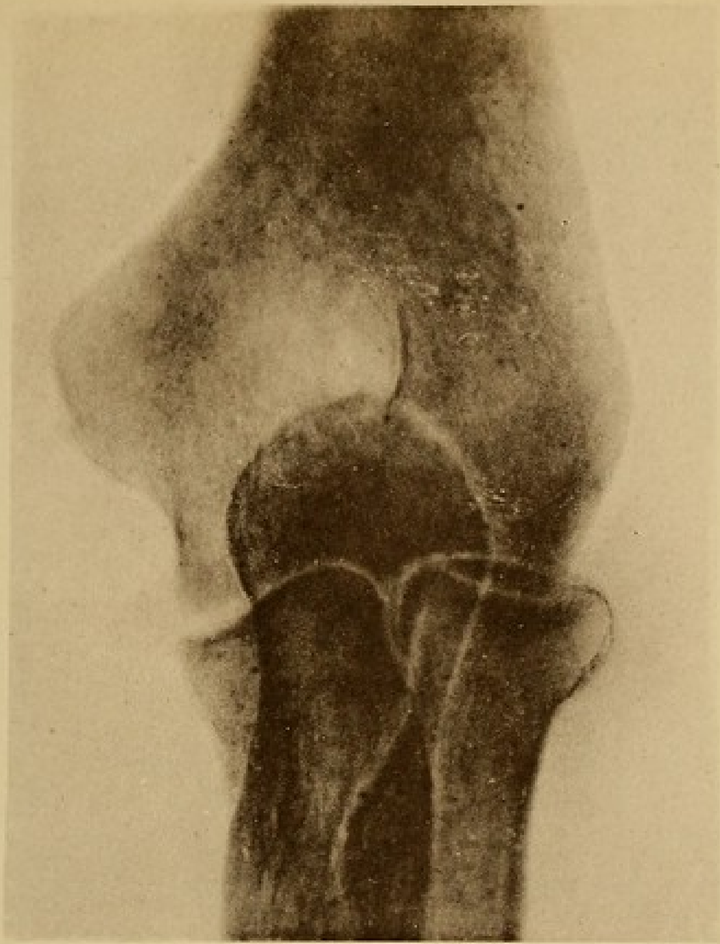


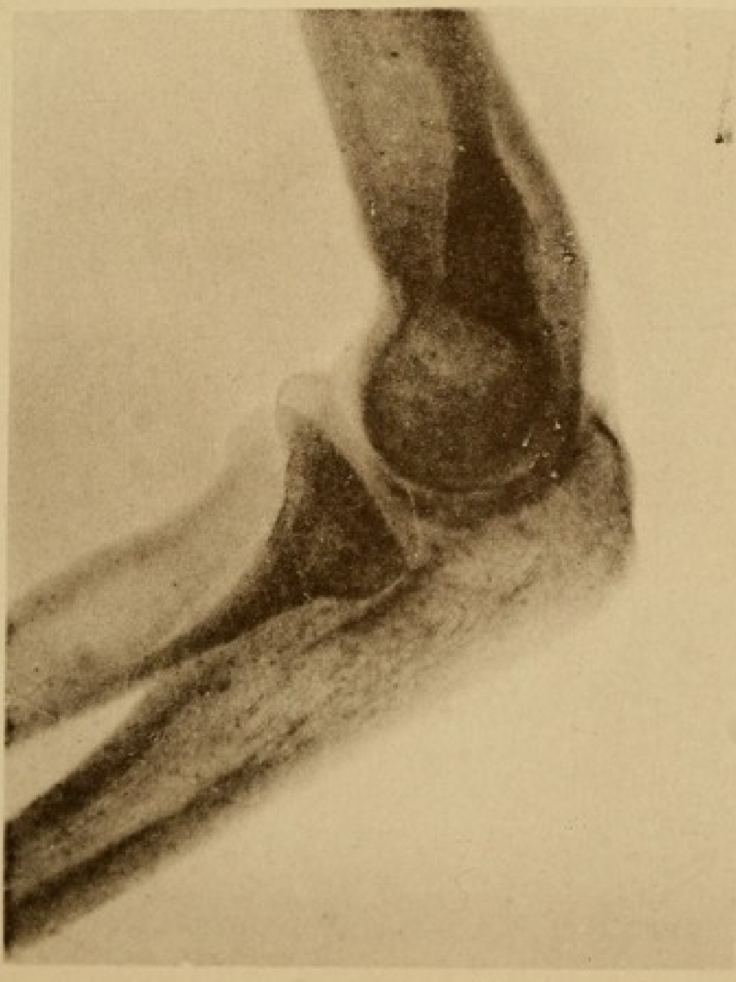
(a) Anterior view.



(b) Lateral view.

Tab. 35 a.





If a wire splint is employed, the method illustrated in figure 67 is the best.—Ed.]

(C) Fractures of the Lower End of the Humerus

The segment of the bone with which we here have to deal extends upward as far as the insertion of the supinator longus. The revised anatomic nomenclature contains some changes which are indicated in the accompanying illustration (Fig. 70).

The diagnosis of fractures of the lower end of the humerus is often exceedingly difficult. It demands a careful examination, especially by palpation, and an accurate knowledge of the anatomy.

The topography of the bony points under normal conditions is important, especially the relation of the condyles to the tip of the olecranon. When the arm is in extension, a straight line connecting the condyles passes through the tip of the olecranon (Fig. 71). When the elbow is flexed at a right angle and the forearm is midway between pronation and supination, the three points form a triangle, the plane of which corresponds with the frontal plane of the body (Fig. 72).

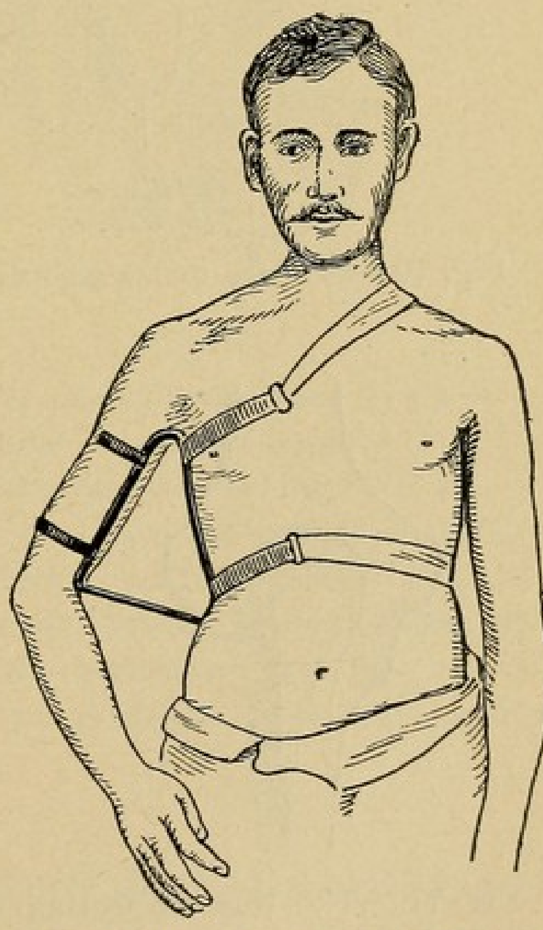


Fig. 69.—Modified triangular dressing of heavy lead strips without padding. (After Dr. Port.)

A knowledge of the normal conditions is supplemented in a special case by comparison with the sound side. This is all the more important as individual variations are not infrequently met with. The Röntgen-ray examination of these fractures is not, as a rule, as valuable and decisive as

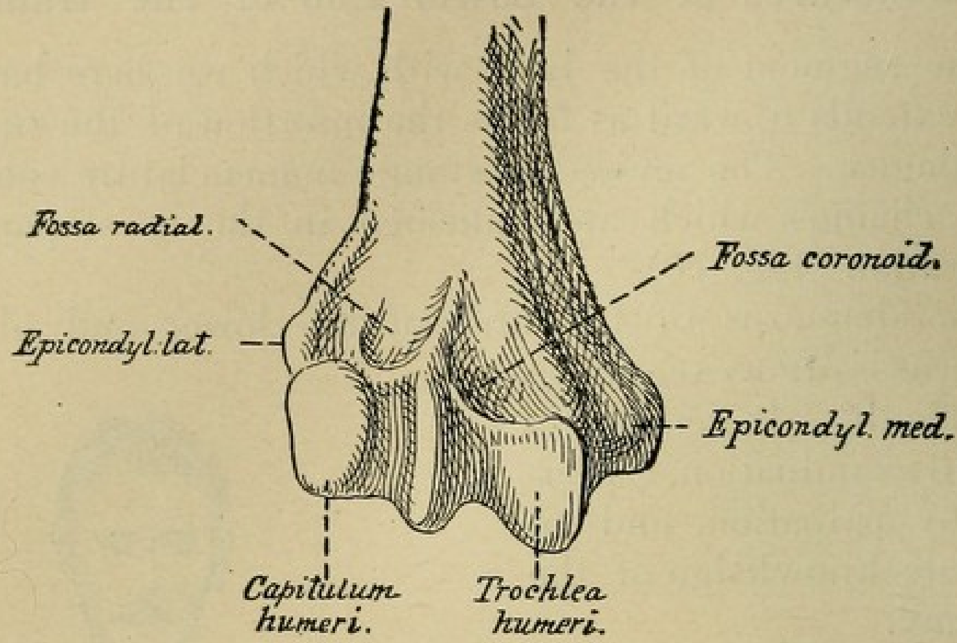


Fig. 70.—Modern terms according to the revised nomenclature.

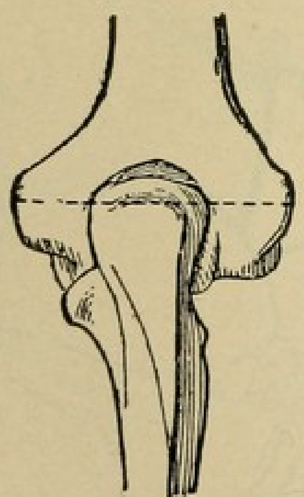


Fig. 71.—The line connecting the condyles passes through the tip of the olecranon.

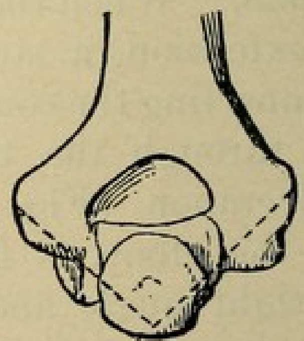


Fig. 72.—The lines joining the condyles with the tip of the olecranon form a triangle.

might be supposed *à priori.* If the method is resorted to at all, the sound side should always be photographed for purposes of comparison.

Fractures of the lower end of the humerus do not lend themselves to classification. They present a great variety of forms which often merge one into the other. In every case, however, the fractures illustrated below must be distinguished.

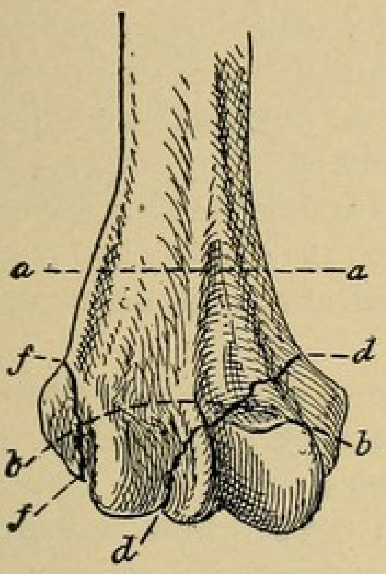


Fig. 73.

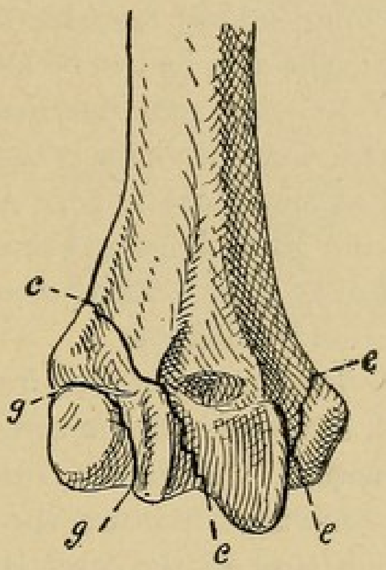


Fig. 74.

Figs. 73 and 74.—Various forms of fracture occurring in the lower end of the humerus: *a–a*, Supracondylar transverse fracture (Fig. 73); *b–b*, transverse fracture of the true articular process (Fig. 73); *c–c*, oblique external fracture (Fig. 74); *d–d*, oblique internal fracture (Fig. 73); *e–e*, isolated fracture of the internal (medial) condyle (Fig. 74); *f–f*, isolated fracture of the external (lateral) condyle (Fig. 73); *g–g*, intra-articular splitting off of the capitellum (Fig. 74). Longitudinal and T, Y, and V fractures are produced by combinations of various lines of fracture.

We shall now proceed to give a detailed description of these fractures :

(a) **Supracondylar Fracture** (*Fractura supracondylica*). (Plate 35, Fig. 3.)—This fracture is usually produced by a fall on the elbow or hand, and is a common fracture in children. The lower end of the humerus may be broken through the shaft by a movement of flexion anteriorly or posteriorly (hyperextension). Kocher ac-

PLATE 36.

Fractures of the Lower End of the Humerus.—Figs. 1 *a* and 1 *b*.—Bones of the right arm of a child, severely injured by a machine accident. Figure 1 *a* shows the transverse fracture and a crack running downward in the shaft of the humerus; also a partial separation of the lower epiphysis at its inner and middle portions. The bones of the forearm are shown in figure 1 *b*. The radius is normal; the ulna presents a longitudinal fracture which has produced separation of the olecranon. The arm had to be amputated. (Author's collection.)

Fig. 2.—Longitudinal fracture of the humerus, extending into the elbow-joint. The specimen is the result of injury from a load of shot discharged at very short range. At its middle the bone was completely shattered; the lower fragment presented the longitudinal fracture seen in the picture. The patient recovered after high amputation of the arm. (Author's collection.)

Fig. 3.—Typical transverse fracture of the humerus above the condyles, with longitudinal fracture extending into the elbow-joint—so-called T-fracture. (Author's collection.)

Fig. 4.—Oblique fracture through the articular extremity of the humerus splitting off the capitellum and external condyle. Oblique external fracture. (Author's collection.)

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cordingly distinguishes between flexion-fractures and extension-fractures (Figs. 75 and 76). These two forms also present certain clinical differences, especially as regards the usual course of the line of fracture, the deformity, and the treatment. Extension-fractures so far as etiology is concerned, are analogous to posterior dislocation of the forearm.

The articular fracture represented in the skiagraph (Fig. 77—from a boy) belongs to the class of extension-fractures.

Symptoms.—The deformity, as a rule, is typical. This is particularly true in supracondylar transverse fractures and in oblique fractures, classified by Kocher among the extension-fractures. The deformity suggests that seen in posterior dislocation of the forearm; the lower fragment is displaced backward (Plate 35, Fig. 3; also Fig. 75) by

Fig. 1 a

Fig. 2.

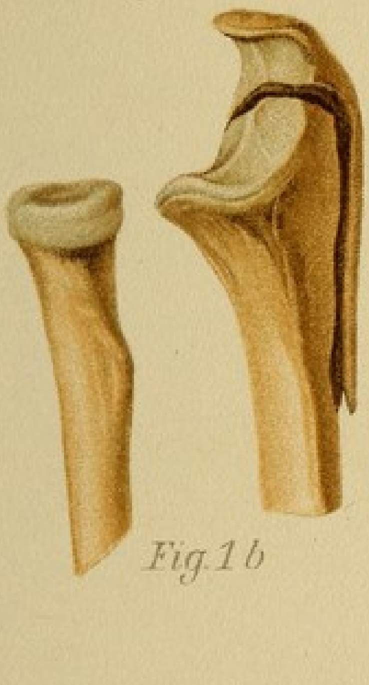

Fig. 1 b

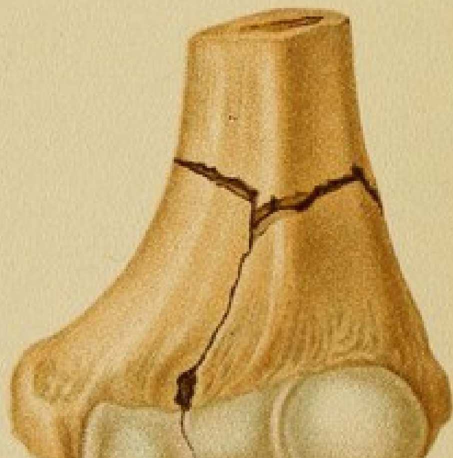

Fig. 3.

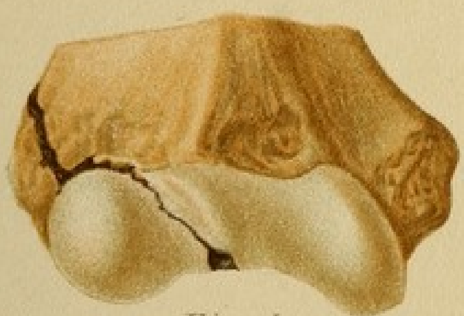

Fig. 4.

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the action of the triceps muscle. An exception is formed by the other supracondylar oblique fractures, the flexion-fractures of Kocher (Fig. 76), in which the course of the line of fracture is such that posterior displacement of the lower end of the fragment is impossible. The sharp end of the shaft of the humerus in these fractures is displaced backward and sometimes enters the triceps muscle, whereas in the so-called extension-fractures it is displaced forward and may penetrate the brachialis anticus.

An important step in the examination consists in seiz-

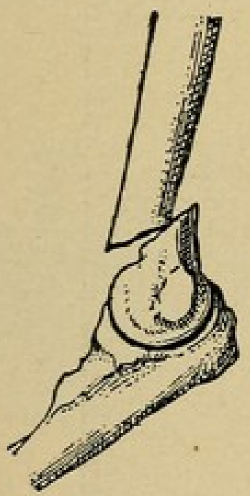

Fig. 75.—Diagram of extension-fracture (Kocher); the direction of the line of fracture is from behind and above, forward and downward.

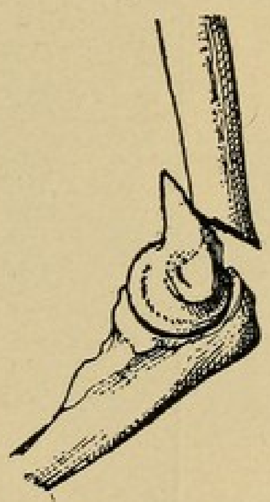

Fig. 76.—Diagram of a flexion-fracture (Kocher); the direction of the line of fracture is from before and above, backward and downward.

ing the lower end of the humerus by the condylar prominences, which are readily felt, and attempting to elicit abnormal mobility with the shaft. A fracture at the lower end of the humerus may also be recognized by fixing the arm and pushing the forearm against it. If a fracture is present, crepitus and abnormal mobility will be discovered. The forearm also presents a certain mobility, both for abduction and for adduction. The position of the olecranon with respect to the condyles is normal ; not infrequently the fragments can be directly felt. Reduction is effected by simple extension with the elbow in flexion,

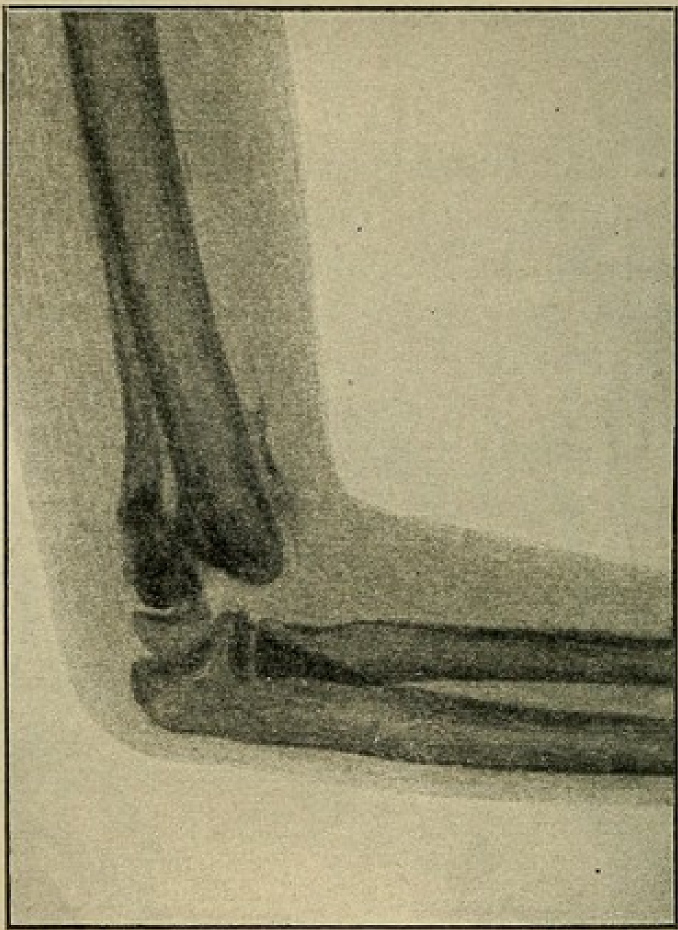

Fig. 77.—Old, supracondylar extension-fracture, with the same deformity as in dislocation. Skiagraph.

Ludwig Maack, ten years old, was injured by a fall three months before admission. An obtuse-angled contracture of the joint, marked osteoplastic thickening at the lower end of the humerus, and paralysis of the musculospiral were present. The skiagraph shows the posterior displacement of the lower fragment; the lower end of the diaphysis interferes with flexion. Operation: The musculospiral nerve was dissected out and found to be completely divided, the two ends grown fast to the bone and cicatricial tissue; the nerve was repaired by a suture, and the lower end of the shaft of the humerus was removed, whereupon flexion at once became possible almost as much as in the normal limb. Result: Improved motion at the elbow after a long course of exercises; the paralysis of the musculospiral nerve did not disappear.

but the deformity tends to return when the extending force is removed.

Treatment.—*Complete reduction,* if necessary under anesthesia, and fixation by means of splints or padded tin gutters applied to both the outer and the inner side of the limb. The arm is fixed with the elbow either in extension or in flexion, in whichever position retention is most effectually obtained. In adults an adhesive plaster dressing with permanent extension by means of weights may be used. The arm is placed in extension with the forearm and hand on a sliding rest; the hand should be exposed and in supination. Lateral loops or sandbags may be necessary to effect counterextension or pressure. In children a splint dressing is all that is necessary. The

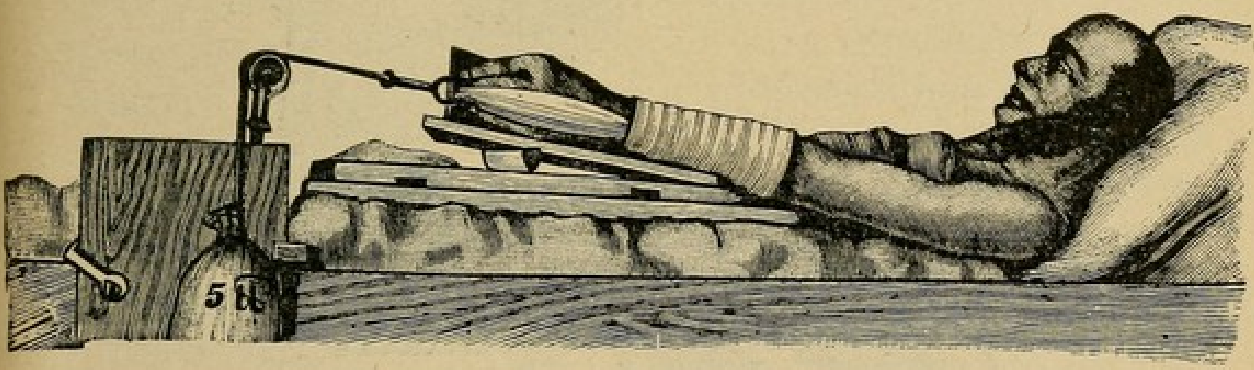

Fig. 78.—Extension dressing applied to the forearm in the treatment of a T-fracture.

wire splints recommended for fractures of the shaft of the humerus and illustrated on page 167 may be used (see also Fig. 67, page 167). The importance of careful reduction and constant supervision cannot be emphasized too strongly. I am in the habit of anesthetizing the children, not only at the first dressing, but in some cases also at subsequent dressings. The dressing should be changed at short intervals. Passive movements, massage, etc., must be begun early. Improper treatment may result in union with outward (varus) or inward (valgus) deformity of the limb (Plate 37).

[The position of the forearm, flexion or extension, is a much disputed point. This subject of elbow fractures in children has recently been exhaustively studied and discussed by Fred. J. Cotton, of Boston,[1] who concludes that in the majority of instances the position of *acute flexion* seems to have given the best results, although he

Fig. 79.—Paralysis of the musculospiral after compound fracture of the lower end of the humerus. The scar is seen at the elbow (boy, eight years old).

agrees with the majority of authors that the most important point in the treatment is proper reduction. Scudder[2] recommends the position of acute flexion, although it may not be possible at the first or second dressing. The expe-

[1] Annals of Surgery, Feb. and Mar., 1902.

[2] The Treatment of Fractures, Saunders & Co., Phila., 1900.

rience in the surgical clinic of the Johns Hopkins Hospital also favors this position. It is a much simpler method than the extension position.—ED.]

As regards accessory injuries, the ulnar nerve is more rarely involved than the musculospiral and median, which are sometimes completely divided; that these complications must be carefully, and as a rule at once, treated by operation needs no more than a passing reference. Injury to the blood-vessels indicated by beginning gangrene of the arm has not infrequently occurred.

(b) Transverse Fracture of the True Articular Process (*Fractura processus cubitalis s. articularis, Fractura diacondylica*, see Fig. 73, page 173, line *b–b*).—Here we have to deal with a transverse fracture below the condyles along the cartilaginous border; *i. e.*, a true intra-articular injury. In actual practice it is produced by a fall on the elbow or hand, the force of the blow being transmitted to the lower articular end of the humerus through the bones of the forearm. Experimentally it may be produced by compressing the bone from below in its longitudinal axis.

This variety includes **traumatic separation of the epiphysis** at the lower end of the humerus, in which the line of separation takes the same direction (see Plate 41, Fig. 3, and Plate 36, Fig. 1 *a*; also text, Fig. 80). This articular fracture is most frequently observed in the form of an epiphyseal separation, in children and youthful individuals. For the development of the centers of ossification in the epiphysis the reader is referred to an anatomic atlas (Toldt's Atlas, Figs. 255–257).

The **symptoms** are those of contusion of the joint with slight deformity; some passive movement remains and is practically painless. By pushing the forearm forcibly against the arm pain is elicited. When the intercondylar line is fixed, there is still a certain degree of mobility at the elbow-joint, both from before backward and from side to side, accompanied by slight crepitation (cracking). The examination must be made under anesthesia.

Treatment.—Reduction. Splints or extension dressing acting in the long axis of the humerus with the fore-

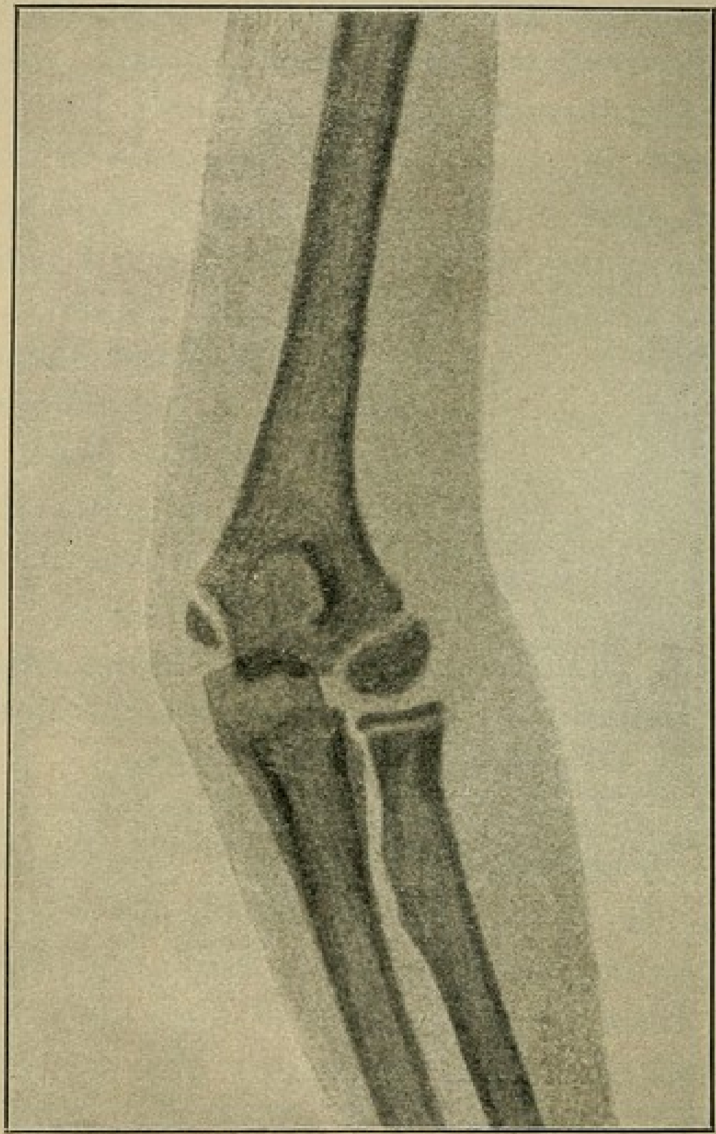

Fig. 80.—Lower end of the humerus from a boy ten years of age; normal; skiagraph. A knowledge of the normal epiphyseal lines, as illustrated in this picture, is of the utmost importance to enable one to judge skiagraphs obtained from children. A mistaken diagnosis of fracture of the internal condyle and external oblique fracture is often made from the skiagraph, an error that could be avoided if the skiagraph were compared with the picture of the sound elbow. (Compare Plate 41, Fig. 3.)

arm either in flexion or extension. Passive movements should be begun early.

(c and d) Oblique Fractures of the Lower End of the Humerus.—In these oblique fractures either the outer or the inner portion of the articular extremity is split off. If, as happens in exceptional cases, both are fractured, the injury might be described as a double oblique fracture, or a *fractura condylica*, as surgeons usually speak of an outer and an inner *condylus* in this injury, although these names are not known to the anatomic nomenclature. The line of fracture does not, of course, always follow the same direction.

These oblique fractures are true joint-fractures, and are not infrequently associated with marked displacement of the forearm at the elbow-joint. A provisional diagnosis may be arrived at by careful palpation of the articular prominences and the determination of abnormal mobility. If pain and swelling are marked, the examination should be conducted under anesthesia. Sometimes parts of the fractured surface and of the articular extremity itself may be felt. Accurate knowledge of the normal outlines and comparison with the sound side will usually enable the surgeon to obtain a correct idea of the nature of the injury. In oblique fractures involving one of the condyles some abduction and adduction of the forearm is possible when the arm is in complete extension and the hand in supination, sometimes even without anesthesia. It is often possible also to determine which is the injured side, for the forearm can only be moved toward the sound side, movement toward the injured side being inhibited by the lateral ligament, which is still preserved if the line of fracture passes through the middle of the joint, and only one condyle is separated.

The most common form of oblique fracture, and one that constitutes an injury of frequent occurrence, is—

(c) The external oblique fracture (*fractura obliqua externa, fractura condyli externi*), or fracture of the external condyle (Plate 36, Fig. 4; Plate 37, Fig. 1 and 1 *a*). It is produced by *direct* violence applied to the outer portion

PLATE 37.

Valgus and Varus Position of the Elbow after Fracture of the Lower End of the Humerus.—Fig. 1.—Old oblique fracture of the lower end of the humerus with the production of cubitus valgus. The specimen shows the intense alteration at the joint which occurred after the splitting-off of the capitellum humeri (compare Plate 36, Fig. 4). Arthritis deformans of the joint: cushion-like thickening of the head of the radius, atrophic condition of the cartilaginous articular extremities with moderate thickening of the surrounding bone. (Author's collection.)

Fig. 1 *a*.—The same condition as shown in figure 1, seen in the living subject. The patient, a man thirty-four years of age (J. Janker, 1884), two years previously had sustained a fracture which resulted in deformity at the elbow. The illustration was copied from a photograph. (Author's observation.)

Fig. 2.—Old fracture of the lower end of the humerus with the production of a cubitus varus. The articular process in the specimen shows little change. The deformity resulted from a badly united supracondylar oblique fracture. The specimen shows thickening of the lower end of the humerus in the anteroposterior direction; slight degree of arthritis deformans. (Author's collection.)

Fig. 2 *a*.—Cubitus varus in the living subject, after fracture of the lower end of the humerus. (Author's observation.)

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of the joint, or *indirectly* by transmission of the force to the outer portion of the joint through the radius (fall on the hand), or by transmission through the olecranon laterally from within outward (fall on the inner portion of the elbow with the arm in abduction). The external oblique fracture (glenoid condyle) corresponds in a certain sense to a backward and posterior dislocation of the forearm.

Symptoms.—Abnormal mobility of the extended forearm inward. The disappearance of the normal position of abduction when the arm is in extension (later the arm forms an angle with the vertex presenting outward). Longitudinal compression of the forearm in abduction produces violent pain; the outer condyle can readily be felt on the articular fragment, which exhibits abnormal mobil-

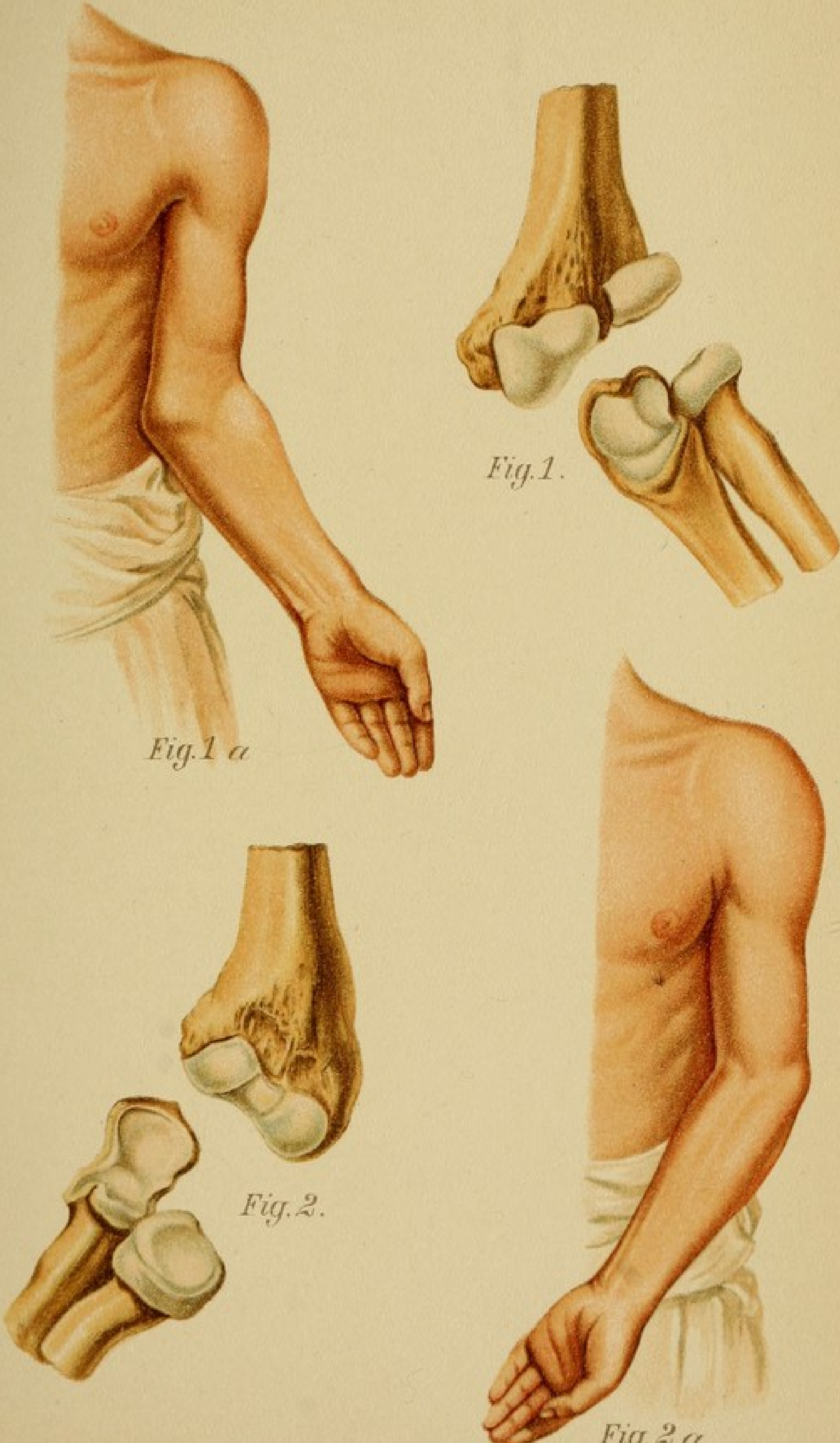

Fig. 1.

Fig. 1 a

Fig. 2.

Fig. 2 a

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ity and crepitus. The fragment is often displaced upward by the pressure of the radius, or, rather, the action of the biceps and all the muscles of the forearm. There is cubitus valgus with anterior rotation of the articular portion (flexion).

The *prognosis* in this fracture is, on the whole, unfavorable; the displacement of the fragment is apt to become permanent and interfere with the normal excursions of the joint by the presence of abnormal prominences on the bone (bony inhibition). In children and youthful individuals the obstacles may in time be worn away and the function improved by proper exercises and the use of appropriate apparatus, such as Kocher's pendulum apparatus for the elbow-joint, which I am in the habit of ordering the patients to use at home. But even in these cases complete restoration of function is never obtained and the valgus (cubitus valgus) may become permanent. (Compare Plate 37, Fig. 1 and 1 *a*.)

Treatment.—Reduction under anesthesia by flexing the forearm in pronation and direct pressure. Splint dressing in the most advantageous position; the position may be varied from time to time, the arm being placed half-way in extension, or in complete extension, and again for a time in flexion. A flexible, padded metal splint is very useful, because it may be bent to conform to the change of position at each change of dressing, which should take place every three or four days during the first two weeks, and later every other day. Permanent extension may also be used with advantage, the traction being applied in the longitudinal direction of the arm with the forearm flexed at the elbow.

(d) Oblique internal fracture (*fractura obliqua interna, fractura condyli interni*), or fracture of the internal condyle, is a much rarer occurrence. It is produced by pressure on the median portion of the articular border by a fall on the middle of the elbow.

Symptoms.—Severe pain, accompanied by crepitus, is elicited by pushing the fragment upward; abnormal mobility, permitting abduction when the arm is in extension; and the fragment can be displaced directly toward the humerus.

The *prognosis,* in view of the slight degree of deformity, is favorable.

Treatment.—Reduction is effected by extension with the forearm bent at the elbow. Splint dressing.

(e and f) Fractures of the Condyles (*Fractura epicondylica*).—These fractures may occur separately or in combination with outward or inward dislocation. The diagnosis is really made by noting the displacement and mobility of the bony part. In moving the elbow it is found that moderate movements of flexion and extension are painless, while active flexion or extension gives exquisite pain on account of the stretching of the lateral ligaments and consequent tugging on the fractured surfaces. This symptom, which was first contributed by Hüter, is of course useless in little children, nor does it occur when the condyle is not only broken, but is also markedly displaced.

(e) Fracture of the internal condyle (*fractura epicondyli interni, fractura epitrochleæ,* Bähr). This is a common injury; it is rarely produced *directly* by a fall or blow on the condyle; much more frequently *indirectly* by muscular action, being torn away with the internal lateral ligament in abduction, which, if continued, may add outward dislocation of the forearm to the injury.

Symptoms.—The downward displacement of the movable condyle is sometimes very slight, sometimes very marked; it may extend as far as the level of the trochlea. Circumscribed ecchymoses. Abnormal abduction is possible.

Treatment.—In marked displacement of the fragment Köcher recommends operative fixation by means of sutures; in an old case, excision of the fragment. Kocher has often had occasion to study the anatomy of the joint in this operation, and believes that the fracture is always produced by muscular action and should be regarded, in a sense, as the first step in outward luxation (compare Plate 39). He has even observed dislocation to take place secondarily after this fracture. I have so far never been obliged to operate.

(f) **Fracture of the external condyle** (*fractura epicondyli externi, fractura epicapituli*, Bähr). This is a very rare injury. I have seen it with inward dislocation of the forearm, just as the one just described occasionally accompanies outward dislocation. *Diagnosis* and *treatment* are the same as for the last-described fracture.

(g) **Intra-articular Fracture Separating the Capitellum Humeri** (*Fractura rotulare partialis*, Kocher; *Fractura processus articularis partialis*).—This fracture is entirely intra-articular. The separated piece of bone lies in the joint as a movable body ("joint-mouse"); or it may become fixed in an abnormal position (Steinthal). It is produced by a fall on the hand, that is, by a blow from below, transmitted through the radius. In some cases, observed by Kocher in youthful individuals, there was more a peeling off of the cartilaginous investment with some adherent bony substance than a true fracture.

Symptoms, according to Kocher: Sudden pain and appearances of a distortion; slight bloody effusion into the joint; somewhat later the arm is held at an obtuse angle and slightly abducted at the elbow; the internal condyle becomes very prominent; the head of the radius appears to be subluxated; that is, it appears wider on account of the diminution in the size of the capitellum. The only movements interfered with are extension and supination, which give great pain. It is said that the separated piece of cartilage can be felt between the external condyle and the head of the radius when the arm is in extension. The injury may be mistaken for fracture of the head of the radius.

The **treatment** consists in removal of the loose bone through a lateral incision.

PLATE 38.

Backward Dislocations of the Forearm.—Fig. 1.—Anatomic specimen, showing a backward displacement artificially produced in the cadaver; right arm. We see the shaft of the humerus and its lower articular extremity; below and behind it, the dislocated head of the radius; and at the upper end of the ulna the semilunar fossa. The external lateral ligament and annular ligament are faithfully reproduced. On the anterior surface of the humerus the biceps and its tendon, and, underneath, the brachialis anticus, may be seen. Behind the humerus the triceps with its insertion on the tip of the olecranon is discernible.

Fig. 2.—The same dislocation in the living subject; right arm. The arm is flexed at an obtuse angle; the tip of the olecranon forms an abnormal prominence, to the inner side of which is another spherical prominence corresponding to the head of the radius. The longitudinal axis of the humerus, instead of being directed toward the end of the forearm, divides it into a short posterior and a long anterior segment.

(h) Longitudinal Fracture at the Lower End of the Humerus (*Fractura intercondylica*, Hüter). (Compare Plate 36, Fig. 2.) **T-fracture** (*Fractura condylo-intercondylica*). (Compare Plate 36, Fig. 3.) **Y- and V-fractures** (Double Oblique Fractures).—These severe fractures are often complicated not only with fracture at the upper articular extremity of the bones of the forearm (Plate 36, Fig. 1 *b*), but also with injury to the soft parts. The lower end of the humerus seems to be particularly liable to longitudinal fractures, as shown by the preparation of Plate 36, figure 2, from a shot-wound of the diaphysis.

The **diagnosis** is not impossible: all the lateral portions of the lower end of the humerus can be moved against each other and against the shaft of the bone.

Treatment.—Antiseptic treatment of wounds in the soft parts. Extension dressing with the arm extended.

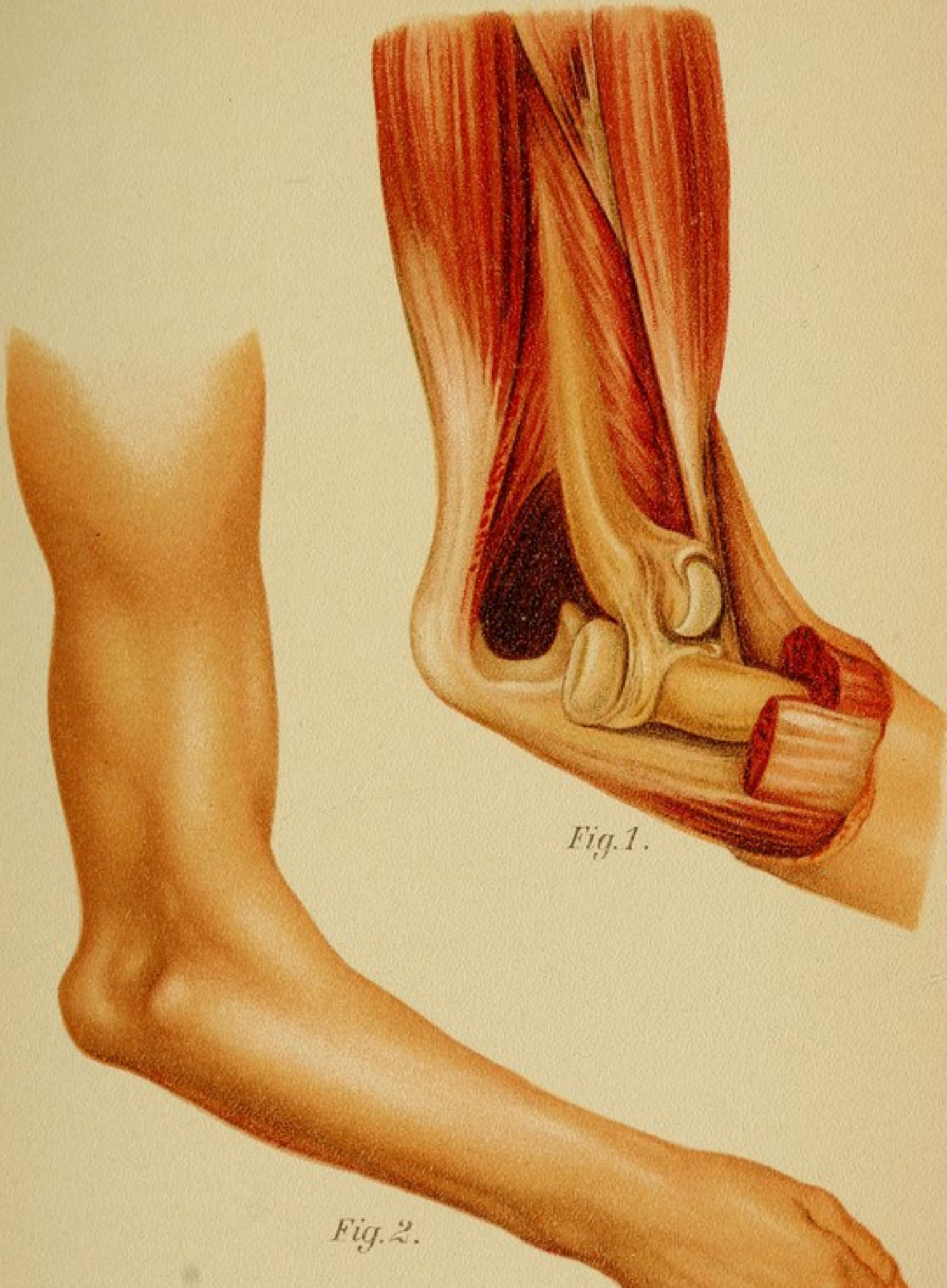

Fig. 1.

Fig. 2.

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5. ELBOW

(A) Dislocations

In the examination of dislocations of the elbow-joint an accurate knowledge of the outlines of the normal joint is indispensable. We feel the condyles, the olecranon, and their relations to one another in various positions of the joint; underneath the external condyle the head of the radius is distinctly felt, especially if the forearm is alternately pronated and supinated. In dislocations the articular extremities can often be distinctly felt—the head of the radius with its central depression, the capitellum humeri, trochlea, and the upper end of the ulna. For the examination to be accurate, not only each individual bony prominence must be recognized, but the position of all the bony parts and their relation to one another must be accurately demonstrated, even if they cannot all be directly palpated. It is well to have a skeleton of an arm at hand in setting these injuries.

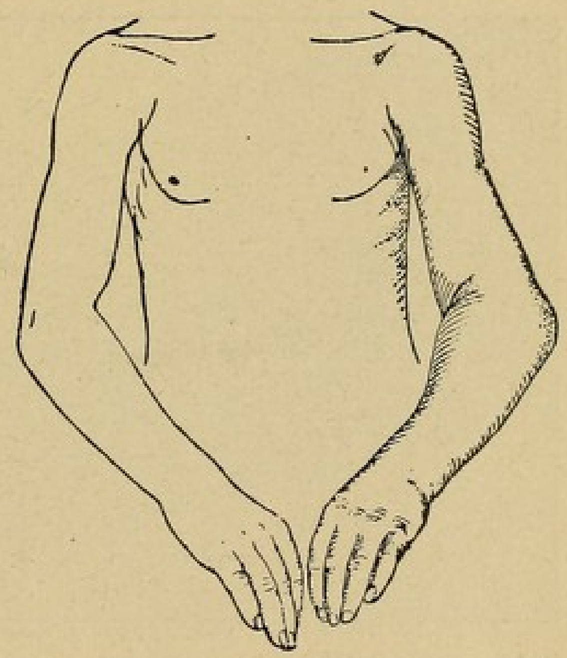

Fig. 81.—Recent backward dislocation of the left forearm in a boy fourteen years of age (Krüger, 1896). Swelling, prominence of the olecranon, shortening of the forearm are seen. The dislocation was reduced and perfect recovery ensued.

We distinguish dislocation of both bones of the forearm (*luxatio antibrachii*), and luxation of one bone alone (*luxatio radii, luxatio ulnæ*).

(a) **Backward Dislocation of the Forearm** (Plate 38).—This is the easiest dislocation to produce in the cadaver. The arm need only be overextended to produce a tear in the anterior segment of the articular capsule; the olecranon during this movement is braced against the posterior supratrochlear fossa, and after the bones have been sufficiently forced apart, the forearm is suddenly pushed backward and then flexed at the elbow-joint—the dislocation is complete. The arm is fixed at an obtuse angle at the elbow. Further flexion is prevented by the pressure of the coranoid process against the articular extremity of the humerus and by the pull of the triceps muscle.

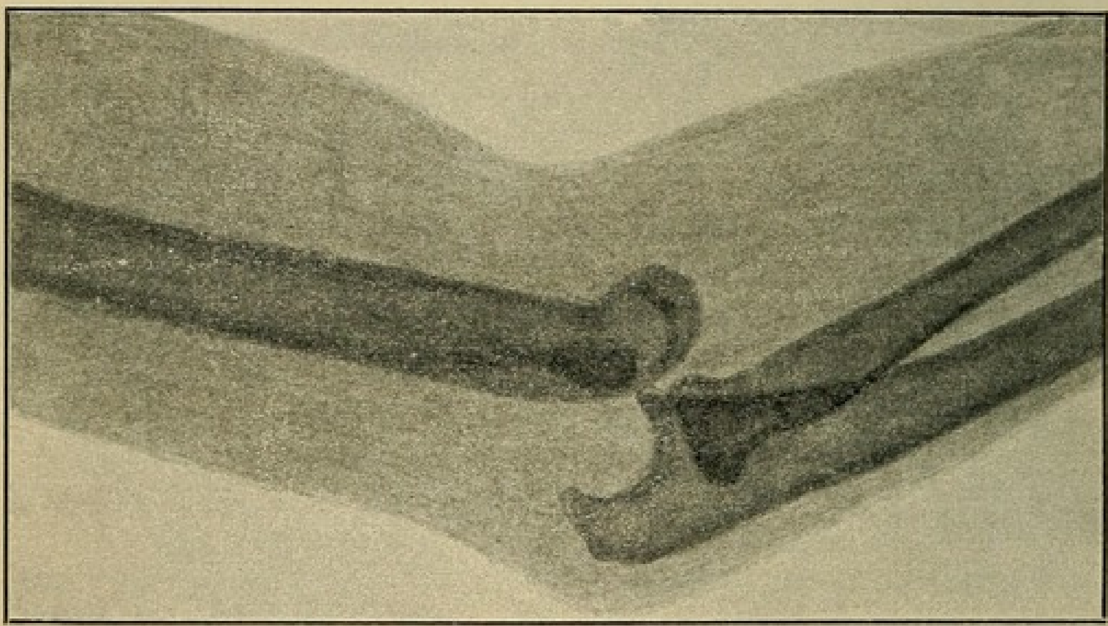

Fig. 82.—Backward dislocation of the forearm; skiagraph. Old dislocation in a man twenty-five years of age (A. Prengschart). The dislocation was reduced and a good result obtained.

This dislocation frequently occurs in the living subject and is often produced by the same mechanism. The injury is said also to be produced by overflexion and forced lateral movement or by a force striking the lower end of the humerus directly from behind.

The **symptoms** are easily understood. The prominence of the olecranon is conspicuous; the lower end of the humerus is hidden under the soft parts at the bend of the elbow, but may be felt somewhat more distinctly if

Method of Reducing a Backward Dislocation of the Forearm.

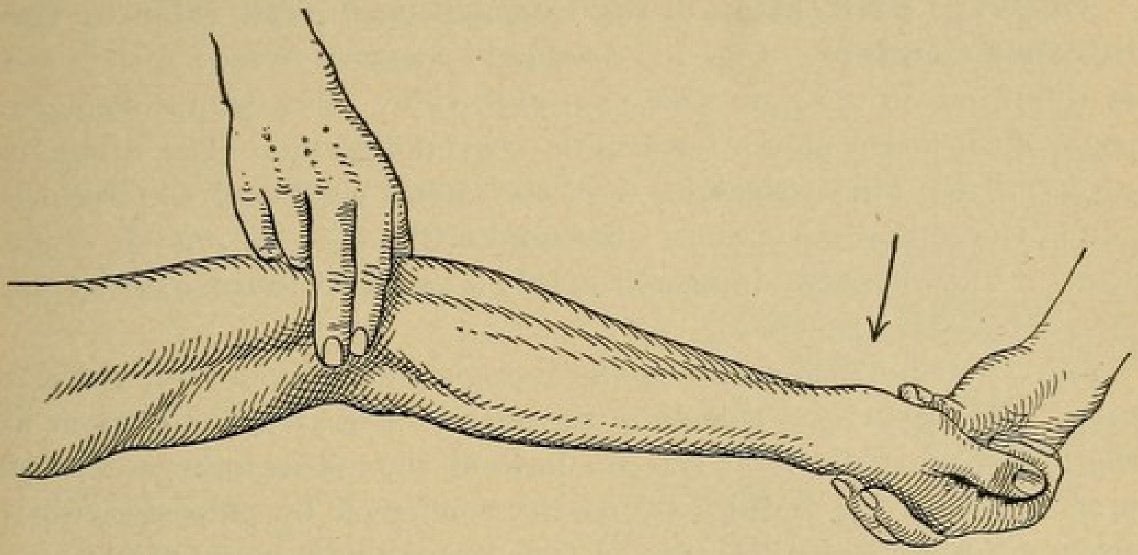

Fig. 83.—Overextension at the elbow—the first step in the manipulation.

FIGS. 84, 85, AND 86.—SHOWING THE MANIPULATIONS IN THE SKELETON:

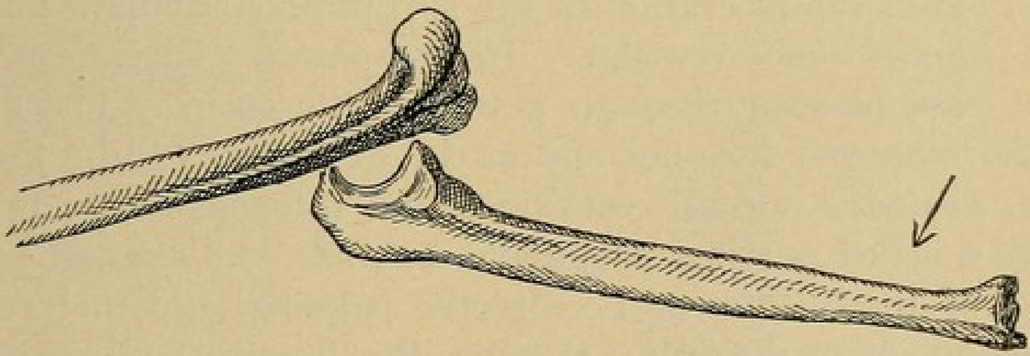

Fig. 84.—Overextension.

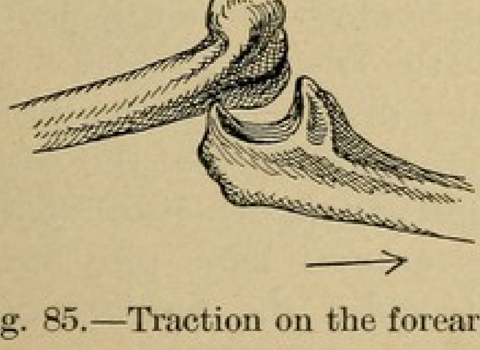

Fig. 85.—Traction on the forearm.

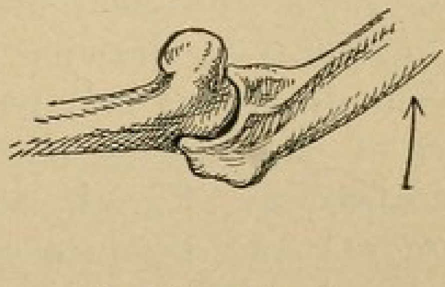

Fig. 86.—Flexion.

PLATE 39.

Outward Dislocation of the Forearm and Separation of the Internal Condyle.—Fig. 1.—Anatomic specimen from a dislocation of this kind on the right arm ; anterior view. The lateral displacement of the bones of the forearm is very noticeable. The articular surface of the ulna articulates with the lateral portion of the trochlea and of the capitellum humeri ; the head of the radius is outside of the joint. The separated internal condyle is attached to the ulna by the internal lateral ligament.

Fig. 2.—Same dislocation in the living subject, right arm, anterior view. There is little change in the anterior and posterior contour of the arm, but on the outer side the head of the radius forms a marked prominence. The findings are readily confirmed by palpation, especially when the forearm is rotated from pronation to supination.

Fig. 3.—Bone specimen of the same dislocation and in the same position as in figure 2, seen from the outer side. Right arm. The illustration is intended to explain figure 2.

---

the dislocation is recent and the swelling is not very great. It can be felt close under the skin only when there has been extensive laceration of the soft parts (brachialis anticus, nerves, and vessels). In compound dislocations it may even be seen through a tear in the skin. The line of the humerus does not end at the extremity of the forearm, as under normal conditions, but intersects it so as to leave a small portion projecting behind. Olecranon and head of the radius can be directly palpated and their excursions determined by moving the forearm. The distances between the condyles and the olecranon are abnormal. The lower end of the humerus does not present abnormal mobility as in supracondylar fracture. The humerus is shortened, and the dislocation cannot be made to disappear by drawing the forearm forward.

The **diagnosis** may present some difficulties in the presence of complicating injuries, such as fracture of the coronoid process. Simultaneous supracondylar fracture of the humerus and fracture of the olecranon have also been observed. In fracture of the trochlea the forearm and

Tab. 39.

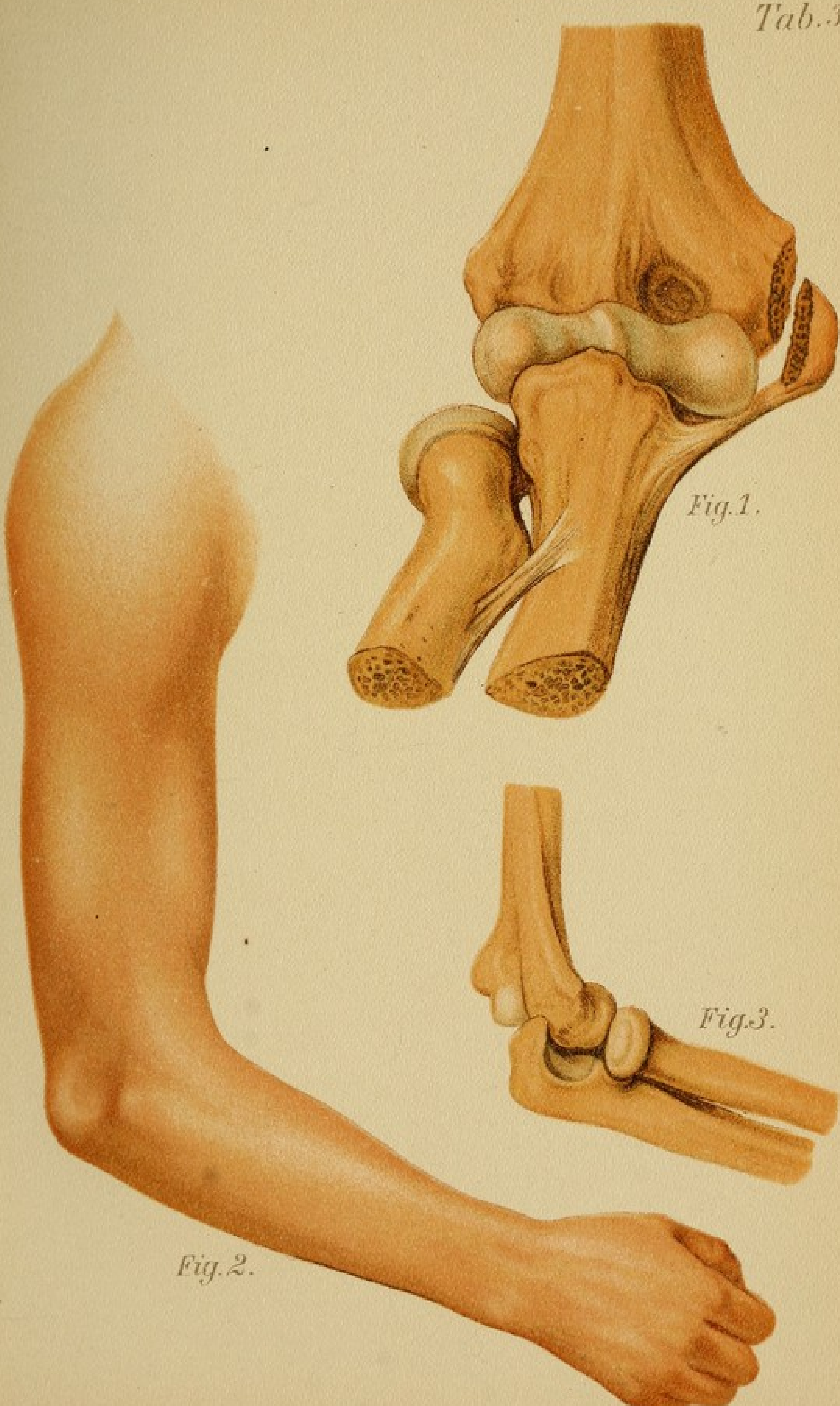

Fig. 1.

Fig. 3.

Fig. 2.

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fragment may be displaced backward with luxation of the head of the radius.

If complications are present, they may render the **prognosis** unfavorable; otherwise passive and active mobility should be restored after reduction.

Treatment.—The method of reduction is shown in figures 83–86. As in every hinge-joint, reduction requires more than a simple pull, no matter how strong it may be. It must be effected without using force, as if the surgeon were toying with the joint, so to speak; anesthesia is usually required. The forearm in supination is first over-extended so as to dislodge the coronoid process from the supratrochlear fossa. Moderate traction then draws the forearm forward, while the other hand seizes the injured elbow and controls the position of the parts; or the thumb may be braced against the lower end of the humerus and the other fingers, especially the third and fourth, against the head of the radius and olecranon behind, and by direct pressure assist in the act of reduction. Flexion of the arm is now found to proceed without any obstacle; the dislocation disappears and the normal contact between the articular surfaces is restored.

After-treatment according to general principles; fixation of the arm for two days, the dressing being changed at short intervals and massage administered; later passive movements.

(b) Lateral Dislocation of the Forearm (Plate 39).—Lateral dislocations at the elbow-joint are not rare; outward dislocation is more frequent than inward, and is usually combined with fracture of the internal epicondyle. This fracture is the direct result of the contusion sustained during the fall which produces the dislocation; or it may be a sprain fracture due to the pull of the lateral ligament. It always affects the condyle furthest removed from the forearm; hence in outward dislocation the internal condyle is fractured, and, inversely, in inward dislocation the external condyle.

The forearm and humerus are still in contact, but the articulation is abnormal. Thus, in outward dislocation the ulna articulates with the trochlea and the head of the radius projects beyond the joint. As a rule, the forearm is at the same time displaced backward, producing the combination of lateral and posterior dislocation (*luxatio posterior externa* or *postero-lateralis*). While backward dislocation may occur without destroying the integrity of the lateral ligaments (although the internal ligament is, as a matter of fact, generally torn), lateral luxation is usually associated with great destruction of ligaments and fracture of the epicondyle. This variety is also described as an incomplete dislocation, in contradistinction to complete dislocation of the bones in which no portion of one articular surface remains in contact with any portion of the other.

A lateral dislocation can only be produced by exaggerated movements of abduction or adduction. The capsule is greatly distended and sometimes presents a lateral tear.

The **symptoms** of a complete lateral dislocation to the outside, for instance, are unmistakable and need no description.

In incomplete outward dislocation (Plate 39) the prominence formed by the head of the radius is distinctly seen and felt. To the inner side, part of the trochlea can be seized between the fingers, and the separated internal epicondyle may be felt or appears as a marked prominence. By gently moving the parts under anesthesia a clear conception of the conditions is at once obtained.

[Recently Eversmann[1] has reported two interesting observations of the outward lateral dislocation of the elbow-joint. In both cases the fragmented internal epicondyle had become displaced into the joint, and after the reduction of the dislocation, the interposition of this fragment produced symptoms and restricted function. Both

[1] Deut. Zeitschr. f. Chir., 1901, Bd. LX, p. 528.

were subjected to operation with good results. The Röntgen photographs of these two cases are quite clear. This possibility should always be borne in mind in this rare form of dislocation.—Ed.]

Incomplete inward luxation (*luxatio postero-medialis*) presents the external epicondyle in marked anterior displacement, or completely separated from the bone. The ulna projects beyond the inner line of the arm and its articular surface can be felt; the head of the radius articulates with the trochlea; and part of the capitellum humeri may be palpated.

The **prognosis** depends on the complications.

Treatment.—Reduction is effected under anesthesia with the least amount of injury to the patient by overextending the arm under direct lateral pressure with the other hand, followed by traction and flexion. If something is found interposed between the articulating surfaces, exaggerated lateral movements, overextension with abduction, etc., are sometimes successful. If efforts at reduction fail, early removal of the obstacle through an incision is indicated, preferably by means of a bilateral arthrotomy. Excellent results may be obtained by this procedure.

(c) **Forward Dislocation of the Forearm** (*Luxatio antibrachii anterior*).—This is a very rare injury. It was formerly said that it never occurred without simultaneous fracture of the olecranon. It may be produced by a fall or blow on the olecranon while the arm is in extreme flexion.

Symptoms.—The prominence of the olecranon is missed from its normal position, and the outline of the lower end of the humerus can be felt on the posterior side of the bone. If the outer side of the olecranon is still in contact with the trochlea, the arm being almost in extension, an incomplete luxation exists. In complete dislocation the tip of the olecranon is found in front of the articulating surface of the lower end of the humerus, and the arm is bent at an acute angle. Reduction is effected by direct pressure, with moderate extension.

(d) **Divergent dislocation of the forearm** (*luxatio antibrachii divergens*), the ulna being displaced backward and the radius forward, so that the humerus is driven like a wedge between the two bones of the forearm, is a very rare injury. The abnormal position of the various parts of the bone can be determined by direct palpation. In reducing the dislocation each bone is to be treated separately, the ulna by overextension and traction, and then the radius by direct pressure.

(e) **Isolated dislocation of the ulna** is an injury that occurs very rarely by a fall on the hand in overextension and pronation of the forearm. The symptoms are the same as those of a posterior dislocation, except that there is no displacement of the head of the radius. The elbow is in varus position and the ulnar side of the forearm is shortened. Reduction is effected by means of overextension and traction.

(f) **Isolated dislocation of the radius** is somewhat more common and occurs in various forms. Injury of the musculospiral or radial nerve has been observed as a complication. The head of the radius may be displaced backward, forward, or outward:

Uncomplicated **outward dislocation** is a very rare form, the dislocation being more frequently associated with fracture in the upper third of the ulna (Plate 43). The head of the radius may be felt at the outer border of the external condyle, the radial side of the forearm is shortened; the elbow is, therefore, in valgus position. Reduction is effected by direct pressure; sometimes the elbow must be brought into varus position.

Backward displacement is very rare. It is readily recognized by palpation of the head of the radius. The elbow is midway between pronation and supination. The patient cannot perform extension or supination. Reduction is effected by direct pressure, assisted by forcible traction on the forearm, which must be brought into varus position.

Anterior dislocation is somewhat more common. It is produced by a blow against the head of the radius from behind, or by a fall on the hand in pronation. The head of the radius is found in front of and above the capitellum humeri and forms a prominence in the region of the supinator muscles. The forearm is slightly flexed and pronated; active supination is impossible; flexion beyond a right angle is impossible. The radial side of the forearm is shortened, unless the injury is complicated by a fracture in the upper third of the ulna (*q. v.*). Reduction is best effected by vigorous traction and simultaneous supination with the elbow in flexion.

In all these cases of isolated dislocation of the radius, the annular ligament is torn, or the head of the bone escapes from beneath it. Not rarely, especially in anterior dislocation, reduction becomes difficult, if not impossible, on account of interposition of portions of the capsule. Arthrotomy is then indicated, and reduction is forcibly secured by removing the interposed tissues. The same procedure is indicated in old cases. The longitudinal incision is made on the radial side of the joint; if the joint is entered from the front, there is danger of dividing the musculospiral nerve. In very severe cases arthrotomy may have to be abandoned in favor of resection.

The *after-treatment* of all these dislocations must be carried out on general principles.

(B) Intra-articular Injuries

Various intra-articular injuries may be united under the designation *dérangement interne*. One example of this has already been referred to in separation of the capitellum humeri (page 185). Another injury deserves special mention, not because the etiology and symptom-complex are not perfectly well known, but because the anatomic details still form the subject of controversy. The accident occurs in little children and is produced by the nurse or attendant violently pulling the child's arm, either to prevent it from falling or to pick it up when it has slipped down from the lap, etc.

Symptoms.—The arm hangs at the side and the elbow is held immovable in pronation; there is no demonstrable deformity. Attempt at supination is very painful, but if it is carried out and traction is at the same time applied, followed by flexion, the pathologic condition disappears. The child can use its arm again, although it is better to have it carried in a sling for a few days. This symptom-complex, which recurs again and again in a most typical form, is regarded by some surgeons as the result of an incomplete dislocation of the radius forward, by others as the result of a compression of the uninjured articular capsule at its posterior side, between the head of the radius and the humerus.

6. FOREARM

An explanation of the frequency of fractures in the forearm is given by its function in the performance of work and in protecting the body against injuries. We distinguish between fractures of the forearm—that is, of both bones—and isolated fractures of the ulna and radius alone.

(A) Fracture of Both Bones of the Forearm (Fractura Antibrachii)

This fracture is usually the result of direct violence, either a fall or a blow. In children infractions with bending of the forearm (greenstick fractures) are common.

Symptoms.—As a rule, the presence of a fracture is at once suggested by the angular deformity (*ad axin*); on careful examination abnormal mobility and crepitation are found. As the fractures preferably affect the middle third of the forearm, these phenomena can, as a rule, be demonstrated with ease and positiveness. Fractures of the forearm bones near their lower end will be discussed

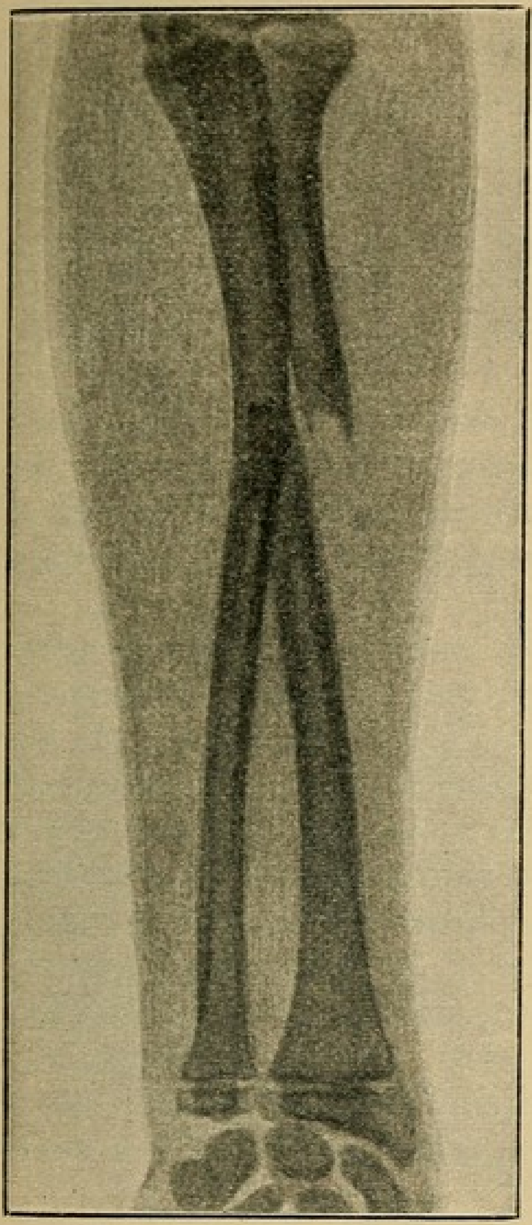

Fig. 87 *a*.

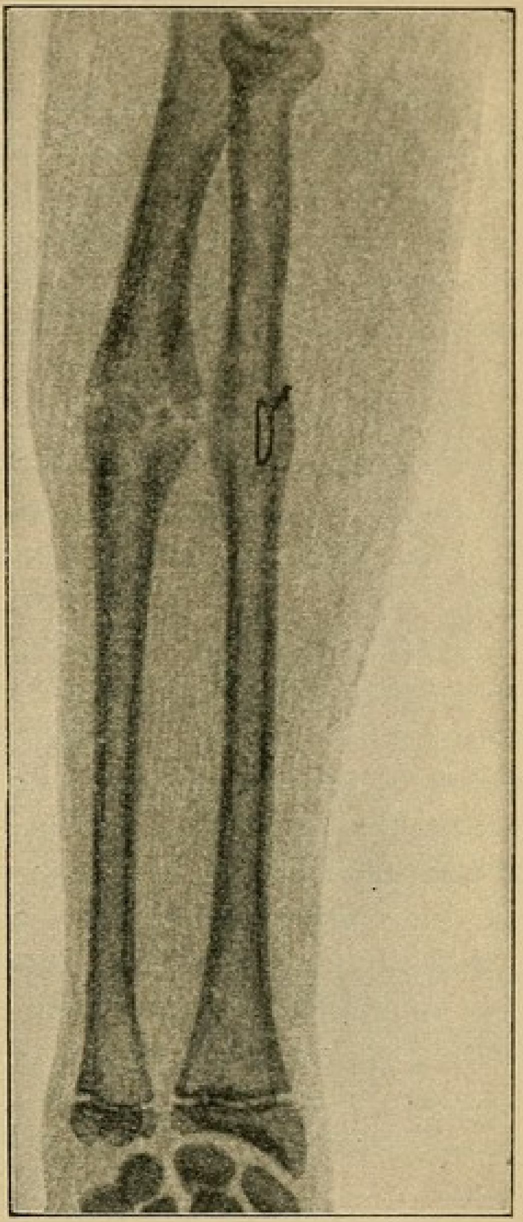

Fig. 87 *b*.

Figs. 87 *a* and 87 *b*.—Fracture of the forearm with marked deformity. The fragments were reduced by operation and the bones united by suture. Skiagraph. The patient, J. Schmidt, seventeen years old, fell from his wheel and struck on the left arm. Fracture of the forearm, with marked dislocation, especially of the lower radial fragment which completely overlies the shadow of the seat of fracture in the ulna. The latter presents only slight displacement of the fragments (Fig. 87 *a*). Although the patient was anesthetized, reduction was impossible; the fragments were therefore exposed by an incision and reduction effected by means of silver wire. Good result (Fig. 87 *b*).

PLATE 40.

Fractures through the Middle of the Forearm.—Fig. 1.—Typical displacement of the fragments in fracture of the right forearm. The picture was taken from a boy. When he first came under observation, the fragments had become united by bony union. The fracture was reduced under anesthesia, the arm was carefully fixed in extension, and bandaged to a long dorsal splint. Good recovery resulted.

Fig. 2.—Bones of the right forearm, anterior view, showing united fracture with position of the fragments similar to that in figure 1. In the radius the union is bony; the ulna shows a false joint at the seat of fracture; both present the same angular deformity. (Author's collection.)

Fig 3.—Specimen of fracture of left forearm, united in comparatively good position. The two bones are united at the seat of fracture, not by a firm mass of bone, but fortunately by a neoarthrosis. In the region of the interosseous crest each bone presents a process tipped with a kind of articular surface, which articulates with that of the prominence on the other bone. In the radius the process is found 1 cm. above the seat of fracture, springing from the shaft, which presents practically no alteration. The fracture of the radius was a multiple one; in addition the peripheral fragment presents a longitudinal fracture which extends obliquely into the joint. The lower articular extremities of both bones exhibit a moderate degree of arthritis deformans. Pronation and supination were evidently reduced to a minimum.

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more in detail in connection with typical epiphyseal separation of the radius. If both bones are broken at the same level, the displacement is, as a rule, greater than when the lines of fracture are separated by an interval.

The relative position of the lines of fracture is of some importance for the **prognosis,** as is also the question whether the dislocation has brought the bones nearer together and led to extensive laceration of the interosseous ligament, for this may be followed by cicatricial contraction and partial ossification of the ligament, and, in addition, the bones may come into lateral contact with one

Tab. 40.

Fig. 1.

Fig. 2.

Fig. 3.

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another, be it by means of bony union or by a kind of conical articulation, as shown in Plate 40, figure 3. It follows that pronation and supination may be greatly interfered with. In the leg complications of this character are quite immaterial, but in the forearm they may produce a marked degree of disability.

Fracture of both bones of the forearm near their

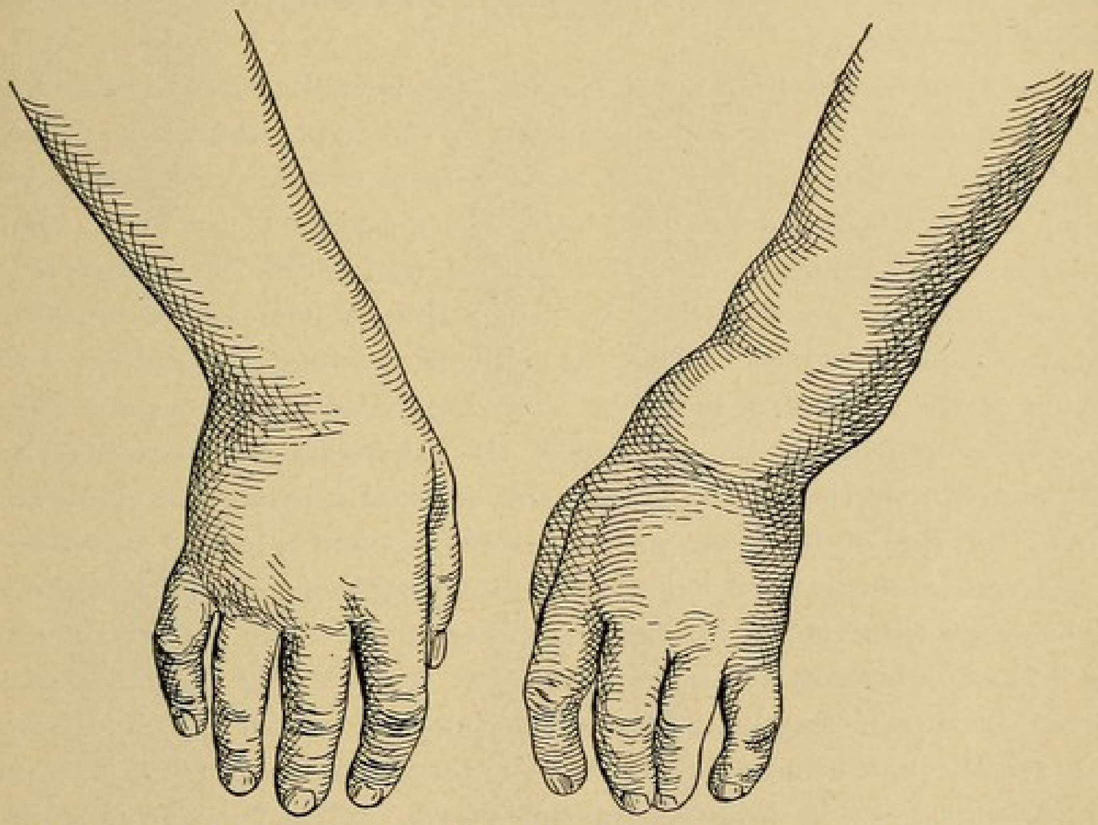

Fig. 88.—Supracondylar fracture of both bones of the forearm (Minna Houdelet, sixty years old, 1890). (Compare Plate 46 and Plate 47, Fig. 1.)

lower extremity deserves especial notice ; it is comparable to a supramalleolar fracture of the leg, hence the term supracondylar has been proposed. This fracture, like typical epiphyseal separation of the radius, is produced by a fall on the hand. Owing to the marked deformity, the **diagnosis** rarely presents any difficulties.

The **treatment** calls for careful reduction and fixation, either in supination or midway between pronation and

PLATE 41.

Various Fractures of the Forearm and Normal Epiphyseal Lines.—Fig. 1.—Specimen of fracture of the forearm (right) with cohesion of the callus of both bones at the seat of fracture. This unfortunate condition is due partly to the abundance of callus and more particularly to the fact that the two fragments of each bone tend to converge. The illustration distinctly shows this abnormal direction of the four fragments. It is probable that the splint in this case was too narrow, and that the bones were forced together by the pressure of the bandage.

Fig. 2.—Isolated fracture of the radius above its middle, showing the effects of the biceps on the position of the upper fragment. This illustration, which was faithfully copied from nature (artificial specimen), represents the forearm and hand with a portion of the arm. The forearm is in pronation, but the upper fragment of the humerus is rotated outward (supination) by the action of the biceps muscle, the function of which being, as is well known, supination and flexion of the supinated forearm. The supination of the upper fragment is recognized by the position of the tuberosity on the radius, by the point of insertion of the biceps, and especially by careful examination of the line of fracture; on the lower fragment a loss of substance is seen on the lower border of the fractured surface corresponding to a slight projection visible on the upper fragment. The projection and the loss of substance are not opposite one another; the outward rotation of the upper fragment (supination) having caused the projection to move through almost 180 degrees. The lesson to be drawn from this is that even in isolated fracture of the radius the arm must be dressed in supination or midway between supination and pronation.

Fig. 3.—Epiphyses of the bones that enter into the formation of the elbow-joint, showing various centers of ossification. Frontal section, right side. The posterior sawed surface seen from in front. We see the center of ossification of the capitellum, the internal condyle, and the head of the radius.

Fig. 3 *a*.—Sagittal section through the upper end of an ulna from a child.

Fig. 4.—Lower epiphyses of the bones of the forearm.

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supination, according to general principles. For this reason the treatment of fracture of the forearm is particu-

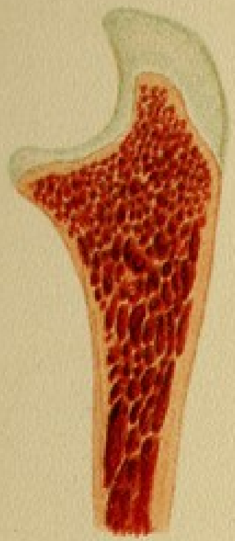

Fig. 3 a

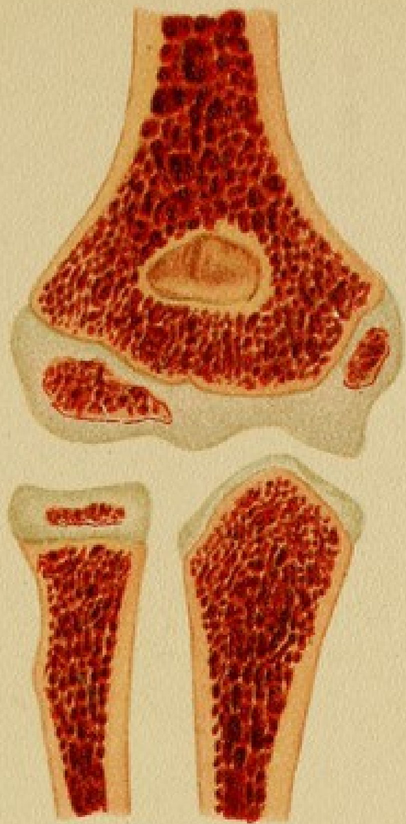

Fig. 3.

Fig. 1.

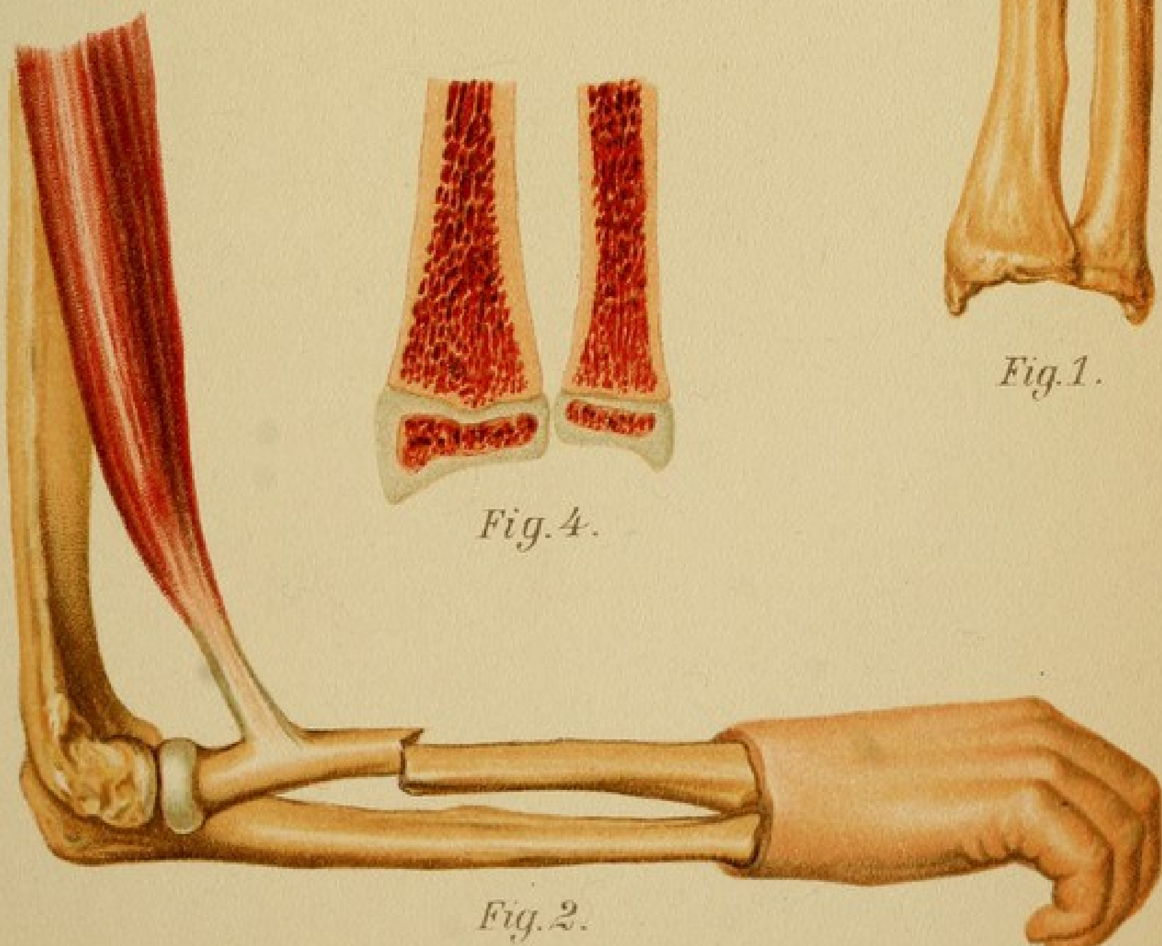

Fig. 4.

Fig. 2.

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larly important and requires expert skill and conscientious attention on the part of the surgeon. The object must be to secure bony union of the fragments with each bone in good position, and unimpaired motion both of the adjacent articulations and of the two bones themselves. Care is also required not to produce any injury with the bandage. The dressing may do harm if the pressure of the circular bandage is such as to force the bones apart and bring the extremities of the fragments together at the seat of fracture in such a way as to induce complete cohesion by an abundant callus-formation (Plate 41, Fig. 1). The splint must therefore be a broad one; it may be improvised from cardboard reinforced with small strips of wood broad enough to project beyond the forearm on each side. Another important point, after careful reduction, is the primary position of the forearm. The elbow is bent at a right angle and the wrist extended; and both joints must be included in the dressing. The chief question is, however, Should the forearm be in pronation or in supination? From what has just been said, it is evident that a position in which the two bones cross each other must be avoided at any cost. From this point of view parallel position of the bones—that is, complete supination—is the most desirable position. Another factor to be considered is the effect of the muscles on the fragments. Plate 41, figure 2, serves to remind us of the effect of the biceps on the upper fragment of the radius. This muscle is a supinator. Should the limb therefore be bandaged with the hand in pronation, while the upper fragment of the radius is in supination, the treatment would result in a very imperfect recovery with loss of supination.

Furthermore, an angular displacement of the radius at the seat of fracture may interfere with the movement or unfolding of the interosseous ligament, thereby diminishing the excursions of the bone in supination.

We conclude, therefore, that after careful reduction of the fragments, the arm is to be fixed in a position of supination on a splint that must not be too narrow. The splint may be applied either to the dorsal or the volar side of the arm; or, better still, fixation may be secured by the use of two splints, a long and a short one. It is in these fractures that especial care becomes necessary to see that the splints are well padded; that the bandage is

Fig. 89.—Improvised extension dressing for ambulatory treatment of a fracture of the forearm with a tendency to angular displacement of the fragments.

not too tight; and that the hand and fingers are left exposed for constant inspection. For it is in such cases that neglect of these precautions, especially the application of a circular plaster-of-Paris bandage immediately after the injury, is most apt to produce gangrene and ischemia (see General Considerations). The dressing should be changed at the end of about a week, and the position of the fragments at this time carefully examined. If one observes a tendency to angular displacement, with the vertex of the angle on the extensor surface, it may be successfully combated by applying an appropriate splint to the extensor side and bandaging the arm in extension. In some cases an extension bandage by means of Cramer's splints may be improvised (Fig. 89). Gentle passive movements and massage should be begun early. The normal course may be disturbed by various accidents, such as delayed callus-formation, the formation of a false joint, etc. These complications must be treated on general principles.

[The treatment of fracture of both bones of the forearm is a very important one. Not only must we avoid too narrow splints, which press the bones together at the seat of fracture, but it is very important to avoid excessive pressure, which can be easily produced in this region. Pressure sufficient to do harm is not necessarily associated with pain and discomfort to the patient. This undue pressure produces marked anemia of the muscles, which if present a number of days is usually followed by an interstitial myositis. The muscle is replaced by fibrous tissue and the loss of function which results is a permanent one. This can be avoided by well-padded splints. Blanket unquestionably is the best form of padding. If the fracture of the shaft is near the elbow-joint, the elbow should be fixed; that is, the anterior or volar splint should be a right-angled wire or tin splint. The posterior splint should extend from the tip of the olecranon at least to the knuckles. In fracture of the middle of the shaft of these bones or lower down, it is unnecessary to fix the elbow-joint unless, on account of position of the fracture and a tendency to displacement, we wish to fix the forearm in forced supination or semisupination. This can only be accomplished by the fixation of the elbow. In children frequent dressings and massage are very important in these fractures. Such measures allow frequent inspection

PLATE 42.

Fracture of the Olecranon and Coronoid Process.—Fig. 1. —Anatomic specimen of fracture of the olecranon, artificially produced. Posterolateral view, right arm. The broken tip of the olecranon is drawn upward by the triceps muscle. The separation between the fragments is increased to the maximum by the flexed position of the forearm ; the elbow-joint is widely opened, as always happens in fracture of the olecranon. The cartilaginous articular surface of the lower end of the humerus is exposed on each side ; the head of the radius and external lateral ligament are to be seen.

Fig. 2.—Bone specimen of an old fracture of the olecranon in which the union was fibrous. Traces of arthritis deformans. (Author's collection.)

Fig. 3.—Section from a fracture of the olecranon in which the union was ligamentous.

Fig. 4.—Fracture of the coronoid process with the brachialis anticus muscle, which is capable of displacing the upper fragment. Left forearm, internal view.

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and, if necessary, correction of the position of the fragments. Tendency to displacement is frequently marked. Before bony union is complete, if there is slight angular deformity it can be molded into a proper position by massage and the proper adjustment of pads. This is especially true of the greenstick fracture in children. The fingers should never be fixed in the dressing.—Ed.]

(B) Fractures of the Ulna

(a) **Fracture of the Olecranon** (Plates 36 and 42).—This fracture is usually produced by a fall on the elbow, —that is, by *direct* violence,—very rarely by muscular action of the triceps or by compressing the olecranon against the posterior surface of the humerus in overextension.

The **symptoms** are obvious, as one usually has to deal with a transverse fracture through the middle of the olecranon, with distinct separation of the fragments. The

Tab. 42.

Fig. 2.

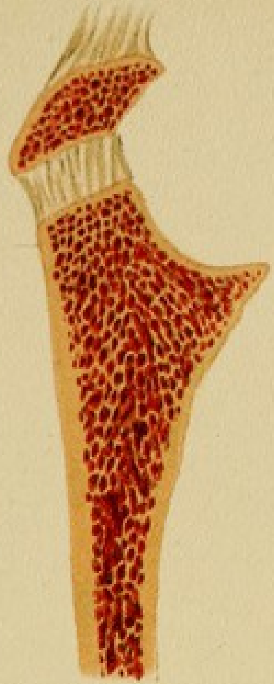

Fig. 3.

Fig. 4.

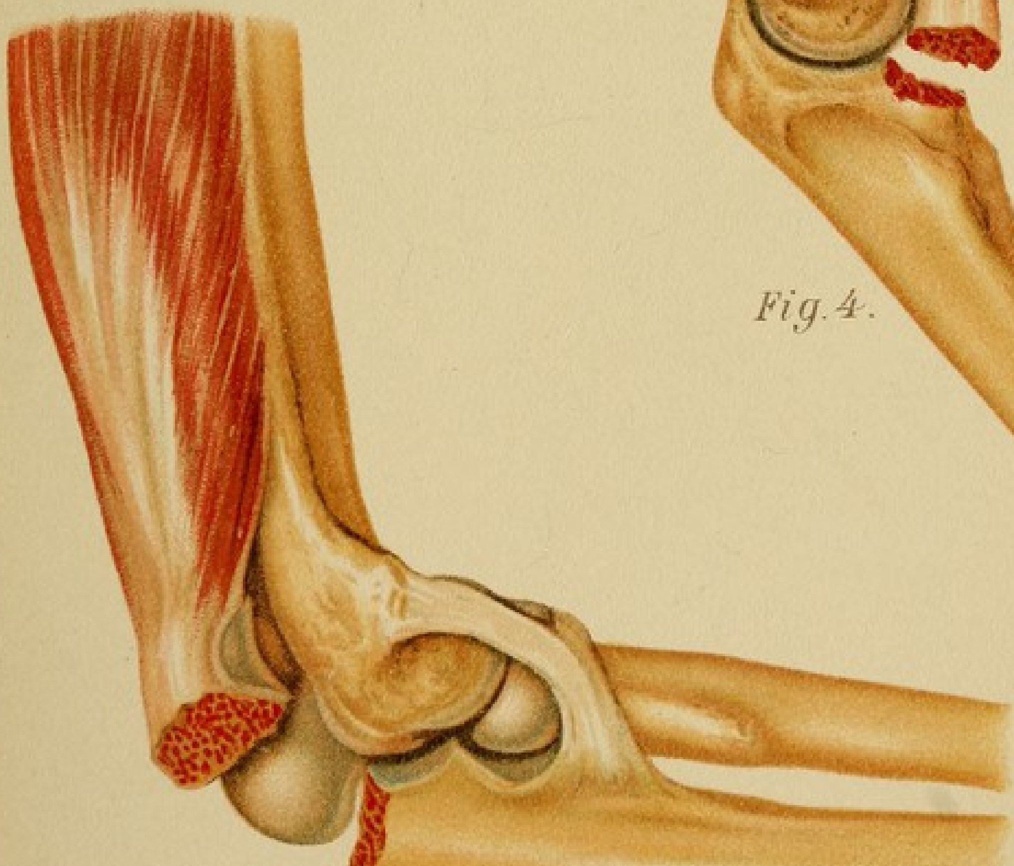

Fig. 1.

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upper fragment is drawn upward by the triceps. Owing to the superficial position of the olecranon, the condition is readily determined by palpation. The joint and the remaining bony prominences of the articular region remain intact, except, of course, that the extravasation produced by the fracture also affects the joint. The patient is unable to extend the arm. As a rule, the upper fragment

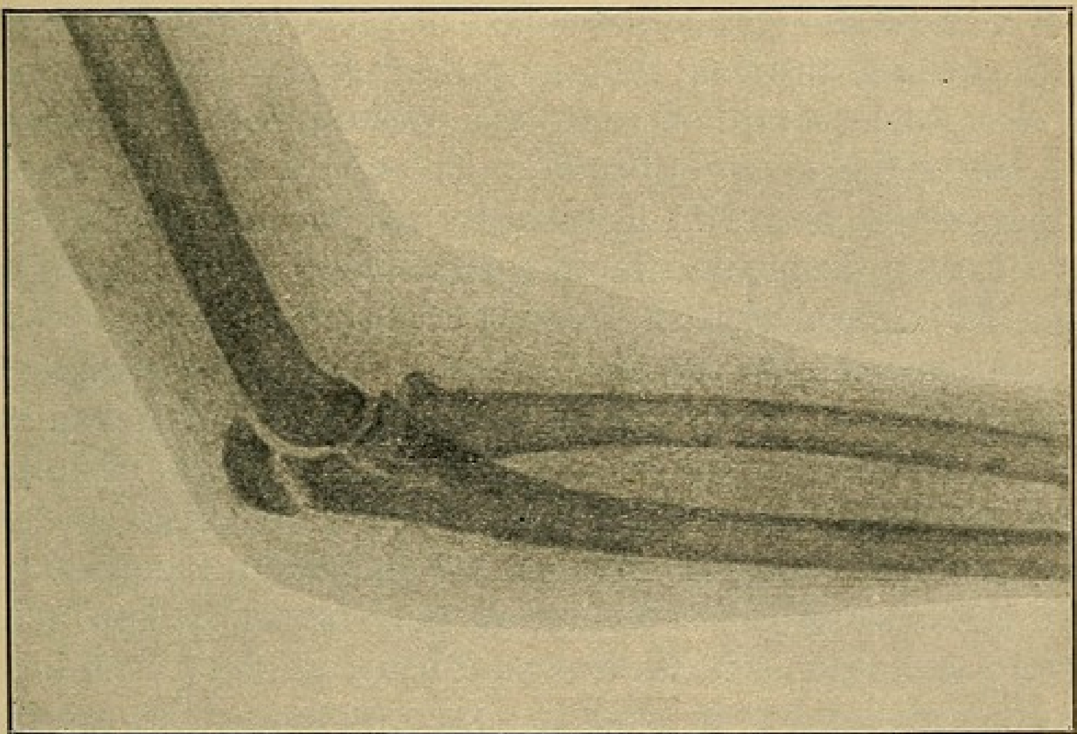

Fig. 90.—Skiagraph of a fracture of the olecranon. Reuter, a roofer, eighteen years old, fell on his elbow. Clinically the symptoms of fracture of the olecranon were found. In the skiagraph there is found, in addition to this fracture, a fissured fracture of the upper articular extremity of the ulna, separating the base of the coronoid process. Good recovery.

may be brought down far enough to elicit crepitation by moving it from side to side.

If the contact of the fragments has been maintained by the partial preservation of the periosteal investment and the lateral fibers of the tendon, the **prognosis** is very favorable for firm bony union without operation. If the fragments are separated, bony union is hardly to be expected. In most cases the bones become united by connective tissue. This is partly due to the fact that the fragments are not covered by periosteum on the side directed toward the joint, but possess a thick cartilaginous investment, while on the outer side they are covered with a dense layer of fibrous tissue (insertion of the triceps tendon). For this reason callus-formation is relatively slight.

Treatment.—Attention must first be directed to the factors which produce the separation ; hence the arm must be dressed in complete extension, because in this position the lower fragment is brought as near as possible to the upper, which is drawn upward by the triceps. It is often advisable to evacuate the blood from the joint by aspiration if it appears that the tension of the effusion contributes to the separation of the fragments. The upper fragment is then fixed as near the lower as possible. This fixation is best accomplished by means of narrow strips of adhesive plaster passed around the tip of the olecranon and attached to the flexor surface of the forearm on both sides. Primary suture of the fragments may be resorted to under certain conditions, if the surgeon has complete confidence in his asepsis ; but it is not to be recommended as a routine method, and should be attempted only when all the facilities of a clinic are at hand.

For the rest, the treatment is the same as that of any other articular fracture. It is important to begin massage of the triceps early ; and it may be pointed out in this connection that massage treatment of olecranon fractures, like that of fractures of the patella, has recently given very good results.

[In fractures of the olecranon, if the fragments are not fixed by suture the treatment should always be in forced extension. The arms should be placed on one long anterior splint extending from a point just below the insertion of the pectoralis major to beyond the finger-tips ; the upper fragment and triceps fixed and pulled down by adhesive straps. The non-operative treatment of fractures of the olecranon has many objections. In the first place, there is so much swelling and joint effusion that the full extension dressing cannot be applied for three or four days; in the second place, this position of full extension and absolute rest to the joint must be maintained for at least two weeks. At this time we are between two dangers: further prolonged fixation and extension is likely to result in more or less ankylosis of the elbow-joint, because in this fracture there is always some injury of the capsule and the synovial membrane, while, on the other hand, early passive motion and the change of the position to one of flexion are very apt to separate the fragments. For this reason many surgeons prefer the immediate operative treatment of this fracture. The operation is very simple and can, if necessary, be performed under cocain. The fragments can be perfectly approximated by a single silver wire. If there is much swelling, the operation can be delayed for a few days without harm. At the operation the most careful technic should be maintained. After the approximation of the fragments and closure of the wound without drainage, the arm can be fixed for a few days in full extension; after three or four days the arm can be placed in a position of flexion, which position can be increased every few days up to a position of almost complete flexion. From my own experience the operative treatment of this fracture has given better results not only for the union of the fragments, but for the function of the elbow-joint.—Ed.]

(b) **Fracture of the Coronoid Process** (Plate 42).—This fracture is rare and is usually observed in combination with backward dislocation of the forearm. It is only when the line of fracture runs through the base of the process that the fracture is acted on by the brachialis anticus, for this muscle is attached not to the tip, but at a point considerably below the tip of the process. [This anatomic point is frequently forgotten.—Ed.] The fracture in its uncomplicated form is produced chiefly by a force

PLATE 43.

Isolated Dislocation of the Head of the Radius with Fracture of the Upper Third of the Ulna; Marked Displacement of the Fragments.

Fig. 1.—Anatomic preparation of this typical injury. Left arm, outer view. The ulna presents marked displacement of the fragments. Above the olecranon the head of the radius is in plain view; between the two bones is the anconeus muscle, in contact with the anterior surface of the upper ulnar fragment. In front of the lower ulnar fragment the extensor carpi ulnaris has been exposed. Below the fragment the flexor digitorum profundis and flexor carpi ulnaris are to be seen.

Fig. 2.—The same injury in the living subject. Right arm, outer view. Copied from the photograph of an adult. (Author's observation.) The angular deformity of the ulna at the seat of fracture and the prominence formed by the head of the radius are very conspicuous.

Fig. 3.—Bony specimen of the same injury, also showing the left arm from without in the same position. This may help to explain figure 2. The head of the radius is displaced more anteriorly in this specimen, while in figure 2 the displacement is more external. [This is a very rare fracture.—ED.]

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that brings the lower end of the humerus against the anterior side of the ulna—that is, against the coronoid process.

The **symptoms** are those of a severe joint-injury. Owing to the thickness of the soft parts on the anterior aspect of the joint, the fragments cannot be directly palpated. By careful palpation, however, it is discovered that the bony prominences are intact. The olecranon sometimes projects a little backward (subluxation), but can be replaced by slight traction on the forearm. If the elbow is flexed at an obtuse angle, this displacement of the olecranon can be brought about by pushing the forearm backward and immediately reduced with the production of crepitus.

The **treatment** includes complete reduction by drawing the forearm forward, followed by fixation in acute-angled

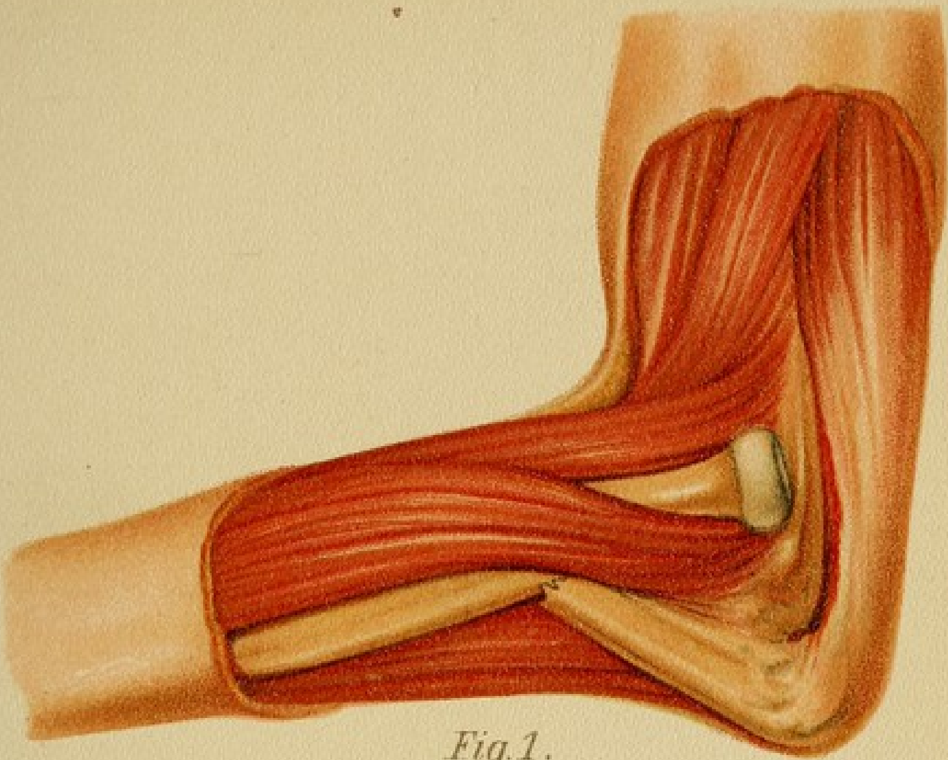

Fig. 1.

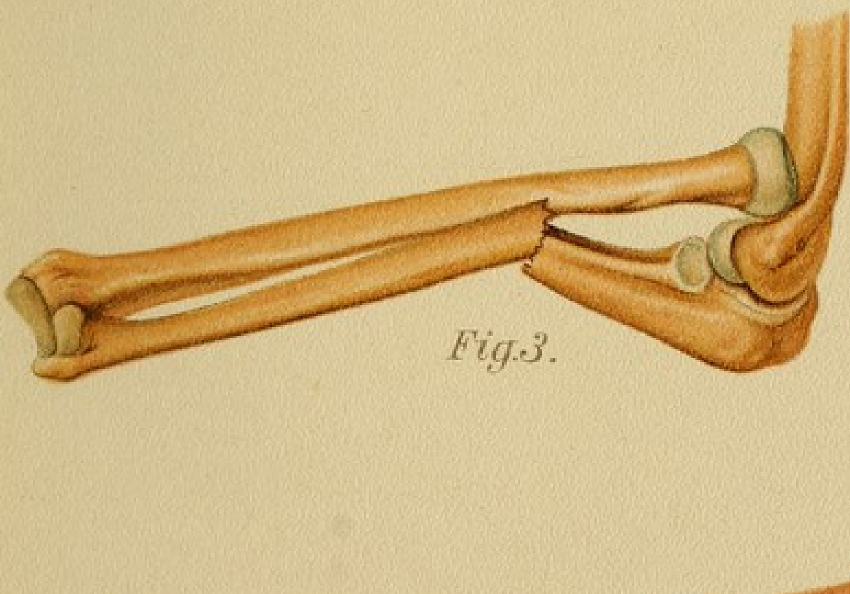

Fig. 3.

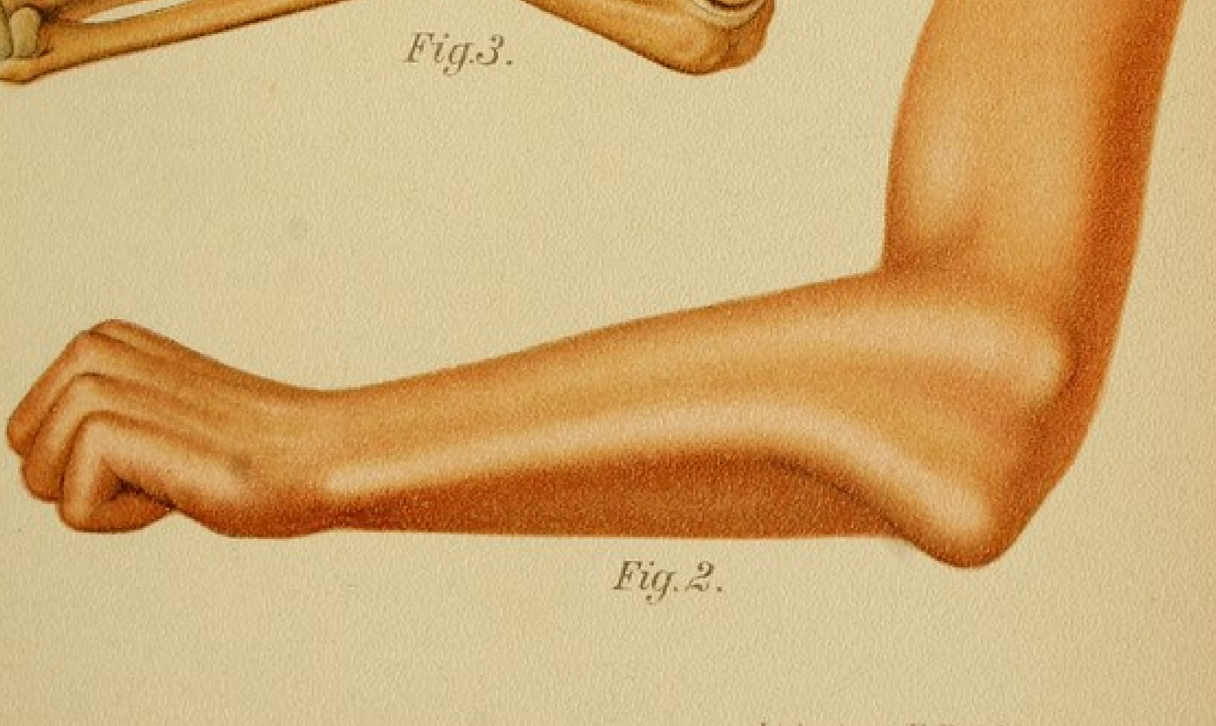

Fig. 2.

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flexion. In general, the management is the same as that of other joint fractures.

[This fracture is quite frequently overlooked. The callus-formation may be excessive, and later very much restrict flexion at the elbow-joint. Recently Carl Beck [1] has reported three very interesting cases illustrated with X-ray photographs. I have observed one case in which it was necessary to chisel away the callus about the coronoid process in order to restore joint function.[2]—ED.]

(c) **Fracture of the Upper Third of the Ulna with Dislocation of the Head of the Radius** (Plate 43).—Those portions of the limbs which contain two bones—*i. e.*, the forearm and leg—present certain typical alterations which are quite easy to explain. If both bones are broken, there may be any degree of deformity; the behavior of the two bones is identical. If, however, one bone only is broken, the remaining bone acts as a sort of splint, and no doubt prevents the production of a high degree of displacement. Hence, if on superficial examination there seems to be a fracture of only one bone, with marked displacement of the fragments, the other bone, as a rule, must have sustained a fracture or a dislocation. The observant practitioner will notice in his practice that fractures of the ulna with marked deformity are usually attended with dislocation of the head of the radius, and that fractures of the tibia are similarly combined with dislocation of the head of the fibula.

Fracture of the ulna in its upper third, with marked angular deformity and shortening of the bones, combined with dislocation of the head of the radius which is usually anterior, constitutes a typical injury. The illustrations on Plate 43 are very characteristic, and faithfully reproduce the conditions that I have often had occasion to observe in the living subject. The **symptoms** of the fracture are

[1] Deut. Zeitschr. f. Chir., Bd. LX, p. 193, 1901.

[2] For a review of the recent literature on fracture of the coronoid process see Progressive Medicine, for December, 1902.

very apparent, and the **diagnosis** never presents any difficulties. On the other hand, the injury at the elbow-joint consisting in dislocation of the radius is often overlooked; by careful study of the introductory remarks this error

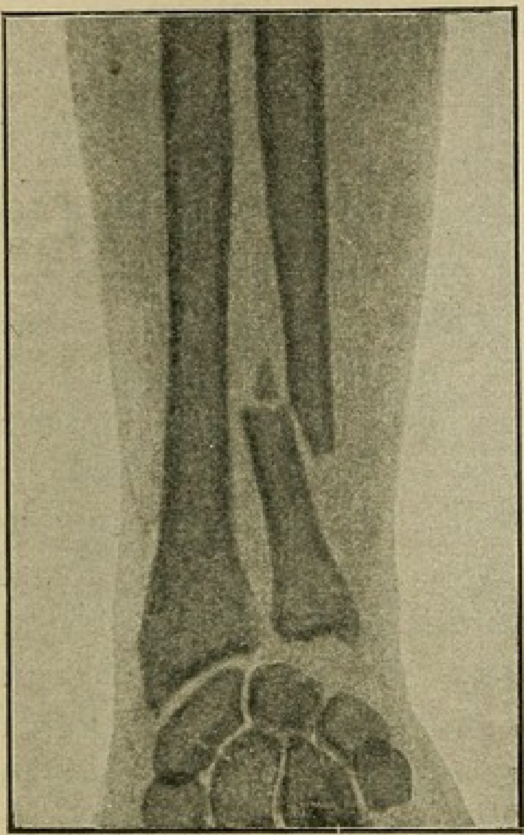

Fig. 91 *a*.

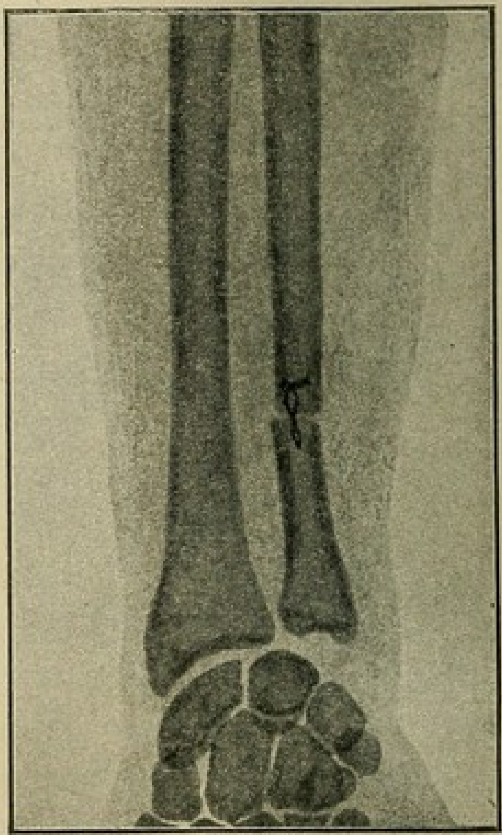

Fig. 91 *b*.

Figs. 91 *a* and 91 *b*.—Fracture of the ulna. Operative reduction. Bone suture. Skiagraph. Späthmann, forty-nine years of age, fell from a wagon and was run over. Fracture of the lower half of the ulna with marked displacement of the fragments. Vain attempts at reduction under anesthesia; the deformity persisted (Fig. 91 *a*), hence operative exposure, replacement, and bone suture (Fig. 91 *b*). Good recovery. [This illustration is a good example of a marked separation of the fragments when only one bone in the forearm is broken.—Ed.]

may be avoided. The displacement of the fragment is so great, and the consequent shortening of the ulna so marked, that the radius must necessarily be either fractured or dislocated. If the surgeon will examine the elbow-joint, he will miss the head of the radius from its normal position, and find it either on the external condyle or on the anterior surface of the joint. The **prognosis** is favorable, providing the correct diagnosis has been made early, for reduction, as a rule, presents no particular difficulties if it is performed under anesthesia. The position of the fragments is corrected by vigorous traction on the forearm, after which the forearm is flexed and direct pressure applied to the head of the radius. The head of the radius sometimes manifests a tendency to repeated luxation, especially subluxation forward. It is, therefore, wise to dress the limb with the forearm at least at a right angle and in supination, and to add a soft pad in the bend of the elbow to produce moderate pressure on the head of the radius. [The position of acute flexion I found most satisfactory in these cases.—Ed.]

In old cases of this kind osteotomy at the seat of fracture, and arthrotomy to effect reduction of the head of the radius, or resection of that bony prominence may be required.

(d) **Fracture of the Shaft of the Ulna.**—When the arm is put forth to guard against a fall, so that the forearm strikes the ground with the elbow-joint flexed ; or if the arm is raised to ward off a blow, the bone that suffers most is the ulna, which is often broken in one of these two ways. Such fractures are direct, and may be correctly termed "parrying fractures." The fracture rarely results from indirect violence.

The **diagnosis** is readily made, owing to the superficial position of the ulna, which enables one to determine without difficulty the presence of abnormal mobility and crepitation. **Treatment** is the same as that of fracture of both bones of the forearm; if the radius is intact, the dislocation is rarely very marked.

(e) **Fracture of the Styloid Process of the Ulna.**—This is rare by itself and easily detected by careful palpation. Recovery is apt to leave a false joint. For further discussion of this fracture see the section on Typical Fracture of the Lower Radial Epiphysis.

(C) Fractures of the Radius

(a) **Fracture of the Head of the Radius.**—The **symptoms** are obviously those of an articular injury and the accident is without doubt often regarded as simple contusion or distortion of the joint. The fracture is completely intra-articular, and may be complete or incomplete (fissure-fracture, infraction). In the latter case the **diagnosis** is, of course, very difficult, and cannot be positively made. Complete fractures may be recognizable if the head of the radius is movable by itself and crepitation is produced, but this is not always the case. It often happens that the movement of the head during supination and pronation is not interfered with. Pain is of course localized to the region of the head of the radius.

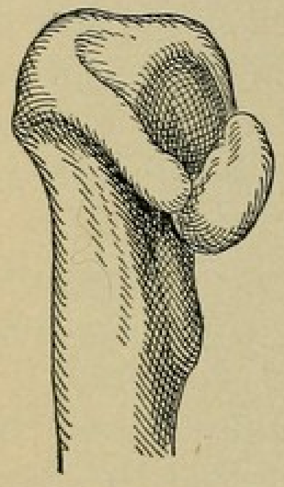

Fig. 92.

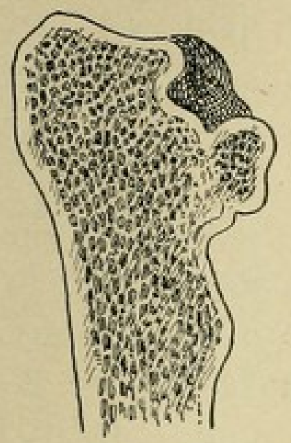

Fig. 93.

Figs. 92 and 93.—Fracture of the head of the radius in a woman twenty-eight years old, produced by a fall on the outstretched hand. The elbow-joint forms an obtuse angle. Pronation difficult. The head of the radius projects. Resection. Recovery (1889). The fragment was united to the bone in a position of dislocation.

The fracture may be produced by direct, but more frequently by indirect, violence, such as a fall on the hand with the elbow in extension or flexion, a piece being broken out of the head of the radius at the eminentia capitata—so-called chisel-fracture.

Treatment.—As we have no means of directly influencing the position of the fragment, recovery often leaves considerable deformity. In the dressing, the elbow- and wrist-joints are of course to be placed at rest, and direct pressure may be applied to the head of the radius. But in spite of every form of treatment indicated for joint-fractures, considerable stiffness of the elbow-joint may remain, and later make it necessary to resect the head of the radius. The radial nerve is sometimes injured in this fracture.

Fracture of the neck of the radius—that is, below the head—is very rare. The chief symptom is a failure of the head to move with the bone in pronation and supination; a bony prominence may be felt at the seat of fracture. The treatment is the same as for the last variety.

Traumatic epiphyseal separation at the upper end of the radius is extremely rare, and is of course only observed in children (see Plate 41, Fig. 3).

(b) **Fracture of the Shaft of the Radius.**—The rarity of fracture of the shaft of the radius alone forms a striking contrast to the frequency of the corresponding accidents in the ulna. The fracture may be direct or indirect. The *symptoms* are obvious and the *diagnosis* presents no difficulties. For the deformity and *treatment*, compare the paragraph on Fractures of the Forearm (page 196).

(c) **Fracture of the Lower Radial Epiphysis** (**Colles' Fracture**) (Plates 44, 45, 46, and 47).—This is a very common fracture and of the greatest practical importance. It is justly called a typical one, because the symptoms are exceedingly characteristic and, with slight variations, appear constantly in every case. Our knowledge of the most important factors in its production has recently been greatly enriched through the agency of the Röntgen rays.

Fractures of the lower end of the radius include the following:

1. *True epiphyseal separation* (see under d, on page 226).

2. *Incomplete fractures* or *fissured fractures*, so-called typical contusions. They rarely occur by themselves, being usually combined with fracture.

3. *Complete fractures*, which may be either *transverse* or

PLATE 44.

Typical Fracture of the Lower Radial Epiphysis.—Fig. 1.—Anatomic specimen showing a longitudinal section of the left arm with fracture of the lower radial epiphysis. The line of section goes through the radius and carpus, the third metacarpal bone, and the phalanges of the middle finger. The typical displacement of the fragment is seen; the axis of the radius and hand is interrupted by small, obliquely placed fragments, and simulates the appearance of a bayonet. The end of the upper fragment forms a prominence on the volar surface, corresponding to which an angular depression is found on the dorsal surface.

Fig. 2.—The same fracture in the living subject. Copied from a photograph. Left arm, inner view. The typical deformity is at once recognized, consisting of a prominence on the volar surface formed by the lower extremity of the bones of the forearm.

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oblique. A transverse fracture involves the entire width and thickness of the bone, and therefore belongs to the class of supracondylar fractures. The line of fracture is usually found about 1.5 to 2 cm. above the lower articular surface, at the point where the compact bone of the diaphysis is replaced by the abundant spongy outgrowth of the articular extremity. The boundary-line between these two sections, for anatomic and mechanical reasons, is very liable to fracture. The length of the epiphyseal fragment varies between 5 and 40 mm. The line of fracture is usually nearer the articular surface on one side than on the other, depending on the mode of production of the fracture. Multiple fractures at this point are much more common than was formerly supposed, especially the form known as a Y-fracture, extending into the joint.

In addition to these transverse, or somewhat oblique incomplete fractures, we have oblique fractures which do not involve the entire width and thickness of the bone. A fragment of variable size is split off from the styloid process of the radius, usually together with the dorsal border of the articular surface. These fractures are rarer than was formerly supposed.

Tab. 44.

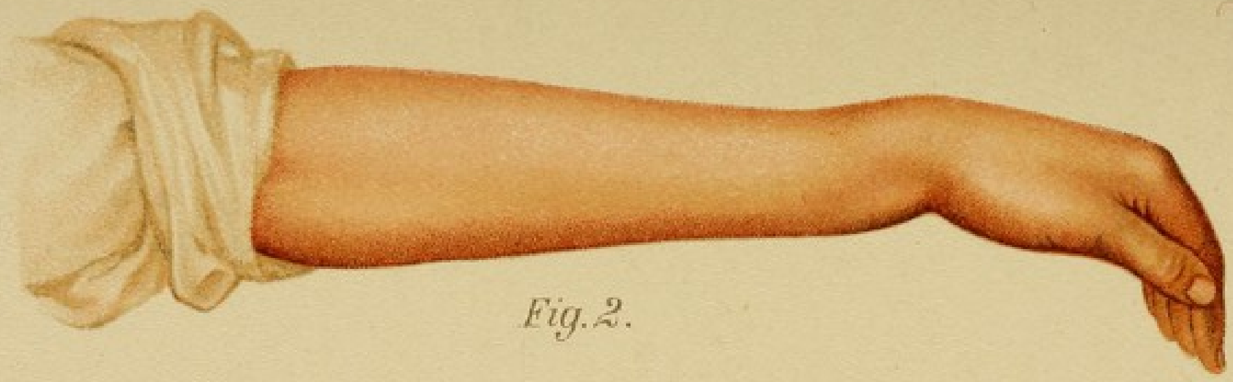

Fig. 2.

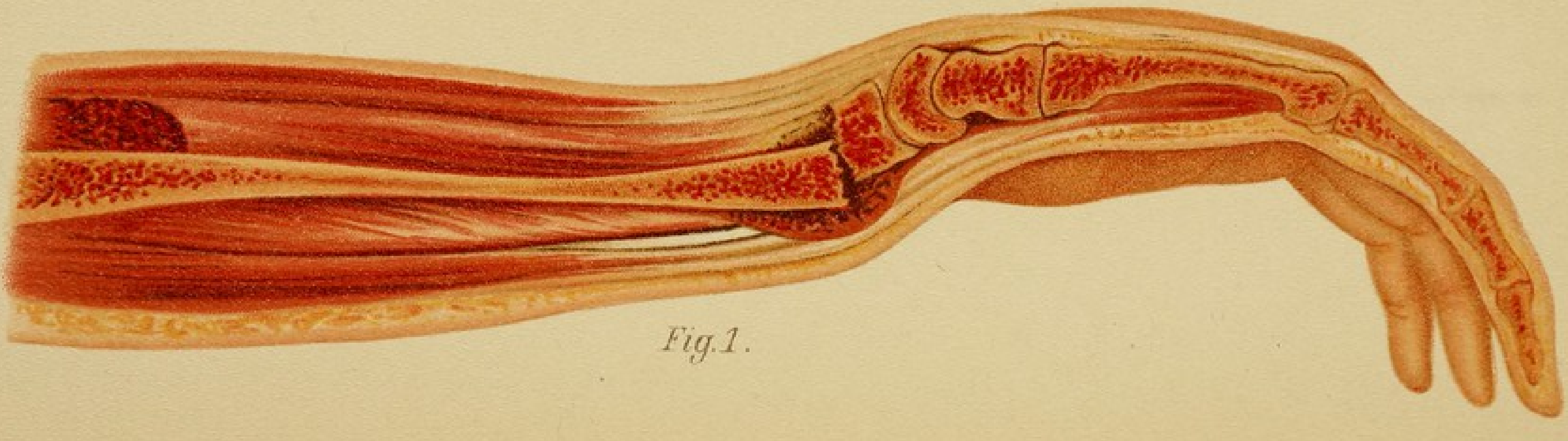

Fig. 1.

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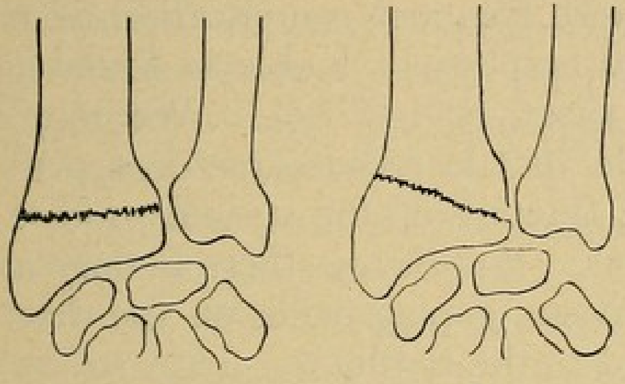
Oblique fractures running from the dorsum downward into the articular surface also occur; the bones exhibit an obstinate tendency to deformity and the diagnosis is less favorable on account of the direct injury to the joint. Investigations were recently made in Professor Oberst's hos-



a. b.

Fig. 94 a and b.—Common forms of complete transverse or oblique fracture.

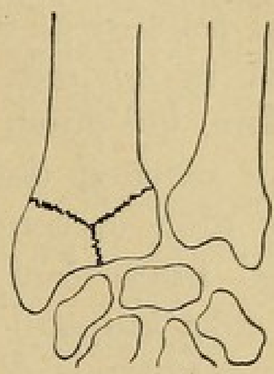
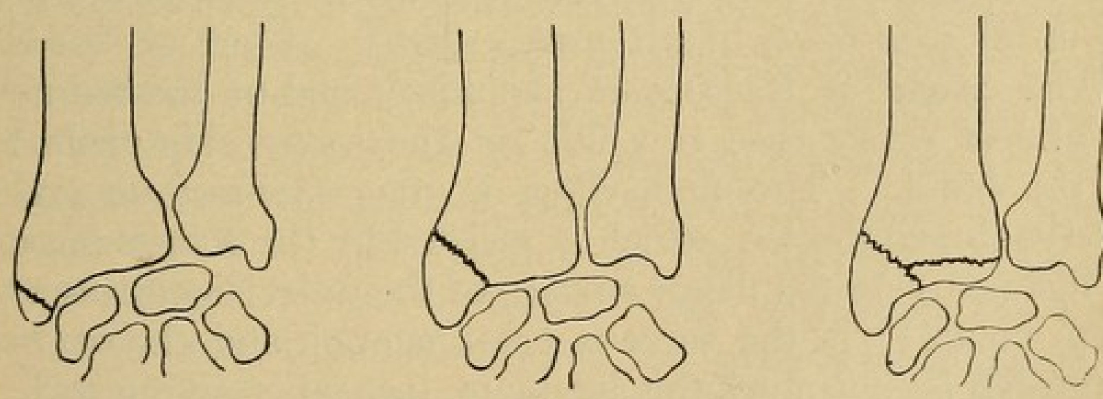


Fig. 95.—Multiple fracture (Y-fracture); a comparatively common form.



a. b. c.

Fig. 96 a, b, and c.—Partial fractures of the lower articular extremity of the radius.

pital by Dr. Kahleyss, and published in the Deutsche Zeitschr. f. Chir., vol. XLV, page 531. The results of these investigations are peculiarly interesting because the fractures were carefully examined with the Röntgen rays. Figures 94, 95, and 96 represent the varieties most frequently observed by Kahleyss among 60 cases.

[The most recent and elaborate contribution to fractures of the lower end of the radius, with illustrations and literature, is by Rosenbach, from the polyclinic of Göttingen.[1] —Ed.]

Involvement of the lower end of the ulna in these fractures is very common. Fracture of the styloid process of the ulna constitutes the most frequent complication of a typical fracture of the radial epiphysis; Kahleyss found it present in 47 out of 60 cases, or in 78%. We may, therefore, lay down the rule that in radius fractures presenting marked deformity, fracture of the styloid process of the ulna is rarely absent. Sometimes there is only a fissured fracture of the process, gaping wide on the free ulnar side, but still attached to the radius.

[In numerous X-ray negatives and illustrations of the literature of fractures of the lower end of the radius, I have observed but rarely a fracture of the lower end of the ulna. Scudder also considers the lesion rare, but states that a fracture of the styloid process of the ulna occurs in about 50% to 65% of all cases.—Ed.]

The **cause** of fracture of the lower end of the radius in almost every case is a fall on the volar side (palm) of the hand. The first effect is overextension or excessive dorsal flexion, which is resisted by the robust mass of ligaments on the flexor surface of the wrist (ligamentum carpi volare); if the force is great enough and the overextension is continued, this ligament, instead of giving way, transmits the strain to the lower end of the radius with the production of a fracture at the spot referred to. It follows from this explanation that the fracture is one by muscular action, but at the same time the weight of the falling body and the resistance of the ground together produce a direct blow on the end of the radius; and when the hand is overextended, the upper row of carpal bones is forced against the dorsal, overhanging edge of the lower end of the

[1] Archiv f. klin. Chir., Bd. LXVI, 1902, p. 993.

radius: hence the fracture is also produced by compression of the bone in its long axis. Whether the fracture be due to muscular action or to a direct blow, and it is probable that both factors are present in most cases, the lower fragment is always displaced toward the dorsum.

If the fracture has been produced by a fall on the dorsum of the hand,—a mechanism which, although rare, has been observed,—the peripheral fragment is usually displaced toward the volar, instead of toward the dorsal, surface of the wrist.

The **symptoms** of this fracture must be determined by accurate examination, beginning with a most careful inspection. The surgeon sits directly opposite the patient, and the latter, after baring his forearms, places both hands together in a symmetric posture.

If there is a fracture, inspection from in front will yield the following result: The styloid process of the ulna is more prominent than on the sound side (see Plate 44, Figs. 1 and 2); in the carpal region the hand is displaced toward the radius; if the axis is marked along the middle of the forearm on each side, the line on the sound side will coincide approximately with the median line of the middle finger, but on the injured side it will be found a little nearer the ulna. The region of the styloid processes appears broader than normal. These symptoms are all due to the radial displacement of the peripheral fragment.

The limb is next inspected from the side, preferably the radial side. In a normal limb the lower end of the forearm in pronation presents, on the radial side, a gentle curve, convex on the dorsal and concave on the volar side. In a broken arm the curve usually presents the opposite conditions; there is an abnormal prominence on the flexor surface and a slight angular depression on the dorsal surface. If the longitudinal axis of the forearm is traced on the skin with a blue pencil, the line on the normal side will cross the carpal region if the arm is held straight, but on the injured side this line is interrupted at a point cor-

PLATE 45.

Typical Fracture of the Lower End of the Radius (Colles' Fracture).—Fig. 1.—Anatomic specimen. Section of an old typical fracture of the lower end of the radius, united with considerable deformity. Left radius seen from the radial side of the pronated hand. (See Plate 44.) Corresponding to the seat of fracture, a prominence is seen on the volar side and an angular depression on the dorsal side. There has been a rearrangement of the trabeculæ in the spongy bone; the original cortex (dorsal) is barely made out as a narrow zone within the spongy bone. The lower articular surface, as a result of the displacement, forms an acute angle with the longitudinal axis of the shaft of the radius.

Fig. 2.—This specimen is analogous to that shown in figure 1; also a section of the left radius. The deformity is somewhat less marked and the prominences, which are useless from a mechanical standpoint, have evidently become absorbed in the course of years. The remains of old compact bone are recognized as a spongy tract. The articular surface forms an oblique angle with the longitudinal axis of the bone. The specimen is a sagittal section of the radius shown in figure 5, Plate 45.

Fig. 3.—The fracture under discussion was produced artificially and the specimen then dissected. Right hand, dorsal view. We see the displacement of the lower epiphyseal fragment and of the entire hand toward the radius, causing an abnormal prominence of the styloid process of the ulna.

Fig. 4.—Typical fracture of the lower radial epiphysis in the living subject. Dorsal surface of the right hand. The radial displacement of the hand and the prominence of the styloid process of the ulna are well shown.

Fig. 5.—Bones from the same forearm (left), in pronation; seen from the volar surface. Typical fracture of the radius (compare with the section of this radius in Fig. 2). The ulna presents a high degree of arthritis deformans (not the bony tuberosities which are eburnated and show smooth surfaces) at the articular circumference (lower radio-ulnar articulation); it is possible that the ulna was also injured at this place in this fracture.

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responding to the radial epiphysis where the line forms a shoulder. When the hand is held straight, this line

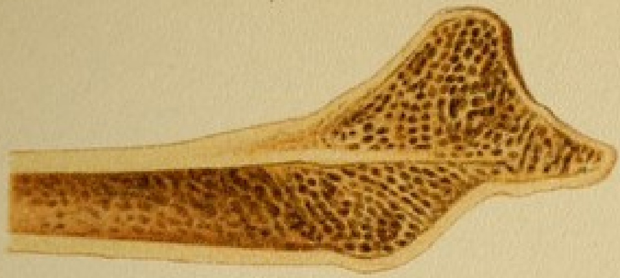

Fig. 1.

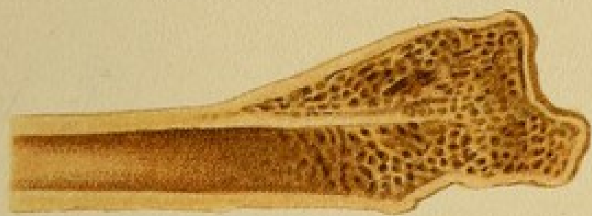

Fig. 2.

Fig. 5.

Fig. 3.

Fig. 4.

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is bent in the shape of a bayonet and constitutes the typical symptom of this fracture. This deformity is best explained by assuming a continued action of the force at the time of injury. As soon as the fracture has been produced, the weight of the falling body must continue to exert its influence until the end of the upper fragment touches the ground. Muscular action may have something to do with the production of this typical deformity, but the chief cause lies in the external force itself. The epiphyseal fragment is displaced upward and comes into partial supination, while the shaft of the radius is pronated. The connection between the lower ends of the radius and the ulna exerts some influence on the character of the deformity, which is produced in the following manner: As long as the ligamentous connection between the two bones remains intact the lower end of the ulna approximately forms the pivot around which the radius moves; but it has already been stated that the styloid process of the ulna is very often split off, especially by a force acting in the direction of the radius.

The other symptoms of fracture are not always very evident. Abnormal mobility is, as a rule, difficult to demonstrate. To elicit it, the surgeon must seize the epiphyseal fragment firmly with his fingers and brace the injured arm against his own body; it is, however, unnecessary to establish the presence of this symptom. The same is true of crepitation, though a characteristic cracking and rubbing is quite often felt. The finding of a painful point is much more important. If the articular region is carefully palpated on the radial side, the line of the joint and the styloid process in the radius will be free from pain in a transverse fracture, while 1 to 2 cm. above that point typical fracture-pain will be elicited. The results obtained by inspection are thus confirmed by palpation. The surgeon feels the abnormal bony prominence on the volar surface and the angular depression of the radius on the dorsal surface.

PLATES 46 and 47.

Differential Diagnosis of Fractures and Dislocations of the Wrist.—Figs. 1 and 1 *a*.—Infraction or greenstick fracture of both bones of the forearm, near their extremities. Marked dorsal angular deformity of the peripheral fragment. (Hans Müller, five years, Greifswald, 1894.)

Figs. 2 and 2 *a*.—Fracture of the lower end of the radius, seen from the side. Typical deformity. (Frau Langhof, Greifswald, 1887.) (See Plate 44, Fig. 2.)

Figs. 3 and 3 *a*.—Dorsal dislocation of the hand on the radio-carpal articulation. Artificial.

Figs. 4 and 4 *a*.—Dorsal dislocation of the hand at the carpo-metacarpal joints of the four fingers. Seen from the dorso-ulnar direction. (Artificial.)

The **diagnosis** is made, as a rule, by accurate inspection and comparison with the sound side; it is important for the differential diagnosis to determine the position of the styloid processes in relation to the painful point or seat of fracture. There can never be any difficulty in distinguishing between fracture and the exceedingly rare dislocations of the hand. On the other hand, it may be difficult, when there is much swelling and the pain is great, to distinguish an infraction or impacted fracture from a so-called typical contusion of the lower radial epiphysis. In doubtful cases the question may eventually have to be decided by means of the Röntgen rays.

The **prognosis** of this fracture depends on the treatment. If it is correctly carried out, complete functional recovery is possible. I have in my possession a specimen of a recently united fracture from an elderly woman who died of pneumonia soon after the bone had healed. In this specimen the union is bony, and not the slightest degree of deformity can be detected.

Treatment.—The fracture is reduced by direct pressure while the hand is in forced flexion, and by traction. It is best performed under anesthesia. It is desirable to have

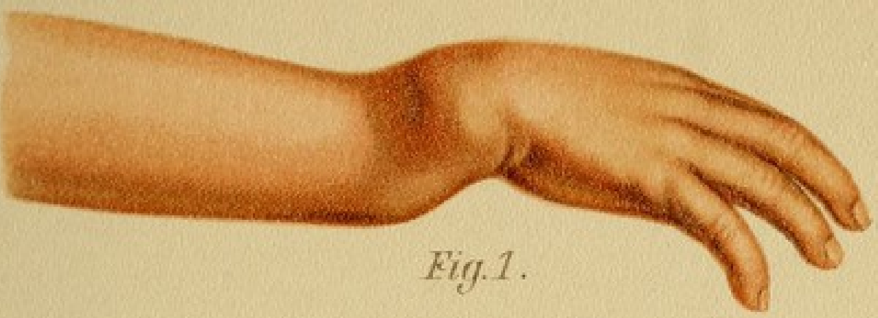

Fig. 1.

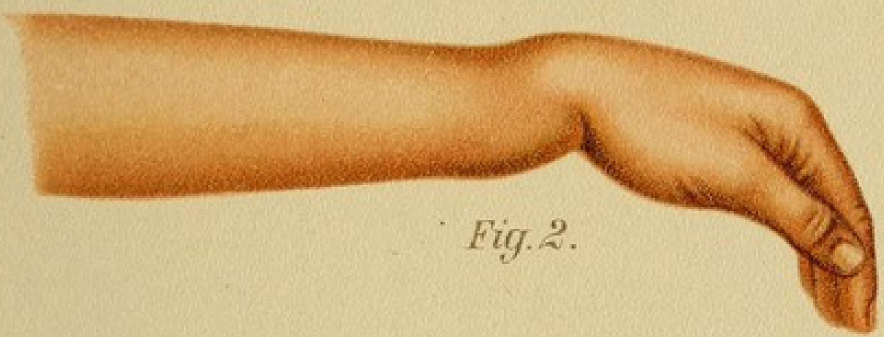

Fig. 2.

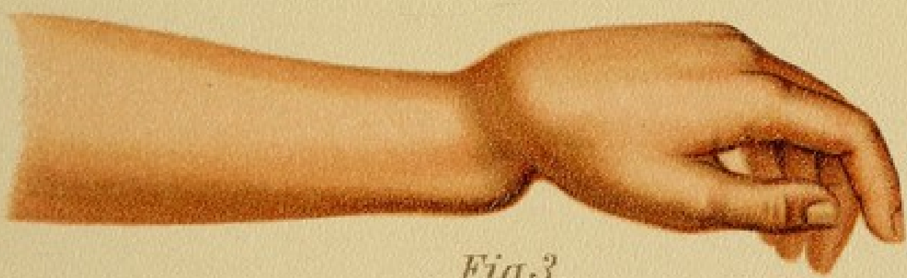

Fig. 3.

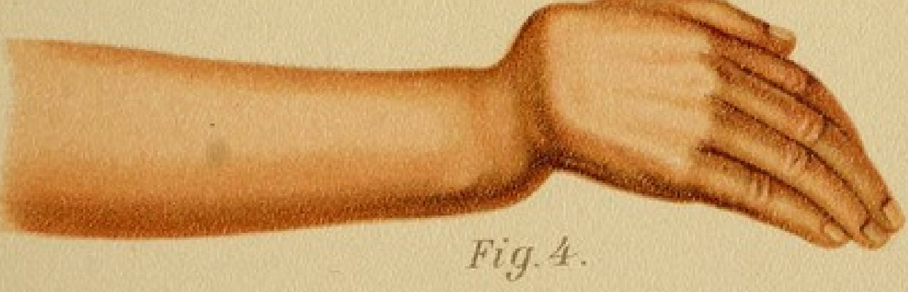

Fig. 4.

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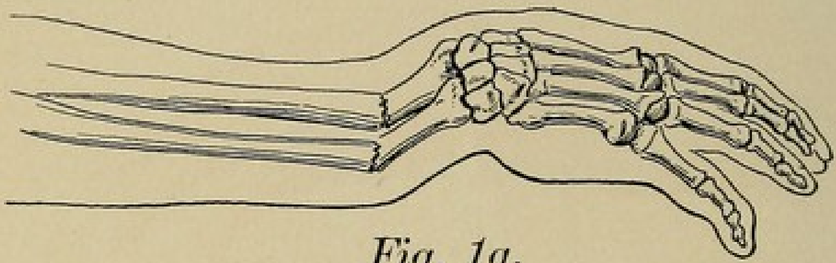


Fig. 1a.

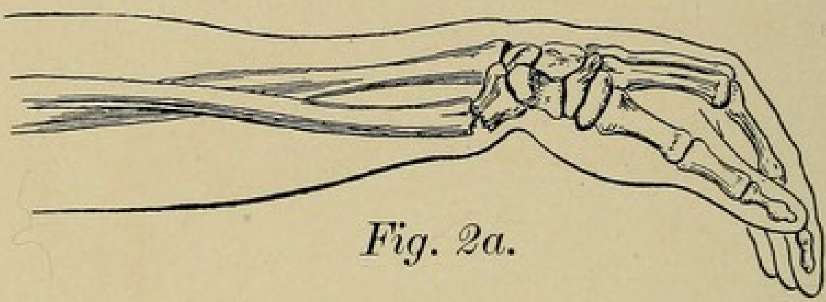


Fig. 2a.

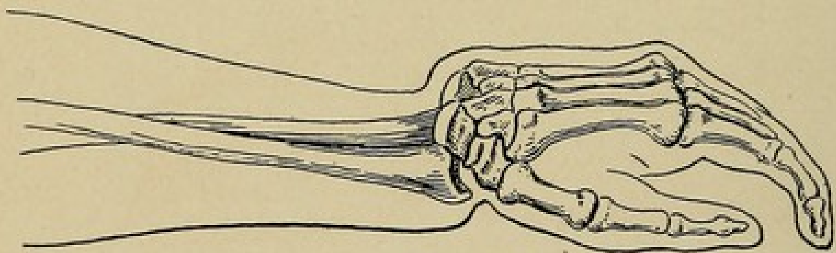


Fig. 3a.

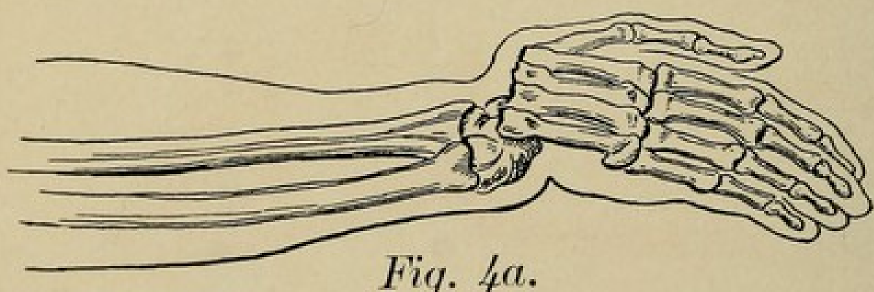


Fig. 4a.

two assistants, especially while the dressing is applied. One of the assistants takes the thumb in one hand and the other fingers in the other, as shown in figure 98. This enables the surgeon to apply the dressing in the proper way. If it is desired to protect the side of the little finger

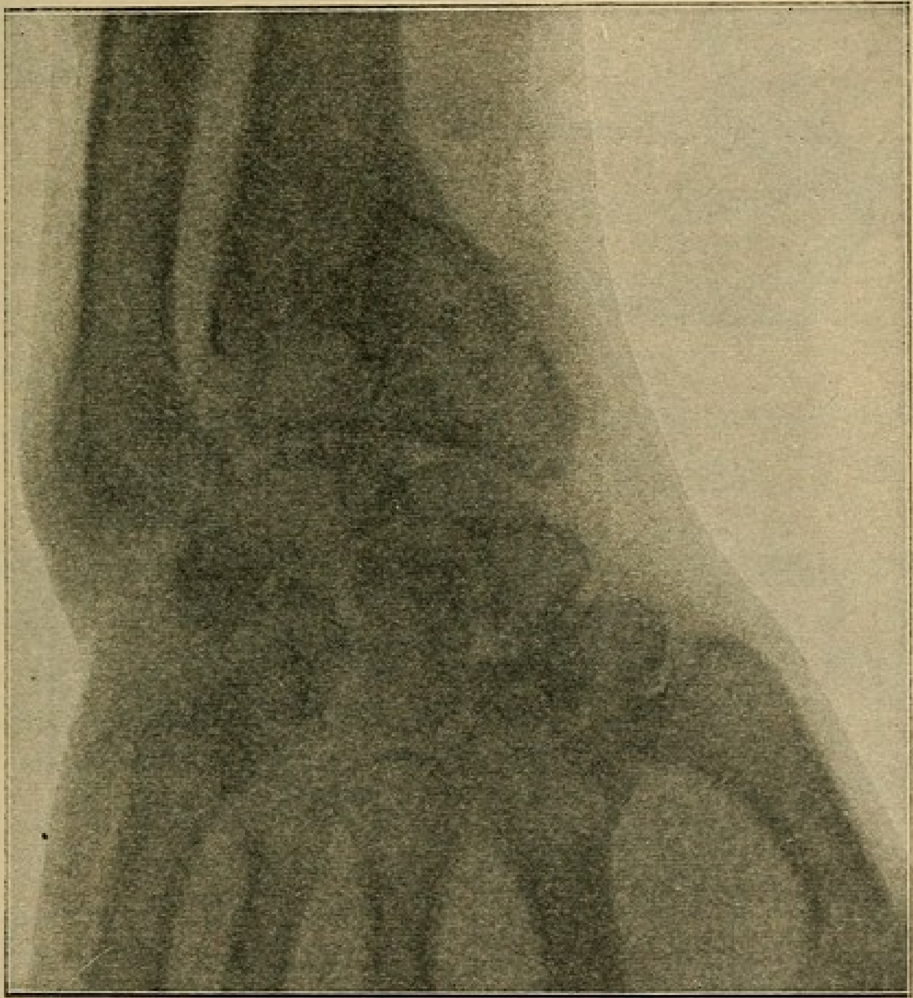


Fig. 97.—Old fracture of the radius with pronounced and typical displacement. Röntgen-ray picture. (Friedrich Schütt, forty-eight years.)

from the pressure of the bandage, it may be left out, as shown in figure 99, so as to prevent the bandage from becoming too tight at this point. If the fracture is well reduced, there is, as a rule, no tendency for the deformity to recur.

[In reducing a fracture of the lower end of the radius

I have found, both in recent and old injuries, that forced overextension of the hand and lower fragment of the radius

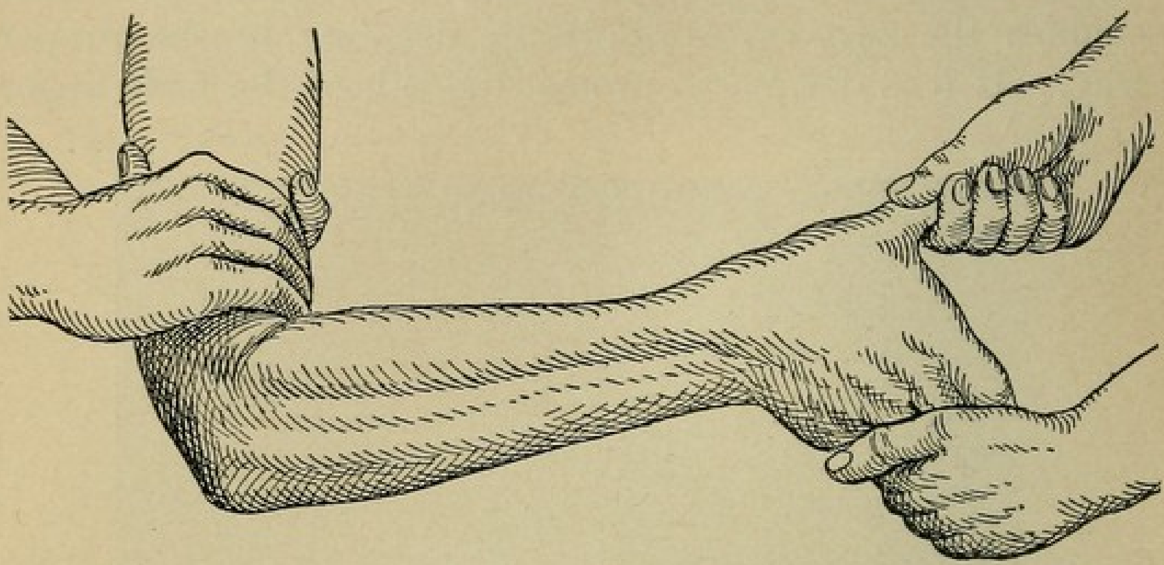


Fig. 98.—Showing assistance in dressing a typical fracture of the lower end of the radius (see Fig. 99).

breaks up the impaction, and then by the forced flexion and direct pressure, associated with full traction, the fragment is more easily brought to the correct position. It is a very important point (one frequently neglected) that the impactions of the fragments should be completely broken up by this manipulation before the attempt is made at reduction.—Ed.]

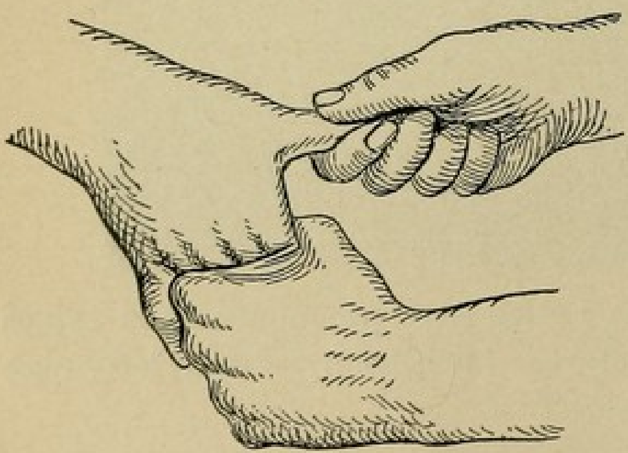


Fig. 99.—Showing another method of seizing the fingers for the purpose of applying extension (see Fig. 98).

The dressing should include the entire forearm, the wrist-joint, and the metacarpal region; the elbow-joint need not be, and the fingers must not be fixed. Forced inaction of the fingers in many persons is apt to produce a troublesome rigidity that can only be removed by painful treatment with massage and passive movements, and may even persist to a greater or less extent.

As the short lower fragment can only be influenced through the hand, the latter must be so placed as to insure correct position of the lower fragment. The hand must be flexed with a slight deviation toward the ulnar side; this will prevent recurrence of the deformity. In effecting reduction and applying the dressing it is not to be forgotten that the hand, including the fragment, must be dis-

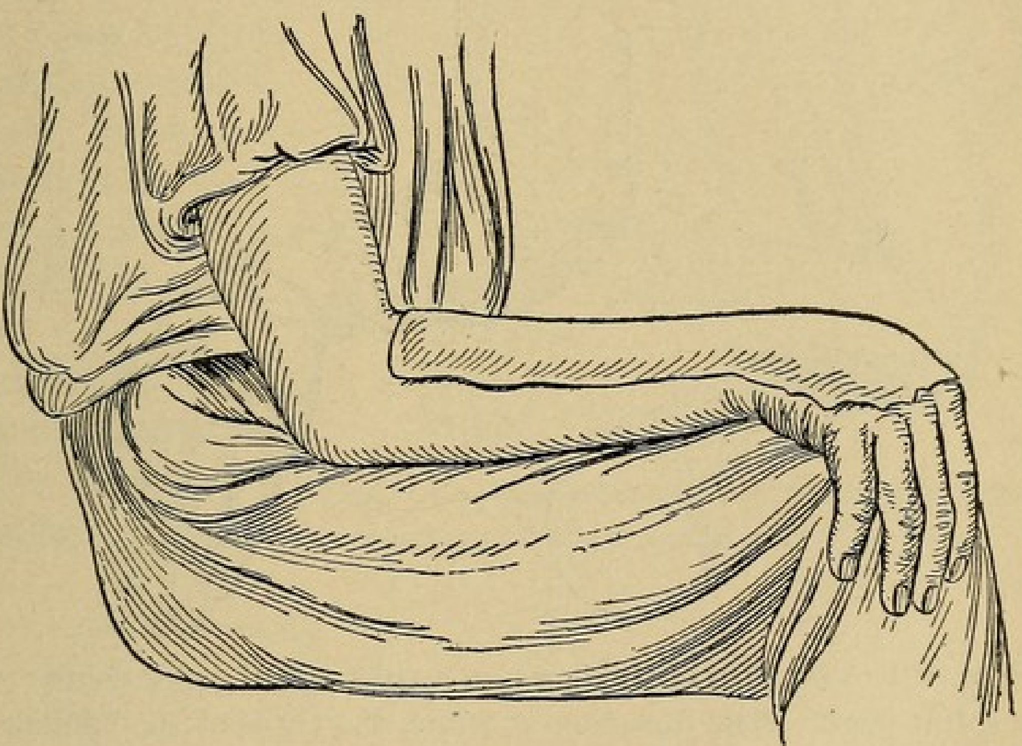


Fig. 100.—Showing the application of a plaster-of-Paris splint. After reduction has been effected, the arm is placed on the patient's thigh, the flexed wrist lying on the knee. (Beely's method.)

placed toward the ulna as a whole, otherwise an unsightly prominence of the styloid process of the ulna will remain.

Whether these indications are met by one method or by another is of no importance. A Beely's plaster-of-Paris splint (Fig. 100) is very useful, or a small curved splint, after Schede (Fig. 101), which fixes the hand in the desired position may be used. In improvising a splint from a piece of pasteboard or board, ulnar flexion of the hand can be effected by giving the splint the well-known pistol shape. A soft pad should be placed under the end of the upper fragment of the radius so as to push it upward; the epiphyseal fragment, being left unsupported, tends to drop by its own weight. Besides similar dressings, which all attain the same object in somewhat different ways (Braatz, Kölliker, and others), a method has recently been proposed by Storp in place of the use of a simple sling, as recommended by Petersen and earlier surgeons. I am

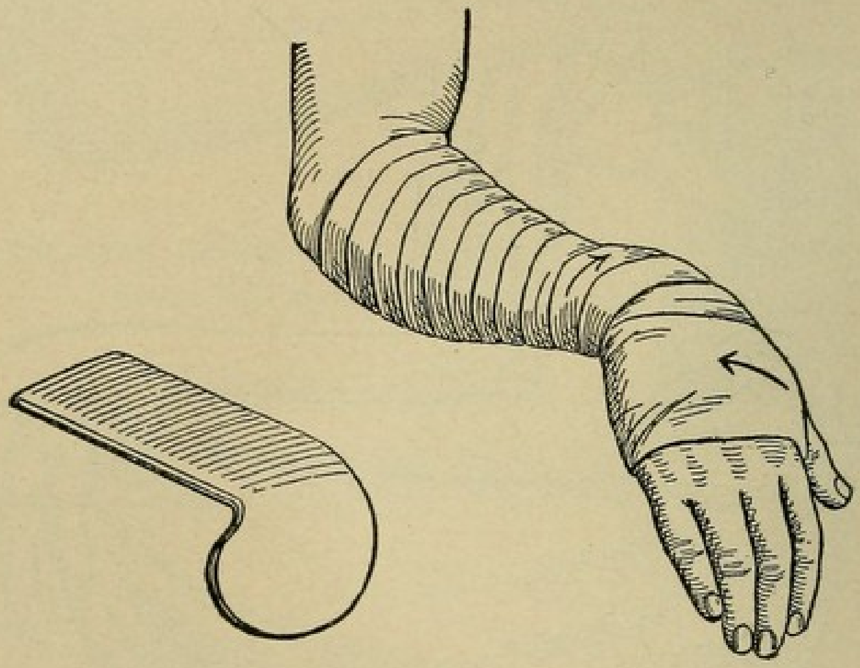


Fig. 101.—Position of the hand on a volar splint, after Schede, with the splint itself. The direction in which the turns of the bandage are best applied is indicated by the arrows.

tempted to propose the name "suspension cuff-dressing" (Fig. 102). After repeated trials I am convinced of its great value.

After the fracture has been fully reduced, if necessary under anesthesia, the hand is brought into extreme ulnar-volar flexion; the lower extremity of the forearm, as far as the styloid processes, is then wrapped with several turns of a strip of adhesive plaster about 10 cm. wide. By means of another strip a loose dorsal fold is added to which the sling is attached. I arrange this fold so as to bring it over the middle of the radius on the dorsal side, so that when the hand is suspended, it hangs down in ulnar-volar flexion. Storp has used this method in 108 cases and found it successful in all but 4, in which the deformity returned. In such cases a splint is indispensable. I have used the method so far in 5 cases and found it exceedingly useful.

In severe cases it is advisable to fix the arm in supination. For this

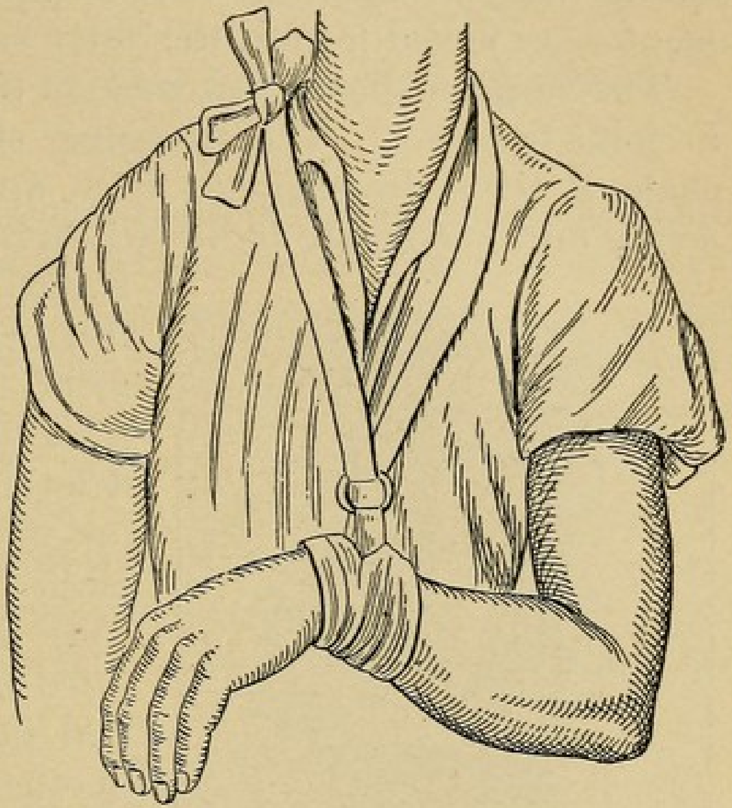


Fig. 102.—Suspensory cuff-dressing of a typical fracture of the lower end of the radius.

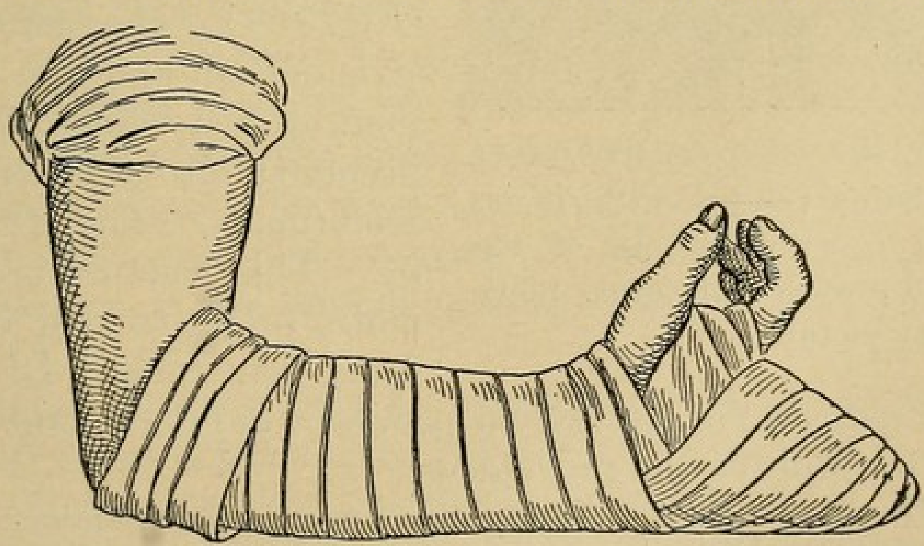


Fig. 103.—Roser's method, with the arm in full supination. The patient looks into the hollow of his hand.

purpose the best dressing is that devised by Roser (Fig. 103), which appears to me somewhat bulky and circumstantial—for most cases of this fracture can just as well be dressed in pronation. The pad is so arranged on a splint that the wrist and radial epiphysis—*i. e.*, the fragment—are flexed toward the volar surface (Fig. 103).

The surgeon should never forget that he is dealing with a joint-fracture. The dressing should be frequently changed (if a dressing has been applied); massage and active movements are indicated early. It is undoubtedly better to get a well-united fracture with good movement, even with some deformity, than one without deformity, but with serious loss of function at the wrist-joint.

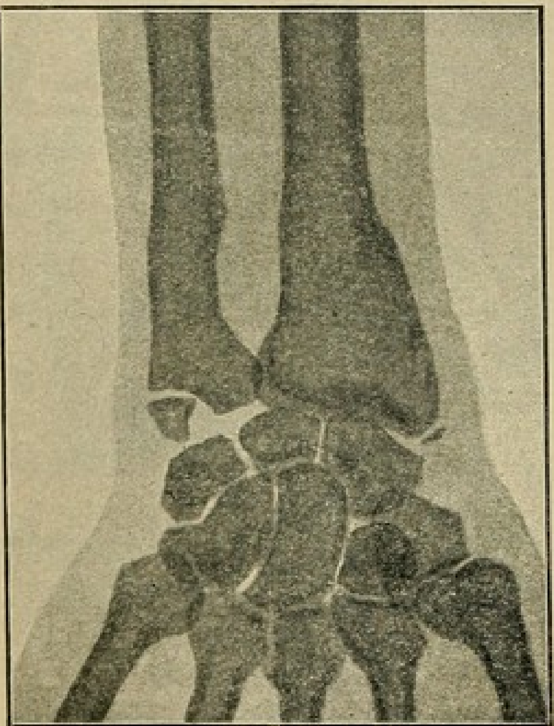


Fig. 104.—Typical fracture of the radius (united without deformity), with fracture of the styloid process of the ulna. Röntgen-ray picture.

If the fracture is complicated by fracture of the styloid process of the ulna,—in other words, if both bones of the forearm are broken at their lower extremity (Fig. 104),—the radio-ulnar articulation and the wrist-joint are very apt to become involved also (see Arthritis Deformans, Plate 45, Fig. 5). This fracture is in the main to be treated on the same principles. In a few cases resection of the styloid process was later found necessary to improve the movement.

[In the original German the term *Colles' fracture* is not used. This name, however, is too intimately connected with fractures of the lower end of the radius to be omitted from any English text.—Ed.]

(d) **True epiphyseal separation of the lower end of the radius** is comparatively frequent in youthful individuals. The symptoms and treatment are exactly the same as in typical fracture of the lower end of the radius in adults (see Plate 51, Fig. 5).

(D) Dislocation at the Lower Articulation of the Ulna

In spite of the weakness of the ligamentary apparatus and the frequency with which the part is exposed to external violence, this luxation is extremely rare. The lower articular extremity of the ulna may be dislocated backward (dorsal dislocation) directly, by a fall or by excessive pronation; or forward (volar dislocation) either directly or by excessive supination. The symptoms are determined by careful palpation. Subluxation of this joint, produced by wringing clothes, is met with in washerwomen. The treatment is based on general principles.

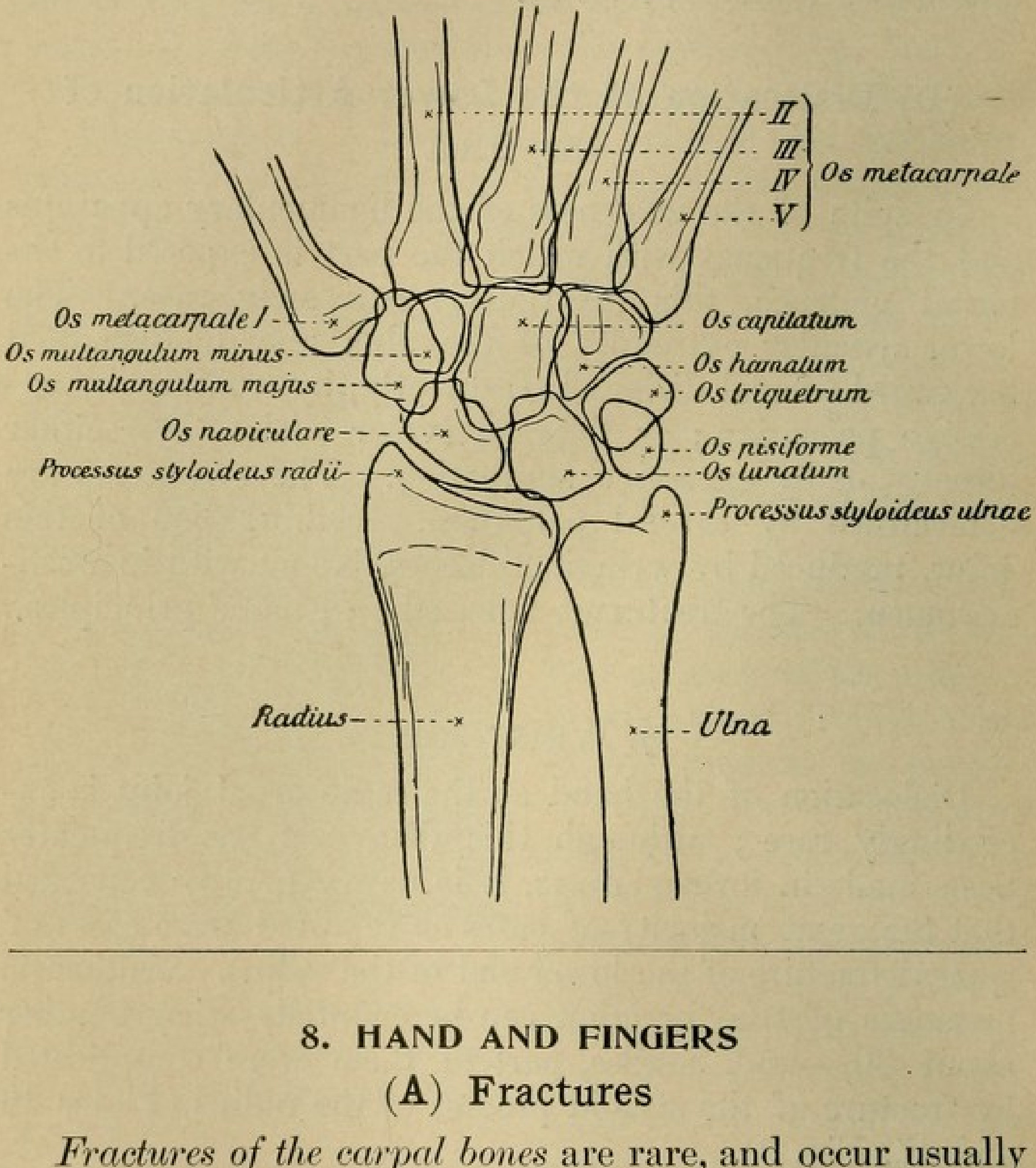
7. WRIST-JOINT

Dislocation of the hand at the radiocarpal joint is exceedingly rare; although this diagnosis has frequently been made in former times, it is now generally conceded that the great majority of cases so reported were cases of typical fracture of the lower end of the radius. Authentic instances of true luxation can be counted,—they number about 30,—and, besides, part of them were complicated by fracture of the styloid process of the radius (Plates 46 and 47, Fig. 3).

The dislocation may be backward (dorsal) or forward (volar); the carpus rests against the dorsal or the volar side of the articular extremities of the bones of the arm. The injury is produced by a fall on the outstretched hand in excessive dorsal (dorsal dislocation) or volar (volar dislocation) flexion. The *diagnosis* is made by careful palpation; *reduction* is effected by traction and direct pressure.

PLATE 47 a.

Skiagraph of a Normal Adult Wrist-joint. Anterior View.

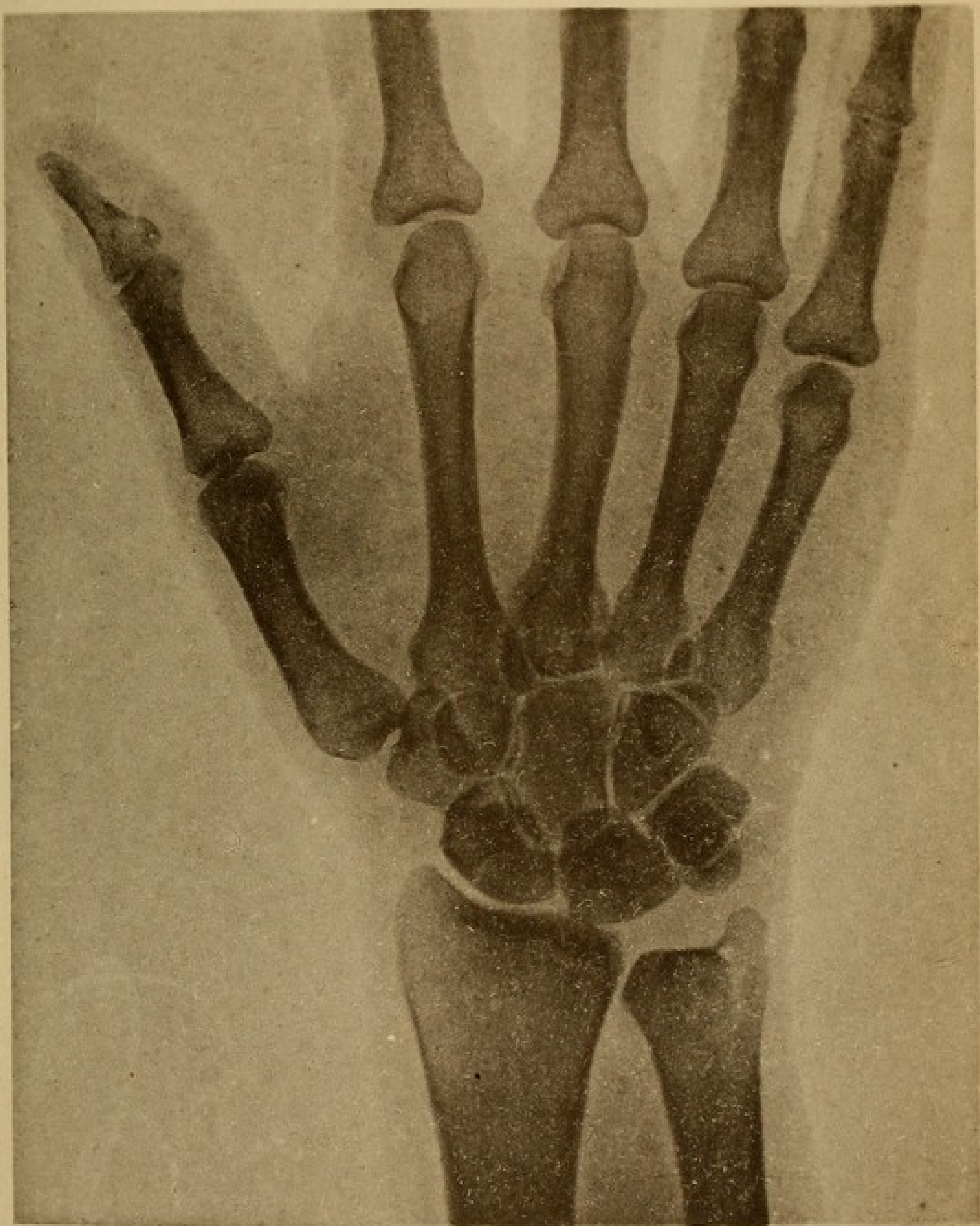


8. HAND AND FINGERS

(A) Fractures

Fractures of the carpal bones are rare, and occur usually in combination with severe lacerated or contused wounds of the soft parts by which they are covered. The degree of the injury depends on the severity of the complicating lesion.

Fractures of the metacarpal bones are not so uncommon, and are produced by a fall on the dorsum of the hand, by a direct blow, etc. Abnormal mobility and crepitation can usually be demonstrated, along with intense pain at



the seat of fracture. Deformity is usually absent, since the bones practically act as splints to one another. The treatment accordingly is simple. If an ordinary dressing and carrying the hand in a sling do not suffice, direct pressure, either on one or both sides, by means of short splints or rubber tubes, may be applied to keep the fragments in position. In compound fractures due to severe

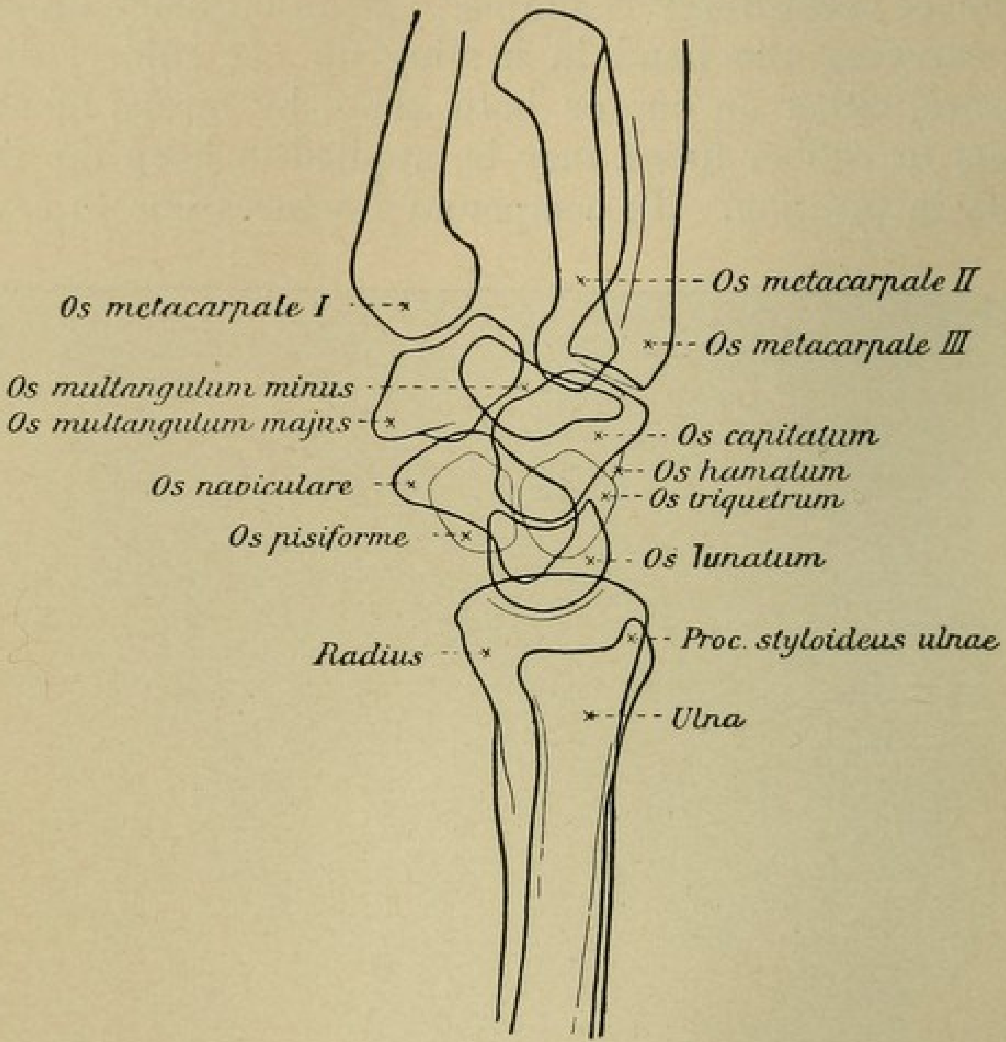
Fig. 105.—Severe compound fracture of the second and third metacarpal bones; marked displacement of the fragments. Skiagraph taken through the bandage.

external violence, operative intervention is sometimes indicated (see Fig. 105). It is well to begin massage and passive movements of the fingers early in the treatment.

[In this country we observe quite frequently fractures of the third and fourth metacarpal bone from a blow upon the knuckle. It is not an infrequent boxing or prize-fighting injury. In the cases which I have observed there

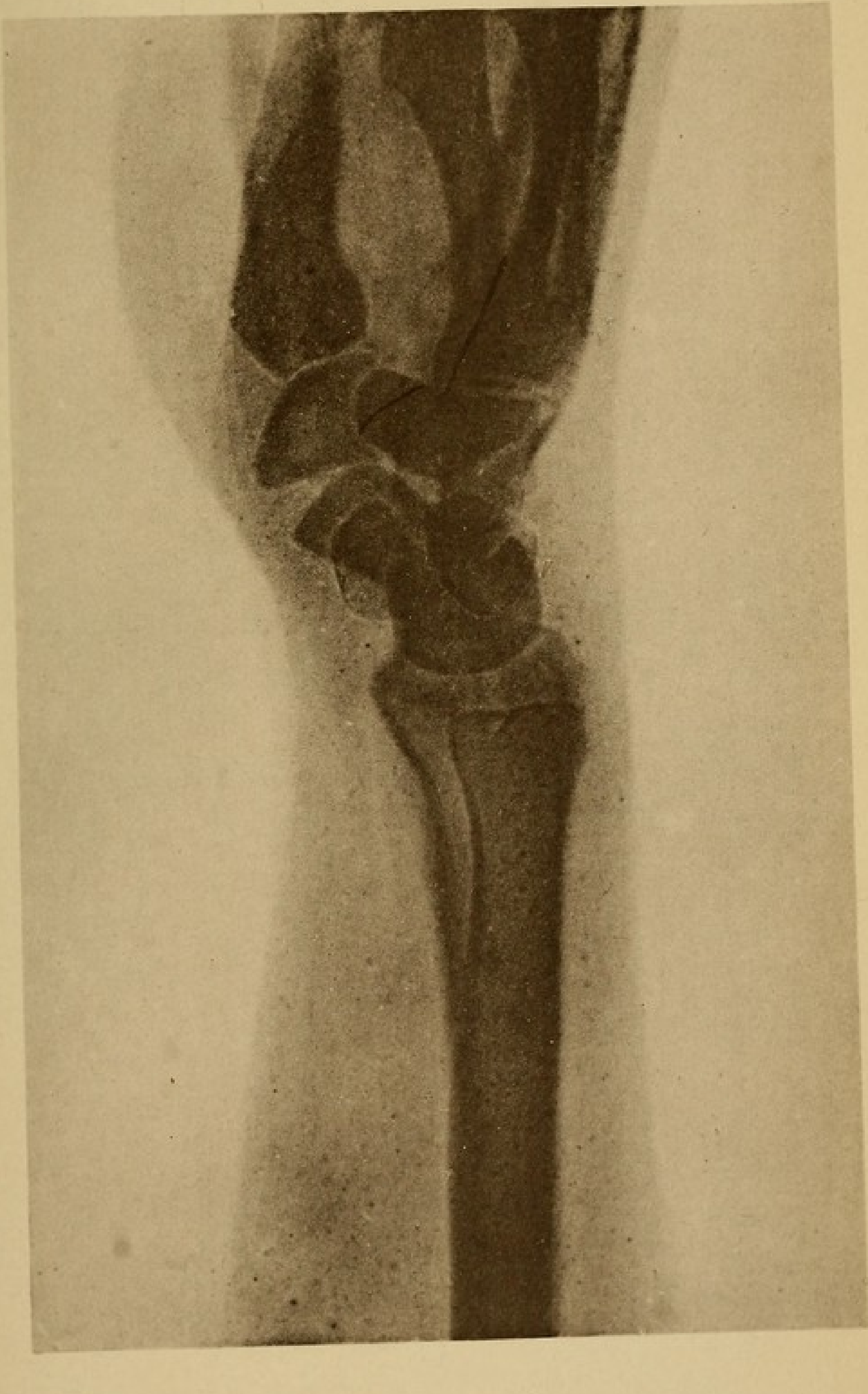
PLATE 47 b.

Skiagraph of a Normal Adult Wrist-joint; Lateral View.



has been a deformity, and I should recommend that the fracture be dressed with a pad in the palm of the hand to preserve the palmar arch, or the fracture be dressed with a roll of bandage in the palm of the hand over which the fingers and thumb are flexed and held in position by a bandage. This is recommended and illustrated by Scudder (*loc. cit.*, p. 236).—Ed.]

Fractures of the phalanges are usually produced by direct violence, but may also result indirectly by a force acting in the longitudinal direction of the phalanges; we thus occasionally meet with longitudinal fractures. They are also said to be produced in the distal phalanges by the



pull of the extensor tendons in forced flexion of the fingers. Owing to the exposed position of the parts, the *diagnosis* and *treatment* (by means of small padded splints) present no difficulties whatever.

(B) Dislocations

(a) **Intercarpal dislocation,** or dislocation altering the relative positions of the two rows of carpal bones, is

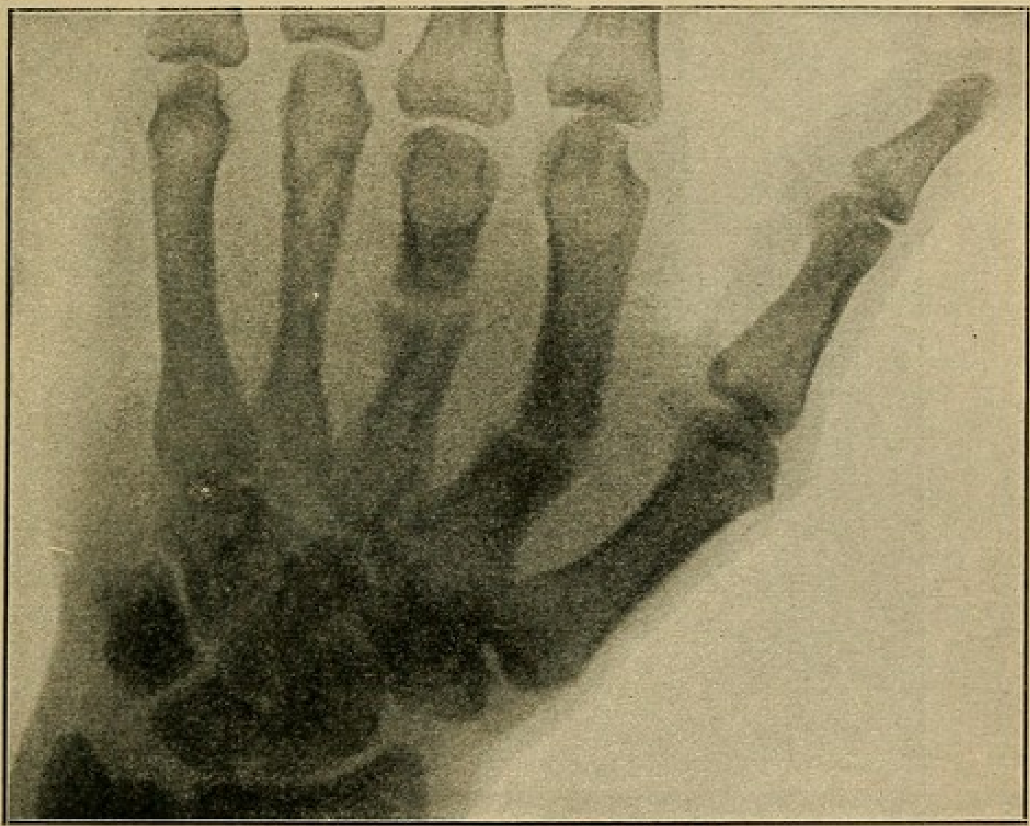


Fig. 106.—Showing the same hand as in figure 105, after operative correction of the deformity. Skiagraph taken in the same way as that of figure 105.

exceedingly rare. Dislocation of a single carpal bone is somewhat more frequent. The dislocated bone forms a prominence, the position and shape of which determine the diagnosis, when it can be made.

(b) **Dislocation at the carpo-metacarpal joints** is also a rare accident. It is met with most frequently at the carpo-metacarpal joint of the thumb. The first metacarpal bone may be displaced backward or, more rarely, forward, and finally to the radial side. The diagnosis is made by the abnormal prominence and the direction of the metacarpal shaft. Reduction is effected by traction and direct pressure (see Plate 46 and Plate 47, Fig. 4).

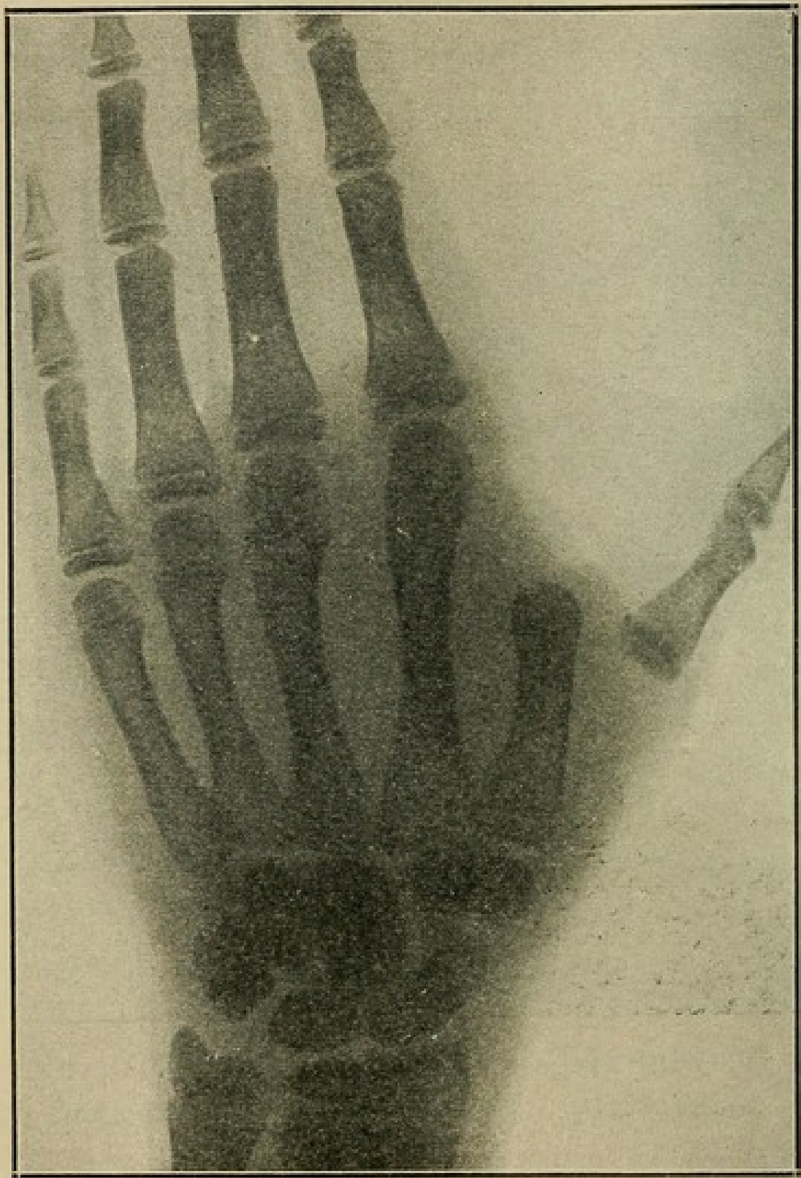


Fig. 107.—Skiagraph of a typical dislocation of the thumb in a youthful individual. The epiphyseal lines are visible. (Obtained by the courtesy of Geheimrat Trendelenburg in Leipzig.)

(c) **Dislocation of the metacarpal-phalangeal joints** occurs rarely at the second, third, fourth, and fifth fingers, but is comparatively frequent at the thumb, and of great practical importance.

Dislocation of the thumb in its typical form is always a backward dislocation ; *i. e.*, the base of the first phalanx slips back over the capitellum of the first metacarpal bone. We distinguish complete and incomplete dislocation of the thumb, depending on whether the two articular surfaces are partially in contact or completely out of contact.

This dislocation can easily be produced artificially in the cadaver by overextension (maximal dorsal flexion) and forcible displacement of the dislocated first phalanx toward the wrist-joint. If after this the thumb, by a slight movement of flexion, is brought into an erect position, all the characteristic symptoms of a typical dislocation of the thumb will be produced. I have even observed the interposition of soft parts in such an artificially produced dislocation, making it impossible to reduce the luxation. This will be referred to again later on. The chief feature, both in artificial and in accidental dislocation of the thumb in the living subject, is fixation of the dislocated member. This is due to the traction of the soft parts entering into the composition of and surrounding the joint. The lateral ligaments often remain intact, and a number of robust muscles and tendons bring about fixation by wrapping themselves about the head of the first metacarpal bone. This constitutes an obstacle in ignorant attempts to effect reduction by simple traction; the more we pull on the thumb, the more closely the tendons and muscles will hug the neck of the metacarpal bone and prevent the thumb from slipping into place. This is the so-called buttonhole mechanism (see Plate 48, Fig. 1, and Fig. 109).

Symptoms.—The lines formed by the thumb and first metacarpal bone suggest a bayonet; the marked prominence of the head of the first metacarpal bone on the volar surface and the abnormal direction of the first phalanx, combined with a peculiar rigid fixation of the parts, point to the correct diagnosis.

Just as in all other hinge-joints, *reduction* must be performed without employing force. After overextension of

PLATE 48.

Typical Dislocation of the Thumb.—Fig. 1.—Anatomic specimen of the right hand seen from the volar side. The base of the first phalanx is dislocated to the dorsal side of the head of the first metacarpal bone ; the capitellum forms a marked prominence ; the capsule is torn on its flexor surface and displaced dorsally with the first phalanx. We will designate the two sides of the head of the metacarpal bones as the radial and the ulnar sides : On the ulnar side the adductor pollicis and the tendon of the flexor pollicis longus are wrapped about the neck of the metacarpal bone, while on the radial side we find first the flexor pollicis brevis and then the abductor pollicis brevis. The capitellum has escaped from between these muscles as through a cleft ; the tendon of the flexor pollicis longus lies closest to the neck of the metacarpal bone and in the illustration is hidden behind the capitellum, coming into view again on the volar side of the first phalanx.

Fig. 2.—Typical dislocation of the thumb in the living subject. Right hand, seen from the volar side. Figure 1 elucidates the characteristic deformity which is here shown.

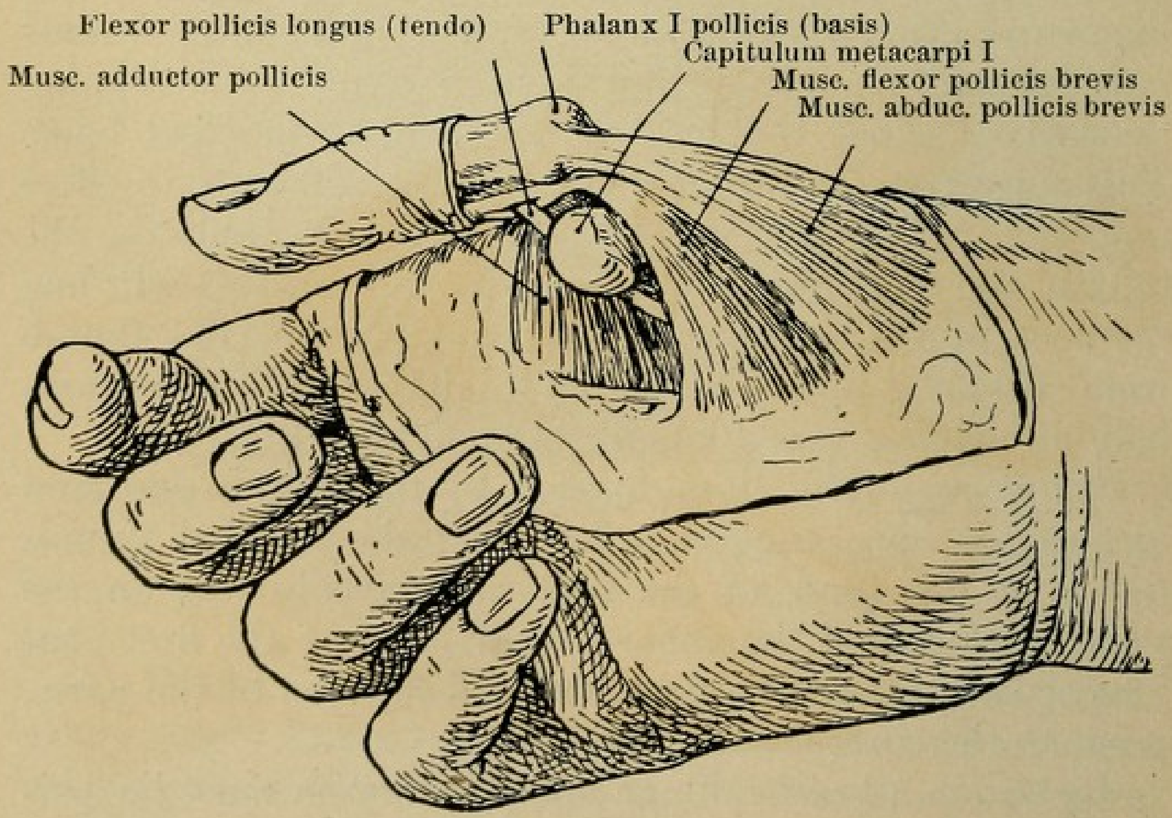


Fig. 108.—(Explanation of figure 1, Plate 48.)

Tab. 48.

Fig. 2.

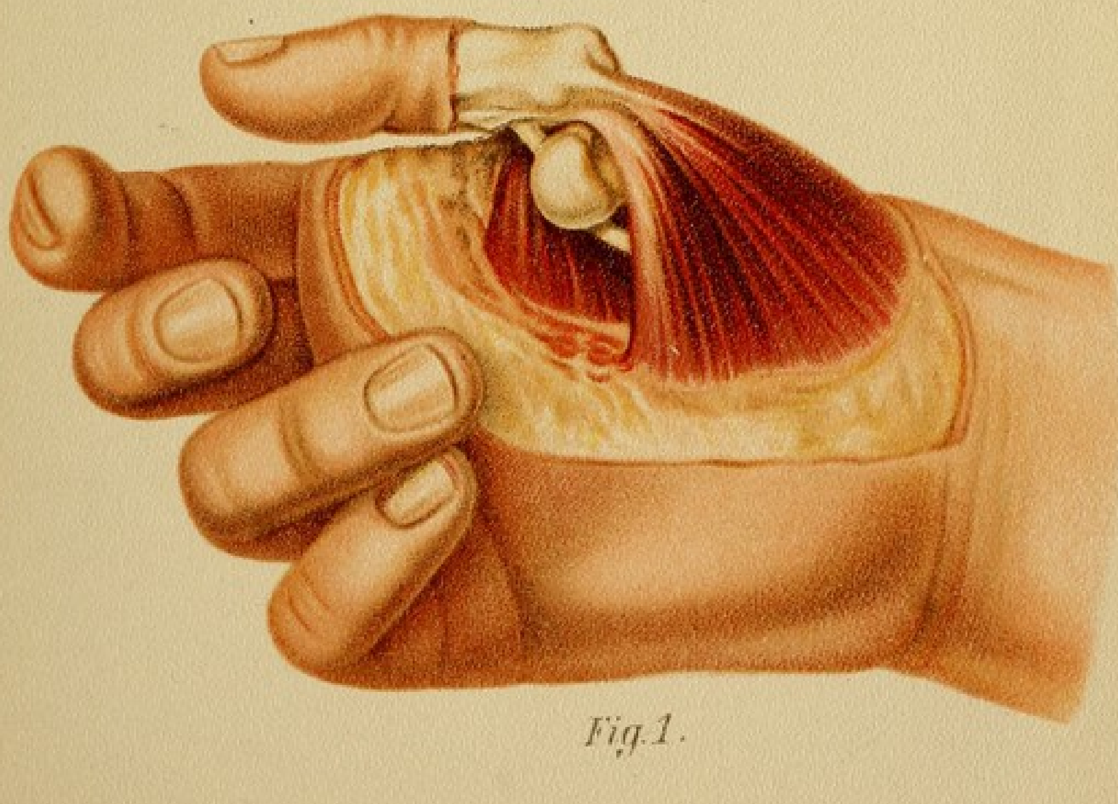


Fig. 1.

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the thumb, direct pressure is applied against the base of

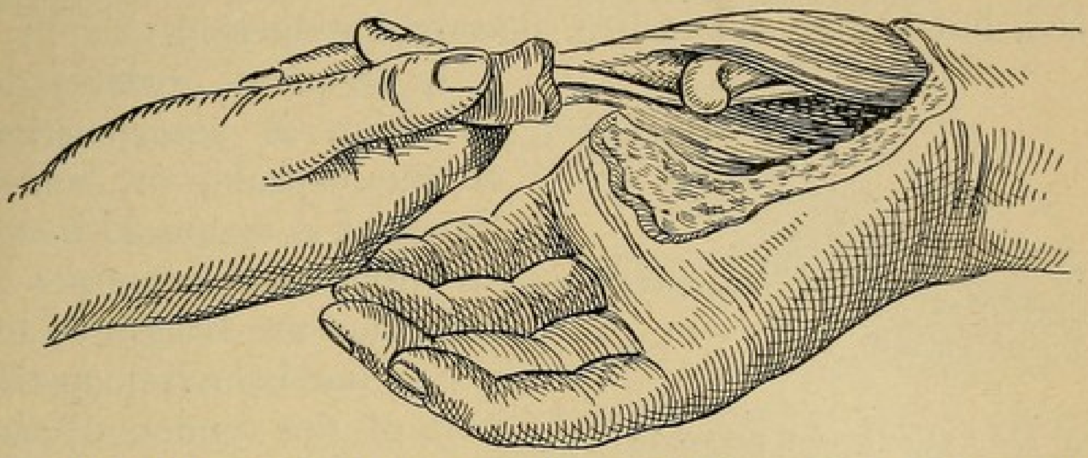

Fig. 109.—Improper attempt to effect reduction by simple traction. Every effort merely increases the fixation (button-hole mechanism).

the first phalanx, and the thumb is pushed directly forward. As soon as more than half of the articular sur-

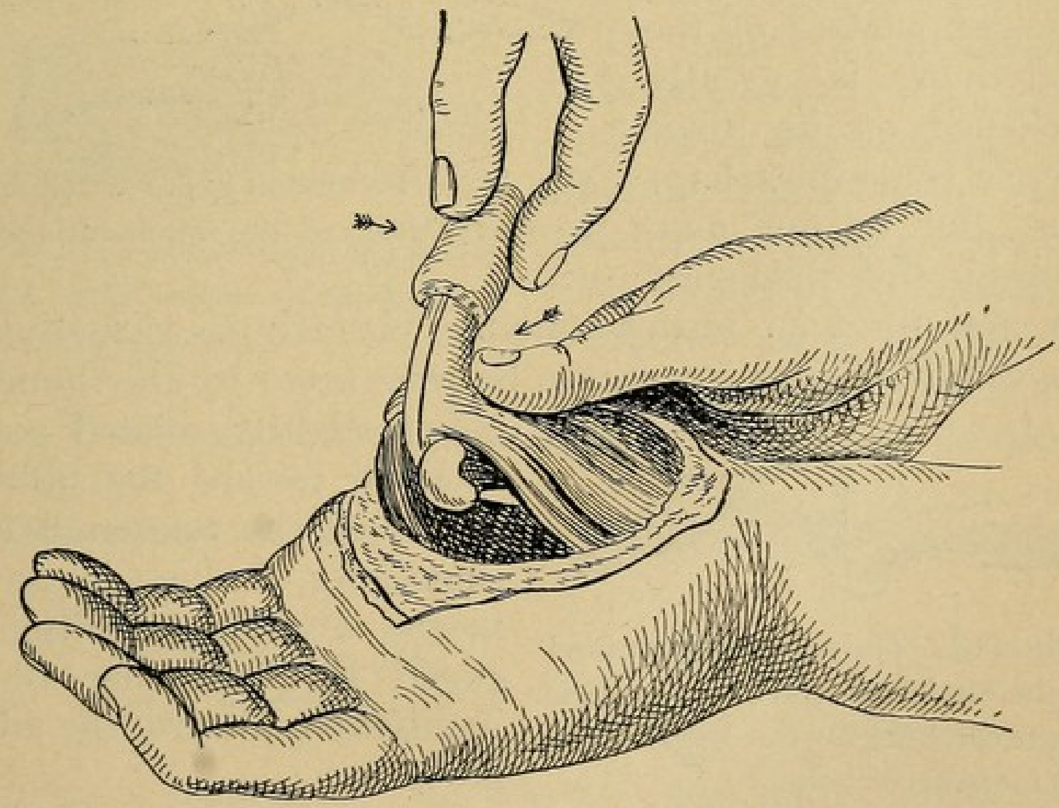

Fig. 110.—Correct method of reduction; the thumb is overextended and pushed forward.

faces are brought into normal contact, flexion becomes possible and the thumb slips into place. The importance of correctly performing this manœuver should be emphasized, but it does not insure successful reduction.

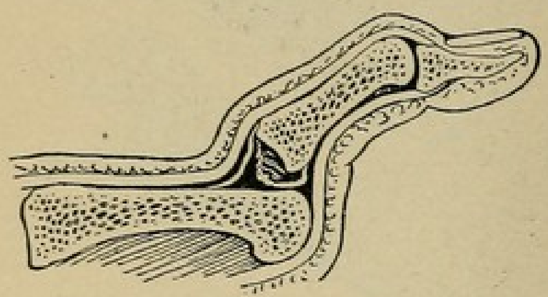

Fig. 111.—Reduction prevented by the interposition of the capsule.

A frequent obstacle to reduction is interposition of the capsule, or, sometimes, of a sesamoid bone. In other cases attempts at reduction are frustrated by a peculiar behavior on the part of the tendon of the flexor pollicis longus, which I have observed both in the living subject and on the cadaver when the dislocation had been produced artificially. The tendon surrounds the neck of the first metacarpal bone; if the articular surface of the capitellum is greatly thickened on its ulnar side, as sometimes happens, the tendon may catch on this thickened rim and form an insurmountable obstacle to reduction. The condition may sometimes be recognized by the thumb being slightly rotated and inclined toward the ulnar side and the tendon may sometimes, but not by any means always, be disengaged by increasing this inclination toward the ulnar side.

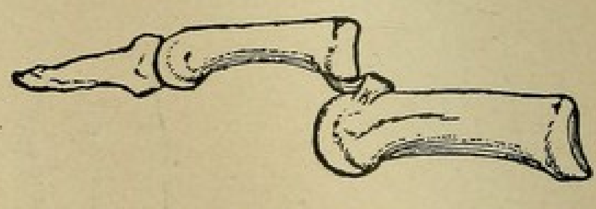

Fig. 112.—Reduction is prevented by the interposition of the sesamoid bone.

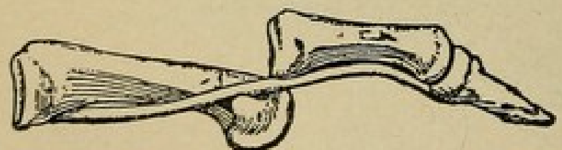

Fig. 113.—Reduction is prevented by the tendon of the flexor pollicis longus catching on the head of the first metacarpal bone.

In exceptional cases it may happen that during the attempts at reduction, especially if traction is improperly applied to the thumb, the capsule and the external sesamoid bone become completely turned over and interposed between the articular extremities in the inverse direction (*luxatio complexa*).

If reduction is found impossible, arthrotomy must at once be performed. In all such cases I have succeeded, by cutting down on the prominence of the capitellum on the volar side and dissecting the tissues, in discovering the obstacle, and, after effecting reduction, have uniformly obtained a good functional result. In old cases resection of the head of the metacarpal bone may become necessary.

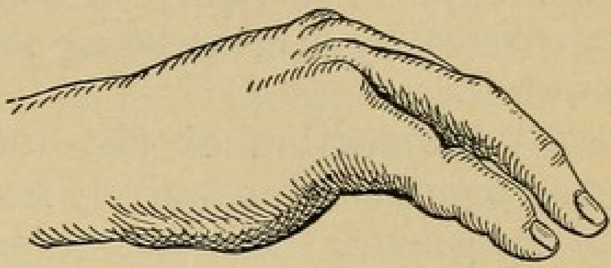

Fig. 114.—Backward dislocation of the second phalanx of the little finger in a boy fifteen years old. (Binschuss, 1896.) The dislocation was reduced and a good result followed.

In regard to the symptoms and treatment of volar or forward dislocation of the thumb, which is a very much rarer injury, there is little to add to the foregoing remarks except to advise an attentive study of Plate 48. The diagnosis and treatment should present no difficulties.

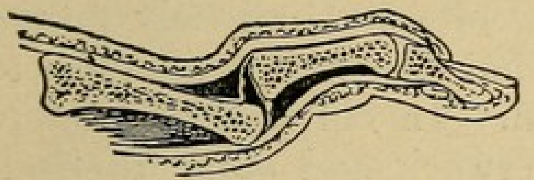

Fig. 115.—Section of the middle finger with dorsal dislocation of the second phalanx.

Dislocation at the metacarpo-phalangeal joints of the second, third, fourth, and fifth fingers, like dislocation of the thumb, is usually dorsal. In this dislocation

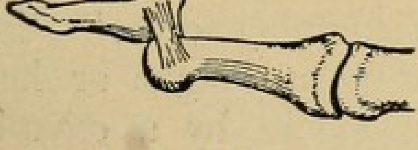

Fig. 116.

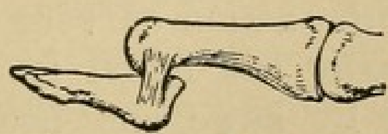

Fig. 117.

Figs. 116 and 117.—Dorsal and volar dislocation of the distal phalanx.

also interposition of the capsule has been observed. Occasionally the dislocated finger presents a lateral angular deformity. The injury is usually compound; reduction is effected by overextending the phalanx and pushing it forward.

(d) **Dislocation at the interphalangeal joints of the fingers** is comparatively frequent, and is often reduced by the patient. The dislocation may be dorsal, volar, or lateral if the lateral ligaments are torn. It may occur in any one of the joints. The diagnosis and reduction present no difficulties.

VII. FRACTURES AND DISLOCATIONS OF THE LOWER EXTREMITY

The importance of injuries to the lower extremity is enhanced by the fact that they demand not only proper correction of the local injury, but also special attention to the patient's general condition. In old persons, and in conditions of debility from overwork and other causes, it is important to avoid a prolonged confinement to bed (hypostatic pneumonia). The patients should be gotten up as soon as possible and allowed to move about with a well-fitting dressing.

1. PELVIS. (Plate 49.)

Solution of continuity in the bones of the pelvis usually implies the action of very considerable force.[1] The victim usually has fallen from a great height or has been crushed by large and heavy objects, by a cave-in, etc. These accidents may produce fractures, or separation of the symphyses of the pelvic bones. The latter are even

[1] Professor Richter has called attention to the fact that fractures of the pelvic ring occasionally occur in comparatively inconsiderable injuries.

more rare than fractures, as their production presupposes laceration of the exceedingly robust ligaments at the symphysis pubis and the sacro-iliac articulation. Separation of the Y-shaped cartilage in the acetabulum (see Plate 49, Fig. 2) is not possible except in connection with some other solution of continuity in the bones that enter into the formation of the pelvic ring. A positive diagnosis can be made only when the separation of the bones is complicated by marked displacement of the parts. Other cases, particularly those involving the sacro-iliac symphysis, present the symptoms of severe distortion which, taken together with a knowledge of the cause of the injury, will usually suffice to determine the nature of the lesion. The treatment is based on general principles.

Fractures of the pelvis are divided clinically into two classes: one in which individual parts of the pelvis are fractured, and one in which the continuity of the pelvic ring is actually interrupted.

The former class includes fracture of a portion of the innominate bone, fracture of the sacrum or coccyx, and fracture of the tuberosities of the ischium. The broken portions of the bone may sometimes be detected on direct examination by their abnormal mobility and, it may be, by the presence of crepitation and displacement. Accessory injuries are rarely present in these fractures. The *treatment* aims at securing union in as nearly a correct position as possible; but even if deformities should result, they are of no practical significance.

Fracture of the pelvic ring is a much more vital injury. In the first place, it requires a severe injury to interrupt the continuity of the pelvic ring; and, in the second place, as a necessary corollary, accessory injuries are comparatively common. Injury of the sciatic and other nerves, of the femoral vessels, of the bladder, and of the rectum are comparatively rare; but an injury to the urethra in men is relatively common in fracture of the pelvis, and is of the highest practical importance. It manifests itself by

PLATE 49.

Fractures of the Pelvis.—Fig. 1.—Severe fractures of the pelvic ring, so-called double vertical fracture of Malgaigne, in an adult; produced by being run over while he was lying on his back. In front, the pelvis has been fractured on each side of the symphysis pubis in the region of the parts surrounding the obturator foramen; the central piece is accordingly completely separated. Posteriorly a second line of fracture is found at the base of the innominate bone, close to the sacro-iliac articulation, justifying the term double vertical fracture.

Fig. 2.—Severe fracture of the pelvic ring through the acetabulum. (W. Kohn, male, fourteen years old, 1889. See explanation of Plate 1, Fig. 1.) The injury was produced by the cogwheels of a threshing machine. The fracture involved the left pubis and ischium, and led to separation of the Y-shaped cartilage in the acetabulum. There was also a large lacerated wound in the region of the left groin, exposing the femoral vessels, as in an anatomic preparation, and communicating with a large wound-cavity between the adductor muscles. Within this wound-cavity the fracture in the bony rim of the obturator foramen can be felt. The left thigh was somewhat adducted, the penis badly contused but the urethra intact; normal urine flowed through the catheter. The patient succumbed to the severity of the injury.

Fig. 3.—Fracture of the innominate bone (not a fracture of the pelvic ring).

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the discharge of blood from the urethra or the admixture of blood in the urine. The introduction of a catheter is necessary both for diagnostic and therapeutic purposes (permanent catheter). If catheterization is unsuccessful, there is imminent danger of the urine infiltrating the surrounding cellular tissues and leading to fatal consequences through gangrene and sepsis. Hence immediate and free incision from without, as in external urethrotomy, and, under certain circumstances, a high incision (suprapubic) and so-called retrograde catheterization may be justifiable. The latter operation should not be attempted without the facilities of a hospital; but any physician may properly be expected to incise the cellular tissue surrounding the urethra and at least establish the diagnosis of a severe injury, so that the proper treatment may be instituted.

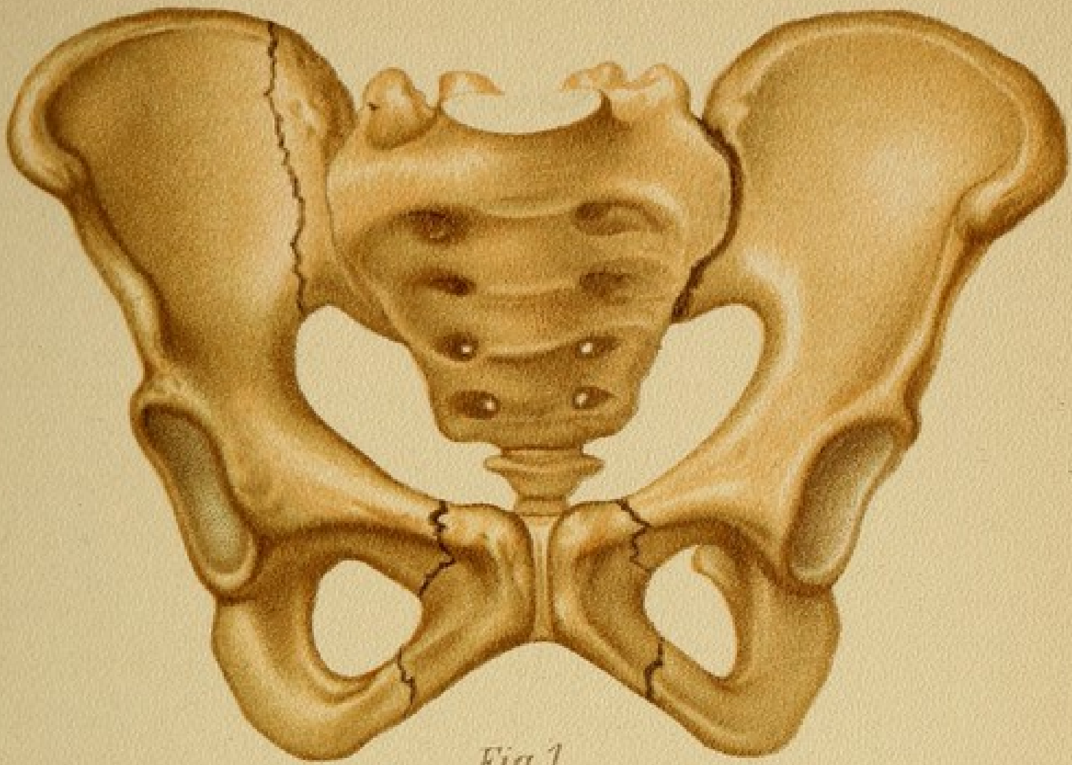

Fig. 1.

Fig. 2.

Fig. 3.

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[Most dangerous complications of fractures of the pelvis are rupture of the bladder and the urethra. These possibilities should always be borne in mind, and they demand immediate treatment. If possible the patient should be sent at once to a hospital, because the after-treatment is almost as important as the early operation. A rupture of the bladder demands an earlier operation than a rupture of the urethra. The early diagnosis and treatment of these injuries is a subject for a text-book on surgery, but it is not out of place here to urge the immediate search for these accompanying injuries in fractures of the pelvis. It is the experience of every large surgical clinic that these patients are frequently brought to to the hospital too late for successful surgical intervention.[1]—ED.]

Fractures of the pelvic ring present many varieties. Besides the injuries due to the action of the vertebral column and of the thigh on the pelvis, we have to deal chiefly with compression of the pelvis, either in its antero-posterior direction,—as when a man is run over, or has his horse fall on him when he is lying on his back,—or in the lateral diameter. The mechanism has been studied experimentally. If pressure acts in the antero-posterior diameter, the anterior wall of the pelvis is the first to give way, the lines of fracture passing through the upper and lower margin of the obturator foramen on both sides. This is followed by a separation of the sacro-iliac articulation or by fracture of the sacrum parallel to the joint. Lateral compression is also followed first by a fracture in the anterior wall, the pubic region, which is the weakest part of the ring; the line traverses the obturator foramen. This is followed by fracture of the innominate bone, parallel to the sacro-iliac joint, providing that the ligamentous apparatus of that joint remains intact. Thus one-half the pelvis may be fractured both in its anterior

[1] James F. Mitchell, Annals of Surgery, February, 1898, contributed a splendid article on pelvic fracture complicated by rupture of the bladder, with a collection of all the cases in the literature.—ED.

and in its posterior wall at the same time; *i. e.*, the so-called double vertical fracture of Malgaigne is produced. Numerous other lines of fracture may be produced, if the pelvis is compressed in a diagonal diameter. In actual practice the injuries leading to fracture of the pelvis are, as a rule, so severe and of so manifold a character that the pelvis is fractured in many places, instead of presenting a typical fracture, such as has been described. At the autopsy fifteen or twenty, or even more, separate lines of fracture and cracks are generally found.

In making the **examination** it is well to begin by attempting to compress the pelvis with the two hands applied to the crest of the ilium. If fracture is present, this will produce a violent pain at the seat of fracture, and may even in some cases elicit abnormal mobility and crepitation.

The tuberosities and the ascending ramus of the ischium, the descending ramus of the pubis, and other accessible portions of the pelvis must always be carefully palpated and tested for sensitiveness. On the posterior surface the region of the posterior superior spines of the ilium, which is normally indicated by a slight depression, must be subjected to careful scrutiny and comparison with the other side. Sometimes rectal examination may yield valuable information.

The **prognosis** depends on the extent of the accessory injuries. If there are none present, recovery may be expected.

Treatment.—The patient should be placed on a water-bed or a mattress stuffed with millet-chaff, or on a specially constructed surgical bed, as in fracture of a vertebra, so as to avoid moving him for the purpose of defecation. A circular bandage around the pelvis is often actually useful in itself, and is usually a comfort to the patient. In fracture of the acetabulum, passive movement of the hip-joint must be carried out during the course of the treatment.

[In fractures of the pelvic ring confined to one side, I have found that extension of the lower extremity on the affected side, especially if the thigh is well flexed, adds much to the comfort of the patient and reduces apparently

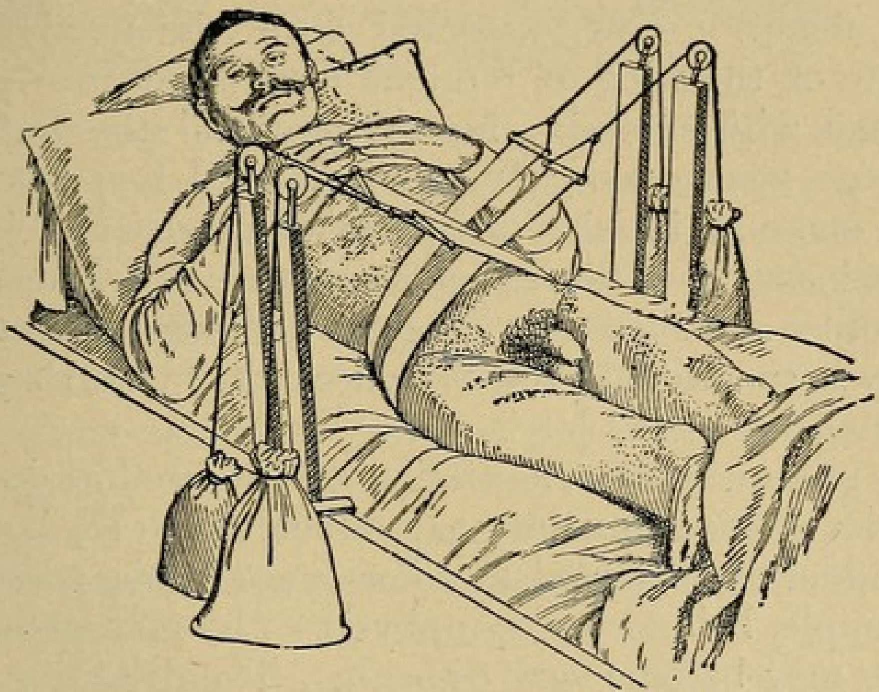

Fig. 118.—Attitude in bed of a patient with fracture of the pelvis (Kurek, 1895), with a circular extension dressing. On the 14th of May, 1895, Kurek sustained a severe injury by the giving way of the floor of a barn loaded with about 25 tons of oats. The joists and other parts of the woodwork fell on his left side. Great extravasation of blood in the region of the left hip and pelvis; pain elicited by lateral compression, with indistinct crepitation and abnormal mobility. The seat of greatest pain was in the region of the left sacro-iliac articulation. The urine was voided spontaneously and was not mixed with blood. There was a large ecchymosis in the scrotum. The pelvis was dressed as shown in the illustration and the patient recovered. He was discharged on the 19th of July, 1895. The left innominate bone is about 2 cm. higher than the right. The region of the posterior superior spines of the ilium is thickened by new-formation of bone and still sensitive to pressure. Patient wore a circular plaster-of-Paris dressing when he was discharged.

the resultant shortening of the limb. A Smith's anterior splint provides the most convenient method of extension. In four cases of fracture of the pelvic ring I have observed a moderate degree of shortening of the limb on the affected side due to the elevation of the pelvis. The leg is also slightly adducted. If not carefully examined, the deformity might be mistaken for an old fracture of the neck of the femur. The functional result is always good. Fracture of the wing of the iliac bone is not infrequently associated with extensive hemorrhage and the formation of a large hematoma. In one instance I found it necessary to make an incision and pack with gauze the bleeding fractured surface of the cancellous bone. The hemorrhage was profuse and checked with great difficulty. If at hand, Horsley's wax would probably check the hemorrhage better than gauze.—Ed.]

The treatment of a laceration of the urethra does not, as a rule, present any unusual difficulties. If, however, the bladder is lacerated at some inaccessible point,—as, for example, behind the symphysis,—the management of the case may become very difficult. The dribbling of the urine irritates the skin over the back of the pelvis and bed-sores develop which are very difficult to control. If possible, the patient should be placed in a permanent bath.[1]

2. HIP-JOINT

Dislocation of the hip-joint is rather a rare injury, and requires severe violence for its production. The force acts indirectly through the trunk or the thigh, as when the injury is produced by a cave-in, by being run over, by a fall from a great height, etc. Dislocation by direct action on the region of the hip must be extremely rare. The most important forms are backward and forward dislocations, but they are very much more rare. Since the investigations of Bigelow in Boston we know that the mechanism and the fixation of the luxated bone are determined by the iliofemoral ligament (or Bertini's ligament) [the Y-ligament.—Ed.], which in all regular dislocations remains in-

[1] See Mitchell's article (*l. c.*) for use of bath.

tact. An irregular dislocation without characteristic symptoms is possible only when that ligament has been torn.

(A) Backward Dislocation (Luxatio postica sive retrocotyloidea). (Plates 50, 51, 52.)

If the flexed and slightly abducted thigh is rotated inward, the posterior portion of the capsule is put on the stretch. If the movement is continued, the neck of the femur catches on the edge of the acetabulum and a fulcrum is provided so that by means of the long arm of the lever (the shaft of the femur) enormous power can be exerted on the short arm—the head of the femur. The head is forced against the capsule, which gives way at its posterior portion, and the head escapes from its articular connections, the ligamentum teres being torn. Thus the backward dislocation is completed.

We distinguish two forms: iliac and ischiatic dislocation. In the former the head is found on the iliac bone; in the latter it occupies a deeper position on the upper segment of the ischium. The position of the tendon of the obturator internus in relation to the head of the femur is an important anatomic distinction. In the iliac form the head of the femur is above, in the ischiatic form below, the tendon. An ischiatic dislocation may be produced experimentally by rotating the strongly flexed thigh inward. The iliac form is also produced by inward rotation, but with the thigh in less pronounced flexion.

In the living subject posterior dislocation is brought about in the same way, either by movement of the leg (rare), or, more frequently, by movement of the trunk or pelvis while the leg is fixed, the head of the femur becoming displaced above or below the tendon of the obturator muscle. Or the head may first escape from the acetabulum in its postero-inferior segment and, by secondary dislocation, approach the position characteristic of iliac dislocation, until the Y-shaped ligament and the external

PLATE 50.

Backward Dislocation of the Thigh.—Fig. 1.—Ischiatic dislocation artificially produced in the cadaver. The gluteus maximus has been split, each part being held aside by retractors, so that the head of the femur and deeper-lying soft structures are exposed. Immediately below the gluteus maximus is a strip of tissue, belonging to the gluteus minimus, and under the latter, the pyriform muscle. The obturator internus occupies a position above the head of the femur, but lies at some depth, so that little is to be seen of it. Below the head, and surrounding it like a cravat, we see first the obturator externus, and lower down the quadratus femoris, some of the fibers of which are lacerated. On the median side of the head of the femur is the sciatic nerve; between it and the edge of the lower portion of the gluteus maximus are the tuberosity of the ischium and the tendon of the biceps femoris, which has its origin at that point.

Fig. 2.—Anatomic preparation of the hip region seen from behind; the conditions are normal. The plate is explained by figure 119.

Fig. 3.—Iliac dislocation, artificially produced in the anatomic specimen (see Fig. 2). The head of the femur is above the obturator internus.

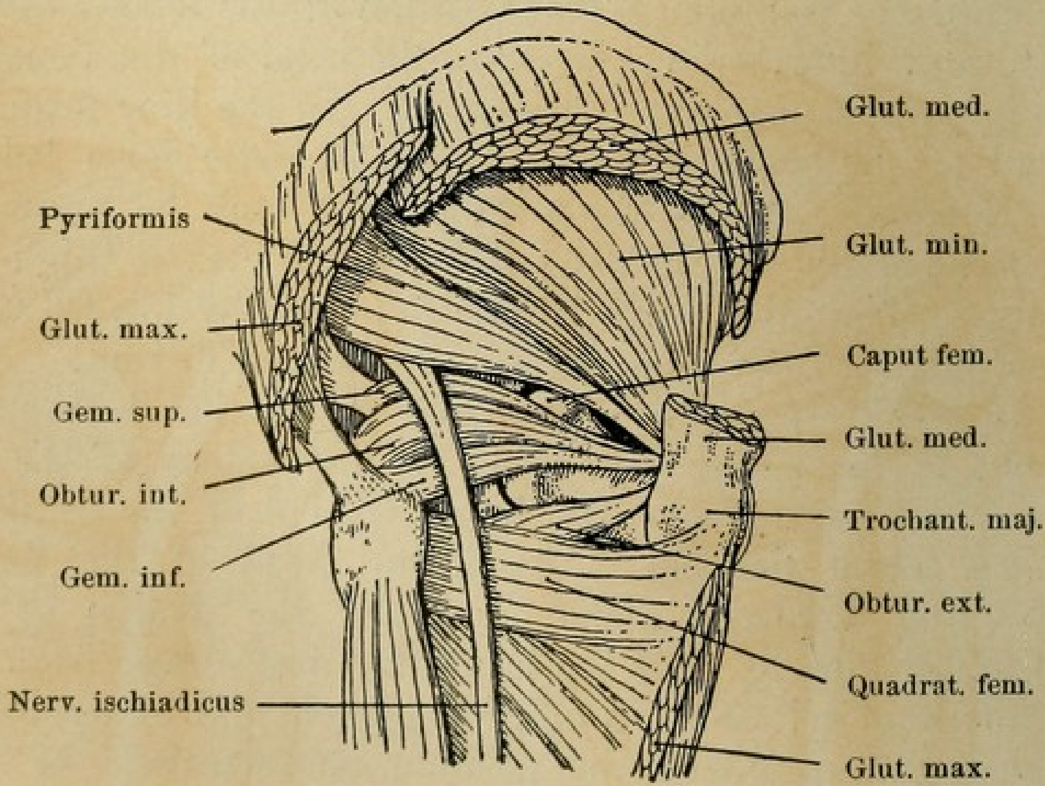

Fig. 119.

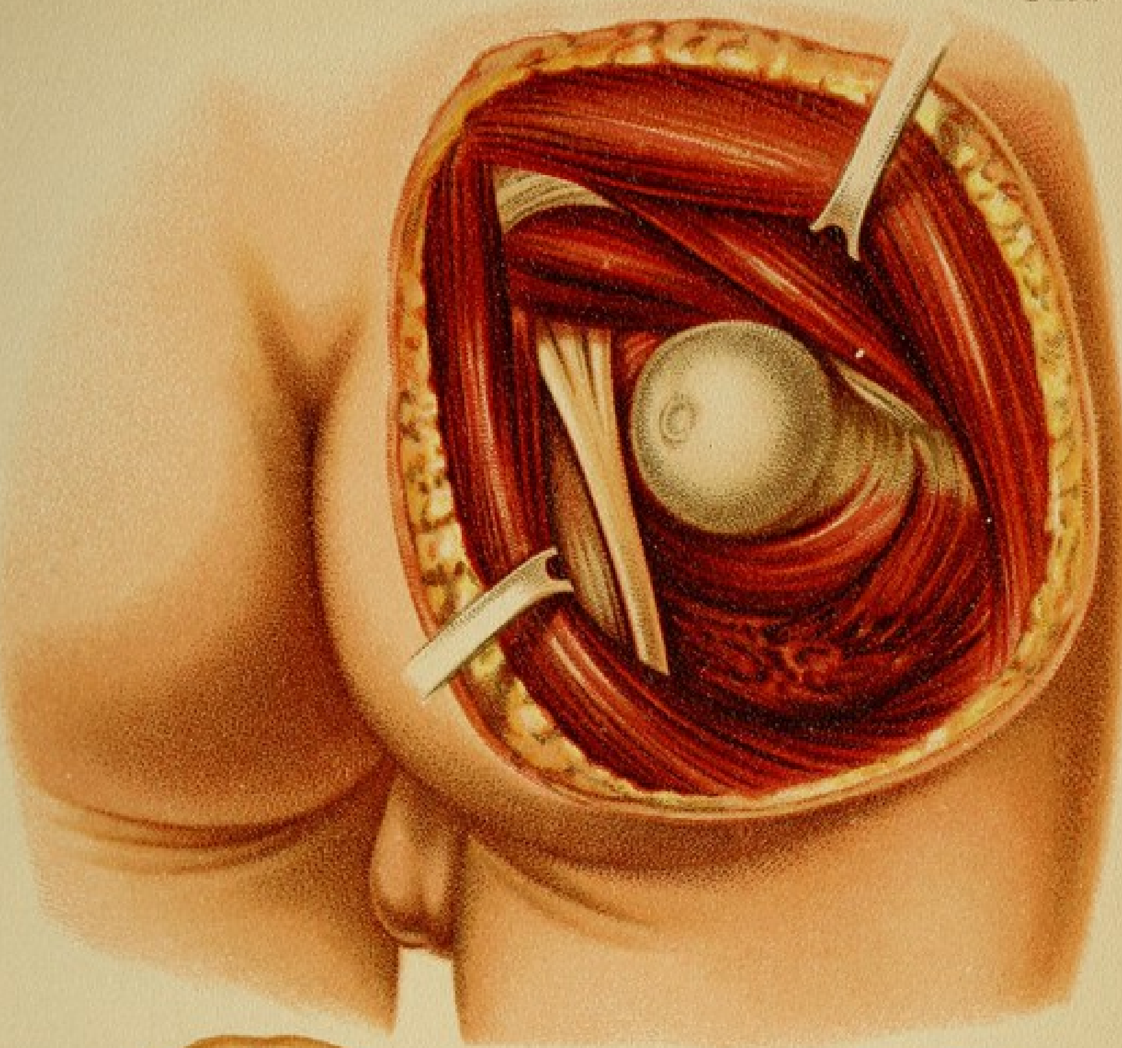

Fig. 1.

Fig. 2.

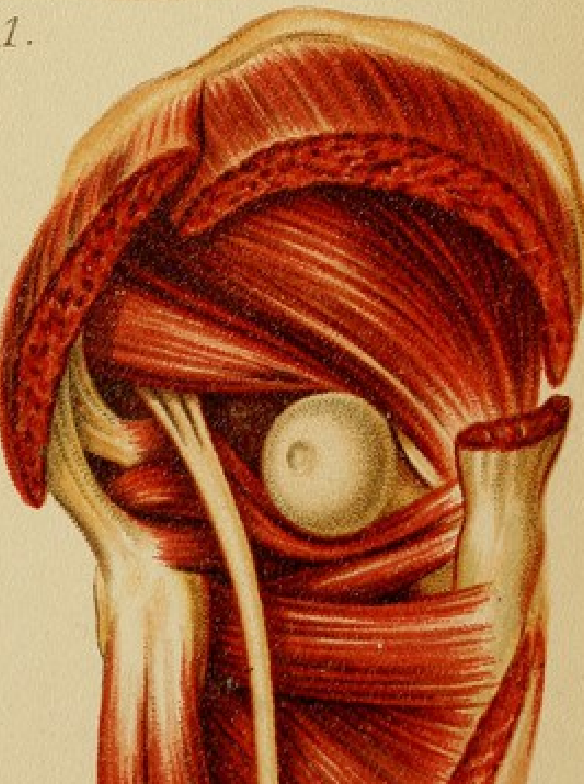

Fig. 3.

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rotators, assuming that they are intact, arrest its progress. In such a case the head of the femur may be found behind the obturator internus ; *i. e.*, the obturator and gemelli lie between the head and the acetabulum, and may constitute an obstacle to reduction.

Symptoms.—In posterior dislocations the leg is rotated inward and fixed in more or less pronounced flexion and adduction. When the patient lies on his back, this deformity is readily recognized and is associated with shortening of the leg. It is greater in the iliac than in the ischiatic form. The shortening is demonstrable by actual mensuration. The legs are brought into symmetric position with respect to the pelvis, and the distances from the anterior superior spines to a point on the knee-joint—say, the lower edge of the patella or the median line of the knee—are measured. An easy method of estimating the shortening consists in flexing the two thighs at a right angle and placing them symmetrically with respect to the pelvis, and then comparing both sides. The pelvis must be absolutely horizontal; that is, both anterior superior spines must be at the same level. In a posterior dislocation the knee of the injured side is considerably lower than the other, because the corresponding femur is displaced backward along the pelvis. This procedure is best carried out under anesthesia.

The displacement of the parts in the hip region can also be accurately measured. Under normal conditions a line drawn from the anterior superior spine to the tuberosity of the ischium through the gluteal region crosses the tip of the trochanter major. This is known as the Roser-Nélaton line. In posterior dislocation the end of the femur, and with it the trochanter, is pushed above this line. Its position above the line may be accurately determined by this method of examination, which requires that the patient lie on the sound side. The trochanter, and hence the head of the femur, providing it has not been separated from the neck and shaft of the bone, may thus be located.

By means of *inward rotation* additional information is obtained in this method of examination. When the conditions are normal and the thigh is midway between external and internal rotation, the tip of the trochanter corresponds approximately with the center of the Roser-Nélaton line. If the trochanter is found in front of this line, it indicates rotation, which is always present [1] in regular posterior dislocations, and shows that the head of the femur is posterior to the acetabulum.

There is a simpler way of arriving at a rough estimate of the dislocation. With the patient in the dorsal position and the limbs disposed symmetrically, the surgeon places his thumbs on the two anterior superior spines and determines the position of the tip of the trochanter with his index-fingers. The distance between the two bony points may be estimated approximately by the number of fingers that can be crowded in between them, and the position of the tip of the trochanter with respect to the pelvis roughly determined.

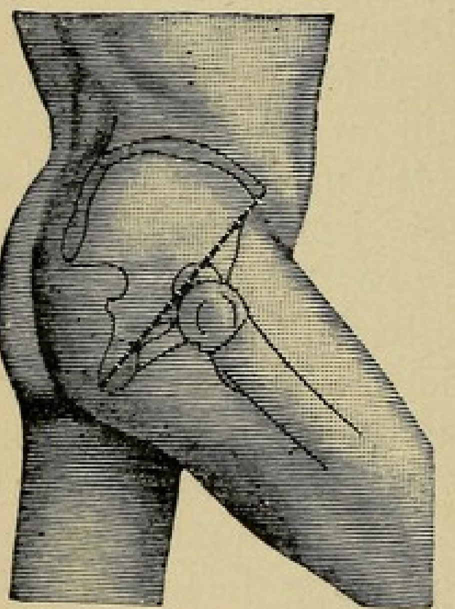

Fig. 120.—The Roser-Nélaton line with the thigh flexed at the hip.

It is not always possible, owing to the overlying mass of the gluteal muscles, to demonstrate the head of the femur in its abnormal position, especially if there is much swelling, and the patient is not under anesthesia.

Active movement is completely abolished. The thigh can be flexed passively, and the abnormal adduction and inward rotation can be increased to some extent, but not

[1] There is a backward dislocation with external dislocation of the thigh. It is a rare injury, and possible only when the outer limb of the Y-shaped ligament is divided and the articular capsule extensively lacerated.

without giving intense pain. In attempting abduction and outward rotation of the thigh, a characteristic resilient resistance is encountered which is here due chiefly to the tension of the Y-ligament. Freedom of passive movements, with great limitation of internal rotation of the dislocated thigh, indicates a large rent in the capsule with laceration of the muscles. The characteristic resilient fixation is more distinct, the smaller the tear in the capsule and the less extensive the injury to the muscles.

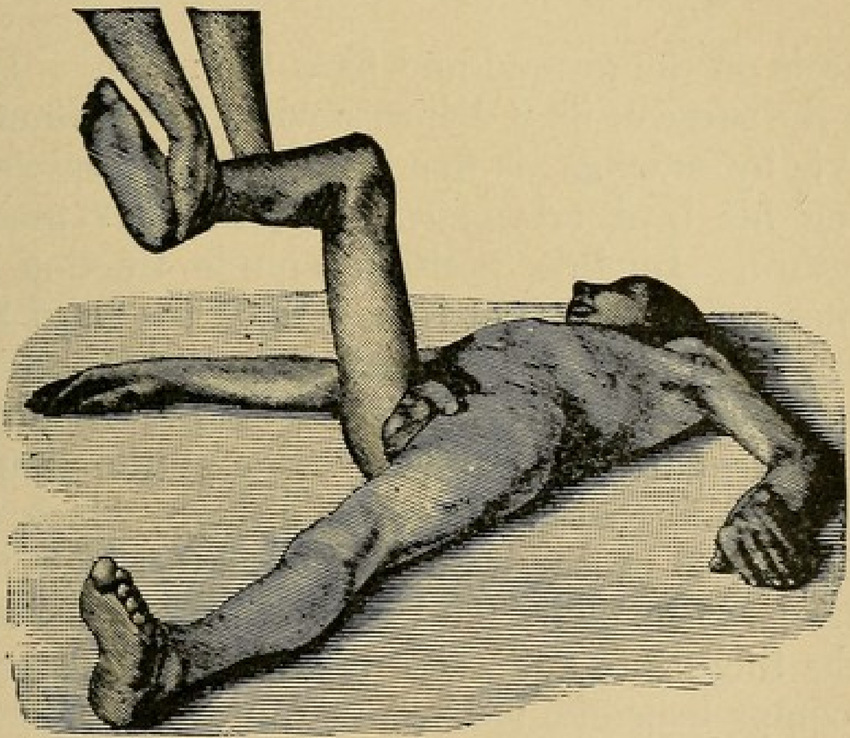

Fig. 121.—Reduction of a dislocated hip-joint with the patient in full anesthesia lying on the ground. The injured leg is placed at a right angle to the body.

Treatment.—I have already remarked that anesthesia is practically indispensable in the examination. As soon as the diagnosis is established, the dislocation should be reduced, and this procedure always demands anesthesia. The patient is laid flat on his back on a blanket or mattress on the ground. The injured leg is raised until the thigh forms a right angle with the body; the surgeon then grasps the leg and flexes it at right angles at the knee. One assis-

PLATES 51 and 52.

Various Typical Forms of Dislocation of the Thigh in Preparations and in the Living Subject.—The corresponding conditions on the two plates bear the same numbers. In the anatomic specimens illustrated in Plate 51, the iliofemoral ligament is preserved.

Figs. 1 and 1 *a.*—Sciatic dislocation.

Figs. 2 and 2 *a.*—Iliac dislocation.

Figs. 3 and 3 *a.*—Obturator dislocation.

Figs. 4 and 4 *a.*—Infrapubic dislocation.

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tant kneels on the ground and fixes the pelvis. In emergencies the surgeon may dispense with the assistant and fix the pelvis by bracing his foot against the symphysis, after removing his boot, taking care not to exert pressure on the urethra. In this position simple traction upward sometimes suffices to effect reduction, if the head lies near the posterior border of the acetabulum. If, however, the head is displaced further backward, simple traction on the leg will cause it to lodge on the edge of the acetabulum, and it is evident that abducting the thigh, which *à priori* seems a rational procedure, only serves to wedge the head more firmly in its abnormal position. Thus the advice to bring the thigh into adduction before exerting traction becomes comprehensible, because this movement permits the head to glide more easily over the edge of the acetabulum. The manipulations, therefore, consist of traction in a position of adduction with some inward rotation. If this fails, the surgeon must try what traction in abduction with outward rotation will do. During this procedure the head of the femur sometimes slips around the outside of the edge of the acetabulum and becomes lodged in front of the articulation—so-called circumduction. The position of the head cannot therefore always be inferred from the nature of the laceration in the capsule, in view of the possibility of these secondary movements taking place. The capsular rent, which may be longitudinal or transverse,

Fig. 1.

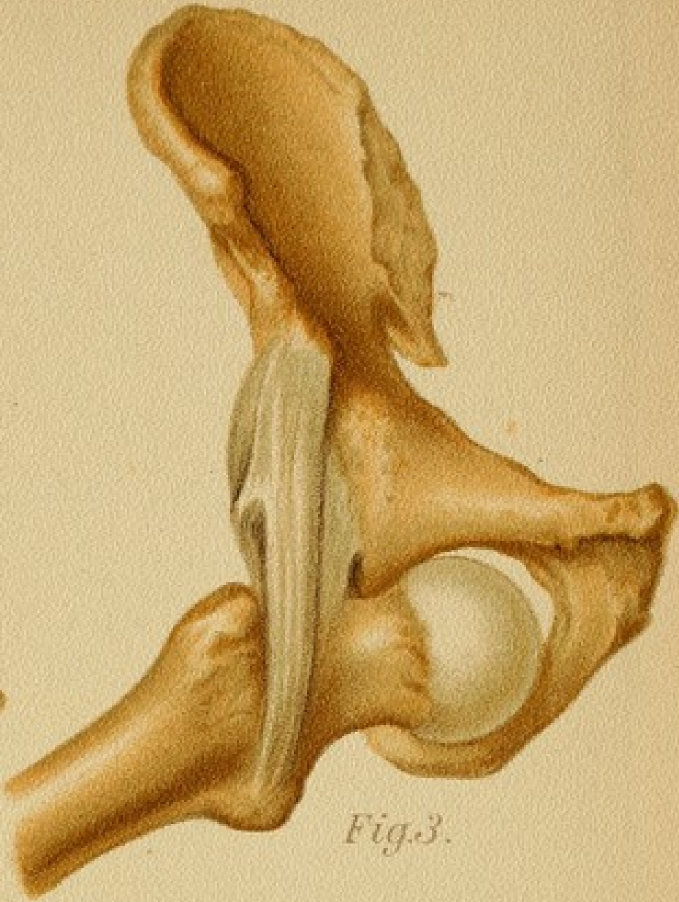

Fig. 3.

Fig. 2.

Fig. 4.

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Fig. 1a.

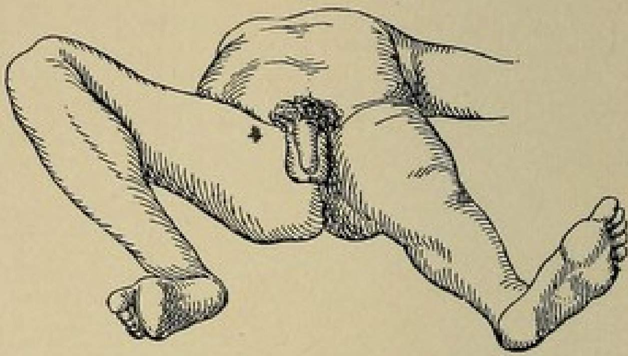


Fig. 3a.

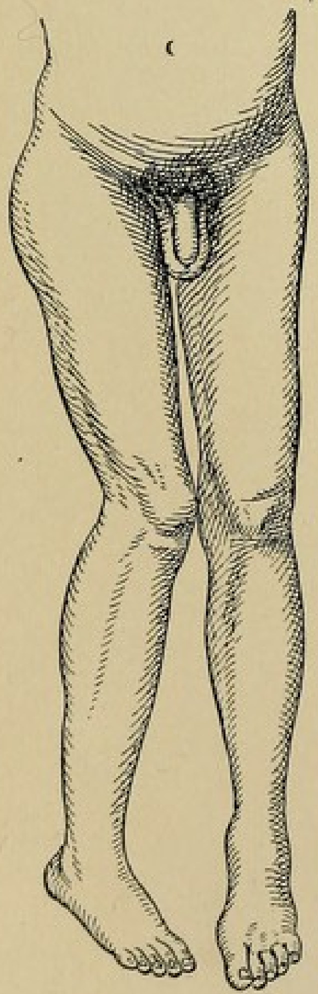


Fig. 2a.

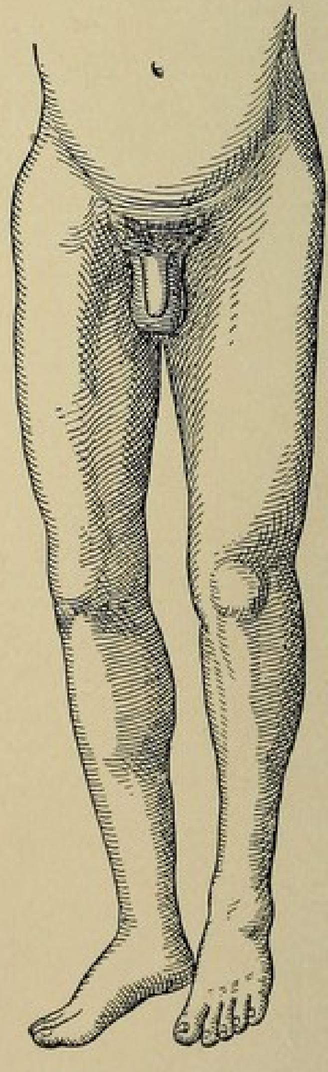


Fig. 4a.

sometimes has to be enlarged by appropriate movements. In some cases it forms a true obstacle to reduction, that cannot be removed without operative intervention. I have repeatedly reduced a dislocation of several weeks' standing in this way and obtained perfect mobility. In very old cases all hope of obtaining a movable joint must be abandoned and a resection or a subtrochanteric osteotomy performed to correct the position of the limb.

(B) Forward Dislocation (Luxatio antica sive præcotyloidea). (Plates 51 and 52.)

The forward dislocation is rarer than the backward variety. After the detailed description which has been given of posterior dislocations, but little space need be devoted to it.

An anterior dislocation may be produced artificially by outward rotation and abduction of the thigh. The capsule gives way in its anterior portion, somewhat above the middle, and if the thigh is at the same time overextended, a suprapubic dislocation results. If the tear in the capsule is lower down and the thigh is flexed, an infrapubic dislocation is produced.

In the living subject forward dislocation is produced in the same way, or by a corresponding dislocation of the pelvis while the leg is fixed.

In all forward dislocations the lower extremity is in a position of pronounced outward rotation and abduction.[1] The degree of flexion varies; in suprapubic dislocation it is slight, sometimes the limb is even in extension. In infrapubic dislocation flexion is always present, its degree depending on the extent to which the head of the femur is displaced inward; it is due to the tension of the Y-ligament.

[1] In very rare cases, when the head of the femur is displaced outward into the interior of the pelvis, inward rotation has been observed.

In suprapubic dislocations the head is directly felt in the inguinal region; it is found close to the edge of the acetabulum (iliopectineal dislocation with very little abduction), or on the pubic bone (pubic dislocation), or below the anterior inferior spine (luxatio subspinosa, luxatio subpubica). The femoral artery is sometimes forced up from its bed by the head of the femur. Pain in the distribution of the crural nerve is present. Sometimes the patient is still able to support himself on the injured leg.

In the infrapubic variety there is outward rotation with marked abduction and flexion. We distinguish *luxatio obturatoria* when the head is found in the obturator foramen; and the very rare *luxatio perinealis* when the head occupies the ascending ramus of the ischium. In luxatio obturatoria the head is buried in the depths of the tissues and cannot easily be felt. The prominence of the trochanter is missed and the leg is fixed in its abnormal position to which it returns after removal of the reducing force.

Diagnosis.—Fracture of the neck of the femur is excluded by the fact that while in this injury the leg is also shortened and rotated outward, the characteristic elastic fixation found in dislocation-fracture is absent. The leg can be straightened without any difficulty, but at once returns to its position of outward rotation. Other movements are not impossible as in dislocation.

Reduction.—In reducing a suprapubic dislocation it may be necessary to begin by overextending the thigh so as to bring the head of the bone nearer the acetabulum. The patient must be laid on a table. In all other forms the same rule holds good as for posterior dislocation; *i. e.*, the patient must be fully anesthetized and laid on the floor, and reduction effected by manipulating the leg, which is flexed at the knee. Inward rotation followed by abduction usually accomplishes the desired result. Circumduction of the head around the edge of the acetabulum can be prevented by pulling on the thigh at the same time.

(C) Rare Dislocations of the Hip-Joint

Downward dislocation (*luxatio infracotyloidea*) is extremely rare; the head of the femur is found at the lower edge of the acetabulum, the leg is lengthened. Marked flexion is always present, and usually a slight degree of abduction. Rotation is of no importance. In several cases the patient was still able to stand and even to walk on the injured leg, the head of the bone being braced against the lower edge of the acetabulum. The dislocation may be produced by forced abduction. Reduction is effected by traction on the flexed thigh.

Upward dislocation (*luxatio supracotyloidea*) is also very rare. The head is near the anterior inferior spine, where it is felt as a spherical prominence. The leg is extended, rotated somewhat upward, and adducted; at the same time it is considerably shortened. Reduction is effected by flexion and inward rotation.

Among the *irregular dislocations* of the hip-joint (see page 245) should be included those in which the dislocation is complicated by fracture of the femur, be it the neck or the trochanteric region, or of the pelvis, whether of the edge of the acetabulum or the acetabulum itself.

The term **central dislocation** (*luxatio centralis*) is used to designate an extremely rare accident in which the head of the bone is forced into the pelvis after the acetabulum has been demolished. The observation is of interest on account of its analogy to fracture of the base of the skull by the lower jaw.

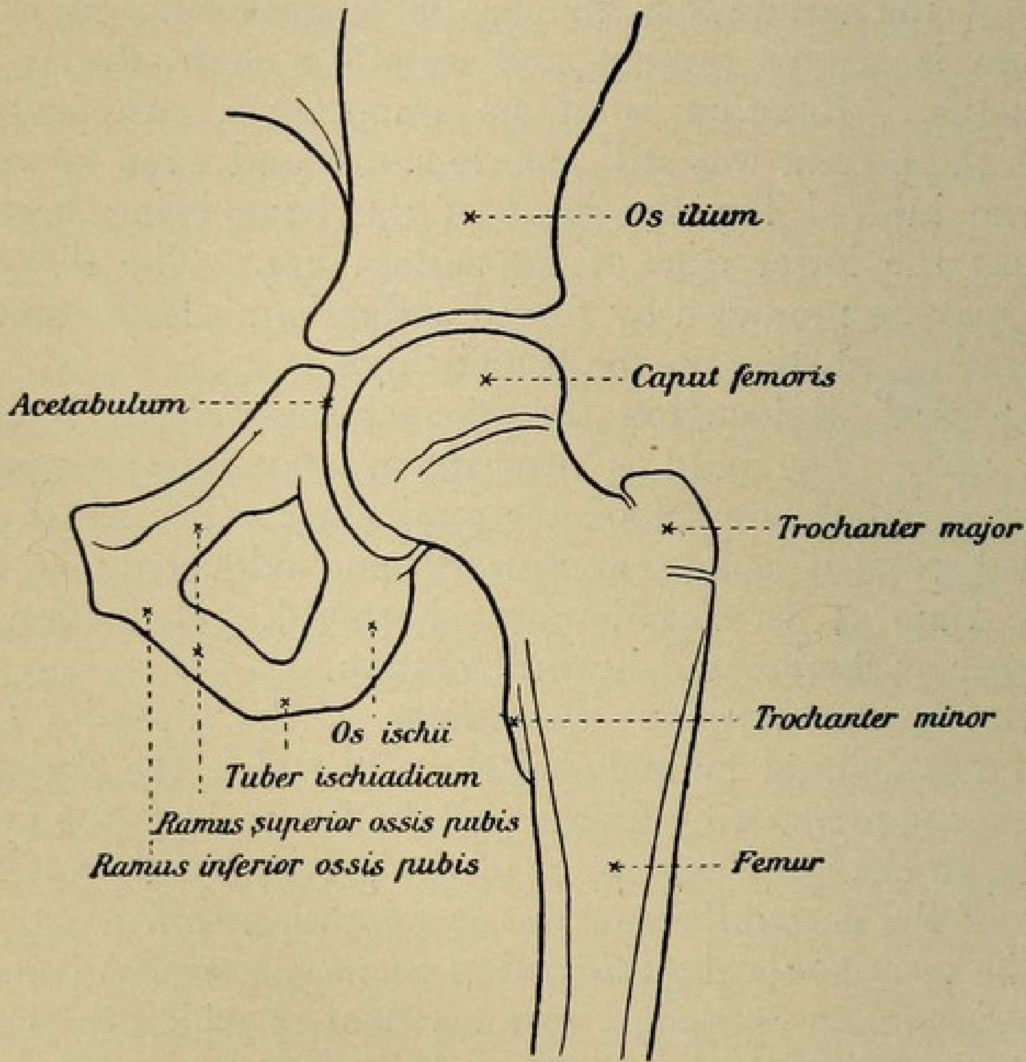
3. FEMUR

(A) Fractures of the Upper End

The upper end of the femur presents for examination the head, the neck, and the trochanteric region. The neck (*collum femoris*) lies between the cartilaginous border of the head and the trochanters; or to be more precise, between the two ridges of bone connecting the two tro-

PLATE 52 a.

Normal Hip-joint of a Lad Seventeen Years Old.—Skiagraph. Anterior view.



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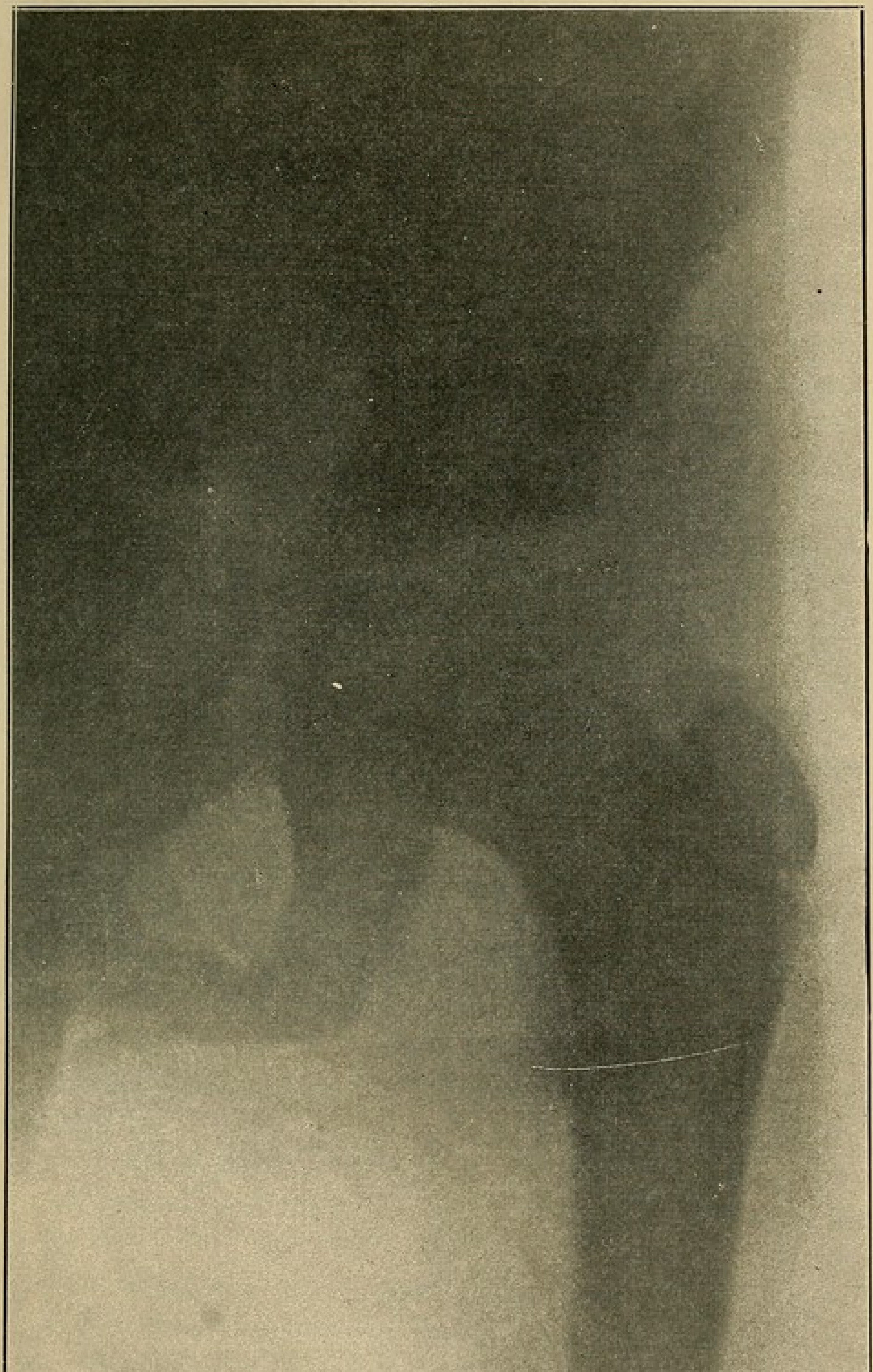
chanters in front and behind; that is to say, the neck lies between the intertrochanteric line in front and the intertrochanteric crest behind, to follow the new anatomic nomenclature. The capsule, under normal conditions, surrounds not only the head of the femur, but also a considerable portion of the neck. It extends forward as far as the intertrochanteric line and backward to a point somewhat beyond the middle of the distance between the head and the intertrochanteric crest.

The upper end of the femur, in addition, includes the



trochanteric region and the upper portion of the shaft immediately below the trochanteric region.

Fracture of the upper end of the femur may be produced in a variety of ways. Except in severe perforating injuries, such as gunshot fractures, the head and neck are not exposed to direct violence. The trochanteric and infratrochanteric regions of the shaft may be broken directly by bending, torsion, or compression; or indirectly by exaggerated movements at the hip-joint, such as adduction, abduction, overextension, or rotation. The last possibility will be readily understood by any one who has tried to produce hip-joint dislocations on the cadaver. The forcible movements of the thigh against the flexed pelvis often lead to fracture of the upper end of the femur before dislocation is produced. In the mechanism of these fractures the iliofemoral ligament, or ligament of Bertini, plays a conspicuous rôle, as do the attachments of the capsule and muscles. [According to Allis, of Philadelphia,[1] fractures of the pelvis rather than the femur quite frequently take place from an indirect violence exerted through the long axis of the femur. He has observed this clinically and experimentally.—Ed.]

Anatomically we distinguish the following forms:

1. Intracapsular fracture of the neck of the femur; the line of fracture corresponds to the junction between the head and the neck.
2. Traumatic epiphyseal separation at the upper end of the femur.
3. Extracapsular fracture of the neck of the femur; the line of fracture crosses the trochanter near the neck of the femur.
4. Fracture of the femur in the trochanteric region.
5. Isolated fracture of the trochanter major.
6. Fracture of the femur in the upper portion of the shaft, immediately below the trochanters.

[1] Transactions of the American Surgical Association, vol. XIX, 1901, p. 145.

PLATE 53.

Intracapsular (Median) Fracture of the Neck of the Femur (Fractura Colli Femoris Medialis).—Figs. 1 *a* and 1 *b*.—Pseudarthrosis at the seat of the intracapsular fracture; the neck of the femur has gradually disappeared by attrition. The head is fixed within the acetabulum by massive, newly formed adhesions. The trochanteric region presents a true nearthrosis within the old articular capsule, and articulates with the broken surface of the head. Both broken surfaces are smooth and almost polished in places, just as in arthritis deformans. Characteristic bony deposits are found both on the edge of the acetabulum and on the upper end of the femur. The latter is thickened and club-shaped by the enormous new-formation of bone. The false joint has permitted the two broken surfaces to glide up and down, and even shows the traces of this movement, as is indicated in the figure. (Author's collection.)

Figs. 2 *a* and 2 *b*.—Impacted intracapsular fracture. The specimen was taken from a woman eighty-two years of age (Glöwe). Figure 2 *a* shows the upper end of the femur seen from the side, with the probable normal outline. The abnormally high position of the trochanter major caused by the fracture is shown. The neck of the femur has been shortened by the impaction. Figure 2 *b* presents a frontal section of the bone. The impaction has been broken up and the head is shown in the position which it was made to occupy by the impaction. The shaft is in adduction with respect to the head of the femur or pelvis. (Author's collection.)

In practice we distinguish the following:

(a) **Fractures of the Neck of the Femur** (*Fractura colli femoris*).—These are relatively frequent. The division into intracapsular and extracapsular, while correct in theory, must be qualified in practice. The lines of fracture are not always transverse, and the relations of the capsule are neither uniform nor of any vital importance. In so-called extracapsular fractures the line of fracture often enters the capsule, if only because, as has been stated, the anterior portion of the capsule extends as far as the intertrochanteric line; hence the extracapsular fractures of the books are usually mixed—*i. e.*, they are partly intracapsular and partly extracapsular.

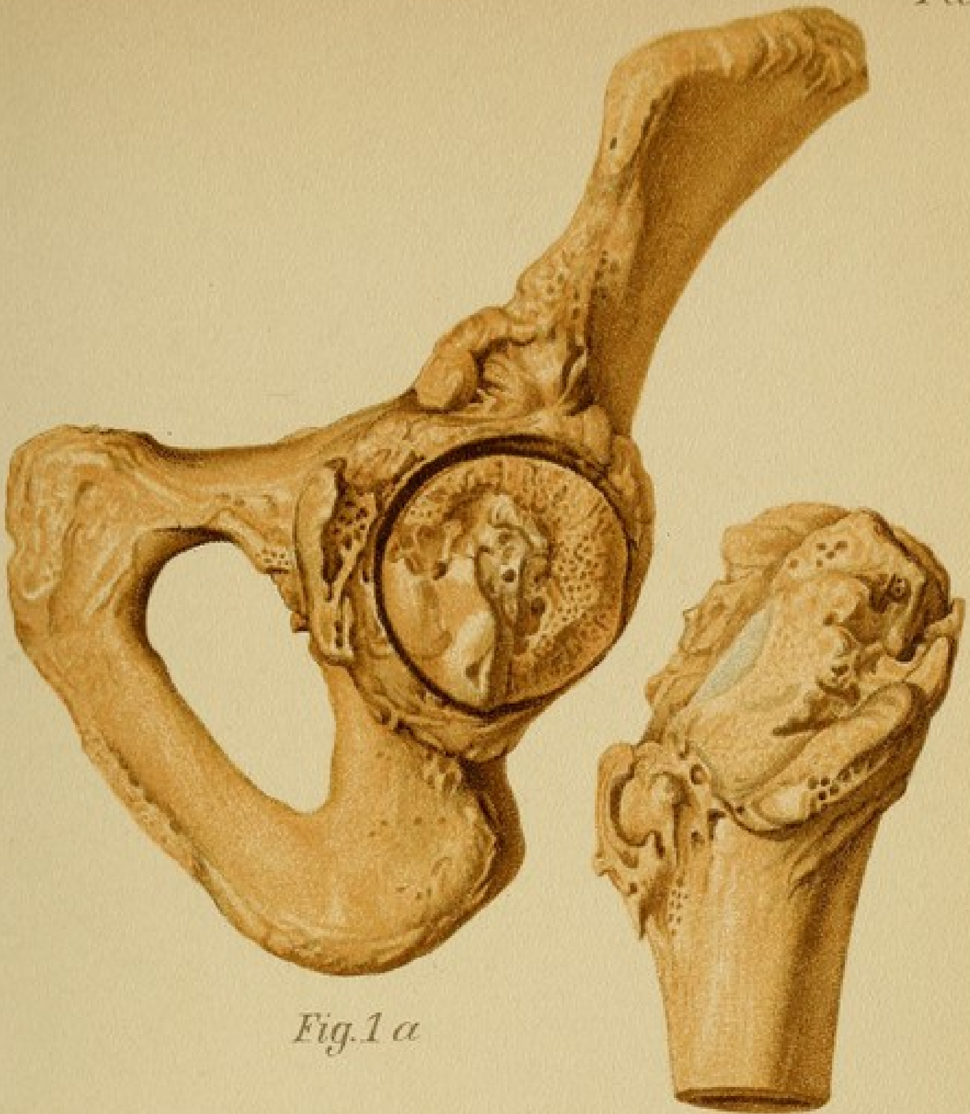


Fig. 1 a

Fig. 1 b

Fig. 2 b

Fig. 2 a

Lith. Anst. F. Reichhold, München.

To preserve the anatomic names, we might divide fractures of the neck of the femur into median or proximal, and lateral or distal, fractures.

Median fractures of the neck of the femur occupy the median segment of the neck of the femur, near the margin of the head, and are almost always intracapsular. The fragments consist of the shaft and neck, on the one hand, and the head, on the other. The head loses that part of its arterial blood-supply which is conveyed by the periosteum and by way of the neck. The circulation through the ligamentum teres, in old persons especially, is poor. The head may be cut off from all nutrition, like a completely separated fragment, and may succumb to retrogressive changes analogous to those that occur in the formation of a traumatic "joint-mouse."

The *lateral fractures* occupy the lateral portion of the neck of the femur near the trochanters. They may be extracapsular, but as a rule they are mixed; *i. e.*, the line of fracture is partly within and partly without the capsule. The upper fragment consists of the head and part of the neck, and is abundantly supplied with arterial blood through the capsule and periosteum.

There is much to be said in favor of this classification; as we go on, we shall learn of still other advantages that it possesses.

Etiology.—The ordinary fractures of the neck of the femur, as already remarked, are as a rule due to direct violence. The injuries which tend to produce them are of two kinds:

1. A *fall on the knee*, or, more rarely, on the foot with the leg extended, so that the blow is transmitted in the direction of the shaft and comes on the neck. As the head is fixed within the acetabulum, a fracture of the neck results if this force is sufficiently severe. In most cases the fracture is median. This is therefore a kind of compression-fracture.

2. A *fall on the trochanter major*—*i. e.*, on the side of

PLATE 54.

Extracapsular or Lateral Fractures of the Neck of the Femur (Fractura Colli Femoris Lateralis).—Figs. 1 *a* and 1 *b*.—Extracapsular fracture of the neck of the femur with impaction ; comparatively recent ; from an old woman. The fracture is distinctly extracapsular and even involves the trochanter. Figure 1 *a* shows the outer and upper surface ; figure 1 *b* a frontal section of the specimen. The impaction is very distinct ; the cervical fragment is driven into the trochanteric region. The neck is therefore shortened and forms almost a right angle with the shaft of the femur. In figure 1 *b* the outline of the corresponding sound limb is indicated, showing the total shortening of the injured thigh and the relatively higher position of the trochanter. (Author's collection.)

Figs. 2 *a* and 2 *b*.—Old extracapsular fracture of the neck of the femur with impaction ; bony union. The specimen was taken from a woman eighty-two years old (Glöwe) who had sustained an intracapsular fracture on the other leg (see Plate 53, Fig. 2). The fracture illustrated in the picture was produced in November, 1888. After the patient's death in March, 1893, the specimen illustrated in the plate was obtained at the autopsy. (Author's collection.)

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the body. The body striking against the ground, stone pavement, or wooden floor brings about a compression of the neck of the femur in its longitudinal axis, between the head and the trochanteric region. This compression, as in the analogous case of force applied to the long bones (upper end of the humerus), produces a fracture at the point of junction between the thinner compact neck of the femur and the more voluminous and spongy tissue of the adjacent region. Fracture takes place either at the junction of head and neck, or at the junction between the neck and the trochanteric region ; in other words, either a median or, what is more usual, a lateral fracture of the neck of the femur is produced. These fractures, like other compression-fractures, are usually characterized by impaction of the fragments.

In lateral fractures of the neck of the femur the lines of fracture extend into the trochanteric region ; inversely,

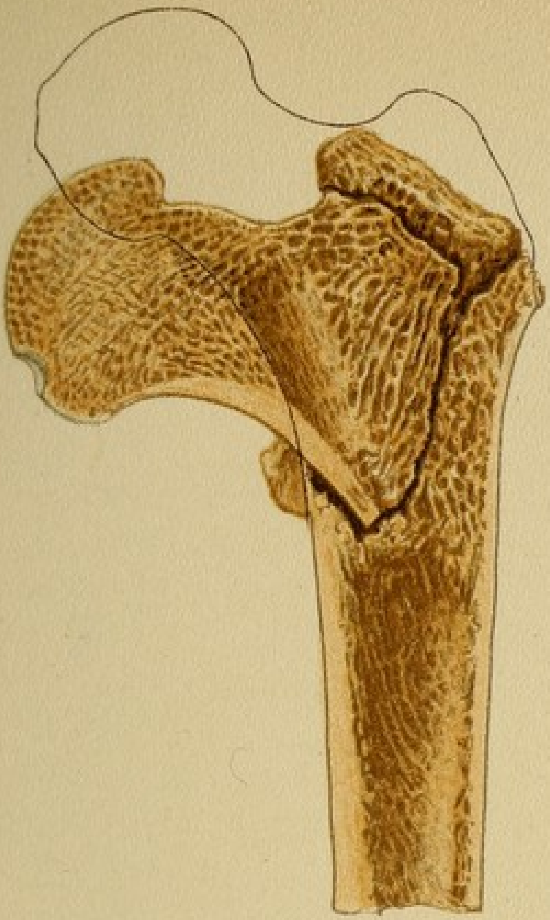

Fig. 1 b

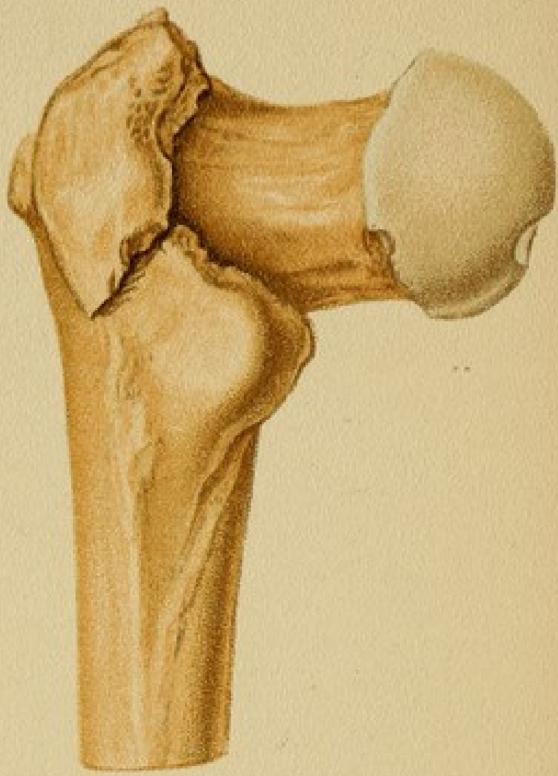

Fig. 1 a

Fig. 2 a

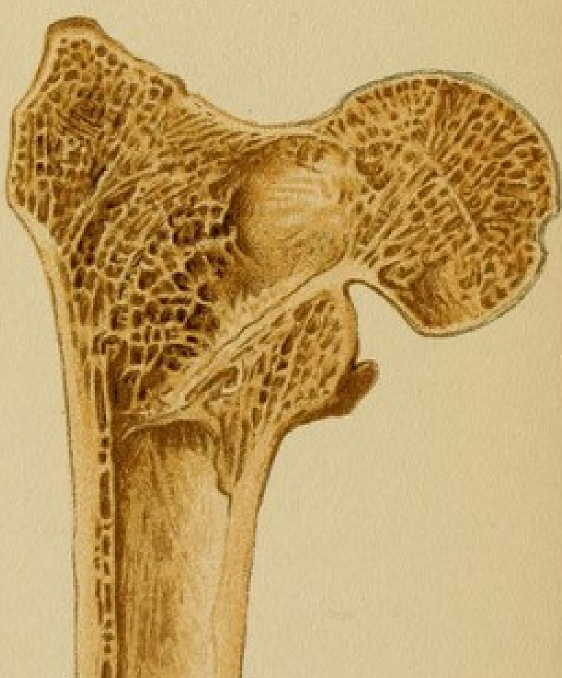

Fig. 2 b

Lith. Anst. F. Reichhold, München.

forced rotation by means of the ligaments, especially the Y-ligament, may bring about fractures in the upper portion of the trochanteric region, the line of fracture extending into the adjacent portion of the neck of the femur. In practice these fractures can probably not be distinguished from fractures of the neck, and are therefore to be included among the lateral fractures.

The great incidence of these fractures in old persons is explained by the greater brittleness of the bones, which is most pronounced at the upper end of the femur. We know that under normal conditions this structure is very firm and quite adequate to the task of supporting the body. The significance of the architecture of the bone trabeculæ is well known; they satisfy the highest mathematical and mechanical demands, and with the least amount of material in the form of bone-substance combine the highest possible strength. In old age the bone trabeculæ become less numerous and the fat-containing cavities between them increase in size, while the bone itself suffers a loss of organic substance. This leads to the production of an osteoporosis, which makes its appearance earlier in women than in men, and thus explains the greater frequency of fracture of the neck in women. Another factor is the angle which the neck of the femur forms with the shaft. This angle is subject to variations. The more it approaches a right angle, the more easily a force acting from below in the direction of the shaft of the femur will cause a fracture. As this angle is said to diminish as age advances, we have another explanation for the greater frequency of the accident in old people; but it is a great mistake to imagine that many older persons are liable to fractures of the neck of the femur. The accident is also observed in vigorous middle-aged men and even in youthful individuals, although, it must be admitted, with much less frequency.

Morbid Anatomy.—The study of Plates 53, 54, and 55, and the accompanying descriptions, coupled with the

PLATE 55.

Outward Rotation of the Thigh in Intracapsular (Median) Fracture of the Neck of the Femur.—Fig. 1.—Anterior view of the upper extremity of the left femur.

Fig. 2.—Posterior view of the same specimen.

Fig. 3.—Horizontal section through the neck and head of the same specimen. The section is somewhat oblique and follows the direction of the neck, upward toward the head.

Fig. 4.—In the same horizontal section of this specimen the cross-section of the corresponding normal neck of the femur is indicated in outline. The high grade of rotatory displacement of the fragments is well seen.

Fig. 5.—Frontal section through the normal upper end of the femur and acetabulum, from a child eight years old. The epiphyseal line is made out between the head and neck of the femur. The epiphysis is formed solely by the head of the femur. The greater trochanter has its own "anlage" (apophysis).

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succeeding remarks, will suffice to show how typical the appearances are in this fracture.

Median fractures of the neck of the femur are rare; they may be either loose or impacted; the impaction is probably never permanent. Bony union is a rare exception; although the anatomic specimens (Plate 55) show that it is a possibility. As a rule, a false joint is formed by the movements of the leg when the patient begins to use it. The pseudarthrosis represents a kind of sliding joint, due to the upward and downward movement of the end of the bone. In the most typical form the neck of the femur is lost through attrition, and the smooth surface of the trochanteric region articulates with the equally smooth fractured surface of the head. The head itself, as a rule, becomes fixed within the acetabulum by fibrous or bony adhesions.

Lateral fractures of the neck of the femur are much more common; in some cases they are impacted. Bony union is the rule, even when the case is not treated by a surgeon. An abundant callus-formation usually takes

Tab. 55.

Fig. 1.

Fig. 2.

Fig. 3.

Fig. 5.

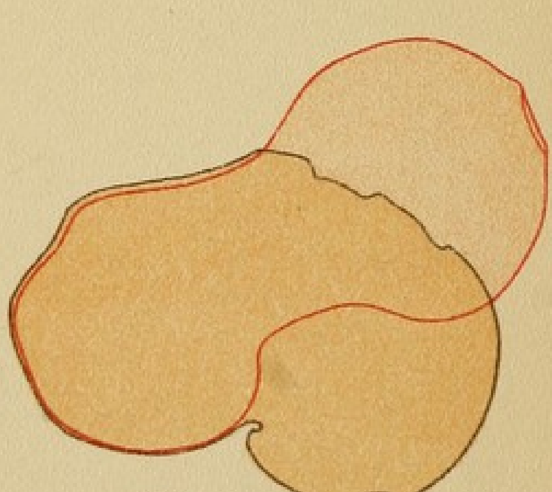

Fig. 4.

Lith. Anst. F. Reichhold, München.

place at the outer portion of the neck, and especially in the entire trochanteric region. The impaction may become loosened, especially if the patient uses his leg too early without any protective apparatus. A slight deformity may in this way become very much increased.

In fractures of the neck of the femur there is nearly always, in addition to the vertical displacement, some degree of outward rotation of the shaft, even when the fracture is impacted. In some cases this is a very prominent symptom. The outward rotation of the thigh is usually interpreted as the result of gravity causing the limb to fall outward. More recently a theory which appears to me more plausible has been advanced—namely, that the posterior portion of the neck of the femur being weaker, a force applied to the trochanter from without causes a more extensive fracture of the posterior periphery of the neck of the femur than in the remaining parts of the structure (Kocher).

What has been said applies equally to incomplete fractures or infractions of the neck of the femur. These may occur in the lateral, as well as in the median region, and may present only an angular depression of one side of the neck, in its upper, or preferably posterior, portion, usually associated with partial impaction. A considerable variation may thus be brought about in the angle formed by the neck of the femur with the shaft.

Symptoms.—If an elderly person is unable to stand after a fall on the knee or on the side of the body, and the injured limb exhibits the phenomena of shortening and outward rotation, the surgeon should always think of fracture of the neck of the femur. The condition must be differentiated from distortions, contusions, dislocations of the hip-joint, and fracture of the pelvis. It is hardly conceivable that the injury should be mistaken for dislocation, since outward rotation occurs only in anterior dislocation of the hip-joint. When the patient is lying in bed, he is unable to raise the injured limb or, in other words, to perform active flexion at the hip-joint. The leg usually lies in full extension without adduction or abduction.

Direct palpation of the seat of fracture is possible only when the trochanter has been involved, and then only to a very limited extent. While it is true that under normal conditions the greater trochanter can be felt in front, on the outside, and behind, it must be remembered that the structure is much less accessible after an injury to this region; hence it is rarely possible to make out the sharp edge of a fracture on the greater trochanter.

An important symptom is the apparent upward displacement of the trochanter, the position of which is determined in the same way as in the backward dislocation of the hip-joint. When the limbs are placed symmetrically with respect to the pelvis, it is found by mensuration that the distance from the anterior superior spine to the knee is considerably shorter than on the sound side. If it is found that the tip of the trochanter projects beyond the Roser-Nélaton line a distance equal to this shortening, it is a sign that the rest of the femur is intact, and the cause of the shortening is to be sought either in the neck of the femur or in the hip-joint. This result is controlled by finding that the distance from the tip of the trochanter to the knee, measured between the corresponding points, is the same on both sides. The shortening in such a case is due to displacement of the fragments occurring at the time of the injury and to the traction of the muscles acting on the shaft of the femur and trochanter (see Plates 53 and 54).

As a consequence of the shortening of the neck the trochanteric region is nearer the median line of the body in fractures of the neck of the femur, but the method of measuring the difference on the two sides is so difficult and inexact that it is of no practical value.

[In mensuration for diagnosis of fractures of the femur most authorities prefer to measure between the anterior iliac spine and external or internal malleolus. The malleolus seems to be a more fixed bony prominence than the patella. In fractures at the upper end of the femur or dislocations we have in English a certain terminology in regard to shortening and lengthening. When the patient is in the dorsal position, with the lower limbs parallel and the anterior iliac spine in the same horizontal plane, the limbs should be, in a normal individual, of the same apparent length. If the extremity under examination is shorter or longer, we speak of *apparent lengthening* or *apparent shortening*. When we measure between the anterior iliac spine and the malleolus, we speak of a *measured lengthening* or a *measured shortening*. If we find a measured difference between the anterior iliac spine and the trochanter, or the trochanter and the external malleolus, we speak of a *real shortening*. These are the most important measurements. The apparent difference or the measured difference between the anterior iliac spine and the malleolus does not of itself indicate that there is any real difference in the length of the limb, because an adducted limb looks shorter, but measures more between the anterior iliac spine and the external malleolus, so that in the normal limb adduction gives apparent shortening and measured lengthening, but no real shortening. The reverse is true of abduction. This should be borne in mind in the mensuration, because it is not always possible to fix the anterior iliac spine on the same horizontal plane and have the lower limbs in the same relation to the pelvis. If an adducted leg measures the same or less than the other limb, there must be some real shortening, and this measurement is of the greatest importance when, on account of swelling palpation of the trochanter is difficult or impossible. In fractures of the upper end of the femur, especially of the neck, the diagnosis can be made by measurements only. Manipulations to elicit crepitus are unnecessary, and would break up impaction if present.—ED.]

The injured limb can be moved in all directions, but not without giving pain. Crepitus is present unless the displacement has been so great that the fragments are no longer in contact. When the leg is extended and rotated about its longitudinal axis, a phenomenon is developed which is readily explained: In a median fracture the shaft of the femur revolves about an axis, the length of which corresponds to the fragment of the neck that is preserved intact and still remains attached to the femur. In a lateral fracture, on the other hand, the shaft of the femur turns only about its longitudinal axis, providing of course there is no impaction.

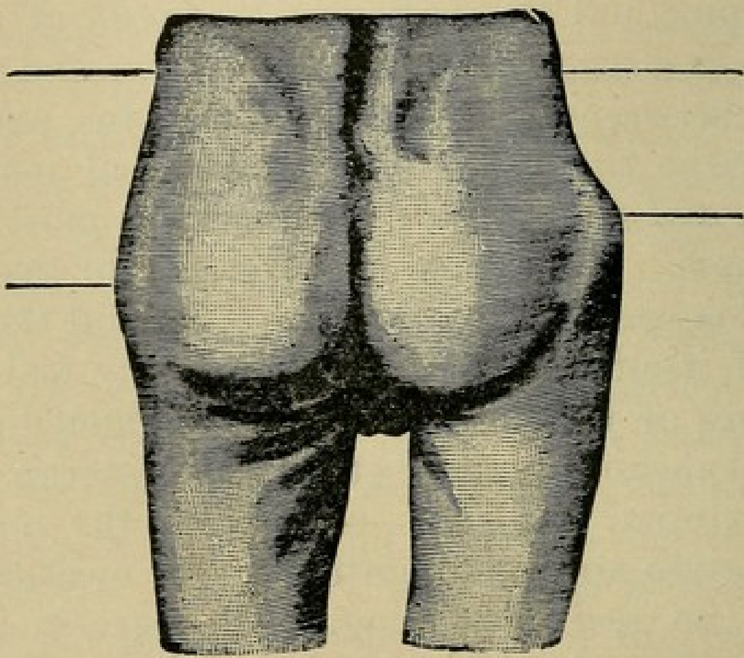

Fig. 122.—Displacement of the trochanter in fracture of the neck of the femur. Posterior view, on the right side. The illustration shows the upward displacement of the trochanter toward the anterior superior spine, which is indicated by a horizontal line. The left side shows the normal relations.

Impacted fractures of the neck of the femur, as a rule, present no diagnostic difficulties; they are always characterized by shortening and outward rotation of the leg, though both these symptoms are less pronounced than in fractures without impaction; in addition, there is sometimes a slight degree of adduction. These phenomena are all directly due to the displacement and subsequent impaction of the fragments. Crepitus is absent in impacted fractures, but considerable movement is often possible at the hip-joint. Rotation of the leg about its long axis at the hip-joint takes place about a radius corresponding to the length of the neck of the femur.

The clinical history that is obtained when an impacted fracture of the femur has been neglected or improperly treated, and the impaction later becomes broken up, is quite characteristic. The following case recently came under my observation: A woman (Lange), seventy-four years of age, on the 17th of May, 1896, fell from a step and struck her hip on the floor of the room. She was able to support her weight and move about, although not without great pain. In the beginning of August the pain suddenly became more severe, having been brought on, according to the patient, by sitting down on the edge of the bed. The patient now took to her bed and was treated with an extension apparatus. In this case the patient had walked about with an impacted fracture of the neck of the femur for a period of about two and a half months, after which the condition suddenly took a turn for the worse and the impacted fragments became loosened.

Incomplete fracture of the neck of the femur (infractions) cannot be positively differentiated from impacted fractures. The same upward displacement of the trochanter with a certain degree of outward rotation is present, owing to the fact that the posterior wall of the neck is thinner and sustains a deeper infraction. This class includes the cases of so-called coxa vara of traumatic origin.

[Incomplete fractures of the neck of the femur are not infrequently overlooked, especially in children, and not uncommonly in adults. The injury may be slight, the patients either do not go to bed at all, or stay there but a short time. The deformity due to the bending upward and backward of the neck of the femur at the seat of fracture may develop very slowly, and it is frequently some months before the complete picture and functional disability of traumatic coxa vara is established. Without much doubt, most of these cases could have been recognized in their recent state by careful measurements or an X-ray photograph. Sprengel [1] was the first to call attention to this. The recent literature is quite full of observations confirming Sprengel (see Progressive Medicine for December, 1899 and 1900.—ED.]

Treatment.—As the accident usually happens to old people, the general treatment and the maintenance or improvement of the patient's strength are of prime importance. If a hypostatic pneumonia makes its appearance, the case is practically hopeless, and the patient should therefore be encouraged to sit up and take deep breaths from time to time. Nutritious food must be supplied and the position of the body changed as often as possible. These are the cases in which the patient should be gotten up out of bed and made to walk about with an ambulatory splint as early as possible.

Lateral fracture usually heals by bony union. In general, the proliferation of bone in fractures or after osteotomy in the trochanteric region is very abundant. Median fractures, on the other hand, rarely unite by the formation of callus, because of the interference with the nutrition of the head, which is connected to its surroundings only by the ligamentum teres; this has been referred to. In many cases a true pseudarthrosis results; the head, which becomes fixed within the acetabulum, and the cervical fragment by constant attrition are gradually rubbed smooth and the two surfaces form a perfect sliding-joint.

If the diagnosis of impaction or incomplete fracture has been made, the limb must be placed at rest and protected against all injuries until sufficiently firm union for functional use has been obtained. For weeks after the injury there is danger of the impaction breaking up and the fragments becoming displaced, an event which is anything but desirable. The greatest care is therefore necessary in such cases. Nevertheless the patient must get up and

[1] Arch. f. klin. Chir., 1898, Bd. LVII.

walk about with an ambulatory splint at an early stage of the treatment.

In ordinary cases of fracture of the neck the fragments should be replaced as accurately as circumstances will permit by extension and inward rotation. A permanent extension dressing is then applied according to the principles of bandaging. The foot is to be supported on a well-padded sliding foot-rest (Volkmann's sled); outward rotation of the leg must be prevented. From 12 to 15 pounds suffice in most cases to bring the fragments into a favorable position. The dressing should be applied in such a way as to allow the patient considerable freedom of movement as he lies in bed. He may lie on his side or even be propped up with pillows without sustaining any injury or suffering pain. No additional splint is necessary. A plaster cast or an ordinary splint dressing may of course be used if desired. The recently invented ambulatory splints of Thomas, Liermann, Bruns, and others are particularly useful for this class of cases. In these splints the tuberosity of the ischium forms the fixed point and allows the application of permanent extension by means of a rubber band which may be replaced during the night by an ordinary apparatus with pulley and weights.

Operative fixation of the fragments by the insertion of a gimlet or nails from without is indicated only in very special cases. Recently Kocher has advised early resection of the head as the best method of treating a simple intracapsular (median) fracture of the neck. If this procedure is contraindicated by extreme age or weakness on the part of the patient, massage and passive movements should be begun as early as possible. The ultimate result in most cases is not very brilliant. In the case of old and infirm persons the surgeon may be glad if they eventually are able to walk at all with the aid of a cane. In more vigorous subjects the results are much more satisfactory; and if the treatment has been successful, may be very favorable, both as regards absence of deformity and the restoration of function (compare statistics on page 60).

[I have had three excellent results after resection of the head of the femur in cases of traumatic coxa vara with marked deformity and functional disability. After removing all or a part of the head, the rounded neck has been placed in the acetabular cavity. I have covered the surface of the acetabulum and the rounded end of the neck of the femur with wax, hoping to prevent bony union. Apparently it has been successful, as these patients have moderate motion at the hip-joint. Many cases of old fracture of the neck of the femur with marked functional disability would be greatly improved by resection of the head.—Ed.]

(b) **Traumatic Epiphyseal Separation at the Upper End of the Femur** (See Plate 55, Fig. 5).—This is a rare injury, and of course occurs only in youthful individuals. In this respect, therefore, there is a great difference between the femur and the humerus, for at the upper end of the humerus epiphyseal separations are relatively frequent. The explanation is found in the small size and hidden position of the epiphysis at the upper end of the femur, and more particularly in the fact that it is strictly intra-articular; that is to say, not even a piece of the capsule, not to mention a ligament, is attached to the epiphysis. The *mode of production* and *symptoms* are the same as for median fracture of the neck of the femur. The *treatment* also is analogous to the treatment of that injury.

Recent investigations of the anatomic conditions in traumatic epiphyseal separation have shown it to be the cause of the clinical picture known under the name of coxa vara (Sprengel [1]).

[This injury in its recent state is frequently overlooked, because at first in many cases the deformity and symptoms are slight, the patients usually walking about, sometimes at first without a limp. For this reason they come to the

[1] Arch. f. klin. Chir., vol. LVII.

surgeon first, a number of weeks or months after the injury, when the symptoms of the deformity of coxa vara traumatica are fully developed. In a few cases observed in the recent state the dislocation of the upper fragment has been so marked that complete reduction has been impossible. An immediate operation in such instances would undoubtedly be the best procedure.—ED.]

(c) **Fracture of the Femur in the Trochanteric Region.**—Fractures extending into the trochanteric region usually form part of a lateral fracture of the neck or, as will be seen presently, of infratrochanteric fracture of the femur. The symptoms and treatment call for no special remarks.

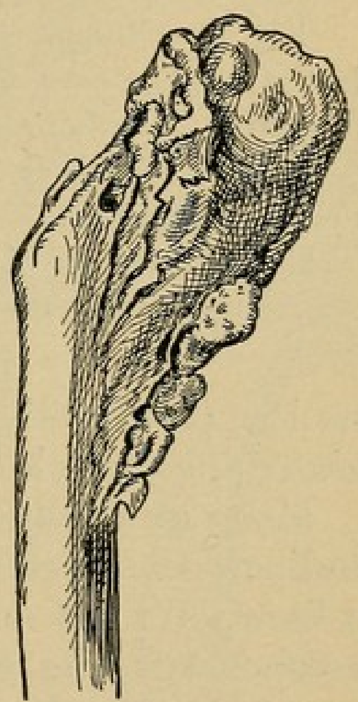

Fig. 123.—The same specimen as shown in figure 1 of Plate 56, seen from without. The upper fragment is in a position of flexion; the shaft is displaced forward and upward.

Isolated fracture of the greater trochanter is significant both from a practical and from a theoretic standpoint. It is a very rare injury, produced by direct violence, and logically characterized by longitudinal displacement with separation of the bony process (*ad longitudinem cum distractione*). The fragment is displaced upward and backward by the action of the gluteal muscles and is directly accessible to palpation; between it and the femur is a wide diastasis.

The simplest **treatment** consists in nailing on the fragment after replacing it as accurately as possible. This is facilitated by bringing the leg into abduction.

(d) **Fracture of the Shaft of the Femur below the Trochanter** (*Fractura femoris infratrochanterica*). (Plate 56.)—Fracture of the shaft of the femur presents

PLATE 56.

Various Fractures of the Femur.—Fig. 1.—Oblique fracture of the left femur below the trochanter ; posterior view (*fractura femoris infratrochanterica*). United by robust masses of callus, with displacement of the fragments. The fracture was probably produced by overextension. (Pathol. Inst., Greifswald.)

Fig. 2.—Oblique fracture of the upper half of the femur. Torsion-fracture with displacement of the fragment. The line of fracture involves the greater trochanter. (Pathol. Inst., München.)

Fig. 3.—Oblique fracture of the lower half of the femur with lateral displacement and shortening ; union by moderate development of callus. (Author's collection.)

Fig. 4.—Transverse fracture of the lower half of the femur with marked displacement ; united by abundant callus-formation. The displacement of the fragments corresponds to that which is typical of supracondylar fractures (see Plate 58). (Pathol. Instit., Greifswald.)

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no less peculiarities than the same injury at the lower end, above the condyles (*fractura supracondylica*).

Mode of Production.—It occurs by bending or longitudinal compression, the result of *direct* violence, such as a blow, or a fall on uneven ground, bringing the part into contact with the ground, in which case a *transverse* fracture is produced ; or, as the result of *indirect* violence by *torsion*, as in falling on the feet, or in twisting of the body (cave-ins, etc.), in which case it takes the form of a *spiral* fracture with an oblique or almost longitudinal line of fracture. Examples of the latter variety are found in relatively large numbers in pathologic collections.

This fracture is occasionally met with in adults who do heavy work which exposes them to accidents ; advanced age exhibits no special predisposition.

Symptoms.—In addition to the general symptoms of fracture, which are usually present in full array, the clinical picture is characterized chiefly by the tendency of the upper fragment to assume a position of marked flexion, sometimes amounting to a right angle, under the influence of the iliopsoas and gluteal muscles. On examining the

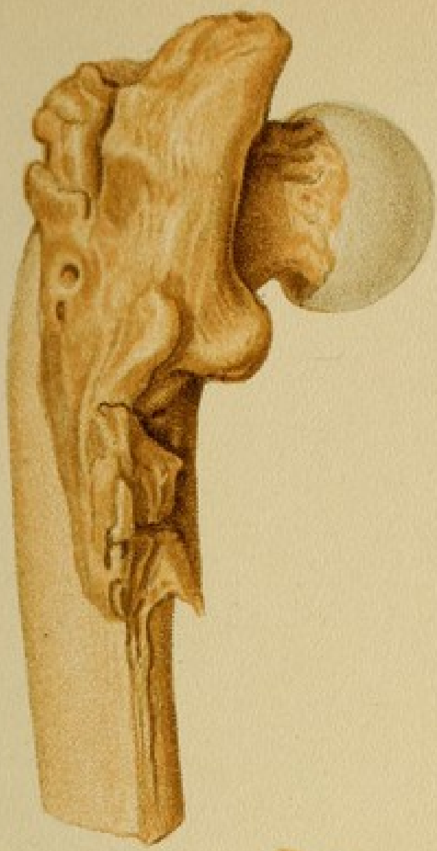

Fig. 1.

Fig. 2.

Fig. 3.

Fig. 4.

Lith. Anst F. Reichhold, München.

injured limb, abnormal mobility, etc., are found below the trochanter. In moving the limb, especially rotating the thigh, it is noticed that the trochanter does not accompany the shaft. If the fracture is seen for the first time several weeks after the injury, typical displacement of the fragments, with abundant callus-formation, is usually discovered.

Treatment.—Replacement of the fragments in as nearly a perfect position as possible, if necessary under anesthesia. Permanent extension dressing with heavy weights, the thigh being flexed to a greater or less degree on the abdomen. For the rest, the treatment should follow the general principles that apply to the management of non-impacted fractures of the neck and shaft of the femur.

[In fractures just below the trochanter I have found a combination of extension with fixation of the thigh, hip, and pelvis in plaster a very satisfactory method. Extension is first applied to a position about the middle third of the thigh; the patient is then anesthetized; strong traction is made on the limb in a flexed and abducted position; the thigh and pelvis are fixed in plaster. If properly applied, this is a very comfortable dressing. The results have been excellent.—Ed.]

(B) Fractures of the Shaft of the Femur. (Plates 56, 57, 58.)

For fractures of the upper, diaphyseal segment see preceding section (page 269).

Fractures in the *central portion of the shaft*, especially somewhat above the center, are common. Some of these fractures are produced by torsion, and assume the form of oblique or longitudinal fractures; but the majority are caused by bending due to *direct* violence, as, for instance, in being run over.

These fractures frequently occur in children, and are relatively favorable from the fact that the fracture is apt to

PLATE 57.

Typical Deformity in Fracture of the Middle of the Femur. —Fig. 1.—Muscle-preparation to explain the flexion of the upper fragment in fracture of the femur. The figure shows the iliopsoas muscle attached to the lesser trochanter. In this position of the specimen the picture, which was taken accurately from nature, can only show the gluteus medius, because it is the only one of the gluteal muscles that extends far enough forward on the pelvis to become visible.

Fig. 2.—Fracture of the right femur about its middle, in a boy twelve years of age (Hermann Binder, 1893); united with deformity. The picture shows shortening of the right femur; depression of the right half of the pelvis; and the right groin more nearly horizontal than the left. The thigh presents, immediately above the middle of the shaft, an angular prominence extending forward and outward.

Fig. 2 *a*.—Condition at the time of discharge from clinical treatment a few weeks later. The thigh had been broken at the seat of the fracture by osteoclasis and the deformity corrected by means of adhesive-plaster bandage and extension with heavy weights, with the thigh in abduction and moderate flexion. Its recurrence was prevented during the second period of treatment. The thigh is straight, and more nearly approaches its fellow in length.

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be transverse, with preservation of the iliac periosteum, thus preventing any considerable displacement of the fragments. In adults, on the other hand, there is usually marked displacement of the fragments; the line of fracture is usually oblique and favors the production of deformity by the traction of the enormous mass of muscles, the effect of which is exerted chiefly in the longitudinal direction. As a rule, it is easy to demonstrate abnormal mobility. Crepitation ought to be well marked, and I must insist on the importance of establishing the presence or absence of this symptom beyond a doubt; for if crepitation is absent, either great overriding of the fragment or interposition of soft parts is to be assumed. Crepitation is established in order to bring the surfaces into the desired contact and guarantee union in good position. The shortening brought about by longitudinal displacement of the

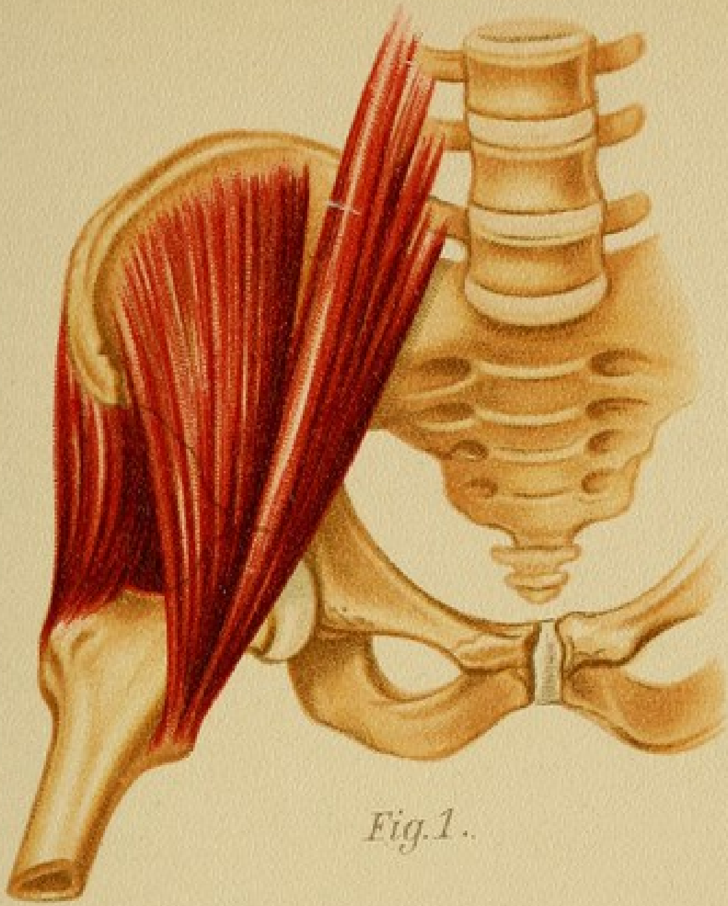

Fig. 1.

Fig. 2.

Fig. 2 a

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fragments is always easy to determine by measuring the distance from the knee,—*i. e.*, the lower edge of the patella to the trochanter, or, better, to the anterior superior spine, —when the legs are in perfectly symmetric position.

Fractures above the middle of the shaft are characterized by a typical deformity which, I regret to say, is only too often noticed after the fracture has united when the patient again seeks medical or surgical aid for the angular deformity. Fracture of the shaft of the femur that has united with deformity shows, above the middle of the shaft, at the seat of fracture, an angular prominence directed outward and forward. In other words, the upper fragment is flexed by the action of the iliopsoas muscle attached to the greater and minor trochanters, and abducted by the glutei. The lower fragment overrides the upper at the seat of fracture, while the lower portion of the shaft is still under the influence of the adductor muscles. In this way the above-mentioned angular deformity is produced. More rarely an incurvated deformity results at the seat of fracture (see Fig. 124); these deformities can easily be avoided by appropriate treatment.

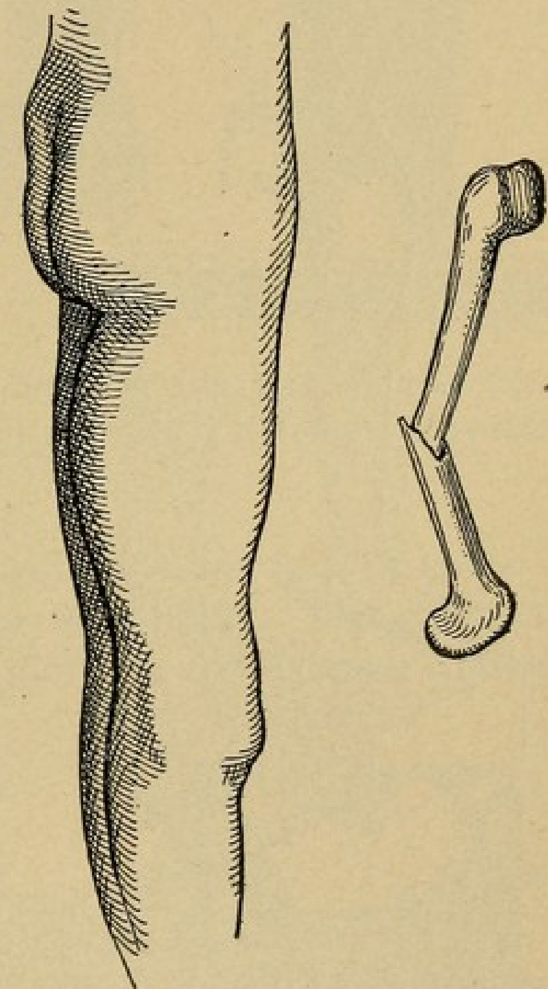

Fig. 124.—Fracture in the middle of the femur in a man thirty years of age, united in bad (incurvated) position, with sketch of a femur to explain the deformity.

In cases with much deformity, especially if some of the soft parts have been interposed between the fragments, a pseudarthrosis quite commonly develops (Fig. 125).

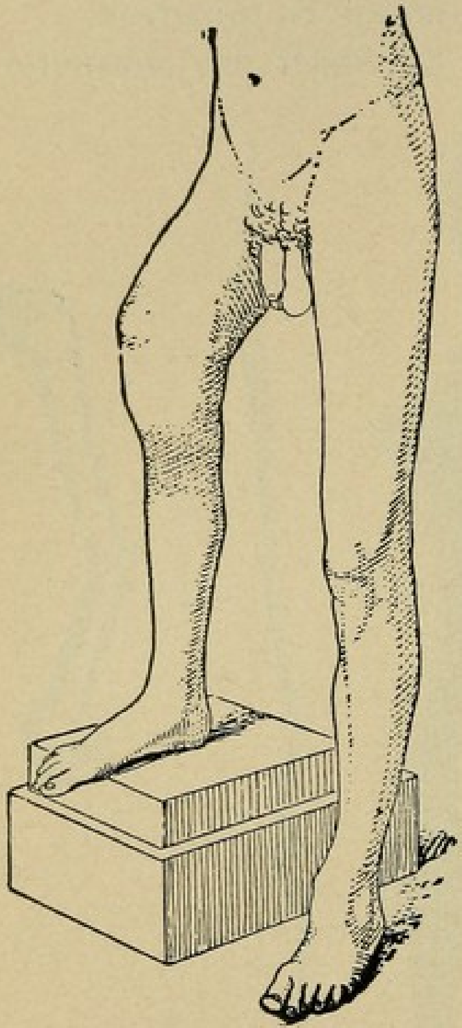

Fig. 125.—Pseudarthrosis of the femur after fracture somewhat below the middle. In this position the prominence of the upper fragment is seen above the knee-joint. Extraordinary longitudinal displacement. Operation : Resection of the ends of the bones and lengthening of the femur. Firm union.

Treatment.—The treatment of fractures of the shaft of the femur has become much simplified since the adoption of permanent extension by means of weights. This method neutralizes the effect of the muscle and enables us to avoid secondary displacement ; but it is a mistake to suppose that the treatment is anything but a laborious one. In the first place, the dressing must be accurately applied so that there will be no pressure at any spot ; it must be wide enough and strong enough to permit the application of 20 to 25 pounds. Adhesive strips made of strong sailcloth or Heusner's strips (see page 71) are used. To prevent friction of the leg against the mattress a sliding foot-rest (Volkmann's sled) is used which at the same time allows the foot to be placed in a certain position, if necessary in rotation. Counterextension is best effected by raising the foot of the bed on blocks of wood or bricks, and laying another block under the sound foot so as to give it something to brace against (Fig. 127). As an aid to the treatment by extension, even when used in fractures of the upper extremity, I would recommend a procedure which I have employed for many years, and which consists in

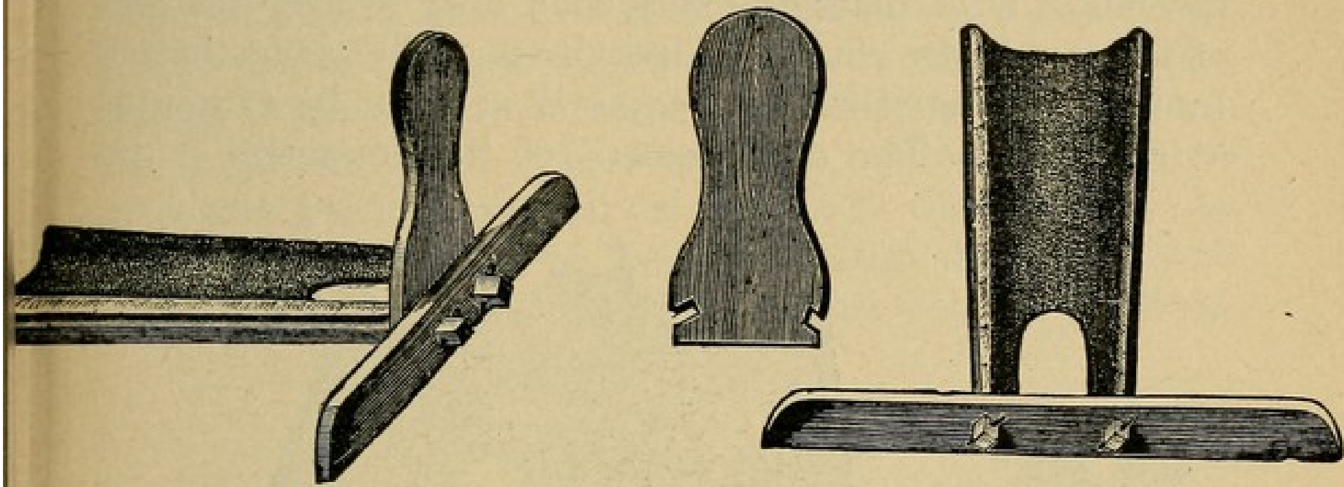

Fig. 126.—Simple "sled" or sliding foot-rest, consisting of three pieces which are easily fitted together and can, if necessary, be readily improvised.

stretching the leg with considerable force once or twice a day after raising it slightly from its support. My assistants do this regularly during their morning and evening rounds.

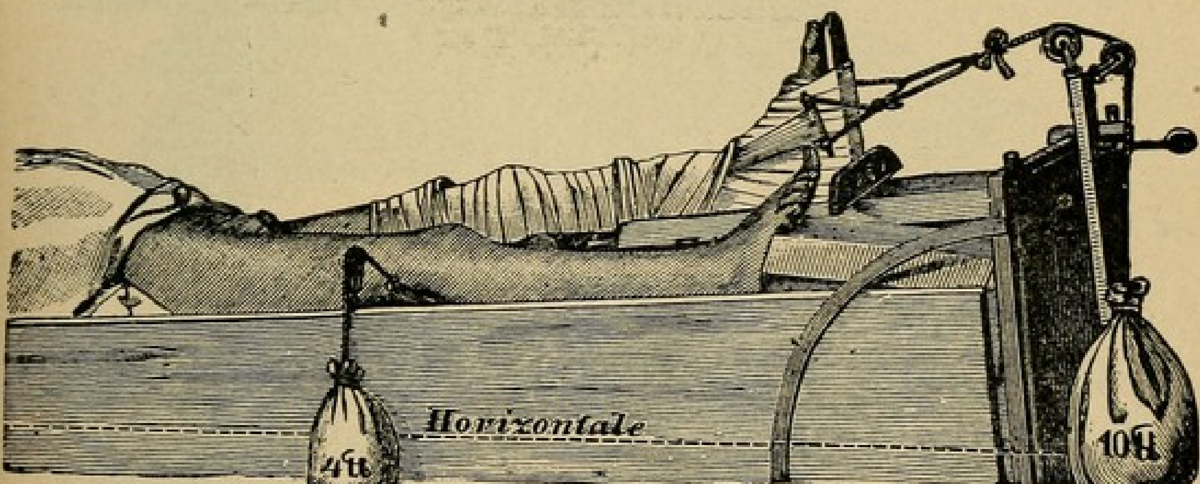

Fig. 127.—Fracture of the femur with extension apparatus (permanent extension by weights), and lateral traction applied under the sound limb.

The advantages of the procedure are that the articular surfaces are moved, though ever so slightly, that the fragments are replaced every day as perfectly as possible, and that callus-formation is hastened.

After the patient has been placed in bed in the manner described, it becomes the surgeon's duty to keep the seat of fracture under constant supervision. This is facilitated by the fact that it is freely exposed and can be examined at any time. The displacement of the fragments is not

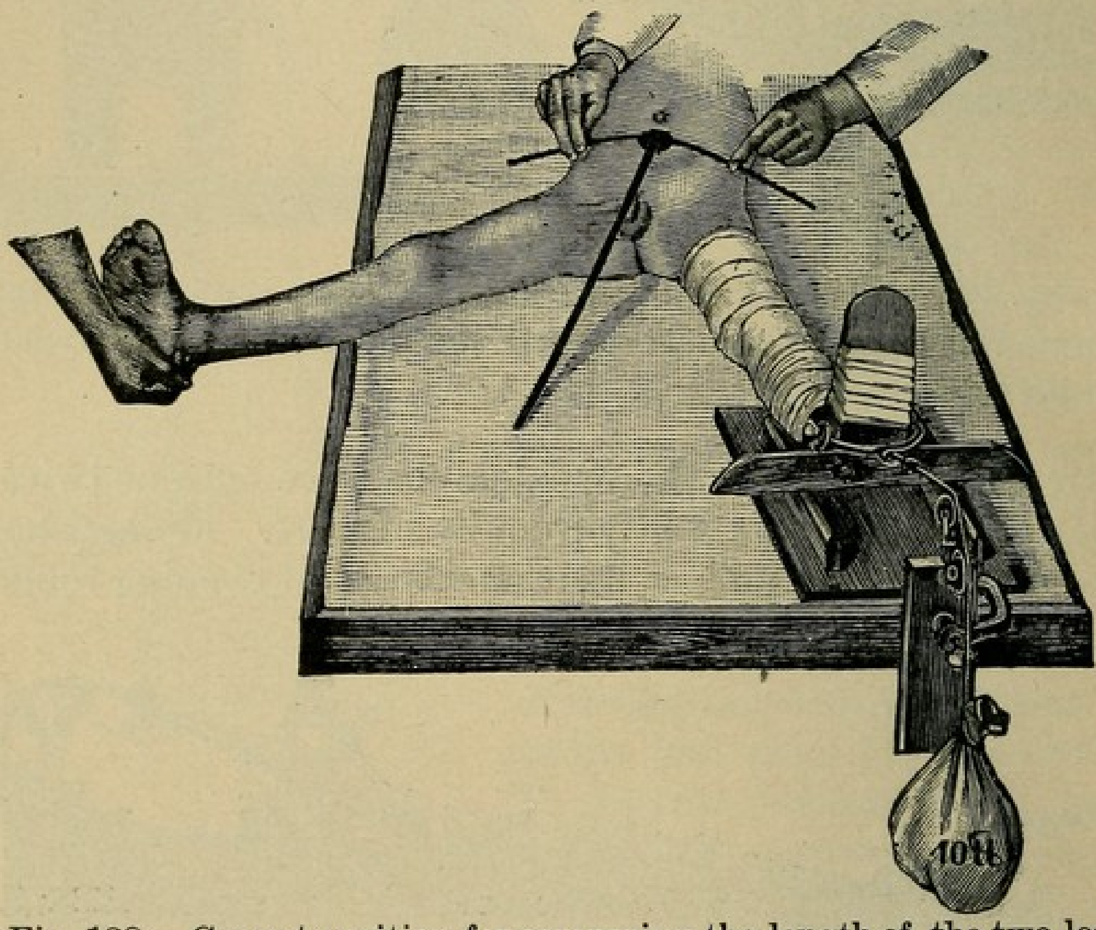

Fig. 128.—Correct position for comparing the length of the two legs in fracture of the femur. The sound leg has been brought into symmetric position as regards abduction and flexion, to correspond with the injured leg in the extension apparatus.

always readily felt, however, on account of the enormous mass of muscles; hence the length of the leg must be accurately measured from time to time and compared with that of the other side. It is not difficult to measure the injured thigh, say, from the lower edge of the patella to the anterior superior spine, without removing the bandage.

The sound limb must, however, be measured in an exactly symmetric position. For this purpose the horizontal axis of the pelvis, *i. e.*, the line connecting the two anterior superior spines, must first be determined. By the aid of a line drawn at right angles to it at the center and prolonged downward,—for instance, a string or a tape-measure,—the degree of abduction of the injured limb, which of course remains undisturbed within its dressings, can be measured, whereupon an assistant brings the sound limb into a similar position of abduction and flexion. Not un-

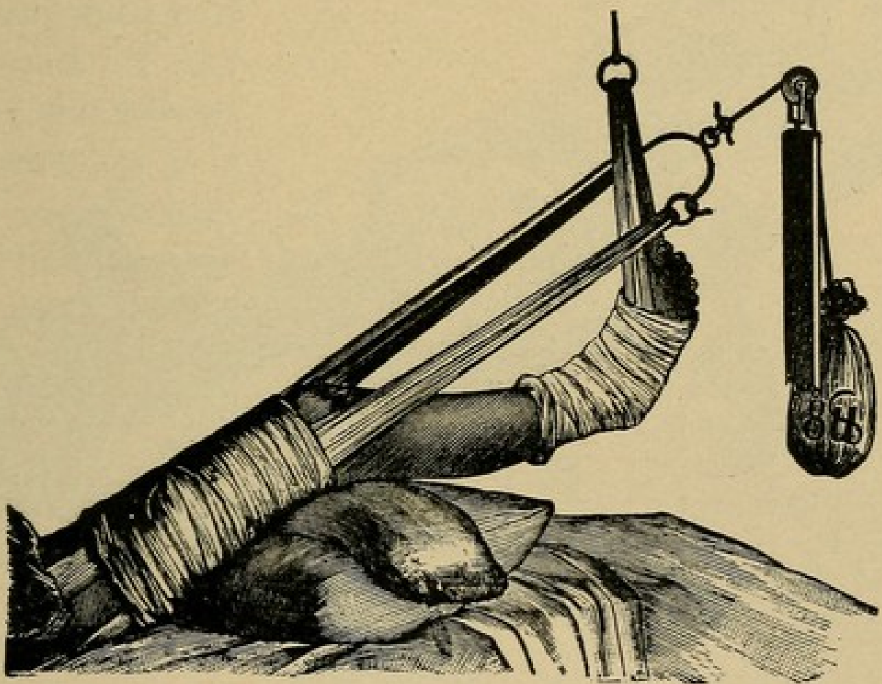

Fig. 129.—Extension in fracture of the femur, when the knee-joint is contracted in flexion and the leg cannot be utilized for extension.

til it is has been done are we ready to measure between the corresponding points on the sound leg and compare the result with that obtained on the injured side (Fig. 128).

While this description appears somewhat complicated, the procedure, as a matter of fact, becomes quite simple after a little practice, and is exceedingly important if a favorable result is to be hoped for.

Mensuration not infrequently shows that simple extension, even with a heavy weight, is inadequate to overcome the deformity. In such cases the old rule, to bring the lower fragment into the same position as the upper one, must be followed. The injured leg is brought into a position of moderate abduction and flexion, and extension by weights is applied both in the longitudinal direction and laterally, so as to limit the abduction of the upper fragment.

In children vertical extension is an excellent procedure. The fear of bringing about anemia of the leg and insuffi-

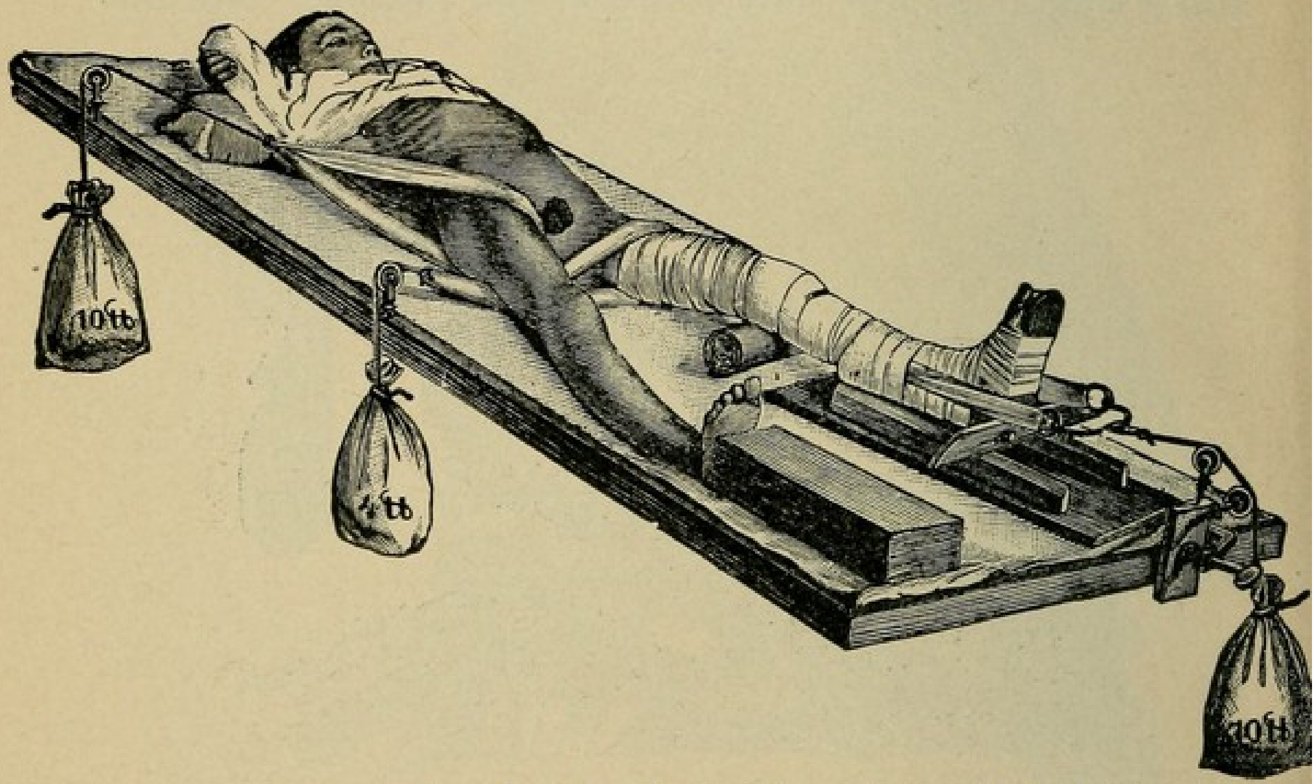

Fig. 130.—Extension bandage in fracture of the left thigh with outer extension on the sound side and lateral traction on the upper fragment to limit abduction.

cient development of callus by vertical elevation is, I am sure, unfounded except in the rarest cases. I have never experienced it, and the difficulty could readily be overcome by applying an elastic bandage (india-rubber drainage-tube, see page 53) with slight pressure around the thigh above the seat of fracture.

In new-born and very small children the best method of treatment consists in fixing the thigh in extreme flexion on the abdomen by means of a broad strip of adhesive plaster passed around the entire body and thigh.

A plaster-of-Paris dressing is sometimes indispensable if the patient is to be transported, or if delirium tremens makes its appearance. It is becoming more generally used, as it enables the patient to walk at an early period and permits ambulatory treatment.

[In fracture of the shaft of the femur, the following dressing is a very satisfactory one: First extension with heavy weights in a slightly flexed and abducted position. The thigh is then fixed with four to six well-padded splints held in place by tapes which buckle. The extension prevents shortening, the splints hold the movable fragments in good apposition. This dressing has the advantage over permanent plaster because it allows the daily examination of the seat of fracture. The posterior splint should be well padded to fit the normal curve of the femur and prevent the angular deformity which is not uncommon in this direction, if not prevented. This dress-

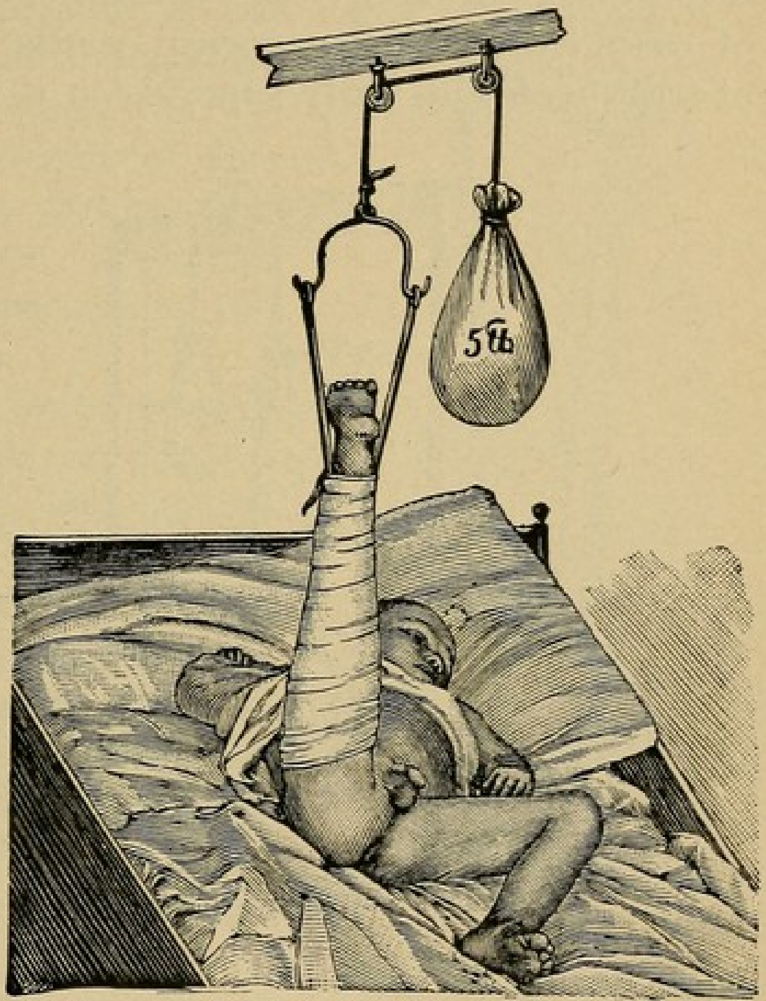

Fig. 131.—Vertical suspension for fracture of the femur in a child. The traction also produces abduction of the injured leg, as shown by the oblique position of the pelvis.

ing is illustrated by Scudder.[1] In a large surgical clinic fractures of the shaft of the femur united with marked deformity very frequently come for treatment, demonstrating the great tendency for not only overriding of the fragments, but marked angular deformity in these fractures. Yet we seldom observe this deformity in the large number of cases treated in the surgical wards, where this method of treatment with daily supervision is followed.—Ed.]

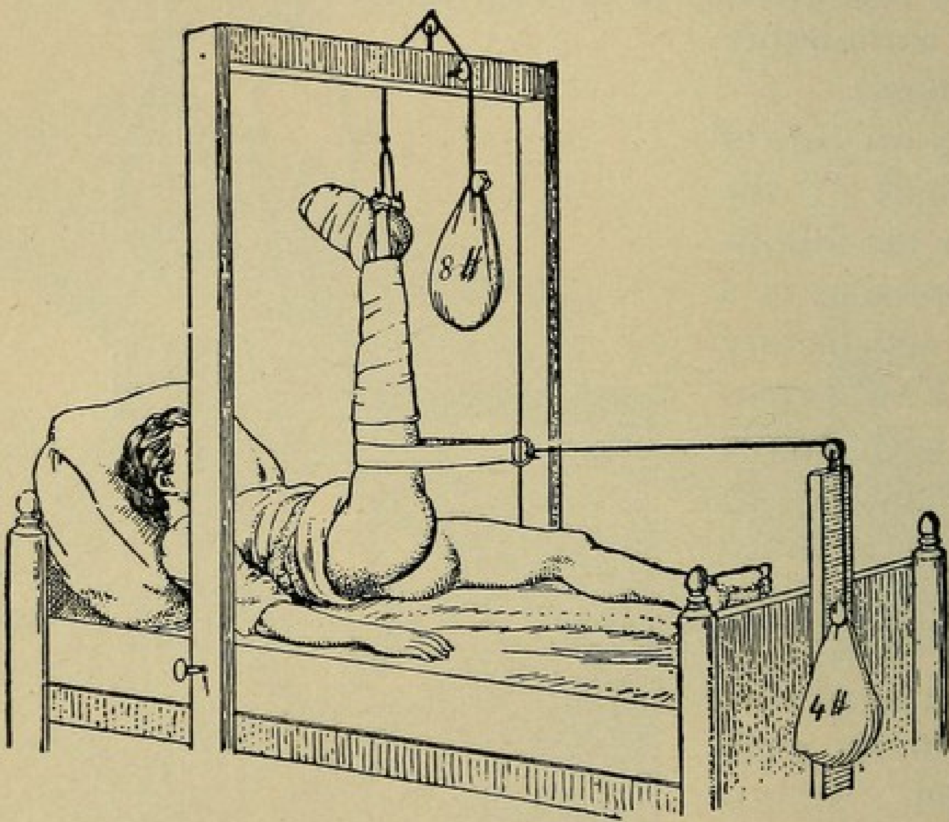

Fig. 132.—Extension dressing with the limb in vertical position, and lateral traction to counteract the excessive flexion of the upper fragment. Child five years old (Else Hoffmann, 1896). Recovery without deformity.

The principle of the ambulatory treatment of fractures of the femur is based on the fact that the bandage supports the tuberosity of the ischium. The pelvis is thus supported and the leg hangs free, or extension may even be applied by the aid of buckles and elastic strips attached to the lower end of the splints, which in that case must be

[1] *Loc. cit.*, p. 276.

longer than the leg. Hessinger has devised a very intricate apparatus of this kind. The simplest model, and one that has long been used in the treatment of various other injuries, such as diseases of the knee-joint, is the very useful splint introduced by a Liverpool physician, H. O. Thomas. Modifications of this splint devised by Bruns, and similar complicated apparatus (Liermann, Roth), possess no additional advantages.

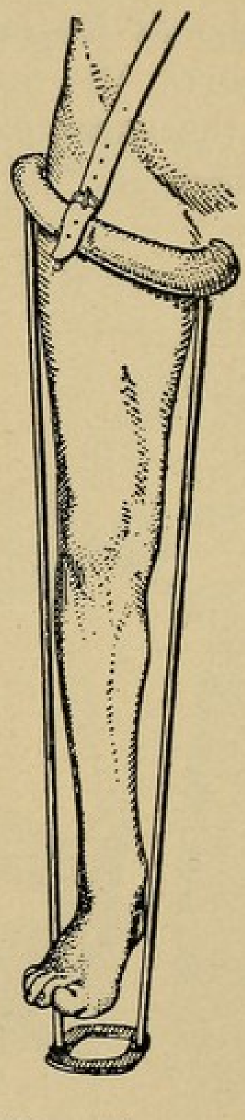

Fig. 133.—Thomas splint. The weight of the body is supported on the tuberosity of the ischium; the leg hangs free within the dressing. By means of a leather loop attached to the leg above the ankle and fastened below to the lower end of the splint, extension —elastic if desired—can be applied to the leg; otherwise the leg is simply fixed by means of roller bandages.

Plaster-of-Paris dressings may also be used for this purpose, as Albers, Dollinger, and others have proved; the technic of applying them is, however, somewhat more difficult, and care is accordingly necessary to avoid the production of pressure-sores. Albers has worked out a very useful method of applying a plaster cast without the interposition of a pad between the dressing and the skin. After thoroughly greasing the skin, he first applies a bandage inclosing the foot, leg, and region of the knee; then a wide thick ring of plaster-of-Paris is fitted on the thigh so as to brace against the tuberosity of the ischium. Vigorous extension is then applied to the foot and the rest of the thigh covered with a plaster bandage which is firmly attached to the first two pieces, which have by this time "set." (See Figs. 134 and 135.)

I should hesitate to recommend the method illustrated in figures 134 and 135, except to one possessing more than the usual experience in the use of plaster-of-Paris dressings.

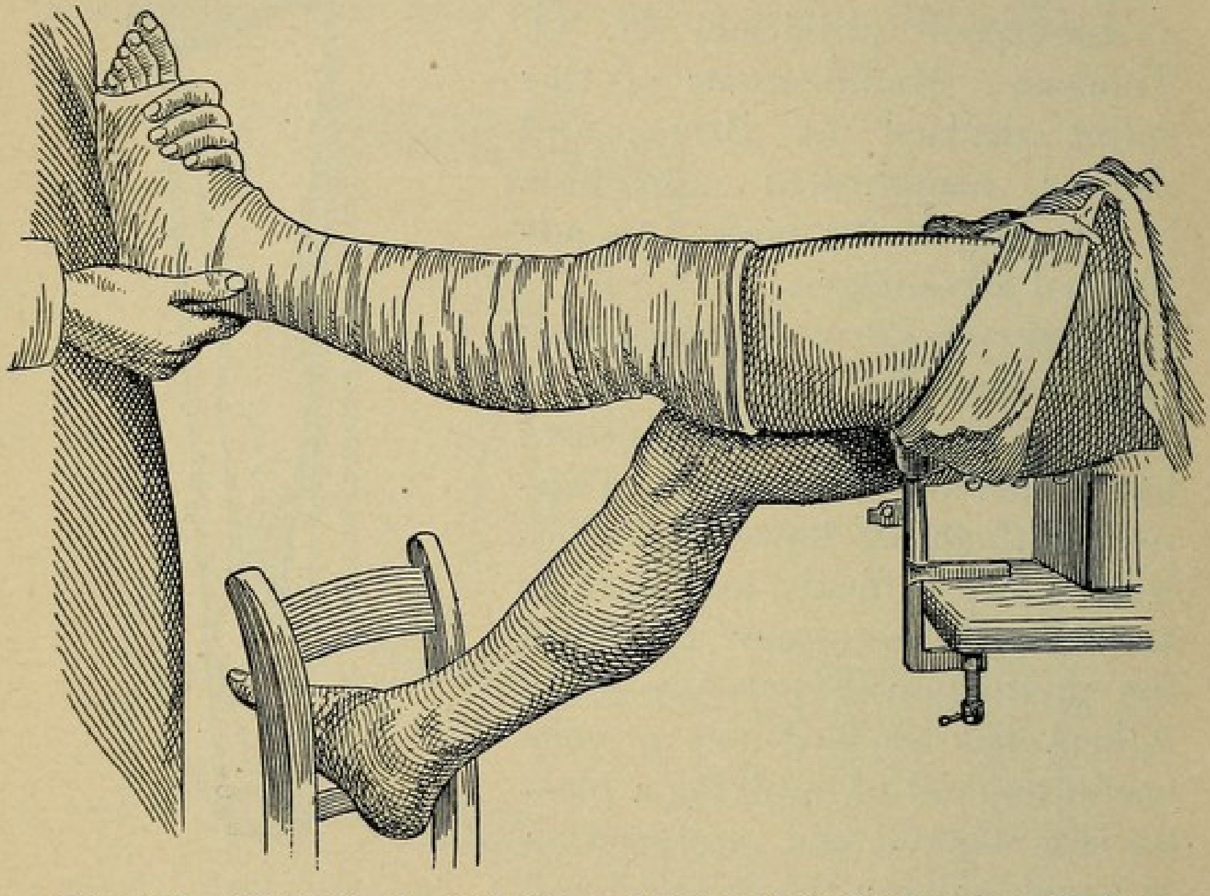

Fig. 134.—Method of applying a plaster-of-Paris dressing in fracture of the femur. That portion of the bandage which incloses the foot and leg and extends above the knee is completed, also the upper ring (Sitzring), which is made up of a number of plaster-of-Paris bandages and fits closely against the tuberosity of the ischium. The figure shows the injured leg. The patient is lying on a pelvic support, while an assistant exerts vigorous extension on the lower portion of the bandage, which is already set. The remaining middle portion of the plaster-of-Paris dressing is about to be applied.

There is no doubt that a large proportion of fractures of the thigh can be treated by the ambulatory method from the beginning without endangering the result, and that the method is greatly to the advantage of the patient's general condition;[1] but in my opinion it is to be recommended only in very special cases, in which in spite of watchful care and nursing, the patient shows signs of suffering from two or three weeks' confinement in bed. The technic of this treatment is difficult; there is a greater tendency to deformity; and it requires a supervision which the practising physician is not always in a position to give. For the present the procedure cannot be said to be a suitable one in general practice (compare page 73).

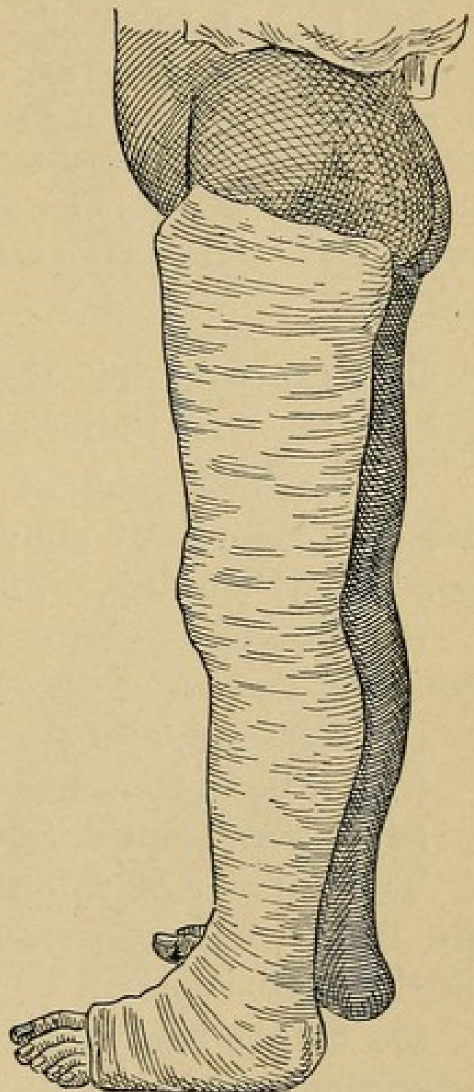

Fig. 135. — Ambulatory plaster-of-Paris dressing applicable in fracture of the middle or lower half of the shaft of the femur. (See Fig. 134.)

When a fracture has healed with marked deformity, the leg must be broken at the seat of fracture by means of osteoclasis or osteotomy, and extension treatment carried out with careful attention to every detail. In this way it is often possible to bring about partial correction of considerable degrees of shortening if sufficiently heavy weights are used; that is, from 20 to 25 pounds. If a false joint has been formed, a good result may be obtained by an appropriate surgical operation.

[1] Ambulatory treatment of fractures of the upper half of the shaft is to be condemned without qualification, on account of the danger of deformity from flexion of the upper fragment.

PLATE 58.

Typical Displacement of the Fragments in Supracondylar Fracture of the Femur.—Fig. 1.—Supracondylar fracture, produced artificially on the cadaver; postero-anterior view.

Fig. 1 *a*.—Skeleton-preparation in the same position as figure 1. The displacement at the seat of fracture is evident; the lower fragment is more strongly flexed at the knee-joint by the action of the calf muscles. In figure 1 the vessels are shown as they lie astride, so to speak, of the projecting edge of the lower fragment (danger of gangrene). The sciatic nerve is also shown alongside of the vessels.

(C) Fractures of the Lower End of the Femur.
(Plates 58, 59, 63, Fig. 1.)

At the lower end of the femur the epiphyseal line is found immediately above the prominences formed by the condyles (Plate 59). The following classification is useful:

(*a*) Fractures of the femur above the condyles—supracondylar fractures, usually transverse.

(*b*) True epiphyseal separations, in youthful individuals.

(*c*) Oblique fractures and T-fractures of the condyles.

(*d*) Partial (split) fractures at the articular extremity.

The number of fractures occurring at the lower end of the femur is much smaller than that of fractures observed in the shaft itself.

(a) Supracondylar Fracture of the Femur (*Fractura supracondylica*).—Most of them are transverse fractures, although very acute oblique fractures, and even longitudinal fractures, due to twisting of the lower portion of the shaft of the femur, have been observed (Plate 56, Fig. 3).

Supracondylar transverse fractures present typical phenomena, both as regards the position of the fragments and their displacement; the lower fragment, being acted upon by the powerful muscles of the calf, is flexed, and the two fragments override (Plate 58). The pull exerted by the muscles of the thigh produces shortening the degree of which is proportional to the amount of displacement and flexion of the lower fragment.

Fig. 1 a

Fig. 1.

Lith. Anst. F. Reichhold, München.

Examination.—*Inspection* discovers shortening of the thigh, swelling, and pain on movement at the seat of fracture. By *palpation* abnormal mobility at the lower end of the femur, at a point just above the condyles, is elicited, especially when the parts are moved in a lateral direction. Crepitus is present if the fractured surfaces are in contact.

The ends of the fragments can often be directly felt, the lower one high up in the popliteal space, the upper one in front. The knee-joint may also be injured at the same time. Anesthesia is desirable, both in making the examination and in effecting reduction.

Treatment.—The best treatment consists in permanent extension with weights. Moderate pressure by means of a roller bandage, or a loop connected with a second extension apparatus pulling directly upward, may be applied against the lower fragment at the seat of fracture so as to keep it in a position of extension. If the displacement is very obstinate, it may be advisable to bandage the leg in flexion, after the fragments have been carefully replaced. It must not be forgotten that displacement of the lower fragment may produce pressure on the large vessels and on the sciatic nerve, and thus lead to serious complications (gangrene of the leg).

[In fractures of the lower end of the femur the lower fragment is flexed by the calf muscles. For this reason the treatment of the fracture with the leg in flexion would seem to be, on the whole, the better method. Most authorities agree to this. I have had excellent results after the reduction of the deformity by placing the flexed limb in a plaster dressing. At each subsequent dressing at intervals of about a week the limb can be re-dressed in plaster in a slightly more extended position, so that by the fourth week it is in a fully extended position. If there is much swelling about the knee (traumatic arthritis), the limb can be placed on a double inclined plane until the swelling subsides.—Ed.]

PLATE 59.

Figs. 1 and 2.—Showing the normal course of the epiphyseal line at the lower end of the femur and at the upper end of the tibia and fibula, in frontal and in sagittal section.

Figs. 3 and 4.—Traumatic epiphyseal separation at the lower end of the femur, with backward displacement of the upper fragment. After a preparation in the College of Surgeons in London. In figure 3 the normal outline is given as a guide.

Fig. 5.—Transverse fracture through the lower end of the femur, with separation of the internal condyle. (After Anger.)

(b) **Traumatic Epiphyseal Separation at the Lower End of the Femur.**—The injury is not so very rare; as the two cartilaginous portions of the bone which unite at the epiphyseal line possess a large surface of contact, and as the lower fragment is very short, it requires considerable force to bring about this injury. For similar reasons, displacement of the fragments is, as a rule, only moderate, particularly as the periosteal investment may be partially preserved. Displacement, when present, is usually analogous to that observed in typical supracondylar transverse fractures. Occasionally, however, it is directly opposite in character (Plate 59, Figs. 3 and 4). It depends altogether on the nature of the injuring force and the direction in which it acts. The knee-joint rarely escapes (hemorrhagic effusion).

On **examination**, thickening and pain on pressure are discovered at the epiphyseal line. Sometimes the displacement may be felt, and soft crepitation may be made out. There is abnormal mobility, especially in abduction and adduction, movements that act like a lever on the leg.

[According to Poland and others, reduction is frequently difficult and sometimes impossible in this epiphyseal separation. In such cases one should operate. My colleague, Dr. Finney, has observed one case in which it was necessary to operate in order to reduce the dislocated lower fragment, with an excellent result. In effecting the

Fig. 1.

Fig. 2.

Fig. 5.

Fig. 3.

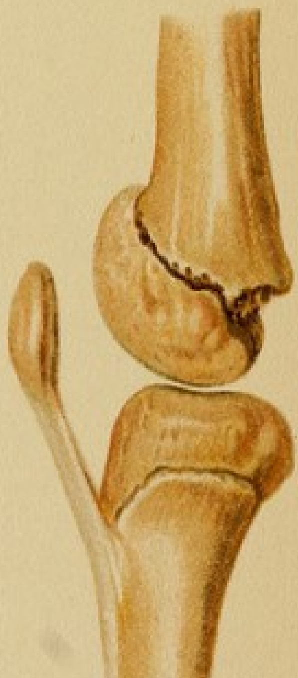

Fig. 4.

Lith. Anst F. Reichhold. München.

reduction, Finney found that overextension of the lower fragment was first necessary, then traction with flexion.—Ed.]

Treatment.—Careful reduction under anesthesia. Extension or splint dressing.

(c) **Oblique Fracture and T-fracture of the Condyles** (*Fractura condyli, Fractura supracondylo-intercondylica*).—This is an extra- and intra-articular injury. The inner or the outer condyle may be broken off obliquely; in still rarer cases a T-fracture (*fractura supracondylo-intercondylica*), analogous to T-fracture at the lower end of the humerus, has been observed.

Diagnosis.—Lateral enlargement and pain on pressure at the region of the condyles; lateral rocking movements are possible at the knee and are accompanied by crepitus; sometimes sharp fragments of bone can be felt. Hemorrhagic effusion in the joint.

Treatment.—As there is danger of varus or valgus position developing at the knee-joint, great care is necessary in the treatment. The best method consists in extension with compression about the joint, and, if necessary, puncture to evacuate the hemarthrosis; passive motion should be begun early.

(d) **Partial (Split) Fractures at the Articular Extremity.**—These include separation of thin plates of bone from the cortex, corresponding to the insertions of the lateral ligaments, by severe twisting of the joint and split fractures separating pieces from the cartilaginous cap of the femur. They are pure intra-articular injuries, and will be discussed later on.

4. KNEE-JOINT

(A) Dislocation of the Knee-joint

Intra-articular injuries of the ligamentous apparatus of the knee-joint are not as uncommon as true dislocations of the joint. The latter are exceedingly rare, making up about 1 % of all dislocations. The leg may be dislocated:

Forward (*luxatio genu antica*), by overextension, if the lateral and crucial ligaments have been torn.

Backward (*luxatio genu postica*), or, rather, a forward dislocation of the condyles of the femur.

Laterally (*luxatio genu lateralis*), bringing the leg into abduction or adduction.

In addition, a number of varieties of incomplete dislocations occur.

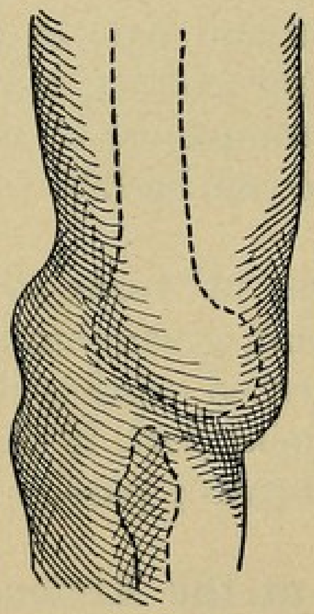

Fig. 136.—Forward dislocation of the leg.

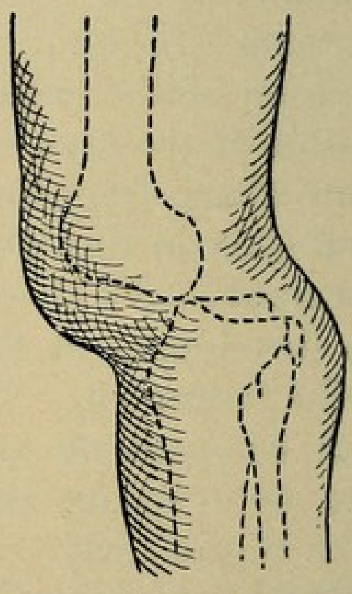

Fig. 137.—Backward dislocation of the leg.

In every case the condyles of the femur can be more or less distinctly felt in an abnormal position. As it requires an enormous force to produce these dislocations, it is readily understood that they are often complicated with other severe injuries: compound fracture or dislocation. Primary lesion of the popliteal vessels, or pressure on the vessels when the dislocation remains unreduced for some time, may lead to gangrene. Reduction is said to be easy and is effected by traction and direct pressure. [Partial or complete rupture of the popliteal artery is the most frequent arterial lesion associated with dislocation, and should be constantly borne in mind. I observed it in one instance in which the posterior dislocation became reduced almost immediately after the injury. It was necessary to amputate the limb on the third day for gangrene.—Ed.]

(B) Dislocations of the Patella. (Plate 60.)

Dislocation of the patella is regarded as an unusual injury. Its attachments are not very firm, and it acts much like a sesamoid bone, as it lies between the ligamentum patellæ and the quadriceps muscle, but has very imperfect lateral attachments.

(a) **Outward dislocation of the patella** is the most frequent form; its occurrence is favored by the position of the patella, which overlies the outer condyle rather more than the inner. A tendency to valgus constitutes an especial predisposition to this dislocation. The dislocation is called incomplete when some portions of the articular surface are in contact; complete, when the knee-cap is displaced *in toto* to the lateral side of the external condyle. The injury may occur while the knee is extended or flexed; in the former case the patella glides directly over the anterior surface of the lower edge of the femur outward. This form may also be produced when the knee is extended by the action of the quadriceps. When the knee is flexed, the bone is displaced along the groove between the external condyle and the tibia. It is not rarely produced by direct violence acting from in front and within, as, for instance, when a man on horseback receives a blow on the knee. The *diagnosis* is easy; the knee-cap is absent from its normal position and is felt in an abnormal position. Reduction is effected by direct pressure, with the knee in extension and the thigh flexed at the hip, so as to relax the quadriceps muscle.

(b) **Vertical dislocation of the patella** exists when the patella is turned through 90 degrees in such a way

PLATE 60.

Dislocation of the Patella.—Fig. 1.—Specimen showing outward dislocation of the patella. The cartilaginous surface of the patella is in contact with the lateral surface of the external condyle. Anterior view.

Fig. 2.—Preparation showing an internal vertical dislocation of the patella. The cartilaginous surface of the patella presents inward or toward the median line of the body. Inner view of the right leg.

Fig. 3.—Specimen showing complete rotatory dislocation of the patella, produced by continuing the rotation from the position shown in figure 2. Anterior view of the right knee-joint.

Fig. 4.—Outward dislocation of the right patella in a man twenty-nine years of age (1880). The leg and region of the knee-joint are shown in marked flexion. The prominence of the patella to the outer side of the external condyle is very marked.

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that its edge comes to occupy the depression between the two condyles of the femur. We distinguish between inner and outer vertical dislocation, depending on whether the cartilaginous surface of the knee-cap presents inward or outward. Internal vertical displacement is probably the more frequent of the two. It is produced by a direct violence acting from in front or from the side, and is also said to be produced by simple muscular action. The position of the patella is readily recognized when the leg is extended.

(c) **Complete Inversion of the Patella.**—This is a rotation through 180 degrees, or, in other words, an exaggeration of the vertical dislocation just described. *The articular surface of the patella presents forward.* The injury is exceedingly rare. The *diagnosis* is difficult, unless accurate palpation is possible, and the twisting of the quadriceps and of the ligamentum patellæ can be recognized.

(C) Fractures of the Patella. (Plates 61 and 62.)

Fractures of the knee-cap are much more common than dislocations. They occur frequently in adults, usually in males under fifty years of age.

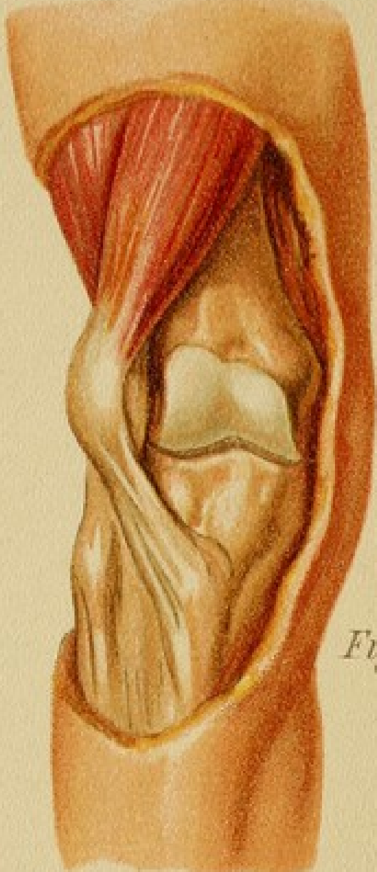

Fig. 1.

Fig. 4.

Fig. 2.

Fig. 3.

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The patella in common with the entire region of the knee-joint is greatly exposed to injury. Fracture due to *direct* violence may follow a fall or a blow on the knee. Direct fractures sometimes assume the form of so-called *radiating* or *stellate* fractures; that is, the patella sustains a blow on its flat surface and is shattered into several fragments, separated by radiating lines. The fragments usually remain in good position. Direct violence may also lead to the production of oblique, longitudinal, and transverse fractures; as, for instance, after a fall on the ground on a sharp stone, or the edge of the curb, etc.

Indirect fractures are produced by contraction of the muscles. It is a common saying among the people that a drunken man rarely or never breaks any bones when he falls. This is quite true, for he falls to the ground like a sack. A sober man, on the contrary, will consciously, or, as is nearly always the case, in obedience to reflex stimuli, make some effort to prevent a fall whenever he stumbles. The sudden contraction of the quadriceps fixes the patella and may produce a fracture; especially if the knee gives way at the same time, and the flexion at the knee-joint by means of the patellar ligament increases the tension on the patella while it is fixed above by the quadriceps muscle. A fracture by muscular action produced in this way usually runs transversely through the middle, or slightly below the middle of the bone, corresponding approximately to the point where the body of the patella merges into the apex below. According to Bähr, this spot also corresponds to the point where that portion which is supported by the lower end of the femur joins the unsupported portion.

The variation in the size and shape of the patella, which is considerable, has an important bearing both on the production of the fracture and on the examination of the limb. Hence comparison with the sound side must never be neglected. The density of the knee-cap is also subject to individual variations.

The extent to which the strong aponeurotic structures

PLATE 61.

Fracture of the Patella.—Fig. 1. – Specimen of typical transverse fracture of the patella with extensive laceration of the aponeurotic layers on each side of the bone. Marked displacement of the fragments; the knee-joint is wide open, and the lower end of the femur is exposed. The fringes from the tendinous investment formed by the tendon of the quadriceps project over the edges of the patellar fragments like a closely trimmed forelock on a pony's forehead.

Fig. 2.—Specimen of transverse fracture of the patella, without laceration of the lateral aponeurotic structures. Although the knee is almost bent at a right angle, there is no displacement of the fragments.

Fig. 3.—Same preparation as that seen in figure 2; seen from within, *i. e.*, behind. Below, are recognized the cartilaginous articular surface of the tibia; above, the ligamentum patellæ and the cartilaginous surface of the patella. The latter presents a transverse fracture through its middle. The edges of the cartilage are sharply outlined. There is no displacement, as the lateral aponeurotic structures are uninjured.

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on each side of the knee-cap are involved in fractures of the patella is a factor of the greatest importance. As a rule, they are more seriously affected (torn) in indirect than in direct fractures. Even in direct fractures, however, the tear in the lateral aponeurosis may be considerable, especially if the knee-joint continues to bend after the fracture has been produced; that is to say, when the distending and lacerating force reaches a maximum by continued flexion at the knee-joint.

These conditions have recently been subjected to a careful investigation by König.[1]

The importance of the tear in the lateral aponeurosis lies in the fact that it determines the degree of displacement, *i. e.*, separation of the patellar fragments. In simple transverse fracture of the patella the gap is almost

[1] See König, Zur Entstehungsgeschichte der Verletzungen des Streckapparates vom Kniegelenk, Deutsche militärärztl. Zeitschr., 1897.

Fig. 2.

Fig. 3.

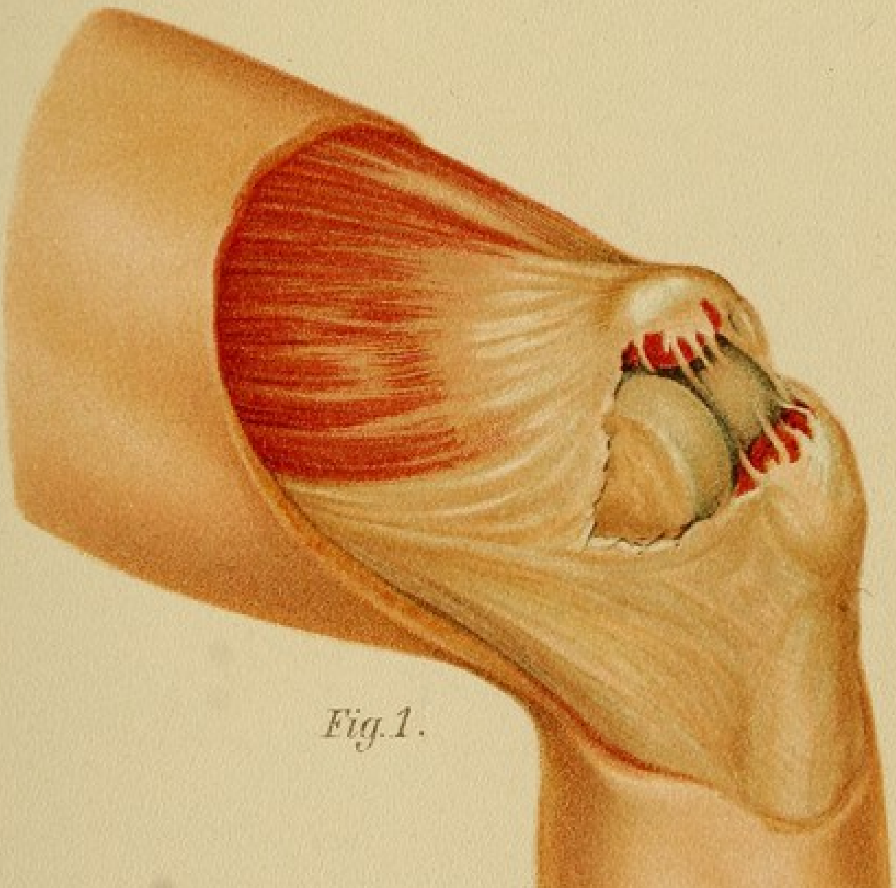

Fig. 1.

Lith. Anst. F. Reichhold, München.

nil; but if the lateral aponeuroses are extensively lacerated, the separation may be quite wide (Plates 61 and 62).

The frequency of indirect fractures was formerly overestimated; it is true that the histories do not always furnish a reliable basis to determine the frequency of the injury. Bähr estimates the number of indirect patellar fractures at about 20%.

The force that indirectly produces the fracture is obviously exerted equally on the quadriceps tendon, on the ligamentum patellæ, and even on the tuberosity of the tibia; but fracture of the patella is by far the most common result of such indirect violence.

The **symptoms** are very clear, if, as is usually the case, the fracture runs transversely across the middle of the patella and produces some separation of the fragments. As the patella is completely inclosed within the capsule of the joint, this injury constitutes a pure intra-articular fracture. The extravasation of blood is into the joint and may be great enough to cause a good deal of tension. In recent cases the fragments can usually be pushed together until they come in contact and give forth distinct crepitation. If only a small piece from the edge of the patella is broken off, and in all cases in which the periosteal investment of the knee-cap is preserved, the diagnosis may be somewhat more difficult. By careful examination, however, both in recent cases and in cases of some standing that have not healed by bony union, some unnatural mobility of the fragments can usually be discovered, especially if they are moved from side to side.

Prognosis.—The prognosis of fractures of the patella depends chiefly on the nature and severity of the injury (stellate fracture; transverse fracture; or fractures complicated by extensive laceration of the ligamentary apparatus; etc.) and on the method of treatment employed. The strength and resistance of the patient also have some bearing. Direct fractures, except transverse fractures associated with a great deal of separation, on the whole,

PLATE 62.

Fracture of the Patella.—Fig. 1.—Right leg of an elderly man with a transverse fracture of the patella, united by a broad mass of ligamentous tissue. The two fragments are separated by a broad interval running transversely across the bone.

Fig. 2.—Young man (Gutsch, 1896) with bilateral fracture of the patella. The patient sustained a fall on both knees. About eight weeks after the injury, massage was begun and, as the illustration shows, the patient by that time was able to raise the right leg from the bed and hold it for a short time almost in extension, in spite of the marked separation of the fragments. As massage and other measures failed to secure a satisfactory result, I employed a bone-suture on both legs to bring the fragments together. The operation was therefore secondary and with a good result.

Figs. 3 and 4.—Specimens of patellar fractures united by fibrous tissue. Seen in sagittal section. From the Museum of the College of Surgeons in London.

Fig. 5.—Specimen showing a united stellate fracture of the patella. The fragments are united by a sufficient amount of callus, without displacement.

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have a better prognosis. As the strength, and to a certain extent the mobility, is often permanently impaired by fracture of the patella, the amount of economic disability depends greatly on the patient's calling. Persons whose work is light or who lead a sedentary life suffer less disability than those engaged in active work; although I know army officers of high rank who continue in active service in spite of the fact that they have a fracture of the patella with ligamentous union. In the case of a laborer, fracture of the patella usually means great disability. Even if both extension and flexion are restored approximately or even completely, the knee-joint and the entire leg in most cases remain weaker and less useful than before. Bähr made an accurate analysis of 44 old cases and found that 42 (up to the time of his observation) had lasted on the average more than four years, and about 35% showed complete disability so far as gaining a livelihood was concerned.

Fig. 1.

Fig. 4.

Fig. 3.

Fig. 5.

Fig. 2.

Lith. Anst. F. Reichhold, München.

Treatment.—In this fracture more than in any other it has been observed that cases with marked separation of the fragments nevertheless heal with very satisfactory functional results, while fractures in which the position of the fragments is quite good sometimes produce intense and lasting impairment of function. The ultimate result depends largely on the behavior of the quadriceps. In many cases this muscle presents the appearance of a high degree of atrophy, due partly to prolonged disuse, and particularly to reflex influences conveyed through the spinal centers. An important prognostic consideration is that this atrophy sometimes does not begin to develop until later, when the treatment is considered to be completed. To counteract the evil effects of prolonged immobilization and consequent disuse of the quadriceps, a method of treatment has recently been developed in which the attempt to approximate the fragments is abandoned and the condition of the quadriceps is maintained by massage (chiefly petrissage and tapotement). Massage is performed daily, the fragments being pushed toward each other. The leg is placed on a splint with the knee in extension and the thigh flexed at the hip, because this position relaxes the quadriceps. While the value and logic of this procedure cannot be doubted, it must nevertheless be regarded as a somewhat one-sided treatment, and there is no good reason why it should not be combined with an attempt to bring about direct approximation of the fragments.

The causes that are responsible for an unfavorable result in the treatment of fractures of the patella are many. The action of the quadriceps and consequent separation of the fragments is an important factor; and no less important is the already mentioned atrophy of the muscle, which in many cases, even when the injury to the patella is slight, may be very great and even become permanent. The effusion of blood into the joint is another condition that tends to keep the fragments apart. It is also said that the vascular supply of the patella and its tendency to form new bone are less than in other bones. The truth of this statement may be doubted, however; though it is true that the patella differs from other bones in the fact that its surface is formed on one side by a thick layer of cartilage, on the other by fibrous tissue.

A form of interposition occurs which is of the greatest importance. The fibers of the outer fibrous layer are greatly lengthened and finally torn by the excessive tension, and form overhanging fringes on the fractured surfaces where they may catch and become interposed between the fragments. This condition increases the tendency to ligamentous union, even when the fragments are in good position (Plate 61, Fig. 1).

In the *treatment* of this complication the obstacles referred to must, of course, be avoided as completely as possible: The leg must be fully extended at the knee and flexed at the hip, so as to relax the quadriceps. The knee-joint is fixed by means of a posterior splint, one made of plastic felt which is heated before it is fitted on, for instance. The fragments are to be approximated and freed from interposed tissues by vigorously rubbing them together. They are then held in position by means of adhesive strips passing around the upper fragment like a loop and crossing each other on the posterior surface of the splint. Profuse extravasation of blood, if recognized with certainty, may be removed by puncture. The trocar should not be too small, so as to permit clots to pass through. The quadriceps should be subjected to petrissage and tapotement once or twice a day, the movements being directed downward so as to push the upper fragment down. To counteract the evil effects of immobilization, faradic electricity is used on the muscles, especially the quadriceps, with a weak current so as not to give pain. This should be combined with massage and, especially, gymnastic exercises. The patient is allowed to get up out of bed and use the leg at an early stage of the treatment. Painting with iodin is of no use, and may even be harmful.

In many cases permanent extension has been found useful (Bardenheuer, Lichtenauer). A plaster-of-Paris dressing may also be used in cases with slight dislocation of the fragments. The patient is seated on the edge of the table, the knee overextended, and the thigh flexed at the hip. A trustworthy assistant seizes the upper fragment from above and forces it down as far as possible toward the lower fragment, which is pushed upward. While one holds the bone in the best possible position with his finger-tips, the plaster bandage is applied around the leg as close as possible to the assistant's fingers, which are not removed until the bandage has hardened. A dressing of this kind, if well applied, may be left in place for from one to two weeks—*not longer, because massage should be begun at least after two weeks.* The posterior half may be converted into a gutter splint and used for immobilization.

When the patient is discharged, he should always be given a leather knee-cap with the injunction to wear it for some months. Appropriate exercises to be performed daily are ordered at the same time.

The more perfect the approximation of the fragments, the firmer will be the union and the better the ultimate functional use. The most complete union of the fragments is by a kind of first intention of the fractured surfaces, and there is unquestionably enough proliferation of bone for this purpose. A knee-cap united by ligamentous tissue, even though the separation of the fragments is inconsiderable, never regains its normal strength.

For this reason many surgeons advocate primary operation; in severe cases it is indispensable. The fragments may be united subcutaneously by various methods. Thus, an extra-articular method utilizes a kind of tendon suture passing through the quadriceps tendon and the ligamentum patellæ close to the patella, the two ends being drawn together and tied in a knot over the knee-cap. An intra-articular method consists in introducing a silver wire or strong silk ligature in such a manner as to surround the patella in the

PLATE 62 a.

Skiagraph of a Normal Adult Knee-joint; Anterior View.

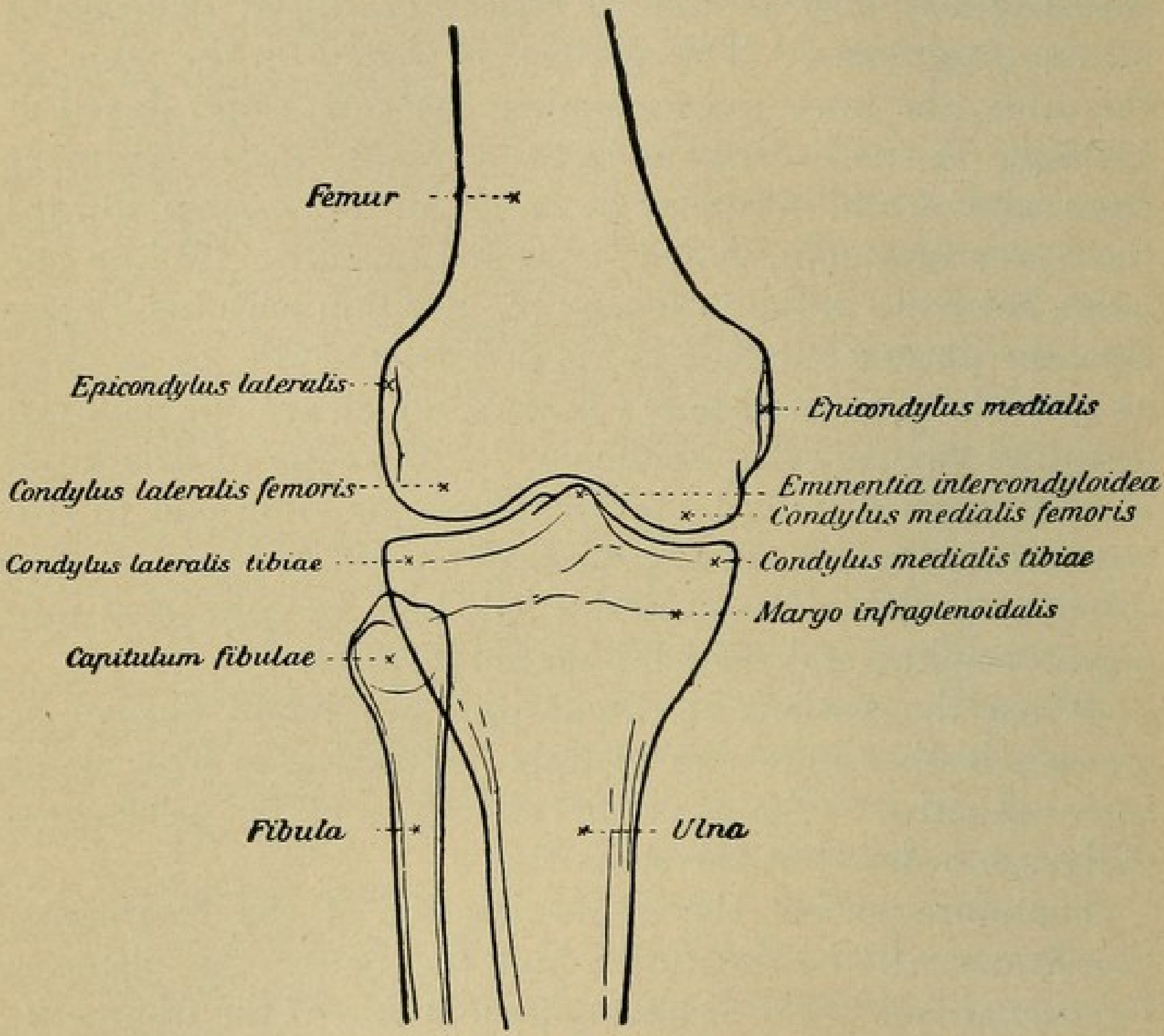
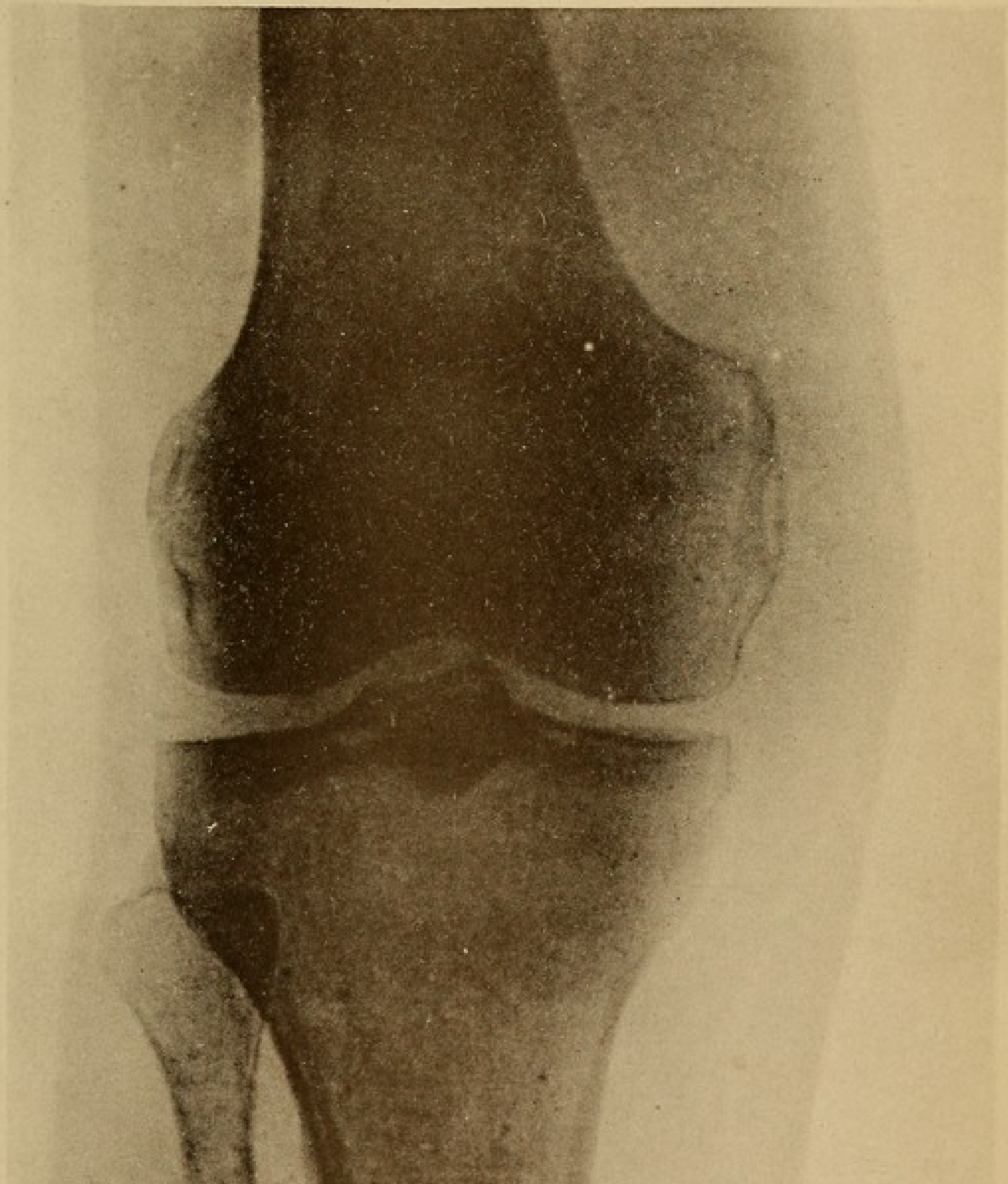


Fig. 138.

sagittal direction (vertical) and draw the fragments together in the form of a buried suture (Barker). The ligature is introduced by means of a long, appropriately curved needle, through two small incisions, one above, and one below, the patella. The old method by means of Malgaigne's hooks has now fallen into disuse. On the other hand, primary suture of the fragments, after exposing the seat of fracture and opening the joint, is constantly gaining adherents. It can, of course, only be intrusted to a practised surgeon, but has the distinct advantage of removing all the disturbing factors that interfere with complete union, and securing the nicest adaptation and fixation of the fractured

Tab. 62 a.



surfaces. The extravasation of blood is removed, the tags of fascia adhering to the fracture surfaces snipped away, holes are bored with as little damage as possible to the cartilaginous surface, and the wire sutures drawn through and twisted. Every step in the operation should be performed with carefully sterilized instruments, without touching the parts with the hand, which is so difficult to disinfect (König). Some surgeons confine their efforts to repairing the tear in the aponeurosis on each side of the knee-cap; but an additional suture through the bone undoubtedly secures a better result. Instead of inserting sutures through holes previously drilled in the fragments, a single vertical loop of strong silver wire may be passed around the patella, after the manner of Barker, after the seat of fracture and the joint have been laid wide open by a curved incision running transversely over the entire joint. The wire is removed at some later time. I have frequently employed a bone suture secondarily after simpler methods of treatment (splints, adhesive strips, massage, etc.) had failed to secure the desired result. If, after the wound has healed and firm union has taken place, the patient is subjected to a careful course of massage and manipulation, correctly carried out, good results may be obtained in this way.

Among *particularly unfavorable events* occurring after fracture of the patella the following should be mentioned:

Failure of any kind of union between fragments.

Union of the upper fragment with the anterior surface of the femur, a condition very rarely met with in old cases, and chiefly, in my experience, after direct, radiating patellar fractures. Every attempt to flex the knee of course increases the separation of the fragments and only diminishes the strength of the knee-joint. Permanent separation of the fragment from the femur, if there is true bony union, is probably never to be achieved ; an operation consisting in the interposition of a flap of muscle from the surrounding tissue may be tried.

It happens comparatively often that the patella is *fractured a second time;* the second fracture is produced by laceration of the ligamentous union, and usually occurs not long after the first fracture has healed, sometimes during the first weeks or months, and frequently at the first attempt to walk. A second fracture of the bone, at a point other than the old fibrous seat of fracture, has also been observed, but it is very rare. The treatment is the same as for a recent injury.

[Powers,[1] in a very exhaustive consideration of the treatment of fractures of the patella, found that the majority of surgeons in this country and abroad were not willing to commit themselves to advise the operative treatment of every case of fracture of the patella. Nevertheless in almost every large surgical clinic in which the surgeon has a better control of the technic, operation is the rule rather than the exception. In my own experience it has been difficult to select cases for non-operative treatment, and in a few instances in which the separation of the fragments was very slight, and in which apparently we could bring about close apposition, we have found at the operation torn shreds of ligament between the fragments, which might have prevented solid bone union. The operative treatment of recent fractures of the patella unquestionably promises a better result than the non-operative treatment. In old fractures of the patella with separation of the fragments and functional disability of the limb the question of operation is sometimes more difficult to decide. In cases with wide separation of the fragments it may be necessary in order to approximate to do an extensive plastic operation of the quadriceps muscle. The results of such an extensive operation are usually good as far as bony union of the patella is concerned, but it may be followed by considerable ankylosis of the knee-joint and atrophy of the muscle. For this reason the patient might prefer his former condition, even if it were necessary to wear some

[1] Annals of Surgery, 1898.

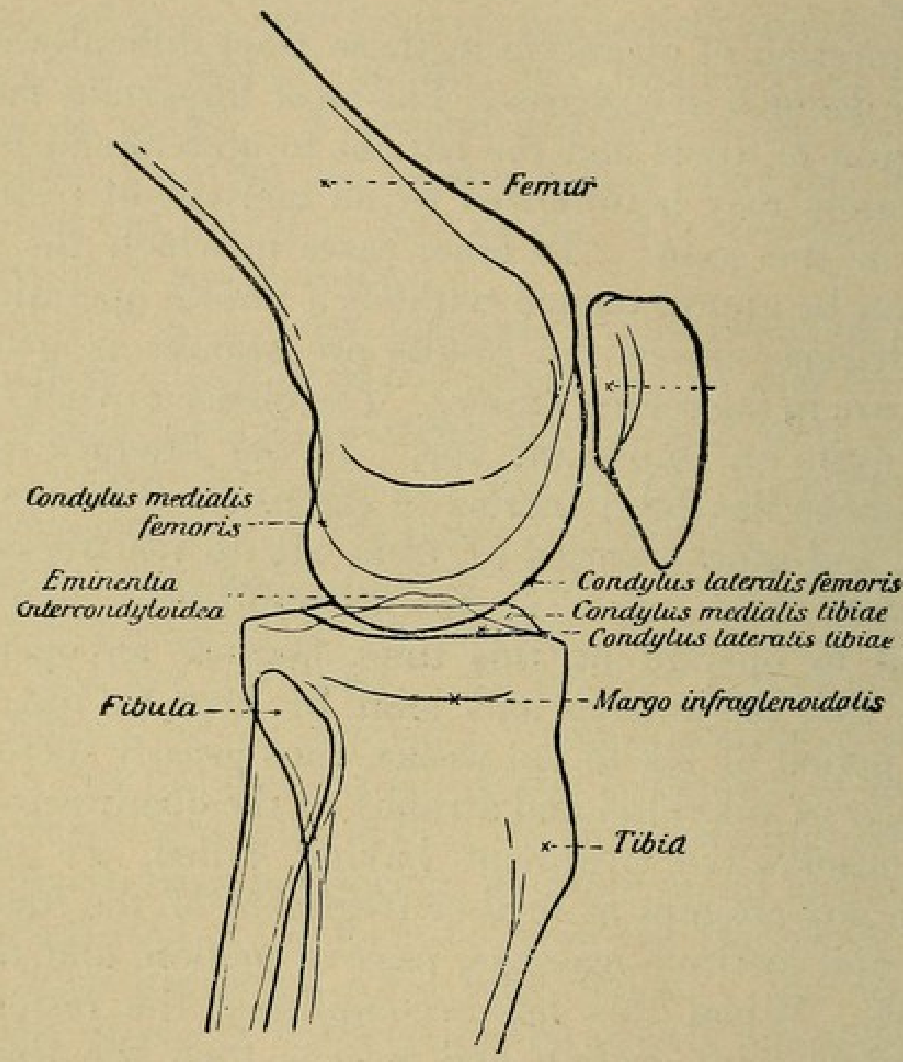
apparatus, because many would much rather have a weak but movable knee-joint than a stronger but partly ankylosed one.

The question of operation in these more difficult cases is one to be decided in each case. The most important fact for the surgeon to know and the patient to understand is that the operation may be followed by an increase of restricted motion in the joint. In other cases in which the fragments can be approximated without a plastic operation on the quadriceps muscle the results are almost as good as after suture in the recent injury. The choice of time, however, is quite an important one. If the fracture in the first instance has been treated in the usual non-operative manner, and after a period of from six to ten weeks it is found that bony union is not accomplished, then it is very bad to operate at this time, because an operation requires that the muscles and joint be kept at rest for a second period of six to ten weeks, thus greatly increasing the danger of ankylosis and atrophy of the quadriceps muscle. Conservative treatment having failed, we should abandon any attempt at further treatment of the fractured patella, and institute massage, passive motion, and use of the limb. When this has accomplished the restoration of complete joint motion and muscle tone, the time for operation has arrived. In a few cases we will find that although there is some separation of the fragments, the functional use of the limb is so good that many patients will be satisfied with the result and decline operation. If they are young individuals and wish to do much walking or heavy work, the operation should be urged, because in time, especially when the individual is active and the joint subjected to any unusual strain,. the fibrous union will give way.

In both recent and old fractures of the patella the joint as well as the muscles, especially the quadriceps, demand appropriate treatment as well as the fracture itself. This is frequently overlooked.—ED.]

PLATE 62 b.

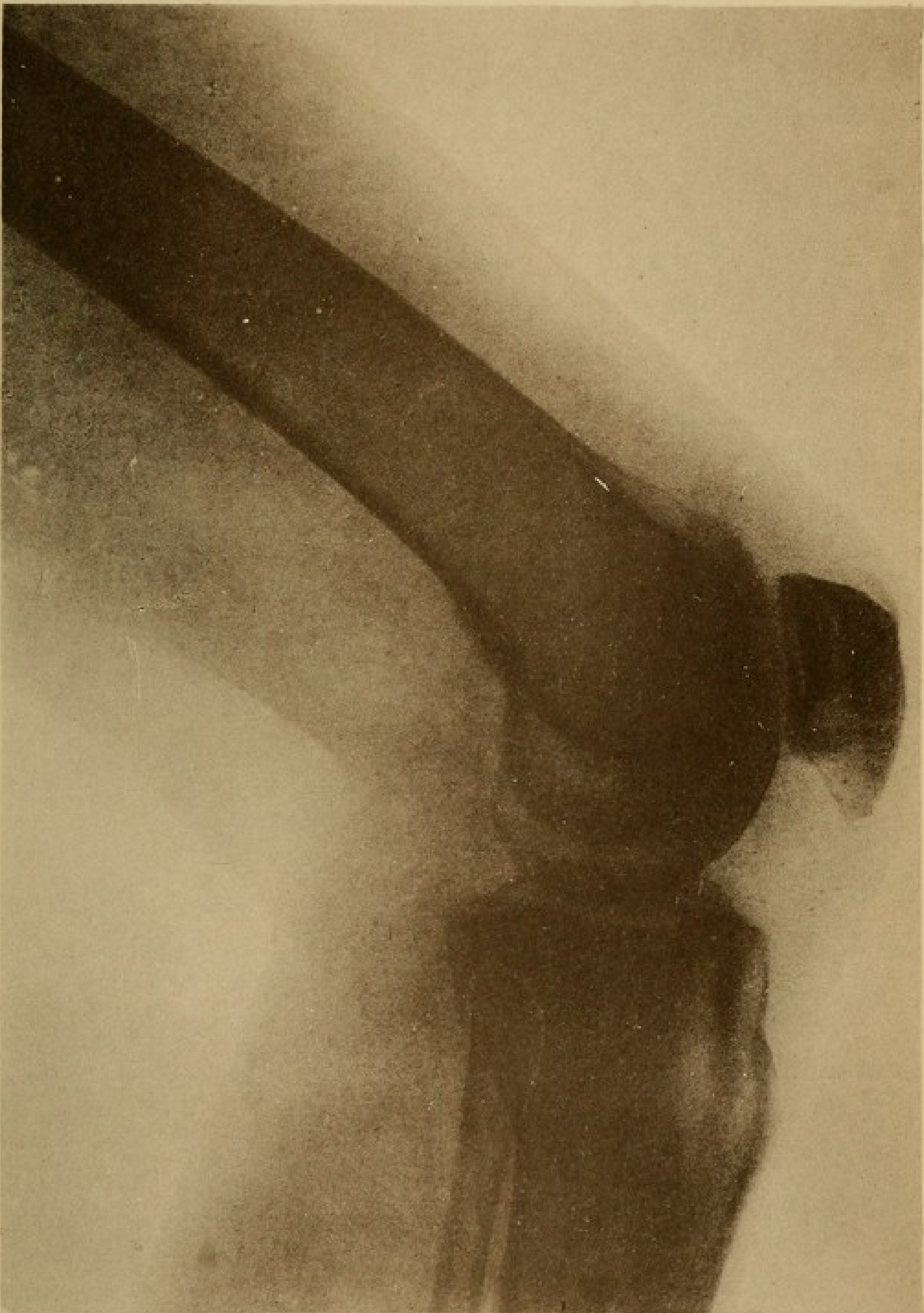
Skiagraph of a Normal Adult Knee ; Lateral View.



(D) Other Intra-articular Injuries of the Knee-joint

(a) Separation of a Fragment from the Cartilaginous Covering of the End of the Femur (Plate 63, Fig. 1).—The arrangement of the bones entering into the construction of the knee-joint is somewhat different from that seen in a pure hinge-joint; when the knee is flexed, the leg is capable of a certain amount of abduction and adduction, and a considerable degree of rotation. This mechanism depends largely on the integrity of the crucial ligaments and of the semilunar cartilages. A force striking the knee in partial flexion, in such a way as to

Tab. 62 b.



compress it and force apart the bones that enter into the formation of the knee-joint, combined with a certain amount of lateral displacement or rotation, may cause the separation of a piece of the cartilage with a portion of the spongy bone to which it is attached. The force that produces such an accident is often very slight; it may be nothing more than an awkward movement on the part of the individual. The fragment of cartilage has sharp edges, as it is broken in its entire thickness. The size and shape of the fragment vary from that of a bean to that of an almond. The injury can be produced experimentally on the cadaver (Kragelund). The fragment may be completely separated by the injury and act like a movable body (*corpus mobile*, "joint-mouse") within the knee-joint; there are probably also cases in which the fragment maintains a certain amount of connection with the bone by means of fibers or a thin plate of bone, and gradually becomes completely separated by the repeated pressure and dislocating action incident to active movement, so that it eventually assumes the character of a movable body ("joint-mouse"). We refer to Völker's Arch. f. klin. Chir., vol. XXXVII. The fragment must of course be removed by operation according to established surgical principles.

(b) **Injuries of the Semilunar Cartilages** (Plate 63, Fig. 2).—These include dislocation, and laceration or rupture of the semilunar cartilages, which may occur without any accessory injuries. Up to the year 1892, 43 cases had been reported (Bruns). The internal semilunar cartilage is affected twice as often as the external. Complete dislocation, with separation of both anterior and posterior insertions of the cartilage from the capsule of the joint, does not occur, but partial dislocation, forward, backward, or to one side, of one or the other cartilage from traumatic loosening of its attachment has been observed. Separation of the anterior insertion is the most common form. Abnormal mobility of the cartilages from gradual loosen-

PLATE 63.

Fig. 1.—Separation of a fragment of cartilage from the surface of the internal condyle of the femur. The illustration shows the loss of substance in the end of the femur and the separated fragment.

Fig. 2.—Rupture of the internal semilunar cartilage in the knee-joint.

Figs. 3 *a* and 3 *b*.—Specimens from a compression-fracture at the upper end of the tibia. The articular surface is viewed from above; the bones of the leg from behind. The fracture occurred in a young woman and was produced by a fall from the top of a loaded hay-wagon. The condyles of the femur exerted pressure on the upper surface of the tibia. The woman died of acute sepsis which had its origin in a torsion-fracture of the same tibia in its lower half. (See Langenbeck's Archiv, vol. XLI, p. 357.)

Fig. 4.—Elderly man with a fracture of the left tibia, near its upper extremity (*fractura tibiæ infracondylica*). Union with the deformity known as the O-leg. The fracture was produced by the kick of a horse.

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ing of their insertions has been rarely observed. A solution of continuity in the semilunar cartilage is rare.

The injuries are produced by active rotation of the end of the femur while the knee is flexed, thus extruding the cartilage. A sound normal joint is therefore a prerequisite condition, and the injury is accordingly observed most frequently in England among athletes (football players, etc.).

The **symptoms** of a recent luxation vary in intensity in accordance with the degree of distortion which produced the injury. There is always intense pain in the affected side of the joint, which is in partial flexion and can be flexed but not extended. There is a good deal of effusion and swelling, with a considerable degree of functional disturbance. In old or habitual luxation, pain and interference with movement occur paroxysmally, being evidently caused by a sudden displacement and compression of the cartilage.

On examination we frequently find, if the cartilage has been torn from its anterior insertion, a flat movable body

Fig. 4.

Fig. 3 a

Fig. 3 b

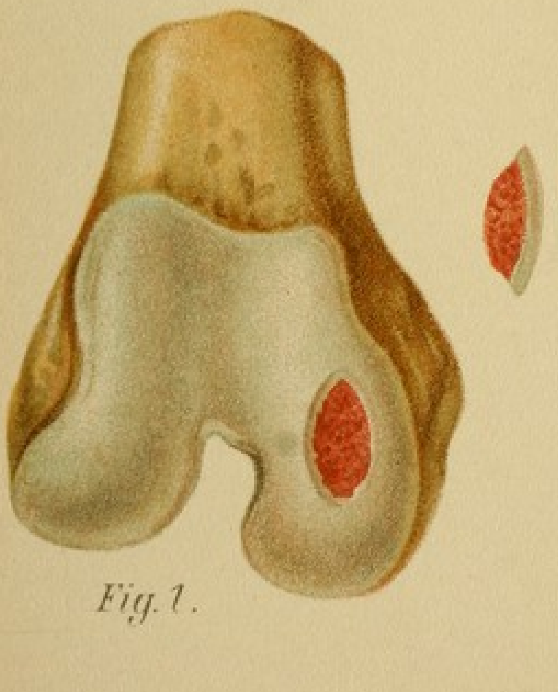

Fig. 1.

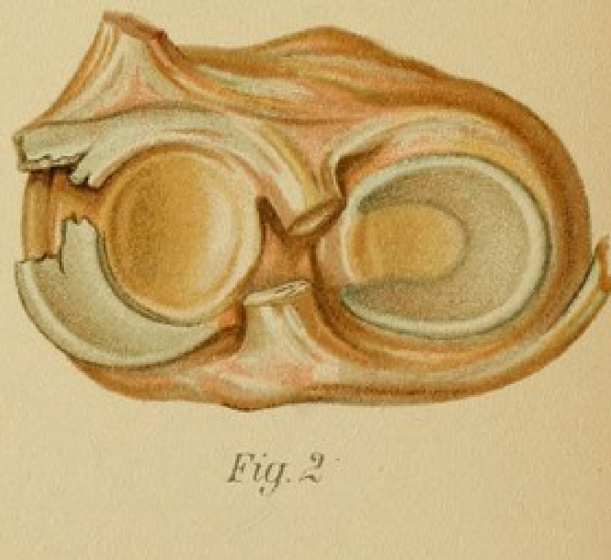

Fig. 2

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within the cleft of the joint. This body disappears in the depths of the joint during flexion and becomes more prominent during extension. Both the patient and the surgeon may be able to feel it slipping in and out distinctly. More rarely the site of the cartilage in the articular cleft is broader or deeper, and sensitive to pressure, conditions that are due to permanent displacement of the fragment of semilunar cartilage into the interior of the joint. If there is much effusion, examination may be impossible. As regards the **differential diagnosis,** it may be very difficult to distinguish the cartilage from a free movable body within the joint.

Treatment.—In recent cases the cartilage should be replaced as completely as possible; a slight pressure bandage applied, and later replaced by a plaster-of-Paris cast fitted on while the leg is in extension. The cast is left on for six weeks, and after that period the patient should protect his knee by wearing a leather knee-cap. In old or habitual cases an attempt should be made to obtain fixation by means of buried sutures. Ideal results are sometimes achieved by this means, better than by complete extirpation of the semilunar cartilage, which is often performed and has been highly lauded, although it is not followed by any marked impairment of function.

5. LEG

(A) Fracture of the Leg at the Upper End

I. Isolated Fractures at the Upper End of the Tibia

(a) **Compression-fracture of the Upper End of the Tibia** (Plate 63, Fig. 3; see also Plate 3, Fig. 1).—This fracture is produced by sudden compression of the articular extremity of the tibia by one or both of the condyles of the femur. It may follow a fall on the feet from a great height, as, for instance, in mining when the elevator shoots to the bottom and the passengers strike on their feet, or a fall from a hay-wagon. I once saw this fracture produced by jumping off a bicycle.

The injury consists in an infraction of the upper articular surface of the tibia with depression of the fragments and, sometimes, fissures on the surface of the bone. The latter occur particularly in compound injuries when torsion takes place through the medium of the fibula (see Plate 63). In severe cases (see Plate 3) the upper articular end of the extremity may be broken into two or three pieces and the shaft firmly wedged in the spongy tissue of these fragments.

Examination.—The appearances of a severe distortion or contusion of the joint are manifest, the injury being wholly or at least in great part intra-articular. Accordingly there is an effusion, first hemorrhagic and later serous, into the joint; movements of the joint are painful; and abnormal rocking movements are possible in most cases. The upper end of the tibia appears enlarged laterally and there is characteristic pain on pressure. If only one-half of the articular surface is involved in the fracture, either varus or valgus deformity is apt to result. The inner half —that corresponding to the internal condyle of the femur —is fractured more frequently than the outer half, hence varus is common and may become permanent. There is also great danger of secondary arthritis deformans.

Treatment.—The injury is best treated by means of permanent extension with weights, the foot being supported on a sliding rest, supplemented if necessary by lateral traction extension by means of a loop to prevent varus or valgus deformity by overcorrection. Massage and passive movements should be begun early.

(b) **Transverse Fracture of the Upper Extremity of the Tibia** (*Fractura tibiæ infracondylica*). (Plate 63, Fig. 4.)—This is a rare fracture. It is produced either by *direct* violence,—for example, by the kick of a horse, as in the case from which our illustration is taken,—or more rarely by *indirect* violence, the causative force being the same as would under other circumstances result in fracture of the lower end of the femur or luxation of the knee-joint. It is a transverse fracture of the upper articular portion of the tibia. When the line is more oblique, the joint itself may be affected directly and primarily. Even in a transverse fracture the joint is usually involved (hemorrhagic effusion).

The **diagnosis** is based on lateral enlargement of the bone, pain on pressure, and abnormal rocking movements. It is best to have the patient anesthetized.

Treatment.—I prefer permanent extension with weights, the seat of fracture being left exposed, so as to permit compression and massage to be begun early both at the seat of fracture and at the joint. If there is a tendency to varus or valgus deformity, the same preventive measures must be adopted as in compression-fracture of the tibia.

(c) Traumatic Epiphyseal Separation at the Upper End of the Tibia (Plate 59, Figs. 1 and 2).—This is a rare injury; but if a history of severe contusion at the

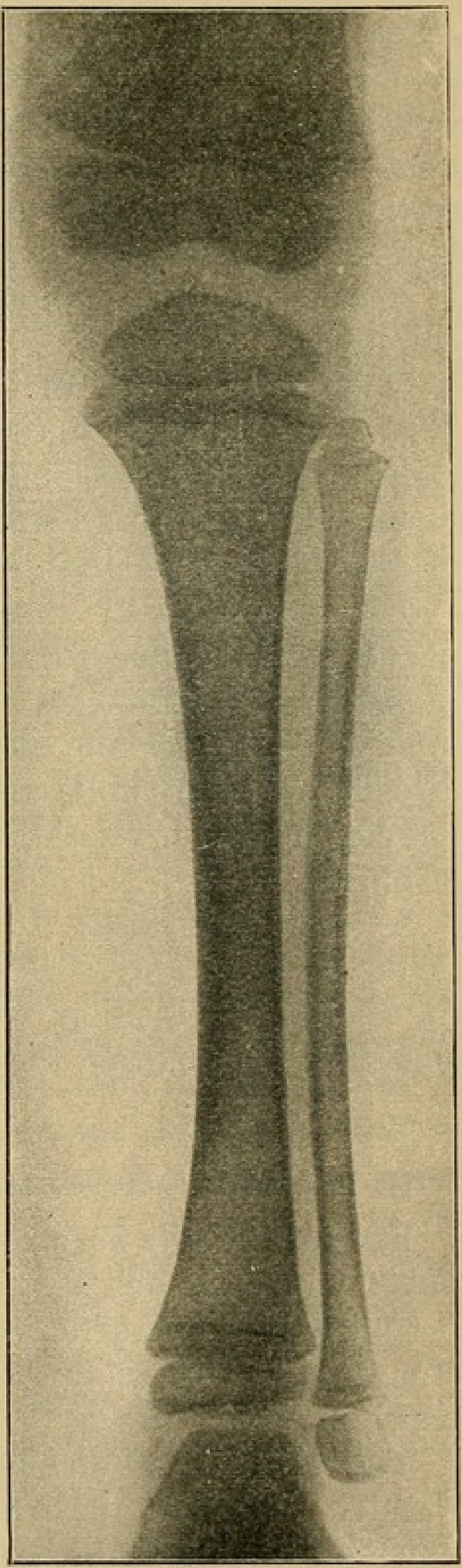

Fig. 138 *a.*—Skiagraph of a knee-joint and leg from a child 3 years old. The epiphyses are easily recognized.

upper end of the tibia in a child is obtained, the surgeon should bear its possibility in mind. A positive diagnosis can be arrived at only under anesthesia, by demonstrating abnormal movability and characteristic crepitus. For the rest, especially for the question of treatment, the reader is referred to sections a and b. As there is little tendency to displacement, an ordinary splint dressing may also be employed.

(d) **Tear-fracture of the Tuberosity of the Tibia.**—This is a very rare injury observed in adults, and especially in children, when it takes the form of an apophyseal separation. As in all fractures of apophyses the tendency to displacement is considerable: the fragment in this case is drawn upward by the quadriceps acting through the patella and ligamentum patellæ. The patient finds it impossible to extend the leg at the knee-joint; the fragment is felt under the skin, and is readily moved in any direction. The patella above is intact; the knee-joint is not necessarily involved, but usually contains an effusion of blood.

A treatment similar to that used for fractures of the patella is applicable. The best method consists in effecting thorough reduction, which may be done by overextension, and then nailing the fragment in place.

II. Isolated Fractures at the Upper End of the Fibula

Fracture of the head of the fibula may be produced by *direct* violence, such as a blow or the kick of a horse; or *indirectly* by a powerful contraction of the biceps femoris (fracture by muscular action). The external popliteal nerve may be injured.

The tendency to displacement is not constant. If deformity is present, the best and safest procedure is to cut down on the injured bone and unite the fragments with a silver wire. In other respects the treatment should follow general principles.

(B) Fracture in the Middle Portion of the Leg

I. Fracture of Both Bones in the Region of the Diaphysis.

(Plates 64 and 65.)

This injury is very common. It is usually produced by *direct* violence, such as being run over, the two bones being broken at about the same level. An isolated fracture of the lower portion of the tibia may first be produced *indirectly* by torsion of the body when the foot is fixed, and followed by secondary fracture of the fibula which is unable alone to support the weight of the body. The fibular fracture is in the form of a bending fracture, and usually occupies a higher level (Plate 65, Fig. 1). Oblique fractures, whether by bending or by torsion, are, generally speaking, more unfavorable—*i. e.*, exhibit more tendency to displacement—than transverse fractures. The sharp upper fragment is frequently driven against the skin and may perforate it, especially when the line of fracture extends in front as far as the crest of the tibia in the form of the mouthpiece of a flute.

The **diagnosis** is usually quite easy, as there is no difficulty in demonstrating abnormal mobility, crepitus, and deformity. Rotatory displacement of the lower fragment may be recognized by noting the position of the patella and of the foot as compared with the other side, and by running the finger along from the crest of the tibia above and from below as far as the seat of fracture. On the other hand, it is often difficult to determine the point where the fibula is fractured. Nowadays with the aid of Röntgen rays it can be ascertained with certainty.

To determine the presence of abnormal mobility at the suspected seat of fracture it is well to have an assistant who should firmly fix the knees with both hands, the patient lying flat on the table or in bed. The surgeon meanwhile with one hand, say the left, feels for the seat of fracture, while with the other (the right) he seizes the leg at the ankle and alternately performs abduction and adduction. If the surgeon experiences unusual difficulty and the data obtained by other methods of examination are uncertain, it is a good plan for the surgeon to brace the suspected seat of fracture and the left palpating hand against his own body, for instance, the thigh, while he attempts to move the leg with the right hand.

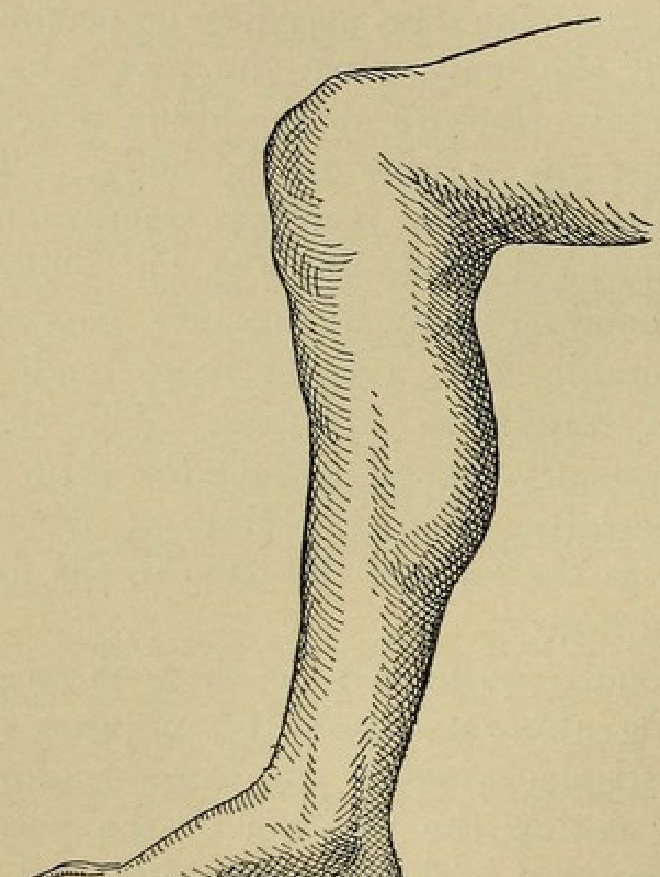

Fig. 139.—Old fracture of the leg with deformity; the bones are bowed backward.

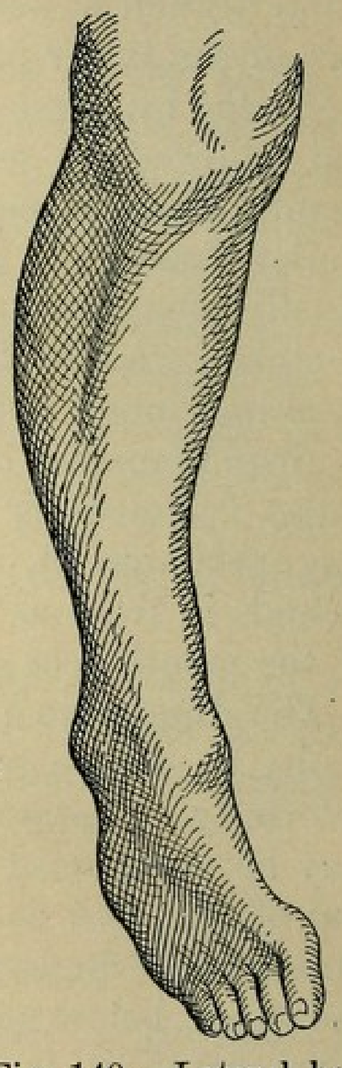

Fig. 140.—Lateral bowing in an old fracture of the leg.

Treatment.—All possible care should be exercised to reduce the fracture; it may be done by vigorous extension on the injured foot and counterextension of the thigh or pelvis, with direct manipulation at the seat of fracture. If the fracture is transverse, however, the displacement is very apt to recur. The tendency for the upper or, in exceptional cases, the lower fragment to injure the skin in front where it is thin must be combated by position, the limb being slightly overextended at the seat of fracture.

A certain amount of care is needed to bring about correct reduction and maintain the fragments in position. The rule that when the leg is in the proper position, the anterior superior spine, the inner border of the patella, and the inner side of the great toe lie in the same straight line does not hold in the majority of normal legs (see Plate 64,

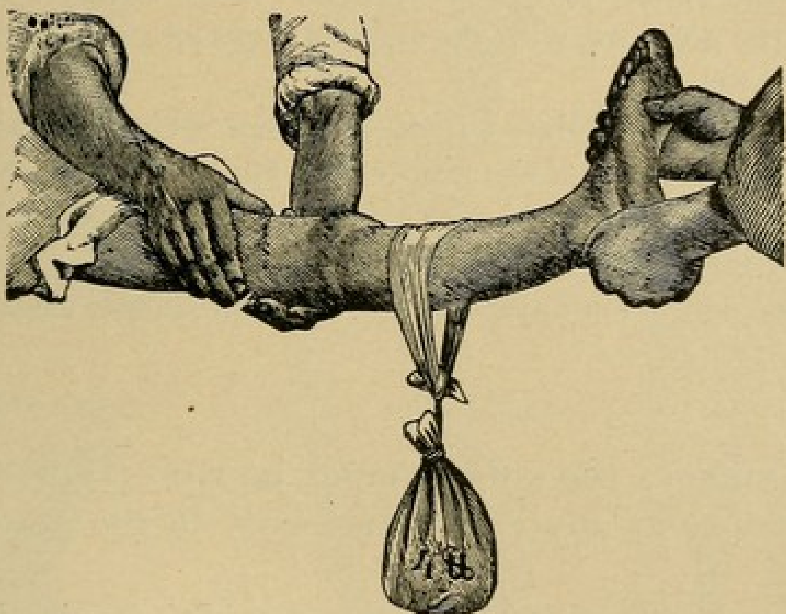

Fig. 141.—Extension and counterextension in fracture of the leg. A weight has been attached to the leg by means of a loop of gauze to counteract the forward displacement of the upper fragment at the seat of fracture.

Fig. 3). It is better to place the two legs in such a position that the patella will be perfectly horizontal, and then to fix the injured leg in a position to correspond with the shape and direction of the sound leg. In this way the very objectionable *dislocatio ad peripheriam* will be avoided.

Knee and foot must be included in the dressing; the former in extension, the latter at a right angle to the leg.

During the first week a so-called Volkmann's T-splint of strong tin, or two lateral flexible splints, may be used

PLATE 64.

Fractures of the Leg.—Fig. 1.—Specimen of united fracture of both bones of the leg with marked displacement of the fragments. Both bones were broken at about the same level, suffered the same kind of displacement, and all the four fragments are connected to each other by abundant callus-formation. (Pathol. Inst., Berlin.)

Fig. 2.—Specimen of a united fracture of both bones of the leg. Slight displacement. Good recovery. The tibia was fractured in the lower, the fibula in the upper, half.

Fig. 3.—Line to determine the correct position of the fragments in fracture of the lower leg. It is seen that in the normal leg the line connecting the great toe with the anterior superior spine approximately bisects the patella.

Figs. 4 and 4 *a*.—Isolated fracture of the tibia with upward displacement (dislocation) of the head of the fibula. The anatomic specimen, figure 4 *a*, is intended as an aid to understanding the conditions. Figure 4 is copied exactly from nature; it is the leg of a man twenty-nine years of age. The injured leg was 3 cm. shorter than the sound leg.

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with advantage; the splints must be well padded so as to avoid pressure at any point, especially in the region of the heel.

In many cases of this kind I consider it absolutely indispensable to anesthetize the patient at the end of the first week and, after a thorough examination, to replace the fragments in position. At this time a well-padded plaster bandage is very useful. A second revision, followed by the application of a well-fitting plaster-of-Paris dressing, without padding, should be held about a week later. In this way lateral deviations may readily be avoided. If there is rotatory displacement, even greater care is necessary. A rotatory displacement in fracture of the upper half of the leg usually takes the form of inward rotation of the lower fragment. Should a tendency to overextension at the seat of fracture be overlooked, a permanent deformity, consisting in backward bowing of the bones, may result. This deformity is particularly apt to develop during the

Tab. 64.

Fig. 4a

Fig. 4.

Fig. 3.

Fig. 1.

Fig. 2.

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application of the plaster-of-Paris dressing, when the leg is supported only by extension applied to the foot and counterextension if insufficient force is used. It is, therefore, a good plan to raise the bone at the seat of fracture by means of a loop or with the hand, while the dressing is being applied.

If a sharp fragment of bone should press against the skin, a Malgaigne hook may be used to keep it in position. This is a special instrument which is fastened within the dressing, and, by means of a steel point which is extruded, exerts direct pressure on the offending fragment. Effectual reduction, appropriate position, and, in many cases, the employment of permanent extension with weights will, however, do all that is necessary and enable the surgeon to dispense with this instrument, which at one time enjoyed considerable repute.

A permanent extension dressing is equally applicable in fractures of the leg and yields very good results (Bardenheuer). In fractures exhibiting a tendency to recurring deformity, permanent extension applied immediately after reduction is a very useful dressing for the first week, and secures the best possible position until it is time to apply a rigid dressing; but it must be constantly and carefully looked after and, if necessary, supplemented by lateral traction (see page 72).

May not a plaster-of-Paris dressing be applied in the very beginning of the treatment of a fracture of the leg?

This question must be answered, as many physicians find it the most convenient and practicable method. First of all, the reader is referred to what has been said in the general part of this work (pages 63 and 64). There is no doubt that treatment with plaster-of-Paris dressings from the very beginning is perfectly feasible, but it requires higher technical skill and may involve great danger. A well-fitting and well-padded dressing, even a plaster-of-Paris dressing, may be applied at the very beginning if the fracture is recent when the patient first presents himself for treatment. If only one or two hours have elapsed since the injury, the swelling is as yet inconsiderable, and if the fragments are accurately replaced and a tight bandage is applied, any marked degree of subsequent swelling is, as a rule, prevented. In such a case, therefore, even a primary plaster-of-Paris dressing might do no harm; but in view of the possibility of many accidents, partly owing to the stupidity of the patients themselves, a primary plaster-of-Paris dressing should be employed only when the surgeon possesses technical skill and can see his patient every day.

Ambulatory Treatment of Fractures of the Leg (So-called Walking Dressing).—Of recent years various procedures have at different times been recommended with a view to allowing the patient to walk about while under treatment for fracture of the leg. Splints may be used similar to Thomas' splint (see page 281), such, for instance, as those designed by Bruns; extension may be applied to the leg by means of elastic strips attached to the lower end of the splint; or the leg is allowed to hang free but at the same time fixed by specially devised splints, the patient supporting his weight on the tuberosity of the ischium when he walks. The plaster-of-Paris dressings act in a similar way, or at least reach as far as the middle of the thigh, the knee being slightly bent (Krause, Korsch). Others recommend splints or plaster-of-Paris dressings that do not quite reach to the knee, thus immobilizing only the leg and foot and permitting free movement at the knee-joint (Schmid, Dollinger, and others). The technic of these dressings includes perfect reduction, and the application of a thinly padded bandage with a maximum amount of pressure to keep the fragments in good position. The dressing must be rigid enough to prevent displacement of the fragments even when the patient is walking. The pressure is in part applied over the region of the uppermost fragment; as a precautionary measure the dressing may be renewed once or twice. With a bandage of this kind the patient is said to be able to walk about without pain and without the aid of crutches.

For the present I adhere to my opinion that procedures of this kind and any other ambulatory dressings are not

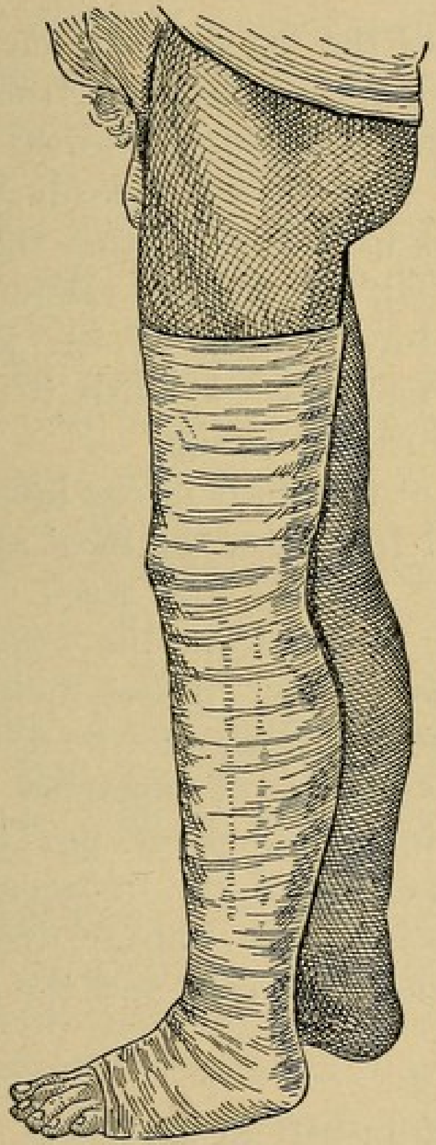

Fig. 142.—Plaster-of-Paris dressing in ambulatory treatment of fracture of the leg, either at the middle or above the middle of the bones.

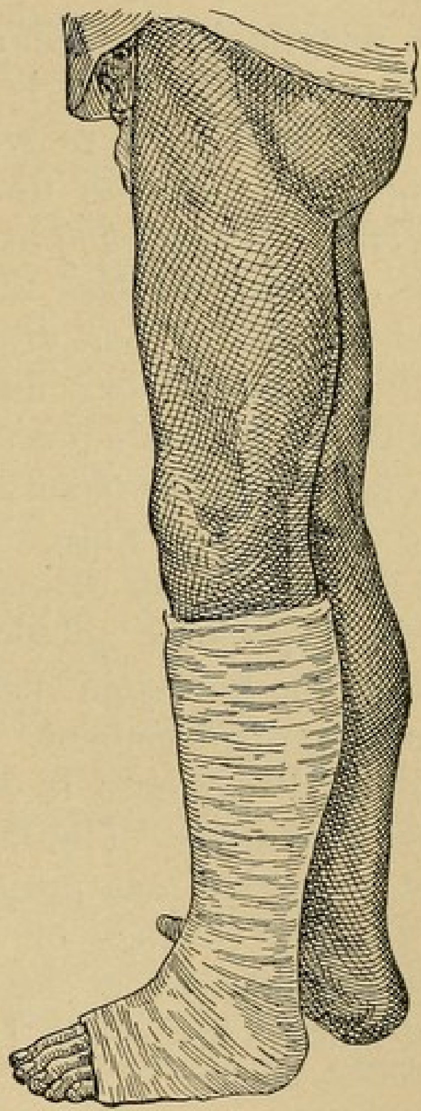

Fig. 143. — Plaster-of-Paris dressing in ambulatory treatment of fracture of the leg below the middle of the bones, especially fracture of the ankle.

appropriate in general practice, though they may give excellent results in the hands of a few surgeons.

After the bones have united, baths, douches, massage, and active and passive movements are required to restore the function. If a bony prominence remains at the seat of fracture and requires correction, because it is painful or otherwise distressing, it should be removed with a chisel; the bone should be exposed by turning back a flap of tissue.

The **prognosis** of fractures of the leg depends entirely on the treatment. If it is correctly carried out from the beginning, the fracture will be completely healed and function fully restored unless very special complications supervene. Experience teaches us, however, that this result is obtained in less than half the cases. Deformity and edema at the seat of fracture, rigidity of the joints, etc., often continue for a long time or permanently to interfere with the victim's power to earn a living.

[In my experience fractures of the shaft of the bones of the leg (one or both) are, of all fractures, the most appropriate for the plaster dressing. For the first week or ten days the knee-joint should be included in the dressing; after this the knee-joint may be left out, unless there is a tendency to displacement. These patients can be allowed to walk with crutches in the majority of instances after the first few days. The most important point, next to the perfect reduction and proper fixation of the fragments, is more frequent change of dressing; the plaster dressing should be changed at least once a week, and the limb bathed and rubbed.—Ed.]

II. Isolated Fracture of the Shaft of the Tibia

(Plate 64, Figs. 4 and 4 *a*.)

It has already been remarked that fracture of both bones of the leg begins in many cases as a fracture of the tibia alone, that of the fibula occurring secondarily. Fracture of the tibia may be produced by bending, as well as by torsion. In the operation of osteoclasis for the correction of rachitic legs it is often observed that the tibia alone gives way, and that fracture of the fibula requires a second effort on the part of the operator.

Isolated fracture of the tibia may therefore be produced by *indirect* or by *direct* violence ; if the latter, by a blow, a fall, the kick of a horse, etc.

The **diagnosis** of isolated fracture of the tibia, if it is oblique and associated with some degree of displacement, is not difficult, even though the intact fibula acts as a kind of splint. If the fracture is transverse, however, and the fragments are in good contact without displacement, the diagnosis is difficult. In the absence of other signs the surgeon must rely on a certain crackling noise elicited by forced movements, with pain on pressure and on striking the bone. If the isolated fracture of the tibia is associated with marked displacement, the fibula must also be involved. Either the bone is broken and the fragments are displaced as those of the tibia, or, as happens particularly in fractures of the upper half of the shaft of the tibia, the fibula is dislocated, the head of the bone being displaced upward (Plate 64). The mistaken diagnosis of isolated fracture of the tibia is the more easily made from the fact that the fibular fracture, instead of being at the same level with the tibial fracture, is quite frequently at some distance from it, usually at a much higher point (Plate 64, Fig. 2).

Treatment.—The fragments should be replaced as perfectly as possible; in a recent case, any displacement of the fibula that may exist can at the same time be corrected. To keep the fragments in position a well-fitting plaster-of-Paris or splint dressing suffices. In transverse fractures without displacement the ambulatory treatment is more easily carried out than in fractures of both bones of the leg.

III. Isolated Fracture of the Shaft of the Fibula

This is a very rare injury that can only be produced by violent direct force, as the fibula is protected by a robust layer of muscles. The injury is treated on general principles.

(C) Fracture of the Lower End of the Leg

I. Fracture of Both Bones at their Lower Ends

In this section I shall repeatedly speak of forced movements of the foot, of the foot being bent over sidewise, etc. In addition to dorsal and plantar flexion, we also speak of a lateral movement or bending of the foot toward the outside, described as abduction or pronation, and to the inside, described as adduction or supination. The movement concerns the posterior segment of the tarsus, the astragalo-tarsal articulation, and the robust lateral ligaments of the astragalo-crural articulation. The foot is rotated about a line that corresponds approximately to its long axis. Finally an injury may also be produced by rotation of the foot, which really consists in a rotation of the leg about a vertical line corresponding to the longitudinal axis of the leg, and is also known as inversion and eversion.

(a) **Supramalleolar Fracture of Both Bones of the Leg** (*Fractura cruris supramalleolaris*). (Plate 65.)—This fracture merits special consideration. It may be compared to supracondylar fractures occurring at the lower end of the femur or of the humerus, and especially that occurring at the lower end of the forearm.

The fracture is produced by *direct* violence, or *indirectly* by sudden abduction or adduction of the foot; it is also frequently produced by torsion of the foot, so that the line of fracture may extend into the ankle-joint.

The **diagnosis** of supramalleolar fracture as such is not difficult. The displacement, which is usually quite considerable, may produce a talipes valgus (Plate 65, Fig. 3), or, as I have observed in a number of cases that healed with deformity, a varus-position or curvature of the leg in the so-called O-shape (Plate 65, Fig. 4). The lower fragment may also be displaced backward, causing the foot to drop at the heel.

Treatment.—After the fragments have been replaced, a

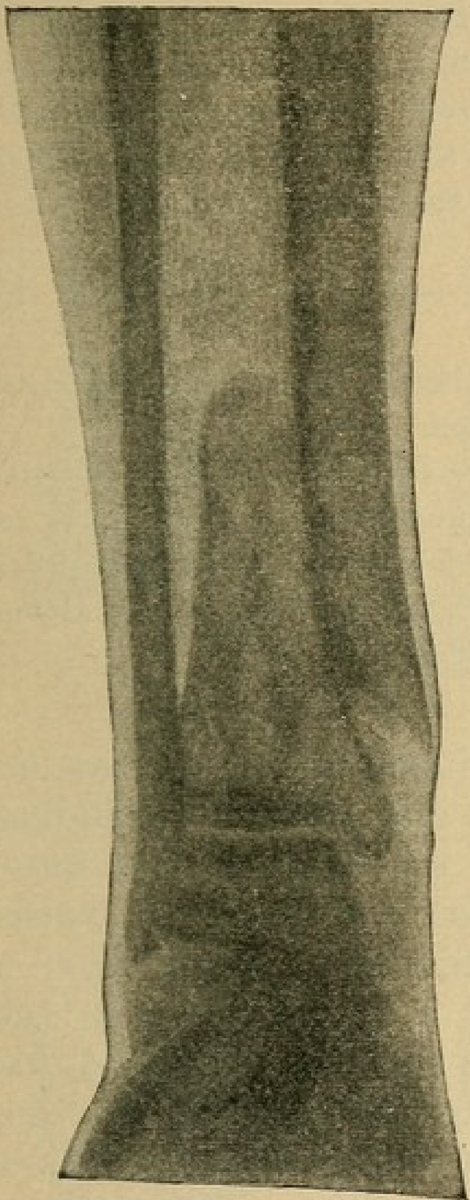

Fig. 144.—Skiagraph of a supramalleolar fracture of the tibia (torsion-fracture) with great displacement of the fragments, produced by a fall from a bicycle. When the patient presented himself for treatment, nine weeks after the accident, the fragments were firmly united with callus. The tip of the upper fragment was removed by operative means, after which the injury was treated by massage and passive movements, the patient wearing a special apparatus to relieve the ankle-joint.

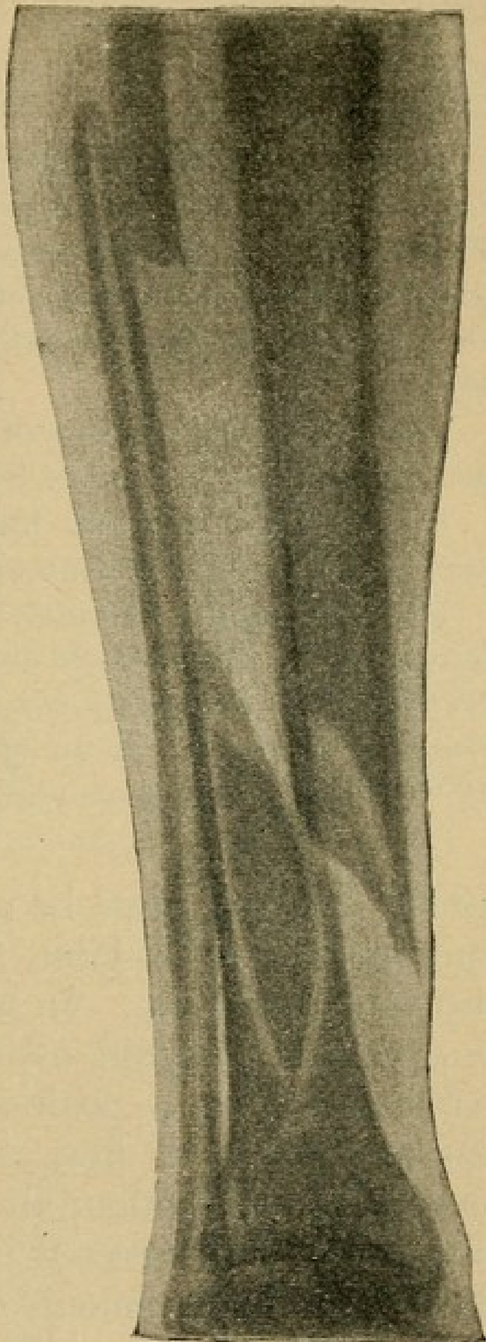

Fig. 145.—Skiagraph of a supramalleolar spiral fracture of the tibia. There is also a fracture of the fibula at its upper extremity. Frd. Helm, fifty-two years of age, 1897. When the patient was admitted, three weeks after the injury, the deformity here depicted was found at the seat of fracture, with marked inversion of the foot. The position of the fragments was corrected as well as possible; later the projecting point of the bone was removed with a chisel. The fracture healed slowly with good ultimate position of the limb.

PLATE 65.

Fractures of the Lower End of the Leg.—Fig. 1.—Torsion-fracture of the lower end of the tibia with typical bending fracture of the fibula. The specimen was taken from a patient who had sustained a compression-fracture of the same tibia (Plate 63, Figs. 3 *a* and 3 *b*). The torsion-fracture extends into the astragalo-crural articulation.

Fig. 2.—Torsion-fracture of the lower half of the tibia, fibula intact. The ankle-joint is not involved.

Fig. 3.—Supramalleolar fracture of both bones of the leg, with great deformity, producing a talipes valgus. Bony union.

Figs. 4 *a* and 4 *b*.—Supramalleolar fracture of both bones of the right leg, with considerable deformity, producing a talipes varus or O-shaped leg. Figure 4 *a* is a posterior view of both limbs in parallel position. Figure 4 *b* is an anterior view of the injured leg alone. (Christian Sass, forty-nine years old, 1896.)

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careful dressing must be applied, immobilizing the seat of fracture, the ankle-joint, the foot, and, at first, including also the knee-joint. In applying the dressing, care must be exercised to avoid overcorrection. I have seen varus deformity—*i. e.*, a position of adduction—result from a fracture which at first presented a displacement in the sense of an abduction, all because the limb was fixed too long in an overcorrected position by the pressure bandage. Backward displacement of the foot along with the lower fragment is to be specially guarded against.

In badly united fractures the degree of deformity is at once recognized by inspecting the foot from behind, especially if the two legs are placed in parallel positions. The only way to correct the deformity is by osteoclasis or osteotomy at the seat of fracture; and the operation should by all means be performed, in the hope of avoiding or at least diminishing the functional disability which otherwise becomes permanent.

Fig. 1.

Fig. 2.

Fig. 3.

Fig. 4 a

Fig. 4 b

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Fractures of the Ankle (b and c)

These fractures form a group which is of the greatest practical importance. They are produced indirectly by forcible pronation or supination of the foot at the ankle-joint, or by sudden rotation (eversion or inversion). We may accordingly distinguish supination-, pronation-, and inversion- or eversion-fractures. For practical purposes, however, fractures of the ankle are divided into *dislocation-fracture* (Stromeyer) and *sprain-fracture* (v. Burckhardt). The former are combined with simultaneous dislocation of the foot, the latter only with distortion of the ankle-joint. These two groups have the following points in common: They are produced by indirect violence; they are combined with a fracture of one or both bones of the leg at their lower extremity; the ligamentary apparatus of the ankle-joint is involved, the injury ranging from simple distortion to complete luxation with extensive laceration of the ligaments (v. Burckhardt).

Fractures of the ankle by direct violence are clinical curiosities. In the treatment of all fractures of the ankle the fundamental fact that we are dealing with a joint-fracture must never be lost sight of (see page 74); hence systematic passive and active movements with massage must be employed. First, however, the fragments must be replaced as accurately as possible if any deformity exists.

Deformity is always present in dislocation-fractures, while in sprain-fractures the deformity is apt to be slight or absent. Reduction is effected by vigorous extension applied to the heel, followed by sudden compressing, forcing the foot into its proper position. The positions of the bones should be re-examined and, if necessary, again corrected at the end of the first week. Anesthesia is usually required.

(b) Typical Fracture of the Ankle (Pott's Fracture) (Plates 66, 67). (*Fractura malleoli interna cum fractura fibulæ supramalleolaris*, or *Fractura malleolaris tibiæ et supramalleolaris fibulæ.*)—A typical fracture of

PLATE 66.

Typical Fracture of the Ankle (Pott's Fracture).—Fig. 1.—Illustrates an anatomic preparation after the artificial production of a fracture of the ankle-joint. The joint has been opened in front and freely dissected. The internal malleolus is seen to be broken, although still attached to the tarsus by the strong deltoid ligament. We also see the two small fragments torn loose from the tibia by the anterior and posterior tibiofibular ligaments. The external malleolus is displaced outward, away from the tibia. This displacement is made possible by fracture of the fibula above the ankle, permitting considerable outward excursion of the external malleolus.

Fig. 2.—Frontal longitudinal section of the leg and foot, after the artificial production of a typical fracture of the ankle. The internal malleolus, which is broken off from the tibia, is seen alongside of the astragalus. The supramalleolar fracture of the fibula is particularly well shown, with the angular deformity of the bone at this point which is responsible for the pronounced valgus position of the foot.

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the ankle may be compared to a typical epiphyseal fracture of the radius; just as in the latter, the mode of production, the symptoms, and the principles on which the treatment is based present certain typical features. That the fibula should be included in a fracture of the ankle is readily understood on account of the anatomic relations; *i. e.*, the intimate connection between the tibia and the fibula.

Etiology.—A typical fracture of the ankle is usually produced by a sudden fall of the body outward when the foot is fixed, or by sudden eversion of the foot. The fracture can also be produced on the cadaver as follows: The leg is placed in such a position that the outer surface lies flat on the table, the foot and ankle projecting over the edge; the operator suddenly throws the weight of his entire body on the foot so as to bring about abduction, the internal malleolus is torn loose, and, if the force is continued, the fibula gives way a little above the outer malleolus at the point where the leg projects over the edge of the table.

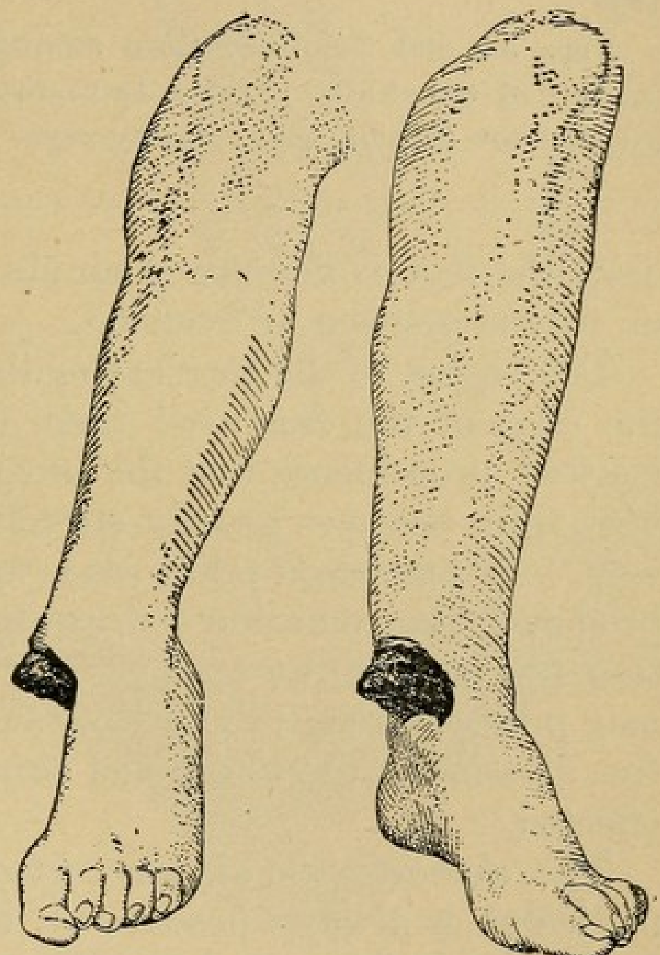
Precisely the same conditions are found in the majority

Fig. 1.

Fig. 2.

Lith. Anst. F. Reichhold, München.

of fractures of the ankle. The abduction or pronation of the foot at the astragalo-crural articulation throws great strain on the internal lateral ligament or deltoid ligament. If the movement is continued, the tip of the internal malleolus and not the ligament, as a rule, gives way. As the next step the foot as a whole, and especially the heel, is forced against the external malleolus, and the fibula gives way at its weakest point a few inches above the ankle. In a number of cases the weight of the body on the abducted foot after the internal malleolus has been fractured produces a bending and finally a fracture of the fibula, as that bone alone is unable to support the weight of the body.



Figs. 146 and 147.—Compound fracture of the ankle in a woman twenty-five years of age. Reduction was finally accomplished after division of the interposed skin. Under strict aseptic treatment recovery ensued with good function at the ankle-joint.

Symptoms.—Accordingly, the tip of the internal malleolus in a typical fracture of the ankle is abnormally movable and often displaced downward, while the fibula presents a fracture above the external malleolus. By holding the foot in one hand and fixing the leg above the region of the ankle, abnormal lateral movements, especially abduction or pronation of the foot, are possible. In most

PLATE 67.

Fracture of the Ankle.—Fig. 1.—Normal epiphyseal lines at the lower end of the tibia and fibula.

Figs. 2 *a* and 2 *b*.—Fracture of the ankle, healed with deformity—*i. e.*, severe traumatic pes planus, after a typical fracture of the ankle. Anterior and posterior views (Lohrke, male, thirty-nine years old, 1896).

Figs. 3 *a* and 3 *b*.—Backward subluxation of the foot in typical fracture of the ankle. Figure 3 *a* represents the living foot, figure 3 *b* the skeleton (Schön, male, twenty-eight years old, 1895).

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cases the foot is already in an abnormal position—a kind of valgus position or eversion.

The region of the internal malleolus, or, more correctly, the edge of the fractured tibia, sometimes forms such a marked prominence that the integument over it, which is very thin, becomes greatly stretched and threatens to give way. If laceration takes place and a compound injury is produced, the condition not rarely becomes a true dislocation (dislocation-fracture). The lower end of the tibia may project through the skin to such an extent as to require free division of the interposed skin before reduction can be effected.

The *characteristic angular deformity* above the external malleolus is always present in the fibula to a greater or less extent. Abnormal mobility of the fragment can often be determined by palpation, although not without considerable pain to the patient. The upper end of the fragment can occasionally be reduced by pressing on the tip of the malleolus, effecting a kind of rocking movement, which is sometimes accompanied by palpable crepitation. It is extremely important to keep the anatomic details of this fracture well in mind. The fragment of the internal malleolus is often extremely small. The fracture of the fibula as just described is, of course, possible only if the ligaments uniting the tibia and fibula at their lower extremities have been divided. These ligaments may be torn, but there is

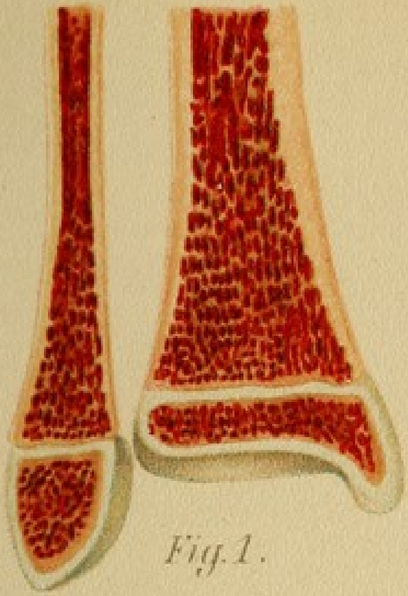


Fig. 1.

Fig. 2 a

Fig. 2 b

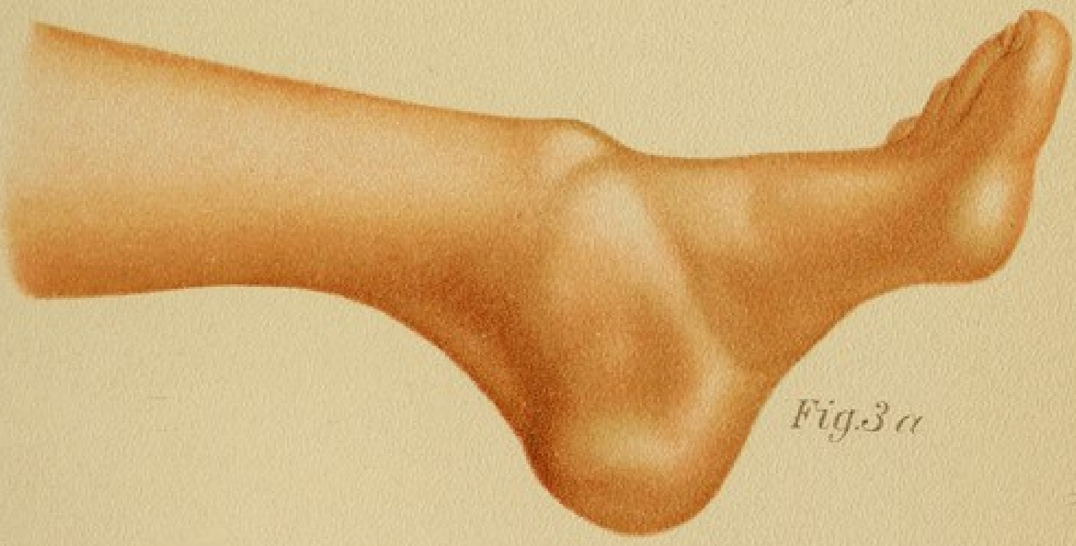


Fig. 3 a

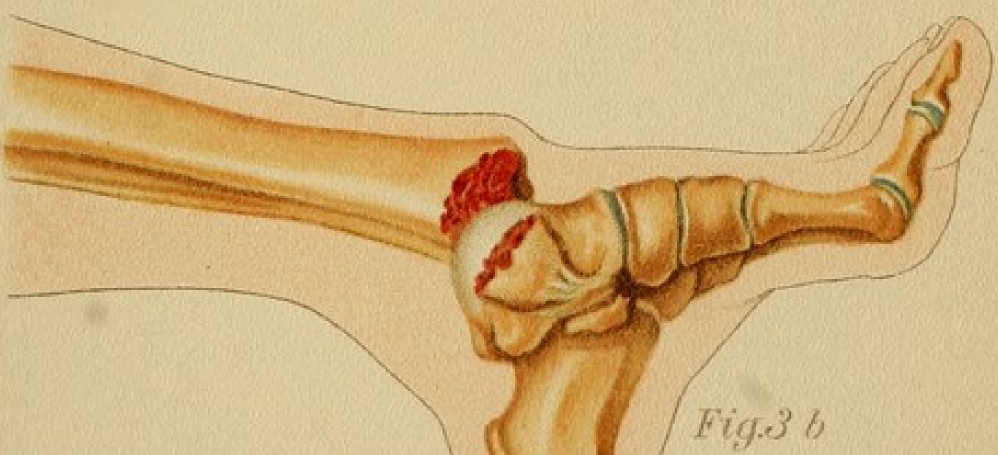
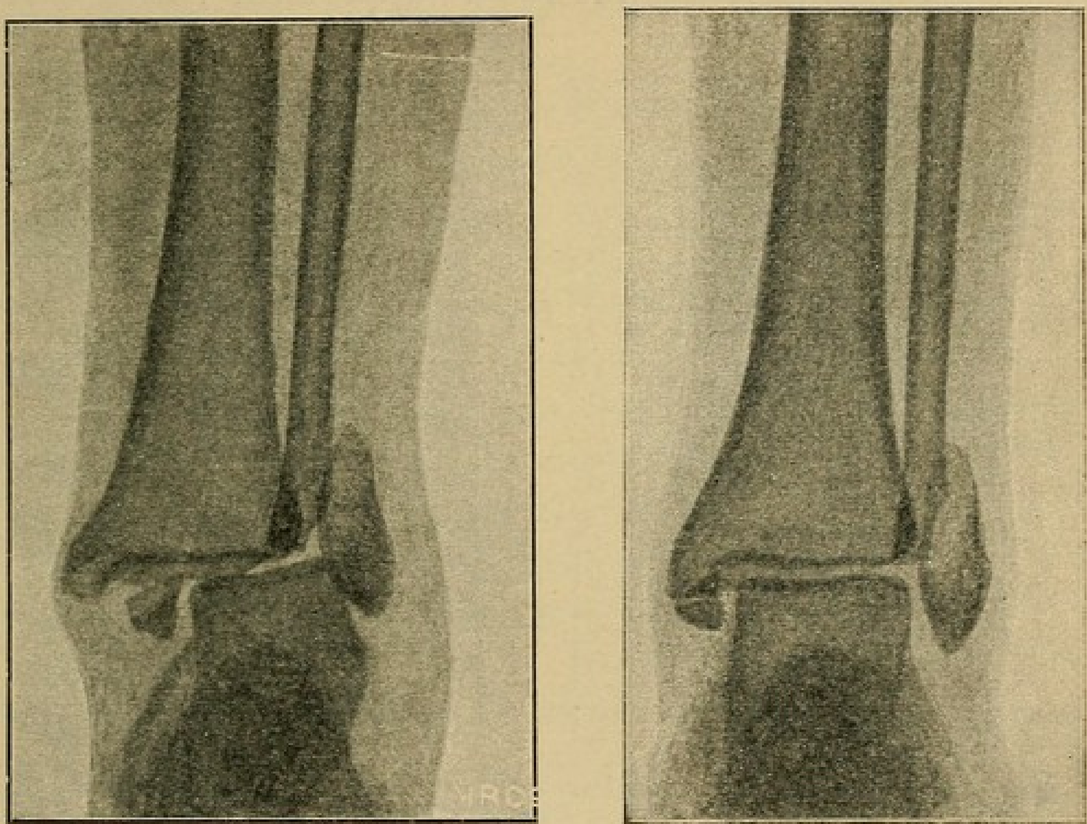


Fig. 3 b

Lith. Anst F. Reichhold. München.

always a possibility of a fragment being torn loose from the articular end of the tibia. In this way a fragment of variable size, sometimes from an oblique fracture extending into the joint, may be torn away in front by the anterior tibiofibular ligament, and occasionally also behind by the posterior tibiofibular ligament (see Plate 66). It is



Figs. 148 *a* and 148 *b*.—Typical fracture of the ankle before and after reduction. Wilhelm Hamann, male, aged fifty-two years, stumbled and fell on his right leg. Typical ankle-joint deformity. In Fig. 148 *a* the fractured and outward displaced tip of the inner malleolus, the supramalleolar fracture of the fibula, and the displacement of the lower fragment are well shown. Under anesthesia reduction was successfully accomplished (Fig. 148 *b*). The direction of the bones at the seat of fracture is good, though the lower fibular fragment still forms a prominence. Recovery with good functional result.

only after the connection between the tibia and the fibula has been severed, that the fibula can be displaced laterally until a bending-fracture is produced.

It is a point of clinical importance that the function in these cases is not always completely abolished. Individuals with unusual grit, sometimes even children, may be able to limp along quite a distance.

Prognosis.—Typical fracture of the ankle, even when it is not compound, always represents a grave injury. It is a true articular fracture and doubly important from the fact that the affected joint must support the entire weight

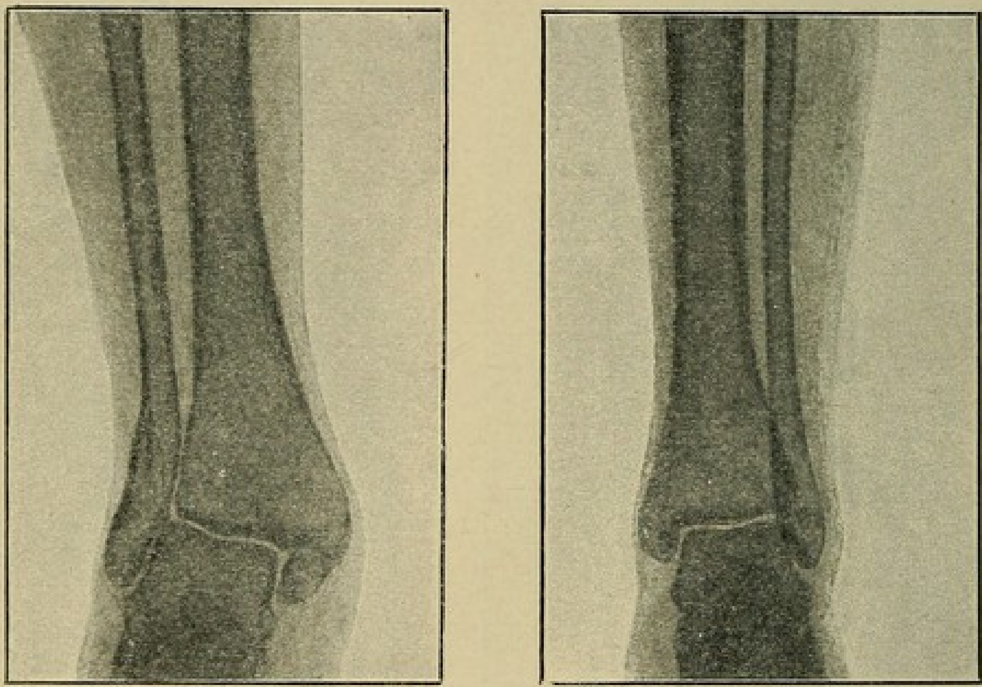


Fig. 149.—Röntgen-ray pictures of a typical fracture of the ankle of some standing, with a skiagraph of the sound leg. Saklowsky, female, forty years old, sustained this fracture fourteen years before pictures were taken. The fracture healed without medical treatment of any kind in the course of a year. Typical deformity. Increasing difficulty in walking and standing. Operation: Osteotomy of the internal malleolus and fibula, followed by correction of the deformity. A week later another attempt to correct the position of the foot was made under anesthesia. Uneventful recovery with considerable improvement in position.

of the body. Gross mistakes are still made in its treatment, with grave consequences to the function of the joint and the individual's ability to earn a living for the rest of his life.

Treatment.—First and most important is complete replacement of the fragments. The foot as a whole must be forced over toward the tibia by a movement of adduction. It was formerly taught that the foot should actually be brought into the varus position so as to correct the valgus deformity that is present, or to prevent its occurrence. But this procedure is neither necessary nor advisable, providing only the position of the foot is completely corrected and the angular deformity of the fibula above the external malleolus is made to disappear. To effect this, the fibula must be forcibly pushed against the tibia; or the two malleoli may be forcibly brought together. In a severe compound injury of this kind I replaced the lower fragment of the fibula and then nailed it to the lower shaft of the tibia. If there is backward displacement, it must be corrected at the same time by drawing the foot forward.

After reduction has thus been effected, if necessary under anesthesia, the foot and leg must be placed in the proper position. It is of the utmost importance to keep the foot at a right angle with the leg and otherwise in correct position, so that when the patient begins to walk, the foot will rest on the ground in the normal manner. During the first days a splint dressing—either a tin or a wire splint—is best; later, a plaster-of-Paris splint or two plaster-of-Paris gutters made by dividing the dressing and not too thickly padded should be used. In a short time the patient can leave his bed and begin to use the leg.

During the first two weeks the dressing should be removed at intervals of three or four days, and after that every other day, to permit massage and passive movements of the joint. The position of the foot must be constantly watched, for I once saw a very unfavorable position of the foot result from careless bandaging several weeks after the injury, although the position during the first few weeks had been quite good. Even much later, when the fracture is firmly united, the surgeon's attention should be directed to this point, and when the patient is discharged he should be given an appropriate brace to prevent the formation of talipes valgus. I have known a great deal of good to result from the use of medico-mechanical apparatus.

To combat an obstinate tendency to talipes valgus a dressing after the manner of the old Dupuytren's splint is of advantage. Dupuytren's dressing consists of a splint applied to the inner side of the leg and a cushion covering the leg from the knee to the ankle-joint. An interval is thus left between the splints and the region of the internal malleolus and foot, permitting the latter to be drawn over toward the splint and secured by a few turns of a roller bandage.

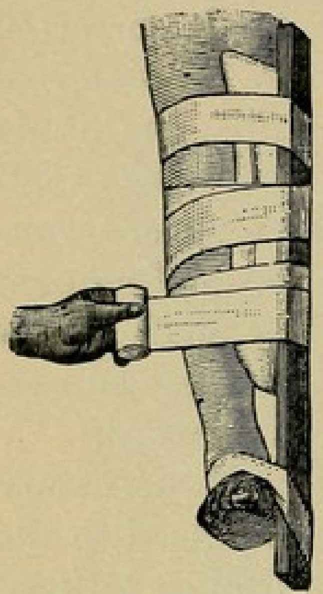


Fig. 150. — Dupuytren's dressing for typical fracture of the ankle with deformity, producing a traumatic talipes valgus. A cushion is interposed between the splint and the side of the leg, so that the free projecting end of the splint may be utilized to fix the foot in the proper position.

The advantage of this dressing in counteracting outward displacement of the foot and the production of talipes valgus is at once apparent.

If the limb is in a bad position when the patient presents himself for treatment, and the fragments have for weeks been fixed in their incorrect position, appropriate operative measures must at once be resorted to. If it is found impossible to break up the adhesions that have formed, osteotomy of the fibula at the seat of fracture, and *of the internal malleolus* as well, must be performed in order to bring the foot into the correct position. The after-treatment is then the same as for a recent fracture.

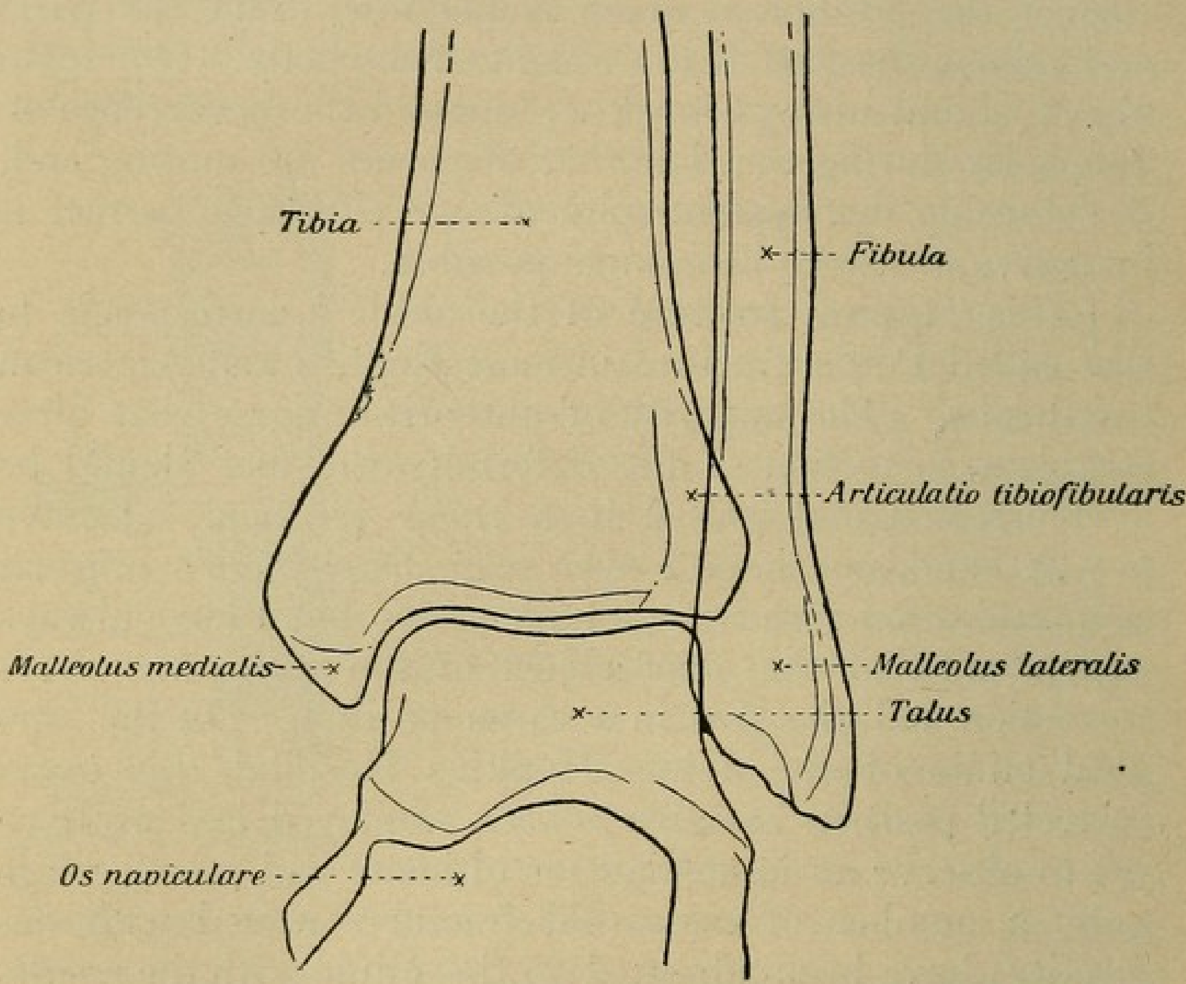
In these cases with bad deformity it is useless to hope for gradual improvement by the patient's becoming accustomed to the condition. The interference with the movement and position of the heel and of the remaining bones of the tarsus, produced by the injury in the ankle region, are more likely to become aggravated as time goes on. If the patient refuses operation, some improvement may be secured by means of a brace so applied as to correct the position as much as possible, to fix the parts and relieve the foot of the weight of the body. Our main object is, and always must be, to avoid the occurrence of deformity during the time that the bones are uniting and, if deformity develops in spite of our efforts, to correct it by active measures as soon as possible.

[This "typical fracture of the ankle" corresponds to that called Pott's fracture in most English and American text-books. The majority of authorities agree that after complete correction of the deformity the foot should be overcorrected and placed in a *varus* position. I have not at hand, nor have I ever seen, Dupuytren's original communication with regard to his splint, but I have always understood that the chief object of the splint was overcorrection and the foot in a varus position. In the surgical clinic of the Johns Hopkins Hospital this overcorrected position has always been employed, and we have yet to observe an immediate or ultimate bad result, while quite a number of cases (old fractures united with deformity) have been admitted to the clinic with the resultant flat-foot when this overcorrected position was not employed. My own experience teaches me, then, emphatically to favor the overcorrected position.

Flat-foot following Pott's fracture is not uncommon. In many cases the functional disability can be relieved by a proper shoe and a flat-foot brace. The operative results, even in the worst cases of deformity, are most satisfactory. The older operation was an osteotomy of the tibia with forced correction of the deformity (Trendelenburg's operation). Osteotomy at the seat of fracture in the fibula is a much simpler procedure, and with rare exceptions will overcorrect the deformity. After this latter operation the foot is almost restored to its normal appearance, while after Trendelenburg's osteotomy there results a rather unsightly curvature of the lower end of the tibia.—ED.]

PLATE 67 a.

Skiagraph of a Normal Ankle-joint; Anterior View.

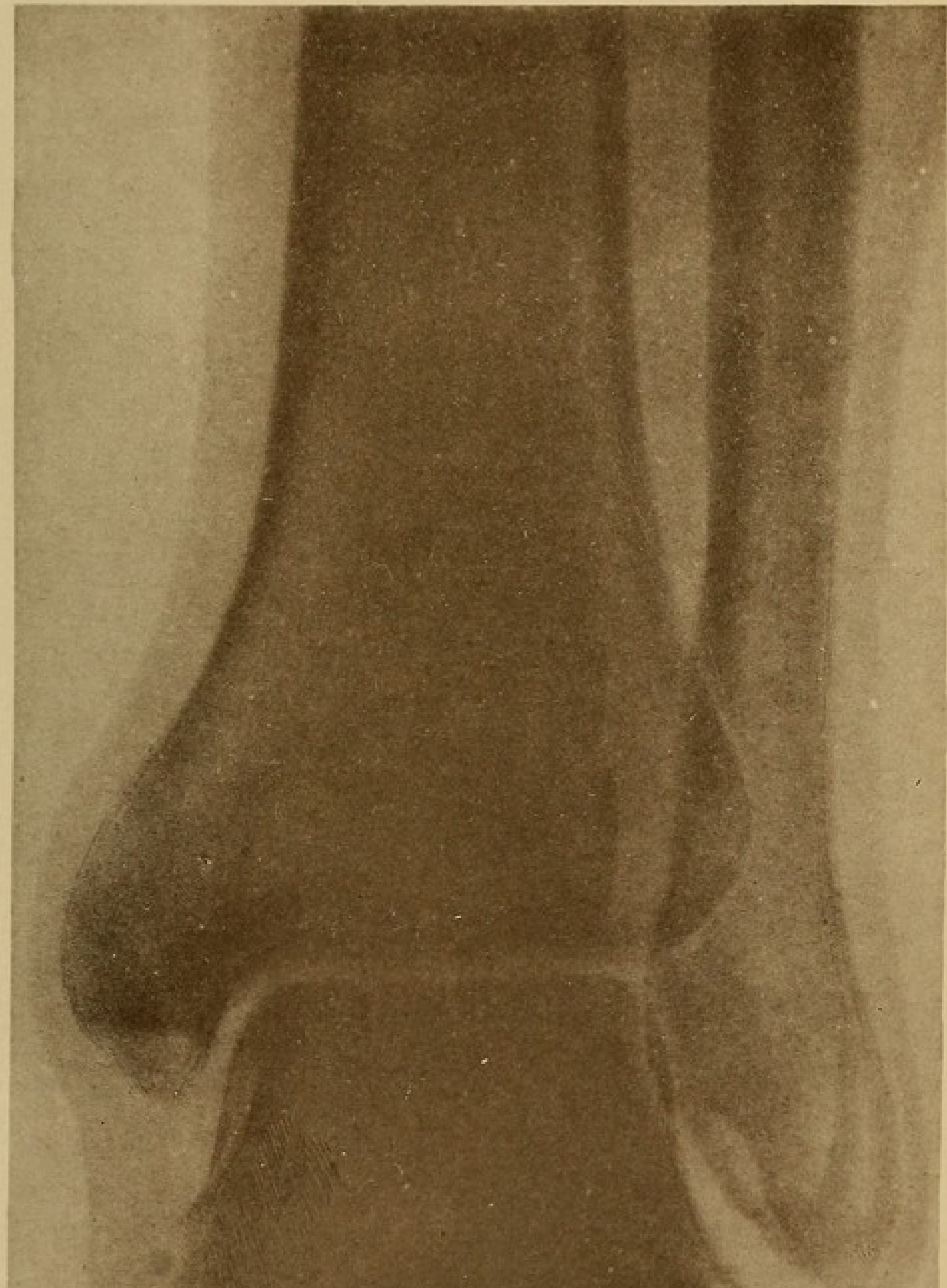


(c) **Fracture of Both Malleoli** (*Fractura malleolorum, Fractura malleoli externi et interni*).—If the foot is adducted or supinated until the external malleolus gives way, with the production of a talipes varus, the internal malleolus may also be fractured. For mechanical reasons the shaft of the tibia does not become fractured as in the typical fracture of the ankle, as we can readily understand.

This injury is very much less frequent than the typical fracture of the ankle described under b (Pott's fracture). We may here include certain other rare fractures, such as fractures by rotation of the foot at the astragalo-crural articulation about a vertical axis corresponding to the long axis of the leg.

The diagnosis requires only a careful examination, and

Tab. 67 a.



the treatment is analogous to that of typical fracture of the ankle.

(d) Epiphyseal Separation at the Lower Extremities of the Bones of the Leg (Plate 67, Fig. 1).—This is a rare injury which is only observed in children. It

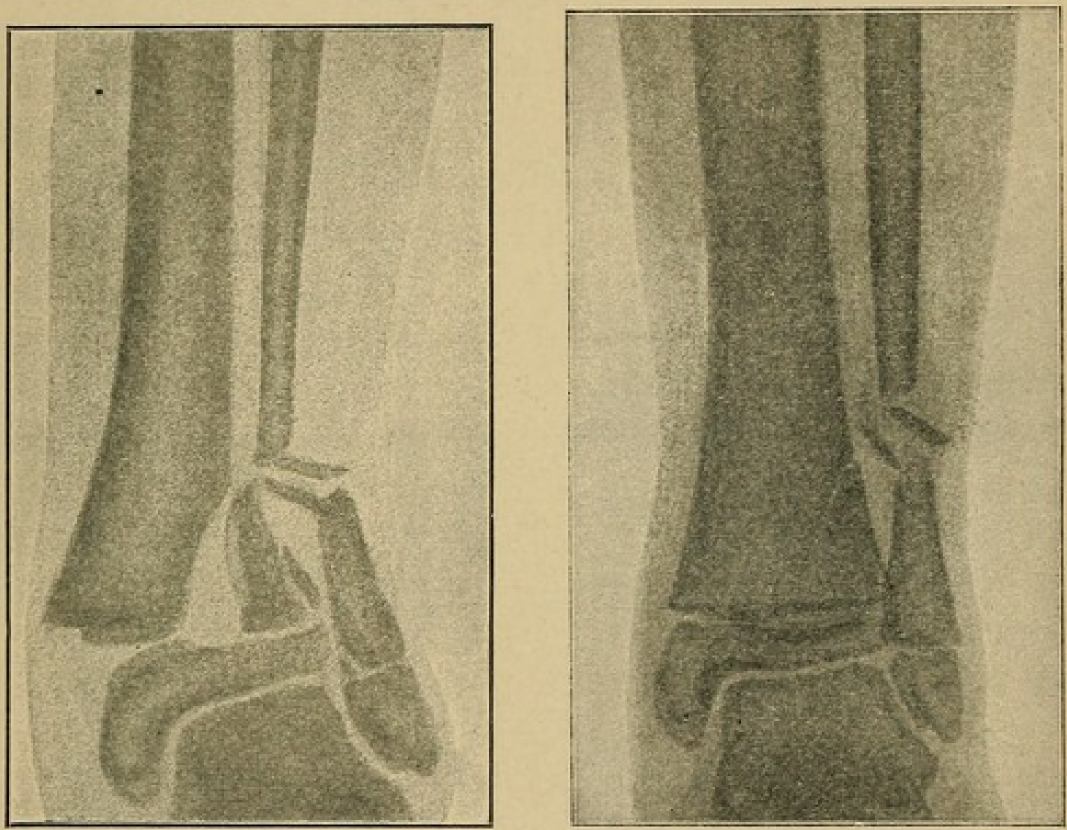
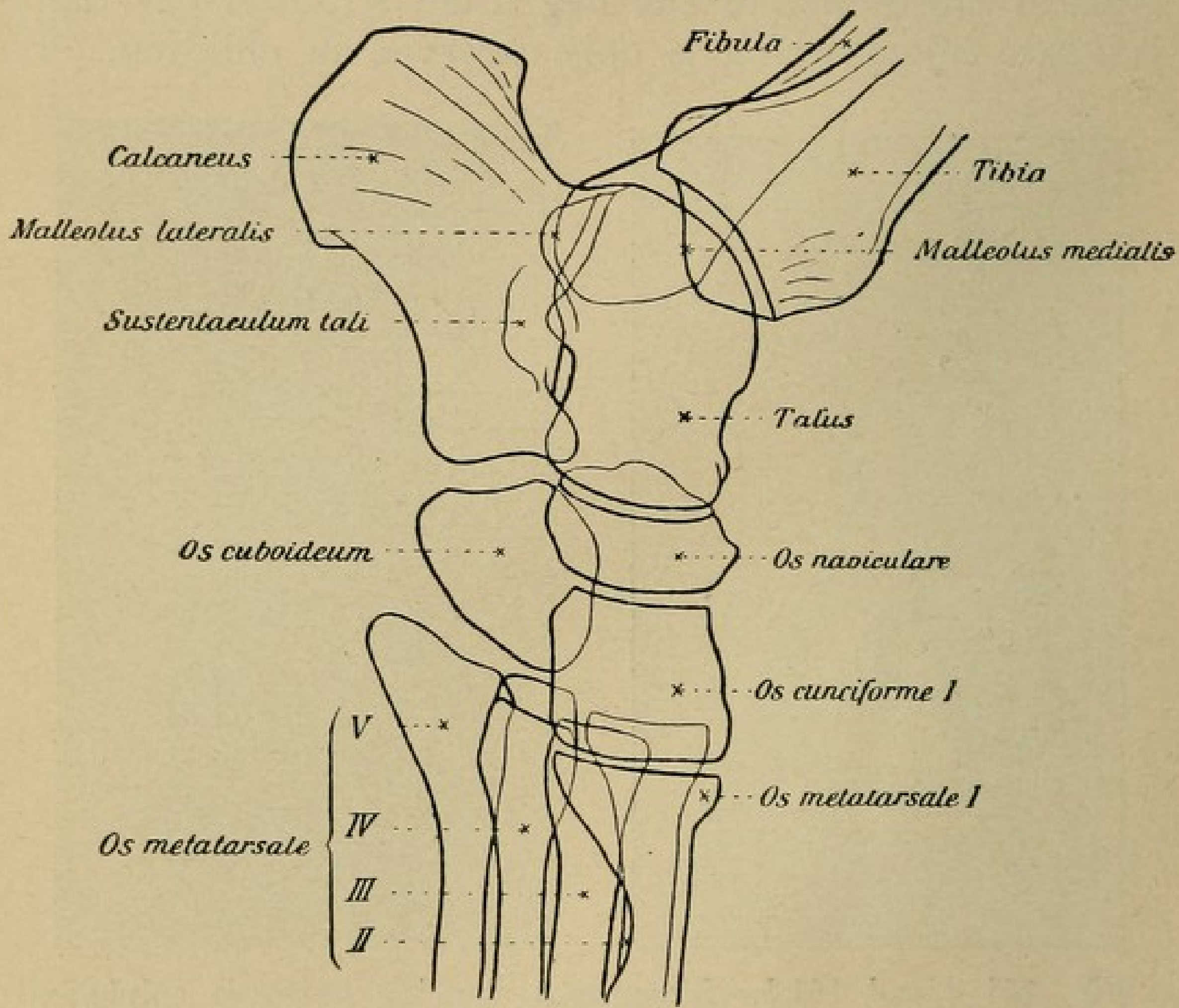


Fig. 151 *a* and 151 *b*.—Skiagraphs showing a severe epiphyseal separation at the lower end of the tibia, with fracture of the fibula before and after reduction. Wilhelm P., sixteen years old, fell downstairs and injured his right ankle. On admission (December 2, 1899) the leg presented extreme deformity as in a typical fracture of the ankle. The diagnosis of epiphyseal separation was made by the characteristic symptoms and the skiagraph (Fig. 151 *a*). Reduction was successfully accomplished under anesthesia; recovery with very good functional results. Skiagraph (Fig. 151 *b*).

sometimes occurs during the forcible correction of severe grades of club-foot. The separation is recognized by the presence of abnormal mobility above the region of the ankle and by cartilage crepitus. The treatment demands complete rest and, later, exercises.

PLATE 67 b.

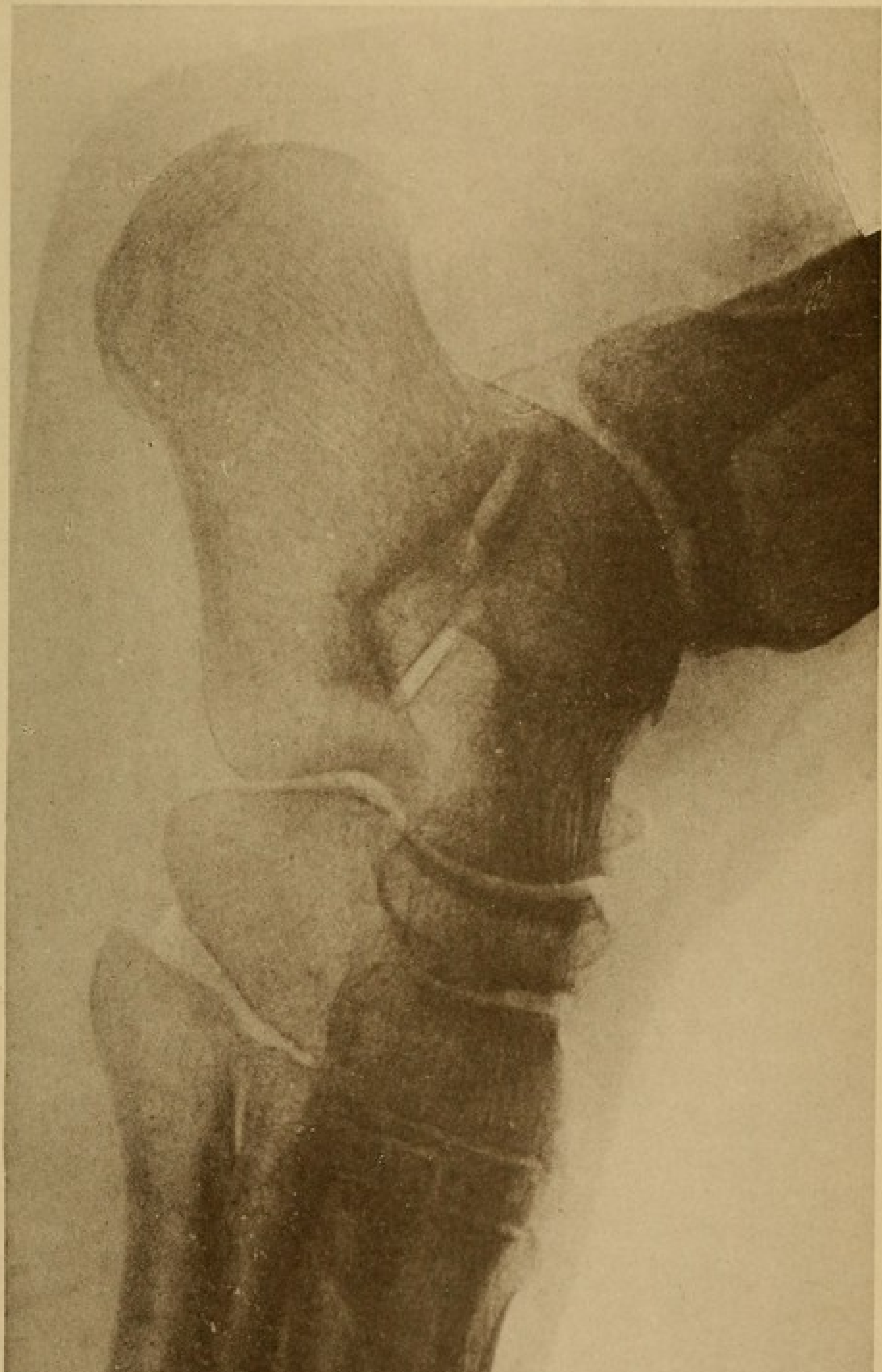
Skiagraph of the Normal Astragalo-tarsal Articulation and Tarsus; Lateral View.



II. Isolated Fracture of the Tibia, and III. Isolated Fracture of the Fibula at their Lower Extremities

These two classes include isolated *supramalleolar* and *malleolar* fractures of one or the other of the two bones. They are produced indirectly in the same manner as the fractures of the ankle which have just been minutely described, except that the force required is less intense or the application less prolonged. They may also be produced by direct violence through the agency of a sharp body striking the bone or by the individual's falling against such a body.

Tab. 67 b.



Isolated fractures of one malleolus are relatively common, while isolated supramalleolar fractures are rare.

Examination sometimes fails to yield positive results, but the pain elicited by abduction or adduction of the foot, or by pressure, or by a blow, will at least suggest the presence of a fissure. Doubtful cases must be treated as if fracture were present. The **treatment** should follow the general principles laid down for the treatment of fractures of the ankle.

6. ASTRAGALO-CRURAL ARTICULATION

Movements of the foot include flexion and extension at the astragalo-crural articulation, and pronation and supination at the astragalo-tarsal articulation. In pronation and supination the full connection between the astragalus and the bones of the leg is maintained, the movements affecting only the articular connections between the astragalus and the os calcis and those between the talus [astragalus] and the os naviculare [scaphoid].

When external violence produces forced movements of the foot ending in a sprain or dislocation, the foot performs one of the following movements: Flexion (plantar flexion) or extension (dorsal flexion) about a horizontal frontal axis; pronation (abduction) or supination (adduction) about a horizontal sagittal axis, corresponding to the long axis of the foot; eversion (tip of the foot turned outward) and inversion (tip of the foot turned inward), or rotation about the vertical axis of the leg.

(a) Dislocations at the Astragalo-crural Articulation (Plate 68).—These are the true luxations of the foot. We may have a forward, by excessive dorsal flexion, or a backward dislocation, by excessive plantar flexion. The position of the foot is so characteristic (see Plate 68) that the diagnosis is made without any difficulty. The dislocation is reduced by direct pressure on the tibia, forcing it forward or backward, with simultaneous flexion in one

PLATE 68.

Dislocation of the Foot at the Astragalo-crural Articulation.—Figs. 1 and 1 *a*.—Specimen showing backward dislocation of the foot. The astragalus is observed behind the external malleolus, and between the two bones are the tendons of the peronei muscles. The foot is shortened, the posterior portion, corresponding to the heel, being lengthened. Figure 1 *a* shows the appearance in the skeleton.

Figs. 2 and 2 *a*.—Specimen showing a forward dislocation of the foot. The astragalus is in front of the bones of the leg the tendons of the peronei muscles are stretched, the foot is lengthened, the part corresponding to the heel being shortened. Figure 2 *a* shows the condition in the skeleton.

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direction or the other, according to the kind of dislocation present. If one of the tarsal bones is fractured, it is of no importance. Lateral dislocations are not possible without the presence of fracture of the ankle.

(b) **Dislocation at the astragalo-tarsal articulation,** or so-called *luxatio sub talo,* when outward, is produced by excessive pronation, when inward, by forced supination of the foot. Anterior and posterior dislocations at this joint are even more rare. The diagnosis may present some difficulties, but can usually be made by carefully palpating the bony prominences, by finding the movement of the astragalo-crural articulation to be normal, and by noting the altered shape of the foot, especially if the examination is made under anesthesia.

Reduction is very difficult and requires complete relaxation of the muscle. It may be accomplished by appropriate manipulation and pressure.

Isolated Dislocation of the Astragalus (Talus)

The astragalus may be dislocated in various directions. The mechanism is extremely complicated, and has never been fully explained. The injury is accompanied by great deformity; the astragalus may be felt more or less distinctly through the skin. The tibia approaches the sole

Tab. 68.

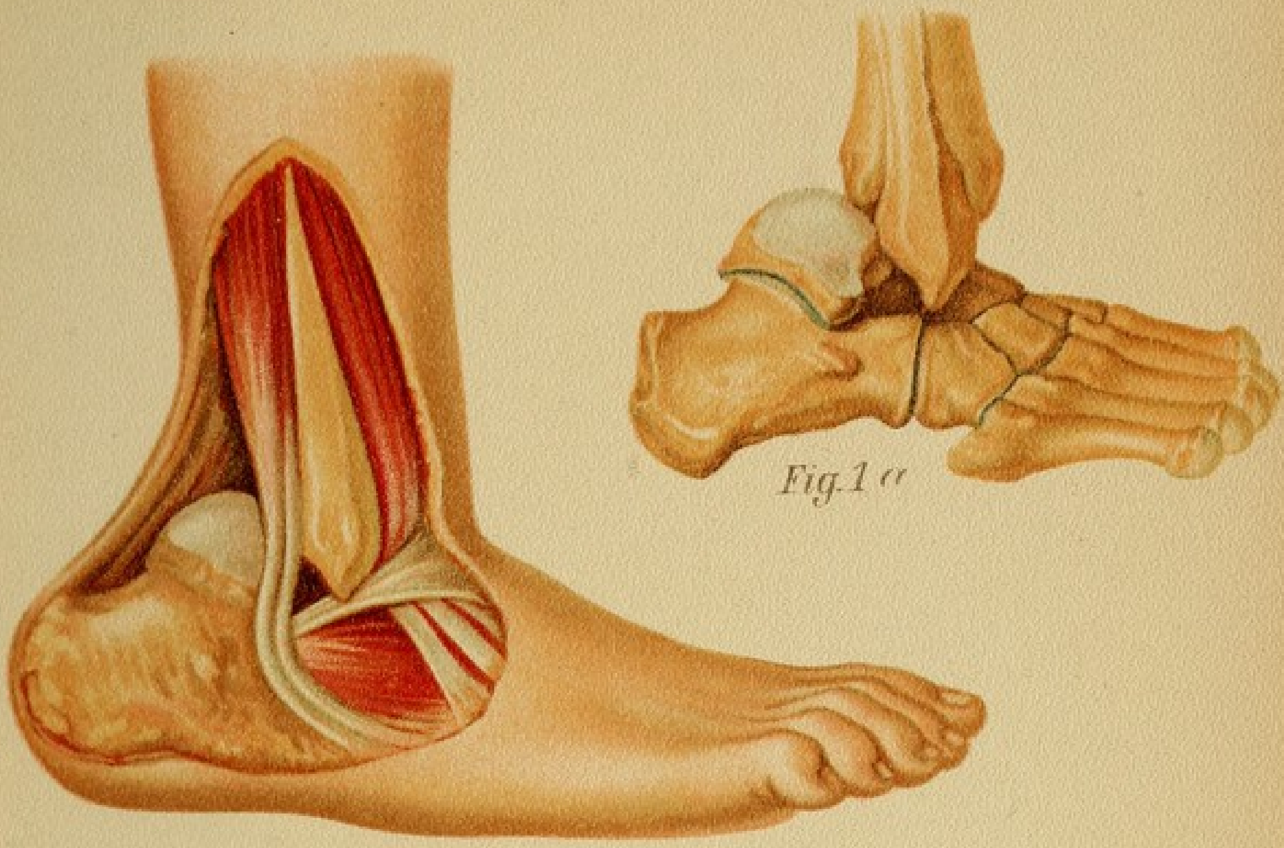

Fig. 1 a

Fig. 1.

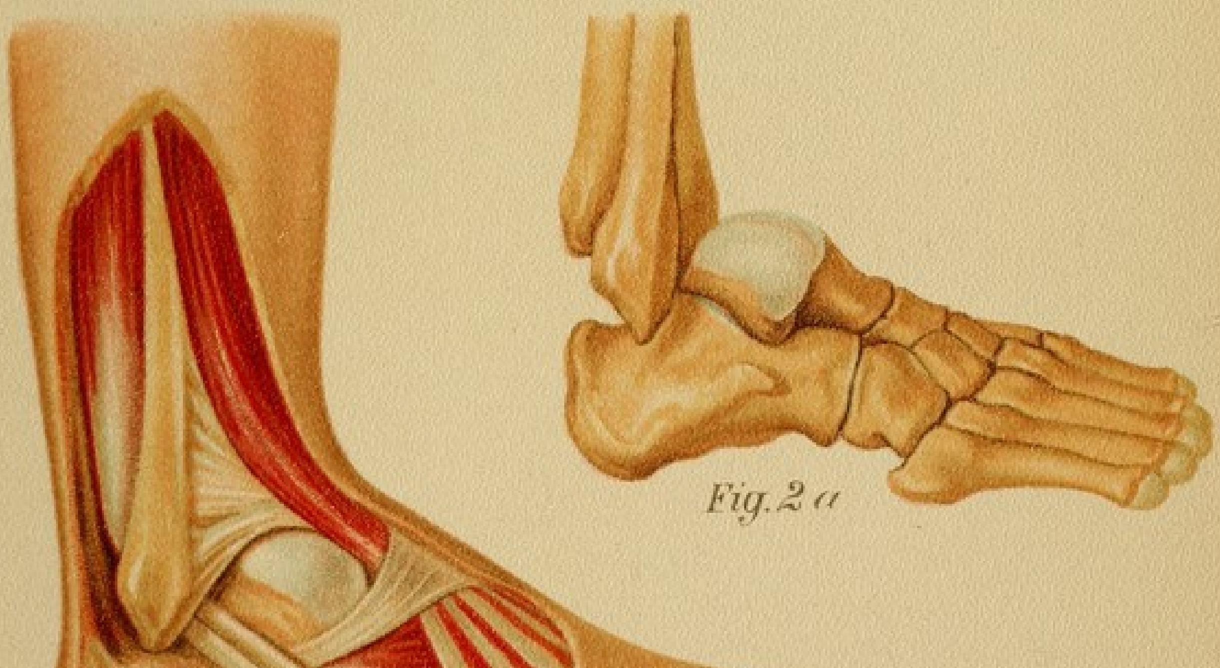

Fig. 2 a

Fig. 2.

Lith. Anst F. Reichhold, München.

of the foot and sometimes articulates directly with the os calcis.

Reduction is difficult. If it cannot be effected by manipulation, it must be brought about by operative means both in this and in the above-mentioned dislocations. The good results often obtained if the asepsis is perfect are somewhat remarkable considering that the astragalus loses part of its connections and blood-supply.

7. THE FOOT

The skeleton of a foot should always be at hand, not only in studying the injuries of the foot, but also when an individual case is to be examined. In addition, the injured foot must of course be carefully compared with its fellow, providing the latter is uninjured. During inspection the two feet should be placed parallel, so that their long axes correspond with the observer's line of vision, and enable him to compare them accurately both from in front and from behind. In addition to minute palpation, not omitting a single detail, it is well to take impressions of the sole of the foot by having the patient step on smoked paper and fixing the paper with a 5% solution of shellac (or compound tincture of benzoin).

(A) Fracture of the Tarsal Bones

(a) Fracture of the Astragalus.—Fracture of the astragalus rarely occurs as an isolated injury, being almost always combined with injuries of the knee-joint or of the tarsus. Dislocation of the astragalo-crural articulation is often accompanied by infractions, tear-fractures, and fractures of the astragalus. Fracture of the astragalus, especially of the neck, has also been observed in severe fractures of the os calcis. The appearances obviously depend on the complicating injury, and are not always very distinct. The diagnosis may be made by the visible alteration in the shape of the foot; swelling of the dorsum; pain following pressure on the head or neck of the bone, the

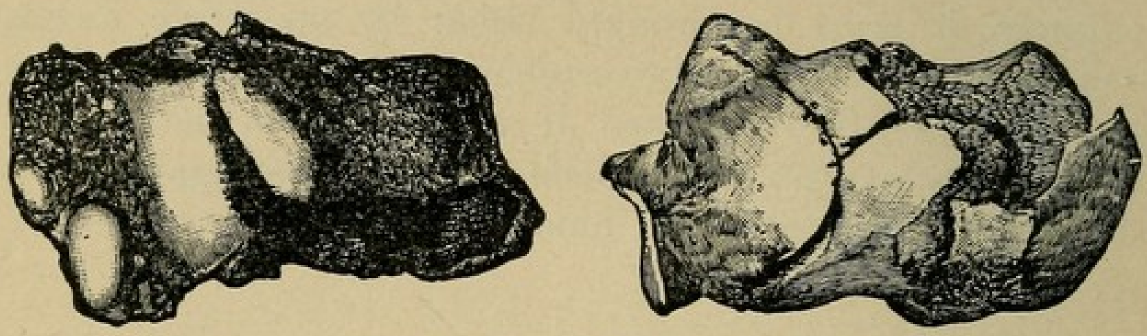

Fig. 152.—Compression-fracture of the right os calcis in a young man, nineteen years old. Seen from above and from the outer side. (Artificial.)

presence of thickening; narrowing of the tarsal fold, interference with dorsal flexion; and, finally, mensuration with a pair of compasses. Treatment is based on general principles.

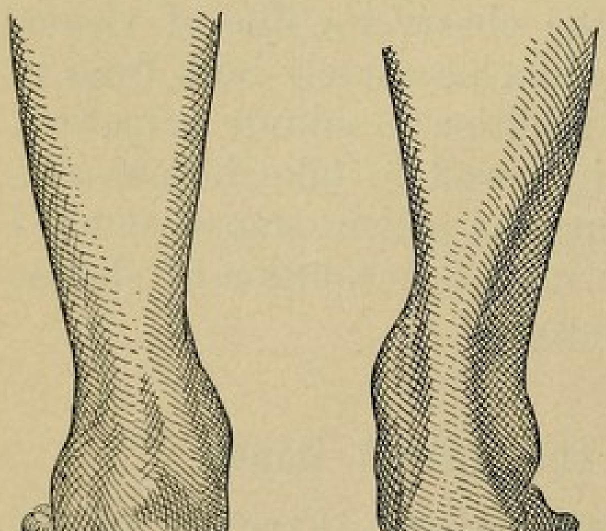

Fig. 153.—Compression-fracture of the left os calcis, produced by a fall on the foot. Wilhelm Rell, 1895. Posterior view.

(b) Fracture of the Os Calcis.—The fractures are classified according as they involve the body of the bone or one of its processes, which are described as the posterior, or tuber calcis; the anterior, or capitulum calcanei, or sustentaculum; and the lateral, or processus trochlearis sive inframalleolaris.

Compression - fracture of the os calcis is produced by falling on the feet or awkward jumping. The etiology is usually quite typical. Masons, roofers, miners, and painters furnish the largest contingent. The bone is demolished by the astragalus being driven against it. As a rule, a longitudinal fracture is found in the upper surface of the bone. In severe cases numerous additional lines of fracture are observed, so that the bone is literally demolished. In a severe case the following characteristic symptoms are present: The bone is enlarged in its lateral diameter, flattened, and painful. The malleoli, especially the internal malleolus, are nearer the sole of the foot than they should be; pes planus is often present. Movement at the astragalo-crural joint is not affected, while the movement at the articulation concerned in pronation and supination of the foot is limited. Sometimes the injury is bilateral.

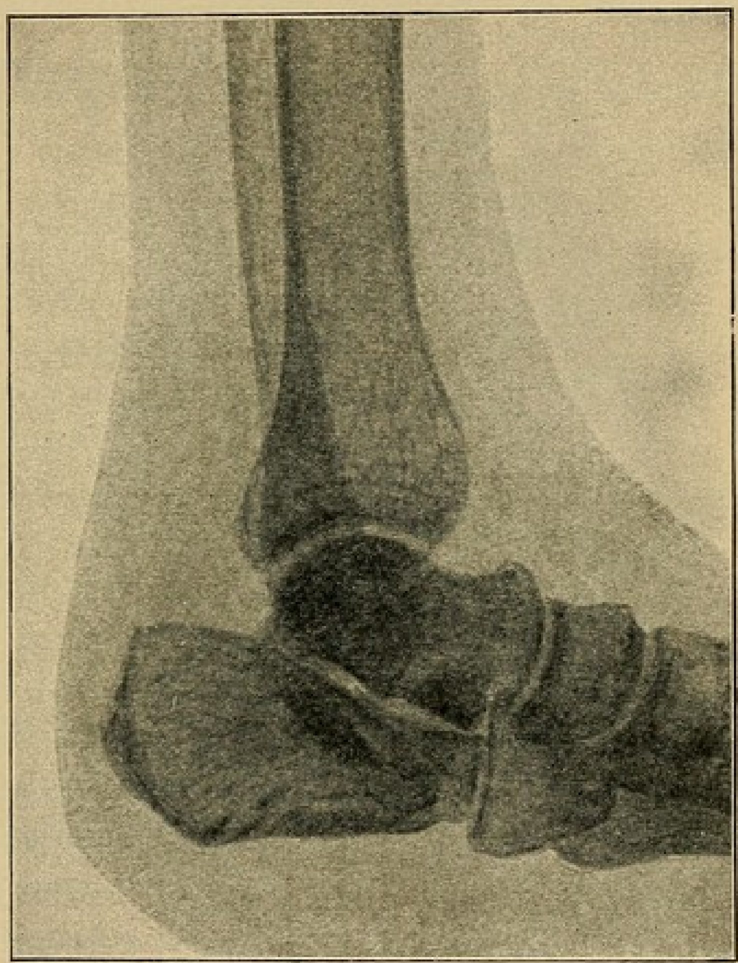

Fig. 154.—Typical compression-fracture of the os calcis. Skiagraph. The alteration in the shape of the anterior half of the bone is distinctly shown; the distance between the upper and lower surfaces is shorter than normal. Disability in this case was permanent.

In old cases the **diagnosis** is sometimes easier than in a recent case, on account of the callus and secondary changes. In addition to the lateral enlargement of the os calcis which may reach 2 cm., the grooves on either side of the tendo Achillis are obliterated by edema; the muscles of the calf are atrophied; walking is greatly interfered with; there is constant pain; and characteristic anomalies in the position of the foot, with depression of the malleoli, are noted.

This fracture is much more common than was formerly supposed. The injury is often mistaken for a severe sprain. The most accurate examination is indispensable.

The prognosis of this fracture is not very favorable. Even when it is recognized early, the functional use of the foot is, as a rule, greatly impaired for some time. If the case is recognized very late, the individual's ability to earn his living may be greatly diminished for a long time or even permanently. This is no doubt in part due to the fact, established by more recent methods of investigation, that the fracture in many cases is not confined to the os calcis, but involves other adjoining bones, such as the malleoli and the neck of the astragalus.

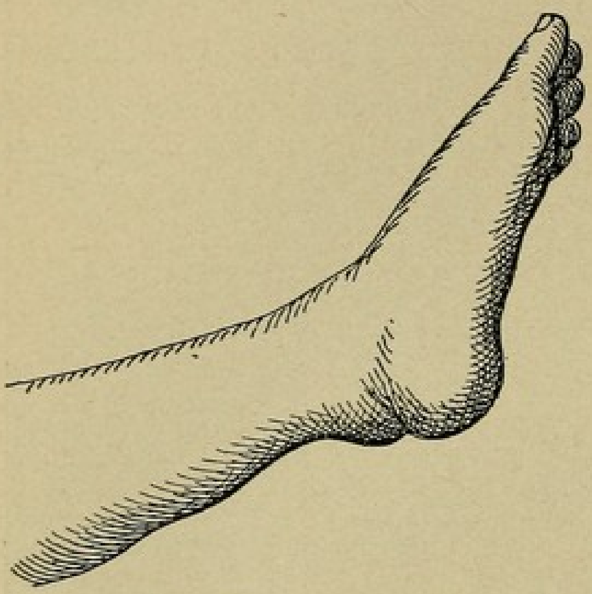

Fig. 155.—Fracture of the tuberosity of the os calcis by a fall on the feet, four weeks old. Female, forty-eight years of age. There is marked upward displacement of the fragment. Operation. Recovery.

Treatment.—Unless the fragments are replaced and the foot remains fixed for a long time in good position, traumatic flat-foot is apt to develop. The heel should not be subjected to excessive pressure at first on account of the danger of fat embolism; later on, compression, combined with massage and passive movements, is of distinct advantage.

Fracture of the tuberosity of the os calcis is not common. It is due to muscular action, such as sudden contraction of the muscles of the calf, or to direct contusion. It also complicates the clinical picture of severe compression-fractures of the body of the os calcis. The fragment is displaced upward by the action of the muscles of the calf. It can be replaced by flexing the knee, and fixed to the body by means of a nail. At first the foot should be dressed in extension, with the leg flexed at the knee. Under certain conditions it may be necessary to drag the displaced fragment down forcibly and fix it by means of a nail, after dividing the shortened Achilles tendon by an oblique cut, and uniting the ends with a suture so as to lengthen the tendon.

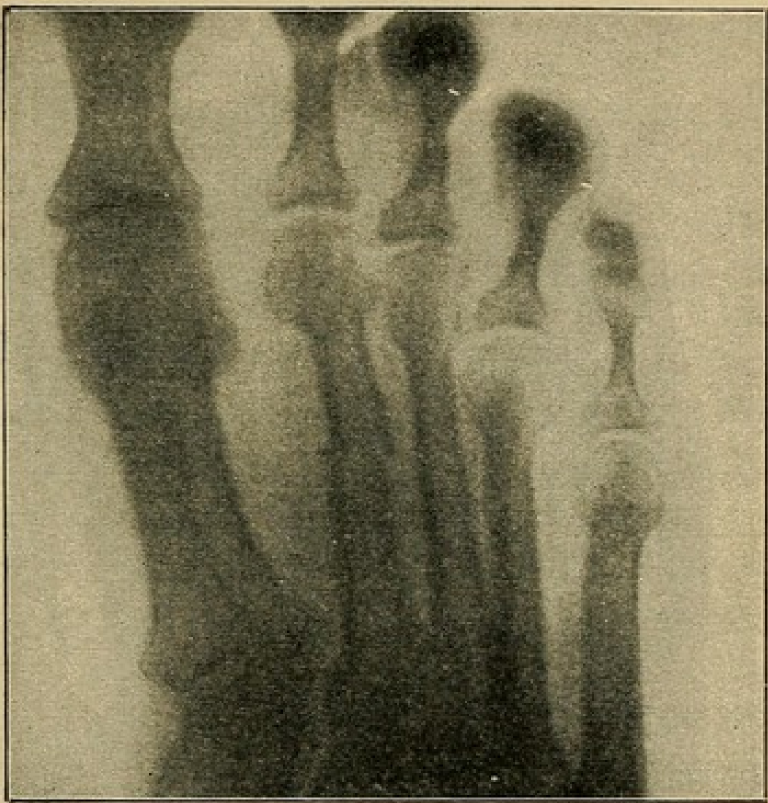

Fig. 156.—Fracture of the second metatarsal bone. Skiagraph from a sailor twenty years old injured in marching. Typical "swelled foot." Transverse fracture about the middle of the second metatarsal, with lateral displacement. The diagnosis could only have been made by means of the Röntgen rays.

Fracture of the Median Process, or Sustentaculum Tali.—This injury consists in fracture of the bony process at the inner surface of the os calcis, which supports the astragalus and contributes to the formation of the groove for the transmission of the tendon of the flexor hallucis. Accordingly there is violent pain on pressure at this point, the astragalus is displaced inward and downward, and the foot is in valgus position. There is some interference with flexion and extension of the foot at the astragalo-crural articulation; abduction and adduction are greatly limited.

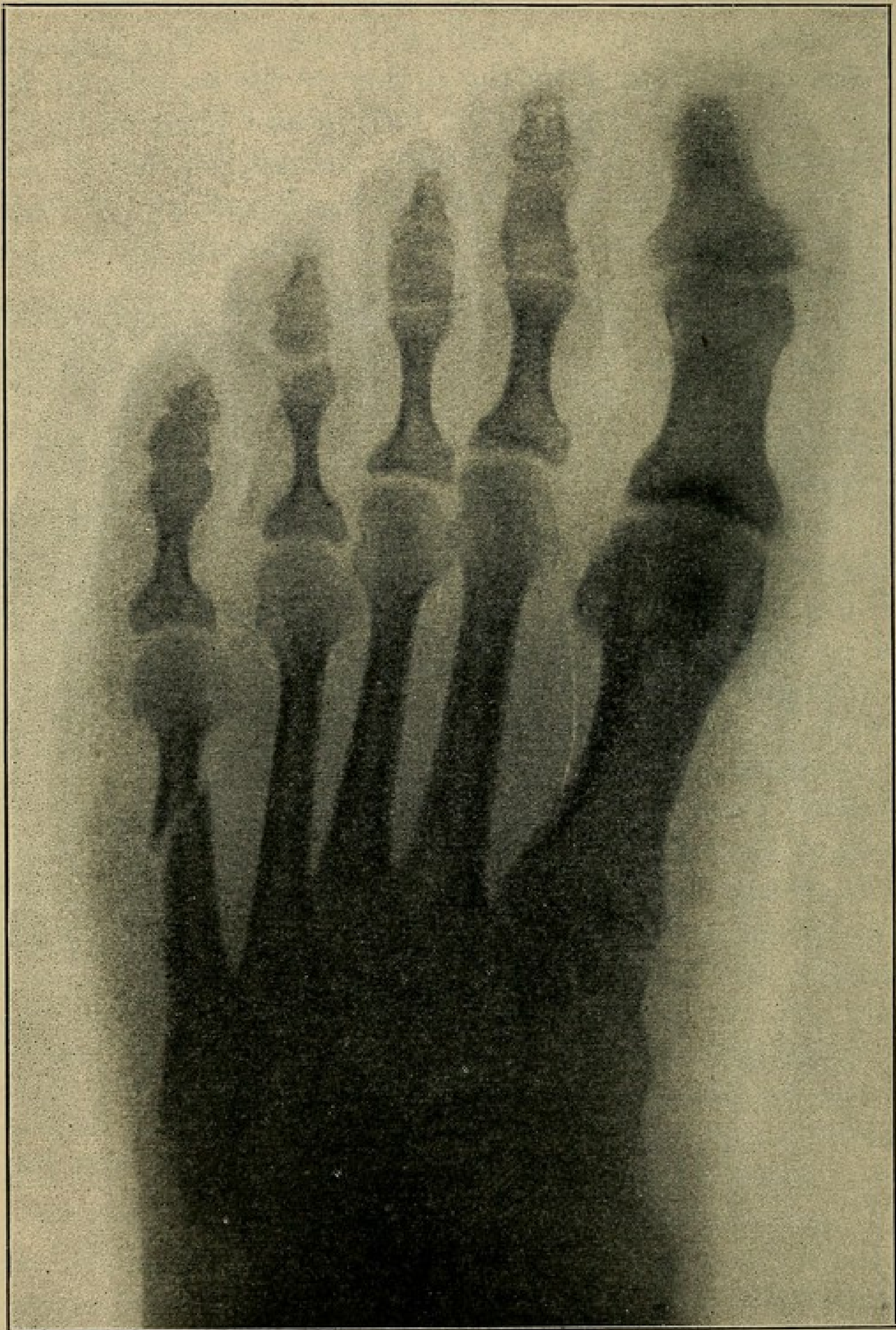

Fig. 157.—Fracture of the fifth metatarsal bone (X-ray). Fielitz, male, twenty-four years old. The injury was produced by a very heavy piece of iron falling on the foot. It is therefore a direct fracture or crushing-fracture of both phalanges of the big toe. Soft parts uninjured; marked swelling. Ordinary dressing; recovery.

In old cases a bony thickening is usually observed about the sustentaculum below the internal malleolus. In anatomic specimens the sustentaculum is often found united by callus with the posterior median process of the astragalus.

This *isolated* fracture of the sustentaculum is rare. It may be produced by great violence when the foot is in supination or in pronation, such as making a misstep in going upstairs or downstairs, jumping, or falling from a horse. In most fractures of the sustentaculum the body of the os calcis and the internal malleolus are also fractured.

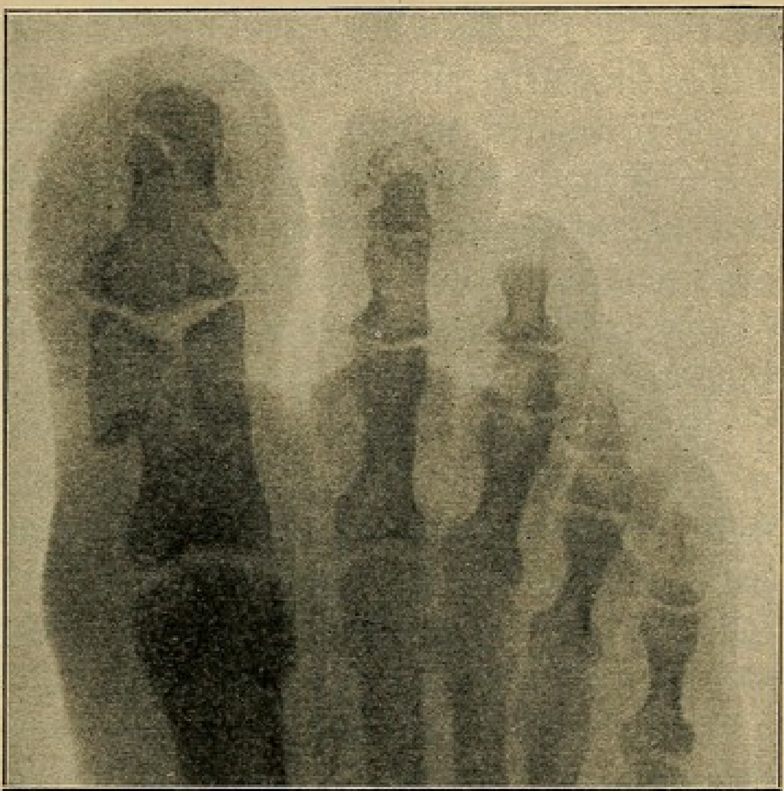

Fig. 158.—Fracture of the great toe. Wiese, male, thirty years old. Produced by a 100-pound weight falling on the foot. Fracture and abrasion of the great toe, and fracture of the distal phalanx of the second toe. Ordinary dressing; recovery. The swelling, however, persisted for some time.

Fracture of the anterior process of the os calcis may form part of a compression-fracture of the body of the bone. As an isolated injury it must be exceedingly rare. The contiguous cuboid bone may also be involved.

Fracture of the inframalleolar or trochlear process is also extremely rare. It is more apt to be produced by a direct injury splitting off the bony process, than by the action of the calcaneo-fibular ligament, as was formerly thought. The tendons of the peronei muscles may be injured.

The *treatment* of these injuries should be carried out according to general principles. In every case the foot should remain fixed in its normal position for a considerable length of time.

[Helbing [1] reports and illustrates a most interesting case of tear-fracture of the os calcis. These are very rare fractures. Martens,[2] in reporting nine cases of fracture of the os calcis with excellent X-ray photographs, considers the entire subject, with some interesting experimental work in regard to compression-fractures.—Ed.]

(c) Fractures of the Remaining Bones of the Tarsus.—Isolated fractures of the remaining bones of the tarsus are rare, and when recognized, should be treated by exposing the fragments by an incision and securing prolonged rest of the foot by means of firm bandages. Later a brace should be worn.

Fractures of the metatarsal bones are much commoner than was formerly supposed, as recent investigations by Kirchner and others have proved. By the help of the Röntgen-ray examination, it has been shown that the swelling of the foot which occurs after a trifling injury, "swelled foot," as the soldiers call it, is in many cases due to fracture of a metatarsal bone. It is astonishing to find out how small an injury to the foot, protected as it is by the boot, suffices to produce an isolated fracture of a metatarsal bone. The injury may consist in a blow against the sole of the foot, or in the long axis of the foot, as in marching, especially on frozen and uneven ground. The fracture is more often produced by direct violence, and is then complicated with injuries of the soft parts. In figures 156, 157, and 158 several skiagraphs taken from cases of this kind are reproduced.

Isolated fractures of the phalanges are rare.

The **treatment** of all these fractures is based on general principles.

[1] Deut. Zeitschr. f. Chir., Bd. LVIII, p. 489, 1901.
[2] Arch. f. klin. Chir., Bd. LXIV, 1901, p. 899.

(B) Dislocations

Dislocations in the tarsus, particularly at the so-called Lisfranc's articulation, are somewhat more common than was formerly supposed. In these cases examination by means of the Röntgen rays is of the greatest value and should never be neglected, especially in the initial period of the treatment, no matter how great the swelling may be, because the latter disappears very slowly and valuable time is lost before reduction is effected.

(a) **Dislocations of the tarsal bones** are rare injuries, but more frequent than was formerly supposed. They comprise luxations of individual tarsal bones or of several bones in various combinations, not infrequently in the form of a subluxation. The **diagnosis** is made by careful palpation, but not until the swelling has subsided. This may be expedited by massage, elevation, and compression. By means of the Röntgen rays the examination may, of course, be made at once. Reduction may be extremely difficult and may require incision. In order to effect reduction it is justifiable to exert every means to enlarge the opening through which the bone has escaped. The bone or bones, after reduction, must be firmly fixed, if necessary by means of a bone suture or a nail. In old cases the treatment is merely palliative; the wearing of a rigid sole made to correspond with a plaster-of-Paris cast, etc.; or partial or total extirpation may be resorted to.

(b) **Dislocation of the metatarsal bones**—that is, at the so-called Lisfranc's articulation—usually assumes the form of complete displacement of several or all of the metatarsal bones on the dorsum of the foot. The dorsum presents an abnormal bony prominence; the foot has the form of a pes cavus and simulates talipes. Plantar dislocation is much more rare. Reduction is difficult; each bone may have to be replaced separately. It may be successful in recent cases; in an old case operative intervention becomes necessary.

(c) **Dislocation of the Toes.**—This injury is similar to dislocation of the fingers, but is of course much less frequent. Upward dislocation of the phalanx is produced by forced dorsal flexion. The diagnosis is easy, and reduction is readily effected by pushing the dorsally flexed (extended) phalanx forward.

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