RÖNTGEN RAY DIAGNOSIS AND THERAPY

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WITH 322 ILLUSTRATIONS IN THE TEXT

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O light, of all the gifts of heaven,
The dearest, best! From light all beings live—
Each fair created thing—the very plants
Turn with a joyful transport to the light.

—SCHILLER.

PREFACE

LITERATURE upon the application of the Röntgen rays has become very extensive. Many contributions have been made during the last few years, and a number of splendid text-books, like those of Morton, Gocht, Müller, Donath, Williams, Walsh, and Albers-Schoenberg, were written on this fascinating subject. Still none of those standard works, while indispensable for the Röntgen-ray worker, treats the large field from a strictly clinical view-point. To demonstrate how the Röntgen rays can best be utilized in medical and surgical practice has therefore been the author's aim. This desire underlies the continuous allusion to clinical points, and especially the numerous illustrations of therapeutic means. It entailed representation of methods (operative steps, application of splints, etc.), which at first glance may appear foreign to a treatise on the Röntgen rays. But on a closer study it will be evident that these can be understood only on the basis of an exact knowledge of the new science.

While these factors are the predominating feature of the book, the technical points are not neglected. They are of so complicated a nature that they require special study, as do the microscope, the laryngoscope, the ophthalmoscope, asepsis, etc. The employment of the apparatus must be mastered and the complicated *rationale* of the various changes in the tubes thoroughly understood.

In the General Part the author has tried to furnish a guide for practical work, emphasizing the essential points only. Thus he refrained from discussing the elementary principles of electricity and from describing the large number of apparatus in the market because they are thoroughly advertised and explained by the various firms interested. So much may be said, however, that nearly all of them are useful, as long as they are in good order.

As this book is written for physicians, great stress has been also laid on topographic anatomy. None except the physician is deemed as competent in Röntgen science. It is only the knowledge of anatomy and pathology which permits correctly placing the part to be examined and proper interpretation of the result. The many errors which were and are still attributed to the rays are not only due to technical faults, but, in the large majority of cases, to insufficient knowledge of normal anatomy. To recognise the atrophic area in osteosarcoma, or to differentiate a renal calculus from intestinal contents in a mediocre skiagraph, to appreciate a sesamoid or to define the shadow of an aneurysm, requires much scientific knowledge and Röntgen experience.

It must, furthermore, not be forgotten, that valuable as the Röntgen method is, it cannot serve as a substitute, but only as an important adjunct to our well-tested clinical methods.

In the part devoted to Röntgen therapy the author has carefully tried to keep facts and conjectures well asunder, appreciating the limitations of this new field, which is still in a stage of development.

The skiagrams are exact reproductions of photographic prints. The author resisted all temptation of emphasizing their essential points by artistic interference, with the exception of two illustrations in which the important points were lost during the process of reproduction. None of the representations were selected for their pictorial excellence, but to illustrate the points of the text; therefore the author often had to sacrifice some of his beautiful reproductions for mediocre ones that would better subserve the special purpose.

It affords the author special pleasure to thank Professor Röntgen for the many courtesies of which he has been the recipient at his laboratory. His sincere acknowledgments are also due to Professors von Bergmann, Czerny, Koenig, Pfuhl, Koehler, Hildebrand, Koerte, Hoffa, Lesser, Lassar, Hochheimer, Gocht, Helbig, Surgeon-General Stechow, Dr. Max Levy, and to Messrs. Siemens and Halske, Max Kohl, and the Allgemeine Elektricitaetsgesellschaft. Great credit is due to Dr. J. R. Broome and the publishers, Messrs. Appleton & Co., for the typographic and pictorial excellence of this book.

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INTRODUCTION

THE NATURE AND THE PROPERTIES OF THE RÖNTGEN RAYS

THE discovery of the wonderful rays was not a mere lucky hit, but represents the result of indefatigable scientific research. That electric induction obeys the same laws as those governing the diffusion of light waves, and that the speed of transmission of the electric waves is equal to that of the light waves, has been proved before Röntgen. In fact, the phenomena of electric discharge in closed tubes of various degrees of exhaustion and filled with different gases, had been a favourite subject of experiment for a large number of physicists. That there was a marked difference between the phenomena of light at the two electric poles was known, as well as the fact that as soon as the vacuum of a tube is increased to a high degree the light of the positive pole decreases, while that of the negative pervades the vacuum more and more.

The light emanating from the negative pole is called the *cathode ray.* Lenard and Hittorf found that such rays have power of creating fluorescence, heat, etc., and that they can be deflected by a magnet. The vacuum-tube commonly used is generally called the Crookes tube, after Sir William Crookes, who described and modified the tube by bringing the vacuum up to 0.000001 mm. The credit for having originally devised it, however, is due to Geissler, the ingenious mechanician of Bonn, a German university town.

As soon as an electric current of high intensity goes through the conducting wires fused into the end of a tube of this kind the negative electrode, or cathode, becomes surrounded by a faint dark-blue light, while the positive electrode, the anode, sends a peach-coloured light through the tube as far as the light of the cathode. As the air is gradually rarefied the positive light almost disappears, while the negative cathode light extends more and more, and finally fills the whole tube.

Hertz, of Bonn, found in 1892 that these rays penetrated gold-leaf and other sheets of metal. His experiments were continued by Lenard, his assistant, but it was reserved for Röntgen to lift the veil. In the course of a study of these properties he discovered an astonishing phenomenon. He surrounded an exhausted tube with black pasteboard, thus making it impermeable by light. As soon as an electric current went through the tube now, the latter threw light upon a screen painted with a light colour (*barium platino-cyanide*).

Now it became evident at once that there was a radiant power which, although not perceptible to the eye, permeated the paste-board. This force, heretofore unknown, also showed a marked effect on the screen. After finding that the effect of these invisible rays upon the screen was constant, Röntgen tried photographic experiments also. He then discovered that under the influence of these rays his hand, resting on the cover of a wooden box, gave a sharp silhouette on a drying plate below, although the cover was not removed. He also found that paper, wood, and even thin disks of metal were permeable by the rays, while thick disks of metal, bones, etc., produced silhouettes. The greater the density was, which to a great extent is proportional to the atomic weight, the less the translucency became. Röntgen modestly suggested naming the new rays "X-rays," until their nature should be discovered. It is generally assumed that the Röntgen rays are transverse vibrations of the ether, there being a series of isolated impulses in contradistinction to the regular wave phenomenon of ordinary light.

Scarcely eight years have elapsed since the discovery of the Röntgen rays. While we still may speak of an experimental stage, the results obtained are marvellous. Many doctrines formerly regarded as incontrovertible have since been completely changed. It is significant that the progress of our pathological knowledge has altered many clinical pictures, and in extending our diagnostic horizon has simplified our therapy. In the better understanding of numerous pathological processes a revolutionary change has taken place, and it is gratifying to note that with the clearing up of the anatomical conditions by the miraculous rays, the ratio between therapy and pathological knowledge has been altered by a great increase in the latter. It is an old dictum that the largest number of medicaments is recommended for those ailments which are least understood. The clearer the understanding becomes of the genesis and the anatomical relations of a pathological condition, the more the manifold therapeutic methods shrink into a few simple principles, which, in fact, could be written on a finger-nail, like the classic prescriptions of our great medical ancestor.

Indeed, the proofs of the great usefulness of the rays in surgery as well as in medicine are now overwhelming. The recognition of foreign bodies in the remotest corner of the living organism has become a matter of ease. Fractures and dislocations are shown as they really are in life. Accuracy takes the place of ignorance and doubt, and painful manipulations cease to be necessary for diagnostic purposes. Even the most skilful experts in fractures are unable to deny that there is a large number of bone-injuries, the character of which could formerly not be recognised on account of the swelling of the area involved or of the obscurity of the symptoms. The number of cases of fracture formerly mistaken for contusion or distortion was enormous. It is in such a case that a simple glance with the fluoroscope furnishes the most precise evidence. Whether there is comminution or impaction, or the intervention of muscular tissue, or intra-articular fracture, or association with a dislocation, can be at once clearly determined. If the picture is fixed on a photographic plate the nature of the injury can be studied at leisure, and the proper line of treatment easily decided upon, without subjecting the patient to any tentative manipulations. After a dressing is applied the skiagram shows whether the fragments are in proper position. The execution of all therapeutic measures can be verified through it, the course of treatment by the skiagram, the dressing itself, even if consisting of plaster of Paris, offering no obstacle to the rays. Thus the therapy is simplified and perfected, the Röntgen guide showing the true nature of the conditions. Now it is easily determined whether an ankylosis is fibrous or osseous; and, consequently, the question whether the breaking up of adhesions or resection is indicated is settled at once.

It is needless to call attention to the frequent importance of a skiagraphic proof in court, for the protection of the surgeon as well as of the patient.

Especially in the better understanding of fractures a revolutionary metamorphosis has taken place. It was not an agreeable feature of the rays that they soon told most impolitely how often we have erred in the true recognition of the various fracture types. For those surgeons, however, who soon appreciated the immense value of one of the greatest discoveries of all times, the increasing capacity of recognising their own errors has become a continuous source of scientific satisfaction, which found its culmination in the blameless results of their cases. "Our sight," says Addison, "is the most perfect of our senses," and the small flock of Thomases who imagine that by virtue of their own especially developed palpatory talent they can just as well judge any fracture without the aid of the Röntgen rays will not escape, in the course of time, the natural shrinking of their cell-walls. They will share the fate of antiasepticists and of obstructionists in general.

When the microscope was invented great authorities used to speak with unutterable contempt of it, and others denounced anæsthesia as an unscriptural procedure. When Helmholtz invented the ophthalmoscope, some of those who hear the grass grow pronounced it to be a nice little thing which might be useful for bad eyesight, while they themselves, thank God, enjoyed good eyesight, and had no need of this new acquisition for their diagnostic armamentarium. When the immortal genius of the Italian physician, Galvani, practically discovered electricity by his experiments with the frog, the new force was regarded as a nice plaything—but what has become of it? Who would, in the face of the telegraph, phonograph, telephone, the trolley, the cystoscope, etc., dare to say now that electricity is only a little plaything?

Who nowadays would dare to make a diagnosis of renal disease without the microscope? Is it still an instrument merely for specialists? No, it is indispensable for the general practitioner, for if he does not possess such an instrument, and use it intelligently, he will be left behind. The microscope alone does not make the diagnosis, but without it the diagnosis is not perfect. It is just the same with the Röntgen rays. The general practitioner must use them, and if he does not he will be left behind. *Qui non proficit, deficit!* This may be unjust and cruel, but it is a fact, and facts are often cruel.

The knowledge of the various diseases of bones has been much augmented, and new laws of differentiation between inflammatory, syphilitic, tuberculous, or osteomyelitic processes, and osteoma, osteosarcoma, and osseous cysts have been established. The presence of concretions in the urinary and biliary tracts can be demonstrated.

In internal medicine the rays are also more and more appreciated to their full value. For the expert they prove to be of incalculable service in the diagnosis of many obscure ailments.

If it is only realized that most of the diseases of the thoracic organs can be recognised and studied by the rays, as, for instance, pleurisy, pyothorax, pneumothorax, lung abscess, tuberculous foci and cavities, and emphysema, furthermore that the relations of the heart and of the aorta, aneurysms, mediastinal tumours, and arteriosclerosis can be thoroughly studied, the immense importance of the rays for internal medicine becomes at once apparent.

Besides their diagnostic properties the X-rays exert undeniable therapeutic effects. It is marvellous that not only certain integumental affections are completely relieved, but that even malignant growths are strongly influenced and some of them cured. And there is still greater hope for the future!

SECTION I

GENERAL PART

CHAPTER I

THE APPARATUS

As alluded to before, the rays are projected by an electric discharge from a platinum disk, included in a highly exhausted glass-tube, which is opposite the negative electrode, or cathode.

To produce the necessary excitation in the exhausted tube (vacuum-tube or Röntgen tube) an electric current is required. But the electric current generally used in an electric-lighting circuit would not be powerful enough to span the space of air left in a Röntgen tube. The ordinary electric-lighting current, as it is used for incandescent lamps, is of low pressure or "voltage" (generally 120 volts), and of a large rate of flow or "ampères." The current for the excitation of a Röntgen tube requires a high voltage and an extremely low ampèrage. Therefore a transformation is necessary. In other words, transformation from a current of high intensity and low tension into one of less strength and high tension must be made. This is accomplished by means of a transformation apparatus, preferably in the form of a simple induction coil (Ruhmkorff coil). Tesla or high-tension induction coils or static machines are also in use.

The essential mechanisms therefore are represented by the source of the current (the *exciting apparatus*), the *transformer* which converts the electric energy, furnished by the exciting apparatus, into a form suitable to the Röntgen tube, and the *tube*, in which the electric energy is transformed into Röntgen rays. Some additional apparatus, like stands, fluoroscope, and photographic appliances, the utilization of which will be considered below, is also necessary.

The Source of the Current.—Excitation may be produced by means of a battery or of a direct current, the latter, of course, being far superior to any other, since there is neither charging nor supervising necessary. Not the least of its advantages is that it never embarrasses the operator by proving to be ineffi-

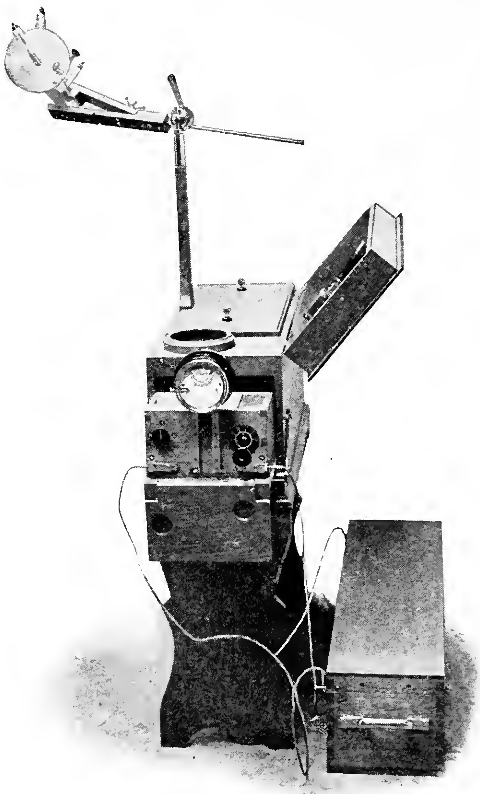

Fig. 1.—Portable Röntgen-Ray Apparatus.

cient. Accordingly, whenever possible, connection with the 110- or 120-volt direct current should be made.

If the direct current is not available, a so-called Edison-Lalande cell-battery may be chosen. For use when travelling storage batteries may be preferred, the great trouble, however, being that if they become exhausted at a distance from a city they cannot be charged, while the Edison-Lalande cells can be re-charged anywhere.

Wherever the question of transportability must be considered, portable apparatus must be used. They are best made up in two

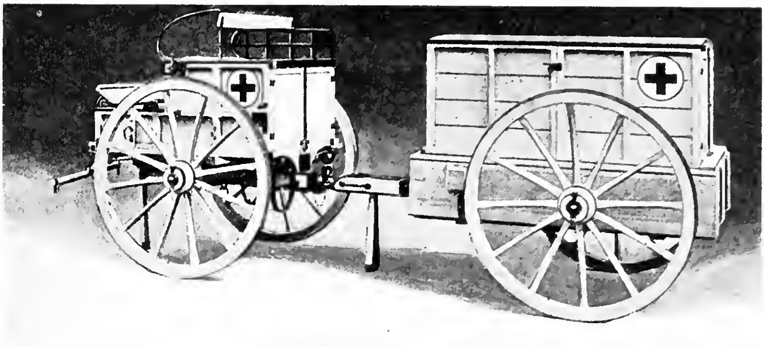

FIG. 2.—FIELD APPARATUS.

boxes, so that a man can carry one in each hand (Fig. 1). They are made equally well by a number of American manufacturers. In the field, accumulators answer the purpose best.

They are placed in large, closet-like boxes. Figs. 2 and 3 represent a field-apparatus made up by the German Government.

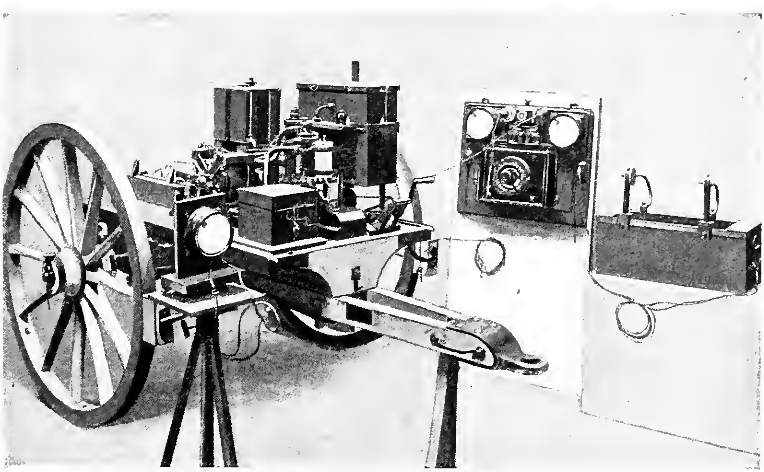

FIG. 3.—FIELD APPARATUS READY FOR USE.

They resemble the ammunition boxes used by the artillery, and are easily moved around.

How much a real master can achieve with poor means is shown by Kuettner and Hildebrand, who during the South African War made splendid skiagrams in the battle-field. There was only small portable apparatus at their command, they had only poor if any assistance, but their enthusiasm overcame all difficulties.

When automobiles containing a 100-volt storage battery are available, insulated wires may be run from their batteries to the sick-room, where they are connected with the coil.

The Induction Coil (see Fig. 9).—While good results can be obtained with small induction coils, if the hand, forearm, foot, or leg are concerned, the best work can be done only with strong coils. The higher the vacuum of the tubes, the more penetrating are the rays and the more energy is needed to excite them. The tubes also become impaired pretty soon, if used in connection with small coils. It is furthermore impossible to regulate them as well as large coils. For the examination of the thicker portions of the body, such as the pelvis, spinal column, and for the representation of concretions, a small coil is useless. It is certainly tempting to buy a cheap apparatus if the firm promises that equally good results can be obtained, but practice shows that the more expensive apparatus pays best by giving far superior results.

This fact is, of course, most deplorable. It is indeed the main obstacle in the way of general popularization of the Röntgen-ray method.

It is agreed among the best authorities in this field that a large coil of a spark-length of at least 15 inches answers the purpose sufficiently well. An inductor of this power, with a 110-volt direct current, should afford a current strength of from 1 to 2 ampères. It consists of the core, the primary and secondary coil, the terminals of the secondary coil, a condenser, a contact breaker (electrolytic interrupter, vibrator, or air-brake wheel), and a rheostat (or shunt board).

The *core* consists of a cylindrical bundle of soft-iron wires which are firmly bound together. To secure proper insulation the core is soaked in shellac or paraffin. In order to insure quick demagnetization, and especially to prevent heating effects, the wires should have as small a diameter as possible.

Upon the insulated core the primary coil, which consists of two layers of coarse copper wire, is wound. After it is covered with a tube consisting of many layers of paraffined paper or of hard rubber, the secondary coil is carefully wound upon it. The diameter of the wire for the secondary coil, which is generally wound with cotton or silk in sections, is small. Each layer must be insulated with either shellac or paraffin. Many thousands of turns are required. The terminals of the wire connect with two binding posts containing two freely sliding rods.

In order to adapt the coil to sources of different potentials the primary windings are best arranged in four layers, the connection of their terminals being such that they can be employed in different combinations (see Walter arrangement, Fig. 4). By inserting plugs (see Fig. 4) into sockets at the end of the core any connection of the primary can be made. The resistance of the vacuum-tube is greatly influenced by this adjustment. (Compare description of Wehnelt interrupter, p. 13.)

In the interior of the coil a *condenser*, made of a number of sheets of tinfoil, is placed. This makes the interruptions of the current more sudden, thus increasing the electrostatic capacity. If an electrolytic interrupter is employed no condenser is required.

The Static Machine.—As alluded to, the various kinds of induction coils and transformers represent what is generally known as current or dynamic electricity, while the static machine represents electricity at rest. In a coil the induction results from the variation of currents, which flow in the adjacent conductors. But in a static machine the induction effects are created by the opposite and like electricities attracting and repelling each

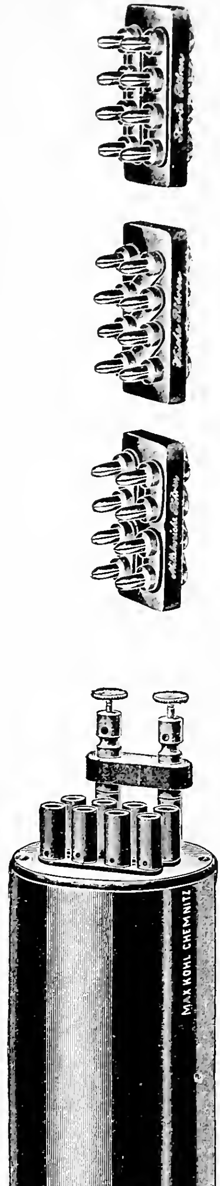

Fig. 4.—Walter Commutation Arrangement.

other. While the coil needs a continuous supply of current, the static machine requires only an initial charge of electricity which is imparted as the result of friction. Thus the static machine repre-

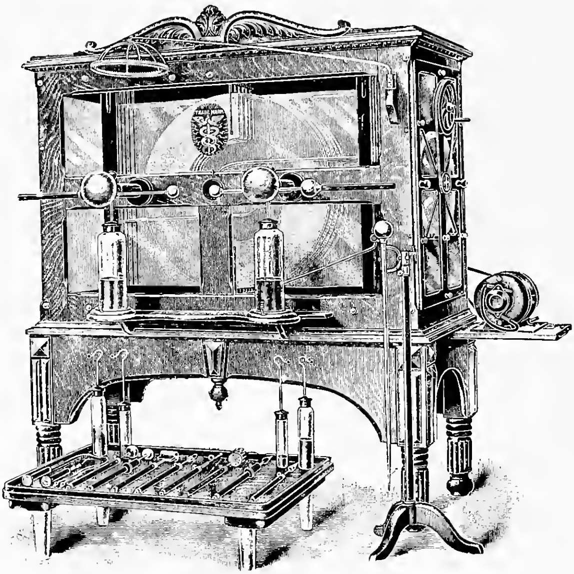

Fig. 5.—Static Machine.

sents the most perfect mechanical means for creating a rapid and continuous succession of electric discharges. A static machine best adapted for Röntgen-ray work is one in which a high rate of motion is developed, and the current is at high speed. Of course the faster the apparatus is run the more current is generated. Some of the modern static machines can be revolved at a speed of 3,000 revolutions a minute.

The advantage of the static machine is that it requires no cells or chemical action. For good Röntgen-ray work it must also be connected with a motor. Under favourable circumstances splendid work can be done with it, but it condenses moisture, which affects its reliability. The temperature also influences it. The fragility of glass gave an impetus to make the revolving plates of a mixture of mica and shellac. Thus higher speed (2,000 revolutions in a minute) can be obtained with safety, but the practical advantage is questionable.

In *running a static machine* care must be taken to separate the sliding-pole pieces about 8 inches, to unscrew the large balls from the pole ends, and to remove the Leyden jars. The condenser must then be screwed on and the square platinum disk attached to the positive pole of the condenser. The length of the spark gap should be regulated so as to suit the vacuum; it must be long if the tube has a low vacuum, and be short if it has a high one. The case should often be ventilated in order to give the hygroscopic compounds of the oxygen and nitrogen, which form during the operation, a chance to escape. As the oil at the bearings easily becomes sticky, great care must be taken to keep the ends always oiled. If the machine oil has become thick and gummy, the bearing must be cleaned with thin oil. The machine must never be run backward or with wrong poles. Static machines require tubes with a special vacuum. The strong tubes described below are generally not to be used in connection with them. The best static machines are made in the United States.

The Interrupter.—With the introduction of the electrolytic interrupter by Wehnelt the technic became greatly simplified. This apparatus, invented by Spottiswoode and modified by Wehnelt, gives a most powerful secondary discharge, the break of the circuit being very rapid.

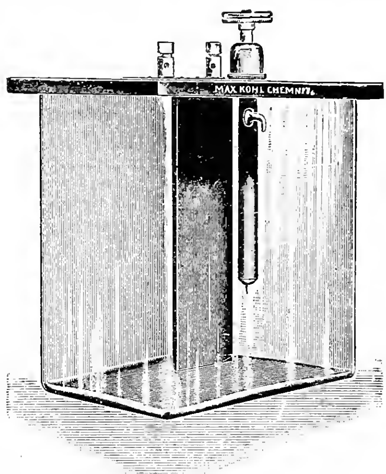

FIG. 6.—SIMPLE WEHNELT INTERRUPTER.

The principle of its construction is that a small platinum wire is passed through a porcelain tube, from the sealed end of which its tip projects into an aqueous solution (10 per cent) of sulphuric acid (Fig. 6). (The regulation of the extent of the exposure of the platinum surface will be explained further below in connection with the handling of the tubes—p. 32.)

A lead cathode of a large surface is immersed into the same fluid, through which the current is sent. The efficiency of the apparatus is due to the rapid break caused by the sudden generation of an envelope of non-conducting gas (hydrogen and oxygen) around the platinum tip. As the expression of the formation of detonating gas continuous explosioisn are perceived. The number of breaks varies with the amount of the platinum area exposed, and may reach 10,000 per minute. The large amount of secondary energy liberated permits of very short exposures.

The fluid is contained in a thick glass jar, the cover of which consists of hard rubber. It carries the wires, and is perforated in order to permit the escape of the gas.

To prevent the collection of gas the interrupter should not be kept in a closet. Explosion of the accumulated gas may ignite the closet. The terminus must be connected with the positive pole of the supply circuit, while the lead plate carries the negative wire. Non-observance of this rule is followed by the burning of the platinum tip. If the interrupter stops on account of a gas-bubble collecting over the platinum tip, so that it prevents contact between it and the fluid, the current must be reversed for a moment. It will then at once functionate again.

The number of interruptions is somewhat influenced by the amount of the surface of platinum exposed to the electrolyte as well as by the strength of the current which passes through it. The amount of the projection of the platinum tip is regulated by a screw attachment, which permits of adjusting it to interruptions of different frequencies.

The interrupter of Caldwell is based on similar principles. It is described by the inventor as follows: "It consists of a jar containing diluted sulphuric acid, within which is a cup of insulating material perforated by a small hole. Lead electrodes are placed in the outer jar and in the insulating cup.

"When the primary current of an induction coil is passed through this apparatus there is comparatively little heating of the liquid except in the aperture connecting the two chambers, where the current density is very large on account of the small area of the aperture. At this point, therefore, sufficient heat is developed to vaporize the liquid rapidly, and bubbles of steam which form break the connection between the liquid in the inner jar and that in the outer jar. As soon as the current is broken the heating stops and the two portions of the liquid come together again, completing the circuit. The frequency of the interruptions will depend upon the strength of the current, the size of the aperture, the resistance of the electrolyte, and to some extent upon the inductance of the circuit. [An arrangement for varying the frequency of interruption by adjusting the size of the aperture was described by Caldwell in the New York Electrical Review, May 11, 1899.] In this arrangement the aperture is at the bottom of the inner cup. It is partly closed by a pointed rod of non-conducting material which protrudes through it. By raising or lowering the protruding point the cross-section of the annular aperture between it and the cup may be varied, and thus the frequency of interruptions adjusted through a wide range. Swinton devised a screw adjustment for the regulating of this interrupter.

"This apparatus is not so susceptible to changes in the strength of the exciting current, or to changes in the temperature of the liquid, as the Wehnelt. It will therefore remain in operation somewhat longer, and admits of a wider range of adjustment of the exciting current. The action of this interrupter is quite independent of the direction of the current through it, therefore when employed for operating induction coils on the alternating current circuit the current will be broken at each alternation, and the secondary discharges will alternate in direction. Such discharges are not suitable for operating single-focus tubes, and the interrupter is therefore not adapted so well for alternating currents as the Wehnelt interrupter. With the alternating current it is possible to use double-focus tubes, but these are usually unsatisfactory except for therapeutic purposes."

In order to avoid overheating, the interrupter may be provided with a water-cooling jacket. Running water from a local supply system may be passed through it. If only moderately used, and if the jars are made sufficiently large, this precaution can be dispensed with. As alluded to above, no condenser is required with the Wehnelt interrupter.

There are other interrupters, but the advantages of the electrolytic principle are so apparent that the others are very little used. Most of them wear rapidly as soon as currents of high voltage are used. This drawback, which is especially found in interrupters which break the circuit by metallic contact, is somewhat overcome by the mercury jet interrupters, whose circuit is broken by a jet of mercury. As a rule the mercury is covered with a layer of alcohol or petroleum in order to prevent sparking when the rod emerges from the mercury.

The *mercury interrupter* of Kohl is worked by a battery, the speed being controlled by a rheostat. The regulation takes place by a lever by means of which the mercury vessel is lowered or raised.

The reliability of these interrupters, however, is still questionable. A poor interrupter jeopards the whole induction coil, which in view of its high price is no small matter. There are reports from clinics, in which the simple Wagner interrupter attached to an old induction coil required an ampèrage of 22 in order to produce an effective light. Such apparatus is soon burned out. If the direct current is not available, so that a battery must be used, a contact breaker must be adjusted, which, by quickly making and breaking the current passing through the primary coil, controls the periodicity of the vibration.

Before the Wehnelt interrupter came into general use the *air-brake wheel* was extensively used in connection with the direct current. This attachment permits of great rapidity of change in the electric circuit, thus intensifying the electromotive force in the secondary coil. It consists of two toothed wheels, the projections of which are brought into close contact with two flat brushes, which lead the current in and out, while the dentated wheels are rotated at a high speed by a small motor. This motor runs a pressure blower at the same time, the air-blast from which is directed to a two-forked tube, through which it is led out again by two flat nozzles placed directly above the brushes. There the spark is blown out by the air-blast as soon as it forms (Fig. 12).

For coils of small size simple vibrating interrupters are still employed, which operate like the vibrating hammer of the electric bell.

Rheostat (Fig. 74).—The ampèrage is reduced by an adjustable rheostat, which permits of perfect control over the current passing through the coil. Instruments of this kind are made in various forms, their principle consisting in winding thin wires in many coils around an ebonite cylinder. A movable key is constructed in such a manner that it can be made to press on any part of the wire. If this travelling key is passed along the bobbin, the current goes through as much of the resistance wire as may be desired. The greater the length of the wire, the greater the resistance will be. In order to reverse the current a double pole-*switch* is attached to the coil. This opens and closes the circuit (see Figs. 8 and 9).

To prevent a powerful current from passing the coil by accident a protecting *fuse* is included in the circuit. This prophylactic medium consists of a small piece of wire which by virtue of its low melting-point becomes fused and opens the circuit as soon as the current is too powerful. Fuses should always be on hand, so that they can be substituted if one is burned out.

The Röntgen Tube.—The Röntgen tube (see Figs. 7, 8, 9, and 10) represents the most important instrument in the armamentarium. It is sometimes possible to get a good result from a poor outfit, if there is only a good tube; but the best outfit will be useless if a poor tube is connected with it. The principle of construction at the present time is virtually the same in all tubes. They all consist of a glass vessel, usually of an oblong or globular shape, from which the air is exhausted and into which the ends of electrodes are fused. One of the electrodes ends in a disk of globular concave shape, which is made of aluminum; this electrode is called the *cathode*. The other ends in a disk of flat shape, which is of platinum; this is called the *anode*. The anode is situated opposite the cathode at an angle of about 45 degrees. Its shape may be circular as well as square. Almost all of the modern tubes contain a second anode, which is connected with the main anode.

To attain a suitable vacuum is the main point aimed at. The technical difficulties of obtaining the desired result are great, considering the fact that the intratubal pressure must be reduced to about two millionths of atmospheric pressure. It is only then that the remaining gas becomes radiant. This rarefaction of the intratubal air is brought to this height by suitable exhaust pumps.

The cathode rays emanate from the aluminum disk. Their focussing point is situated on the platinum of the anticathode. If this point is situated exteriorly or posteriorly from the platinum instead of being reached directly there are no so-called focus rays, and the tube is practically useless.

Another difficulty encountered in the use of the tubes is due to their soon becoming inefficient on account of the permanent change of pressure that occurs within them. The cathode rays striking the platinum disk and the glass walls generate a certain amount of heat. The higher the temperature, the more the amount of current passing through is increased, and the more the vacuum is lowered. Unless the heat is dissipated again at once the tube is unstable. On the other hand, as soon as the tube becomes colder the vacuum increases. Consequently the current must overcome a greater resistance, a lesser amount of it passes through, and therefore a lesser amount of rays is generated.

In view of this variation of pressure, tubes have been constructed that permit lowering and raising of the vacuum within them at will. Siemens found that the fluorescing air forms dense bodies with the vapours of phosphorus, hydrate of potassium, iodine, and other similar substances, thereby diminishing the presssure within the tube. On the other hand, if the walls of the tube are warmed, the stratum of air that condenses on the glass surface is driven away, thereby intensifying the pressure. In utilizing this principle, tubes with adjustable vacuum have been constructed which are provided with an adjuster, shortening the space between the spark rods.

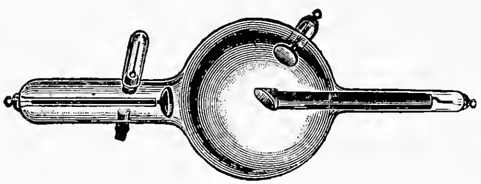

FIG. 7.—GUNDELACH TUBE PROVIDED WITH OSMO-REGENERATION.

The self-regulating tube of Queen & Co. (Philadelphia) is constructed after these principles, the small auxiliary tube containing hydrate of potassium, which by being heated gives off vapour, and absorbs it again when cooling. In the automatic tube of Müller (Hamburg) a plate of selenite is substituted for the phosphorus or hydrate of potassium, because this mineral does not re-absorb the gas after it is given off.

The principle of osmosis, first applied in France, and introduced into practice by Gundelach, utilizes the diffusion of hydrogen for regulation (Fig. 7). Into the cylindrical wall of the Gundelach tube a small palladium wire is fused, the end of which protrudes outside to the extent of 2 inches. If this protruding piece of palladium is heated by an alcohol lamp the hydrogen of the flame diffuses into the interior of the tube, thus augmenting the intratubal vacuum. The heating process must be kept up for two seconds. With very few exceptions the skiagraphic illustrations of this book were made with this tube.

The Müller, Kny, Voltohm, Hirschmann, and Levy tubes are constructed after similar principles, and are also useful. All their self-regulating tubes are good as long as they are comparatively new. After being used for a while the usefulness of all the various types becomes impaired. The fact must not be lost sight of that the vacuum of the tubes is increased during their use, which necessitates a proportional increase of the intensity of the current. Therefore, even for inductors furnishing a very long spark, tubes with a low vacuum should be chosen, as the latter increases so much during use that at last the full power of the apparatus is required for producing an efficient light. Finally, however, the fluorescence of the tube ceases, even if the high current is employed. Then the vacuum can be reduced by heating the tube with an alcohol lamp, while a weak current is used, until the fluorescence becomes distinct again. If this fails, the tube should be surrounded evenly and tightly by gauze compresses slightly moistened with water.

At last, of course, all these procedures will prove to be without avail. Some tubes regain their efficiency simply by being left untouched for a few weeks, but finally they all become useless for diagnostic purposes. Then the resistance of the tube becomes so great that, while the interior hardly shows any fluorescence, most of the sparks go around the external surface. The presence of purple or red light points to a leak, which naturally renders the tube inefficient. Leaky tubes may be repaired by sealing the defect.

If currents of very high intensity are used the platinum disk of almost all tubes becomes white hot after a short time, often after a few seconds, and if it is kept glowing a little longer the platinum melts. To obviate this most embarrassing occurrence, tubes have recently been constructed in such a manner that the metallic parts were made very thick and resistant. Such tubes permit of a current of maximum intensity for about one minute; then the very marked outlines of the picture become less distinct; the tube filling with blue light at the same time, which indicates that it is overheated. In order to permit of longer exposures Gundelach has recently added a regulating tube (ventile tube) (Fig. 8) consisting of a small evacuated glass-ball, which is provided with anode and cathode only. By prefixing this valve-like arrangement to the tube, the formation of disturbing alternating currents inside of the tube is prevented. So the current can pass the tube in one direction only, thus producing a brighter and steadier light (Fig. 9).

The best tubes are those which, when new, show a red-hot focus at the platinum disk while a low current is employed. New

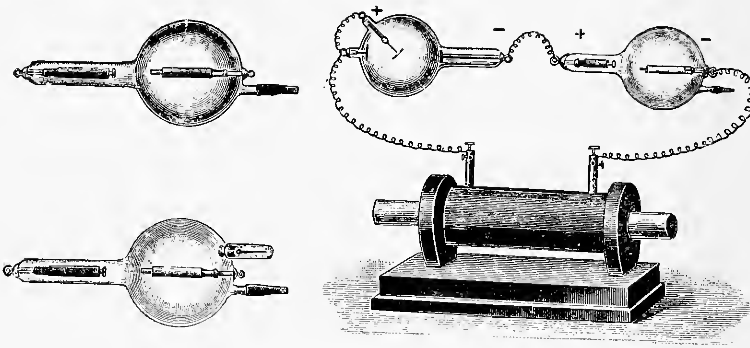

FIG. 8—REGULATING TUBE.

tubes that show fluorescence only when a high current is used should be rejected. It is one of the main characteristics of a good tube that it stands intense glowing of the platinum disk without

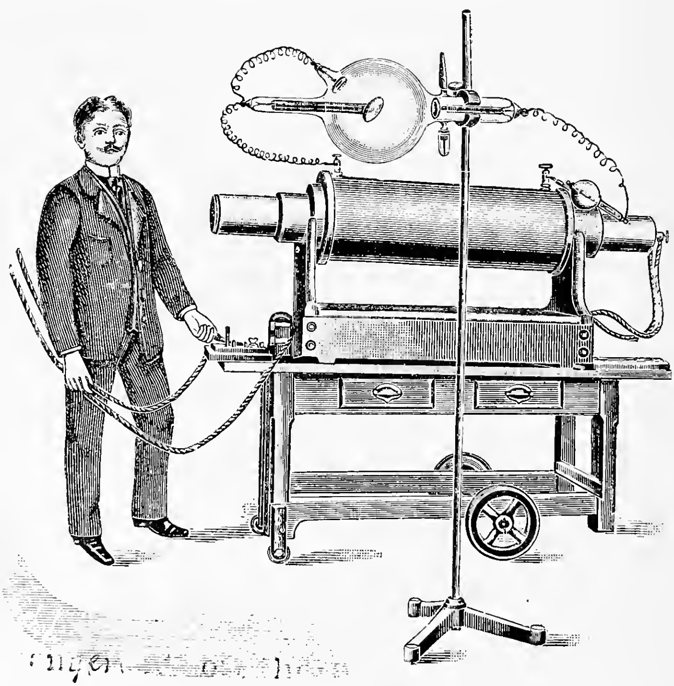

FIG. 9.—REGULATING TUBE IN USE.

being impaired after a few seconds; in other words, that it stands currents of high intensity. A good tube must also furnish a uniform light.

The variety of tubes now manufactured in various parts of the world is very great. It seems to the writer that, while the best coils are made in this country, Germany still furnishes the best tubes. It must also be considered that it requires a vast amount of experience and repeated experimentation to select tubes suitable for the particular apparatus employed. Static machines, as alluded to before, require tubes with a special vacuum, while tubes prepared for a battery set generally do not give satisfaction with an air-brake wheel apparatus or a Wehnelt interrupter, which per-

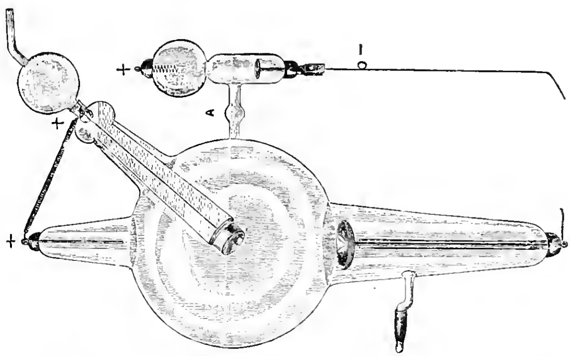

FIG. 10.—GRUNMACH-KNY TUBE PROVIDED WITH WATER-COOLING APPARATUS.

mits the use of the highest vacuum obtainable at present. Tubes must be carefully studied, individualized, so to speak, just as different patients are to be judged differently, although suffering from the same disease.

In order to prevent overheating, Grunmach advised tubes provided with a circulation of a stream of cold water. Thus the glowing metal is cooled off, and the vacuum cannot be lowered by the heat radiating from the anticathode. A good tube of this kind is constructed by Kny (Fig. 10).

Walter constructed tubes of large size which permit of changing a pint of water into vapour. These tubes excel by their strongly marked focussing point. The vacuum of a tube of this kind shows more stability than any other. The largest consists of a platinum cap which is sealed in the end of a glass tube. This projects within the bulb, while outside of it it is enlarged into a small bottle for containing the cooling fluid. This adjustment permits of the fluid coming in contact with the target. Tubes of this kind give splendid results, and it is deplorable that the technical difficulties connected with their construction make their price extremely high.

Tubes must be preserved in a closet in which there is a uniform medium temperature. They should rest on padded shelves. Dust, which in the course of time always becomes adherent to the tube while in use, is to be wiped off by passing the dry palm of the hand gently over it.

The Vacuum of the Röntgen Tube.—As alluded to before, if the intratubal pressure is reduced to its utmost, if, in other words, the degree of evacuation is very high, we speak of a high vacuum. As a rule such tubes are called hard. It is assumed that the paths followed by atoms repelled from the cathode are free from obstruction, so that they can strike their points of destination with great rapidity, thus producing small wave lengths which penetrate matter freely. This accounts for the great power of penetration. If the intratubal pressure is reduced to a lesser degree, so that a comparatively large amount of air remains inside of the tube, we speak of a low vacuum. Tubes showing a low vacuum are called soft. Since a greater number of atoms radiate in all directions, the points of destination are touched with less velocity. Thus the production of short wave lengths is prevented and the free passing obstructed. Consequently dense objects are not penetrated by the rays of tubes of this type, and the objects are never able to absorb their rays.

So we learn that the intensity of the rays increases in proportion to the height of the vacuum. If very high vacua are used, even the bones of the hand may become so translucent that they can hardly be distinguished on the plate, while too low a vacuum does not generate any Röntgen rays at all, the current passing the tube by forming cathode rays. Thus it will be understood why, for the representation of the bones of the hand, a tube with a low vacuum (so-called soft tube) is to be chosen, while if the rays must permeate a very thick body, such, for instance, as the pelvis of a fat person, it is the high vacuum tube (hard tube) that would be capable of throwing so much light through it as to show a well-defined shadow on the plate. From these facts we appreciate that, according to the thickness and permeablity of the object to be skiagraphed, tubes of low, medium, high, and very high vacuum must be at hand.

The degree of the tubal vacuum is unstable. At first a tube becomes softer when in use, because the particles of air which adhere to the tubal wall are detached from it by the warming influence of the current. After the tube is cooled off, it becomes harder again, because the particles of platinum dissipated from the glowing anticathode, while cooling, find particles of air in the interior of the tube. The longer the tube is in use the more air is bound by this process, so that the amount of the intratubal air finally becomes too small to permit the passing of a current. Tubes of this kind are characterized by the dark-brown deposits in the intratubal walls, which were produced by the dissipated particles of the platinum. The degree of a vacuum is in proportion to the length of the spark. The higher the degree of evacuation therefore is the larger the length of the spark, and consequently the harder the tube must be. The lower the evacuation, the shorter the spark length and the softer the tube.

CHAPTER II

RÖNTGEN TECHNIQUE

Methods of Measuring the Degree of the Vacuum.—In order to estimate the intensity of the rays and the amount of their penetration various kinds of *skiameters* were advised. The principle of these instruments consists in the insertion of an obstacle to the rays. This is accomplished by attaching small squares of tinfoil, of various thicknesses, to a fluorescing screen. The difference of thickness is indicated by little figures made of lead, which appear more or less distinct according to the thickness of their corresponding tinfoil. The author had found it useful to construct a skiameter consisting of 50 staniol disks. To each disk a number, made of wire, is attached, which indicates the number of the staniol lamellæ. No. 1, for instance, contains one lamella only; while No. 50 contains 50. That number which just permits the recognition of the shadow of its wire cipher indicates the degree of the intensity of the tube. Most operators, however, prefer to test the vacuum of the tube by simply holding their own hand before the fluorescing screen. In fact, the hand is a most reliable indicator, since it contains many different types of bones, from the massive carpal end of the radius to the delicate third phalanx of the little finger. But such tests lead to pathological changes of the integument, which may become permanent, and may even lead to the loss of the extremity. The detailed description of these changes, as well as of the means of protection, is found in Chapter XVIII on the Therapeutic Effects of the Röntgen Rays.

Recently Walter has constructed a skiameter, the metallic plates of which are made thicker in proportion to geometric instead of arithmetic progression. For the tinfoil platinum is substituted. Then but a small number of lamellæ is required, which renders numbering superfluous. Walter uses eight apertures. The fluorescent screen placed before the disk shows one lamella only when a very soft tube is employed, while all lamellæ are recognised if a very hard tube is selected.

The photometric scale of Benoist also permits a minute precision of the degree of the vacuum, but needs further modification to become useful in practice. Its principle is based upon the transparency of the metals with an atomic weight of 100 to 150, sil-

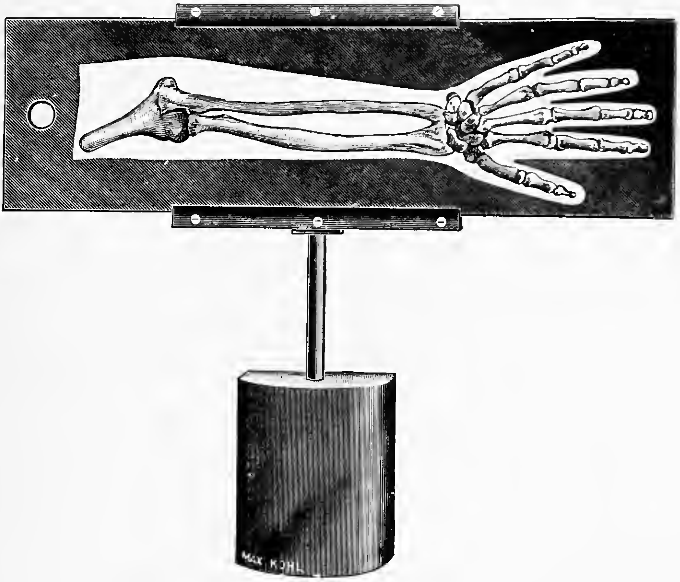

FIG. 11.—AUTHOR'S OSTEOSCOPE.

ver, for instance, varying in a lesser degree than the other elements in regard to the radiations of tubes of different vacua.

An experienced operator is often able to estimate the degree of the vacuum by simple inspection, the colour of the light, and its division, the mode of induction, the character of the noise of the apparatus in combination with minor signs being the indications of quality.

Still, as the wrinkled and shrivelled Röntgen hands of physicians (compare Fig. 245) show, who employ the method frequently, the danger of continuous exposure is great. As emphasized in Section III on Röntgen-Ray Therapy, even apparatus like the ingenious chromoradiometer of Holzknecht, or the radiochromometer of Benoit, or the ampoule osmo-regulateur of Villard, in their present shape, proved to have only a limited field of usefulness.

As said above, men of great experience are able to estimate by the general appearance of the light. But this is certainly not reli-

FIG. 12.—CONTROLLING THE VACUUM BY THE OSTEOSCOPE DURING EXPOSURE.

able. With the Walter combination the degree of the vacuum can approximately be estimated by the arrangement, but this is complicated and not favoured by the average practitioner.

Instead of sacrificing the living extremity of physician or patient, the author has suggested to utilize the skeleton. His *osteoscope* will, in fact, be found to answer all practical purposes.[1] The bones of the forearm and hand are fastened to a sheet of pasteboard or similar translucent material, by being inserted in the frame of a fluorescent screen it can be moved to and fro, so that the phalanges, the carpus, or elbow can be studied. To make the apparatus more compact, besides the hand only, the epiphyseal ends of the forearm may be utilized. When the hiatus between the eminentia capitata and the radial head is distinctly shown, sufficient contrast can be expected on the plate (Fig. 11).

[1] The osteoscope is made by Max Kohl of Chemnitz.

The elbow is a better mentor than the wrist, if permeation of thick tissues is considered. Just as in the living carpus the bones appear black if a soft, and light gray if a hard tube is chosen. The handle of the osteoscope is surrounded by a shield of lead, so that the hand is perfectly protected while holding it. It is no small advantage of the osteoscope that only one hand is needed for manipulation. The bones of the apparatus may be hidden under black muslin or pasteboard. By attaching a tapering box to the

Fig. 13.—Lateral Dislocation of Elbow and Old Fracture of External Condyle.

frame, like the one used with the fluoroscope, the osteoscope can also be used in a light room (Fig. 12).

As mentioned in the foregoing chapter, it is desirable to distinguish hard and soft tubes from those of medium hardness.

If a tube shows the bones of the osteoscope light gray and translucent, it is of excessive hardness, the contrasts are insignificant then, and it is practically useless for Röntgen examination. Tubes of this kind take a skiagraph of a hand in one second, and of a pelvis in ten, but there is no contrast, the image being blurred and foggy. Under extraordinary circumstances they may be used for the representation of metallic foreign bodies, when the osseous structures do not need consideration. Fig. 13, for instance, illustrates the indistinct skiagraph of a lateral dislocation of the

Fig. 14.—Normal Ankle-joint, taken with a Tube of Medium Hardness.

elbow-joint. Tubes of this kind show little fluorescence, and if excessively hard, no rays are produced at all. The amount of fluorescence can be estimated from the depth of shading which is given to the lower part of the Röntgen tube. There is a large amount of secondary rays and of ozone. The spark often jumps around the tube.

A tube of medium hardness is the tube *par excellence*. It shows the bones of the wrist, especially the lower radial epiphysis,

Fig. 15.—Fracture of Lower End of Radius followed by Displacement, taken with a Soft Tube.

grayish-black, but the contrasts are marked and the structures well outlined. Such tubes are especially fit for the representation of thick bones, and of renal concretions. The fluorescence finds its expression in the deeper shading of the globe. There is exterior discharge to a lesser degree than in the former variety. Therefore a tube of this degree of vacuum cannot be touched without receiving a shock. The picture from such a tube, which shows the bony structure, is illustrated by Fig. 14.

A soft tube shows the outlines of the phalanges and the metacarpus black and the soft tissue dark. There is bright fluorescence and marked contrast on the screen. But the denser portions of the

FIG. 16.—FAINT INDICATION OF BULLET IN THE OS MAGNUM AND EVIDENCE OF SMALL FRAGMENTS IN THE CARPUS (LOW VACUUM TUBE). (Compare Figs. 17 and 18.)

bones are not penetrated. Therefore tubes of this kind produce excellent skiagraphs of the bones of the hand and forearm, but are not powerful enough to represent structural details. A skiagraph taken with a soft tube is illustrated by Fig. 15. Excessively soft tubes produce violet light and show the carpus as black as ink, no contrast being recognisable at all. Tubes of this kind can be touched without receiving a shock.

The various degrees were also illustrated by the author in his publication on Tenontitis and Tenontothecitis. New York Medical Journal, April 27, 1901.

How to interpret the different vacua is also illustrated practi-

FIG. 17.—BULLET CASE, ILLUSTRATED BY FIGS. 16 AND 18, LATERAL EXPOSURE (LOW VACUUM TUBE).

cally by the simple case of a man of twenty-four years who was shot eleven years before the skiagraphs No. 16, 17, and 18 were taken. Fig. 16 shows a very faint indication of the presence of the bullet in the os magnum, while the small fragments in the carpus are recognisable, a low-vacuum tube having been chosen. The hand rested on the palm. The bullet being near the dorsal surface and the small fragments near the palm, it is appreciated why the latter are recognised in spite of the low vacuum. Fig. 17, also taken with a low-vacuum tube in the lateral position, was exposed ten seconds longer. It shows the bullet a little more distinctly. The fragments are also visible. Fig. 18 was also taken in the lateral position, but this time a tube of medium hardness was used. This accounts for the distinct representation of the bullet in the os magnum, from which it was extracted after being mobilized by the chisel. The bones appear black in Figs. 16 and 17, while Fig. 18 appears gray, the bony structures being indistinct. The patient was not disturbed for eleven years, and the author would not have advised extraction if there were not a slight inflamma-

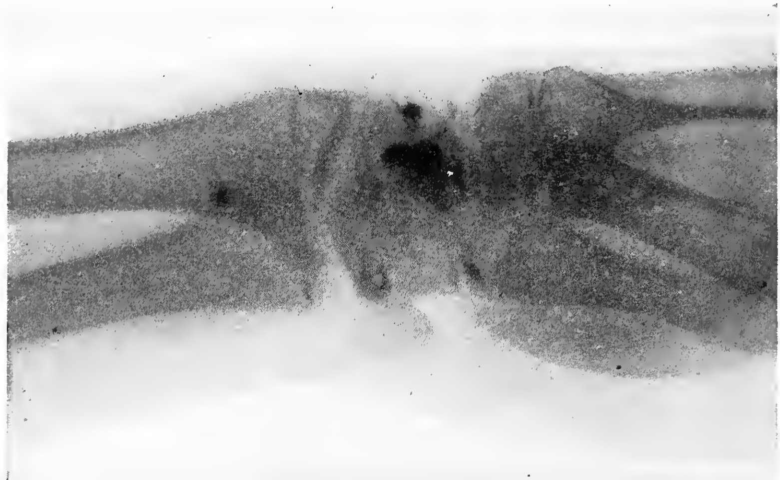

Fig. 18.—Bullet Case, illustrated by Figs. 16 and 17, showing Bullet Distinct and Bones Translucent (Tube of Medium Hardness).

tory process induced by an injury, which caused the patient considerable disturbance.

By studying the three skiagraphs the seat of the bullet was made out without measuring.

The Handling of Tubes in Connection with the Wehnelt Interrupter.—It is highly recommended to have a number of tubes at one's disposal, so that fresh tubes can always be used. The vacuum of a tube is affected after being used, therefore it is desirable to have another tube on hand in case a second exposure is required. As alluded to before, the success of a Röntgen examination depends largely upon the proper degree of vacuum and the time of exposure. The character of the current can, as described above, approximately be estimated by the appearance of the tubal light. If a Wehnelt interrupter is employed, it may be said that but a slight greenish fluorescence without a marked division of the luminous cone is noticed if there be an undercharge. There may also be frequent irregularity in the interruption. The cause may be twofold. Either the current employed is too weak, or the mode of self-induction is improper. If the function of the tube appears to be regular, but if the current is too weak, a slight increase of the primary current is indicated. On the other hand, if there is good fluorescence and normal division, but the induction is irregular, the spark length of the tube being larger than the one produced by the self-induction of the inductor, the latter must be reduced.

If there be regular but weak function, which does not react on a stronger current, self-induction is insufficient, the wire of the Wehnelt interrupter not projecting far enough. This condition is remedied by increasing the current and by lengthening the platinum tip.

If there be an overcharge the anticathode soon begins to glow, thus lowering the vacuum so much that the tube becomes practically useless. If the current is not stopped, the anticathode becomes white hot and a hole is melted through the platinum, while there is flickering light, ring formation, and crepitation: once in a while there are rays of great power of penetration, but as a rule no rays are generated at all. In such an event the primary current was too strong or the platinum tip projected too far, so that the spark became too thick.

Diaphragms.—The fact that the currents are not unidirectional, sometimes even the whole of the tube becoming a source of the Röntgen rays, has given an impetus to the construction of lead diaphragms, which do not permit a larger amount of light to pass than the reproduction of the area to be traversed requires. Thus the injurious secondary rays are kept off, the effective cone of light only being projected on the plate.

Thick portions of the body reflect the rays diffusely. So, for instance, in making an exposure of the pelvis of a fat individual each muscular portion irradiates the whole plate individually, so that the contrast is considerably diminished. The fact that soft tubes are least apt to diffuse the rays would naturally suggest their exclusive use. But their small power of penetration makes them unfit for representing thick layers.

The introduction of the methodical use of the diaphragm marks a great advance in the Röntgen technique. It is only possible by

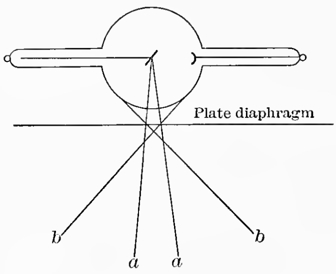

Fig. 19.—Plate Diaphragm.

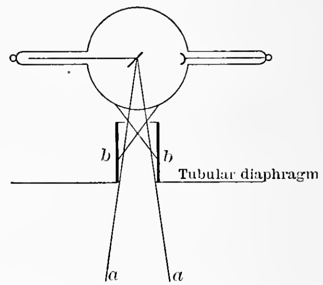

Fig. 20.—Tubular Diaphragm.

these means that the structural details of thicker portions of the body can be well reproduced. Especially in diagnostic differentiation the value of the diaphragm method is immense. Errors, as

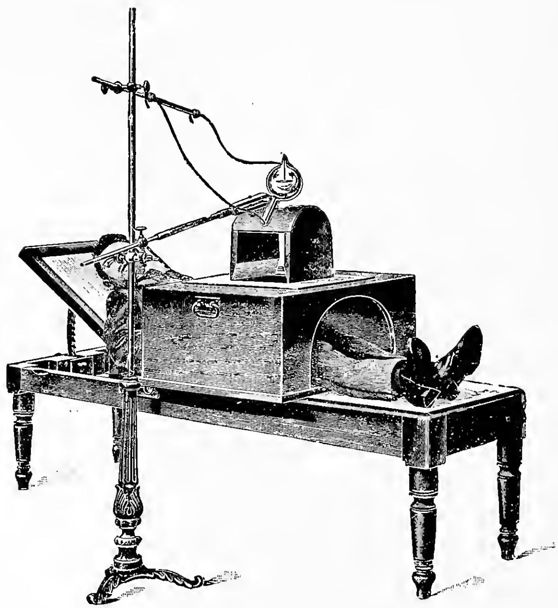

Fig. 21.—Simple Form of Lead Diaphragm.

they are illustrated in the chapter on the medico-legal aspects of the Röntgen rays, are simply impossible. Bone-fissures cannot escape detection.

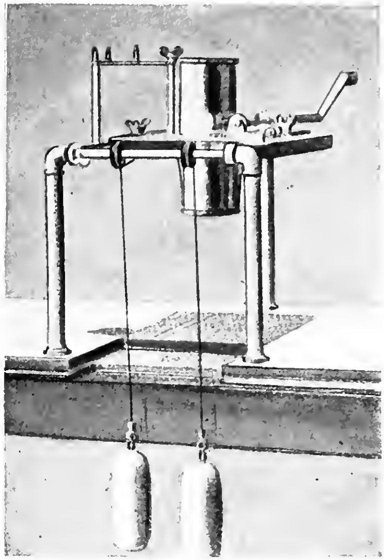

Fig. 22. — Simple Compression Diaphragm.

The original diaphragm consisted simply of a sheet of lead into which a hole was cut. Fig. 19, for instance, shows a diaphragm of a diameter of 2 inches, which is traversed by the rays emanating from a tube placed above. Besides the rays from the target (*aa*), those emanating from the tubal wall (*bb*) pass the hole in the diaphragm. Thus a certain amount of diffusion is still produced. To obviate this, tubular diaphragms were constructed which permit the passing of the focal rays only, those emanating from the tubal wall being excluded. Fig. 20 shows the principle of the tubular diaphragm, which is passed by the focal rays (*aa*), while the rays emanating from the tubal wall (*bb*) are reflected.

The use of the simple form of a lead diaphragm is illustrated by Fig. 21.

Albers-Schoenberg deserves great credit for having constructed a compression diaphragm (Fig. 22), which not only prevents diffu-

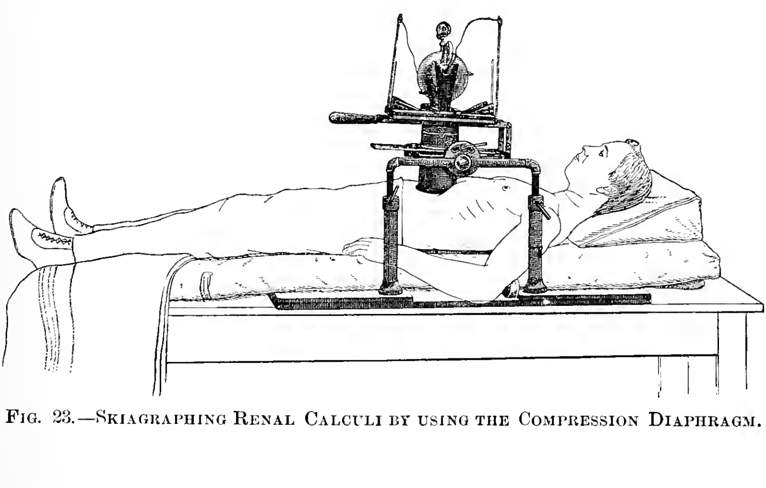

Fig. 23.—Skiagraphing Renal Calculi by using the Compression Diaphragm.

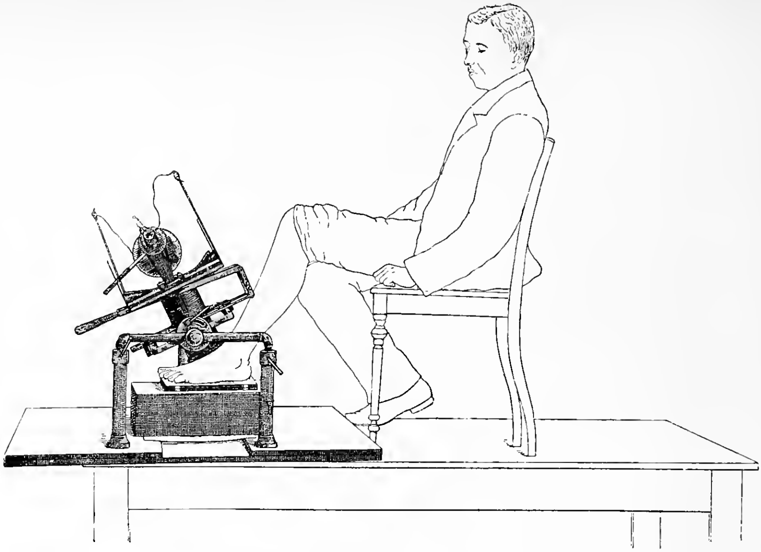

Fig. 24.—Examining the Foot by the Compression Diaphragm.

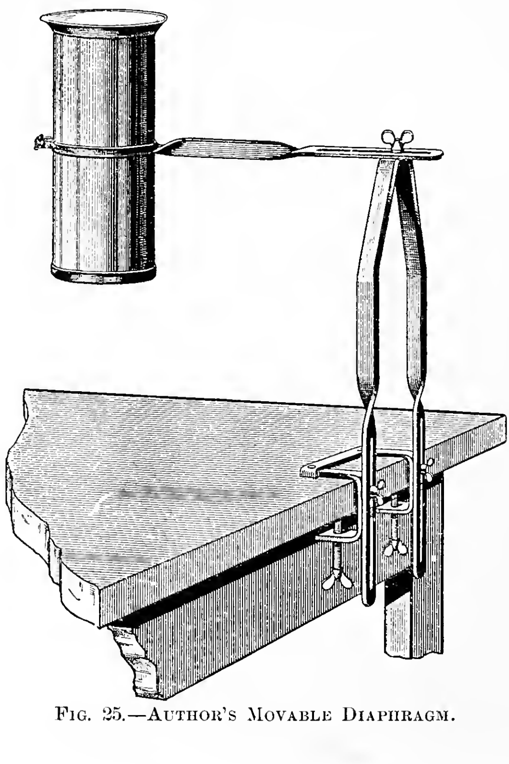

Fig. 25.—Author's Movable Diaphragm.

FIG. 26.—TEXTURAL DETAILS SHOWN BY THE AID OF AUTHOR'S DIAPHRAGM IN FRACTURE OF RADIUS, ASSOCIATED WITH FRACTURE OF STYLOID PROCESS OF ULNA.

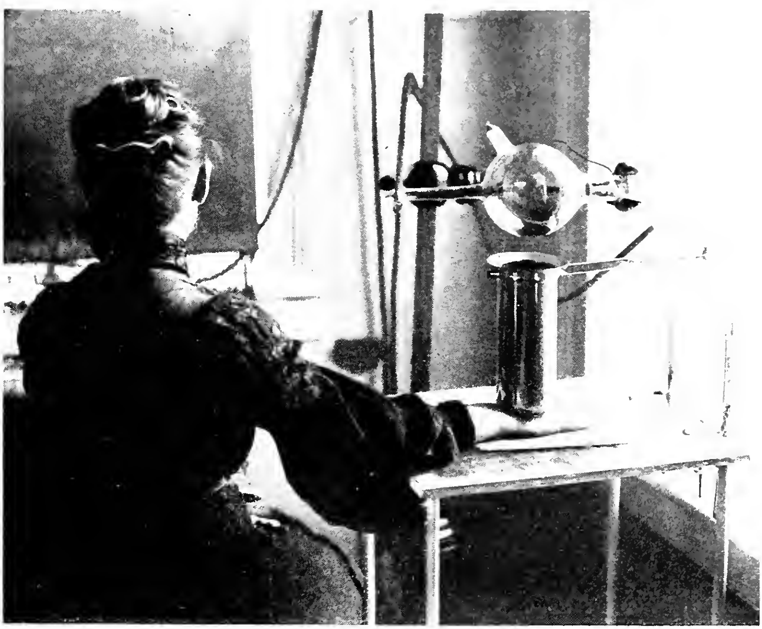

FIG. 27.—SKIAGRAPHING HAND BY THE AID OF AUTHOR'S DIAPHRAGM.

sion, but also permits immobilization of the area to be irradiated by compression, a decided advantage of the latter also consisting in the possibility of bringing the area nearer to the photographic plate. The compression also has the great advantage that all exposures are taken at the same distance of the tube from the surface of the body. Thus an exact standardization is guaranteed, and the

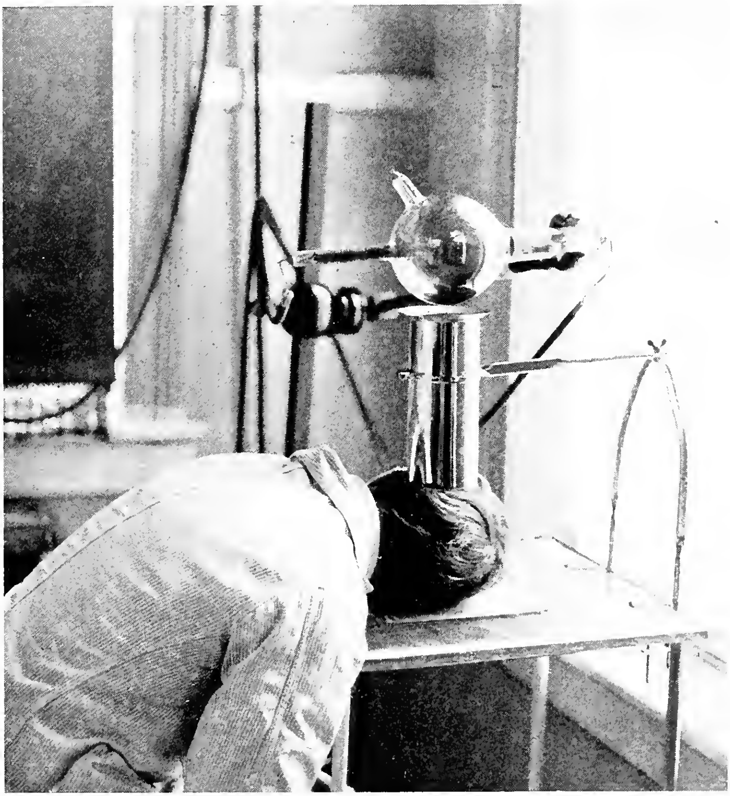

Fig. 28.—Skiagraphing Head by the aid of the Diaphragm.

perspective always remains the same. The elaborate metallic compression-diaphragm illustrated by Figs. 23 and 24 is movable in any direction. Its diameter is proportional to the size of the skiagraph to be made. Tubes provided with various diameters are therefore recommendable. In general, however, a diameter of 4 inches is desirable. Even in fat persons structural details can be obtained with this apparatus.

No perfect Röntgen outfit can be without a compression diaphragm nowadays, the only drawback being that the splendid apparatus of Albers-Schönberg is extraordinarily high priced. The author has therefore devised a simple movable tube (Figs. 25, 26, 27, and 28), which is portable and can be fastened to any table, and practically answers the same purpose. It prevents diffusion and permits of immobilization and compression. Its cheap price places it within the reach of every physician.[1] (The upper margin of the tube of the diaphragm must be wider than it appears on the illustrations.) The tube can be made in three diameters of various size.

[1] The apparatus is made by Friedrich Dröll of Heidelberg.

CHAPTER III

FLUOROSCOPY

The Field of Fluoroscopy (Röntgoscopy).—In the introduction, page 1, it is described that the rays in falling upon a screen which is covered with fluorescing salts, such as tungstate of calcium or platinocyanide of barium, cause fluorescence on it. The human hand, for instance, if placed between the tube and a screen evenly covered with one of the fluorescing salts, shows the condition of its bones. Even the soft tissues can be distinguished to some extent. There are many other salts fluorescing under the Röntgen rays, but up to the present day the platinocyanide of barium, as it was first used by Röntgen, has proved to be the best fluorescing material. It gives a yellowish-green and brilliant fluorescence.

The use of the fluorescing screen is facilitated by attaching it to a suitable framework formed like that of a stereoscope, the body of which is of a tapering form. The large end of such an instrument, generally called *fluoroscope*, contains a piece of cardboard on the inner surface of which the fluorescent salt is distributed, while the small end of the apparatus has two apertures formed in such a manner as to fit over the eyes of the operator. The pasteboard is liable to contamination and injury if *suppurating* or *wounded areas* must be examined. In such cases it is advisable to cover it with a non-absorbent material which permits of sterilization, such as very thin sheet celluloid, for instance. If used during a surgical operation, the hood should also be covered with a material which can be sterilized. Hard rubber may be used for this purpose. For examining the largest parts of the body the screen should have a dimension of about 12 to 18 inches.

For examination with the screen a room must be chosen which can be darkened at will. If there is colour sensitiveness for green, the operator will find the tungstate fluoroscope more satisfactory than that of the barium.

A rough sketch may be obtained from the screen by simply tracing (Fig. 29).

The advantages of the screen are obvious. In the first place, there is no necessity for a previous exposure, and the development of a photographic plate, as in skiagraphy. Secondly, the irradiated area can be examined while it is in action. Thus the motions of the joints, the larynx, the hyoid bone, furthermore the pulsation of the heart, the lungs, the diaphragm, etc., can be thoroughly studied. Especially the continuous motions of heart and lungs are an impediment for distinct skiagraphy, while they are a direct aid in diagnosis if watched by the screen. The excursions of the diaphragm during inspiration and expiration can be noted and measured.

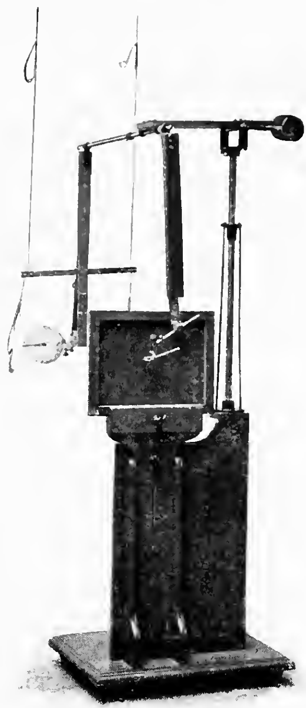

Fig. 29.—Tracing Apparatus.

A fluoroscopic examination should also precede the skiagraphic exposure as a kind of preliminary survey. This is especially important in fractures and dislocations, since it calls attention to the seat of the injury. It furthermore determines the best position of the limb for proper fixation during skiagraphic exposure, so, for instance, that angle of flexion or extension in which the injured portion can be brought out best on the plate.

This shows the greater importance of fluoroscopic examination in internal medicine, while in surgical practice its usefulness is limited because of the production of the numerous fluorescing impressions, which, by succeeding each other with great rapidity, are apt to deceive the human eye wherever the features of the lesion are not distinctly marked. Fixation of the condition to be examined on a photographic plate (skiagraphy) is therefore to be preferred as a rule.

In thin areas of the body, however, like the hand, projectiles or needle-fragments are so well shown by the screen that a skiagraph is a mere luxury as a rule. Fluoroscopy also permits the examination of an extremity while it is turned in various directions. The superficial localization of foreign bodies is facilitated, as it is ascertained whether it is situated in front or behind a bone, etc.

But in making a thorough examination of the thigh, the shoulder, and the large cavities of the body for foreign bodies, fluoroscopy should not be relied upon. Fractures are recognised by the screen only if there is displacement. But if the fragments remained in apposition the fragment line is indistinct. If it must simply be ascertained through a plaster-of-Paris dressing whether the fragments are in exact apposition after reduction, fluoroscopic examination is sufficient as a rule, since it is not necessary to see the fracture line then. The salient point is simply to verify whether the bones were reduced in the proper direction. (Compare Chapter XV on Fractures.)

In some forms of dislocation the screen gives ample information. Dislocation of the shoulder-joint, for instance, may be recognised at once on the screen, while the result of the palpatory examination was rendered uncertain by the presence of a large bloody effusion. On the other hand, the dislocation of a small bone, like the radical head, in so complicated a joint as that of the elbow is, may be overlooked or misinterpreted on fluoroscopic examination. In dislocation of the hip fluoroscopy must also not be trusted. The same can be said of the detection of concretions and of the diseases of the teeth and the bones as they are described in Chapter VI and XIII.

As a rule, hard tubes should not be employed for screen work on account of their great penetrating power, which permits but little contrast. Soft tubes give the best fluoroscopic differentiation. Especially in studying the thoracic organs this kind of tubes should be chosen. If thicker portions of the body must be examined, tubes of medium hardness are required. The mobility of the tube is a condition *sine qua non* in fluoroscopic examination. The tube-holder must be so arranged that the tube can be turned in all directions. The author's diaphragm, as described on page 39, is also extremely useful for detailed observation in fluoroscopy. An advantage of fluoroscopy not to be underesti-

FIG. 30.—ORTHODIAGRAPHIC EXAMINATION.

mated is its cheapness. A disadvantage of the screen for patient and physician is the necessity of long exposure, which may once in a while result in dermatitis.

Orthodiagraphy.—The fact that the size of all skiagraphs is larger than that of the objects they represent, led to the construction of orthodiagraphic apparatus, by the aid of which the exact size of a body is determined. Levy-Dorn, Moritz, Hirschmann, and others have constructed useful apparatus of this kind. The orthodiagraph made by Hirschmann permits direct tracing by the aid of a movable screen (compare Fig. 30). The measuring-stand devised by Hoffmann (Fig. 31) has also come into favour. Its main prin-

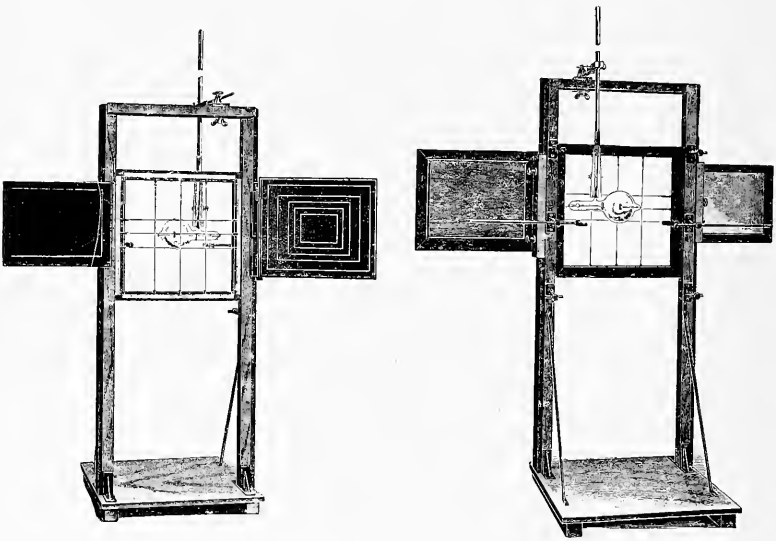

Fig. 31.—Hoffman's Measuring Stand.

ciple consists in the construction of registering wire screens which can be moved in various directions. Apparatus of this kind, however, permit only of measuring the shadow of the foreign body, while its natural size must be guessed at.

Donath's modification, which allows the movement of the tube above a millimetre scale, the tube being placed perpendicularly at a measured distance, gives very nearly the exact size of a foreign body.

CHAPTER IV

SKIAGRAPHY

Skiagraphy (Röntgography).[1]—As previously stated, skiagraphy is based on the photographic effects which are produced by the Röntgen rays. Its main advantages are the possibility of permanently retaining and recording the shadow thrown on the sensitized plate. In fact, structural details can be shown exactly on the photographic plate, and it is the skiagraph only which permits the thorough study of the various features of a lesion. Its comparison with the normal skeleton will make the abnormalities evident at once, and will help the physician to a thorough judgment of the case. In addition, the value of a skiagraph for future information—especially in case of complicated fracture for forensic purposes—should not be underestimated. Therefore whenever exactness of result is desired, fixation on a photographic plate is to be preferred. The photographic technique can easily be learned.

It is well known that if silver is combined with bromine or chlorine, bromide or chloride of silver is formed. This combination has the property of being sensitive to light, and the chemical decompositions taking place while it is exposed to the light cause a change of colour. For proper utilization in photography the salts of silver are mixed with hard white gelatin. On a surface consisting of either glass or paper or celluloid this composition is spread, thus constituting what is called a sensitive plate or paper or film. The image received by the sensitive plate or film is invisible, and must be treated by a peculiar chemical process, called *development,* in order to bring it out. The developing process of a skiagraphic plate is practically the same as that of an ordinary photographic plate exposed to sunlight. There is no doubt that the anatomical knowledge of a physician makes him more fit to develop the important parts of a plate properly. It is

[1] The author objects to the much-favoured expression "radiography," which, as many other modern terms constructed by violent word-composers, is a hybrid.

a great advantage besides if the physician is able to develop the plates himself, since he learns the result at once, while the sending of a plate to a photographer involves a great loss of time. A busy physician should, however, have the services of a well-trained assistant, who does the tedious work of developing under his supervision. If within reach, a learned photographer should be engaged for that purpose, since a physician seldom learns to master all the minute details of the delicate art of photography.

The *plates* are the most important requirements for photographic work. For skiagraphic purposes special plates are generally used. Some manufacturers furnish specially prepared plates which are separately wrapped and sealed in black and in yellow envelopes. But while it is very convenient to have the "individually wrapped plates" ready for immediate use, it must be remembered that the wrappers affect the sensitized surface, and consequently injure their keeping qualities. They are therefore not to be recommended. All these plates are extremely sensitive and slightly radioactive. They must therefore be well guarded against injury by too strong a light while developing, or by traces of diffused light entering the dark room or the envelope, lens, or camera. As the object to be skiagraphed must rest on the film side, it is important to ascertain before the exposure which is the film side. In holding the film against the red lantern light its dull appearance becomes evident, while the plain glass side shines. But even this kind of light should not be trusted too much; consequently the test had better be made by the touch. A practised finger will ascertain at once which is the sensitive side. In case of doubt, however, the moistened finger may carefully touch the corner of the plate, which, if covered by the film, will feel sticky. It should also not be forgotten that perspiration of the hand leaves marks and spots on the plate.

The developing of the plate must be done in a *dark room,* if possible of ample size. Moisture as well as heat spoil the plate. It must not be situated too near the room in which the Röntgen-ray apparatus is placed, because the rays may penetrate the door and even the walls, thereby influencing the plates in their boxes. There must be an abundant supply of water. A sink about 5 inches deep and 3 feet square, consisting of wood and lined with zinc, should be placed in front of 2 or 3 faucets. A grating, on which the developing trays are set up, must be above, and a table which serves for chemical manipulation and the mixing of developers, etc., near by. Shelves for storing the bottles, which contain these, are placed above this table.

The dark-room *lantern* also deserves thorough attention. Ruby light is recommended as the best "dark-room light." As alluded to above, it is used while the plates are taken from their boxes and put into a photographic envelope or into a plate holder, or during the process of developing. As it is described in Chapter XVIII, on the Chemical Actions of the Röntgen Rays, red and yellow colours affect the sensitiveness of the plate very much less than green, blue, or violet. This lack of sensitiveness to red light is utilized in the process of handling and studying a sensitized plate. But while being the least actinic light—that is, while affecting it the least—even red light produces slight changes after a long exposure. It is advisable therefore to study the plates at a distance from the ruby light, as there is, in fact, no light which is absolutely safe. As the source of light, electricity is far preferable. But gas and kerosene may also be used.

By developing the plate—that is, by producing the latent image with the aid of a chemical solution, called developer—the silver salts, which had been influenced by the rays during exposure, are reduced. The areas not affected by the light will not be affected by the developer, while those acted upon by the light show more or less opacity in proportion to the degree of influence. Thus the brightest areas appear the darkest, therefore the image is called a "negative."

Among the various *developers* recommended may be mentioned hydrochinone, hydrochinone-eikonogen, and metal-hydropowder. The latter seems fit especially for short exposures. Some firms produce these chemicals in tablet form, which is rather commodious for a novice.

Very large plates should be immersed in water before the developer is used. The strength of the developer, which is mixed with cold water, should be moderate. During the hot weather the developer must be more diluted and cold, while it may be stronger and warmer (70° F.) during the cold season. Too warm and too strongly alkaline developers cause stains and fog on the plate.

After the mixture is properly prepared it is poured into a hard-rubber tray and the plate is placed in it with the film side up. The developer must at once cover the plate all over. If the plate is rocked then from side to side for about three minutes the image appears. The rocking can be done automatically by using a motor. Gocht has constructed an ingenious apparatus in connection with an accumulator which answers the purpose well.

Then the plate remains in the solution for another two minutes until it appears dark and the image has nearly entirely disappeared. Sometimes it may last as long as twenty minutes until a sufficient amount of density is reached. If there is a lack of clearness, a few drops of a 10-per-cent solution of bromide of potassium should be added. Thus we see that the process of developing often requires considerable loss of time. It may therefore well be undertaken by an intelligent servant. The plate should not be studied too frequently during development, and must not, as demanded above, be brought nearer to the ruby light than a distance of one foot. In studying it, its film side must be turned towards the lantern.

If there should have been *overexposure*, the plate must be thoroughly washed, and may then be finished with a bromo-hydrochinone developer. But if *undertimed*—the details not being distinct—a fresh developer must be used. Then the plate is immersed in a tray containing water to which some sulphite and carbonate of sodium have been added, and is left in this solution until the details come out more clearly. The same procedure may be repeated if the image does not appear to be satisfactory.

If the condition of the development harmonizes with that of the exposure no correcting steps are necessary, and the plate is simply taken out of the tray. It is inserted in a tray which contains fresh water, or it may be held under the faucet, a gentle stream of water being permitted to wash off the developer. It is this second hard-rubber tray which contains a solution of hyposulphite of sodium. After the plate has remained in this solution for about four minutes its light colour will change into black. Now the image is regarded as fixed, and the plate may be exposed to light without being injured.

The process is completed by washing the plate in running water for thirty minutes, and then setting it upon a stand.

The details of instruction regarding the properties of various developers are best studied in the guiding prescriptions given with the developers by each firm. Recently Albers-Schönberg recommended the so-called "stand developing" with glycon as the best method for skiagraphic work. The plate is immersed in the glycon developer for fifteen to sixty minutes, being inspected every ten minutes, until it appears satisfactory. Then it is well washed and kept in the fixation tray for fifteen minutes.

Foggy negatives may sometimes be caused by a decomposed developer, or by one containing too much carbonate of sodium or potassium without bromide. Weak negatives with distinct details in the shadows are produced either by overexposure or by too weak a developer.

Overexposure is at once recognised by the quick and simultaneous appearance of the image over the whole plate and its lack of contrast. It disappears just as rapidly, leaving a dark veil. The sensitiveness of the photographic plate being affected too long, too much detail is produced in the shadows, and consequently the difference between the highly lighted and shaded areas is small. Weak negatives with clear shadows indicate underdevelopment. Too strong negatives with distinct shadows indicate underexposure.

Underexposure is recognised by the slow and difficult appearance of the image. The latter is transparent and shows only general outlines. The highly lighted areas come out first. There is too much contrast in fact. The sensitiveness of the photographic plate was not affected long enough to be impressed, therefore blank areas are left which should have shown structural details. After a normal exposure the various areas appear in the order of their individual transparency.

If the plate is insufficiently developed it may be strengthened by a so-called *intensifying* solution. The plate may be immersed in a solution tray containing the following: Water, 20 ounces; bichloride of mercury, ammonium chloride, $\frac{1}{2}$ ounce each. The tray is rocked until the image is thoroughly white. After being removed from the solution the plate is washed for thirty minutes, and then bathed in ammonium chloride (20 ounces of water containing $\frac{1}{2}$ ounce of the ammonium chloride). Then it is washed over again, and finally immersed in a solution of ammonia (1 drachm of ammonia water to 8 ounces of fresh water) till the whitish appearance has changed into dark. Another washing for five minutes may finish the process, which is often overdone, the skiagraph then becoming transparent. In such an event the density may be reduced again by placing the plate in a reducing solution, after it is soaked in water for about half an hour. A useful solu-

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tion of this kind consists of 10 ounces of fresh water containing 100 grains of ammonia-persulphate.

The proper tints of the light and dark shades are obtained by producing a *positive print*. Some of the finer details of the plate are lost in this process. The positive can be made on glass, celluloid, or paper coated with an emulsion of albumin, collodion, or gelatin in which silver chloride is incorporated. If put on paper, it is customary to simply call the positive a print. Paper of this kind, called printing paper, is placed in a printing frame with its face on the photographic plate and is pressed towards it by a spring clamp in the back of the frame. The glass in the frame must then be reached by the sun at a right angle. The time required for printing depends upon the time of the day and the year, and the density of the image. If exposed to bright sunlight the printing may not last longer than five minutes. It must be continued until there is a tone which is slightly darker than the one expected for the final print. The fixing of the print is done virtually in the same manner as that of the plate. The proper formulas are always sold with the paper. After being taken out from the fixing bath. the print is washed and fixed. Finally it is washed in running water for about an hour. In a good skiagraphic print the dense areas are shown in a dark tone.

Stereofluoroscopy and Stereoskiagraphy.—A skiagraph being a map-like reproduction of tissues naturally does not show any depth or perspective. So it neither gives any information on the dimensions in the depth nor on the relations of the individual bones to each other. Stereofluoroscopy was introduced by Elihu Thomson by switching the secondary discharge of the induction coil from one Röntgen tube to another by a revolving switch arrangement.

The distance between the tubes and their relation to the screen must be so arranged that no distortion of the shadows occurs. By means of this mechanism the space relations can be estimated so that foreign bodies can be located. The reduction of bone splinters may also be controlled in this manner. Weigel and Johnson constructed excellent modifications of the Wheatstone stereoscope. Weigel's instrument permits of varying the intensity of the light as the distance of the lamp is shifted from the negative.

With the methodical introduction of stereoscopy into Röntgen practice by Hildebrand and Kuemmell new information was obtained. The principle of ordinary stereoscopic photography consists, like in stereofluoroscopy, in a system by which two exposures of the same object can be made in two different positions. If the views obtained from these positions are combined by a reflecting or refracting apparatus, the parts stand out in their natural relationship.

In order to be able to take two skiagraphs of the same area, the arrangement of the plates must be such that they can be

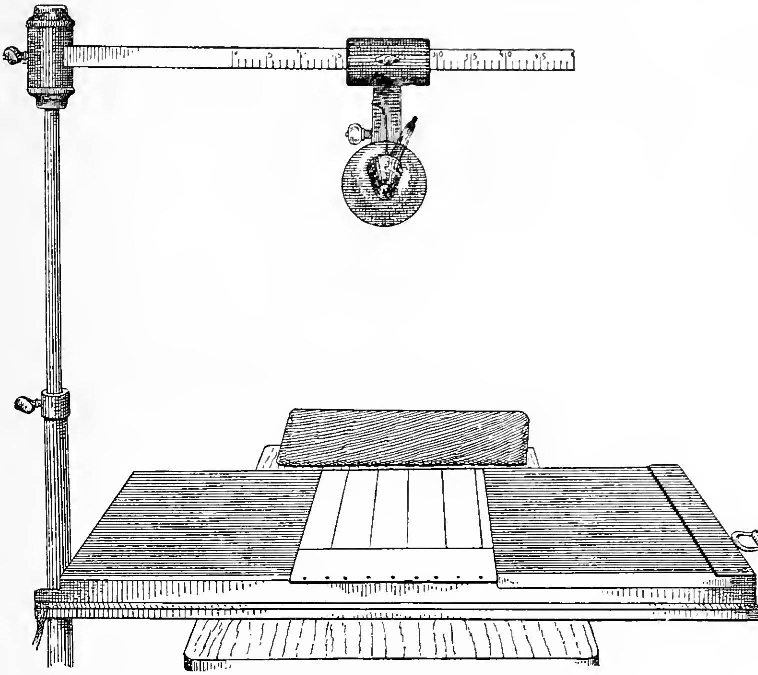

Fig. 32.—Apparatus of Hildebrand.

changed without altering it. The plate must then be marked for registration. The *modus operandi* consists in placing the patient upon a table or couch to the sides of which two uprights and a cross-piece are fastened. The latter is provided with a clip which holds the tube so that it can slide along it in either direction. Over a square frame placed in the opening which is cut through the centre of the examining table a sheet of vellum is stretched. The distance of the tube from the area to be examined should amount to about 15 inches, while that of the two positions of the anode should be 3. Across the vellum and parallel to the graduated cross-bar two thin wires are also strained and graduated. The

FIG. 33.—FRACTURE OF FEMORAL DIAPHYSIS, SHOWING ANGULAR DEFORMITY (ANTERIOR VIEW). (Compare Fig. 34.)

centre of the skiagraphic plate must be vertical underneath the vellum. After the skiagraph is made, the plate, without altering the position of the patient, is inserted and the clip run back till it makes a halt at the other sliding piece. The same tube is used and the same length of exposure given. Hildebrand (Fig. 32) constructed a stereoscope which permits skiagraphing on one plate. One-half of the glass plate is covered with a thin plate of lead, which does not permit penetration by the rays. After the exposure is completed the photographic plate is shifted forward, and its exposed area is covered with the lead plate. Then the non-exposed area is irradiated. By adding a sliding mechanism Albers Schönberg has modified his compression diaphragm in such a manner that it can be utilized for stereoscopic skiagraphy.

Routine, however, often enables the surgeon to locate a bullet, as in the case illustrated by Fig. 16, or bone fragments, as in the cases illustrated by Figs. 33 and 34. They show the overlapping of the fragments of the femur in a boy of seven years seven weeks after the injury. The fact that the end of the upper fragment appears less translucent than the lower indicates that the latter was near the plate—that, in other words, it was situated at the outer side of the thigh. As to details of history, see Chapter XVI. Fig. 35 represents a counterpart.

Fig. 34.—Fracture of Femoral Diaphysis, showing Overlapping of Fragments (Dorsal View). (Compare Fig. 33.)

In both instances bloodless re-fracture was successfully done.

Foreign Bodies.—While it is easy, as a rule, to recognise foreign bodies by the screen as well as by skiagraphic exposure, the determination of their position is sometimes very difficult. For locating the position of foreign bodies more than a hundred methods are advised. Most of them are ingenious but somewhat complicated for practical use. They are all based upon similar principles. The wire letters used by the author for registration may serve as landmarks in a simple manner by being attached by means of adhesive plaster to the region of the body to be irradiated, after it has first been marked with the skiagraphic pencil. Wire

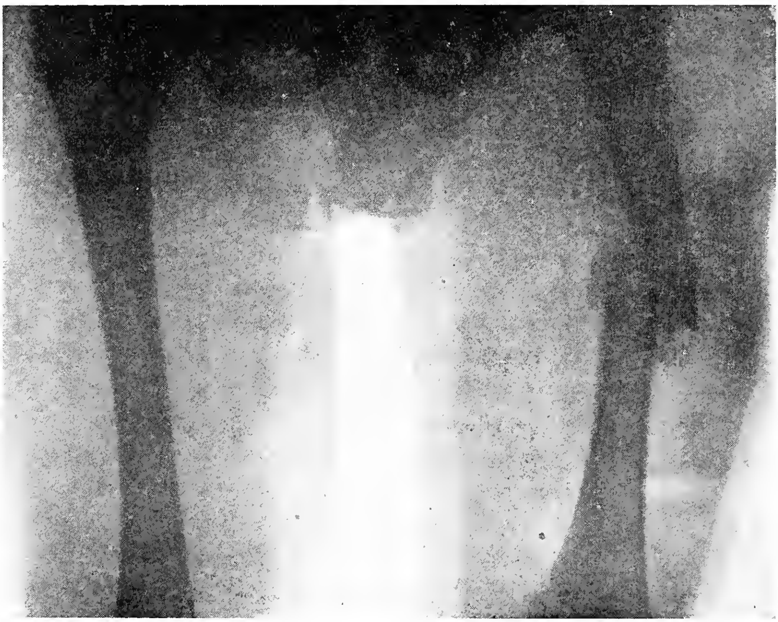

Fig. 35.—Fracture of the Middle of the Femur, showing Juxtaposition, Seven Weeks after the Injury, in a Boy of Seven Years.

letters may also be placed on the plate just below a wound or a scar, indicating the entrance of a foreign body. If there is a wound sinus, a probe may be introduced as far as it is possible. Thus the extent of abscess cavities may be ascertained (Fig. 55).

Fig. 36 illustrates the arm of a man of twenty-eight years who was shot three years before the skiagraph was taken, and who since had suffered from the symptoms of pressure on the median nerve. Two exposures were made, one on the flexor area, another on the extensor side. In proportion to an angle of 90 degrees four metallic letters were attached at equal intervals to the surface of the arm by adhesive plaster, *A* illustrating the anterior, *P* the posterior, *I* the interior, and *E* the exterior aspect, as shown by the skiagraph. The point of recognisable attachment was made at the integument before by marking them with nitrate of silver. The comparison of the various diameters revealed the location of the bullet, which was extracted under local anæsthesia. The bullet, on account of having struck the bone, had assumed a flattened shape.

Fig. 36.—Localization of Bullet in the Arm by Wire Letters.

For foreign bodies which can be seen best in one direction only, as, for instance, needles buried in the foot or in the hand, Shenton (Guy's Hospital, London) suggested the following method:

"The surface of the palm of the hand, for example, is held in direct contact with the screen, seeing that the screen and anode in the tube are as nearly parallel as possible. When the needle and bones are seen distinctly, sway the screen and hand from side to side and note the change in relation of bones and needle. It is evident that the image of whichever is farthest from you and from the surface of the screen will move the faster. If the needle moves across the bone, its position is deeper than the bone; if the bone moves across the needle, the latter's position must be between the surface and the bone.

"Should the needle appear stationary, place a pointer against the image on the screen and ascertain whether it moved a little or not at all. Verify these results by reversing the hand and repeating the manœuvres. A little practice enables one to give as near an estimate of the needle's real depth as any surgeon could require, and such suggestions as 'just beneath the skin of the palm,' 'lower and between bones,' 'upper end $\frac{1}{8}$ of an inch between the skin of the back of the hand' are in my experience sufficient for any operator.

"The needle's depth being ascertained, it only remains to find its position in the horizontal planes—a task which represents few difficulties. When found, this position should be marked upon the skin. The advantages of this method are its rapidity of performance, the process taking but a few seconds, and the economy of the material both photographic and electrical.

"For localization in other parts of the body and for photographically recording results I have constructed an instrument which in principle is the same as the method just described, save that the tube is swayed while the part viewed is held in position by bands and tension springs. The tube is moved by the observer from his side of the screen, the distance it travels being regulated by sliding steps. A fine vertical wire is stretched in the centre of, and in contact with, the screen. The image of the foreign body is to correspond with this line from the extreme right to the extreme left; the image of the foreign body on the screen is seen to pass from left to right. Its relative rate of travelling compared with the same portion of bone is noted as before.

"For accurate measurements the true position assumed by the foreign body is marked by a pencil on a celluloid film in contact with the screen. This measurement being secured, the distance the tube travels, and the distance from the midpoint of the line adjoining the two extreme positions of the tube, must be ascertained. A simple rule of three will now give the distance of the object sought from the screen."

For locating foreign bodies in the skull, the wire letters recommended above may also be used by being fastened to a wire head-band wound around the temples. Then the intervals between the individual letters must be measured. The same procedure can be carried out on the extremities by winding the wires around the limb and also fixing them at the plate. This principle may also be utilized on other regions of the body.

It must furthermore be remembered that the size of the foreign bodies varies with their distance from the tube. In the case of oblong bodies great errors as to the exact size may be made if a second exposure in a different projection plane is omitted. Early in the Röntgen era the author was not a little surprised in the case of a seamstress in whose palm a needle fragment had entered in a perpendicular direction. The plate, while indicating the presence of the needle distinctly, created the impression that the fragment was only 2 millimetres long. When extracted, its length was found to be more than an inch. The rays had reached the hand in a perpendicular direction, so that the circumference of the fragment was reproduced rather than the length. A side view, of course, would have cleared up the error at once. In fractures exposures in different projection planes are almost a necessity.

CHAPTER V

EXAMINATION OF THE PATIENT

The Technique of Examination.—For fluoroscopic as well as for skiagraphic examination the area to be studied must be freed from clothing. It is true that a good tube permits irradiating, even through an overcoat, but small details become lost. So the shadow of a button or a buckle may just cover a region of special importance. Dressings are, of course, best removed if structural details are simply wanted, but if the position of the fragments in fractures is to be ascertained, they must not be removed during examination. It is desirable therefore to choose such dressing material which is translucent, like gauze. For fractures the plaster of Paris is the best immobilizing agent, because it permits of a sufficient amount of penetration as to allow recognition of the relations of the fragments. It does not impair the judgment on account of its regularity, while wooden splints may veil important areas. Adhesive plaster, iodoform, and rubber drains cast dense shadows.

Fluoroscopy may be done while the patient stands before the examiner, who is seated in a chair. The head is fluoroscoped best while the patient is seated in a chair. In fluoroscopy of the lower extremities the patient may be seated in a chair placed on a table, so that the soles of his feet rest on the latter. As a rule, tubes of medium hardness are most useful in fluoroscopy.

In order to study any region of the body with leisure, and to observe its structural details, a skiagraphic exposure is necessary. In most instances the patient is skiagraphed best in the recumbent position. This may be done on one of the tables which are provided with a box for receiving the photographic plate (Fig. 37). The patient may also be placed on the carpeted floor. This simple arrangement offers the advantage of a wide operating field around the patient. The extremities can be placed in any position desired, and blocks, sand-bags, large books, etc., may be used to surround and immobilize the area to be skiagraphed. In the case of nervous children there is no fear of their falling from the table.

The tube-holder is placed best between the Ruhmkorff coil and the patient. The wires connecting the secondary terminals of the

FIG. 37.—QUEEN'S EXAMINING TABLE.

Ruhmkorff coil with the tube may be loosely hooked in the terminals.

These must be kept separate in order to avoid shocks. Their calibre should be very small, but they must be surrounded by a thick layer of insulating material.

The anticathode should be connected with the anode, and the anode with the positive electrode of the Ruhmkorff apparatus, while the cathode is to be connected with the negative electrode of the apparatus. The tube-holder must permit the tube to be moved in any position desired. A false direction of the current is indicated by the appearance of a marked shadow originating from the anticathode and the formation of blue light.

The *distance* of the *tube* is also a matter of great importance. Various distances produce various relations. The smaller the distance is between the tube and the plate, the larger the silhouette of the irradiated part appears. On the other hand, the smaller the silhouette is, the more correct the proportions of the tissues appear.

Under ordinary circumstances the tube should be as near the object to be skiagraphed as possible (6 inches), in order to make the exposure short. The effect of irradiation is reduced in proportion to the square of the distance between plate and target. As an average it may be assumed that an equally good skiagraph of the human hand is made when the distance is 6 inches, the exposure lasting half a minute, as when the distance amounts to 12 inches, the exposure lasting a whole minute. It is not possible to set down any definite ratio, because the duration of the exposure is dependent upon the coil as well as upon the kind of the tube, the thickness of the irradiated areas, the distance of the tube, and the nature of the plate.

If a good tube is used in connection with a Wehnelt interrupter, it may be expected that twenty seconds' exposure suffices for the reproduction of an adult's hand. The forearm requires a little less than a minute, and the elbow, the arm, and the foot one to one and a half minutes. The leg, the knee, and the thorax take about two, the skull two to three, and the pelvis about three to four minutes.

Position of Patient.—The position during irradiation is of importance. The nearer the area to be irradiated is to the tube, the clearer and more promptly appears the image. The fact must not be lost sight of, however, that the nearer the tube is, the greater is the danger of burning the patient; but this, as will be seen later, need be considered in repeated exposures only.

The position of the special part to be skiagraphed is also of great importance. It is difficult to lay down any definite rules for this, since each case demands a special perspective. In general, however, the following directions may be adhered to:

The skull is examined either in the recumbent position or while the patient is seated on a chair. An antero-posterior as well as a lateral view are generally necessary. (Fig. 28.)

The neck is best shown in the lateral direction.

The forearm is best seen in supination, although this position is by no means the most comfortable for the patient. In injuries or ankylosis of the elbows special supporting devices must be sought. The olecranon and the external condyle serve as landmarks. The arm and the thigh can be taken in any position. The humero-ulnar joint is best irradiated from the flexor to the extensor side. The hand is usually traversed from the dorsum to the palm.

The foot, from the toes up to the upper third of the metatarsus, is best skiagraphed in the direction of the dorsum towards the sole. This is done while the patient is seated in a chair, the sole of his foot resting on the plate. Farther back the first and third cuneiform bones and the scaphoid present an obstacle, so that it is advisable to irradiate these portions of the foot transversely by having its outer surface resting on the plate. By this procedure the isolated shadows of the astragalus, the calcaneum, the cuboid, the scaphoid, and the fourth and fifth metatarsal bones can be represented. (Fig. 24.)

The knee-joint is reproduced best by resting the external condyle on the plate. The leg should be skiagraphed while its external surface is placed on the skiagraphic plate, the knee being flexed and the thigh rotated outward. The lower margin of the patella serves as a landmark. The hip-joint is preferably taken by turning the patient from his recumbent position inwardly, so that the anterior axis of the thigh forms an angle of from 30 to 40 degrees with the underlying plate. The opposite hip is elevated and supported accordingly.

The area to be skiagraphed must be brought as near the plate as possible. Exposures for special purposes require special appliances. In skiagraphing gall-stones, for instance, pillows must be placed under the clavicles. Thus an elevation is produced permitting the protrusion of the gall-bladder, which is then brought nearer to the plate. The approximation is increased by turning the body slightly to the right and raising and supporting the left side accordingly. (Fig. 74.)

As the patient has to assume the abdominal position, a landmark indicating the position of the gall-bladder must be made either with nitrate of silver or with a special skiagraphic pencil on his back in order to secure the proper focus. In this way it will be possible to direct the rays vertically on the marked area.

Another point of importance is that the rays should traverse the abdomen in a slightly lateral direction, so that the dense tissue of the liver is not permeated in its whole diameter. The focus line may, in other words, form an angle of about 70 degrees with the dorsum. Thus some of the rays reach the calculi before they are absorbed by the compact liver tissue. The disadvantage of oblique irradiation is that biliary calculi appear somewhat larger than their natural size. When a protrusion, palpable in the region of the gall-bladder, indicates an enlarged gall-bladder, direct irradiation should be attempted, the shadow of the liver not obscuring it then. In such cases, however, the diagnosis of cholelithiasis can as a rule be made without skiagraphic examination.

As to other special arrangements, see Chapters VIII and IX on the Thorax, the Abdomen, and the Spinal Column.

Absolute rest is the condition *sine qua non* for a successful exposure. Involuntary movements like those caused by the respiration cannot be avoided. Sometimes respiration may be suspended for half a minute, so that with a short exposure a skiagraph is obtained. Nervous twitchings are combated best if the patient rests as comfortably as possible. The trunk must be supported by heavy pillows and the extremities by sand-bags. The best immobilization, however, is obtained by compressing the irradiated area by the diaphragm. Intelligent mothers generally succeed in lulling their babies to sleep. By manipulating the apparatus with a low current first, and then increasing it gradually, its monotonous noise sometimes acts as a lullaby. Adhesive-plaster strips or gauze bandages are also useful for immobilization. Straps may exceptionally be used. Anæsthesia for the purpose of keeping patients quiet should be resorted to only under the most pressing necessity.

Density of Objects.—The degree of density is, of course, a determining factor for the distinctness of the skiagraph. It is well known that the higher the atomic weight of any element is, the more energetic the absorption of the rays will be. The atomic weight of those elements with which we have mainly to deal in using the Röntgen method is as follows: Hydrogen, 1; carbon, 12; nitrogen, 14; oxygen, 16; fluorine, 19; sodium, 23; magnesium, 24; phosphorus, 31; sulphur, 31; chlorine, 35.5; potassium, 39; calcium, 40; iron, 56.

The inorganic substances of the body, such as salts of lime in the bones, absorb more light than the surrounding soft tissues; consequently they are but slightly permeable by the rays. The more lime salts the bone contains, therefore, the less permeability exists, and the more distinct the shadow will be on the photographic plate. Thus compact bone tissue shows a very much more distinct image than do the medullary or spongy parts. The special structures of the different bones can be recognised so well, in fact, that the finest details of the structure of osseous tissue can be represented. This offers a splendid opportunity for studying the transformation of bone tissue, which was formerly a sealed book.

The organic tissues of the human body show permeability of a medium degree. The degree of translucency of the muscular layer of the heart or of a hand or foot corresponds with that of a liver or kidney of the same thickness. The tissues of the nerves and blood-vessels are somewhat less permeable. This similarity of the degree of transparency explains why in skiagraphs of soft parts no special variety of tissue, such as muscles, tendons, ligaments, nerves, or vessels is individually marked. With very soft tubes, and by carefully developing the skiagraphic plates, however, hyaline cartilage can be distinctly, and tendons and ligaments faintly differentiated. The greater distinctness of some portions is therefore not due to the character of the individual tissue, but to the greater thickness of the irradiated mass.

Since cartilage is permeated by the rays, as a rule, normal joints show enlarged. The epiphyseal lines appear well marked. In children the line of ossification is translucent, and this has often given rise to false interpretation, especially to an incorrect diagnosis of fracture. The infantile vertebræ appear widely separated from each other, thus giving the erroneous impression that there is a pathological hiatus.

It is evident therefore that the nature of the chemical composition of the organic tissues must be well known in order to appreciate the changes brought on by the various stages of development as well as by pathological changes. As to details reference is made to Chapters XIII and XIV.

SECTION II

REGIONARY PART

CHAPTER VI

THE HEAD

Head.—The examination of the head offers great technical difficulties which are not only produced by the peculiar anatomic conditions, but also by the fact that the motions of respiration and of the heart are communicated to it, thus interfering with absolute quiet.

Intracranial representation is especially difficult on account of the diffusion of the rays. With the screen the head can be examined while the patient is seated on a chair. Skiagraphy may be done in the same position, but it is preferable to have the patient on a table. The facial portion of the skull can be clearly outlined, but the larger portion of the cranium is darkened by the shadow of the brain, as well as by that of the opposite cranial wall. To study the relations properly a sagittal and a frontal exposure must be made. If the left side of the head rests on the plate, the irradiation taking place from the right, the soft tissues and the galea aponeurotica are recognised as a light shadow. The soft tissues of the nose, lips, and chin appear conspicuously.

Of the bony parts, the external occipital protuberance, also the orbital, nasal, and sphenoid cavities are easily recognised. In the centre of the temporal bone the light shadow of the external auditory canal is seen. Below the latter the small cavities of the mastoid process may be perceived; the zygoma is also quite distinct. The nasal bones and the superior maxilla showing the quadrangular shadow of the antrum of Highmore, can especially well be represented. (Fig. 28.)

The nasal process, the hard palate, the alveolar process, and its cells and teeth, the inferior maxilla, showing its mental foramen, the protuberance, the external oblique line, the angle with its two processes, can be well demonstrated. With these osseous structures the shadow of the tongue and the velum palati contrast well.

Fig. 38.—Infantile Skull (Fracture of Skeleton)

The motions of the velum palati and of the tongue can be easily studied by the fluoroscope. Schneier has considerably increased our knowledge on the physiology of the phonation by his fluoroscopic studies in this connection.

By placing the patient's face on the plate, and the tube behind it, the margins of the orbit, the frontal and nasal cavities, and the nasal bones seem well outlined.

Tumours of the facial bones are representable, while intracranial growths show under extraordinary circumstances only. If containing calcareous matter they appear marked, of course.

In a girl of two years (Fig. 278) the connection of glioma with the orbital wall as well as the proliferation into the optic foramen could be proved by skiagraphy. Thus the technical difficulties of the operation were illustrated beforehand, which is important in a case the prognosis of which is so extremely grave. As to other cases of osteosarcoma of face, see Chapter XIV on Neoplasms.

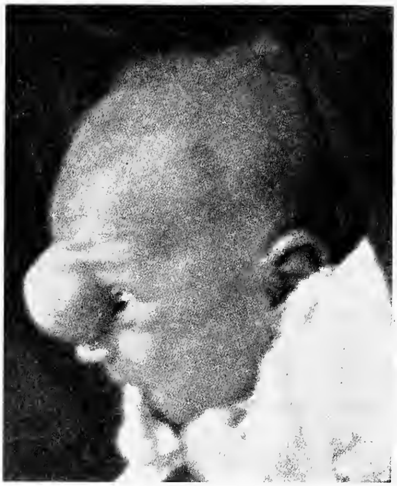

Fig. 39.—Hydromeningocele.

Peculiarities in Infants.—In the infantile skull the details can be represented much better (Fig. 38). Even the interior of the ear (cochlea and semicircular canals) can be shown.

Fig. 143 also shows the internal structures of the skull distinctly. It is the skiagraphic reproduction of the case of rudimentary ear, illustrated by Fig. 142. The question whether there was an auditory canal was settled by the skiagraph in the affirmative.

Fig. 39 represents a boy of five weeks who shows a spherical, non-pulsating tumour, of the size of an orange, projecting from the naso-frontal region, and sinking downward to the alæ nasi. At birth the tumour was a trifle smaller. The walls of the growth were thin, and the integument appeared normal. Contractions of the tumour were observed, especially while the child was crying. During sleep the tumour seemed somewhat smaller. There was exquisite fluctuation, and the contents could be pressed almost entirely into the skull, which did not cause any reaction. Pulsation of the brain could not be detected, nor could the border of the cranial opening be felt distinctly. In view of these facts, especially of the inability to palpate a solid mass with certainty, a meningocele was suggested.

The Röntgen rays, however, modified the diagnosis. The skia-

FIG. 40.—NASOFRONTAL HYDROMENINGOCELE.

graph, Fig. 40, showed behind the light shade, representing the fluid, a dark one, which had to be interpreted as a solid mass, confined to the area of the large triangular bony opening. That this was cerebral substance was verified by the subsequent operation. The skiagraph showed that the nasal bone was shifted downward, so that an interspace of the width of a man's thumb was left between it and the frontal bone. After a constriction of the base of the tumour had been made, for the purpose of ascertaining whether cutting off circulation and pressing upon the contents would produce any reaction, a prophylactic silk suture was conducted around the whole circumference of the tumour at its base, in order to be able to control any excessive hæmorrhage by quickly pulling together the suture ends. An elliptic flap was then dissected from the centre of the tumour and the cavity opened laterally. After about a tablespoonful of normal cerebro-spinal fluid had escaped, further exposure of the sac revealed its lining, which consisted of dura mater partially protecting degenerated cerebral substance. Near the base, according to the darker shadow of the skiagraph, cerebral substance, covered by dark-red, velvety, succulent, and easily bleeding tissue, protruded. After severing the protruding portion from its lateral connections, which were thinly spread over the walls, it was possible to reduce it into the cranial cavity. Two-thirds of the sac were now removed, and the remaining stump was freed from the frontal bone, including the periosteum, until apposition without tension could be obtained. The edges were then united with thin catgut, and supported by another row consisting of overlapping soft tissues; finally, the skin edges were united with stout iodoform silk. At present, three years after the operation, the child appears to be normal in every respect. A comparison with the skiagraph (Fig. 41), taken a year after operation, shows that the bony canal became considerably smaller.

Union having taken place by first intention, the operation was performed without administering an anæsthetic. Although the loss of blood was scant, the author's method of prophylactic suture being used, there was considerable shock, lasting until an hour and a half after the operation. The most predominant symptom was the slow respiration and the anæmia. The infant refused nursing until two hours afterward. No stimulants were administered.

As far as the author's knowledge goes, a bony diastasis of the extent shown by Fig. 39 was never represented before the Röntgen era.

Foreign Bodies in the Eyeball.—To *locate foreign bodies* in the eyeball, the exposure is best made in the oblique direction (Dahlfeld and Pohrt succeeded even in skiagraphing bird-shots of the size of 1 to 4 millimetres), so that the foreign body appears either in front of or behind the orbital margin. The localization

FIG. 41.—CASE OF HYDROMENINGOCELE, ILLUSTRATED BY FIGS. 39 AND 40, ONE YEAR AFTER OPERATION.

of foreign bodies in the skull sometimes encounters considerable difficulties. If foreign bodies are situated in the bones, two skiagraphs, at least, are required—one to be taken anteriorly or posteriorly, and the other laterally. By simply crossing their diameters diagonally the distance from the outer surface can be determined. The same principles of localization, more or less modified, apply to the intracranial localization of foreign bodies.

For localization of foreign bodies in the eyeball it is advisable to place miniature letters at the inner and outer end of the eyelid and one at the orbital margin.

Extraction of Foreign Bodies from the Skull.—In extracting foreign bodies it has been found quite helpful to measure the distance of the foreign body from the nearest bone prominence in both skiagraphs; also to compare the skiagraph with the features of a normal skull. In the case illustrated by Fig. 42 a bullet had entered the right temporal region, and, by passing the orbit transversely, caused traumatic enophthalmos (injury of the sympathetic roots of the ciliary ganglion). The optic nerve was pierced, and considerable hæmorrhage of the chorioid and retina had taken place. Neither the comminution of the orbit nor any injury within the extent of the left antrum Highmori, through which the bullet had taken its course, could be demonstrated by the rays, but the bullet itself was located in the left pterygoid process. The distances were first measured during the operation simply with a graded probe; the distance between the nasal bone and the bullet being taken at the frontal skiagraph (Fig. 43), which determined the direction and the extent of the skin incision, and then the same distance being taken from the lateral skiagraph (Fig. 42), which determined the depth of the incision. Although the bullet was embedded in the bone and surrounded by new bone-tissue, it was not difficult to detect and extract it after the antrum of Highmore had been exposed by osteoplastic resection of its anterior wall. Without the aid of the rays it would have been impossible to trace the bullet. In fact, it was remarkable that it had taken so long and destructive a course without causing any other symptoms than a dull continuous pain all over the skull. The bullet was so compressed that it had changed its longitudinal form into a flat disk, which explains the peculiar shape of the bullet in the skiagraph.

Fractures of the Facial Bones.—In fractures of the facial bones skiagraphy is of great value. In one instance it was possible by skiagraphy to illustrate the depression of the outer and the protrusion of the inner table in the case of a man of twenty-five years who had sustained a transverse fracture of the frontal bone when a child. As the patient suffered from epileptiform attacks after the injury, which was originally taken only for a superficial lesion, osteoplastic resection was performed fifteen years later. The position found at the operation verified the correct-

FIG. 42.—BULLET IN THE SKULL (LATERAL VIEW). (Compare Fig. 43.)

ness of the skiagraph. The attacks have stopped since (the time of observation being four years after the operation).

Fractures of the nasal bones, the alveolar process, and the zygoma can be represented by the rays. Skiagraphy of the base

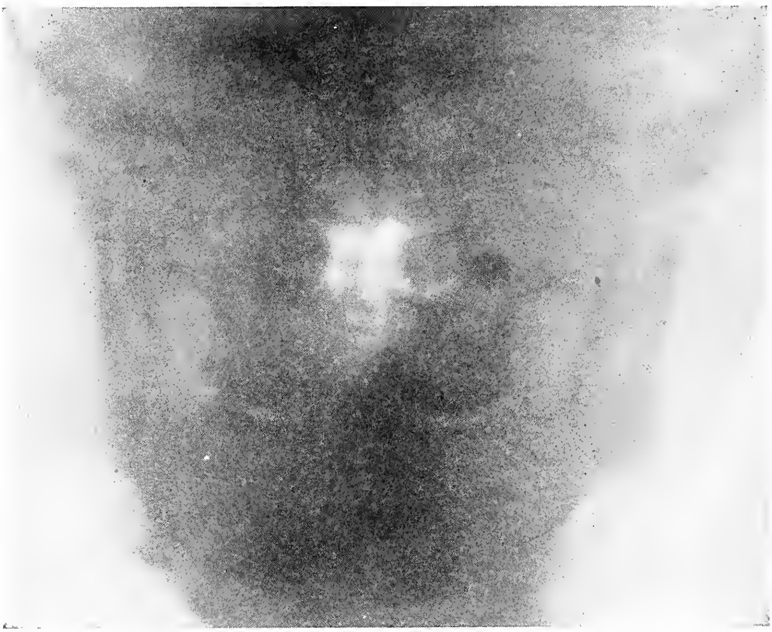

Fig. 43.—Bullet in Skull (Front View). (Compare Fig. 42.)

of the skull can be relied on only under very favourable circumstances. Fracture of the inferior maxilla can also be skiagraphed. After the fragments are wired it is of value to keep them under control by frequent Röntgen examinations. They often reveal slight displacement, which would have escaped ordinary inspection. At an early stage simple pressure by the surgeon's finger permits of the reposition of a projecting fragment.

Fig. 44 shows a transverse fracture of the inferior maxilla in a lad of nineteen years wired. The fragments being in perfect apposition it was self-understood from the beginning that the result had to be perfect. The same illustration shows the hyoid bone rather distinctly.

Fig. 45 illustrates a case of fracture of the inferior maxilla in a boy of eight years. The skiagraph proved perfect apposition of the fragments, so that simple immobilization by a plaster-of-Paris dressing could be resorted to. It may be noted that this illustration shows the epiglottis as well as the outlines of larynx and upper trachea distinctly.

Value in Rhinology.—The Röntgen rays have furnished valuable contributions to our knowledge of rhinology. The frequent presence of foreign bodies in the nose gives many opportunities for their use. The examination of the frontal sinus is of still

FIG. 44.—FRACTURE OF INFERIOR MAXILLA WIRED. (Also note hyoid bone.)

greater importance. The absence of nasal bones and of the hard palate can be well studied (see Figs. 29, 142, and 43). In suppuration of the antrum of Highmore the skiagraph determines the affected side, which shows a much darker shade than the normal.

Growths of the Inferior Maxilla.—The nature as well as the extent of a growth of the inferior maxilla can often be ascertained by the rays. In the case of a man of seventy years, for instance, a carcinoma had originated in the soft palate. Later on the submaxillary region became swollen, the joint finally participating.

FIG. 45.—FRACTURE OF THE INFERIOR MAXILLA REDUCED. (Note outlines of the upper trachea and the epiglottis.)

The question now arose whether the swelling was the expression of the expansion over the maxillary bones, which would give the case an entirely hopeless aspect. But the skiagraph revealed integrity of the bones so that an operation would be advised. After the oral cavity was thoroughly disinfected, the hard swelling disappeared nearly entirely. It had consisted of a number of enlarged glands, which were infected by the decomposed ulcerating surface of the palate. Thus the clinical course proved to be in harmony with the skiagraphic representation.

VALUE IN DENTISTRY

The great importance of skiagraphy in dentistry becomes more and more evident. It is to be deplored that the dentists do not recognise this fact in general. The relation of the dental roots and their position, the presence or absence of the milk-teeth, as well as of the permanent teeth in children, or of an old root, or foreign bodies (fillings, pieces of chisel broken off, for instance, while excavating a carious tooth), the depth of root-filling, the proportion of the antrum of Highmore, and the extent of an alveolar abscess can be clearly demonstrated.

Fig. 46.—Protruding Filling in Tooth.

Fig. 46 shows a tooth whose filling had caused alveolar periostitis followed by the formation of a fistula. This resisted surgical treatment (removal of mandibular portion, repeated scraping, etc.) for several years.

The rays discovered that in filling the molar excavation was overdone, so that the filling material was forced through the root into the inferior maxilla, thus causing ostitis. This knowledge suggested extraction, which cured the fistula promptly.

The presence of molars, which on account of their deformed position produce a painful teething process, can be recognised. Their extraction will relieve the suffering which might have been mistaken for neuralgia.

Disturbances during the period of development are extremely frequent. The question whether there is retention only or complete absence is easily settled by skiagraphy. The position as well as the size and relations of the teeth can be so well ascertained that the dentist will be able to judge whether operative interference is indicated or not. Figs. 47 and 48 show malposition of unerupted teeth in young girls. In Fig. 47 an incisor is situated transversely in the superior maxilla. The exact diagnosis, possible by the rays only, enabled the dentist to place it into a proper position. In Fig. 48 the seat of the malposition is in the inferior maxilla.

Sometimes it is of great forensic importance to determine the age of an infantile corpse by skiagraphing the teeth.

As a rule, it will suffice to place the face portion nearest the tooth in question on an ordinary Röntgen plate. If fine details

FIG. 47.—INCISOR, SITUATED TRANSVERSELY IN THE SUPERIOR MAXILLA OF A GIRL OF FIFTEEN YEARS.

are demanded, flexible films may be introduced into the oral cavity, where they will adapt themselves to the contours of the maxilla. Special metal film-holders must be used for that purpose.

Such holders can be placed on the teeth, the patient being able then to close his mouth.

Cartridges of $1\frac{1}{2}$-inch film, generally used for the Brownie camera, may be used for short exposures.

Especially the anterior upper and lower incisors, the upper and lower canines, the premolars and the first molars of the superior as well as of the inferior maxilla can be well represented by the intraoral method. The upper and lower posterior molars have to be skiagraphed from the outside.

Whenever a longer exposure is required the film is best inclosed

FIG. 48.—TRANSVERSE TOOTH IN THE MANDIBLE.

in unvulcanized rubber, after being envelopd in tissue paper. Thus adherence of the rubber to the film is prevented.

The film must be placed in such a manner that it faces the Röntgen tube, the rays reaching it in a perpendicular direction. In skiagraphing the front teeth the face is directed upward and the chin drawn toward the sternum in order to obtain a correct perspective. The distance of the film from the tubal wall should not be less than 6 inches.

As to differentiation, it must be borne in mind that diseases of the maxillæ are often mistaken for dental affections. Caries and necrosis, producing sequestra, are sometimes treated for simple toothache, the clinical symptoms sometimes being veiled. In such cases the rays not only give the correct information, but also furnish the guide for the proper surgical therapy. Fistulæ and cysts have to be considered from the same points of view.

In a case of severe neuralgia the question arose whether an old root was the cause of the evil. The skiagraph showed that the small screw of the adjacent artificial tooth had been attached in a wrong direction. After it was unscrewed the pain ceased.

The presence of a gumma also puzzles the dentist, the question whether the swelling be due to syphilis or to an old dental root not being solved except the rays come to his rescue. (See Chapter XIII on Diseases of the Bones and Joints.) The fact should not be lost sight of that old roots undergo atrophy in the course of time, so that they appear small and thin. This explains why they may be overlooked in a mediocre skiagraph.

CHAPTER VII

NECK

The neck may be fluoroscoped as well as skiagraphed while the patient is seated on a chair, but for skiagraphy it is better to have the patient reclining on a table or the floor, a small pillow supporting the head. The best exposures of the upper cervical vertebræ are made by turning the patient sidewise. In this position the cervical vertebræ are better shown, the angle of the maxilla not overshadowing their upper portion. The dark shade of the hyoid bone, as well as the lighter shadow of the larynx, the epiglottis, and the trachea are well represented (see Figs. 44 and 45). The œsophagus, while not conspicuous, can be made out behind the trachea as a hollow space. The bodies, the spinous, and the transverse processes, as well as the intervertebral foramina, appear very conspicuous. For the lower cervical vertebræ the recumbent position may be chosen, the patient's occiput reclining and his chin being elevated. Fixation is done best by surrounding the head and neck with sand-bags. The atlas shows its characteristic outlines very distinctly, while the epistropheus is recognised by its bifurcated spinous process.

Aneurysm of the carotid and the subclavian arteries is demonstrable. Tumours of the larynx, especially chondroma and ossification, goître and concretions in the submaxillary gland are easily recognised.

Exploratory incision for suspected foreign bodies in the pharynx, tonsils, larynx, trachea, and œsophagus have become unnecessary. The rays as explorers have indeed realized the old ideal desideratum: *Cito, tuto et jucunde.* Whoever has felt the uncertainty in diagnosticating foreign bodies in these regions, and especially who has been tempted to resort to adventurous procedures, must keenly feel the blessings which the rays have brought. If the Röntgen rays had done nothing else but locate foreign bodies in the throat, they would represent one of the greatest blessings to suffering humanity. Metallic bodies, such as needles, coins, or bone-fragments and buttons are easily recognised by fluoroscopy, and may be extracted through a tracheotomy-wound under the guidance of the bronchoscope. Artificial teeth usually show also well, while shells of a nut or a splinter of wood are demonstrable under favourable circumstances only.

Foreign Bodies in the Œsophagus.—As illustration of the removal of a coin the following case may be mentioned: A baby of one year old had swallowed a penny nine days before the author saw it. When examined first it was decided that the foreign body had passed the œsophagus. The mother watched the fæces of the patient carefully, but did not find the penny. In the meanwhile the baby became feverish and vomited frequently. When the child was first seen it gave the impression that a grave disease was present. Instead of introducing an œsophageal probe, as was done in former years in such cases, the fluoroscope was used, which located the penny at once on a level with the second rib. A coin catcher was then introduced. After having passed the isthmus a resistance was felt; the instrument was then pushed forward, turned, and withdrawn until considerable resistance was encountered, when the steel attachment of the coin catcher broke, so that coin and catcher were both in the œsophagus. After many unsuccessful efforts, the broken fragment of the coin catcher was extracted (with an œsophageal forceps). The coin was now propelled into the stomach with a whalebone pusher. No sooner was this accomplished than the child vomited and the penny was ejected.

Fig. 49 shows the skiagraph of a child of two years who swallowed a 5-cent piece six days before Röntgen examination was resorted to, the child not having shown any grave symptoms during the first few days. On the fifth day respiratory disturbances were noted. When the writer saw the child six days after the accident he could locate the coin at the level of the first rib.

Extensive bronchopneumonia had supervened in the meanwhile. The frequent respiratory movements made it very difficult to obtain a good skiagraph. In spite of the great restlessness of the patient an exposure of fifteen seconds sufficed to produce a distinct representation of the coin. The plate also shows the ramifications of the bronchi.

The extraction of the coin was done too late and the child succumbed to pneumonia. This is the regular course of such cases if their nature is recognised too late. Nowadays there is no excuse for such procrastination.

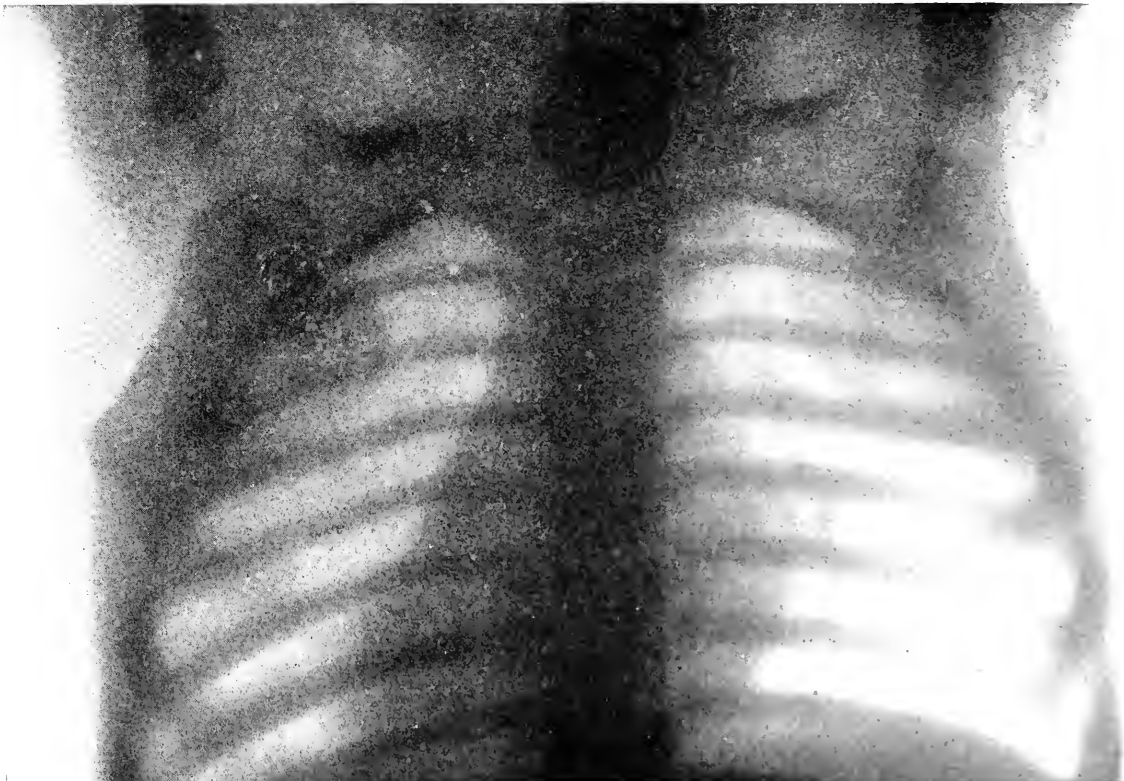

Fig. 49.—A Five-cent Piece in the Œsophagus.

Another remarkable case is that of a girl of fifteen years, who, on the evening previous to the examination, had held a needle between her teeth, which, when frightened by a sudden noise, she swallowed. Medical care was summoned at once. The distinct pain, located at the region of the first and second dorsal vertebræ, was attributed to the injury, which had presumably been caused by the needle passing the œsophagus. The pain becoming more intense during the night, the patient was brought to the hospital, where, after being under anæsthesia, she was advised that the needle was in the stomach and would soon pass per *vias naturales.*

Later, when the neck was examined with the fluoroscope, the needle was found at a level with the first rib. By introducing the finger into the œsophagus, the needle could be distinctly felt at this region, and was successfully dislodged, so that it was possible to extract it with an œsophageal forceps. Without the fluoroscope it would not have been possible to progress with such absolute certainty.

If the fluoroscopic examination had not been successful, the thorax and abdomen should have been skiagraphed and the foreign body would probably have been located somewhere in the œsophagus or the stomach.

Gocht reported the case of a patient who had been submitted to repeated operative procedures on account of severe pain in one of his tonsils without obtaining any relief. The Röntgen rays revealed a needle fragment deeply embedded in the tonsillar tissue, where, of course, it had been inaccessible to palpation.

Fractures of Hyoid Bone, Larynx, and Vertebræ.—Two years ago (New York German Medical Society) the writer reported the case of a woman of twenty-one years, who, in falling downstairs during an epileptic fit, sustained a fracture of the right transverse processes of the first, second, and third cervical vertebræ. That there was a fracture within the cervical vertebræ was at once recognised by the family physician, but its localization, and especially the fact that only the transverse process was concerned, could be verified only by means of the Röntgen rays.

Reduction was accomplished under the guidance of the Röntgen rays. One of the vertebral fragments was felt as a protruding mass from the posterior pharyngeal wall and was pushed backward. The after-treatment consisted in the application of Glisson's cradle. Recovery was perfect after nine weeks.

Goitre.—The various types of goître, viz., the colloid, cystic, and parenchymatous, show different anatomic conditions. The colloid type shows a few coarse non-fluctuating nodules while the cystic is globular in shape and distinctly fluctuating. The parenchymatous type is distinguished by its regular coarse-grained structure.

Sclerotic and hyaline degeneration of the connective tissue leads to calcareous deposits in the course of time. Thus areas of fibrous as well as myxomatous goître may become petrified. Single cysts may also become calcified. The clinical diagnosis of conditions of this kind is based upon the resistance of the tissues, while the vascular types are recognised by the pulsation, the bruit, and the compressibility.

Fig. 50.—Goître containing Calcareous Matter.

There is a variety of goître, however, the type of which can be recognised neither by inspection nor by palpation or the laryngoscope. This is deplorable, because the mode of therapy is influenced by the detailed diagnosis. Sometimes a puncture may show the degree of density of the tissues. If the needle comes into contact with calcareous deposit grating is perceived. Then, of course, the diagnosis is easy.

But differentiation by the Röntgen rays is much simpler. In the frequent cystic or fibrous varieties the calcareous deposits can be well demonstrated by skiagraphy. (See Allgemeines über den Kropf und seine Behandlung. New Yorker Medicinische Monatsschrift, October, 1900.) Whenever the calcereous deposits were found the injection of iodoform-ether, which gives splendid results in the follicular and colloid types, was not tried. Extirpation was resorted to then, provided there was enough disturbance to justify such radical steps.

Fig. 50 (compare Fortschritte auf dem Gebiete der Röntgenstrahlen, Hamburg, Bd. iv) represents the case of a woman of thirty-two years who suffered from a goître of the size of a man's fist. Iodoform-ether injections were tried without success, the reason of which was explained by the presence of two well-marked calcareous foci in the skiagraph (Fig. 51). This showed the character of the growth to be a cystic goître associated with calcareous deposits. In such cases the injection treatment always fails,

FIG. 51.—SKIAGRAPH OF CALCAREOUS DEPOSITS IN GOÎTRE, ILLUSTRATED BY FIG. 50.

therefore extirpation has to be resorted to, provided the disturbance justifies so severe a procedure.

In retrosternal goîtres it can be ascertained by skiagraphy how far they extend to the mediastinum.

Tuberculous glands are faintly shown if they are thick and contain cheesy deposits. Calcareous degeneration, of course, can be distinctly represented.

Never before was the inadequacy of our radical endeavours more clearly illustrated to me than by skiagraph Fig. 52, which represents the case of a woman of twenty-eight years, whose tuberculous glands were repeatedly removed from her neck during the last nine years. The last recurrence showed a number of fairly large and coherent glands, the capsules of which adhered among themselves. Their contents consisted in cheesy pus mixed with calcareous masses. In view of the history, it was natural that the most thorough removal of suspicious tissue was contemplated. In order to gain access to a large area the sterno-cleido-mastoid muscle was divided transversely. Now the superficial glandular chains could be easily removed, but in the deeper strata it appeared difficult to reach the many small glandular globules. Still the author, after having extirpated every suspicious globular element between the interstices, felt contented that he had at least removed all calcareous glands. He could well appreciate that a few of the small soft recent glands could escape palpation, but he did not assume that the hard calcareous masses could not be felt. Still the monumental impoliteness of the rays showed shortly afterward that no

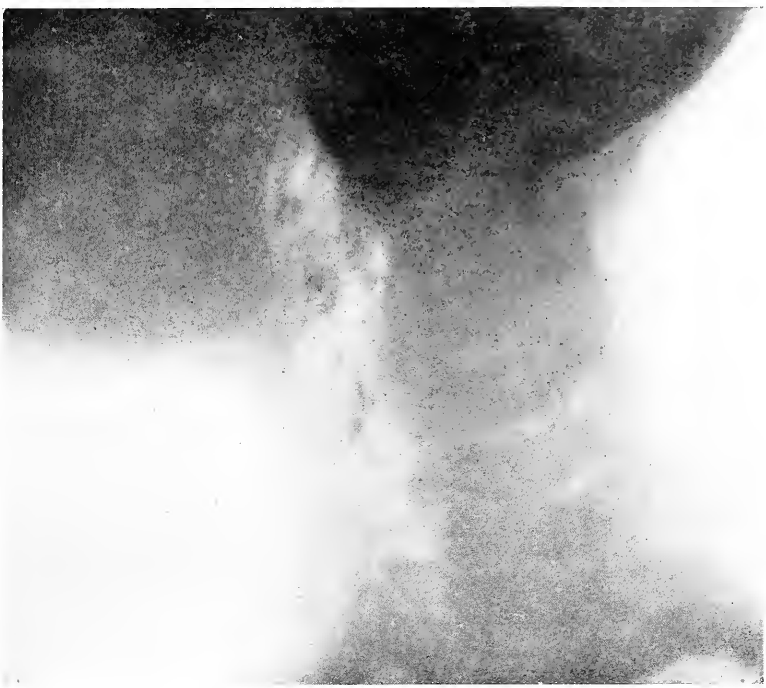

Fig. 52.—Tuberculous Glands of Neck.

less than thirty small calcareous glands were left. The importance of a demonstration of this kind is evident, and suggests repeated operative steps. It shows at the same time how important constitutional post-operative treatment is in such cases.

CHAPTER VIII

CHEST

As emphasized in the General Part, the screen displays its main virtues in the diagnosis of the diseases of the chest, since it permits of the observation of organs while they are in continuous motion. The number, rhythm, and shape of the various motions can be distinctly studied.

The chest may be fluoroscoped while the patient is standing or seated on a chair provided with a low back. As to the peculiarities of other positions, reference is made to the general part on fluoroscopy. As a rule, soft tubes should be used for thoracic examination, the harder variety being preferred for the representation of dense foreign bodies only. The dorsal vertebræ, the ribs, the clavicle, their injuries, diseases, and malformations (supernumerary ribs) can be well seen. The heart, the lungs, the pleura, and the diaphragm can be studied thoroughly. Foreign bodies in the thoracic cavity are easily recognised, and most diseases of the thoracic cavity, so, for instance, enlargement or displacement of the heart and effusion in the pericardium, as well as aneurysm and the various kinds of mediastinal tumours can be studied.

Pneumonic solidification, phthisical foci, cavities, abscesses, tumours, bronchiectasis, emphysema, and retractions of the lungs can be recognised by fluoroscopy as well as by skiagraphy. Effusions in the pleural cavity, also fibrous swards of the pleura and irregularities of the excursions of the diaphragm are noted.

For skiagraphing the patient an even table of strong construction or the carpeted floor is selected. Posterior irradiation is done in the dorsal position, the spinal column, as well as the posterior portions of the ribs with their heads, necks, and tubercles becoming apparent, especially at their right side. The direction of the posterior ribs is downward, while that of the anterior is upward. The image of the anterior aspect of the ribs is naturally diffused on account of the much greater distance from the plate. Soft tubes show the ribs best, the time of exposure not to exceed three minutes.

In skiagraphing anteriorly by posterior irradiation, the patient lying on his abdomen, the clavicle, the sternum, and the adjoining ribs can be well defined. The distinctness of the skiagraph suffers,

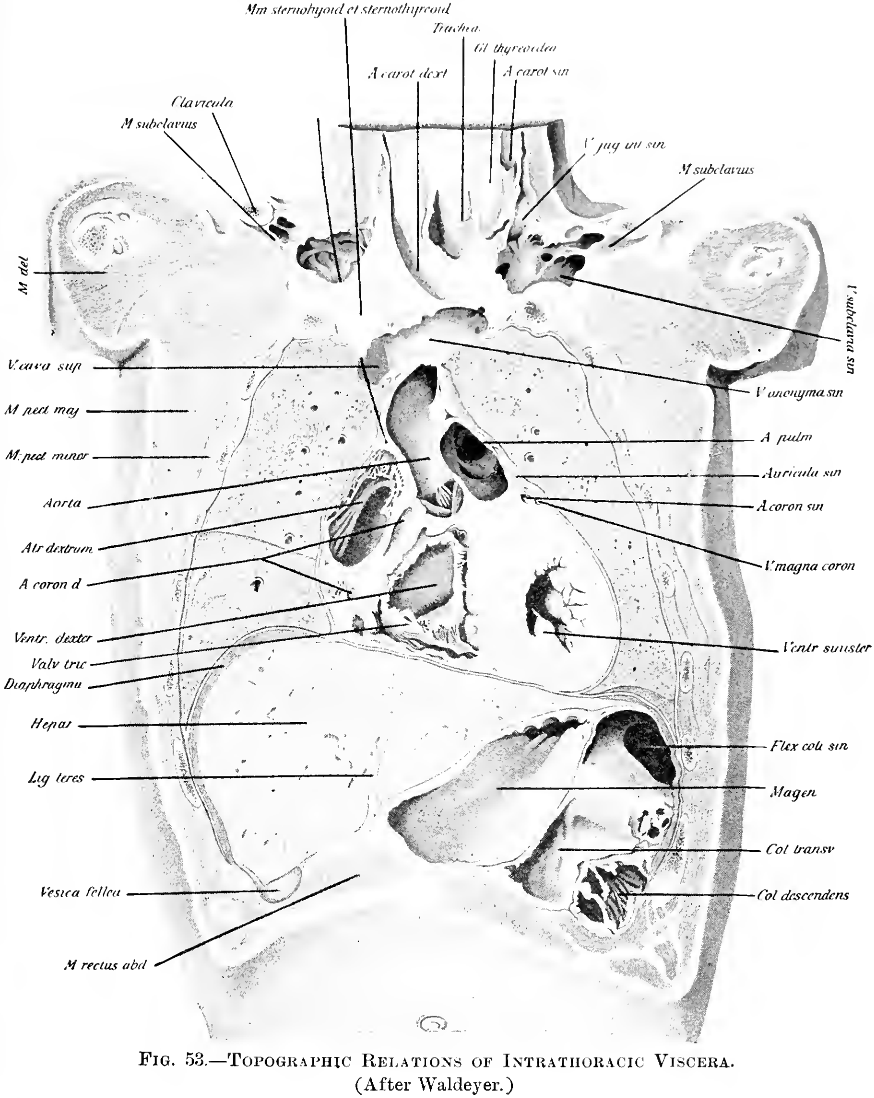

FIG. 53.—TOPOGRAPHIC RELATIONS OF INTRATHORACIC VISCERA. (After Waldeyer.)

however, on account of the patient's oppressed respiration. On account of the distance the spinal column and the posterior ribs appear diffused. The heart being situated so near the anterior chest wall, shows its outline well marked. The shadow of the large blood-vessels is less distinct. The shadows of the normal lungs, especially the middle portions, are extremely light.

The upper dorsal vertebræ, as far as they are not obstructed by the shadows of the heart and the large vessels, show fairly well. The same applies to the three left dorsal vertebræ. The other portions of the spinal column appear indistinct within their extent of the thorax. Abscesses can sometimes be recognised in this region by using the diaphragm. The outlines appear more marked in oblique projection, but there the skiagraph becomes considerably distorted.

The *sternum* is best represented by a short exposure. For this purpose a hard tube must be chosen, the patient being requested to hold his breath for half a minute. The sterno-clavicular junction, tumours, capillary gummata, are frequently noted. For comparison the normal anatomic relations of the thorax should always be kept in mind (Figs. 53 and 123.)

In regard to the study of the diseases of the lungs it may be maintained that whoever does not master the principles of auscultation and percussion is not fit to comprehend the fluoroscopic or skiagraphic signs. There are conditions in these organs that can be better elicited by the so-called physical methods, and others that can be ascertained only by means of the Röntgen rays. While the rays show small tumours or infiltrated foci which, on account of their central location, cannot be diagnosed by the old physical methods, they have the disadvantage of always showing the thoracic image *in toto*—that is, they represent all the shadows of the tissue situated before as well as behind the diseased area at the same time.

At the early stage of tuberculosis of the lungs valuable information can be derived from irradiation. Williams found the diaphragm abnormally high at the affected side in incipient tuberculosis on fluoroscopic examination.

Solidification and atelectasis, as well as exudation and calcification, can be well demonstrated. The infiltrated walls of cavities are recognised as more or less distinct shadows surrounding a light area. The true nature of the various shadows is often better understood, if, after previous skiagraphic representation, the thorax is also fluoroscoped in different positions. In that case we see the area which causes bronchial breathing, so to say, instead of auscultating it. Fig. 54 represents extensive tuberculous foci in the right lung of a woman of thirty-five years.

The large number of the foci and their partial confluence point to an advanced stage. Clinical observation corroborates this assumption. The sharply outlined obscure foci are of an older date, while the light shadows surrounded by foggy contours indicate recent destruction.

Localization of abscess, echinococcus, and gangrene of the lungs by the screen must be done in various positions. The tissue-defects appear as light shadows, with which the surrounding cavity walls contrast as dark shadows of an irregular circular or elliptic shape. If the shadow shows in the abdominal position as well as it does in the dorsal, it must be centrally located.

In gangrene the gradual clearing up of the formerly solidified area is observed. Similar views apply to echinococcus. (See Echinococcus of the Lungs. Journal of the American Medical Association, November 19, 1898.)

Fig. 55 illustrates the case of a man of thirty-five years, who was stabbed in the back. Little reaction following at the time, an injury of the lungs was not thought of until, three days later, chills, hæmoptysis, and pleuritic symptoms announced the development of pleuropneumonia. Later a purulent effusion was discharged by simple thoracotomy.

The suppuration continuing, a resection of a rib was performed a few months later. The patient improved then, but recovery did not take place. Three years after the injury, when the author examined the patient for the first time, moderate dyspnœa, diminished bronchial breathing and rhonchi were observed. Elastic fibres were also found. The injection of liquids into the fistulous tract produced violent attacks of coughing. A few minutes after the introduction of a strip of iodoform gauze the patient noted a decided taste of iodoform in his mouth. After having gained access to the pleura by the exploratory method (see Exploratives Princip und Technik beim secundaerem Brustschnitt. Archiv für klinische Chirurgie, Esmarch-Festschrift) the margins of the pleural canal showed themselves considerably hypertrophied in some portions. The diameter of some of the swards amounted to an inch. After these fibrous areas were removed, access was gained to a pulmonary cavity of moderate extent. The granulations

Fig. 54.—Tuberculous Foci in the Lung.

which lined it were removed and a loose packing with iodoform gauze used.

A probe introduced into the cavity showed a depth of 16 centimetres. The question of localization could be well studied in this case by introducing a penny, enveloped in gauze, into the cavity

Fig. 55.—Abscess of Lungs.

and then attaching the lead-letters outside of the thorax (see General Part) by adhesive plaster. Thus the point of convergence of two lines can be constructed.

The skiagraph shows penny and probe and the various shadow tints—viz., the very light centre indicating the abscess cavity and the slightly darker outlines of the upper portion of its wall. The lower margin is overshadowed by the fragment of the eighth rib. At a slight distance from the abscess wall the dark margins of the remainder of the thickened pleura can be recognised.

The surgical treatment of tuberculous cavities does not show many encouraging results. If the rays, however, show a large solitary cavity, exposure and drainage should be attempted, provided other pulmonal areas are but little involved.

PLEURA

Pleuritic effusions show a marked opacity through the fluoroscope. The larger the amount of effusion the greater the degree of opacity. In pyothorax the opacity is somewhat less complete than in serothorax.

Especially on the right side the outlines of the liver show a marked contrast to the lower boundary-line of the effusion. The inner boundary-line of the effusion generally appears convex, but if the patient inspires deeply, or if he coughs violently, it loses its convexity and becomes horizontal. By changing the position of the patient, of course displacements of the effusions are observed accordingly. Uniform transparency above the effusion points to the result of a simple inflammatory process, while constant opacities of an irregular appearance justify a suspicion of a beginning tuberculosis.

As a rule, it is found that the area of dulness corresponds to the area of shadow.

Pyothorax.—The diseased tissues in pyothorax show a greater density than those of the lungs. The diaphragm appears to be depressed.

The extent of a pyothoracic cavity may be estimated by filling it with iodoform glycerin or with a solution of iodide of potassium. Water will also produce a shadow. The subnitrate of bismuth, which is not permeable by the rays, furnishes a still more marked contrast; but as it interferes with the treatment, its use cannot be recommended for this especial purpose. The screen also shows the degree of expansibility of the compressed lung. The rays prove that, after subperiosteal, sometimes even after total resection of a rib, the exsected portion is more or less reformed.

Fig. 56 illustrates the case of a boy of nine years in whom recovery from pyothorax of three years' standing was obtained after resection of the fifth, sixth, seventh, and eighth ribs and a portion

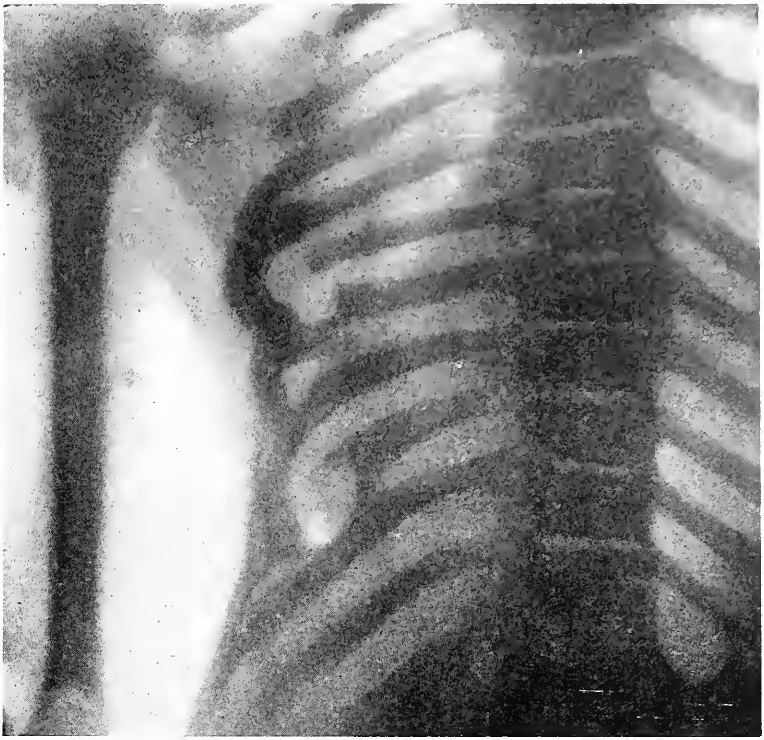

Fig. 56.—Fifth, Sixth, Seventh, and Eighth Ribs, Three Weeks after Resection for Old Pyothorax.

of the scapula. The bone proliferations could be demonstrated as early as three weeks after resection.

Hydropneumothorax shows the very dark outlines of the exudation in contrast to the light shadow of that intrathoracic area which contains air. The dark boundary-line of the exudation can be recognised by the screen as an ascending and descending line during the respiratory movements.

HEART

The patient may be examined in the sitting as well as in the recumbent posture. The tube should be as near to the thorax as possible, but it must not be overlooked that the size of the shadow of the heart is exaggerated. For proper interpretation the distance of the tube must therefore be noted, especially if tracing is done for later comparison.

The importance of recognising an enlargement of the heart is evident. Our physical methods are so highly developed that the diagnosis of an enlargement will seldom be difficult. In some instances, however, comparison can be made with a higher degree of mathematical exactness by the Röntgen method than percussion would permit. So, for instance, Schott (Nauheim) could demonstrate that the hearts of bicyclists were temporarily enlarged after a great exertion.

Our knowledge of the effects of valvular lesions, of fatty degeneration, aneurysm, sclerosis, pericardial adhesions, etc., became very much increased by fluoroscopic examination.

Fig. 57, for instance, shows the hypertrophied heart of a girl of eleven years after an attack of rheumatic endocarditis.

The movements of the heart can be thoroughly studied, its regular contractions especially being easily observed. For exact measuring, the various stages of respiratory movements must be carefully noted, so that no errors occur when comparison is made with later results. The pulsations are most marked during the stage of expiration. The observations of Williams and Benedikt proved that some physiological errors in regard to the mode of contraction of the heart existed. That the heart does not empty itself completely at each systole becomes evident by the presence of a large blood-shadow. Thus we learn that the contractions of the heart are not of the extent assumed heretofore. In proportion to the amount of blood filling the ventricles the shadow of the apex appears lighter or darker.

During deep inspirations it can be observed that the diaphragm becomes distant from the heart, which proves that the heart is suspended by its blood-vessels and is not supported by the diaphragm. Full inspiration shows the lungs more translucent, so that their shadow appears in greater contrast to the dark outlines of the heart.

The importance of ascertaining the accurate size of the heart by skiagraphy should not be underestimated. For this end at least two skiagraphs, under different projection planes, should be made. The principles of localization should be well observed (see

FIG. 57—HYPERTROPHY OF LEFT VENTRICLE AFTER RHEUMATIC ENDOCARDITIS.

General Part). For dextrocardia, see description of case of left-sided cholecystostomy (p. 112).

Pericarditis is sometimes caused by a fracture or rib-fragment which has pierced the pericardium.

A trauma of this kind may be elicited by the Röntgen rays. If the clinical symptoms are slight, the rays showing no displaced splinters, expectant treatment is entirely justifiable. Even if a bullet, after having fractured a rib, has entered the pericardium, there may be no need of surgical interference, providing no severe symptoms are present.

In a man who was shot, eight years before his death, into the supraclavicular fossa from above, the bullet could be located at the apex of the heart. The patient had never suffered from any symptoms pointing to the presence of the bullet. At the autopsy, performed at the St. Mark's Hospital, the bullet was found embedded in fibrous tissue in the pericardium.

The evidence of a large bone-splinter pointing towards the pericardium is an urgent indication for exposing the pericardial sac after the resection of the left fourth, fifth, and sixth ribs. These need not be resected in their totality, but may be folded up at their sternal junctions like a bone flap of the skull. The diagnosis of pericardial adhesions may also be verified by the fluorocopic screen, which would show limited expansion.

Sclerosis of the Arteries.—The diagnosis of arteriosclerosis, while very easy on the surface of the body, was very difficult in the deeper tissues. According to the text-books on internal medicine, the thickening of the tunica intima cannot be recognised if it be confined to a small area or to single small foci. It hardly need be emphasized how important it is to know whether, in a given case of sclerosis of the radial artery, foci in other vessels exist. Neither can the number of these obstructive foci be a matter of indifference, nor whether a large artery, such as the aorta, or only a small one, such as the temporal, is concerned. The presence of a large number of foci means a loss of propelling energy in the circulation, which can be compensated only by the increased working power of the left ventricle. The arterial pressure thus becoming higher, hypertrophy of the overworked ventricle will be the most natural consequence. If such foci are recognised at an early stage, proper prophylaxis can accomplish a great deal in preventing secondary disturbances. The prognostic significance of an exact knowledge of the condition of the arteries is also evident. The Röntgen rays give us a more reliable method of ascertaining this condition of the vessels, and this in nearly every part of the body. So-called intermittent limping is thus sometimes explained by the early recognition of sclerosis of the arteries of the foot.

Sclerosis of the arteries points to lues sometimes. In such cases palpation of the radial artery might reveal nothing abnormal, while skiagraphy of the tibialis antica and postica shows calcareous degeneration.

In a case of sclerosis of both radial arteries (Fig. 58) the forearm, neck, femoral, and aortic regions were studied skiagraphically. Nowhere did the plates show any indications of degeneration of an artery except on the forearm. From the negative state of the other skiagraphs the conclusion was drawn that the patient's arteriosclerosis was confined to the radial and the anterior interosseous arteries—a limitation that harmonized with the good general condition and the absence of palpitation, dyspnœa, and vertigo. As a rule, however, the sclerotic process is first recognised in the region of the foot. Whenever patients between thirty and and sixty years of age, especially if they are addicted to smoking or drinking, complain of "rheumatic pains in the lower extremities," skiagraphic examination is indicated.

Sclerosis and Osseous Degeneration of Veins.—The pathological changes in the veins are similar to those observed in the arteries,

FIG. 58.—ARTERIOSCLEROSIS.

phlebosclerosis (fibrous degeneration of the tunica intima) being nearly as frequent as arteriosclerosis, but as a rule being of a lesser extent. Calcareous deposits in the veins are sometimes reported as vein-stones, or *phleboliths*. But that there is a degeneration of the intima which shows real *osseous* structures seems not to have found any attention. Fig. 59 shows the presence of perfect osseous texture in the saphenous vein, as well as in the beginning of its ramifications, in a lady of fifty-six years. Dr. Ludwig Weiss, of New York City, to whom the author is indebted for observing the case, found that the patient had suffered from varicose veins of both lower extremities for thirty years. There were frequent attacks of thrombophlebitis followed by dilatation

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as well as by cicatrization, the latter causing the signs of phlebitis obliterans on various portions. There was also a large ulcer from which profuse hæmorrhage had taken place several times.

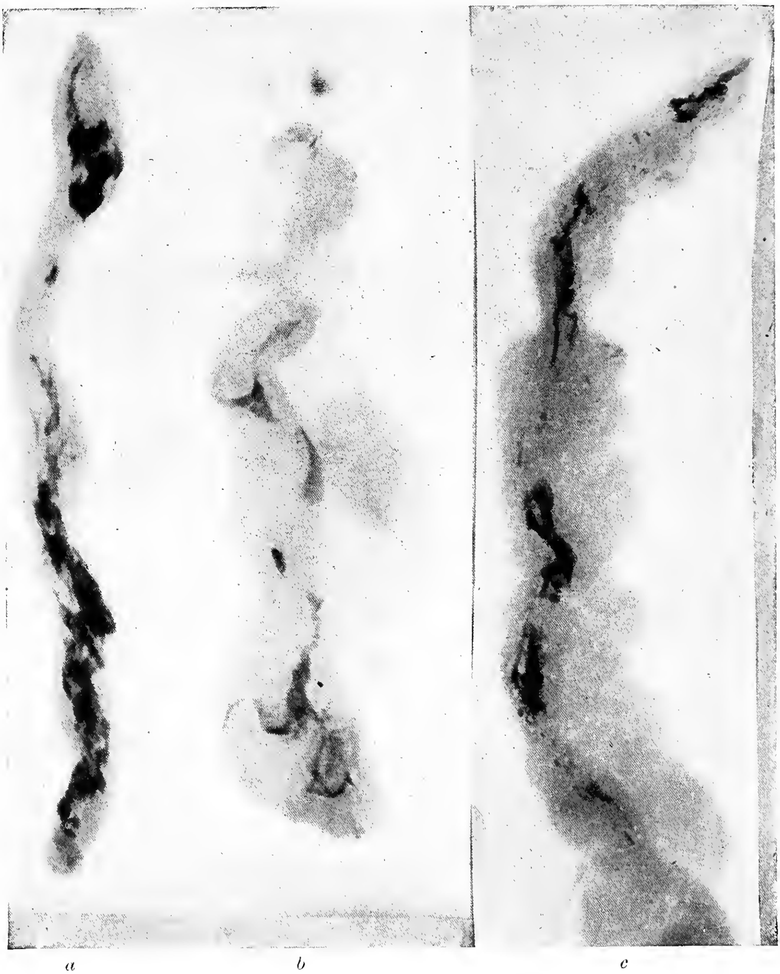

Fig. 59.—Osseous Degeneration of the Saphenous Vein.

a, Internal saphenous vein—late stage; *b*, same—early stage; *c*, small saphenous vein.

The patient suffering continuously from more or less pronounced inflammatory condition, and consequently from œdema and induration, extirpation of the varicous areas was advised. On removing them the author found a number of thrombi in the dilated veins which on some portions resembled aneurysmatic sacs. The hard consistency of the thickened portions induced him to make them the object of skiagraphic exposure. The anatomical information obtained from such skiagraphic examination seems to be of practical value. Whenever the Röntgen rays show the presence of osseous degeneration, it is obvious that the much favored methods of using massage, which is so effective in arteriosclerosis, laced stockings, elastic bandages, injections into the circumvascular tissues, or ignipuncture represent not only futile, but directly dangerous efforts, the only procedure which guarantees recovery being extirpation. If performed under strict aseptic precautions the risks of the operation are practically nil. The diagnosis of the presence of osseous degeneration can not be made by palpation, the indurated areas not appearing different from simple fibrous convolutions. Thus the Röntgen rays are the only means to give anatomical evidence before operation.

FIG. 60.—MYELOSARCOMA OF THORACIC WALL.

Tumour of the Mediastinum.—As to type, shape, and size of any mediastinal tumour much more reliable information can be obtained by skiagraphy than by percussion. In the case of a patient, aged fifty-three years, the symptoms of œsophageal stenosis became apparent, the œsophageal sound stopping at the level of the fifth dorsal vertebra. Signs of cachexia supervening, carcinoma of the œsophagus was thought of, and the question of operative interference arose. The skiagraph showed a mediastinal tumour of the size of a newborn child's head that pressed upon the œsophagus. Therefore an operation was not expected to be of any benefit. The autopsy verified the diagnosis five weeks later.

Tumours of the Thoracic Wall.—In tumours of the chest-wall (fibroma, osteoma, chondroma, osteochondroma, myelosarcoma, osteosarcoma, etc.), the question as to how far the pleura and lungs are involved is of great importance, and may determine whether removal still offers any hope or benefit for the patient. The same may apply to far advanced cases of carcinoma mammæ, which, thanks to the advances of surgery, are rarely seen at the present time.

FIG. 61.—PERFORATING PYOTHORAX RESEMBLING SOLID TUMOUR.

A case of sarcoma in a boy of seven years is illustrated by Fig. 60. The skiagraph indicated that the intrathoracic organs were free. The correctness of the indication was corroborated at the operation. (The microscopical examination, made by Dr. L. Fischer, who kindly referred the patient to the author for operation, showed the tumour to be a myelosarcoma.)

Fig. 61 illustrates the case of perforating pyothorax in a child of three years three months after the onset of the disease. The swelling being of a hard nature and the course being slow, a tumour was suspected first. Of course, the diagnosis could be well made without skiagraphy, still it was interesting to note the integrity of the intrathoracic organs by it.

In the case of carcinoma mammæ, described in Chapter XVIII on Röntgen-Ray Therapy, the beginning metastasis, which was the precursor of pleuritic exudation, was also shown by the Röntgen method. Thus the imminent fatal end was predicted, although the patient still felt well at that time.

Œsophageal Stenosis.—To localize stenosis of the œsophagus a rubber tube containing thin, flexible steel wire in spiral form may be used, the skiagraph demonstrating where the stoppage of the tube occurs. Most patients, however, will not tolerate this otherwise effective procedure. Fig. 62 illustrates the stoppage of a sound at the point of stricture, caused by carcinoma of the œsophagus, in a man of fifty-eight years. Gastrostomy was performed,

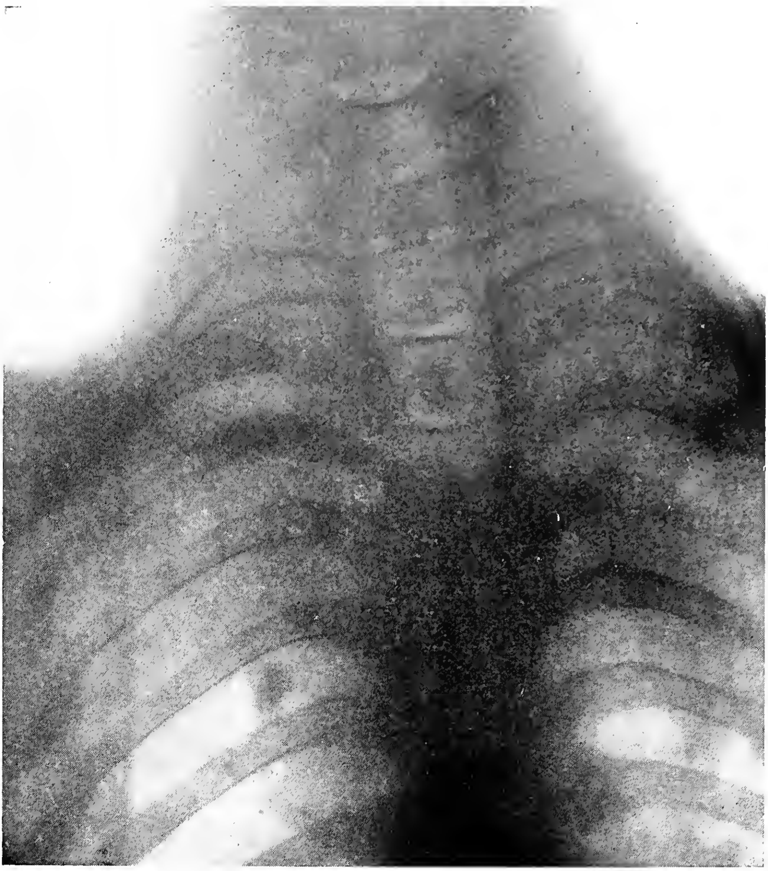

FIG. 62.—ŒSOPHAGEAL STENOSIS CAUSED BY CARCINOMA.

which prolonged the life of the patient for eighteen months. The Röntgen method permits of differentiation between real stenosis, produced by pathological changes in the œsophagus wall, and contractions, such as may be found in hysteria, caused by disturbances of innervation.

For fluoroscopic observation it is advisable to administer an opaque substance, like subnitrate of bismuth in a wafer. The tube is adjusted in front of the patient's right shoulder in such a manner that the chest is irradiated from the right upper anterior aspect towards the left lower posterior. The bismuth (about 15 grains) can be seen during the act of swallowing as a marked shadow that becomes diffused after a few seconds; then a portion of it is detected in the area of stenosis, while the other œsophageal parts show nothing abnormal. In carcinoma the bolus remains at the seat of the stenosis.

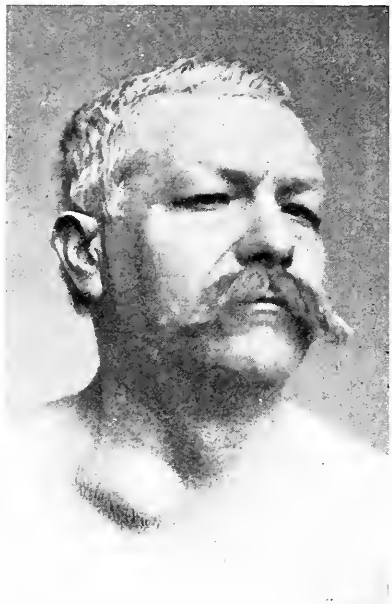

Fig. 63.—Aortic Aneurysm Projecting into the Supraclavicular Space.

Œsophageal diverticula may be recognised by introducing a sound the end of which is provided with a rubber balloon. If the latter is inflated *in situ,* the diverticulum is shown as a light globular mass.

In a patient of sixty-five years asthmatic symptoms were in the foreground. Percussion and auscultation showed dulness of the left side, reaching from the lower border of the third rib to two inches below the arch of the ribs.

There was a slight bruit, but no visible pulsation. Deglutition was slightly interfered with. The patient was thin, but apparently there was no cachexia. The skiagraph showed a tumour occupying nearly the entire left thoracic cavity. The irregular outline, together with the absence of pulsation, pointed to the presence of a solid tumour. The autopsy, made two months later, showed an enormous sarcomatous degeneration of the bronchial glands.

Aneurysm of the Aorta.—Aortic aneurysm can be studied by the screen as well as by skiagraphy. In the case of an Italian

Fig. 64.—Aortic Aneurysm Showing Improvement after the Administration of Iodide of Potassium.

labourer a pulsating tumour was detected at the left intraclavicular fossa (Fig. 63). The diagnosis aneurysm of the subclavian artery had been made and ligation advised. In the meanwhile several skiagraphs were taken that showed the presence of aortic aneurysm, the supraclavicular tumour being only a portion of it. Shortly after iodide of potassium was administered the supraclavicular tumour disappeared entirely. The size of the aneurysm had considerably decreased, as was shown by the skiagraph (Fig. 64). In harmony with the anatomic diagnosis is the excellent condition of the patient, who has now been under observation for three years.

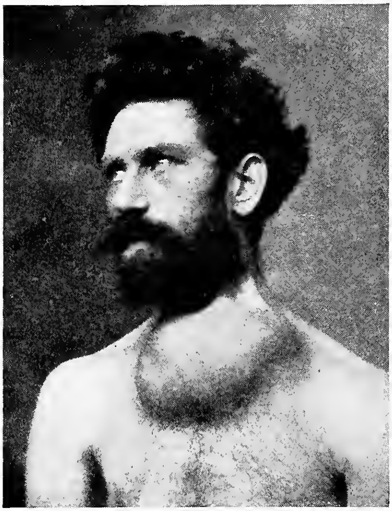

Fig. 65.—Enormous Aortic Aneurysm, Causing Atrophy of the Clavicles and the Sternum. (Compare Fig. 66.)

It should be borne in mind that under normal circumstances the aorta is seen in the left mediastinum at the first intercostal space. A sac-like bulging of the arch, showing considerable pulsation above this space, points to the presence of aortic aneurysm. Vehement pulsation, if there is no sac-like bulging, points to aortic insufficiency.

In a most extraordinary case of aortic aneurysm, illustrated by Fig. 65, it was possible to demonstrate not only complete atrophy of the sternum down to the xiphoid process, and of the sternal portions of the clavicle, but also the overlapping of the heart over the parasternal line and downward displacement of its apex. (Fig. 66.) The patient, an architect, aged thirty-nine years, German by birth, single, gave the following family history: Father died suddenly when sixty-five years of age; mother also died suddenly when sixty. His only brother died of typhoid fever at twelve. There were no sisters.

The patient denied lues, and the examination verified his statement. Gout and chronic nephritis, as well as any erotic excesses, were to be excluded. He was always well until five years ago; then, after lifting an excessively heavy weight, he noticed a small protuberance on the left side of his neck; this grew constantly, invading at last the whole anterior surface of the neck and the upper portion of the chest. It is highly probable that the exertion in lifting caused an enormous increase in the circulatory pressure,

FIG. 66.—AORTIC ANEURYSM (see Photograph Fig. 64).

followed by an overextension, and probably a laceration of the tunica intima and media.

Shortly after this he was admitted to a hospital, where he was treated for torticollis, as he states, for five weeks. During that period slight dysphagia and hoarseness had been present. He recovered again so far as to regard himself well for an entire year. Then a "severe attack of malaria" induced him to seek hospital treatment again. At that time the tumour had not exceeded the size of a large apple. The hoarseness was considerable then. After having improved again he left the hospital, and for eighteen months after had been under medical treatment occasionally. Then he began to suffer from slight dizziness, with constriction of the throat and chest. Slight dysphagia and hoarseness recurred.

On October 31, 1898, when the patient entered St. Mark's Hospital, the author saw him for the first time. The tumour had reached an enormous size, then extending over the sternum, the sternal portions of the clavicles, and the whole anterior surface of the neck, the diameter of the latter portion being $7\frac{1}{2}$ inches (see Fig. 66). The constant pressure of the tumour had caused complete atrophy of the adjoining osseous structures, so that no visible trace was left of the sternum or of the sternal portions of the clavicles.

The examination of the heart both by percussion as well as by the Röntgen method revealed hypertrophy of the left ventricle. The apex beat was felt in the sixth intercostal space an inch beyond the mamillary line. Above the jugulum and in the right parasternal line a diastolic as well as a systolic murmur was noticed, the latter being more distinct at the systole. On placing the hand gently on the tumour slight vibration could be felt.

The lungs were normal. No cough was present. Sometimes, especially after any muscular exertion, there was dyspnœa. The respiration was 20 to the minute, the pulse 78, the temperature oscillated between 97° and 98° F. The pulse of the right radial artery was weaker than that of the left, and lagged behind it appreciably. There were no signs of arteriosclerosis. The voice was clear and its resonance simply remarkable, the previously existing hoarseness undoubtedly having been due to pressure paralysis of the recurrent nerve. The dysphagia, caused by pressure upon the œsophagus, was very moderate on his admission.

The subjective disturbances of the patient were then insignificant. He had a fine appetite, and had attended to his business for the preceding four weeks.

The pulsation was unusually moderate in comparison to the large size and hardness of the tumour, a circumstance which pointed to the presence of abundant coagulation. It must also be assumed that the aortic wall formed by adventitia and the abundant proliferation of connective tissue had become so much fortified that the blood could discharge again from the subadventitial sac in the peripheral portion to the proper vascular channel. To these fortunate circumstances, the coagulation as well as the patency of the vascular channel, the surprising euphoria may be attributed.

As alluded to above, the skiagraph shows complete atrophy of the sternum down to the xiphoid process, and of the sternal portions of the clavicles. The heart overlaps the parasternal line, and its apex shows a slight displacement downward. Its oval shape is distinctly recognisable, and is well demarcated from the aneurysm, the intrathoracic extent of which is enormous. Other skiagraphs taken by the author show the aortic arch, which is not as well represented in the otherwise distinct skiagraph (Fig. 66).

Thus it can be seen that often more reliable information as to type, shape, and size of intrathoracic tumours can be obtained by skiagraphy than by percussion. There can be no doubt that the Röntgen rays enable us to recognise aneurysms at their earliest stages, so that frequently a series of prophylactic measures can be taken which may counteract any further aneurysm formation. The therapy being under perfect control, it can be ascertained whether under treatment either improvement, arrest, or still further expansion may take place.

The patient had been subjected to Barwell's diet and to gelatin injections after the manner of Lancereaux for two months. The injections had been well borne, except on one occasion, when a slight rise of temperature followed and persisted for three days. During that period the patient's general condition was considerably affected. There could be no doubt, however, that the tumour decreased in size; the hoarseness disappearing entirely, and the subjective condition of the patient being much improved.

In July, 1899, the patient died after three days of an acute attack of pneumonia. The autopsy showed no rupture of the enormous sac, but suppuration of the bronchial glands, probably caused by the gelatin injections. The specimen, Fig. 67, obtained at the autopsy shows the correctness of skiagraphic representation.

Fracture of Ribs and Scapular Neck.—Fig. 68 shows fracture of the neck, of the scapula, and of the second and third ribs. The diagnosis of these simultaneous injuries was not made because the swelling caused by the injury seemed to be a part of the effusion around the shoulder-joint. The swelling perceived there was also

Fig. 67.—Heart and Aortic Aneurysm. (Compare Figs. 65 and 66.)

attributed to the main injury. There were no physical signs present, and the subjective symptoms consisted in pain that was also thought to be caused by injury of the shoulder. The slight cough noticeable now and then was erroneously explained by bronchitis, from which the patient had suffered before he sustained the injury. The recognition of the nature of the joint injury enabled the author to reduce the fragment, which was displaced downward.

Fractures of Dorsal Vertebræ.—In those cases in which a clear skiagraph of fracture of the dorsal vertebræ can be secured (as to technique see page 79), the type of fracture, the size and num-

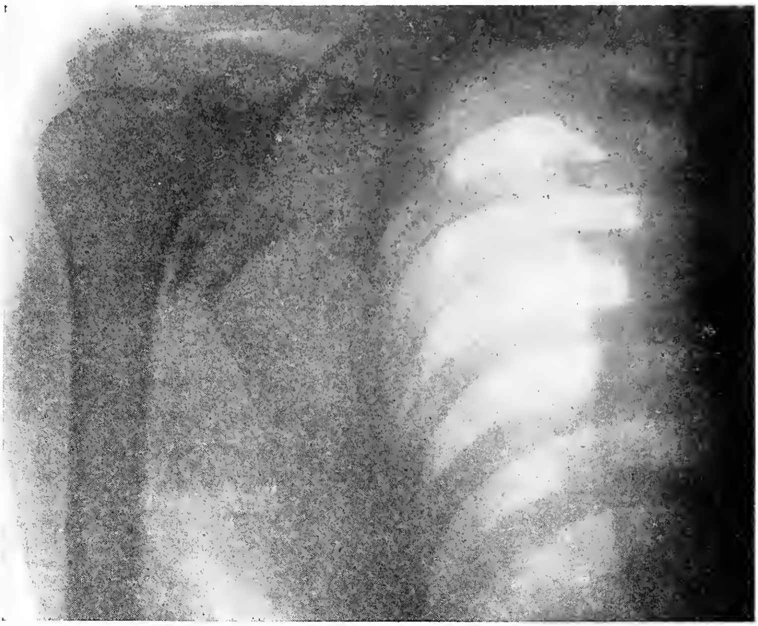

Fig. 68.—Fracture of Scapula and Ribs.

ber of the splinters, and their location may be represented so well that the indications for the mode of treatment can be clearly set forth. After a general view is obtained, the seat of the injury is skiagraphed by the aid of the diaphragm in order to obtain structural details. If there is only slight angular displacement, reduction can be accomplished. But in the event of intraspinal hæmorrhage and when bone-fragments, driven into the canal, press upon the cord, operative interference is required. In children, of course, the best reproductions are obtained, one minute's exposure generally being sufficient.

Under the application of the Röntgen rays the results of operations which formerly had been confined to exploration have become much more encouraging. The field of operation being outlined by the skiagraph, the *modus operandi* can be determined beforehand. While at one time it was deemed advisable to expose a large portion of the spinal column in order to ascertain that every possible injury had really been reached, now all the operative procedures can be carried on under the indication of the rays with ease and security, even the length of the incision necessary for the removal of bone splinters being suggested by the skiagraph.

It is surprising that surgeons, who find it most natural to relieve, by immediate operation, brain pressure caused by a depressed fracture of the skull, should hesitate to perform the similar operations upon the spinal column. Nothing, indeed, is more natural than reduction or removal of a fragment pressing upon the spinal cord.

As to scoliosis, kyphosis, and lordosis, it may be said that their treatment can be well controlled by repeated skiagraphic observations.

Inflammatory processes, like spondylitis, can be differentiated from fractures of the spinal column. Tuberculous foci in the vertebræ are also demonstrable. The same applies to osteomyelitis and necrosis.

Localization of *bullets* in the thoracic cavity is not always easy. The temptation to extract bullets that cause no disturbance is greater than formerly, a fact which is not to be registered among the advantages of the Röntgen rays (compare page 95 on Pericarditis).

Nowhere is the necessity of careful interpretation of skiagraphs so important as in thoracic diseases. It is utterly impossible to instruct a non-medical skiagrapher and to impress upon him the necessity of emphasizing certain points. If the physician does this work himself he will be able to judge much better. But even then a great deal of doubt as to the real nature of an abnormal shadow may exist. The scientific physician must never be tempted to tax his power of imagination, but must base his diagnosis on *all* the methods at his command, of which the Röntgen rays, however, form an integral part.

CHAPTER IX

ABDOMEN

The abdomen is best fluoroscoped while the patient is standing. Skiagraphy is done either in the abdominal or dorsal position. Sometimes an examination in an oblique perspective must be added.

The value of abdominal skiagraphy is greater than that of fluoroscopy. The study of the various abdominal organs, however, leaves much to be desired. Considering the thickness of the abdomen, it seems natural that hard tubes should be employed in order to obtain sufficient penetration. But their great disadvantage is that they diffuse the rays so that the image becomes blurred. On the other hand, it is difficult to utilize soft tubes because they do not penetrate the abdominal wall. This factor will be discussed further below. The solid masses of the liver can be easily represented, but the intestinal loops are only occasionally shown. The intestinal contents, especially those of the transverse colon, are recognisable. The outlines of the stomach can be made visible by substances impermeable by the rays. The spleen and kidneys are rarely demonstrated at the screen, but can be outlined by skiagraphy. Below the shadow of the liver, especially of its left lobe, the lower ribs are clearly seen. The triangular shadow of the psoas muscle, from the beginning at the twelfth dorsal vertebra, must always be recognised.

The chief practical results in abdominal skiagraphy have so far been obtained in the representation of the injuries and diseases of the lumbar vertebræ and of concretions and foreign bodies. Thus fractures, dislocations, inflammatory processes, and growths of the lumbar vertebræ can be diagnosed, as also calculi of the kidneys, ureter, bladder, prostate, urethra, gall-bladder, and hepatic ducts.

LIVER

The liver is best represented with the patient in the abdominal posture. In newborn children its shadow is especially well marked. The position, size, and shape may give valuable information in many obscure hepatic ailments.

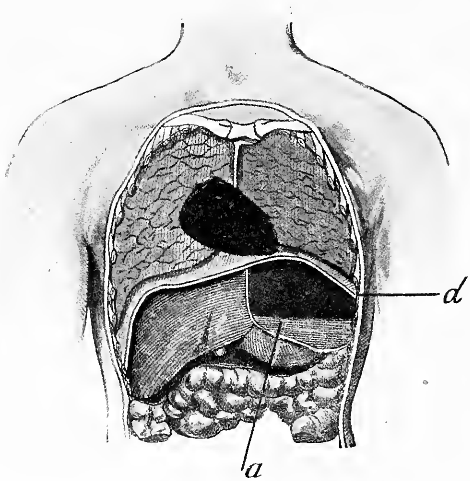

Fig. 69.—Subphrenic Abscess.

Subphrenic Abscess. — The diagnosis of subphrenic abscess is simplified by fluoroscopy as well as by skiagraphy, the space between the diaphragm and the lower boundary-lines of the abscess showing distinctly. If the patient is seated on a chair, the screen being held in front of the thorax and the Röntgen tube behind him, the upper portion of the diseased side must appear normal—that is, light. Below this area a dark one appears which indicates the diaphragm (Fig. 69, *d*). Below the diaphragm a very dark shadow is found if fluid is present. This would correspond to the dark area indicated by Fig. 69, *a*.

When the patient's position is changed the dark area, indicating the fluid, also changes. Sometimes there is an accumulation of gas in the subphrenic abscess. Then a light area will be seen above the dark shadow. As soon as the patient is shaken, the horizontal line, indicating the border-line between gas and fluid, becomes wavy.

In the recumbent position the dark area is shown only, even if gas be present. (As to further information, see author's monograph on Subphrenic Abscess, Medical Record, February 15, 1896.)

Total transposition of the viscera was well represented in a case depicted in the Annals of Surgery, May, 1899. Never before has cholecystostomy for cholelithiasis been performed on the left side, as it was in this remarkable instance.

The greatest usefulness of the rays in hepatic diseases is, however, displayed in the recognition of cholelithiasis.

Cholelithiasis.—Gall-stones have not been skiagraphed until recently. It was the privilege of the author to show the first undisputed skiagraph of gall-stones in the living subject at a meeting of the New York County Medical Association in October, 1899.

As emphasized above, the diffusion of the rays, especially in the liver, is the main obstacle. The use of the diaphragm obviates this to a certain extent, but not sufficiently for the purpose. The harder the tube, the better the penetration, but the greater the diffusion of the rays. If there be little diffusion, the bones may be represented well, but the biliary calculi are penetrated by the rays to such an extent that they cast no shadow on the plate, unless there should be a large amount of calcium, which is rare.

It is obvious, therefore, that the representation of biliary calculi had to be expected from a soft tube, or at least from a tube the vacuum of which stands at the border-line between softness and medium hardness. Such tubes show the osseous tissues faintly, a fact which can be readily observed in all the successful cases of the author.

Fig. 70 is a striking illustration of this fact. It represents the case of a woman of sixty-eight years whose skiagraph shows several biliary calculi distinctly, while others are faintly reproduced. Cholecystostomy, performed on the following day by the author, revealed the presence of 231 small calculi and one larger stone which was arrested in the common duct, thus having prevented the passage of the smaller sized. The distinctness with which the ribs are reproduced proves that the vacuum of the tube employed was too high, wherefore it permeated the calculi which were situated directly underneath the focus, while those around it are not so well penetrated.

There is one advantage in the skiagraphy of the contents of the gall-bladder over those of the kidney—viz., the possibility of bringing the plate very near the area to be skiagraphed, the intervening tissues being a great deal thinner than in the renal region.

Various Types of Biliary Calculi.—The results, of course, are to a great extent dependent on the chemical composition of the biliary calculi, which is far more complex than that of urinary concretions. All the different types of calculi (Fig. 71) were skiagraphed by the author (Fig. 72) (see "On the Detection of

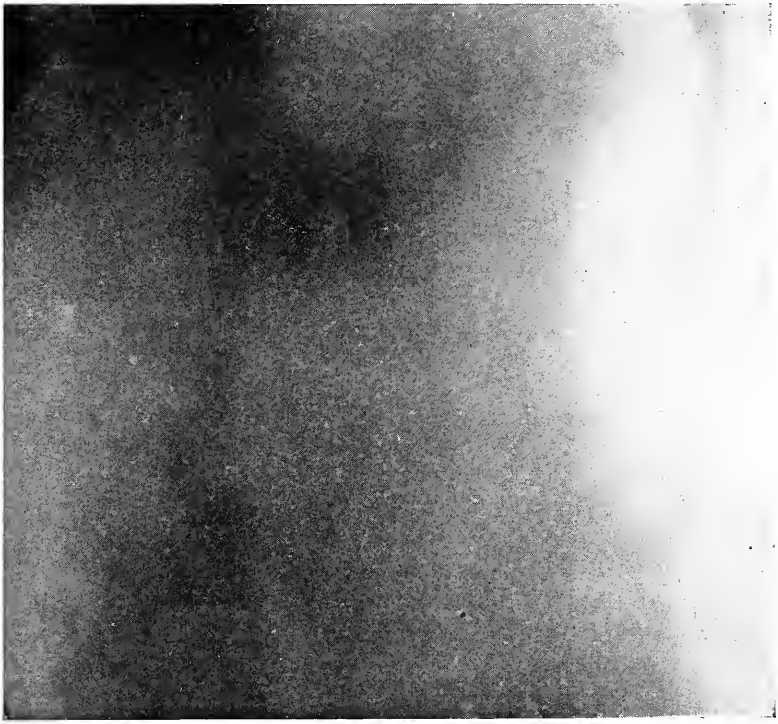

Fig. 70.—Concretions in the Hepatic Ducts.

Calculi in the Liver and Gall-bladder," New York Medical Journal, January 20, 1900). By this procedure he obtained a visual comparison of their impermeability. The same calculi were irradiated then through the living body, thus practically demonstrating the difference in translucency (Fig. 73).

The common biliary calculi, the most frequent type, are found to be quite permeable to the rays, and therefore produce only a light shadow. If present in large numbers, the shadow is somewhat more conspicuous (Figs. 71, 72, and 73, No. 2). Calculi composed of pure cholesterin are less permeable than those of the common type, and show a slightly more distinct shadow (see No. 5).

The stratified cholesterin calculi, on account of their admixture with calcium, show much less permeability, and therefore produce a distinct skiagraph (Nos. 1 and 12). The mixed bilirubin calculi, which contain traces of copper and iron, in addition to the bilirubin-calcium, are less permeable than all the former varieties, and consequently give a very distinct shadow (No. 6). The same applies to the pure bilirubin-calcium calculi.

Calculi composed of pure bilirubin-calcium, on account of their mixture of calcium, show a larger degree of permeability, and their outlines can be nearly as distinctly shown as those of the bilirubin-calcium calculi (No. 7). But with a good tube even the more translucent calculi are sometimes represented. Recently, calculi that were only the size of a pinhead have been shown in the gall-bladder. Calculi of the hepatic ducts have also been represented.

These results, which could formerly hardly be hoped for, are attributed mainly to the excellent quality of the soft tubes used, which permitted of the employment of a strong current. In fact, the most important requisite for skiagraphic success in such delicate

Fig. 71.—Various Types of Biliary Calculi. (Compare Figs. 72 and 73.)

work is a strongly built tube of a low vacuum in connection with a large Ruhmkorff coil.

It has been found that the soft tubes used for the reproduction of biliary calculi display their best energy so long as they are comparatively new. Later on they show less contrast, just like very hard tubes, even if provided with an attachment for regeneration. If the tube works well from the beginning, the average

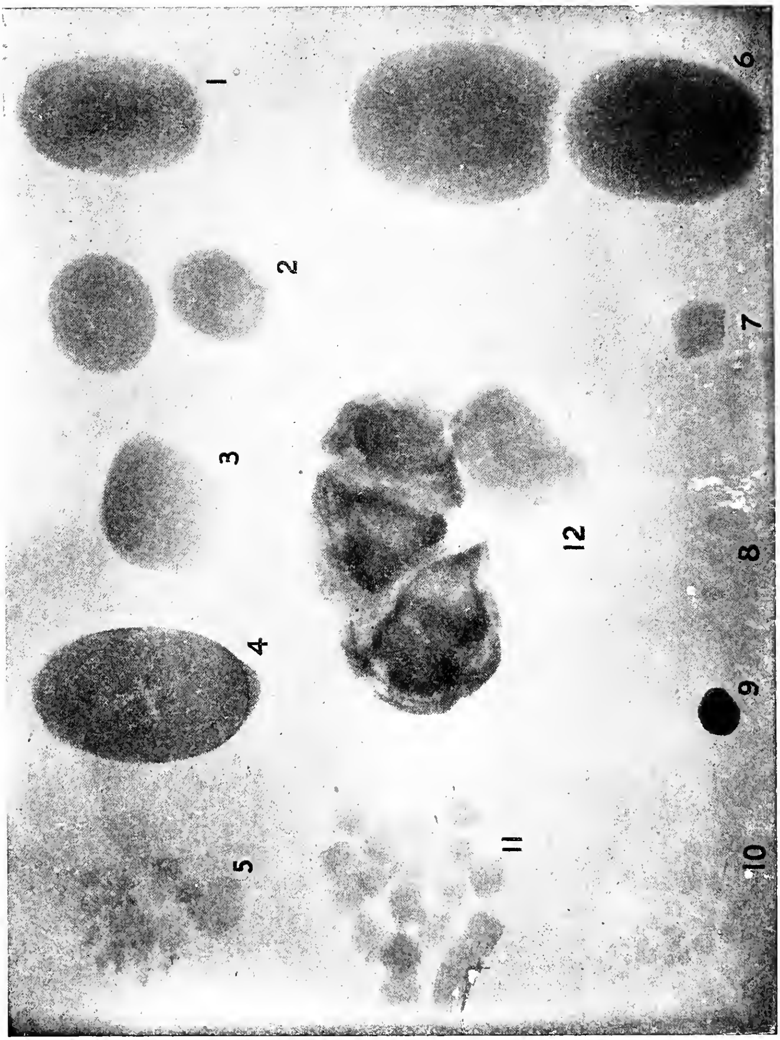

Fig. 72.—Translucency of Gall-stones. (Compare Figs. 71 and 73.)

time of exposure should be about four minutes in thin individuals, and about six in stout cases.

The position of the patient while being skiagraphed is also an important factor. He should lie on his abdomen with about three pillows underneath his clavicles, as the elevation produced permits

Fig. 73.—Biliary Calculi, Illustrated by Figs. 71 and 72, Irradiated Through the Living Body.

the protrusion of the gall-bladder, thus bringing the calculi nearer the photographic plate. The approximation is increased by turning the body slightly to the right and raising the left side. A diaphragm should always be used (Fig. 74).

A pencil mark should be made on the back to correspond to the site of the gall-bladder in front.

In order to exclude any possible source of error from intestinal

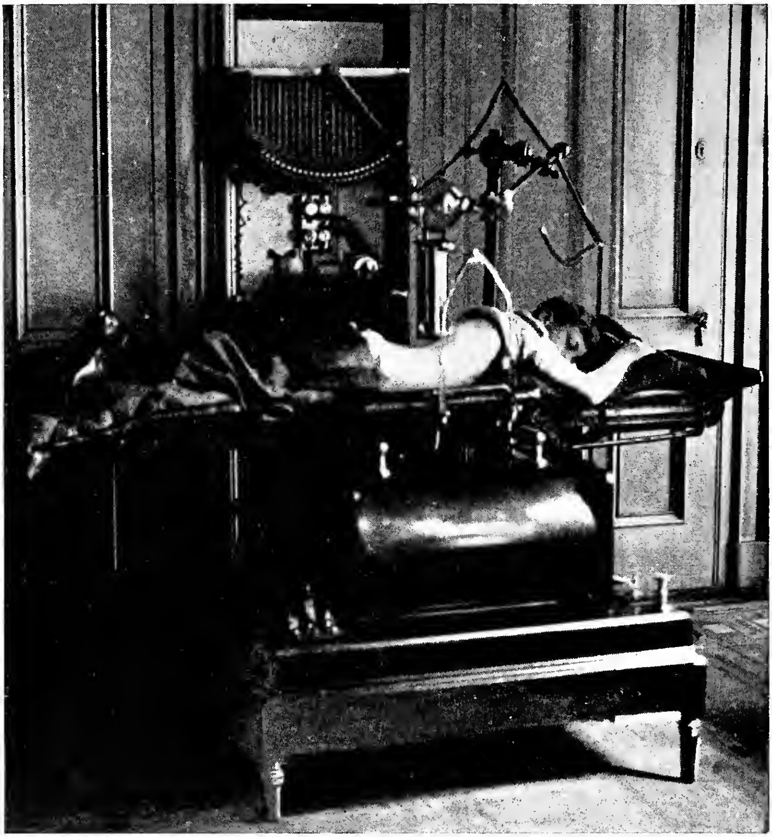

Fig. 74.—Position for Skiagraphing Region of the Gall-bladder by the Aid of Author's Diaphragm.

contents, the bowels must be thoroughly evacuated before irradiation.

By using this method the size, shape, and diameter of the gall-stones can not only be determined in suitable cases, but they can also be localized. The importance of knowing whether there are also calculi in the liver besides those present in the gall-bladder needs no discussion.

Intrahepatic Calculi.—The presence of calculi in the liver tissue explains why cholelithiasis is often only partially cured by cholecystotomy. This fact shows why calculi have sometimes surprised the surgeon, who has thoroughly evacuated the gall-bladder, by their appearance a few days after the cholecystotomy. That in cholelithiasis sometimes hundreds of calculi are contained in the hepatic ducts is a well-known fact, but why calculi appeared after cholecystotomy has heretofore been explained only on the autopsy table. (See author's monograph: When shall we Operate for Cholelithiasis? in the New York Medical Journal, May 8, 1897.)

Practical Value of Skiagraphy of Biliary Calculi.—It is evident that a positive skiagraph renders exploratory laparotomy for suspected cholelithiasis unnecessary. It can be ascertained by subsequent exposures whether any calculi have been dislodged or whether some have escaped. If they are of very large size, their removal by other than surgical means would, of course, not be expected. So the question whether or not operation is advisable in cholelithiasis may be settled by the Röntgen rays. When only small stones are present, there is a chance for medical treatment. When stones are found too large to pass the common duct, medical treatment can only be palliative, and cholecystotomy should be performed as soon as the calculi prove to be a source of irritation and danger.

Deficiencies of the Method.—It is appreciated that the method given for diagnosing biliary calculi is incomplete and needs further modification and improvement, as there are many delicate technical details on the correct appreciation of which success depends. Skiagraphy of biliary calculi is not so perfect a diagnostic method as that of renal, ureteral, and vesical calculi. While a negative result in the case of suspected urinary calculi can now be pretty safely taken as evidence of the absence of calculi, provided the skiagraph is blameless, the same cannot as yet be said of biliary calculi. But, on the other hand, it can safely be asserted that even a faint skiagraphic reproduction of biliary calculi proves their presence to the expert reader. With increased knowledge and improved technique the skiagraphic reproduction of biliary calculi will become a great deal easier.

The outlines of the gall-bladder are often shown if there is cholelithiasis. On account of the long-continued irritation, the bladder walls become thick and fibrous and consequently less permeable to the rays.

FIG. 75.—BILIARY CALCULI (two of them are faceted).

Fig. 75 represents two large faceted gall-stones in the gall-bladder, and four in the vicinity, one probably in the cystic duct and three in the intrahepatic ducts. Their elliptic shape, their size, and their diameter can be well recognised. The patient, a man of forty years, is still in the possession of his stones, which cause only occasional and very slight disturbance, so that the author did not feel justified in persuading him to submit to an operation. The patient is the brother of the woman whose large biliary calculus was removed from the left side (see p. 112); from a sister of this patient the writer also removed two large biliary calculi. There are ten members of this family in whom cholelithiasis could be diagnosed.

Fig. 76 shows a large and two small biliary calculi in a man of forty-five years. In this case the large gall-stone is overshadowed by the rib. If the tubal vacuum had been slightly lower, the outlines would probably also have been more distinct.

Fig. 77 shows a solitary calculus faintly, while smaller intrahepatic calculi are represented distinctly. Cholecystotomy performed by the author a few days after exposure proved the pres-

Fig. 76.—Three Biliary Calculi.

ence of a large calculus (Fig. 78) in the gall-bladder. No evidence was found of the others in the ducts. This must be explained by their intrahepatic domicile, which could not be exposed. In favour of this assumption was the extremely severe cholangioitis from which the patient suffered after the operation. The skia-

FIG. 77.—SOLITARY BILIARY CALCULUS.

graph shows the extracted stone translucent, as it consisted mainly of cholesterin.

Fig. 79 shows the presence of a large number of calculi of various sizes.

It is interesting to observe that a woman of thirty-seven years, whose calculi were skiagraphed three years ago, was re-examined recently. Three skiagraphs taken at different times, in different positions, showed a negative result. The patient had submitted to diet, much better, and the regular administration of Carlsbad Muehlbrunn for more than a year, and the result was that the tumour in the region of the gall-bladder had disappeared. Her general condition had also improved accordingly, and no colicky attacks were noted during the last eighteen months. One may feel justified in believing that the negative skiagraph confirmed the impression that the stones had passed away.

KIDNEYS

The kidney must be skiagraphed in the dorsal position. Tubes of moderate hardness are best for their skiagraphic representation; very hard tubes penetrate the organs and leave no shadow. Renal fluoroscopy cannot be relied on with our present means.

Hydronephrosis and echinococcus cyst can be represented under favourable circumstances. The greatest usefulness of the rays in renal disease, however, is displayed in diagnosticating concretions. Great credit is due to McIntyre for having been the first to skiagraph renal calculi. Soon afterward Twain, Thyne, Kümmell, and Ringel, as well as the author, obtained distinct skiagraphic representations of nephrolithiasis.

Naturally such calculi can be represented best which consist of hard and firm material, like oxalates, while the more penetrable phosphates cast an indistinct shadow, and the translucent urates hardly at all. Thus we learn that the success of skiagraphy in calculi of the urinary tract depends largely on the chemical composition of the calculi, and, consequently, on their greater or lesser opacity. Still, with the aid of the diaphragm more or less marked shadows even of the urates are obtained. The beautiful work of Abbe, Bevan, and Leonard, all of this country, furnish striking illustrations of the immense progress of this young science in the short space of a few years.

Fig. 78.—Biliary Calculus.

As to the technique of the skiagraphy of renal concretions many of the principles emphasized in connection with biliary calculi hold good (see p. 113). Considering the diffusion of the rays, the use of a diaphragm is indispensable. Thus even small calculi may be represented.

In regard to their chemical composition, it should also be remembered that a calculus may consist of different salts. In one of the author's cases five layers were found, the nucleus and third layer consisting of calcium carbonate, its branches of a combina-

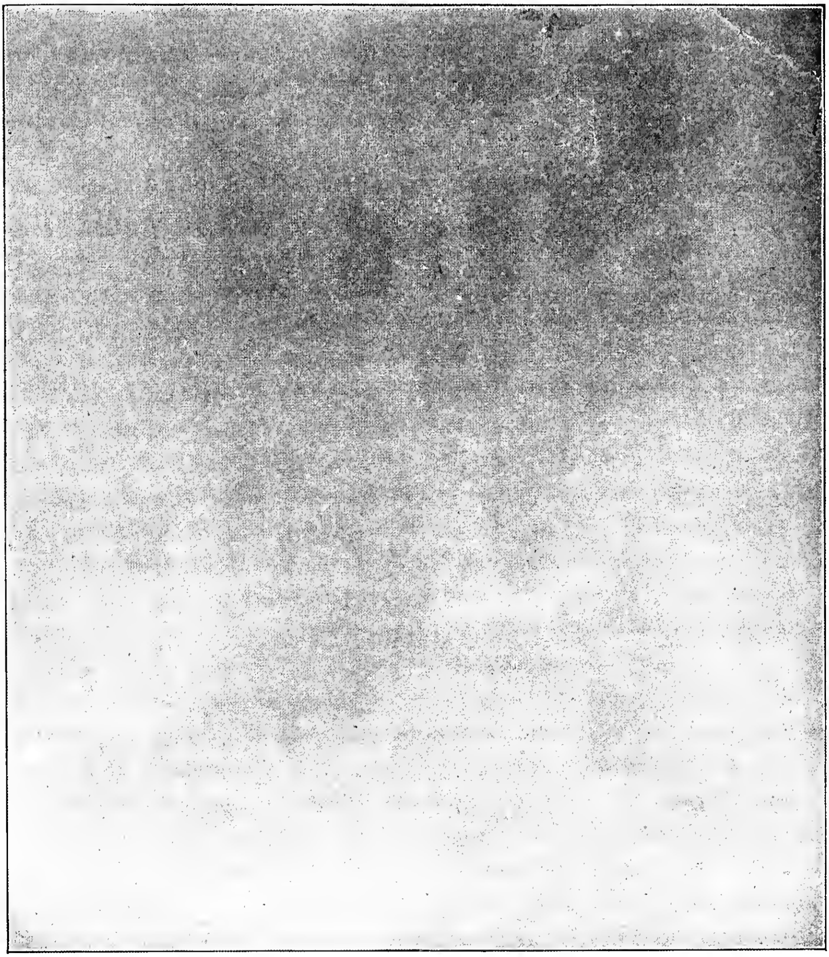

Fig. 79.—Numerous Biliary Calculi in much Distended Gall-bladder.

tion of calcium carbonate and triphosphate, and the outer crystalline layer of carbonate of magnesium and ammonium.

Under such circumstances the nucleus will be more marked if a tube of moderate hardness is used, while the branches will be more conspicuous if a soft one is employed. As a rule, tubes should be chosen that are slightly harder than those used for skiagraphing biliary calculi. The time of exposure should be four minutes in thin and about six minutes in stout individuals. A good skiagraphic representation of nephrolithiasis renders an exploratory incision unnecessary. It will settle the question of the presence or the absence of concretions, and in case an operation is indicated, it will give valuable hints as to the technique.

While, as has been said above, a negative result cannot be relied upon in a case of suspected cholelithiasis, a good skiagraphic plate which does not show the presence of renal calculi may safely be regarded as diagnostically conclusive. Kümmell verified the skiagraphic diagnosis in all cases, the operation proving its correctness sixteen times and the autopsy twice. The characteristics of a reliable renal skiagraph are that it shows the outlines of the psoas muscle and the lower ribs and the structure of the transverse processes. If they show distinctly, a calculus which is not smaller than a pea would necessarily also leave its shadow on the plate. Very small concretions may be overlooked. But if these marks are not distinctly shown, the negative plate must never be relied upon.

When we bear in mind the high mortality of nephrolithiasis at a late stage and how many lives will be saved by early operation, the importance of early recognition of the calculi becomes evident.

Nephrolithiasis as well as cholelithiasis is often confounded with appendicitis. It is in the interest of the patient as well as in that of the medical profession that differentiation is made beforehand, instead of removing the appendix first and then being told, by the continuation of the painful attacks, and finally by the passing of a calculus, that there was an error loci as far as the field of operation is concerned. (Compare author's monographs on Appendicitis, New York Medical Journal, November 14, 1898, and Wiener klinische Rundschau, August 2–16, 1903.)

Fig. 80 shows a large renal calculus in a man of forty-two years.

It should also be borne in mind that palpation may fail to reveal calculi of moderate size. In such cases fluoroscopy during the operation is indicated. A special fluoroscopic arrangement must be prepared for such occasions (compare p. 39). The fluoroscope should be of small size, and must be surrounded with sterile gauze.

In interpreting skiagraphs taken for suspected nephrolithiasis, it should be borne in mind that under extraordinary circumstances biliary calculi may be taken for calculi of the right kidney. It may be said, however, that as a rule the shape of biliary calculi is different from that of renal concretions; the former are located higher up, and do not show so clearly from the back as they do from the front. Of course, in those cases in which the shape of the kidney is recognized, the shadow of the renal calculus will hardly be misinterpreted. In case of doubt, an oblique exposure

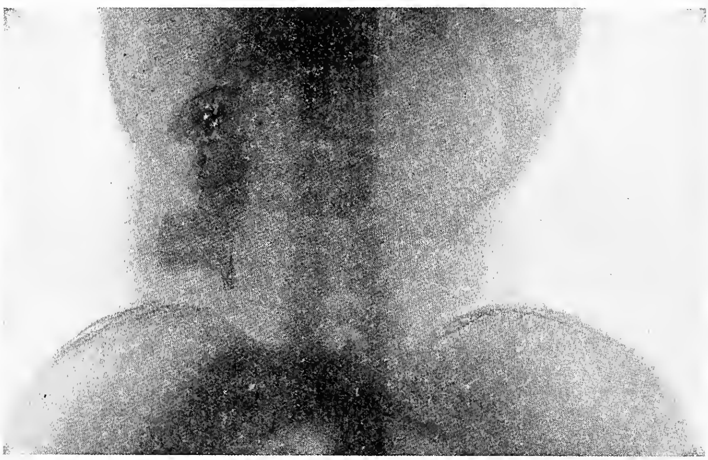

FIG. 80.—RENAL CALCULUS.

may show a renal calculus in the back, while gall-stones would appear more in front.

The shape of renal calculi is characteristic. Their contours are generally well marked. They are usually of an irregular shape unlike that in biliary calculi, projections often being present. As a rule, the renal calculi are detected around the two last ribs, about 2 inches laterally from the spinal column. The clinical symptoms should also be properly considered before conclusions are drawn. Just as in cholelithiasis, the skiagraphic proof of the presence of small calculi shows that much is to be hoped for from medical treatment, while the removal of large calculi cannot be expected by any other than surgical means.

The distance of the tube from the patient's skin in skiagraphic representation of the kidney should be about 4 inches. Several exposures are always necessary. The preliminary exposure should comprise a surface the border-line of which is formed by the crista ossis ilei and the eleventh rib on one side and by the spinal column on the other. This area is marked on the patient's plate for future comparison. If the signs of a calculus are found on the preliminary plate, the diaphragm is placed above the indicated area for better differentiation. Just as in skiagraphs of biliary calculi, it is not required that the outlines of renal concretions should be so distinct that they can be reproduced in print. By keeping off the daylight it is often possible for the expert reader to detect a calculus which escaped superficial inspection. The plate must be studied from various directions, and must not only be held in the vertical, but also in the horizontal position. Thus the faint contours of a stone are sometimes shown which were overlooked by ordinary examination.

The advice of an operation should never be based upon the result of a Röntgen examination alone. It cannot be repeated too often that the Röntgen rays do not represent a substitute of our old standard methods, but are a most valuable addition to them. *Careless interpretations of indistinct skiagraphs will only discredit it.*

The clinical and chemical methods of examination should always be employed in the first place. They must work hand in hand with skiagraphy then. The presence of blood and pus-corpuscles in the urine, if not explained by infectious diseases or by vesical affections, demands a skiagraphic exposure.

Skiagraphy of biliary as well as of renal calculi taxes the patience of the operator greatly. Whoever does not possess this virtue would better concentrate his activity upon other useful fields. Sometimes it takes two hours of uninterrupted work to obtain a satisfactory reproduction.

Concretions in Ureter and Bladder.—Ureteral and vesical calculi can be skiagraphed after the same principles. Difficulties arise only in stout individuals. A vesical calculus shows best with the subject in the recumbent position, the centre of the tube to be directed to the upper margin of the symphysis pubis. Any vesical calculus, except it be very small, will surely be evident on a good skiagraph. A good skiagraph of the vesical region must show the structures of the coccyx well. By oblique irradiation the shadows of the calculi are generally found just below those of the coccyx. An oblique exposure should always be made besides, because it may show whether the stone is free or encysted. If the patient bends lightly forward in the lateral position, the calculus, if free, sinks towards the anterior vesical wall and becomes conspicuous directly behind the anterior abdominal wall. If it is not free, it usually shows far back towards the sacrum, since encysted calculi are nearly always attached to the posterior vesical wall. If the stone is of very large size, or if a great number of them are present, the whole vesical space is filled up and displacement is not apt to occur.

FIG. 81.—BISECTED HALVES OF VESICAL CALCULUS, ILLUSTRATED BY FIGS. 82 and 83.

So far as the diagnosis of the number, shape, and position of vesical calculi is concerned, the Röntgen rays afford a more valuable means than the cystoscope. The time of exposure should be about three minutes. A tube of medium hardness is best.

Foreign bodies, such as hair-pins and similar objects, which entered the bladder by the urethral route, must be frequently looked for by skiagraphic examination. They are soon surrounded by incrustations which make their recognition so much easier.

In children the representation of vesical calculi is especially easy, an exposure of a minute's duration generally being sufficient.

Fig. 81 shows the bisected halves of a calculus extracted from the bladder of a boy of six years. It has an elliptic shape, its length being 9 and its width 6 centimetres. Although the restless patient moved considerably, the displacement amounting to a whole inch, the shadow of the calculus can be distinctly recognised on the plate (Fig. 82). It appears as consisting of two shadows, however. The exposure only lasting half a minute, the density of the bones also appears weak.

A later exposure, Fig. 83, shows the calculus very distinctly. An oblique exposure showed the calculus faintly. It seemed to be situated above the coccyx. It was assumed that it was impacted

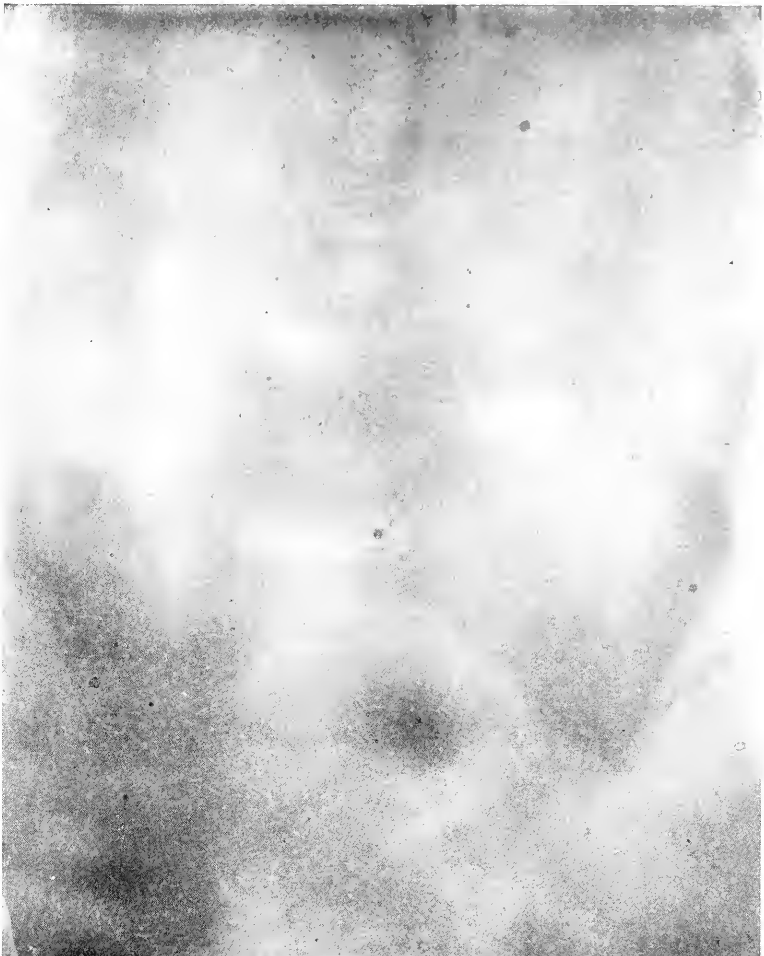

FIG. 82.—VESICAL CALCULUS. (Compare Figs. 81 and 83.)

there, because no displacement could be noticed when the position was changed. Suprapubic cystotomy corroborated the correctness of this assumption. The mucous membrane of the bladder had overlapped the calculus to a great extent, so that its removal from

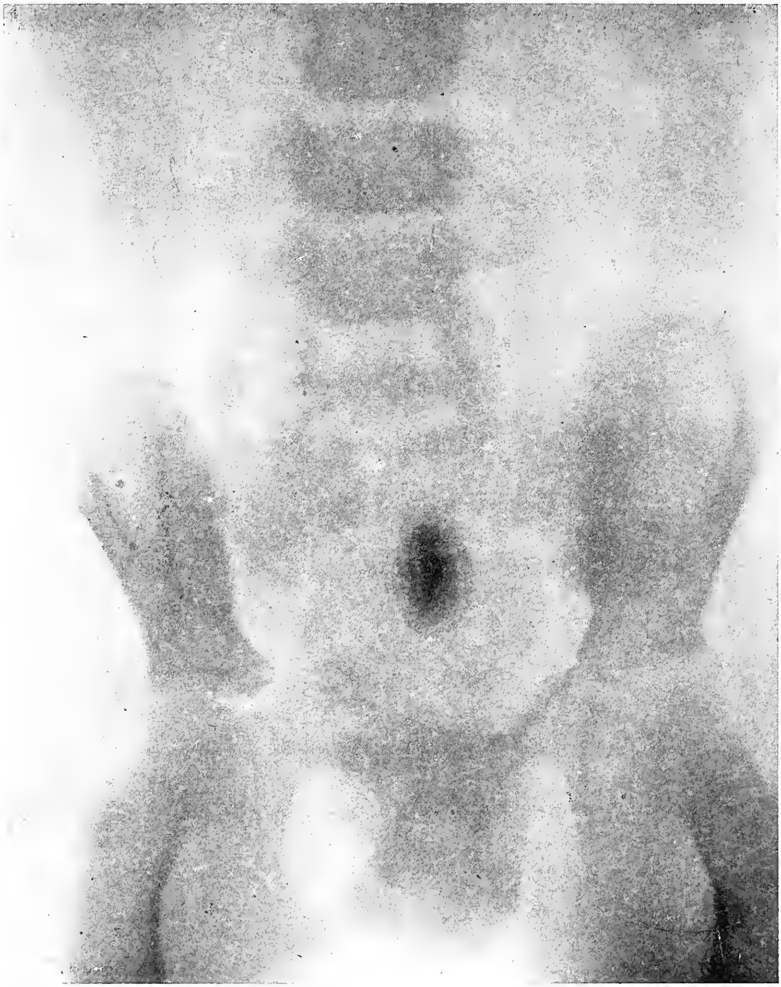

FIG. 83.—VESICAL CALCULUS (Compare Figs. 81 and 82).

the deep pouch was connected with considerable technical difficulties.

Fig. 84 shows a large vesical calculus in a man of seventy years. Ureteral calculi are skiagraphed after the same principles.

Whether the concretions are in the bladder or in the ureter is sometimes difficult to ascertain. Kryoscopy, cystoscopy, and ureteral probing is a most valuable adjunct in such cases. The combined examination ascertains whether there is general functional disturbance, or bilateral or unilateral stone-formation. It also shows whether simultaneous lesions of a different nature exist besides.

Foreign Bodies in the Abdomen.—Metallic bodies in the abdomen are, of course, easily demonstrated. As modern surgery makes

FIG. 84.—VESICAL CALCULUS IN A MAN OF SEVENTY YEARS.

immediate laparotomy imperative in all bullet wounds of the abdomen, it may be realized how important is skiagraphic localization. Tacks and needles can be easily localized. The popularity of the Murphy button gives frequent opportunities to observe its characteristic shadow while it travels through the intestinal tract.

Tumours of the Stomach are representable only if their texture shows a considerable degree of density. The outlines of the stomach can be mapped out if the viscus is filled with salts, such as subnitrate of bismuth, that are impermeable to the rays. The introduction of a soft rubber tube the lumen of which is filled with mercury is, however, preferable. A rubber tube containing a thin, flexible steel wire in a spiral form, as advised by the author, permits the rapid representation of the outlines of the stomach. The stoppage of this tube indicates its arrival at the large curvature of the stomach and further propulsion shifts it along the wall. There the steel spiral is clearly shown by the skiagraph.

Inflation of the stomach by carbonic-acid gas, air, or a mixture of tartaric acid and bicarbonte of soda has also been used to define its outlines. The large and small curvatures, as well as the cardia, can thus be represented. The infantile stomach is especially fit for skiagraphic representation. In selected cases, the relations, especially the motions of the spiral wire, can be studied by the aid of the screen. Tubes of medium hardness should be chosen.


FIG. 85.—SPINA BIFIDA (See Fig. 86).

The different phases of digestion can be studied by fluoroscopic as well as by skiagraphic observation after subnitrate of bismuth is swallowed. The lower animals can also be utilized for that purpose. Frogs, mice, cats, or guinea-pigs may be given a mixture of flour, milk, and bismuth. Skiagraphic exposures, repeated every twenty minutes, can then be studied with leisure.

Spina Bifida.—The diagnosis of the various types of spina bifida is facilitated by the rays. In speaking of this malformation in general one is apt to think only of its cystic form and of its location in the lumbo-sacral region. But besides this most common type there are several others which require to be distinguished before we can choose the proper therapy. Thus it cannot be a matter of indifference whether there is a so-called simple meningocele—in other words, a hernia-like protrusion of the pia, containing cerebral fluid; or a myelomeningocele, a frequent variety, which is characterized by the spinal cord expanding itself, like the optic nerve in forming the retina, around the protrusion, and, together with the pia, constituting the sac; or whether there is a myelocystocele—that is, a tumour caused by cystic dilatation of the central canal of the spine.

Fig. 86.—Spina Bifida, showing Hiatus (See Fig. 85).

It is also important to discriminate whether the tumour is situated in the cervical, dorsal, lumbar, or sacral region. If situated in the cervical or dorsal region, the cord cannot protrude into the hernial sac, as it does in the lumbar or sacral portion, which corresponds to the end of the cord. It is also desirable to know whether there is a hiatus in the spinal column, and how extensive it may be; and, furthermore, whether or not the fluid contained by the tumour can be dislodged into the spinal canal.

In view of these anatomical distinctions, it will be easily understood that simple meningocele gives the best chances for cure. Whether injection treatment or extirpation should be preferred is not yet agreed upon among the profession. The writer remembers having cured three or four cases of simple meningocele by repeated aspiration, followed by the injection of a few grams of a 10-per-cent iodoform-glycerin emulsion. He generally prefers injection to extirpation, provided the surface of the skin be normal. Of course, if there be well-developed gangrene, or even any considerable abrasion of the epidermis, then septic infection of

FIG. 87.—SPINA BIFIDA (See Fig. 88).

the cyst wall cannot be arrested unless immediate and extensive removal is undertaken.

On the other hand, myelomeningocele and myelocystocele offer a less favourable prospect. In these cases the injection treatment is always a failure. If in myelomeningocele the nerves are freely dispersed in the sac, the area medullaris vasculosa, after being circumcised, must be reduced into the vertebral canal, and the union of the soft tissues above must be reduced in the same

Fig. 88.—Spina Bifida, illustrated by Fig. 87, in Antero-posterior Projection.

way. If situated in the lumbo-sacral region, the preservation of the nerve strings is of but little importance.

In myelocystocele the reposition should be made in the same manner. If there be any opening in the bone, protection should be sought by covering it with a strong flap, consisting of integument and muscle.

One of the greatest difficulties encountered in the treatment of spina bifida is that its various types cannot, as a rule, be defined before operation. Between meningocele and myelocystocele, indeed, distinction is often quite impossible. Sometimes conclusions may be drawn if an opening of the bone can be palpated, or

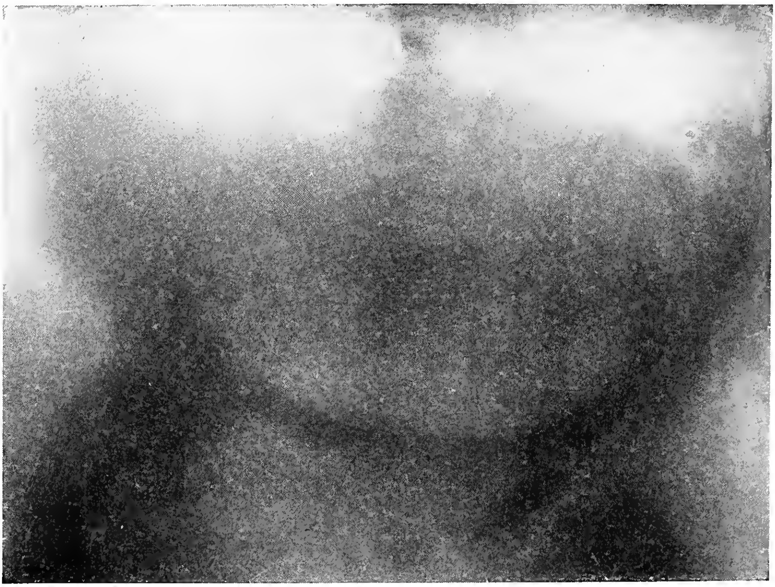

FIG. 89.—RHACHITIC PELVIS.

if a portion of the fluid can be reduced into the spinal canal by pressure. Paralysis of the lower extremities, of the rectum and bladder point to the existence of myelomeningocele; but all these signs are far from being absolutely reliable. Considering only this one point—that in meningocele aspiration should be tried first, while in the other varities extirpation must be resorted to—it must be admitted that our deficiency in scientific knowledge makes itself rather strongly felt as regards therapy. Some authors advise opening the lower portions of the tumour first, in order to ascertain whether the spinal column is open, as in myelomeningocele, or not, as in meningocele. Koenig and Hildebrand go so far as to emphasize the necessity to ascertain how the nerve strings are dispersed, by first making a lateral incision into the tumour, even after they can state that there is a myelomeningocele.

All these procedures, the reason for which no surgeon would dispute until recently, may now be rendered superfluous by the Röntgen method. The skiagraph shows not only whether there is an opening in the bone, but also tells of the presence and sometimes even of the expansion of the nerve substance in the sac. Fig. 85 shows the meningocele of a boy of two months. In Fig. 86 the communicating opening in the column can be recognised.

Fig. 90.—Extrauterine Mole, containing Fœtus, removed by Laparotomy.

In those rare cases in which the presence of lipoma or fibromyoma is in question, it is again the skiagraph which gives the needed information.

Fig. 87 represents a specimen of the lumbo-sacral type of spina bifida in a boy of five weeks. The integrity of the spinal column and the cystic character of the contents of the sac are apparent.

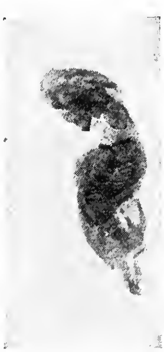

Fig. 91.—Embryo of Three Weeks.

Fig. 88 illustrates the same case in antero-posterior projection.

In this case gangrene of the surface of the tumour induced the author to resort to extirpation, which verified the correctness of the skiagraph. Had there been no gangrene, he would have, on the testimony of the skiagraph, selected the injection treatment.

Value in Gynæcology.—The usefulness of the Röntgen rays in gynæcology is still limited. Many trials have been made to obtain representation of the uterus, but they have always given unsatisfactory results. In a few instances the gravid uterus and the faint outlines of the fœtus have been detected.

Value in Obstetrics.—In obstetrics the advantages are greater, since so many important questions hinge on the condition of the

FIG. 92.—EMBRYO OF TEN WEEKS.

Fig. 93.—Fœtus of Four Months. Abortus caused by Syphilis.

pelvis. Symmetry and asymmetry of the pelvis, ankylosis, changes in the iliosacral joint, and the length of the various pelvic

FIG. 94.—FŒTUS OF FIVE MONTHS.

diameters can be well shown. Fig. 89 illustrates the elliptical shape of the rhachitic pelvis in a woman of twenty-two years. The deformity explains fully why she could never be confined in a normal way. A successful Cæsarean section has been performed on her.

If the exposures are made strictly under the same conditions, the tube being at the same distance from the plate and in the exact perpendicular direction, the measures of the conjugata vera, the introitus pelvis, and the transverse diameters can also be relied on.

After symphysiotomy it can be ascertained whether any diastasis of the pubic bones has remained. In case there is proof of the existence of considerable diastasis, a second operation may be avoided. The different phases of development of the fœtus may be studied by Figs. 90–94. (As to Osteomalacia, see respective section, Chapter XIII.)

CHAPTER X

PELVIS AND LOWER EXTREMITY

Pelvis.—The technical difficulties encountered in skiagraphing the abdomen are also observed in the representation of the pelvis. The fact that soft tissues of considerable thickness must be overcome explains why there is diffusion of the rays.

If the pelvis is skiagraphed *in toto,* structural details cannot be obtained. For the representation of malformations and other pelvic abnormalities a general view is perfectly sufficient. The same can be said of pelvic deformities due to congenital dislocation of the hip or to coxitis of old standing, the latter generally being associated with atrophic changes. (Compare Chapter XIII, section on Osseous Atrophy.)

Examination of the pelvis is best done in the perpendicular direction, the tube being held as near as possible and the symphysis ordinarily being regarded as the centre. A dorsal as well as an abdominal exposure is necessary as a rule. In children soft tubes must be chosen, the time of exposure not being longer than two minutes. The best position of the body is when the legs are slightly inverted, heavy sand-bags supporting them. When the patient is in the abdominal position the dorsum pedis must also be supported by a sand-bag. Fractures of the pelvis can be recognised, and by the location of displaced splinters a conclusion can be drawn as to possible injuries of the intrapelvic organs. If structural details are wanted, the use of the diaphragm is indispensable. If the author's diaphragm is used, its centre must be 4 inches below the umbilicus. The iliac arteries show markedly in case of calcareous degeneration.

In *exstrophy of the bladder* skiagraphing may succeed in demonstrating the extent of the symphyseal gap, and furthermore the result of a plastic operation.

Congenital Dislocation of the Hip.—In the treatment of congenital dislocation of the hip skiagraphic evidence will influence the plan of treatment. The position of the femoral head and the size and shape of the acetabulum are well recognised. If the condition of the acetabulum is unfavourable, bloodless reduction should not be attempted, and a cutting operation must be performed.

The skiagraph also shows whether reduction of a dislocated hip has been successfully effected or not. It is true that after perfect

Fig. 95.—Congenital Dislocation of Both Hips in a Girl of Two and a Half Years.

reduction the head of the femur can be felt between the spine and the symphysis in the majority of cases, and also that the characteristic noise can be perceived while the head is sliding over the margin of the acetabulum. But, on the other hand, it cannot be denied that the noise is often indistinct, and that the thickness of the muscles ofttimes impairs our judgment, so that it is the skiagraph that gives indisputable information. Fig. 95 shows congenital dislocation of both hips in a girl of two and a half years. The skiagraph proves the moderate extent of the dislocation, which

Fig. 96.—Congenital Dislocation of Left Hip in a Boy of Four Years, the Right Hip being Normal.

justified conservative measures—viz., bloodless reduction. This was done under anæsthesia, and the result after three years' treatment is entirely satisfactory.

Fig. 96 illustrates the case of a boy of four years who suffered from congenital dislocation of the left hip. Reduction was performed by Professor Lorenz, of Vienna, at St. Mark's Hospital, the skiagraph promising a favourable course in advance. Recovery was perfect.

Fig. 97 illustrates unilateral congenital dislocation in a girl of seventeen years. The acetabulum proves to be well formed. The age of the patient, of course, was not in favour of bloodless reposition, so that division of the muscles and permanent extension was resorted to. The result is good.

Inflammatory Processes in the Hip.—At the early stage of inflammatory processes in the hip-joint a correct diagnosis is of ut-

FIG. 97.—CONGENITAL DISLOCATION OF HIP IN A GIRL OF SEVENTEEN YEARS, THE EMPTY ACETABULUM SHOWING WELL FORMED.

most importance. In doubtful cases the rays will determine whether simple, traumatic, or tuberculous coxitis (Fig. 98) is present. In view of the great difference in treatment, the immense importance of a positive diagnosis is evident. It is always advisable to skiagraph both hips, so that the healthy and diseased side can be com-

FIG. 98.—TUBERCULOUS HIP-JOINT.

pared. After a general view is obtained the diaphragm must be used for the better recognition of structural details.

In a normal hip-joint there is a regular semicircular light area between the femoral head and the acetabulum, while in a tuberculous hip the articular outlines, instead of being regular and marked, are irregular and diffuse. In the beginning of the process, however, these signs may be overlooked. Slight projections of the femoral head are often found at an early stage and indicate the presence of fungous granulations. Later, cheesy foci in the acetabulum, the head, the neck, and the trochanter major can often be detected. Such processes must be differentiated from osteomyelitic foci, which have originated within the bone and gradually entered the joint. After the healing process is completed, the degree of atrophy of the femur and the extent of the ankylosis can be well studied. Osteomyelitic foci and sequestra are naturally well shown. (Compare section on Osteomyelitis, Chapter XIII.)

Arthritis Deformans Coxæ is characterized by the skiagraphic representation of osseous proliferations from the articular outlines of the head of the femur, the shape of which sometimes reminds one of a papilloma. (Compare section on Arthritis, Chapter XIII.)

FEMUR

It is acknowledged that in differentiating between *fracture* of the *acetabular margin* or of the *neck of the femur* and *dislocation* and *contusion* of the *hip*, grave errors were formerly committed by the best surgical authorities. The Röntgen rays have made it possible to avoid these embarrassing errors. Especially has fracture of the acetabular margin, with its bad functional prognosis, seldom been diagnosed before the advent of the rays, fracture of the neck of the femur generally having been assumed. On the strength of skiagraphic information the author was able to remove acetabular splinters with safety, thus restoring functional ability in two instances.

The rays also show that a sharp line of distinction between intracapsular and extracapsular fracture of the neck of the femur cannot be drawn, and that in the so-called extracapsular variety the fracture line generally extends into the intracapsular region, and conversely that in intracapsular fracture the fracture line often extends somewhat outside the joint. The principles of treatment must be modified accordingly.

The skiagraphic proof of the presence of impaction implies the omissions of many manipulations, and suggests immediate immobilization in the impacted position.

The diagnosis of isolated fracture of the trochanter major will also no longer be confounded with contusion.

Fig. 99 shows fracture of the neck of the femur in a girl of fourteen years. It is interesting to note the transverse position of the fragment, while the normal femoral neck of the healthy side shows a longitudinal direction.

Fracture of the *femoral diaphysis* can be easily diagnosticated as such without the aid of the Röntgen rays. Still, in view of the

Fig. 99.—Fracture of Femoral Neck.

well-known tendency of displacement, recognition of the exact relations of the broken fragments is of great practical importance. After reposition is accomplished and an immobilizing dressing applied, it is advisable to ascertain by skiagraphic examination whether apposition is perfect. One is often surprised about this aberration, the fragments still being displaced to one side or another. Then there is still enough time to correct after the dressing is again removed. (See Chapter XVI on Corrections.)

The necessity of always taking two skiagraphs in different projection planes is also illustrated by Figs. 33 and 34. The frontal skiagraph, Fig. 33, represents the fracture of a boy of seven years sustained seven weeks before being skiagraphed. It shows angular deformity only, which would suggest no other correcting procedure than inward pressure. But Fig. 34, taken in the dorsal position, shows malunion, the fragments overlapping each other. A condition of this kind would certainly not be corrected by such simple interference.

The direction of the fragments also suggested the direction of the force which had to be alongside and parallel to them. This was accomplished by placing the anæsthetized patient at the edge of the table where manual force sufficed to separate the fragments,

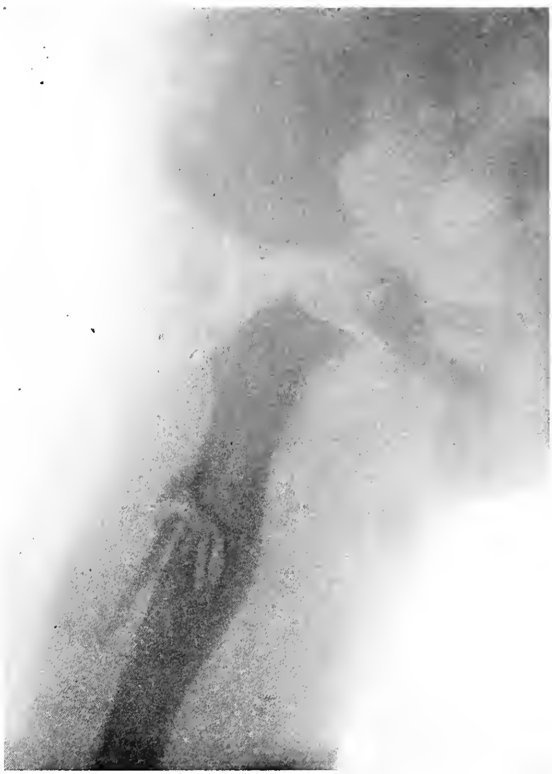

FIG. 100.—FRACTURE OF FEMUR, FOLLOWED BY NECROSIS. (See Fig. 101.)

so that the lower one could be pulled downward into proper apposition. Recovery was perfect, no shortening being present. If this procedure had been unsuccessful, separation by the chisel would have been resorted to. As to the question of translucency in this case, see p. 52.

Fig. 100 illustrates the case of a boy of seven years who was thrown from the roof of a six-story house, the wash-lines in the yard fortunately diminishing the force of the fall. He sustained a compound fracture at the upper third of the femur, and was discharged from the hospital four months after the accident. When the author saw the patient for the first time there was still disturbance of function, and a fistula in the middle of the thigh discharged a moderate amount of pus. The skiagraph revealed the presence of four bone-splinters, three being exfoliated from the cortex and one lying in its coffin in the centre. Their removal under the guidance of the rays was a matter of ease, because their size, shape (Fig. 101), and position could be ascertained beforehand. Thus the exact direction as well as the length of the incision could also be determined.

FIG. 101. — SEQUESTRA INDICATED BY SKIAGRAPH FIG. 100, AFTER REMOVAL.

The large splinter, which is recognised as exfoliating from the outer aspect of the femur, could be felt on introducing the probe, but nothing pointed to the presence of the other splinters. Without the Röntgen method the author would probably have been satisfied with the extraction of this large splinter, and might not have thought of the probability of the presence of the other sequestra until the continuation of the suppuration would have called his attention upon so deplorable a fact. And this might not have occurred until months afterward, while under the present favourable circumstances recovery was perfect after six weeks.

Femoral Aneurysm.—In studying the current literature on this subject one gets the impression that the diagnosis of femoral aneurysm is very easy. It is true that in the majority of cases the symptoms are well marked, and the diagnosis can be made on simple inspection. But in some instances, as the following case will show, the greatest diagnostic difficulties may be offered.

The patient, a healthy man of sixty-nine years, was struck heavily by an iron bar at the lower third of his left thigh three years before being examined first by the author. He was laid up for several weeks, constant pain being present in this region. Later the pain was supposed to be rheumatic, until the patient noticed a tumour of the size of a lemon in the same area, which gradually increased, the pain sometimes being intense. The surface of the tumour becoming red and tender, slight fluctuation also being assumed at several places, the development of an abscess was thought of. Immobilization and fomentations reduced the inflammatory signs and the swelling decreased somewhat.

When the author saw the patient for the first time he found a very large, well-defined ovoid tumour of extreme hardness, a small area of it only appearing elastic. There was *not the slightest sign of pulsation* within the extent of the tumour, which reached from the internal femoral condyle up to the groin. Nothing abnormal could be detected at the lower leg or foot.

There had been slight fever as long as the inflammatory process had lasted, but now the temperature was normal and the pulse 84. Considering the seat, the slow growth, the immobility, the bone-like hardness, and the entire absence of pulsation in the tumour, the author thought that the favourite neoplasm of this region might be present—viz., the osteosarcoma, originating from the femoral epiphysis. This could have meant disarticulation of the diseased extremity. But before resolving on such a grave suggestion the author determined to consult the Röntgen rays. The skiagraph revealed the absolute integrity of the femur, thus excluding the possibility of osteosarcoma. Exploratory aspirations yielded blood, the microscopical examination of which showed nothing extraordinary. Echinococcus appeared to be improbable, in view of its extremely rare occurrence in this country. Osteomyelitis could be excluded definitely on the basis of the history. In osteomyelitis, because of its transparency, a focus would also have shown itself on the skiagraphic plate, and the same would be true in the case of necrosis.

There was, however, the possibility of a sarcoma of the sheath of the femoral artery, or of a fibroma, originating from the intermuscular tissue and fascia, or of an angiolipoma.

In view of these diagnostic uncertainties, the author thought it best to resort to an exploratory incision in order to exsect a portion of the tumour for microscopical examination.

After making an incision alongside the inner margin of the sartorius muscle, the fibres of the vastus internus muscle were divided with great care. But in spite of these precautions, a jet of arterial blood sprang up, and now the riddle was solved. A large femoral aneurysm was situated above the adductor. By forcible pressure the hæmorrhage was stopped until Esmarch's bandage was applied, and the author ligated the femoral artery in Scarpa's

Fig. 102.—Popliteal Aneurysm, showing Phlebolith.

triangle. The large sac, which was entirely filled up by fibrin-clots, was now exsected.

It seems probable that the aneurysm was of traumatic origin, dating from the injury sustained three years ago. The arterial walls having been squeezed and partially crushed, the artery became dilated; and from the enormous thickening of the sac it would seem that this dilatation was followed by abundant cell-proliferation in the arterial walls and their vicinity. There was also an enormous amount of pale fibrin in tough layers. One of the fibrin clots showed the circulatory channel, the calibre of which was much smaller than that of a normal femoral artery. All these points would account for the absence of pulsation.

Fig. 103.—Popliteal Aneurysm (Compare Skiagraph Fig. 96).

While in this case the Röntgen rays failed to give any positive information as to the character of the tumour, the shadow caused by the aneurysm being so slight that interpretation would have been hazardous, they were of great value inasmuch as they excluded several possibilities—viz., osteoma, osteochondroma, and osteosarcoma. (As to Osteosarcoma and Syphilis, see Chapter XIII.)

Fig. 102 illustrates a *popliteal aneurysm* in a man of fifty years who had sustained an injury of the popliteal space three years before being skiagraphed. The outlines of the large sac are not very marked, but could still be recognised. Most of the details are lost in the reproduction. At the inner margin a phlebolith is shown. The tumour did not pulsate at all. It was only on auscultation that a bruit was observed. The thickness of the sac (Fig. 103), as shown after extirpation, explains this rare phenomenon.

KNEE-JOINT

A good skiagraph of the knee-joint (Fig. 104) illustrates its anatomical relations better than any of the illustrations in the text-books on anatomy, no matter how beautiful they may appear. Being the frequent seat of simple as well as of traumatic and tuberculous inflammations, it offers many opportunities for skiagraphic differentiation. Recognition of the various injuries of the knee-joint has become much easier, since we are able to show

Fig. 104.—Normal Knee-joint.

even a displacement of one of the menisci tibiæ. Floating bodies in the knees can be located and calcification of the popliteal artery is easily recognised.

Patella.—While the diagnosis of a fracture of the patella by the ordinary method is easy, as a rule, there are instances reported in which contusion or impaction has been assumed. But the skia-

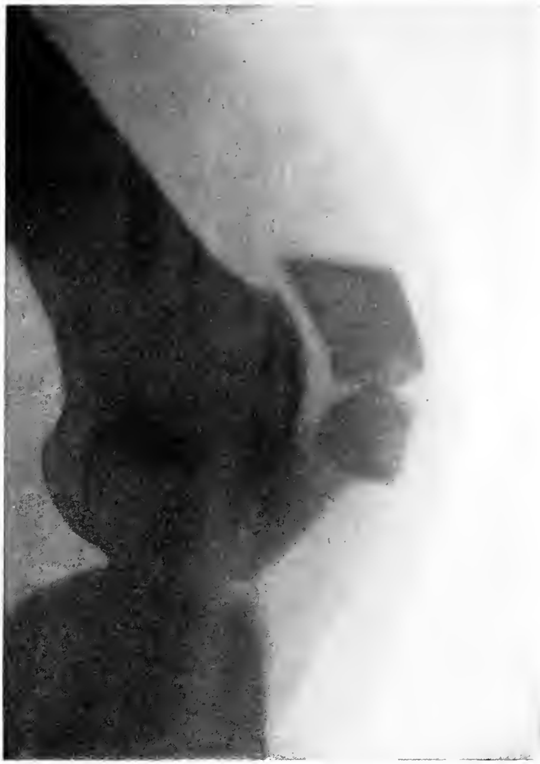

FIG. 105.—PATELLAR FRAGMENTS TURNED AFTER WIRING.

graph has revealed the presence of multiple fractures. It is true, that if the injury is examined just after the fracture occurred, crepitus is generally produced, but afterward the intervention of blood-clots between the fragments prevents its production.

If the periosteal coat of the patella remained intact there is no displacement, and consequently no crepitus. The same rule applies to fracture of a small portion of the patella.

It is evident that in case of extreme extravasation, when, for instance, the præpatellar bursæ are distended by coagula, palpation of the fragments becomes so difficult that the injury may be taken for contusion of the knee-joint.

With few exceptions union in transverse fracture of the patella, if not sutured, fails to become osseous, fibrous bands filling up the gap between the fragments. In such an event the function

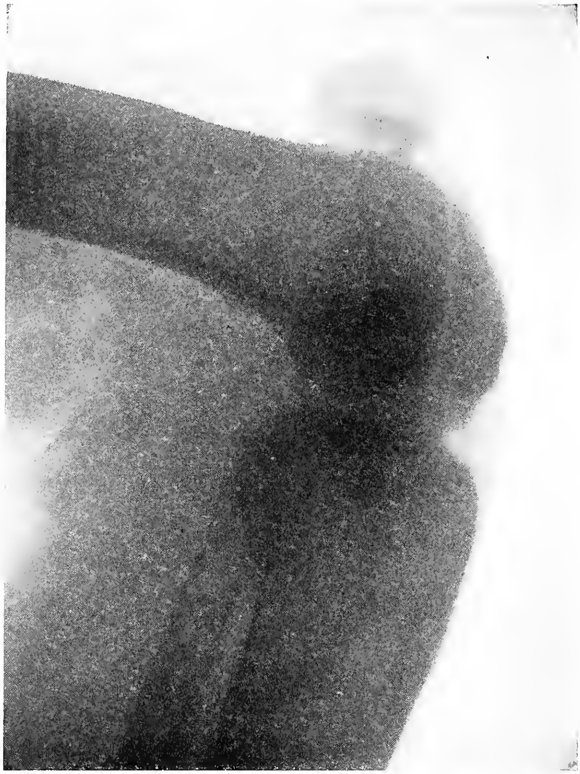

FIG. 106.—DIASTASIS OF PATELLAR FRAGMENTS TWENTY YEARS AFTER THE INJURY.

of the joint is impaired—inability to perform extension and thorough flexion, considerable atrophy of the muscles and greater or lesser degree of knock-knee being the predominating symptoms. While those patients who follow a light occupation may not be incapacitated and can carry their burden with the aid of a knee-cap, working men are deprived of their means of making a living by not possessing the use of their limb. This shows how important it is, when the question of an operation turns up, to have an exact anatomic representation of the area involved—in other words, a good skiagraph.

Whether an indentated plaster-of-Paris dressing will in cases of little or no diastasis suffice to hold the fragments together, will best be determined on the basis of a skiagraph. And, furthermore, whether this mode of immobilization was successful in keeping the fragments in apposition will be ascertained by skiagraphic examination made through the plaster-of-Paris dressing thereafter. This indentated dressing consists in applying the plaster bandages around the surgeon's fingers, while the displaced fragment is tightly grasped and pushed down by an assistant.

FIG. 107.—TRANSVERSE FRACTURE OF THE PATELLA.

Thus a wall is formed around the digital impressions, which, after becoming dry, holds the reduced fragments in place.

Whenever apposition by this bloodless method is tried in vain, wiring should be performed. This is done by introducing a long and strong needle armed with silver wire into the quadriceps tendon just above the patellar margin and through the patellar ligament on the lower margin of the lower fragment, the wire being twisted above the middle of the fracture line and its ends protruding through the suture line of the skin.

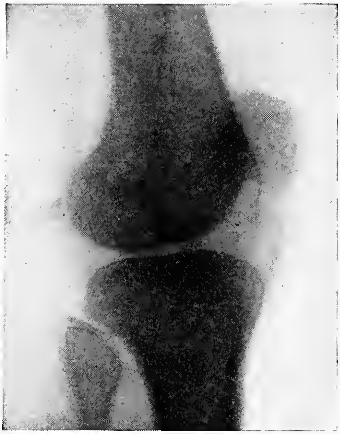

FIG. 108.—NORMAL SESAMOID OF THE SEMITENDINOSUS MUSCLE.

It could be observed by the author, thanks to the Röntgen method, at an early stage, that the fragments became separated because muscular traction broke the wire. This observation makes it imperative to select very strong wire for this special purpose. Fig. 105 illustrates a case in which the fragment turned outward because the wire broke three weeks after the operation.

Fig. 106 illustrates the immense diastasis of the fragments in a man of fifty years who sustained the fracture twenty years ago. His walking was rendered uncertain so that he slipped repeatedly, which resulted in a fracture of both wrists, the humerus, and several ribs at various intervals.

Fig. 107 shows a considerable gap caused by a transverse fracture of the patella, in a man of thirty-two years. The patient was a letter-carrier and when showed the skiagraph he realized fully that for the thorough restoration of the function wiring was necessary, the diastasis being too large to be overcome by an indentated dressing. The results of these operations are always good, provided thorough aseptic precautions are taken and the hands kept off the tissues.

Regarding the *popliteal space,* it must be borne in mind that a well-defined shadow sometimes shows in it which might be taken for a bone fragment or a foreign body, but which in reality is a normal sesamoid of the semitendinous muscle (see Fig. 108). This sesamoid is found in about 8 per cent of all persons examined.

As to phleboliths, compare Fig. 102.

Differentiation between bony and fibrous *ankylosis* is now easy.

This is most important, since bony ankylosis can be remedied only by separation by a chisel, while in fibrous ankylosis forcible motions may be resorted to. Fig. 109 illustrates a case of osseous ankylosis, which did not seem to be a favourable object for operation.

In *tuberculosis of the knee* the progress of healing can be observed by the rays after resection as well as after the injection of iodoform glycerine. While a normal knee-joint shows marked regularity of the outlines of the articular surfaces, the contours of a tuberculous knee appear irregular and diffuse, and the interarticular gap is enlarged. Later, when cheesy foci have formed, their areas become translucent. The cartilage is sometimes en-

FIG. 109.—OSSEOUS ANKYLOSIS OF KNEE.

tirely destroyed and produces no shadow. As to further details, compare section on Tuberculosis, Chapter XIII.

The best skiagraphs are, as a rule, obtained in the lateral position, the external condyle resting on the plate. The dorsum must be well supported during this procedure. As a rule an exposure of two minutes is sufficient in an adult. To show details, the use of the diaphragm is necessary, by which the outlines of the joint, the interarticular space, the eminentiæ intercondylicæ, and the condyles are well represented. The patellar ligament and the infrapatellar and suprapatellar bursæ must also be recognised.

No attempt should be made to remove a foreign body before skiagraphic evidence is furnished. How disappointing it will often be if this advice is disregarded, is illustrated by the case of a man of twenty years who was shot in the middle of the right femur. Suffering considerable pain along the thigh, he demanded the immediate removal of the bullet. It seems pardonable in this case that the family physician should attempt to extract the bullet without the aid of the Röntgen rays. He was punished, however, for his adventurous attempt. Although the soft tissues were exposed to a great extent, from the middle of the thigh down to the knee, he could not find the bullet. When a skiagraph was taken at last, the bullet was located in the knee-joint near the popliteal space. Extraction could then be performed in a few minutes, a small incision having proved to be sufficient for the purpose. While there was no reaction within the knee-joint, the patient had to suffer for weeks from the large gaping wound of his thigh, which was the result of the futile and prolonged searching.

It is a deplorable fact that this *modus operandi* still corresponds to the every-day routine of a number of surgeons.

LEG

When we realize that *fractures of the leg* constitute about 16 per cent of all fractures, and that they show a great tendency to displacement, the importance of the Röntgen rays as a controlling means during treatment becomes evident at once. Fig. 110 illustrates an oblique fracture of the tibia in a boy of ten years, showing slight axial displacement only, which suggested a small degree of downward pressure on the anterior aspect of the tibia.

Fig. 111 illustrates the same type of fracture in a boy of eight years. There is a moderate degree of angular displacement, and the considerable gaping at the anterior side suggests *forcible* downward pressure.

Fig. 112 illustrates that type which is called fracture *à la bec* *de flûte* in a boy of nine years. The skiagraph suggested simple immobilization, since there were no signs of displacement.

As to the necessity of taking two skiagraphs in different projection plans, see Chapter XVII on the Medico-Legal Aspects of the Röntgen Rays (Figs. 259, 260).

The presence and extent of osteomyelitis, so frequently found in the tibia, can be diagnosed by the rays, the focus of the dis-

FIG. 110.—OBLIQUE FRACTURE OF THE TIBIA, SHOWING SLIGHT AXIAL DISPLACEMENT.

ease always appearing well marked. The ease and security with which operative procedures in these cases can be carried out under the control of the rays cannot be too strongly emphasized. Just as in osteomyelitis of the femur and humerus it was deemed advisable in former years to chisel up the whole length of the bone in order to be sure that every possible focus had really been reached. Now the skiagraph shows the length of the incision that is necessary for a thorough removal. It is naturally easier to represent the foci in the tibia than in the femur. Periosteal proliferations are especially well shown at the tibia.

Fig. 111.—Fracture of Tibia, showing Anterior Gaping.

In cases of mal-union, the rays indicate the mode of correction, thus simplifying a hitherto complicated procedure. The arrest of growth of the tibia after operations for necrosis can be well studied. Rachitis and tuberculosis also offer a wide field for study in this region. See chapter on these special diseases (Chapter XIII).

Osseous cysts at the upper as well as at the lower end of the tibial epiphysis are not of infrequent occurrence. They are confounded sometimes with osteosarcoma—a most unfortunate accident, indeed, since it would usually mean unnecessary amputation. As will be emphasized in the chapter on osseous cysts, the outlines of the bone in osteosarcoma are more or less irregular and indefinite, some areas even appearing entirely translucent; while in osseous cysts the cortex appears thin and narrow, but well marked and regular. The fluid centre of the bone is entirely translucent, the light shadow showing the same regularity. The adjacent epiphyses are normal.

The principles of examining the leg by the Röntgen method are essentially the same as those observed in studying the thigh. For textural details the use of the diaphragm is recommended.

The Ankle-Joint and its vicinity are frequently the seat of injuries and diseases of various kinds. The history of the faulty diagnosis in this region would fill many volumes. Nowadays, differentiation between fracture, dislocation, distortion, contusion, and inflammatory processes is not only easy, but the mode of reposition as well as of the after-treatment is also materially influenced by the skiagraphic findings.

If in the much-dreaded malleolar fracture the Röntgen rays show the direction of the fragment to be upward, downward pressure must naturally be used by the surgeon, and *vice versa*. If the direction of the fragment is lateral, sideward pressure is indicated. After reposition is accomplished a plaster-of-Paris dressing is applied in proportion to the tendency to displacement. (See Fig. 113.) As alluded to before, the screen or skiagraph indicates, then, whether reposition was perfect or not. If imperfect, the dressing must be removed and the position corrected. The character of the mistake made being recognised now, proper reposition can be expected with a greater degree of probability. But if the surgeon has failed again, he must change his dressing until the Röntgen guide shows him that he has succeeded in his efforts at reduction.

Fig. 112.—Fracture à la Bec de Flûte of the Tibia in a Boy of Nine Years.

The text-books generally speak of one kind of displacement only. That such information is insufficient is proved by the Röntgen rays. Fig. 114, for instance, represents a Pott's fracture in a woman of thirty-five years. The fact that the internal as well as the external malleolus was fractured had been ascertained before the Röntgen rays gave detailed information, since ecchymosis, intense pain, crepitus, and abnormal lateral mobility at the ankle were present.

The author was taught that reduction is best accomplished in such cases by pushing the calcaneum inward and forward. He has been surprised that in spite of carefully controlling the after-treatment, which consisted in the application of a Dupuytren's splint, an unsatisfactory result was obtained in most of his cases. Finding undue prominences around or below the malleoli, he consoled himself that there was excessive callus formation.

Fig. 113.—Dressing in Pott's Fracture, as indicated by Skiagraphic Anatomy.

The Röntgen rays have shown the fallacy of such theories. What we so readily used to term callous proliferation was nothing else but a projecting piece of bone-fragment, adherent in a displaced position.

Skiagraph 114 shows that while the fibular fragment is laterally displaced, the tibial is directed downward. Naturally, inward pressure upon the fibular fragment must put it into perfect apposition. But the tibial fragment could not be reduced laterally because it would meet an obstacle in the astragalus, to which it descended. But even if there was really no obstacle, the fragment could not be pushed into its normal position by being pressed inwardly because of its descension. The skiagraph, by showing us the downward displacement of the fragment, tells us distinctly that proper reduction can be accomplished by ascension only—in other words, by pressure in the *upward direction.* It is only thus that the widening of the mortise is prevented and the normal arch restored.

The immobilizing dressing must be applied after the same principles. In this case the foot was immobilized after being turned inward in club-foot shape, because this position permitted of ascension—in other words, of the thorough adaption of the internal fragment to the tibia, as the rays proved.

FIG. 114.—POTT'S FRACTURE.

No dressing accomplishes the purpose of retaining the fragments better than plaster of Paris, since it adapts itself to the contours of the limb in any desired shape or direction. The plaster-of-Paris dressing may be applied at once, provided there is thorough reposition.

Fig. 115.—Fracture of the Internal Malleolus Reduced.

From this experience we learn that the proper treatment of this type, just like many other fractures, is based upon individualization. And this can very seldom be carried out without resorting to application of the Röntgen rays.

In the case of a boy of twelve years, illustrated by Fig. 115, it was the tibial fragment only which was displaced. Reposition was accomplished after the principles emphasized in the case just described. There was considerable descension, which, as the skiagraph, taken two weeks after reduction, shows, was well corrected.

How important it is to take at least two skiagraphs in two different projection planes is illustrated by Figs. 116 and 117, which represent a Pott's fracture associated with enormous displacement in a man of forty years. Fig. 116 shows the fractured internal malleolus very distinctly, while the fibular fragment is veiled. At the same time backward displacement of the foot appears well marked. During the exposure the external surface of the foot rested on the plate. Fig. 117 taken in slightly oblique antero-posterior direction, the posterior aspect of the leg resting on the plate, does not indicate the enormous backward displacement of the foot, but shows both fragments markedly. In other words, the deficiency of Fig. 116 consists in not showing the exter-

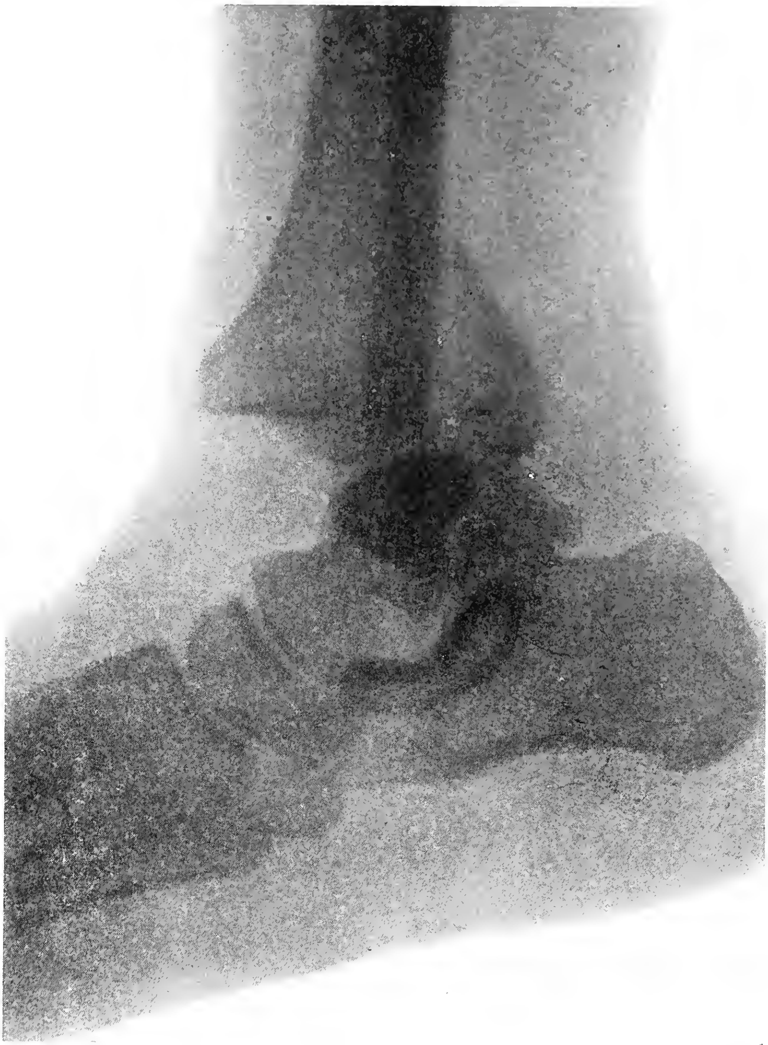

FIG. 116.—FRACTURE OF BOTH MALLEOLI, ASSOCIATED WITH BACKWARD DISPLACEMENT OF FOOT. (Compare Fig. 117.)

nal malleolus well enough, while Fig. 117 fails to indicate the backward displacement of the foot. On the other hand, each skiagraph shows one part of the injury better than the other, thereby supplementing each other.

In former years the author would not have thought that he could succeed under such aggravating circumstances in getting

Fig. 117.—Case illustrated by Fig. 116, in Oblique Antero-posterior Projection.

a good functional result, while with the Röntgen guide reposition was not only accomplished without the use of an anæsthetic, but the functional result was also blameless. As is evident from the observation of the cases described, the ankle-joint must always be examined in different positions. To obtain a good antero-posterior view the use of the diaphragm is necessary (see Fig. 25). This is best accomplished while the patient assumes the recumbent position. Or a board, like the well-known Volkmann's resection splint, may support the planta pedis in this position. With a gauze bandage the foot is fastened to this plantar support. Sometimes an Esmarch bandage is preferable for thorough immobilization during the exposure. Sand-bags must be placed then around the ankle-joint as well as the knee. The time of exposure should be two to two and a half minutes. In the lateral position a good skiagraph can be obtained without such preliminaries, but it must be considered that a representation in this position is far less important than that in antero-posterior projection, as far as the proper analysis of the ankle-joint is concerned. The time of exposure in the lateral position may be somewhat less than two minutes.

The healing process, after operation for *pes equinovarus* and *valgus,* can be easily studied and influenced accordingly. Most cases of so-called distortion prove to be fractures pure and simple when looked at by means of the "Röntgen eye-glass." Sometimes very small splinters are represented which are severed from the bone surface. They are embedded in bloody effusion, which prevents their recognition by palpation, so that naturally a diagnosis of "sprain" is made. Massage can seldom be borne by the patient, because the friction caused by this treatment presses the sharp splinters forcibly against the injured bone. The patient will, on the other hand, be comfortable if treated after the general principles of fracture treatment—i. e., immobilization.

If there are no little bone fragments, but only hæmatoma from lacerated tissue, massage is the treatment *par excellence,* of course, and immobilization means unnecessary delay.

FOOT

Astragalus and Calcaneum.—Fractures of the *astragalus* and *calcaneum* were often confounded with Pott's fracture, the final surgical result naturally being very unsatisfactory. Minute anatomical knowledge is necessary to appreciate a skiagraph of these bones thoroughly. Fig. 118 shows fracture of the calcaneum, causing slight downward displacement, in a man of thirty-eight years, two months after the injury.

How misleading the lack of such knowledge may become is evident from the fact that the os intermedium cruris (os trigonum tarsi) has been mistaken for a fragment severed from the astraga-

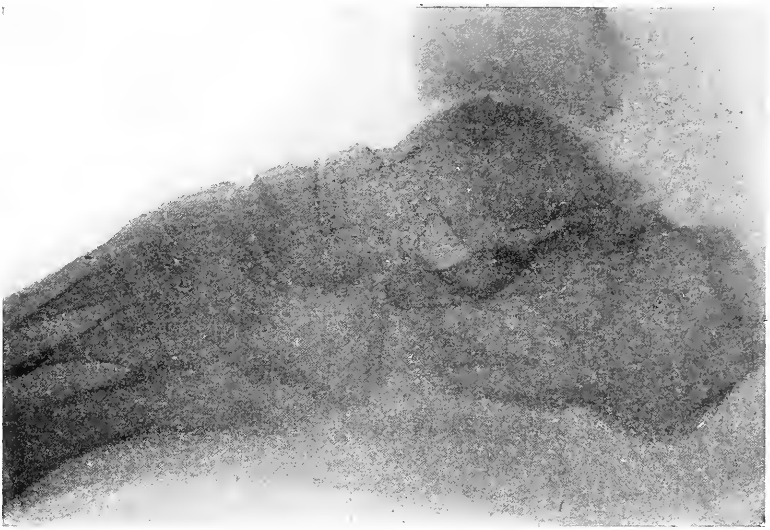

Fig. 118.—Fracture of the Calcaneum.

lus. This bone is a typical part of the tarsus of all mammalia, and its frequency is estimated at from 7 to 8 per cent. Shepherd, who mistook this bone for a fractured fragment, says: "The fact that this fracture is not mentioned in any of the text-books on surgery or in special treatises on fractures would easily be accounted for by its only being discovered by dissection; it causes no deformity, and the symptoms it would cause during life would probably be obscure." The same author tried to produce this fracture artificially on the cadaver, but "in every case," he says, "where this manœuvre was performed, I failed, even when the greatest force was used, to break off a little process of the bone mentioned above." Pfitzner regards the os trigonum tarsi as an integral part of the posterior process of the astragalus in the adult, which is analogous to the os intermedium antibrachii. Fig. 119 shows a normal os intermedium cruris at the posterior aspect of the astragalus. This condition was detected accidentally when the patient was skiagraphed after his foot was crushed by an elevator. The ossa cuneiformia were shattered.

The examination of the tarsal bones is best done in the lateral position. A skiagraph, taken in this position, shows the ankle-joint as a well-marked line. The interstices between the astragalus and the calcaneum, between the cuboid and the calcaneum, the cuboid and the metatarsal bones, the scaphoid and the cuneiform, and the astragalus and the scaphoid must also appear distinctly. The tendo Achillis is well recognised. Arteriosclerosis of the arteria tibialis postica and antica show well in this position. The use of the diaphragm is recommended only for the representation

FIG. 119.—FOOT SHOWING OS TRIGONUM TARSI.

of osseous foci or articular affections in this region, although the structural details are generally fairly well shown without it. The time of exposure varies between one and two minutes, the vacuum of the tube to be taken low.

The isolated fracture of the *other tarsal bones* was seldom recognised in a living person prior to the discovery of the Röntgen rays. While the foot is easily skiagraphed in the direction of the dorsum towards the planta pedis from the toes up to the upper third of the metatarsus, the first and third cuneiform bones and the scaphoid offer an obstacle, so that it is necessary to skiagraph these portions transversely by having the outer surface rest on the plate. It is by this procedure only that the isolated shadows of the astragalus, the calcaneum, the os cuboideum, the scaphoid, and the fourth and fifth metatarsal bones can be distinctly outlined, so that false interpretations can be excluded (see Fig. 24).

In children short exposures should be striven at, the difficulties of keeping them quiet being great. Fig. 173 illustrates a case of synostosis of the first and second metatarsus in a child of two weeks. Although the exposure lasted a few seconds only, a distinct reproduction was obtained, the foot being firmly pressed down on a table by the fingers of an assistant while the planta pedis rested on the plate.

A good skiagraph taken in antero-posterior projection must show the outlines of Lisfranc's as well as Chopart's joint—that is, the metatarsal bones must show individually separated.

METATARSUS

As indicated above, the metatarsus is represented best while the patient is seated on a chair, the planta pedis resting on the plate.

Our knowledge on the pathology of the much-neglected metatarsus became greatly widened by the Röntgen method. Especially the true appreciation of its injuries is entirely due to the rays. And injuries of the metatarsus are of extreme frequency.

As to fractures, it may be said that it is generally accepted that their superficial location makes their recognition easy. Still, while this may be true of the first and fifth metatarsal bones, on account of their accessibility, the dense tendinous and ligamentous tissues overlying the second, third, and fourth metatarsi are apt to veil the fracture signs within their tract. The difficulty of differentiation is much greater when, as is the rule, the fracture is associated with injuries of the soft tissues, causing œdema and swelling.

How often metatarsal fracture has been overlooked can be estimated by the fact that, before the discovery of the Röntgen rays, most cases of fracture of the second or third metatarsal bones were mistaken for pathological change in the soft tissue—in the German army known as "foot œdema." It was reserved for the Röntgen rays to disclose the fact that this much-dreaded condition was a fracture pure and simple, and that it was produced by overburdening the marching soldier (Stechow).

Text-books give but little treatment for metatarsal fracture, most of them saying that it requires neither detailed description nor any special mode of treatment. A few maintain that if there is any displacement it will be towards the dorsum of the foot. Only Hoffa alludes to the possibility of plantar displacement also. But nowhere is reference made to the lateral displacement, which we regard as of not infrequent occurrence, and also as an important complication, since it is always followed by considerable functional disturbance. The fact that the lateral displacement was never before recognised explains fully why efforts of reduction have been neither made nor advised; consequently the fragments left to themselves, whether in a general immobilizing dressing or not, unite in a deformed position, and bony enlargements, as well as functional disturbances are the result. The œdematous feet of persons who must work hard, or march or stand on their feet during the whole day, furnish a striking illustration of the consequences of badly united metatarsal fractures, as they are disclosed at the present time by the Röntgen rays. It is obvious that the more accurate and varied the diagnoses are which these rays enable us to make, the greater difference there must be in our plans of treatment. The experiments of the writer have shown that metacarpal fragments are held in place by elastic pressure (see section on Metacarpus). The same principles obviously apply to metatarsal fracture.

For the fracture of a displaced metatarsal bone, two rubber drainage-tubes of moderate size are chosen and lightly pressed into the adjoining interosseous spaces at the dorsum so that they fill them to a certain extent. If two metatarsi are fractured, three drainage-tubes are necessary, and so on. The tubes are kept *in situ* by strips of adhesive plaster; thus the recurrence of the displacement is absolutely prevented. The dorsum is then surrounded by a moss-splint, a material that after being dipped in cold water adapts itself to the contours of the foot like a cast.

The whole is protected by a plaster-of-Paris dressing which reaches from the toes to the lower third of the leg. The patient remains in bed for about ten days. Then an ambulatory dressing is applied after the principles elucidated above.

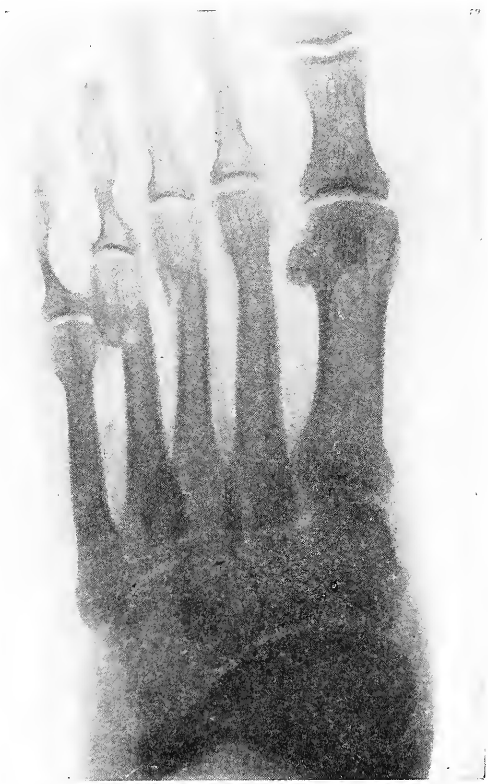

FIG. 120.—FRACTURE OF SECOND AND THIRD METATARSUS, FOLLOWED BY LATERAL DISPLACEMENT.

When skiagraphed through the plaster-of-Paris dressing the formerly displaced fragments should be found in exact apposition. If not, the dressing must be reapplied in the correct position. There is no doubt that in pursuing these therapeutic principles, which are based on a correct anatomic diagnosis, alleged metatarsalgia and similar ailments will become very rare affections.

Many cases of so-called neuralgia, neuritis, rheumatism, osteomyelitis, suspected tuberculosis, etc., belong to the same category. The small bony enlargements of the foot, its broadening, and sometimes the callosities following metatarsal fracture, were observed in former years; but they were misinterpreted in the majority of cases, since they were due to the badly united fracture only. Union in a displaced position, especially in lateral displacement, must necessarily lead to compression of the digital nerves. It is evident that treatment of such cases of "peripheral neuritis" can consist only in reducing the fragments to their proper position by osteotomy.

Pain induced by walking points to dorsal or plantar displacement, while metatarsalgia, coming on in a paroxysmal manner, is generally due to lateral displacement. Metatarsalgia is somewhat analogous to coccycodynia, which, as the author proved (see Appendix to his Text-Book on Fractures, p. 288) was produced by fracture in most cases, the fragments also having united in a deformed position.

Fig. 120 illustrates the case of a man of thirty-one years who sustained a fracture of the lower epiphyseal ends of the third and fourth, and a fissure of the second metatarsus. While

Fig. 121.—Fracture of Second Metatarsal Bone.

smoothing the asphalt pavement on the street, holding an iron bar of 40 pounds in his hands, he was knocked down by a street engine which came from behind, so that he fell forward. While the second metatarsus shows only a slight sideward bending, the dentated fragment of the third metatarsus is markedly displaced outwardly. The lower fragment of the fourth metatarsus is not only displaced, but its external portion is also tightly pressed against the fifth metatarso-phalangeal joint. The patient was able to walk in one week in an ambulatory dressing, and made an uneventful recovery.

Fig. 121 shows the fracture of the second metacarpal bone in a man of thirty-six years. The displacement was mainly directed upward. Downward pressure sufficed for reposition, still there was slight lateral deviation, which was overcome by the intervention of a small rubber drainage-tube.

Fig. 122 is a striking illustration of an injury of this kind. The patient, a boy of fourteen years, sustained an injury of his foot three years before the skiagraph was taken. The swelling following the injury was thought to be due to contusion, and the foot was consequently treated by the application of fomentations. The thickening of the injured area, which remained, was supposed to be caused by an inflammatory process, massage as a local and iodide as a constitutional therapeutic agent being administered. The possibility of a fracture, as shown by the skiagraph, was not thought of.

The *sesamoid* (compare Fig. 121) below the head of the first metatarsal bone is sometimes fractured by direct violence, a fact that was also never before recognised.

The various osseous changes of the foot in *acromegaly* (see Fig. 232) are an interesting subject for skiagraphic study. The phalanges appear broader and thicker than normal and show no osteophytes. The metatarsi also show massive structures.

The pathological anatomy of *hallux valgus* and that of *arthritis* of the large toe are also much better appreciated and judged since the advent of the rays. Skiagraphs of the toes are frequently serviceable in the detection of foreign bodies, especially of needles and headless tacks. Malformations, like syndactylism (Fig. 172), etc., can also be well studied. The exact anatomical diagnosis that we are now able to make enables us to determine whether surgical interference is possible, and if so, it outlines the *modus operandi.*

To avoid false interpretations of skiagraphs of children, it should be remembered that the lower epiphyses of the tibia and the fibula show their osseous nuclei in the first and second years, and unite with the diaphysis between the eighteenth and the twenty-fifth year, or, according to skiagraphic evidence, sometimes even before the eighteenth year. The osseous nuclei of the astragalus and of the calcaneum appear intra-utero, that of the cuboid shortly before or after birth, that of the cuneiform between the first and fifth year, and that of the scaphoid from the first to the fifth year. The osseous nuclei of the metatarsal bones and of the

FIG. 122.—MALUNION OF FRACTURE OF LARGE TOE, THREE YEARS AFTER THE INJURY, CAUSING CONSIDERABLE PRESSURE.

phalanges appear from the second to the ninth year, and unite with the diaphysis between the sixteenth and the twenty-second year.

Injuries and diseases of the phalanges are, of course, easily recognised. For a general view the tubal focus should be directly above the first phalanx of the middle toe. For differentiation from arthritis and chronic inflammatory processes skiagraphy is most important. The time of exposure should not exceed half a minute—even in a few seconds useful reproductions of the toes can be obtained under favourable circumstances.

CHAPTER XI

SHOULDER AND UPPER EXTREMITY

Shoulder.—The shoulder is fluoroscoped best while the patient is seated on a chair. (Compare section on the Position of the Patient, page 59.) Skiagraphy may be done in the sitting, recumbent, and abdominal position. A table is less convenient for skiagraphing of the shoulder than the carpeted floor, because the outstretched arm occupies much more space than a table can give, and special attachments are cumbersome.

The respiratory motions interfere to a certain extent with a faultless reproduction. Children tax the patience of the skiagrapher to a great extent because they find it very difficult to keep their arms quiet. Still, as the skiagraphs of the author may show, in most instances a fairly good reproduction is obtained, if patience is exercised.

Irradiation should also be done perpendicularly, the joint itself being regarded as the centre, and the tubal focus being right above it.

A good skiagraph of the shoulder-joint is best obtained from the posterior aspect, if the plate is kept very close to the scapula, the patient being in the recumbent position.

If the Wehnelt interrupter is used, children require about one and a half, thin adults two, and stout adults three minutes' exposure.

If the anterior aspect of the shoulder is skiagraphed, the sigmoid form of the clavicle must appear well marked. The triangular shadow of the scapula can be well differentiated from that of the ribs. Its spine can be followed in its course, running parallel to the clavicle, and ending at the acromion. The acromio-clavicular junction shows a hiatus which in the early days of skiagraphy was mistaken for a diastasis of the joint. An increased knowledge has taught that this apparent diastasis is by no means pathological, and that there is a normal gap between the osseous ends of the acromion and the acromial end of the clavicle. The glenoid cavity, containing the head of the humerus, and the major and minor tubercula should also be well marked (see Figs. 126 and 127). Between the clavicle and the scapular spine appears the dark shadow of the coracoid process (Fig. 124). For structural details the diaphragm is absolutely necessary. The compression diaphragm, however, is contraindicated in certain injuries, if there is, for instance, much effusion in the shoulder-joint or considerable inflammation, which would make its use intolerable to the patient.

Skiagraphy of the scapula is indicated in tumours, especially in osteosarcoma.

Tumours of the clavicle can be differentiated, and atrophy of the clavicle in aortic aneurysm represented by skiagraphy. The true character of pulsating tumours, erroneously taken for subclavian aneurysm, may also be shown (see Fig. 631). Tuberculous foci are sometimes found in the clavicle. It is needless to say that dislocation of the clavicle is easily differentiated from fractures by the aid of the rays.

SHOULDER–JOINT

As to fractures of the shoulder, see Fig. 68.

Fractures of the clavicle are usually recognised easily, but there are cases of impaction and fissure in which no deformity or crepitation is observable, and which could not be recognised except by the aid of the rays. In case of extensive displacement, it is important to control the treatment by repeated observations.

Indeed, the shoulder-joint was formerly regarded as a real crux medicorum. While dislocation, for instance, should be easily differentiated, by the possibility of palpating the joint-surface of the shoulder, there are, in fact, many unrecognised cases.

Fig. 123 shows deformed union after fracture of the *surgical neck* in a girl of fifteen years who fell from a window in the fourth story. The force of the fall fortunately was broken by wash-lines strung below, so that the patient escaped with an extensive contusion of the right foot, a wound of the length of 6 inches at the frontal region, and a fracture of the surgical neck of the right humerus. The competent family physician reduced the fragments at once, but they slipped out again; five weeks later, when the author saw the case for the first time, a protrusion of the lower fragment was noticed, which was united to the small upper fragment in juxtaposition. It was a surprise to find that in spite of the immense deformity there was hardly any functional disturbance

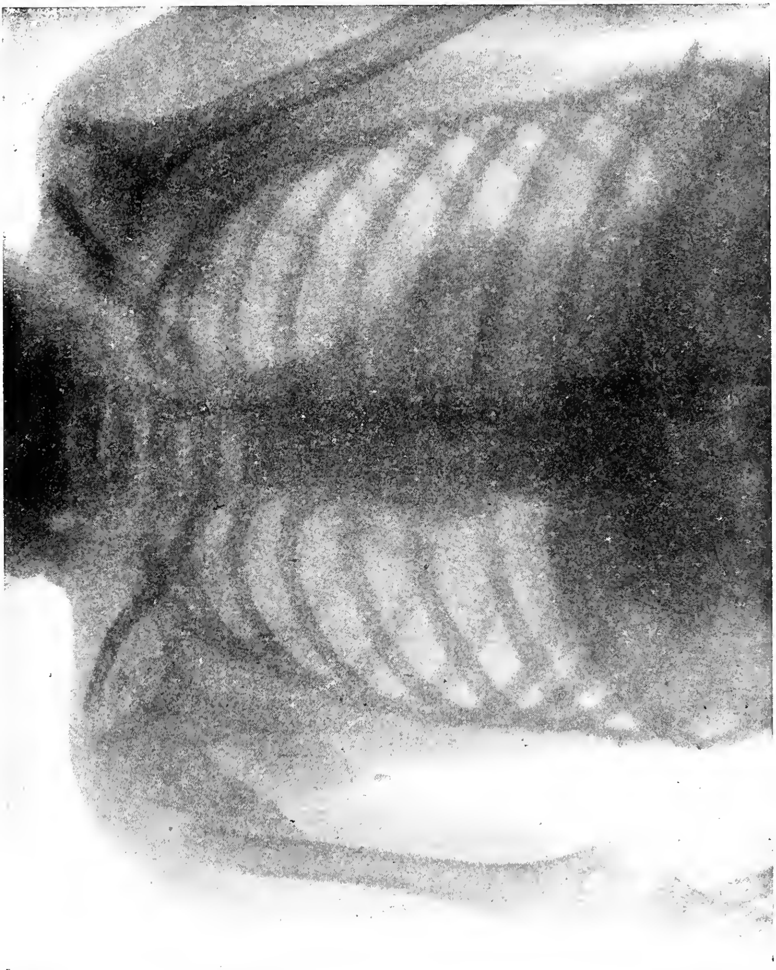

Fig. 123.—Deformed Union in Fracture of the Upper End of the Humerus—Also note the Normal Relations of the Thoracic Organs.

at the time. Osteoclasis, however, was performed, which, while not restoring the fragments to a faultless position, brought them into apposition.

This again shows that the significance of a skiagraph for the purpose of estimating the degree of functional disability is not always conclusive. (See Chapter XVII on Medico-Legal Aspects.)

Fig. 124 illustrates the case of a fracture of the surgical neck of the humerus in a girl of twenty-four years, who was first treated for a contusion, later for rheumatism. Two months

FIG. 124.—IMPACTED FRACTURE OF THE SURGICAL NECK OF THE HUMERUS.

after the injury had taken place a slight swelling could be noticed round the shoulder, especially at the area of the surgical neck of the humerus, but no signs of fracture could be elicited. The disturbance of function was insignificant, the patient being able to elevate her arm considerably. There was occasional pain and weakness. The skiagraph revealed the presence of an impacted fracture of the surgical neck of the humerus. The impaction explains the absence of crepitus and false mobility, which may serve as an excuse for not having recognised the injury in its true light.

Fig. 125 —Deformed Fracture of Surgical Neck of Humerus.

By studying the skiagraph one should assume that the protruding portion of the diaphyseal fragment could be palpated through the deltoid muscle, but the author did not succeed in doing so. This is another proof of the fact that palpation of deep tissues is not only difficult, but its result frequently imaginary.

Similar conditions were observed in the case of a man of fifty years who had sustained the same fracture type six months before the skiagraph was taken (Fig. 125). The diagnosis was contusion, the patient being discharged from the hospital a few weeks after the injury occurred. There was considerable disturbance of function, which was attributed to the atrophy of the deltoid muscle, developing a few months afterward. The skiagraph showed the humeral head united to the diaphysis in an oblique direction. After having studied the skiagraph, the author was able to palpate the protruding portion which had escaped his notice before.

Attention is called to the irregularity of the articular surface of the scapula, indicating osseous atrophy, which went hand in hand with the atrophy of the soft tissues.

In a case of this kind osteotomy should be considered, especially if the patient is poor and has to live from the income of his manual labour.

Just as in intrascapular and extrascapular fracture of the head of the femur the Röntgen rays show that in fracture of the head of the humerus, schematic distinction between the fracture of the anatomical and surgical neck, as well as transtubercular fractures, cannot always be made. In the case of a woman of fifty-six years this was well illustrated. The patient had fallen about five weeks before, striking the right elbow on the pavement. There had been ecchymosis at the elbow at the time, suggesting a fracture there, but no fracture had been found at this point. When examined four days later there had been absolutely no objective symptoms of fracture except a slightly abnormal mobility in the region of the head of the humerus. The pain there was intense. There was, however, no swelling or deformity. The skiagraph (Fig. 126), taken in the antero-posterior projection, showed a fissure line running downward and inward from the tubercles to about the surgical neck of the humerus. Another skiagraph (Fig. 127), taken two weeks later, and viewing the bone from the back, showed a line that might lead one to look upon the case as one of fracture of the anatomical neck. The second skiagraph showed chips of bone—a condition that, as mentioned before, is not infrequently met with in other cases supposed to be only examples of contusion. When such chips of bone can be recognised, the massage treatment for sprains is manifestly inappropriate.

Fig. 126.—Anterior View of Shoulder. (Compare Fig. 127.)

To avoid erroneous interpretations, the fact must also not be lost sight of that the union between the epiphysis and the diaphysis of the head of the humerus is not perfect before the twentieth year.

As a counterpart the case illustrated by Fig. 128 may serve. It represents the shoulder-joint of a lady of fifty-eight years,

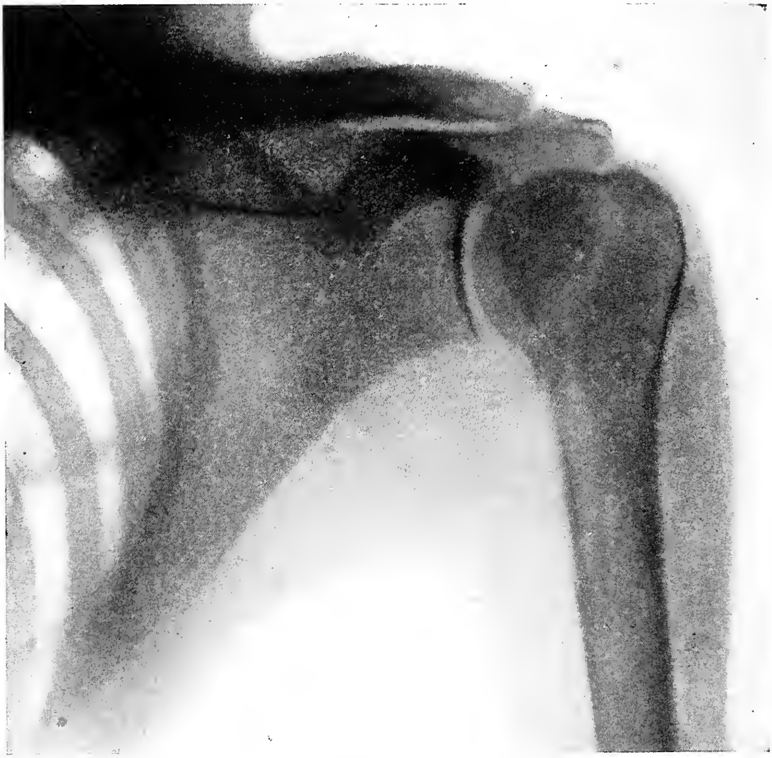

Fig. 127.—Fracture of the Anatomical Neck of the Humerus, Posterior View. (Compare Fig 126.)

who, after having fallen from a chair, had her arm forcibly pulled. Shortly afterward a swelling was noticed around the shoulder, and a fracture suspected. Immobilization was kept up for two months. The skiagraph revealed the absence of a fracture and the presence of an ankylosis, probably due to an inflammatory process, the shadows of both articulation surfaces running into each other. Bloodless breaking up of the adherent area is indicated in such a case.

The *shaft* of the *humerus* is best examined while the patient is seated on a low chair, his extended and slightly flexed arm resting on the examining table. As a rule, a general view suffices: for structural details the diaphragm may be employed. Especially if there are thick muscular layers, or in case of osteomyelitis necrosis, or osseous cyst, it is desirable to obtain well-defined outlines.

In *children* immobilization during exposure is obtained best by the diaphragm. Or a small-sized plate is fastened to the humerus by a gauze bandage. Short exposures should be given whenever possible; of course if the exposure lasted a few seconds only structural details cannot be expected. The bone also appears light then, because a soft tube cannot be selected for rapid skiagraphy. Fig.

FIG. 128.—FIBROUS ANKYLOSIS OF SHOULDER.

129 illustrates the fracture of the diaphysis in a new-born child. Although the exposure lasted a few seconds only, the fracture-line and the angular as well as the axial displacement of the fragments are well represented. The focus of the tube being situated right

above the humerus, it is appreciated why this area appears light, while the other areas show a darker tint.

As to *dislocation*, it is generally assumed that in the frequent subcoracoid type the flattening of the shoulder, the axial change,

Fig. 129.—Fracture of the Diaphysis of the Humerus in a Baby, sustained during Labor. (Rapid exposure.)

and the flat prominence of the anterior aspect of the axillary region should be sufficient indications of its presence. In the subglenoid (axillary) variety a diastasis between the head of the humerus and the acromion is observed. Thus differentiation appears to be easy from a theoretical standpoint. But practical experience shows that in spite of these symptoms many diagnostic errors occur in this direction. Fig. 130 shows a case of old subcoracoid dislocation in a man of forty-three years, who was run over six months before the skiagraph was taken after operation. He was treated for contusion of the shoulder for that length of time. On examining for the first time the author found the shoulder much flattened and the acromion unduly prominent. The joint cavity was empty and the head of the humerus could be palpated in Mohrenheim's groove. The arm was slightly shortened, the motion of the arm greatly impeded, and the patient suffered from intense periodical pain, which seemed to be dependent upon nerve-pressure.

The Röntgen rays revealed the typical signs of subcoracoid dislocation. At the anterior surface of the neck of the scapula a thickened area was noticed, which made the author suspect that there was a co-injury of this portion, but the skiagraph showed the bones to be intact. As the operation proved afterward, the thick-

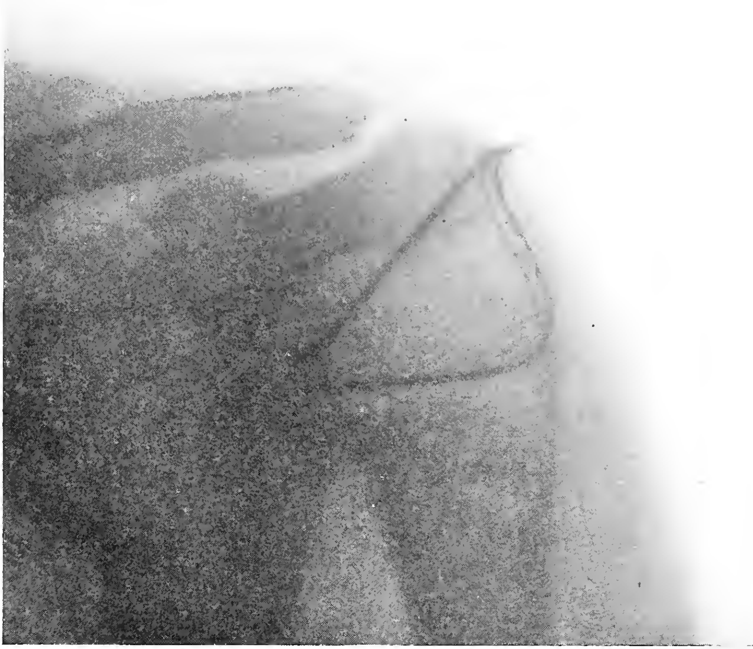

FIG. 130.—WIRING OF HUMERAL HEAD TO THE ACROMION FOR OLD SUBCORACOID DISLOCATION.

ened portion, which might have corrresponded to callus formation, was caused by the presence of fragments of the glenoid capsule, which had formed an irregular mass.

After various methods of reduction were tried in vain under anæsthesia, a nearly semilunar incision was made which began at the acromion, and running over the intertubercular sulcus was extended vertically alongside the anterior surface of the arm. Thus both the joints and the acromion were exposed. After careful and extensive dissection of adhesions the author succeeded in rotating the head of the humerus in its glenoid cavity. There was a pronounced tendency to forward displacement which could not be overcome by additional exposure. Therefore, the author fastened the head of the humerus in the cavity by suturing

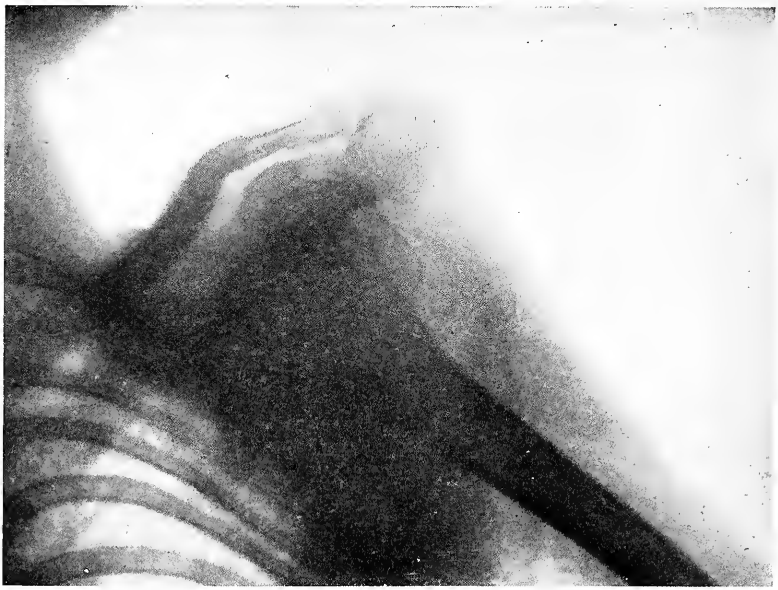

FIG. 131.—SUBCORACOID DISLOCATION OF HUMERUS.

it to the acromion after having drilled a hole through the head of the humerus. On boring, the head was found to be very soft, a fact which was also illustrated by the light shadow of the skiagraph. The skiagraph (Fig. 130) taken two weeks after the operation, showed the humerus in good position. Recovery was perfect. It seems to the author that this procedure is far preferable to the resection of the head of the humerus, as advised by so many surgeons. No force being required, laceration of muscles, blood-vessels, and nerves is avoided.

In a case of habitual dislocation of the shoulder similar steps were taken (see New York Medical Journal, July 14, 1903).

FIG. 132.—GREENSTICK FRACTURE OF HUMERUS.

Fig. 131 shows subcoracoid dislocation in a woman of sixty-five years. Although five weeks had elapsed since the injury was sustained, reposition was successful, prolonged rotatory motions preceding the reducing efforts.

In periostitis or osteomyelitis of the humerus, a preceding trauma is often reported, just as in osteosarcoma. The pain, the œdema, the fever, and the general debility may be sometimes so little marked that differentiation becomes difficult. Such difficulty of diagnosticating this disease is not only removed by the skiagraph, but a trustworthy guide for the operative technique is furnished at the same time. In the case of the girl described in Chapter XIII on Osteomyelitis, the slow onset of the symptoms did not seem to be in favour of an acute inflammatory process. Pain being present only temporarily, the fear of a malignant growth was apparently not unjustified. The skiagraph at once did away with all anxiety, since it justified the presence of a circumscribed osteomyelitic focus.

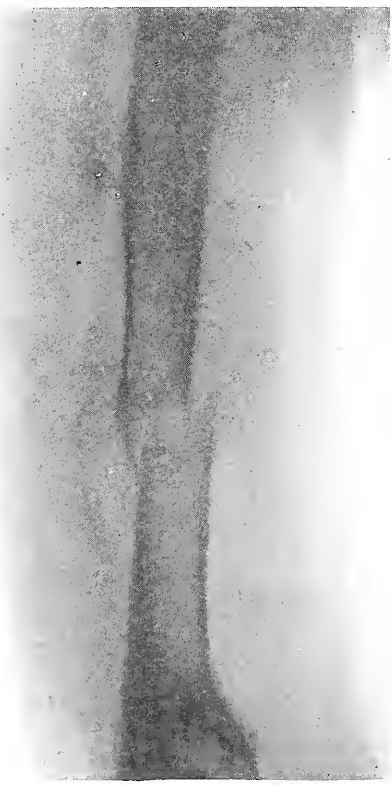

Fig. 133.—Fracture of the Diaphysis of the Humerus, non-united after Nine Weeks.

Fracture of the Shaft of the Humerus.—While fractures of the shaft of the humerus are usually well recognised without the aid of the rays, there are some details that cannot be ascertained without them. Fig. 132 illustrates a greenstick fracture in a lad of nine years. The skiagraph showed that the axis of the humerus was bent. This knowledge enabled the author to redress the fragments into their proper direction three weeks after the injury, the character of which was not recognised. Still, who has never been guilty of misinterpreting some of these injuries? Aside from differentiation between preglenoid and subglenoid dislocation and fracture of the anatomic neck of the humerus, there remain the various inflammatory processes—traumatic, rheumatic, arthritic, syphilitic, and tuberculous—and the tumours, like enchondroma, osteoma, and osteosarcoma. Osteosarcoma can be recognised at an early stage. It should well be borne in mind that most cases of osteosarcoma give a history of a preceding injury, so that the swelling is sometimes erroneously taken for callus proliferation (see Chapter XIV).

FIG 134.—REFRACTURE IN CASE ILLUSTRATED BY FIG. 133.

The healing process in *fractures* can be well studied in Figs. 133 and 134, which illustrate the case of a lady of forty-five years who sustained a transverse fracture at the lower third of the humerus nine weeks before Fig. 133 was taken. At this time the fragments had failed to be united, although as the skiagraph indicates, callus tissue was present in moderate quantity. Where the cortex of the outer portion of the lower fragment joined the medulla of the upper fragment no consolidation had taken place.

It was obvious to shift the protruding fragment into place by inward pressure at the upper and outward pressure at the lower fragment. This procedure resulted in perfect recovery seven weeks thereafter. The function of the arm was not disturbed at all until a year afterward the patient, in falling downstairs again, sustained a fracture at the same place. The skiagraph (Fig. 134), taken the day after the injury occurred, shows considerable axial

FIG. 135.—EXTREME DISPLACEMENT CAUSING DIASTASIS OF FRAGMENTS AND MUSCULAR INTERVENTION.

and angular displacement. At the same time it indicates the presence of a large amount of ensheathing callus, which encircled the upper fragment to such an extent that it assumed the form of a socket. The lower end of the fragment became round shaped accordingly. Thus it seems that while thorough apposition was obtained after the correction of the first injury, consolidation took place by ensheathing callus formation, that is virtually in the same way as it does if the fragments are in juxtaposition. Recovery was perfect seven weeks thereafter.

The *median* as well as the *radial nerve* may become lacerated by the splintering of the bones. This requires immediate neurorrhaphy. Of course, the nerve fragments cannot be represented by the rays, but the location and the character of the fracture, the displacement and eventual diastasis of the fragments, in conjunction with the symptoms in the sphere of these nerves, establish the diagnosis and dictate the operative steps. (See Chapter XVI on Operative Treatment of Deformed Fractures.)

Fig. 135 illustrates muscular intervention caused by excessive displacement in a man of fifty years. The diagnosis could be made by the enormous swelling, the intense pain, and the pressure symptoms in conjunction with the skiagraph.

ELBOW-JOINT

The Elbow-Joint must always be examined in at least two different positions—viz., in pronation and supination. In pronation the forearm is flexed and the arm elevated up to a level with the shoulder, while the patient is seated on a chair, the internal condyle occupying the centre of the plate (Fig. 121). In supination the patient assumes the recumbent position, the olecranon occupying the centre of the plate. The position is often dictated by the subjective condition of the patient. In the case of an inflammatory process or in certain injuries the patient is not able to place his forearm in supination. The humerus as well as the hand may be immobilized by means of sand-bags. In children the plate can be fastened by gauze bandages. The vacuum of the tube must be very low, considering the translucent state of the cartilaginous epiphyses. An exposure of one to two minutes is required if soft tubes are chosen then. As a rule the diaphragm is indispensable in the examination of the elbow-joint. In nervous children short exposures may be resorted to if other means fail, but important details may escape notice then. Tubes provided with a cooling apparatus are especially advisable for such purposes.

If exposure in two different projection planes is omitted important fractures above the condyles may be overlooked. The same applies to the fracture as well as to the isolated dislocation of the radial head.

In *children* the skiagraphic anatomy of the elbow-joint may be falsely interpreted. It should be remembered that the osseous nucleus of the interior of the capitulum humeri appears between the second and third years. Another nucleus shows in the internal epicondyle at the fifth year, a third in the trochlea between the eleventh and twelfth years, and soon afterward a fourth in the internal epicondyle. The nucleus of the internal epicondyle unites with the diaphysis between the sixteenth and twentieth years; but the other three nuclei form a synostosis among themselves at the seventeenth year, then constructing the uniform osseous epiphysis which completes its synostosis with the diaphysis at about the twentieth year.

In very young children the eminentia capitata appears as if entirely severed from the humerus, although the relations are normal. The explanation of this important phenomenon is that the epiphyseal tissues are not sufficiently ossified to produce a shadow on the plate. If these points are not thoroughly considered the diagnosis of a displaced fracture fragment might be erroneously made. The lower epiphysis of the humerus consists of four nuclei, which do not ossify until from the eighth to the seventeenth year. The epiphysis of the trochlea and of the olecranon do not ossify until between the seventh and the twelfth year, which explains why an osseous nucleus is still connected with its neighbouring epiphyseal nuclei, and why the diaphysis, connected by cartilaginous tissue, appears as an isolated piece of bone, which erroneously may be taken for a fragment.

The normal relations of the infantile elbow are evident from Fig. 136, which is that of a girl of four years. Six weeks before the skiagraph was taken fracture of the external condyle was sustained, which accounts for the enlargement of the external condyle and the outward bending of the ulna.

It must also be borne in mind that in fractures in childhood the process of ossification is influenced by various affections of the bone, such as rachitis, for instance.

As stated before, inflammatory processes in the elbow-joint are to be viewed from the same points as those of the knee-joint.

The elbow-joint has always been a source of grief to the medical profession, and it is only since the introduction of the Röntgen rays that more light has been thrown upon the injuries of this joint, and that accordingly the therapeutic results have become satisfactory.

Fig. 136.—Well United Fracture of the External Condyle, associated with Slight Downward and Inward Displacement, and with Outward Bending of the Ulna, the Relations of the Infantile Cartilages being Normal.

Most text-books describe a number of well-marked signs supposed to be characteristic of the various types of these injuries, but before the Röntgen era, the final result, and since the Röntgen era, the skiagraphic result—showed that apparently even the simplest injuries of the elbow were misinterpreted.

Koenig, in his classical text-book on Special Surgery (vol. iii, 1900, p. 229), maintains that "we are but rarely able to make an exact anatomical diagnosis of the most frequent types of fractures of the elbow." This dictum fortunately cannot be substantiated, since irradiation gives us the most detailed information. It is unjustifiable nowadays to attempt the treatment of a fracture of the elbow without a skiagraph. How accurate, in fact, an anatomical diagnosis can be made with the rays is well illustrated by the following cases:

A boy of five years fell from a second-story window, sustaining an injury of the elbow. Besides a few insignificant contusions, there was a fracture of the external condyle of the humerus, and special surgical care was recommended. The patient was transferred to a hospital, where the arm was immobilized in an ex-

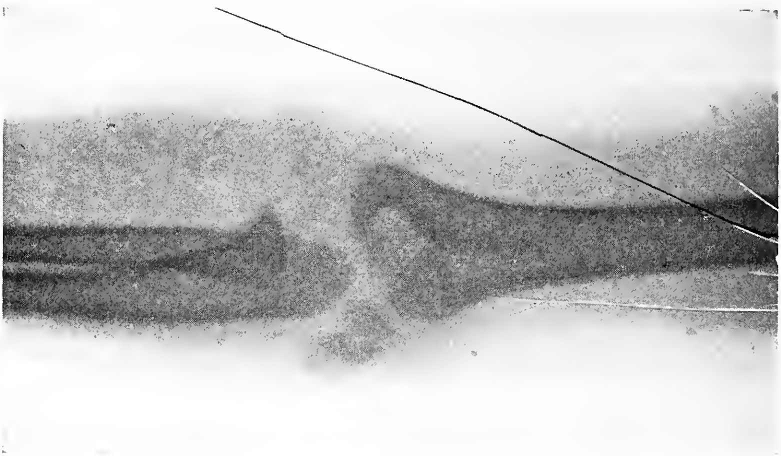

Fig. 137.—External Condyle completely turned after being Fractured.

tended position. After five weeks the patient left the hospital because his general condition was good, and the swelling about the elbow had disappeared, the only remaining trouble being that the elbow could not be flexed.

When the author examined the patient at this time, palpation revealed a bony mass near the lower end of the humerus externally, which could be easily moved in a vertical direction. A skiagraphic picture taken while the joint was resting on its dorsal aspect showed the presence of a bony fragment, which was detached from the humerus (see Fig. 137). The space between the upper articular surfaces of radius and ulna on one hand, and the lower articular surface of the humerus on the other, seemed to be empty, which finds its natural explanation in the fact that the epiphyses were still cartilaginous in this young patient, and therefore translucent by the rays.

If these points are not thoroughly considered, a displaced fragment might be assumed where normal relations exist.

It would be very desirable that a commission of surgeons should classify these complicated conditions of epiphyseal ossification during the various periods of development, in order to obtain authoritative rules for the text-books.

A second skiagraph was taken in supination, which showed the joint in lateral projection, so that the fragment appeared somewhat larger. The lower end of the fragment was situated directly below the integument, which presented a slight prominence in proportion. At first the author intended to make an attempt to reduce the severed fragment and suture it, and with this purpose in view he made a longitudinal incision above it, which showed it to be loosely connected with the surrounding tissues. The articular end consisted of the eminentia capitata. A small part of the trochlear end had turned towards the surface of the epiphyseal fragment, while the fractured surface of the small fragment adhered to the skin. In other words, the fragment had turned entirely around on its own axis. Its nutrition seemed to be so much impaired that the author thought it wise to remove it. The

FIG. 138.—SUPRACONDYLAR FRACTURE SHORTLY AFTER REPOSITION.

largest portion of the fragment consisted of cartilage only, a small lateral area representing real osseous tissue.

It hardly needs to be mentioned that after the removal of the fragment the arm could easily be flexed without any forcible efforts. Recovery was uninterrupted. After a week passive motion was begun, and the final result was perfect, in spite of the elimination of so important a bone section. If the parents of the

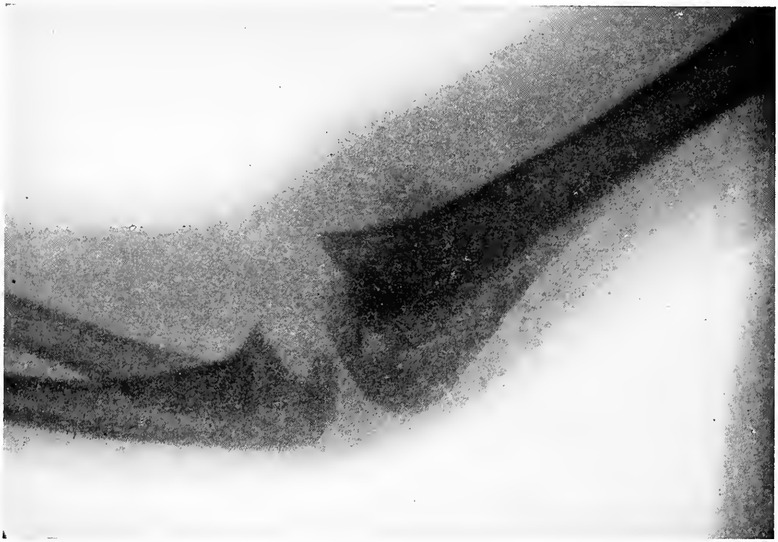

FIG. 139.—SUPRACONDYLAR FRACTURE DISPLACED POSTERIORLY (EXTENSION FRACTURE).

patient had followed the instructions of the family physician to ascertain the exact anatomical nature of the injury by immediate irradiation, the torsion of the fragment would have been recognised at so early a stage that reposition might still have been possible.

Reposition is not always easy, because the head of the radius, by being pulled forward through the biceps muscle, favours the displacement of the fragments, but repeated efforts under guidance of the Röntgen rays may overcome this difficulty. (As to further details of this instructive case, see Fortschritte auf dem Gebiete der Röntgenstrahlen, September, 1902.)

The result in *supracondylar fracture* also used to be unsatisfactory because the direction of the fracture-line could not be recognised, and therefore the direction towards which reposition had to be attempted was only guessed at. Thus the efforts at reduction were in most instances only partially successful.

Fig. 138 illustrates the supracondylar fracture of a boy of ten years shortly after reposition. There was considerable backward displacement, the recognition of which enabled the author to reduce it completely, skiagraphic control through the plaster-of-Paris dressing verifying the successful reduction afterward. It is needless to emphasize the fact that such skiagraphic evidence proves from the beginning that the final result will be good, while before the Röntgen era such knowledge was only gained weeks afterward when the gunstock deformity was an established fact—when, in other words, it was too late for correction.

In the case of a boy of six years who had sustained a similar injury the Röntgen method was not resorted to until four weeks after the injury occurred. As Fig. 139 indicates, there was an oblique supracondylar fracture, followed by backward displacement. The humeral end being pressed backward during the fall

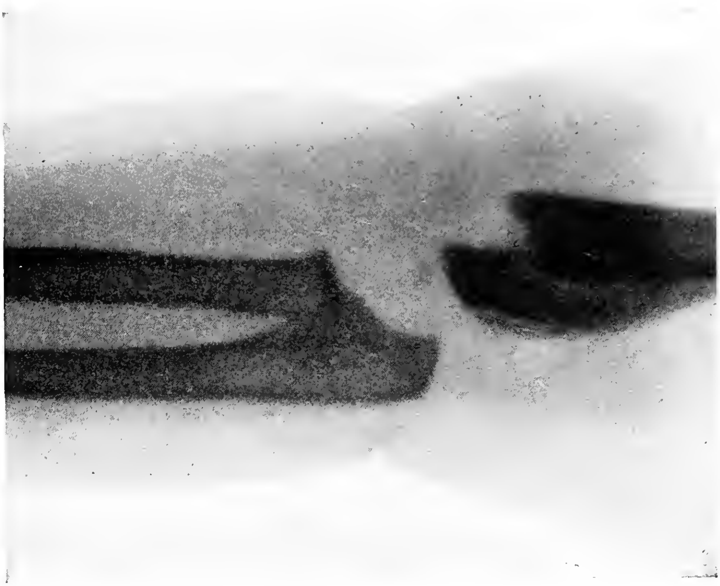

Fig. 140.—Oblique Supracondylar Fracture associated with Backward Displacement, in a Baby of Six Months.

on the hand, the flexed forearm was hyperextended (extension fracture), which explains that in cases of this kind the oblique fracture-line is directed from behind backward and downward. Attention is also called to the sharply protruding point at the lower end of the diaphyseal fragment, which offers an obstacle to flexion. In this case it was too late to correct the malunion by force, and a chisel operation had to be suggested therefore.

In Fig. 140 the same injury is illustrated in a boy of ten months. In this case the fracture was associated with epiphyseal separation. Although three weeks had elapsed since the injury had occurred, refracture and reduction were successful, the elbow of the anæsthetized child being brought to the edge of the table,

Fig. 141. Supracondylar Fracture.

and the manipulations being made in a longitudinal direction. The gunstock deformity disappeared completely then.

Fig. 141 illustrates the case of a boy of eleven years, whose supracondylar fracture was mistaken for backward dislocation. The skiagraph, obtained three days after the fracture occurred, demonstrated that the protrusion of the olecranon, noticeable in midst of the swollen elbow, was due to its backward displacement, which was produced by fracture. The enormous swelling prevented false motion and crepitus, hence the error. It is, of course, a great deal more difficult to reduce the fragment in a swollen area, as it was in this case, while early recognition would have made reposition easy.

As to fracture of the external condyle associated with lateral dislocation, see Fig. 13.

In regard to the various kinds of fractures of the external condyle, occurring during the period of development, the reader is referred to the author's illustrations in Fortschritte auf dem Gebiete der Röntgenstrahlen, Band v, Hamburg.

FIG. 142.—OLD FRACTURE OF EXTERNAL CONDYLE.

The participation of the *radial nerve* is discussed in the chapter on the Operative Treatment of Deformed Fractures. An extraordinary case of this kind, however, may be reported in this connection.

The arm of a girl of fourteen years who sustained a fracture of the external condyle of the humerus by falling from a high stairway, was immobilized in extension by an experienced surgeon. Shortly afterward considerable functional disturbance set in, and gradually paralysis of the extremity developed. The grasping power became lost, and supination was impossible. When the author saw the patient for the first time there was considerable deformity in the region of the elbow (Fig. 142) and the typical drop-hand. Supination of the forearm was just as impossible as abduction of the ulna (Fig. 143). Both phalangeal ends could be extended slightly by the lumbricales and interossei.

FIG. 143.—DROP WRIST, DUE TO PARALYSIS OF THE RADIAL NERVE CAUSED BY FRACTURE OF THE EXTERNAL CONDYLE. (See Fig. 142.)

Skiagraphic examination revealed the presence of an immense thickening of the external condyle of the humerus, which pointed to an injury of the radial nerve. This suggested the presence of a callous mass in which the radial nerve was buried. Although after the lapse of seven years recovery could hardly be expected, the author still thought, by exposure of the nerve and resection of the superfluous bone masses, that the

FIG. 144.—BACKWARD DISLOCATION OF ELBOW.

function of the limb might be materially improved. In fact, the radial nerve, when exposed by a longitudinal incision, showed itself to be surrounded entirely by osseous tissue. It was released by extensively chiselling off the bone masses. The considerable improvement of the symptoms was quite surprising. After six weeks the result was further improved by elongating the shortened flexor tendons by tenoplasy. The hand, which had formerly hung powerless, thus regained the power of grasping.

The signs of supracondylar fracture often resemble those of posterior dislocation of the elbow, three signs being common to both injuries—viz., shortening, false position, and the axial direction. From a strictly theoretical point of view it seems to be impossible to mistake a fracture for a dislocation, and *vice versa.* In dislocation the flexor side of the forearm and the extensor side of the arm are shortened, and the tendon of the triceps muscle appears like a small arch, the concavity of which is directed towards the olecranon. This process is noticed as a posterior projection then. The trochlea can be palpated in front and the outlines of the joint surface of the head of the radius are grasped in the back. That the transverse diameter of the joint always remains normal is another characteristic feature of the dislocation.

In spite of all these well-known points dislocation is often mistaken for fracture, and *vice versa*, as clinical experience shows. The supracondylar fracture, illustrated by Fig. 141, was taken for backward dislocation on account of its posterior projection, and the backward dislocation illustrated by Fig. 144 was regarded to be a supracondylar fracture.

The explanation of such fatal errors is given by the presence of considerable swelling which prevents exact palpation. Still there is no more excuse for it because the rays are not influenced by the swelling and will tell the exact truth, thus enabling the surgeon to take the proper therapeutic steps. The author may be pardoned for repeating his warning so often, but the "Catonic Ceterum censeo" cannot be emphasized too often in this connection. The postero-medial type of dislocation is of rare occurrence, but may also be misinterpreted. Fig. 145 illustrates a case of this kind in a boy of eleven years. The reduction was easy.

Fig. 145.—Postero-medial Discoloration of Elbow.

Fig. 146 is a sad illustration of indifference. A labourer who had been injured by a machine sustained severe injuries, which were interpreted as fracture of the middle of the humerus and at the lower third of the ulna. He was treated by an experienced surgeon who, relying on his palpatory talent, did not care for using the Röntgen method. The treatment of the humerus was excellent, the fragments having been held in exact apposition, as was shown by the skiagraph taken two years later. The ulnar fracture had not been well reduced, yet it is improbable that the

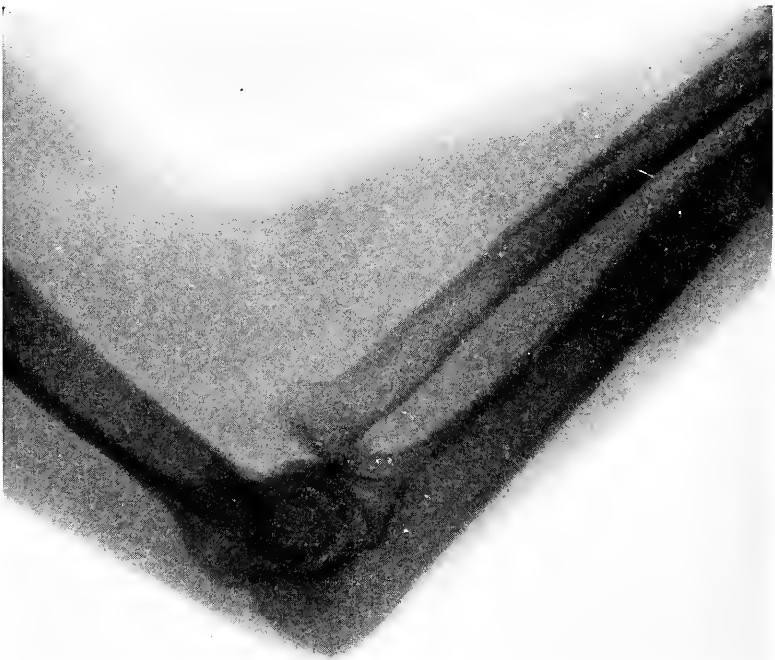

FIG. 146.—FRACTURE OF CORONOID PROCESS OF ULNA, ASSOCIATED WITH FORWARD DISLOCATION OF RADIUS.

deformity of that bone would have interfered seriously with the function of the arm. But in the elbow-joint a very important lesion was shown, which had not been detected by the palpatory enthusiast. The man's arm eventually becoming paralyzed, it was thought that there might be some callus proliferation at the humerus, therefore it was decided to free the nerve by operation. Still the condition remained unchanged. If at that time, one year and a half after the injury, skiagraphic examination had been resorted to, no such operation would have been performed, because the picture would have proved the absence of displacement. This fact would have excluded the possibility of compression of the nerve at this point. And if there were compression of the nerve, the skiagraph would have pointed to the respective area.

And in fact, skiagraphy of the elbow revealed the presence of fracture of the coronoid process of the ulna and outward dislocation of the radius. Now, if the Röntgen method had been resorted to two years before, it would have shown the humerus in perfect and the ulna in a displaced position; the latter would easily have been averted then by slight inward pressure. The radial dislocation would also have been discovered, and could have easily been reduced at that time. The patient is still paralyzed, and it is very questionable if he will recover. It is true that we are all liable to error, but we should endeavour to correct our errors as soon as possible, and not procrastinate two years. This is an every-day example, and the single individual is not to blame for it, because the majority still follows this routine.

The injuries of the upper ends of the radius and ulna are also to be regarded as important factors in the pathology of the elbow-joint.

In considering the radius, it must be appreciated that the *fracture* of its *head* is a very important injury. If the upper fragment is entirely severed, it may be recognised as a separate piece of bone by palpation. In addition, it will not share the motions of the arm, while alternately turned in pronation and supination, and in that case crepitus is seldom absent. Intense pain may point to the seat of the fracture; and sometimes it may be guessed by simple inspection, the biceps drawing the shaft forward and causing a slight projection.

But whenever there is entire absence of displacement, contusion or distortion may be thought of. This error is apt to take place so much easier when the swelling soon following the injury veils the symptoms, abnormal mobility especially not being noticeable. In former years it was only under anæsthesia that such cases were once in a while properly diagnosticated.

It is evident that the diagnosis of *fissure* of the *radial head* is still more difficult. It seems to the author, indeed, that until recently its presence could never be clearly ascertained. Fortunately, the Röntgen rays throw light on this subject as well as on many others, and there can be no doubt that, with our increasing knowledge and experience, fissure of the radial head will also be recognised more frequently.

The following case may serve as an illustration: it is one which in the pre-Röntgen era would surely not have been recognised in its true nature.

A girl of twenty-four years of age, on the evening of October 4, 1900, in falling downstairs, struck her right elbow against a piece of iron projecting from the stairway. She called upon a physician

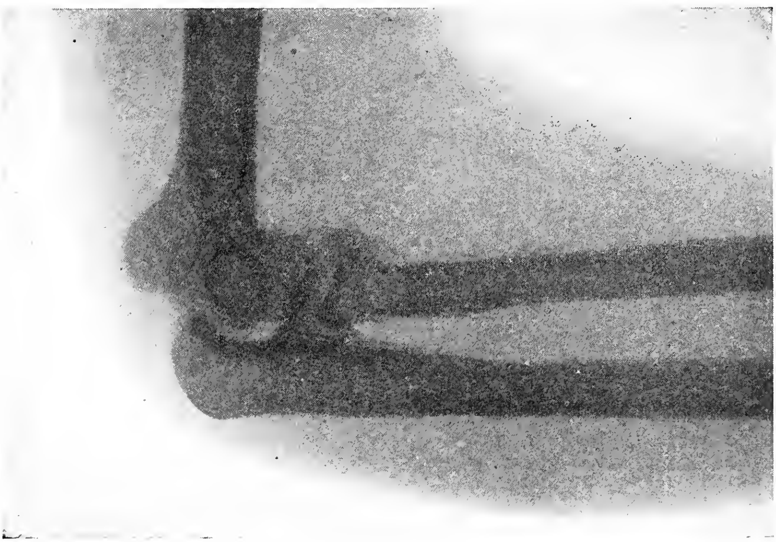

FIG. 147.—FISSURE OF THE HEAD OF THE RADIUS.

at once, who found the elbow much swollen and painful. No signs of a fracture were then detected.

On October 6th, when the author saw the patient for the first time, the arm was in right-angled flexion, and the region of the elbow-joint showed considerable swelling and tenderness equally distributed. The area above the radial head showed the presence of ecchymosis.

A skiagraph was taken at once in supination, the patient lying on her back (Fig. 147). It revealed the presence of fissure of the radial head beyond any doubt. There were, in fact, two distinct fissure-lines, one running through the circumferentia articularis alone at its external margin, and the other one creating a triangular segment, the base of which was formed by the internal margin of the circumferentia articularis and the tip by a splinter detached from the radial neck.

The therapy consisted simply in the application of a plaster-of-Paris dressing in rectangular flexion, the forearm being kept in semipronation. A second skiagraph, taken four weeks later, showed ideal union, the external portion of the circumferentia articularis only protruding farther than it should normally. It shows also how quickly the evidence of the presence of a fissure becomes lost if there be perfect approximation—a circumstance to be borne well in mind from a medico-legal standpoint.

The function of the forearm did not become perfect until three months after the injury, the joint showing considerable stiffness at first, which yielded gradually to massage treatment.

Fissure of the radial head being of a decidedly intra-articular character, an effusion in the joint is a natural sequence, which explains the uniform swelling at the beginning as well as the stiffness at a later period.

From the study of this case we may learn that wherever skiagraphic observation shows no tendency to displacement, it will be advisable to begin motion at an early stage, say after ten days, in fissure as well as in fracture of the radial head. In relying on the skiagraphic mentor, our results will be far superior to those of the past. Even in the much-feared cases of fracture of the radial head, where the fragment is considerably displaced, a great deal can be done, or rather prevented, under the guidance of the rays.

In the case of a man of thirty-two years of age the author had an opportunity to diagnosticate a fracture of the radial head before he employed the Röntgen rays. This was easy because the much-displaced fragment was freely movable. It had seemed to the author that he had succeeded in reducing the fragment, but a skiagraph taken twelve hours after the injury, through a plaster-of-Paris wire splint, showed that the reposition was not perfect. Anæsthesia enabled him then to correct the displacement perfectly in the half-extended position. The result was very satisfactory.

Immobilization should be kept up for weeks in such cases, for premature contraction of the biceps muscle might separate the replaced fragment. If the fragments are not properly retained in place, the production of extensive adhesions might demand resection of the radial head. The same operation might be indicated if small fragments separated from the cartilage remain detached and act like foreign bodies, so as to disturb the function of the elbow. The Röntgen rays enable us, in the event of this rare necessity, to trace out the mode of such operations definitely beforehand.

As to the diagnostic difficulties, reference is made to Figs. 239, 240 and 241, described in the chapter on Deformed Fractures. As to fractures of the olecranon, see Figs. 243 and 244 in chapter on Deformed Fractures.

It was thought that fractures of the *coronoid process* of the *ulna* were of rare occurrence. But, as in many other instances, experience with the Röntgen rays has taught that this type of fracture is much more frequent than was formerly believed. By realizing that the normal coronoid process cannot be palpated through the thick muscular strata that protect it, the difficulty of making out the broken fragments becomes apparent. The strong lateral ligaments, as well as the annular ligament, which is strengthened by the brachialis muscle, form so strong a protection to the process that a displacement of its fractured fragment seldom takes place. This usual absence of displacement also explains why crepitus is ordinarily not produced. The presence of ecchymosis, as well as of intense circumscribed pain in the cubital fold produced by strong flexion, are suspicious signs. The latter would indicate that the process is pushed into the fossa anterior. It should not, however, be forgotten that this valuable symptom is entirely of a subjective nature.

Thus, a positive diagnosis can but seldom be made without using the Röntgen rays. The diagnosis will also determine the prognosis. If there is but little tendency to displacement, the prognosis is favourable even when the diagnosis has not been made. But if there is any marked displacement the function of the elbow is greatly disturbed. In such an event, of course, the diagnosis is so much easier the greater the displacement is. Nowadays this much-dreaded condition need not be feared, since reposition of the fragments has become greatly simplified under the guidance of the rays.

The after-treatment is best conducted in a rectangular dressing of plaster of Paris. In the cases referred to the fragments were invariably found in a displaced position, so that they projected into the joint, interfering with free motion. The projecting bone-mass therefore had to be chiselled off. (Compare Fig. 198 in Chapter XIII on Arthritis.)

FOREARM

The forearm is examined after the same principles which were emphasized in the study of the arm. The anatomical relations of this region are more favourable for irradiation, because the bones are near the integument and the soft tissues are thin. The best reproductions are obtained if the surface extensor is placed on the plate, for the reason that the bones are situated directly underneath the skin there. In spite of this accessibility, however, it is always preferable to expose in two different projection planes—viz., in antero-posterior or postero-anterior direction, and in the lateral.

Injuries of the forearm, the extremity used for working as well as for protecting the body—this member being instinctively outstretched when one is afraid of falling—are of great frequency. In fracture of the bones of the forearm thorough adaptation of the fragments is essential for the preservation of the functional ability of this important part. If there is no displacement the course is naturally not disturbed. No reposition being necessary, the therapy consists in simply applying some suitable immobilizing apparatus. The author prefers the plaster-of-Paris dressing here just as well as in most other fractures.

Fig. 148 illustrates this type. Although there was considerable splintering, the bones remained in good apposition, so that no efforts at reduction were required. The patient, a labourer of twenty-five years, suffered considerably and showed extensive swelling around the fractured area, so that the author had the impression that extensive displacement had taken place. If the Röntgen rays had not shown the fallacy of this impression, forcible efforts at reduction would have been made, and the splinters might have been dislodged, so that the same hands which were expected to correct and heal would have increased the severity of the injury.

How far the correcting tendency of nature goes is evident from Fig. 149, which illustrates the antibrachial fracture of a boy of three years. For two months no medical advice was sought,

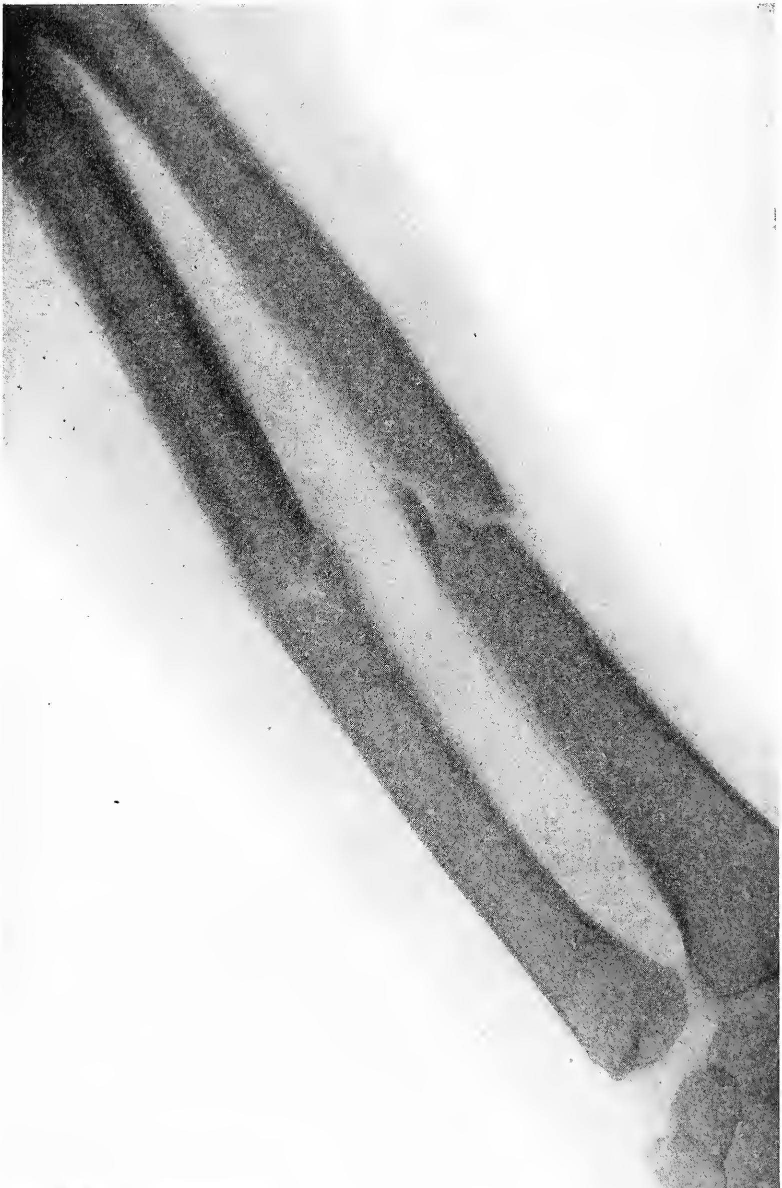

FIG. 148.—FRACTURE OF BOTH BONES OF THE FOREARM.

until the loss of the power of pronation and supination and the protrusion caused by the formation of ensheathing callus gave the impetus. Apparently the fragments were not displaced at the time the fracture occurred. Still the fact that no immobilization was attempted explains why a large mass of ensheathing callus was thrown out. The irritation of the soft tissues produced adhesions between themselves and the callus-masses, which accounts for the impossibility of pronation and supination. Under anæsthesia the adhesions were destroyed. In such neglected cases

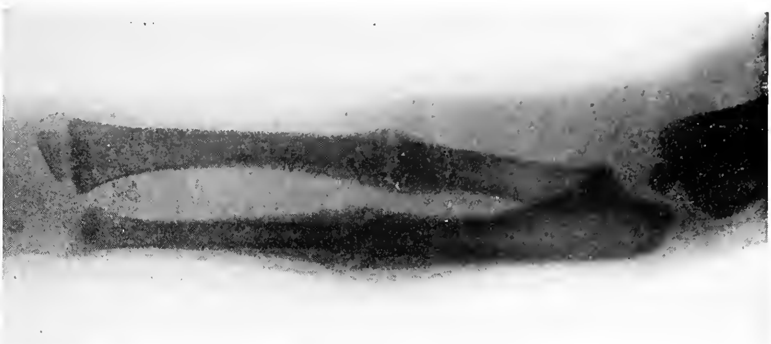

FIG. 149.—FRACTURE IN THE MIDDLE OF THE FOREARM IN A BOY OF THREE YEARS.

the excessive callus-masses may cause synostosis between the two bones, although there was no displacement at all.

Thus we see that in fracture of the bones of the forearm thorough adaptation and immobilization of the fragments is essential to preserve functional ability. Fracture of either the radius or the ulna alone, when perfect coaptation is not secured, may prevent supination to such an extent that the unfortunate patient may be unable to follow his occupation. How much more is the functional ability impaired, when, after fracture, both bones unite in false positions, with overlapping of the fragments and angular deformity.

To what extent the Röntgen rays enable us to overcome some of the technical difficulties, even in desperate conditions, is illustrated by the following case:

Both forearms of a labourer, aged thirty-four years, were caught in the wheel-strap of a powerful machine and broken.

The patient was brought to the hospital, where proper efforts were made to reduce the displaced and partially splintered fragments.

At first reposition seemed to have been successful, and the swelling disappeared, but both hands remained stiff and paralyzed, and, excepting the thumbs, were without sensation.

Extensive œdema having repeatedly been present the disturbance in motion as well as in sensibility seemed to be of an ischæmic nature rather than caused by a direct trauma to the nerves. The muscular atrophy, which was still present, also pointed to the breaking down of contractile muscular elements. When the author saw the patient for the first time he found angular deformity, abnormal mobility, and the functional disturbances, described above, on both sides.

The skiagraphs of both forearms showed considerable overlapping. In the right forearm overlapping of the radial fragments existed in the middle and lateral deviation of the ulnar fragments an inch below. The skiagraph of the left side showed the overlapping of both sides, and also the formation of a bone bridge between

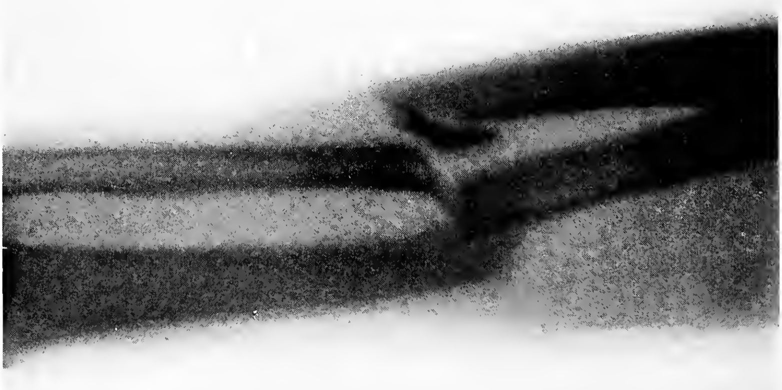

Fig. 150.—Displaced Fracture of Radius and Ulna, Producing Synostosis.

the lower fragments of the ulna and the upper fragments of the radius, which alone would exclude any possibility of rotation (Fig. 150).

First an attempt was made to correct the position of the fragments of the right forearm, by exposing and freeing them. Under the guidance of the skiagraph a semilunar incision in an

FIG 151.—CASE ILLUSTRATED BY FIG. 150, AFTER WIRING.

oblique direction was made. The shortening was overcome by resorting to forcible extension. The fragments were then united by silver-wire sutures. The *modus operandi* consisted in freeing the old adhesions thoroughly with knife and chisel, and folding the arm, so to say, completely. By encircling the two antibrachial fragments with a strong bandage the folded mass could be steadied by an assistant, so that the necessary holes could be bored (Fig. 151). As shown by a skiagraph, taken six weeks after this operation, the radial fragments were in ideal apposition. The ulnar fragments showed slight lateral displacement, while the callus-formation had assumed so fortunate a character that no other depression or protrusion remained.

Five days after the first operation the left-sided fracture was exposed in the same way. In spite of extensive exposure of the fractured area the fragments could not be forced into apposition except by shortening them. So the author made a virtue of necessity by giving the ends of the fragments a triangular shape, which enabled him to indent them into each other. As the skiagraph showed, taken four weeks after this operation, the apposition of the radial fragments was perfect. The ulna did not show lateral deviation, none of the medullary lines presenting any axial divergence. The skiagraph showed, however, that there was a slight angle, which could be corrected in time by simple pressure.

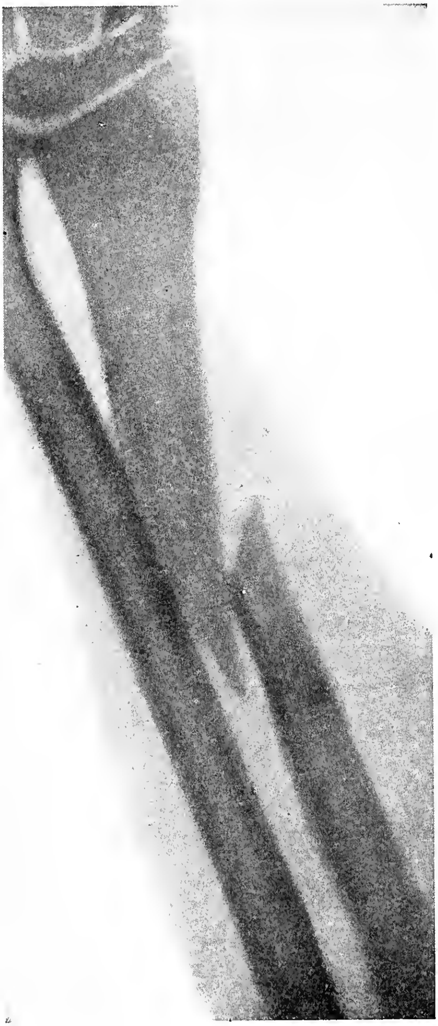

Fig. 152.—Fracture of Radial Diaphysis.

Union took place by first intention without any reaction. The healing process was quicker on the left side, which is explained by the absence of wire suturing. To be sure that consolidation was perfect, the author immobilized the arm until two months after operation, leaving off the plaster-of-Paris splint temporarily for the employment of massage. The final result was perfectly satisfactory.

Thus we see how the happy era of combined asepsis and skiagraphy permits of the correction of even the most extensive deformities in a simple and safe manner.

From a theoretical point of view it should be expected that on account of the more abundant callus-proliferation, induced by the irritation of the wire suture, consolidation would be quicker and more thorough. But practice proved the contrary in this instance, and it seems to the author that indentation permits of more accurate adaptation and immobilization. At the same time larger surfaces for agglutination are obtained, and the soft tissues are less liable to be disturbed.

Triangular indentation of the fragments should therefore be preferred whenever possible.

Fig. 153.—Fracture of Radial Diaphysis after Alleged Reduction. (Compare Fig. 152.)

The *modus operandi* for indentation is practically the same as demonstrated by Fig. 151.

As to further observations on important injuries in this region, see chapter on Deformed Fractures.

Fracture of *either the radius or the ulna* are generally recognised without difficulty. Still, as Fig. 258 shows (chapter on Medico-Legal Aspects), fracture associated with little or no displacement might be easily overlooked. In the case of displacement the radius may be pressed against the ulna, so that synostosis takes place, an event which would render rotation impossible. Fig. 152 illustrates a case in which the upper radial fragment was pressed against the ulna. Reposition was made

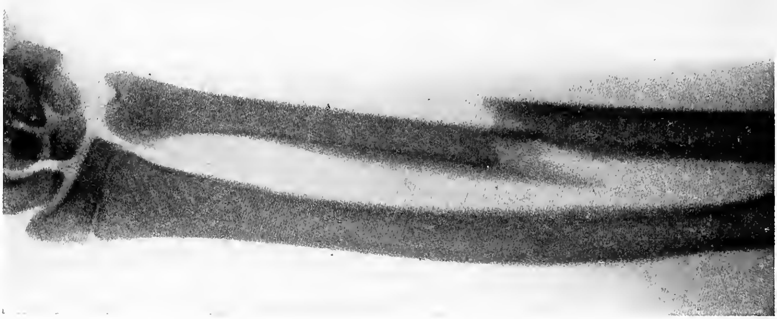

FIG. 154.—FRACTURE OF THE ULNAR DIAPHYSIS.

by bending the forearm in the same manner as a greenstick is crossed over the knee, the ulna resting on the edge of a table.

When it was thought that reposition was perfect a plaster-of-Paris dressing was applied. But the skiagraph, taken at once through the plaster, showed that reposition was imperfect (Fig. 153); therefore a second effort was made, which proved to be successful. In such cases it is advisable to flex the opposite bone as much as possible—that is, in isolated radial fracture the ulna, and in isolated ulnar fracture the radius, must be bent.

Fracture of the *ulnar diaphysis* also shows a great tendency to inward displacement, thus causing the same disturbances observed in fractures of its fellow, synostosis rendering pronation and supination impossible. The same principles apply to the correction of this injury as those emphasized on fracture of the radial diaphysis.

Fig. 154 illustrates the fracture of the ulnar diaphysis of a girl of eight years. While the lower fragment did not come in contact with the radius, it still protruded so far that it impaired the soft tissues, thereby setting up an inflammatory process. The result would have been excessive callus-formation, so that virtually the same conditions would prevail as if the ulnar fragment had ridden on the inner radial surface. It is evident from the illustration that outward pressure must force the fragments in place. To hold them *in situ* the rubber-drainage splints advised for metacarpal fracture (see Fig. 165) are recommended in order to avoid recurrence of the displacement. Attention is called to the bending of the radial diaphysis, which would be permanent if it was not corrected synchronously with the reposition of the ulnar fragments. In adults such bending is not found, the force applied to the ulna generally being sufficiently strong to fracture its fellow.

WRIST

No bone of the human skeleton is so great a source of trouble for the practising physician as the *radius*, and especially its *lower end*. If it is only appreciated that fracture of the carpal end of this bone is the most frequent fracture type—at least 18, but perhaps 22 per cent of all fractures—its importance is well understood.

The old dictum, "Qui bene diagnoscit, bene medebitur," applies preeminently to the treatment of this fracture, generally known as Colles's fracture. In fact the laws that govern the treatment of this much-disputed injury, and last but not least the final results, are entirely determined by a correct diagnosis. The principles of treatment are then reduced to a few points of simple common sense.

Such complete and correct diagnosis could not, as a rule, be made before Röntgen's great discovery. It can safely be maintained that in most cases skiagraphy has revealed conditions that were not expected, and required the original diagnosis to be more or less modified.

The questions most frequently asked of a surgeon, "How do you treat Colles's fracture?" "Do you use long or short splints?" "Do you prefer the plaster-of-Paris dressing or a splint?" "Are you for Dumreicher's, Roser's, Schede's, Braatz's, Gordon's, Koelliker's, Moore's, Carr's, Bond's, or Middledorpf's bilateral, or for the old pistol splint of Nélaton?" "Are you in favour of immobilization or of early motion?" etc., show that the essential points are generally overlooked, fracture of the lower end of the radius being regarded by many as a constant type, uniformly characterized by the fracture of the bone an inch above the articulation, and followed by a silver-fork-shaped deformity of the wrist.

This point of view is inadequate and erroneous. It has been found that the anatomical aspects of the various forms of fracture of the lower end of the radius differ in fact more than those of any other fracture, and it is self-evident that such variants must greatly influence the manner of treatment.

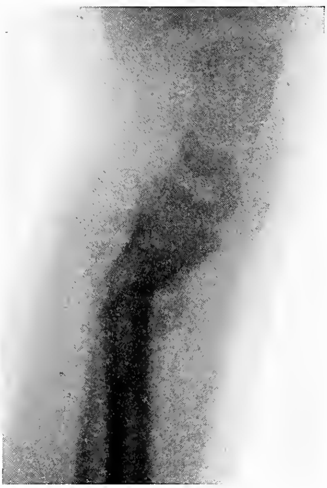

Fig. 155.—Fracture of Radius, Upward Bayonet-shaped Displacement.

In the first place, the question whether the fracture-line is intra-articular or extra-articular is of great importance, because for a simple extra-articular fracture and a Y-shaped intra-articular fracture different therapeutic means must be sought. Again, the varying relations of the fracture of the radius to its fellow, the ulna, influences the plan of treatment considerably.

It is but natural that our therapy should be changed and directed by fuller clinical experience and anatomical observation. In the short space of time which has elapsed since Röntgen's discovery, it has been found that the anatomical aspect of the fracture of the carpal end of the radius (inaccurately called Colles's fracture) shows a number of types. It is true that the majority of cases are characterized by a breach of continuity from 10–30 millimetres above the articular surface of the carpal epiphysis, which, on account of a peculiar turn of the lower fragment, causes that deformity of the wrist which is compared with a fork (displacement *à la fourchette*) or with a bayonet, or with a flat Z (Fig. 155). But besides this type, first described by Colles, there still remains a large group differing from it materially. Without undervaluing the great work of our surgical masters before the

Röntgen era, and particularly commending the work of Nélaton, Velpeau, Volkmann, and Koenig, we must still say that the rays furnish the most convincing proof of the necessity of modifying their interpretations of this injury. Thus, having regard to old experience as well as to information recently gained, the author has tried to classify those different forms of this much disputed fracture which appear to be most characteristic, and must accordingly demand different therapeutic measures; and if we bear in mind the frequency of fractures of this type, and believe they represent 22 per cent of all fractures, the importance of a detailed diagnosis needs no further argumentation.

The author distinguishes the following varieties of fracture of the lower end of the radius: (1) Simple extra-articular fracture without displacement (Colles's fracture); (2) epiphyseal (chondro-epiphyseal and osteo-epiphyseal) separation; (3) fissure; (4) simple or multiple fracture, with displacement; (5) fracture of the carpal end of the radius associated with fracture of the styloid process of the ulna; (6) fracture of the carpal end of the radius associated with fissure, fracture, or dislocation of the lower end of the ulna; (7) fracture of the carpal end of the radius associated with fissure or fracture of a carpal bone (sometimes also with the end of the ulna). The last six varieties may be intra-articular as well as extra-articular; (8) fracture of little bone portions (chips), generally extra-articular.

Simple subcutaneous fractures showing little or no displacement often heal without, or in spite of, any treatment, as the long sin-register of quackery will demonstrate. The number of fractures not recognised as such during treatment is legion. The treatment in such cases is often simply a question of comfort, which may be obtained by encircling the wrist with a bracelet of moss-board.

This appliance sufficiently immobilizes the wrist and at the same time permits enough motion to counteract the formation of adhesions in the sheaths of the tendons. The patient carries his hand in a sling in such a manner that the ulnar margin rests on it. Thus free motion of the hand is permitted. The patient is told to move his fingers as in playing the piano; and the author finds it very useful to advise him to grasp marbles of moderate size and to roll them around in the palm of the hand. Patients are generally willing to keep these marbles in their pockets and play with them while reading or conversing or walking around. If motion is thus constantly kept up, massage treatment as well as forcible motion can be dispensed with, and recovery is perfect in four weeks, or sometimes even in three. Most of these fractures being extra-articular, articular effusion is generally absent.

If the fracture-line extends into the joint, displacement usually follows. The oblique fracture of the lower end of the radius has, as far as the author's knowledge goes, not yet been described. The author has observed it in adults only. It looks as if the fracture-lines were longitudinal at the articular surface, the upper fragment appearing as a triangular piece of bone. The apex of this piece begins about an inch from the wrist, while the base carries part of the joint surfaces, so that the lower as well as the upper show articular surfaces. If there is no displacement, the treatment is the same as in diaphyseal separation, or complete fracture without tendency to displacement. In the triangular type, however, in view of the intra-articular inversion, it is preferable to apply a plaster-of-Paris dressing immediately after the injury is sustained. (See illustration in Journal of the American Medical Association, June 5, 1902.)

But whenever displacement of the fragment takes place, accurate reposition is the *conditio sine qua non.*

Then the *modus operandi* of reduction depends upon the type of displacement. In the majority of cases the lower fragment is directed upward, so that there is dorsal prominence, the joint not being concerned. In such cases (generally called typical Colles's fracture) the shape of the deformed wrist resembles that of a bayonet or a fork (Fig. 155). The Röntgen rays have shown, however, that the upward displacement as a rule is associated with sideward displacement, generally in an outward direction, causing radial inversion, and consequently slight shortening of the radial axis. In such cases the clinical diagnosis is not difficult. The lower fragment pushes towards the dorsum, at which a prominence is seen, near the wrist, corresponding to a groove at the site of the upper end of the fragment. The upper (diaphyseal) fragment presses against the flexors, producing a prominence further upwards. The greater the prominence, the shorter is the radial axis. Crepitus is, even in these typical cases, often absent. In a number of cases, however, the direction of the displacement is found to be towards the ulna, even if the diaphysis is not pronated.

There are also a number of cases observed by the author as well as by others where the lower fragment is turned backward around the transverse axis. Sometimes the sagittal axis of the lower fragment is turned around. The oblique type (triangular fragment), in which the joint surface is split, has been spoken of above. A rare form is the detachment of the posterior border of the joint surface. Roberts also observed forward displacement of

Fig. 156.—Fracture of Lower End of Radius, showing Upward and Inward Displacement and Outward Bending of Ulna.

the fragments. Most of these forms can only be diagnosticated by the Röntgen rays.

By being upwardly dislodged, the lower fragment, in typical cases, is brought into slight supination, while the diaphysis is in decided pronation. The epiphysis being in very close connection with the ulna, the former is slightly pushed towards the ulna if the ligamentous connection between the radial fragment and the ulna remains intact. This phenomenon finds its conspicuous clinical expression in the lateral prominence of the lower end of the ulna. Fig. 156, for instance, shows a combination of upward and inward displacement of the lower fragment, followed by outward bending of the ulna.

Wherever displacement demands reposition the assistance of one or two persons is desirable, who should make counter-extension while the surgeon replaces the displaced fragment. After the exact situation of the fragments is ascertained by the fluoroscope, the surgeon knows at once how to replace it in its former and normal position. This is done by making manipulations, either in the way of pressing sideward and turning the fragment, or by putting the wrist at a proper angle, and thus correcting the abnormal direction. It is needless to say that upward displace-

Fig. 157.—Oblique Intra-articular Fracture, Associated with Spiral-shaped Fracture of Lower End of Ulna.

ment requires pressure from above downward; outward displacement, pressure from within; and inward displacement, pressure from without.

The oblique triangular type generally requires downward and inward pressure. In Fig. 157, however, which shows this triangular type associated with spiral fracture of the ulna, the triangular fragment is turned upward and inward, so that downward and outward pressure is required for reduction.

The author grasps the hand of the patient as in a firm handshake by the left hand, while the patient's thumb is held by his right hand, so that his thumb presses the fragment downward while his index-finger presses it inward at the same time. If the direction of the displacement is towards the ulna, he grasps the patient's hand, including the thumb, with his own right hand, and pushes the fragment outward with his left thumb while he supports the flexor aspect with the rest of his hand. During these manipulations counter-extension must be exerted at the lower end of the arm. If it is impossible to reduce the fragment in this manner, anæsthesia must be employed. This manœuvre is sometimes facilitated by placing a book or a piece of wood underneath the ulna at the edge of a table.

Reposition of the fragments in fractures of this type seldom fails since the Röntgen rays became such a reliable guide. Even in impacted fractures the interlocked fragments can be disentangled.

If there is a simultaneous injury of the lower end of the ulna showing displacement, special care must be taken to press the fragment into its normal place.

In multiple fractures, even in the much dreaded Y-shaped variety, the articular arch of the radius may sometimes be restored by repeated efforts of reposition, controlled and corrected by the Röntgen rays.

After reposition is accomplished a fixed dressing must be employed for the purpose of retaining the fragments in their proper positions. This is not always easy. The author finds that no dressing accomplishes the purpose of retaining the fragments better than plaster of Paris, since it adapts itself to the contours of the wrist in any desired shape or direction, and can be adapted to the individuality of each case.

Before the Röntgen era the fear of ischæmia and gangrene prevented the author from using it immediately after the injury. Now that the premises of ischæmia are known to be wanting as soon as the pressure of displaced fragments is removed, such fear is uncalled for. So, while in former years the author applied splints first and resorted to the plaster-of-Paris dressing four to seven days afterward, he now applies the plaster dressing immediately after reduction, resorting to the splint treatment a week or two later, as the case may require. If the protruding fragment is not reduced, gangrene of the overlying soft tissues may be produced by any kind of dressing. In the Journal of the American Medical Association, November, 1902, two illustrations showing extensive gangrene at the dorsum as well as on the palm, which was caused by well-padded splints, were presented. No effort at reduction had been made. Such results are of grave consequence for the patient as well as for the surgeon.

If the direction of the displacement is slightly upward, or upward and outward (Fig. 158), a plaster-of-Paris dressing em-

FIG. 158.—OUTWARD DISPLACEMENT IN FRACTURE OF THE LOWER END OF THE RADIUS, IN A WOMAN OF SIXTY YEARS—FOUR DAYS AFTER THE INJURY.

bracing the thumb (the direction of the thumb influences that of the fragment to a great extent) is applied (Fig. 159). The hand is moderately flexed at the same time. If gentle pressure with the index-finger does not suffice to keep the fragment down, it must be pressed down by a signet around which the bandages are wound. After the splint is fastened with a bandage, the fluoroscope shows whether the fragment is in a desirable position. A dorsopalmar as well as a lateral examination must be made, because an antero-posterior view only shows whether there is any upward displacement left.

If the fluoroscope shows imperfect adaptation, the bandage must be removed and reposition done over again. Under such circumstances the fragment may better be retained if the thumb is pulled in an outward direction while the hand is shifted to the opposite side. A plaster-of-Paris dressing, applied in this position, resembles the old pistol splint of Nélaton. Of course the outward bending can be increased *ad libitum*. A surgeon must not lose patience if his efforts fail several times. By the fluoroscopic guidance he will at last surely find the proper angle, or in other words, the most suitable position and shape of the dressing or splint for his individual case. A recognised mistake often suggests the best mode of correction.

If the displaced fragment is directed towards the ulna, in which case there is generally an outward bending of the ulna present, immobilization is kept up best by turning the hand inward (compare Fig. 156). After a week the dressing must be removed, and if the œdema has disappeared, a plaster-of-Paris splint, moulded after the same principles, may be substituted, which can be taken off temporarily, so that massage treatment may be employed if necessary. The essential part of these splints is the encircling of the thumb, which guarantees absolute immobilization.

In the multiple T-shaped or Y-shaped variety there are generally two diverging fragments, one being shifted towards the

FIG. 159.—THUMB SPLINT—HAND SLIGHTLY ABDUCTED—FOR FRACTURE FOLLOWED BY DISPLACEMENT.

ulna and the other outwardly. By pressing these fragments asunder, so to say, the diaphysis is made to push itself forward so that it touches the scaphoid bone, the arm consequently being shortened. Here the circular plaster-of-Paris dressing in abduction is indicated. After that fragment, which is outwardly displaced, is pressed forward, a pad of adhesive plaster is placed above it. The fragment which is displaced towards the ulna must be shifted in the direction of the radius. To prevent slipping back a rubber drainage-tube is placed between it and the ulna at the dorsal aspect. By gentle pressure it is squeezed down into the interosseous space, and kept *in situ* by strips of narrow adhesive plaster, which do not entirely surround the arm.

Since this type is intra-articular, it is understood that there is always a well-marked extravasation which may even extend over the sheaths of the tendons. so that palpation is rendered difficult. There massage is best employed to remove the extravasation. Naturally, its presence renders a detailed diagnosis impossible except by the rays.

Among all the different varieties of fracture of the small end of the radius these intra-articular injuries are most serious. Only continuous control by the aid of the Röntgen rays of the proper position of the fragments, together with repeated correction, will give a fair result.

Fig. 15 shows a multiple fracture followed by slight displacement of the lower fragments. Especially that fragment which mainly consists of the styloid process of the radius is shifted downward, thus destroying the symmetry of the wrist-arch. It is very difficult and often impossible to reduce a lower fragment of this character properly; still much can be done by being able to locate it exactly on the basis of skiagraphic knowledge. In this case, which concerned a man of fifty-five years, the result was nearly perfect. Being of the intra-articular type, the injury was followed by the formation of adhesions, which were destroyed during after-treatment.

In the case of considerable comminution, a perfect *restitutio in integrum* cannot be promised. A skiagraph taken at the earliest possible moment is then a valuable document for the surgeon, since it proves the great difficulty of perfect reposition of the splinters.

In the case of a woman of twenty-five years the lower fragment was turned towards the ulna and also around its axis (see Medical News, September 11, 1903). It goes without saying that this extraordinary degree of displacement showed considerable deformity. Reposition was accomplished without anæsthesia, the wrist being immobilized in superabduction. A skiagraph, taken through the plaster-of-Paris dressing, showed that the abduction was overdone, therefore another dressing was applied in moderate abduction. This position showed the fragments in better coaptation, but there was a tendency of the ulnar side of the fragment to project upward, partially filling up the interosseous space. Elastic pressure, recommended by the author in the treatment of metacarpal as well as metatarsal fracture, also proved to be useful in this case. A small piece of rubber drainage-tube (the diameter of a large pencil) was placed alongside the interosseous space and fastened there with a small strip of adhesive plaster. Now the skiagraph showed perfect adaptation. That it had spoken truthfully was evident from the absence of reaction, which should have been expected in view of the enormous degree of displacement and by the speedy and blameless recovery.

There is no doubt that good results can be obtained by other means of immobilization, provided they are preceded by proper reposition controlled by the Röntgen light.

The author confesses freely that he often thought that he had reduced a displaced fragment completely because palpation seemed to give thorough satisfaction. But he sometimes was not a little surprised that the Röntgen plate showed him most impolitely how ill he had succeeded in his alleged reposition.

The main principles of treatment are the same for the other types of fracture of the lower end of the radius. There are, however, several modifications according to their different anatomy.

If in *chondro-epiphyseal separation* no sideward displacement exists, the antero-posterior exposure shows nothing abnormal, while a side view may disclose considerable upward displacement, as is shown by Fig. 160, for instance, the anterior view of which revealed apparently normal relations. Such cases are best treated by gentle downward pressure without using counter-extension and the application of a plaster-of-Paris dressing in extension. If a lateral view shows any sideward displacement under the dressing, a pad of adhesive plaster is attached to the skin above the lower fragment and the dressing reapplied.

In *osteo-epiphyseal separation*, where the fracture-line is not limited to the epiphyseal cartilage, but extends to the diaphysis, a greater tendency to displacement is observed. The principles of treatment are the same as that of the complete fracture described above, since the tendencies to the various forms of displacement are the same.

Fracture of the *lower end of the radius associated with fracture of the styloid process of the ulna* is rather frequent (see Fig. 26). The author's own statistics show that the styloid process is involved in 26 per cent of the cases. This co-injury was discovered long before Röntgen by Nélaton and Velpeau, and studied especially in this country by Pilcher, Roberts, Freeman, Corson, Thomas, Don, Haughton, and Colton. The author recommends a

FIG. 160.—UPWARD DISPLACEMENT IN CHONDRO-EPIPHYSEAL SEPARATION.

circular plaster-of-Paris dressing in moderate adduction for this type. Sometimes it is possible to grasp the process and push it back into its proper place. This is easily provided if the process is displaced outward, but in case of inward displacement reposition is much more difficult. The author has found it useful to press this fragment outward by pushing the dull end of a pencil between the process and the radius, and keeping it there until the dressing is completed, the bandages being wound around the pencil. A small piece of rubber tube may also be placed there.

A small amount of pressure often suffices to push the fragment into position, while after the lapse of weeks the inversion of the process may cause intense pain on any effort of bending the wrist, so that removal by chisel may have to be considered.

In *fractures of the lower end of the radius associated with dislocation of the ulna*, the lower radial fragment generally rides on the diaphysis, the latter protruding at the flexor aspect and the former at the dorsum. The ulnar end then overlaps the carpus. Only a considerable degree of violence can produce this rare injury. In such cases the arm is shortened at least an inch (Fig. 162). Reduction is easier than retention after reduction. Sometimes an extension-splint will answer, but in the majority of cases wiring of the radial fragments is better done at once, and the patient should be thoroughly informed of the grave nature of the injury. Fig. 163 illustrates the condition after operation.

Fracture of the *lower end of the radius associated with fissure of the neck of the ulna* is treated after the same principles as the complete fracture of the lower end of the radius. This applies also to fracture without displacement. But if there be displacement, generally outward bending of the lower fragment, sometimes in spiral shape, as in Fig. 157, a plaster-of-Paris splint in moderate adduction is applied after reposition. A pad of adhesive plaster is also placed at the outer aspect of the ulna. Should there be any inversion, a small rubber-drain must be pressed in the interosseous space.

Fig. 161 shows a case of this type, in which the violence inflicted upon the radial fragment was continued upon the lower end of the ulna, causing fracture.

Another co-injury, the *transverse fracture of the scaphoid bone,* deserves thorough attention. Fortunately, as a rule, but little or no displacement is present, but the character of the injury being intra-articular, it is appreciated that there is considerable intra-articular effusion, which is largely responsible for the great tendency to adhesion formation in these cases. The treatment is practically the same as that for the fracture described above, with the difference that motion must begin early. It is therefore advisable to remove the circular dressing somewhat earlier than in other types and to substitute a plaster-of-Paris splint, the same shape. This splint may be taken off temporarily every day so that gentle massage can be commenced.

Fracture of little bone portions (chips), generally of the extra-articular type, are often confounded with contusion or distortion. In such cases massage treatment is manifestly inappropriate; the treatment should be carried on after the principles of the treatment of fractures—viz., immobilization. This should be kept up for the first week after the injury at least, and after the little fragments are redressed.

Such chips are sometimes no longer than the head of a pin, and if they are separated from the dorsal or palmar surface of the radius, may not be at all conspicuous on the skiagraphic plate, while a lateral exposure will show them.

If the massage treatment so commendable in contusion is used in these cases, it is not surprising that the patient becomes rebellious, it is indeed not at all indifferent whether a simple bloody effusion or keen-edged bone-fragments are kneaded.

It is deplorable that up to the present the question of correcting the deformities must still be considered. Two or three weeks

FIG. 161.—FRACTURE OF LOWER END OF RADIUS ASSOCIATED WITH FRACTURE OF ULNAR END, IN A WOMAN OF SIXTY-EIGHT YEARS.

after the injury correction is possible by simple refracture. After the lapse of four to five weeks the only remedy consists in osteotomy in the fracture-line. Aged persons suffering from deformity of this kind are exempted (see Fig. 161). If they suffer while motion is made, immobilization is best kept up with a moss bracelet until ankylosis of the wrist has taken place. Sometimes a small

Fig. 162.—Fracture of Lower End of Radius, associated with Dislocation of Ulna.

wedge must be exsected from the ulna in order to permit of perfect reposition.

Such operations must be performed under the strictest aseptic precautions, tearing of the wound edges must be avoided, and the wound itself should come in contact with the hands of the surgeon as little as possible, since all the work can be done with well-sterilized instruments. If the Röntgen rays show that the efforts of early reposition were unsuccessful, although anæsthesia was employed, it is much wiser to expose the fragments by open incision at once than to wait until the tissues around the area of faulty union degenerate. As soon as the bloody effusion is absorbed the operation should be performed. Isolated bone splinters, the periosteum of which shows no more coherence, must be removed. If the fragments cannot be brought into apposition by simple reduction, then the ends must be trimmed properly with wire, saw, or chisel, and either indentated or wired.

Fig. 162 shows the fracture of the lower end of the radius, followed by overlapping of the lower fragment and associated with palmar dislocation of the ulna. The protrusion at the flexor aspect corresponds to the projection of the diaphyseal end, while the dorsal prominence indicated the riding of the epiphysis. The skiagraph also shows the forward dislocation of the ulna, the extent of which is proportioned to the amount of yielding on the part of the epiphyseal fragments. Consequently the arm was shortened.

FIG. 163.—CASE ILLUSTRATED BY FIG. 164, AFTER OPERATION, THE TRIMMED RADIAL FRAGMENTS BEING IN APPOSITION AFTER CORRECTION OF THE ULNAR PORTION. (Taken through the plaster-of-Paris dressing.)

Skiagraph (Fig. 163), taken through the plaster-of-Paris dressing two days after osteotomy, shows the trimmed radial fragments in apposition and the dislocated portion of the ulna resected. Consequently the extremity became an inch shorter.

As to tuberculosis of the wrist, the carpus, metacarpus, and phalanges, frequent in children, which can be well studied and treated under the guidance of the rays, the reader is referred to their respective sections.

HAND

The hand is the easiest object for Röntgen examination. It may be fluoroscoped in the dorsal as well as in the palmar position, the best skiagraphic results being obtained if the dorsum rests on the plate.

Especially the interpretation of the small carpal bones is sometimes difficult, and no judgment should be passed without having them exposed in at least two different projection planes—that is, preferably in the postero-anterior and in the lateral position. In children the hand is fastened to the plate with a gauze bandage, a soft tube being employed. In very lively children short exposures must be taken, the hand being held down firmly by an assistant. A fairly good skiagraph may be obtained in one or two seconds, a tube of medium hardness then being needed.

The dorsal position is uncomfortable, therefore support with sand-bags is indispensable. Children may assume the recumbent position if a dorsal exposure is chosen. The hand of an adult can be taken in fifteen seconds. Most skiagraphs of the hand are over-exposed, the contrasts then not being apparent. A good skiagraph of the hand shows the soft parts to a great extent, especially the muscles from which even the finger-nails must be differentiated. Diaphragms are not required in the examination of the hand.

Fracture of the carpal bones received consideration in connection with the description of fracture of the lower end of the radius. The isolated fractures of the carpus are rare.

Fig. 164 illustrates the fracture of the scaphoid bone in a woman of sixty years, caused by a fall on the outstretched hand. In this case a contusion of the wrist must have taken place, the force inflicted upon the very strong radial end having been transferred upon the less resisting scaphoid bone.

As to fractures of other carpal bones (os lunatum), the reader is referred to Annals of Surgery, August, 1901.

The fractures of the carpus are undoubtedly more frequent than is generally assumed. But they were not recognised formerly.

Metacarpus.—The Röntgen rays have also shaken the old dictum of the rarity of fracture of the metacarpal bones. There can now be no more doubt that a large number of alleged dislocations and contusions of the metacarpus were, in fact, either complete fractures in adults or separations of the epiphyses in children.

In most cases, displacement of the fragments being absent, and the other metacarpal bones serving to a certain extent as splints, it is natural that the results in these cases were nearly always good, no matter what treatment was employed; the *post hoc, ergo propter hoc* being sufficient evidence for the superficial

FIG. 164.—ISOLATED FRACTURE OF SCAPHOID BONE.

observer. If, however, he had used the Röntgen rays, he would have been not a little surprised to find, in such a case, the evidence of a fracture; while at the same time he could congratulate himself that in spite of his treatment for simple contusion the result was so perfect.

In the event of displacement the result would be somewhat different. If the displacement is in the dorsal direction, it is not only easily recognised, but also reduced and kept in place without difficulty by coaptation splints. But if the displacement, as it often occurs, is sideways, the result may be very unsatisfactory, the remaining deformity and disturbance of function being considerable. If a common labourer is concerned, but little inconvenience may be caused by it; but if a person whose hands must do delicate work, like a musician, watchmaker, cabinetmaker, or, last but not least, a physician, is the victim, badly united metacarpal fragments of the right hand may seriously interfere with his professional work.

Reduction of the displaced fragments never offers any insurmountable obstacles; but to hold them in place is a far more complicated task, and the recurrence of the displacement under the usual immobilizing methods shows their insufficiency in the end.

The question now is, What is to be our guide in estimating the value of a given immobilizing method before consolidation has taken place? In former years we used to judge the value of one or another method by the final result. But now, just as we estimate the value of a germ-destroying method first of all by bacteriological experiment, so we are able to judge by irradiation at the very beginning. If the immobilizing dressing is perfect, the formerly displaced fragments must be found in exact apposition when skiagraphed through the dressing.

FIG. 165.—DRAINAGE-TUBE SPLINTS FOR METACARPAL FRACTURE.

Various experiments showed the author that the metacarpal fragments are invariably held in place by elastic pressure. For this purpose two rubber drainage-tubes of moderate size are chosen, which are lightly pressed into the adjoining interosseous spaces, so that they fill them up to a certain extent. They are kept *in situ* by adhesive-plaster strips (Fig. 165). Thus the recurrence of the displacement is prohibited, The whole is surrounded then by a moss-splint, a material which, after being dipped in cold water, adapts itself to the contours of the hand like a plaster-of-Paris splint, over which it possesses the great advantages of being absorbent and much lighter.

In the case of a young man, who sustained fracture of the fourth metacarpal bone in its middle as a result of direct violence, considerable lateral displacement was produced (Fig. 166). Reposition was easily accomplished and the fracture area was carefully

FIG. 166.—FRACTURE OF FOURTH METACARPAL BONE, CAUSING SIDEWARD DISPLACEMENT. (Compare Fig. 165.)

surrounded by narrow pads, which were supported by adhesive plaster. A long palmar extension splint was then applied.

There was no swelling of the fingers nor any sign of discomfort. But when examining the metacarpus two weeks later with a view to leaving the splints off, the author found that the fragments had slipped by each other again. He then seriously considered other means of immobilization. After filling up the interosseous grooves between the fourth metacarpal bone and the little finger on one side and the third one on the other with two rubber drainage-tubes, the author took a skiagraph, which showed the fragments in ideal apposition. Shortly afterward he removed the rubber tubes, and then the displacement recurred at once. From this we also learn that it is unwise to rely upon the old dictum that metacarpal fractures show perfect consolidation after three weeks. We should consult the Röntgen rays before satisfying ourselves as to the question of impeccable union. (As to further details, see New York Medical Journal, August 1, 1900.)

Fig. 167 illustrates the fracture of the second metacarpus in a man of twenty-three years. There was but a slight degree of sideward displacement, still the sharp point of the lower fragment projected to the soft tissues, causing much irritation. As soon as inward and downward pressure was exercised the pain ceased.

Fig. 168 shows fractures of the fifth metacarpus. There is good apposition, but much ensheathing callus, which caused adhesions to the soft tissues, so that the function was much disturbed. Thus the patient, a young professional violinist, may be prevented from following the footsteps of Paganini.

Immobilization had been attempted in this case by a short phalangeal splint. While reposition as well as immobilization of the fifth metacarpal bone is easier than that of any of its fellows, the fragments cannot be held *in situ* by simple pressure from with-

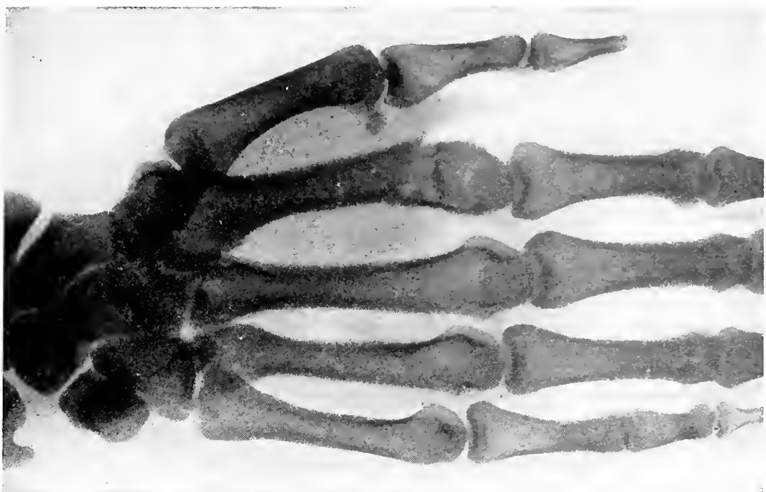

FIG. 167.—FRACTURE OF THE SECOND METACARPAL BONE.

out, a rubber drainage-splint should therefore be placed in the space between them and the fourth metacarpal bone.

Fig. 169 illustrates the deformed fracture of the second metacarpal bone in a musician of forty years. The fracture was sustained fifteen years before the skiagraph was taken, and until then a dislocation had been assumed. The career of the patient was greatly impaired, as he had to descend from his pedestal as a master of the bassoon to the drum. If the rays had been discovered at the time of the injury this would probably have been averted. An effort was made by the author to reduce the fragment after mobilizing it with the chisel, but this proved to be impracticable, therefore the fragment was removed. Thus an impediment for free motion was eliminated. As far as the short observation of the case shows the result is perfect, so that the patient may still be able to perform higher graded work.

Phalanges.—While the signs of fracture of the phalanges are well marked, there are cases in which differentiation from dislocation or inflammatory processes is difficult. The Röntgen method, of course, gives the most precise information. Some-

FIG. 168.—FRACTURE IN THE MIDDLE OF THE FIFTH METACARPAL BONE, SHOWING ENSHEATHING CALLUS.

times a fracture is recognised by palpation, but a number of associated injuries are overlooked. The skiagraph gives a splendid general view in such an instance, calling attention to points which were not thought of.

In treating phalangeal fractures it is recommended to use the rubber drainage-splints advised by the author, and to confine the whole hand. This may be done by a palmar splint or a short plaster-of-Paris dressing, at least for the week following the in-

FIG. 169.—OLD DISPLACED FRACTURE OF THE SECOND METACARPAL BONE.

jury. Then a short wooden phalangeal splint may be resorted to. The much-favoured cardboard splint seems to be useful, but is not firm enough, as is shown by skiagraphy, and should therefore be discarded.

Foreign bodies in the hand are easily shown. Especially needles in the palm often come under the observation of the practitioner.

CHAPTER XII

MALFORMATIONS

As previously mentioned, the great scientific and practical value of the Röntgen rays is also evident in the study of congenital malformations. Skiagraphy of the extremities especially has given more valuable information than dissection. The exact anatomical diagnosis that it enables us to make informs us whether surgical interference in a case of malformation is possible, and if so, outlines clearly our *modus operandi* beforehand. The ingenious operations of Bardenheuer (division of the ulna for carpal implantation) and of von Eiselsberg (transplantation of the toe), and the

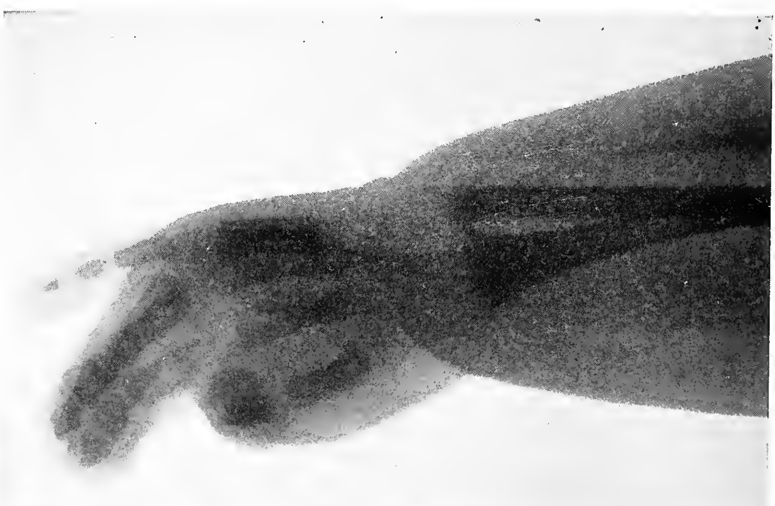

Fig. 170.—Syndactylism of Third, Fourth, and Fifth Finger in a Child of Eight Months.

works of Kirmisson, Vulpius, Middleton, Pagenstecher, von Bardeleben, Joachimsthal, Schede, Lambert, and Grunmach furnish most brilliant testimony to our progress in this direction.

Fortunately the most frequent abnormality is the one that can be easily remedied—namely, *polydactylism*. If there is but a rudimentary finger attached loosely by a pedicle and containing no

FIG. 171.—METATARSAL SYNOSTOSIS IN A BABY.

phalanges at all, removal is very simple. But when, as is the rule, there is a true supernumerary digit articulating with another phalanx or the head or side of a metacarpal bone, the site of exarticulation must be well known before the operation. Otherwise the better developed phalanx may be sacrificed.

Syndactylism, while not so frequent as polydactylism, also represents a large group of cases of malformation of the upper extremity, and is likewise amenable to operative interference.

In a case of syndactylism in a boy of eight months, the second, third, and fourth digits appeared to be fused together, each one of them, however, possessing its own nail. The skiagraph (Fig. 170) showed fusion of the first and second phalanges of the third and fourth digits, while their third phalanges were free. The little finger was more developed than the slightly deformed thumb. The carpus was not yet ossified, and therefore showed no shade. Under the guidance of the Röntgen rays it was easy to divide the phalanges. The middle finger was protected easily by a large longitudinal flap from the dorsal surface of the hand. The other two fingers were covered with their integument, longitudinal flaps being formed from the palmar surface for the second finger, and another one from the dorsal side of the fourth. The final result was good.

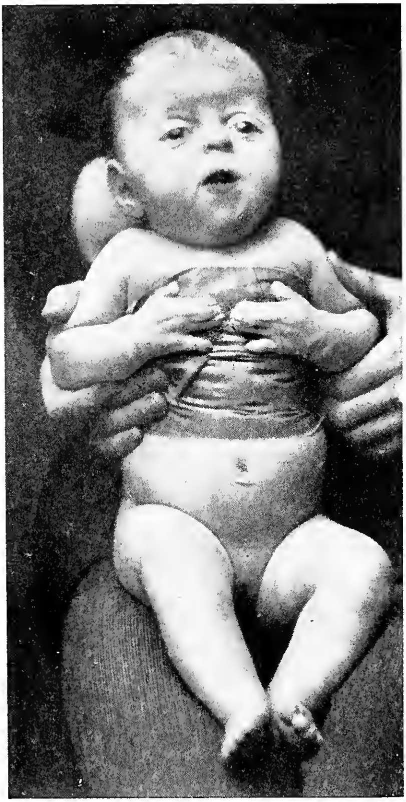

FIG. 172.—WEBBED FINGERS AND TOES.

Syndactylism is sometimes found simultaneously in both extremities. Fig. 171 illustrates metatarsal synostosis in a baby.

Congenital deficiencies are naturally much less amenable to correction. But that surgery is not without resources even in desperate cases of this kind is made evident by the transplantation of a toe to the hand, successfully undertaken by von Eiselsberg.

Fig. 172 illustrates the case of a child of eight months whose second, third, and fourth fingers, as well as his second, third, and fourth toes were webbed. Palpation did not show whether there was synostosis or not. As the bones were very near together, the impression prevailed that there was. But the skiagraph gave the information that the phalanges were well developed individually, and that therefore they did not need to form the object of an operation, the skin being the only part to be considered. A plastic operation performed then showed that the phalanges could be separated from each other without dissection.

The toes were left alone.

In *brachydactylism*, combined with ectrodactylism, the Röntgen rays have also proved to be of great value. In the case of a boy of three months there were five rudimentary fingers. The skiagraph showed the presence of one phalanx of the thumb and of two phalanges of each of the other fingers.

Under the guidance of the Röntgen rays a flap operation was performed, on the principles set forth in the case described above, between the first and second finger rudiment. Thus a fairly good thumb was created. The case, however, offered two more points of interest. In the first place there was a congenital fracture of the ulna and radius at their lower third, as was also illustrated by skiagraphy. The forearm could easily be bent at the seat of the fracture. After wiring the fragments union became perfect. (See Congenital Malformations of the Upper Extremity, New York Medical Journal, June 29, 1901.)

There was, furthermore, congenital constriction at the region of the surgical neck of the humerus, where a deep furrow encircled the whole circumference of the arm. Palpation was unable to detect any soft tissues between the integument and the bone. An exploratory incision revealed the presence of fragments of the biceps, triceps, and deltoid muscles. Their edges were refreshed and united with catgut. For relaxation two deep wire sutures were introduced from without. The result was fair.

Fig. 173.—Congenital Club-hand, and Absence of Radius and Ulna.

It may be added that the otherwise well-developed hand showed a moderately deep constricting furrow near the metacarpophalangeal junction of the middle finger, which did not seem to demand surgical interference, since the skiagraph showed its integrity otherwise.

It seems that this special branch of surgery does not receive the attention it merits. Considering that in the lower animals, as

Fig. 174.—Congenital Dislocation of the Wrist.

FIG. 175.—SUPERNUMERARY TOES.

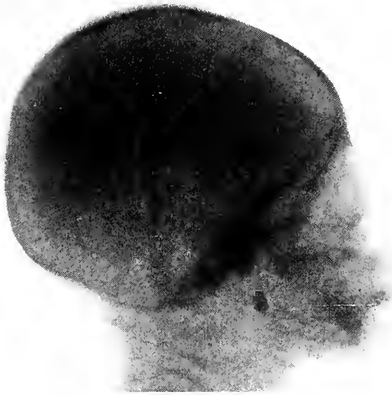

FIG. 176.—CONGENITAL ABSENCE OF NASAL BONES.

long as in the embryonic stage, regeneration of large portions of the head and trunk are possible, it should be expected that the new-born child—in a smaller proportion of course — also offers more chances for regeneration than the adult. If the germinal layer is only present, further development of the tissues can be looked for. If a part of a phalanx is properly severed, its individualization is a

FIG. 177.—SKIAGRAPH OF CASE OF RUDIMENTARY EAR, ILLUSTRATED BY FIG. 178.

matter of great probability, provided the bridge remaining has preserved sufficient vascularity for nutrition, that there is no over-extension of the flap, and that the most minute aseptic precautions are taken.

In a case of congenital club-hand associated with absence of the radius and ulna, only three fingers and three metacarpal bones were present, as became evident by skiagraphic examination (Fig. 175).

Fig. 178. — Rudimentary Ear in a Child of Three Months. (Compare Fig. 177.)

The left arm of the boy was normal excepting the thumb, which was partially ectrodactylic. An attempt was made to improve this deplorable condition by creating a thumb after the principle carried out in the case just described. For this purpose a dorsal incision was made down to the first metacarpal bone, which was divided longitudinally, thus making a kind of bifurcation. The phalangeal end was severed entirely, but the carpal end, after being fractured longitudinally, was left in slight connection with the metacarpal bone. Thus a new bone was obtained that was surrounded by dorsal as well as palmar flaps. There was little trouble during the after-treatment.

Fig. 174 illustrates congenital dislocation of the hand of a man of thirty years. There is considerable atrophy and the function is very much disturbed.

Most malformations of the foot are of a similar nature, and their therapy has to be viewed from the same points of view.

Fig. 175 illustrates the supernumerary toes in a boy of six months. The phalanges of the fifth toe are well developed, while the supernumerary appendix shows only traces of osseous tissue. It was natural therefore that the sixth was to be regarded a true supernumerary digit; therefore it was removed.

In the Journal of the American Medical Association, October 12, 1901, a series of cases representing congenital malformations is illustrated. Among them the case of a boy of three weeks whose left lower extremity was normal, while the right one showed shortening of the femur to the extent of an inch, is especially noteworthy. There was no muscular atrophy. Shortening of the healthy femur for the purpose of equalization was suggested. In a similar case, concerning a child of six months, the shortening of the healthy femur was successfully performed by the author. There was no disturbance of development observed, the time of observations being two years now.

Congenital absence of the nasal bones and insufficient development of the nasal processes of the superior maxilla was observed in a boy of two months (Fig. 176). The patient was ill nourished, and the family history was negative.

As to congenital obliteration of the auditory canal, see Figs. 177 and 178. (Compare page 65.)

CHAPTER XIII

DISEASES OF THE BONES AND JOINTS

As alluded to in the General Part, the bones give the human body form, erectness, and firmness, the latter being the most essential feature of a normal bone. The firmness of the bone is vouchsafed by its heavy, hard, and dense consistency, which is pre-eminently based upon the presence of calcium phosphate. The percentage of this salt amounts to as high as 84. There is also a slight admixture of magnesia and traces of calcium chlorate and fluorocalcium.

It is the density of these inorganic elements which prevents penetration by the rays, thus producing a marked shadow in contrast to the more translucent organic tisues of the body.

It is obvious that any change affecting the density of the bone, in other words, the chemical components, must show on skiagraphic examination. And, in fact, there is no bone affection which is not characterized by more or less marked skiagraphic features. If it is considered how meagre sometimes the information gained by inspection, palpation, probing or aspiration is, the immense importance of a method which gives us definite information by a painless procedure will be realized.

The characteristic points of differentiation between the important osseous diseases were outlined by the author in his essay in the Journal of the American Medical Association, June 3, 1901. In general, the views emphasized there were corroborated by further observation.

OSTEOMYELITIS

While it is not difficult to diagnosticate osteomyelitis in its advanced stage, especially after the cortex as well as the periosteum have participated in the inflammatory process, the initial stage can but rarely be recognised by the usual methods.

Usually the patient complains of pain, which is most intense at night, in one of the large bones. Palpation sometimes reveals a slight thickening of the affected bone. But it may just as well be

FIG. 179.—OSTEOMYELITIC FOCUS OF HUMERUS.

absent. A preceding trauma, a furuncle, or an acute infectious disease (scarlet or typhoid fever, diphtheria, or measles) often open the avenue of infection. The pain, the œdema, the fever, and general debility are sometimes so little marked that differentiation becomes difficult. The skiagraph not only clears this difficulty of diagnosticating this disease, the true ætiology of which is still so obscure, but also furnishes a trustworthy guide for the operative technique. Osteomyelitis is of a decidedly infectious character, generally due to the invasion of the staphylococcus into the blood circulation. Fortunately, the staphylococcus has a tendency of inducing the formation of circumscribed foci in the vascular tissues of the bones—viz., the medulla.

If the infection is due to the typhoid bacillus, the suppuration loses its acute character, an abscess generally forming. The predilection of osteomyelitis is for the long bones of young individuals. It is self-evident therefore that the early recognition of osteomyelitic foci renders the prognosis of their evacuation extremely favourable.

As alluded to in diseases of the humerus in the case of a lady of twenty years, the slow onset of the symptoms did not seem to in-

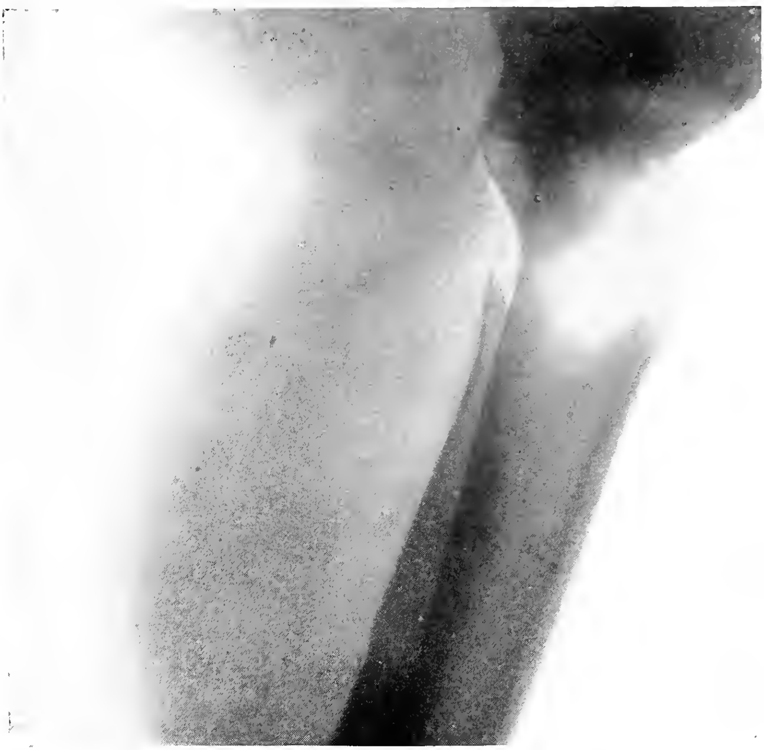

FIG. 180.—ADVANCED STAGE OF OSTEOMYELITIS OF TIBIA.

dicate an acute inflammatory process. Pain being present only temporarily, the development of a malignant growth was feared. The skiagraph at once did away with all anxiety, since it revealed the presence of periostitic proliferation and a circumscribed osteomyelitic focus at the middle of the humerus. The focus was easily exposed by the chisel under the mentorship of the skiagram. That the skiagram had also spoken the truth by demonstrating the in-

FIG. 181.—EXTENSIVE OSTEOMYELITIS AT THE POINT OF PERFORATION.

tegrity of the remaining portions of the humerus was shown by the speedy recovery of the patient.

Thus the foci can not only be localized, but their extent can also be so well outlined that the technical steps of the operation can be definitely traced in advance. The feeling of security the surgeon has while proceeding under the mentorship of the skiagraph gives a satisfaction unknown in former years, when often the whole bone, like the femur, for instance, had to be exposed in order to ascertain whether all the foci had been detected. If the Röntgen rays show but one focus, no other regions of the bone need to be attacked. Fig. 179 shows the osteomyelitic focus in the lower third of the humerus of a woman of thirty years. The patient was treated for rheumatism first. When seen by the author, two weeks after the onset of the violent pain in the lower region of the humerus, a slight swelling and tenderness at this region was noticeable. Skiagraphy revealed the focus and dictated the *modus operandi*. A tablespoonful of staphylococcus pus was discharged and the cavity packed with iodoform gauze. Recovery was perfect after two months. In former years the diagnosis at so early a stage would not have been possible, and consequently so speedy a recovery would not have been obtained. In this case an injury of the tibia, followed by suppuration, had been sustained six months previously.

The osteomyelitic focus is distinguished by its light shadow in the midst of the dark shadow of the thickened cortex. The regularity of the cortical line distinguishes it from osteosarcoma, and the absence of distention from osseous cyst.

In the more advanced stages the cortex and periosteum participate in the process. Then the skiagraph naturally shows proportional changes. The shadow of the sclerotic cortex becomes still larger and the ossifying inflammation of the periosteum finds its skiagraphic expression in a very light shadow-line running parallel to that dark one of the cortex.

Fig. 180 illustrates the advanced stage of osteomyelitis at the upper end of the tibia in a man of thirty years. At the anterior aspect of the bone perforation had already taken place, while posteriorly the cortex is still intact. The evacuation of the focus was easy and recovery was perfect.

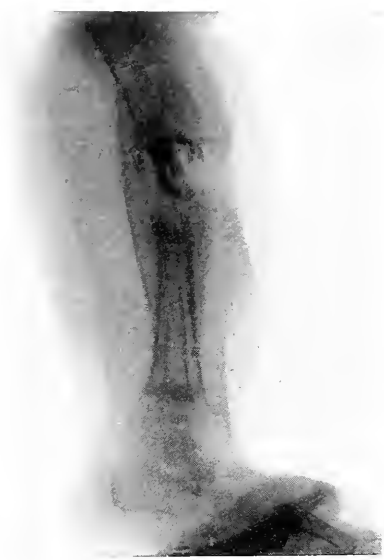

Fig. 182.—Osteomyelitic Focus in the Tibia. (Compare Fig. 181.)

In tubercular abcesses sclerosis, or rather eburnation, is extremely rare, which is of importance in the question of differentiation. After extensive operations for osteomyelitis, eburnation of the cortex is so marked that the contrast appears most striking on the skiagraphic plate.

Fig. 181 illustrates osteomyelitis of the tibia in a girl of fifteen months in an advanced stage. The child, having sustained a fall from her cradle several weeks before being skiagraphed, was supposed to have suffered a severe contusion, and was treated accordingly. The external swelling was insignificant. No fluctuation being present, the attendant did not think of the possibility of the presence of suppuration, although the patient's temperature was elevated once in a while. Skiagraphic examination proved the presence of an extensive osteomyelitic focus, which was at once exposed by the chisel. Two tablespoonfuls of pus were discharged the recovery being uninterrupted. Fig. 182 shows the cavity three weeks after operation. The dark shadow lining the margins of the cavity indicates the presence of iodoform.

NECROSIS

Necrosis and other later stages of inflammatory processes can be represented still more distinctly.

The size and shape of sequestra can be well made out. It can furthermore be ascertained how they are located in their bony

FIG. 183.—SEQUESTRUM EXFOLIATING FROM THE RADIUS.

coffin, and whether they still adhere or are exfoliated. Under the guidance of the Röntgen rays extraction is very easy.

Fig. 183 illustrates the case of a man of twenty-three years who had crushed his little left finger. Amputation was deferred until septic tenontitis and tenontothecitis had developed. The

Fig. 184.—Osteoperiostitis following Phlegmon of Hand.

extensive tissue necrosis in the muscular interstices of the forearm necessitated free and deep incisions, which showed the radius as well as the ulna denuded of their periosteum. Amputation was therefore authoritatively advised; nevertheless, the chances of further conservative treatment were taken. The author's experience had taught him to resort to amputation for sepsis only under the most extraordinary circumstances; and it seems to him that all cases which were saved by amputation would have recovered under the most vigorous conservative measures, especially excessive exposure of the foci and removal of suspicious tissue. Fortunately, the process became confined to the forearm, and recovery seemed to make rapid progress. Only a small fistula at the dorsum of the forearm did not close. The repeated introduction of a probe did not point to the presence of rough bone, and the author was inclined to suppress his suspicion of the presence of a sequestrum. His surprise was great when the Röntgen rays revealed so large a splinter as that which is shown by the skiagraph. The direction of the skin incision, a slightly oblique one, was dictated by the position of the sequestrum as indicated by the skiagraph. When

Fig. 185. Synostosis between Radius and Ulna and Exfoliating Sequestrum.

the sequestrum was reached, it was found covered by thick fibrous tissue at the upper surface, while the inner and lower surfaces were exposed. This explains why the introduction of the probe gave no positive information, since it had touched only the fibrous cover, and did not come into contact with the rough lateral or posterior surface. Recovery was perfect eleven days after the operation. The translucent state of the bones due to inflammatory atrophy is also noteworthy.

The regeneration of osseous tissue can be well studied in such cases by the skiagraph.

That the bones participate in acute phlegmonous processes is evident from Fig. 184, which illustrates the hand of a man of forty years, whose left little finger was crushed in a machine. Medical treatment was not submitted to until the whole hand became swollen. A septic phlegmon developed, which necessitated extensive incisions. When the swelling had subsided thickened bone portions could be palpated, the osteoperiostitic nature of which was shown by the skiagraph.

Before the advent of the rays such extensive participations of the bones could not have been assumed. Later observation often

FIG. 186.—SEQUESTRUM IN THE FEMUR.

showed osseous changes in apparently slight cases of inflammation of an infectious origin. This shows the eventual necessity of exposing intraosseous foci when operating for phlegmon.

Fig. 185 illustrates the sequelæ of puerperal sepsis in a woman of thirty-five years. Septic arthritis and tenontitis developed after childbirth, and was treated by extensive exposure of the foci. Six months after the operation a fistula at the upper end of the radius remained, the cause of which was evident by the presence of a

FIG. 187.—NECROTIC RADIUS AND ARRODED HUMERUS, COVERED BY IODOFORM GAUZE.

small exfoliating sequestrum, shown at the upper portion of the ulna; the skiagraph also explained why rotation of the forearm was impossible, since it showed the presence of synostosis between the radius and the ulna, undoubtedly due to the preceding inflammatory irritation. Accordingly the illustration suggests separation of the united bones by the chisel.

As to further details regarding sequestra of the femur after fracture, the reader is referred to the cases illustrated by Figs. 100 and 101.

Fig. 186 illustrates the case of a man of twenty-three years who had sustained a compound fracture of the middle of the femur four years before the skiagraph was taken. The patient suffered from more or less severe inflammatory attacks now and then, pus discharging frequently from a fistula at the lower third of the thigh. Skiagraphy at first showed nothing but the deformity of the femur, because a soft tube had been selected, while a tube of medium hardness revealed the presence of a small piece of necrotic bone in its coffin at the area of the fracture. The sequestrum was extracted through a small opening made as the skiagraph indicated it, recovery being perfect.

Fig. 187 illustrates necrosis of the inner half of the radius in a girl of seventeen months. The first signs of inflammation manifested themselves five weeks before the skiagraph was taken. At first an injury was thought of. The Röntgen method revealed the true nature of the disease at once, and suggested exposure of the radius. When this operation was performed the impression was that the radius had become a uniform sequestrum, and in former years the author would therefore have removed the bone in its entirety. But the skiagraph indicated that the outer portion of the bone was normal, therefore the inner side was removed by the sharp spoon, so that only a thin long fragment remained,

Fig. 188.—Remnant of Radius, showing Beginning Bone Proliferation after Removal of Necrotic Area. (Compare Fig. 187.)

which was carefully left in contact with the remnant of the periosteum. In spite of the emaciated condition of the patient perfect recovery took place, the function of the extremity being completely restored.

Fig. 188 illustrates the case two weeks after operation, the iodoform-gauze packing also appearing marked on the skiagraph.

ACUTE INFLAMMATORY ATROPHY OF THE OSSEOUS TISSUES

The peculiar character of the bone shadows shown in inflammatory processes, which seemed to be confined to the soft tissues exclusively, suggested that such pathological changes had also extended upon the bony tissues. The similarity of the shadows to those found in rickets or osteomalacia led to the belief that an acute absorption of calcareous matter had taken place. More extensive observation showed that these phenomena generally made their appearance four to nine weeks after the injury.

Before the Röntgen era the clinical symptoms caused by them were attributed to inactivity, but skiagraphy proved that the osseous tissues underlying the inflammatory area participated, the spongiosa showing the first signs of change. Sudeck (Archiv für klinische Chirurgie, vol. lxii) and Kienboeck (Wiener medicinische Wochenschrift, No. 28, 1901) advanced the theory that bacterial invasion was arrested at the spongiosa in mild forms (fractures, for instance), only the signs of congestion and swelling, etc., being present. But in the virulent cases, as in septic phlegmon, septic tenonitis, etc., bacteria have reached the medulla. Then the tissue changes are more marked and consequently show the skiagraph evidence.

Rarefaction of the osseous tissue can be recognised by the presence of some light areas. In the more severe forms the cortex becomes less compact, the translucency reaches a high degree, and the texture disappears entirely.

In phlegmonous processes, septic arthritis, etc., rarefaction may reach such a degree that portions of the bones become so soft temporarily that an aspiratory needle may perforate them without resistance. Such bones are, of course, highly translucent, and consequently show very light shadows on the Röntgen plate. The osseous structure may appear confused and blurred, the trabeculæ become thinner and disappear altogether in some areas. As alluded to before, these conditions resemble osteomalacia, but the process of calcification in these cases is of a decidedly inflammatory nature.

In a case of old pyothorax (see Zwanglose Hefte, Die Röntgenstrahlen in der Chirurgie, Seitz und Schauer, München, 1901) the author did not succeed in reproducing the ribs of a man who had submitted to resection five times. At first a technical fault

FIG. 189.—TRAUMATIC ATROPHY OF SHOULDER-JOINT AND HUMERUS, FOLLOWED BY RELAXATION OF LIGAMENTS (SUB-LUXATION)—POSTERIOR EXPOSURE. (Compare Fig. 190.)

was supposed to be the cause, when a renewed resection, this time performed by the author himself, called his attention to the softened condition of the ribs, which accounted for the lack of skiagraphic contrast. In tuberculous processes, associated with suppuration, the same osseous rarefaction is observed sometimes.

FIG. 190.—SAME AS FIG. 189—ANTERIOR EXPOSURE.

After fractures, caused by great violence, similar osseous changes are noticed.

The author has in former publications (see Ueber deform geheilte Fracturen, Münich Medical Weekly, February 17, 1901) called attention to the intense absorption of calcareous matter in syphilitic gumma and in carcinoma and sarcoma (see respective sections). Fig. 118 illustrates the case of a man of thirty-eight years who sustained a fracture of the calcaneum two months before the skiagraph was taken, which showed a high degree of translucency. At first the impression that this was a fault of the technique prevailed, but repeated exposures showed the same conditions. The great functional disturbance was not in proportion to the slightly deformed union, therefore it had to be assumed that it was due to the acute inflammatory atrophy of the bone.

If the primary focus heals rapidly, the softening of the bones may last but a few weeks, perfect recovery taking place then. But not infrequently the process proceeds further, the diaphyseal cortex also becoming affected. Then deformity of the bones takes place, and the cartilage shows signs of erosion. While in the acute stage the osseous tissues are hyperæmic and softened, later on this becomes anæmic and brittle. The ligaments may be so much relaxed then that a condition resembling dislocation forms. In children the natural growth of the bone may be arrested, so that considerable shortening takes place.

Figs. 189 and 190 illustrate a condition of this kind in a man of nineteen years, whose shoulder was severely injured at childbirth. It is reported that after the inflammatory signs in the joint had subsided, atrophy of the whole area developed. At the time of irradiation the left humerus proved to be an inch shorter than its fellow. The articular surfaces were irregular, and the area of the tubercles still translucent. The deformity of the acromion as well as of the coracoid process is well marked. The subluxation appears more pronounced in the anterior than in the posterior exposure. There is severe functional disturbance.

The great importance of inflammatory atrophy, which at least delays recovery strangely, and in some instances may necessitate amputation, is self-evident from a medico-legal standpoint (see Chapter XVII on Medico-Legal Aspects). Another peculiarity of atrophic bones is that they are more inclined to become fractured than normal ones.

As the pathogenic nature of acute inflammatory atrophy still appears to be obscure, the main factor in its ætiology seems to be a disturbance in the circulation, probably of a trophoneurotic character.

TUBERCULOSIS

As emphasized in the chapter on tuberculosis of the lungs, the clinical signs of tuberculosis are but little marked at its early stage. The same applies to bony tuberculosis. This is deplorable,

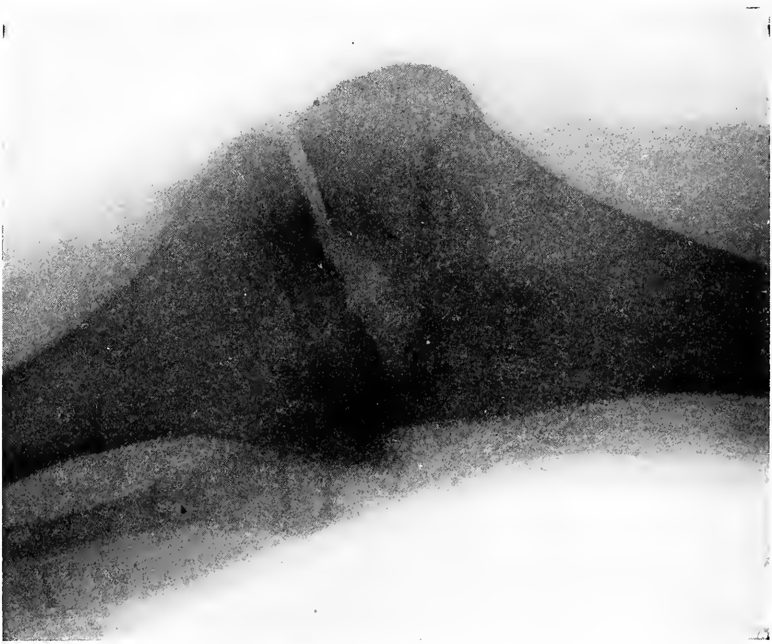

Fig. 191.—Enlargement of Internal Condyle, causing Valgus Position of Knee, in Tuberculosis. (Compare Fig. 192.)

for the reason that therapy is much more effective at the initial stage than when the symptoms are well marked—in other words, when the process of destruction has become advanced. It is, indeed, not at all difficult to diagnosticate osseous tuberculosis if there be the characteristic appearance of fistulous tracts, discharging cheesy pus, the simultaneous development of tuberculosis of the lungs or of other internal organs, and last but not least, a history of tuberculosis.

Fortunately, the Röntgen rays enable us to recognise a tuberculous focus at an early stage, thus giving the surgeon a chance to perform a conservative operation, while at the late stage of extensive destruction such effects prove to be futile.

A slight swelling of one of the tarsal bones may be regarded to be the result of a contusion, while the rays prove it to be produced by a tuberculous focus, the speedy elimination of which means a perfect cure from a tubercular process. One of the prominent features of bone-tuberculosis is its prevalence at the epiphyses. This naturally causes such characteristic changes in the articular ends that they can be represented skiagraphically. At the early stage of tuberculosis osseous atrophy at the epiphyseal ends is always found to a greater or lesser extent, which is produced by a deficiency of calcareous deposits.

The less calcareous substance the atrophic area contains, the more translucent it becomes by the rays, thus showing a characteristic light shadow. In late stages when cheesy foci form, their areas appear still more translucent.

As a rule, the articular outlines of a tuberculous joint have lost their regularity and appear diffuse, cloudy, and often shaggy.

FIG. 192.—TUBERCULOUS KNEE-JOINT AFTER OSTEOTOMY. (Compare Fig. 191.)

The cortex is sometimes partially destroyed, and leaves the impression as if a piece had been bitten out, as in Fig. 191, for instance, which shows enlargement of the internal condyle at the same time. After the process came to a standstill, the deformity became so great that cuneiform osteotomy was done (see Fig. 192).

Fig. 193 illustrates a moderate degree of tuberculosis in a boy of five years, the cartilages being eroded. Such cases generally get well after the injection of iodoform glycerin.

After thorough repair the area of the primary focus gradually indicates its normal saturation on the skiagraphic plate again. The texture, however, has lost its distinct character, the network showing wider meshes. Only the contours of the cortex are well marked, sometimes even more than before.

Fig. 194 illustrates enlargement of both internal condyles of the femur in a boy of fourteen years, four months after his

FIG. 193.—TUBERCULOUS KNEE, SHOWING ARROSION OF CARTILAGES.

tuberculous gonitis was cured by the injection of iodoform-glycerin. The left knee seems to be perfectly restored, while the articular surfaces of the right knee are somewhat shaggy.

In the case of extensive tubercular destruction the eroded and displaced cartilages can be studied.

Fig. 195, for instance, illustrates the tubercular knee of a boy of four years. The texture of the bone, the medulla, and the ex-

Fig. 194.—Enlargement of Both Internal Condyles in a Boy of Fourteen Years, Four Months after his Tuberculous Gonitis was Cured by the Injection of Iodoform-glycerine.

tensive destruction of the cartilaginous tissues are well marked in the skiagraph, Fig. 196. A tube of medium hardness was selected to show these structural details, while a soft tube which was employed before showed only the backward dislocation produced by the erosion of the ligaments, but no foci.

Fig. 197 shows synostosis between patella and femur as a consequence of tuberculous inflammation, valgus position being present besides. After the process had stopped, osteotomy of the condyle was performed. Later the synostosis between patella and femur was divided by the chisel.

In tubercular coxitis, the spontaneous upward dislocation of the femur and the separation of its head in the acetabulum is recognised. In obscure cases the rays differentiate it from rheumatism, arthritis deformans, congenital dislocation, fracture of the neck of the femur, epiphyseal separation, neuralgia, or osteomyelitis. The healthy joint must always be skiagraphed at the same time for comparison. Fig. 98, for instance, illustrates the tuberculous hip-joint of a boy of eleven years a year after the onset of the disease. The articular outlines appear irregular, cloudy, and on some portions shaggy. Recovery took place in this instance after resection. The extent of the destruction, as it is shown by the skiagraph, determines the question whether resection must be resorted to or whether conservative steps are justified.

Fig. 195. — Photograph of Case of Tuberculous Knee, Illustrated by Fig. 196.

Fig. 198 shows the destruction of the left parietal bone and part of the orbit in a boy of ten years. How far the bone became decayed is illustrated by the light area in Fig. 199.

The only marked signs of tubercular spondylitis consist sometimes in the presence of an abscess below Poupart's ligament, the nature of which would not be properly interpreted, if the plate did not prove the existence of vertebral changes.

Skiagraphs of the hip-joint should always be taken by using a diaphragm. As to the details of tuberculosis of the hand, see section on Diseases of the Hand (page 233). How cheesy foci of cervical and bronchial glands are shown is illustrated in Chapters VII and VIII on the Neck and Chest.

Extensive deposition of calcareous matter in the sheaths of the tendons, called *tenontitis and tenontothecitis prolifera calcarea* by the author, seems to bear relations to tuberculosis.

Fig. 200 illustrates the hand of a Russian tailor, forty-two years of age, who had noticed a small and painless swelling formed in the dorsal surface of his right hand eleven years before. This swelling increased gradually, but until it grew painful no medical advice was sought. At the first examination a globular tumour was noticed in the dorsum of the right hand, of the size of a moderately large apple. Its surface was red, its consistence irreg-

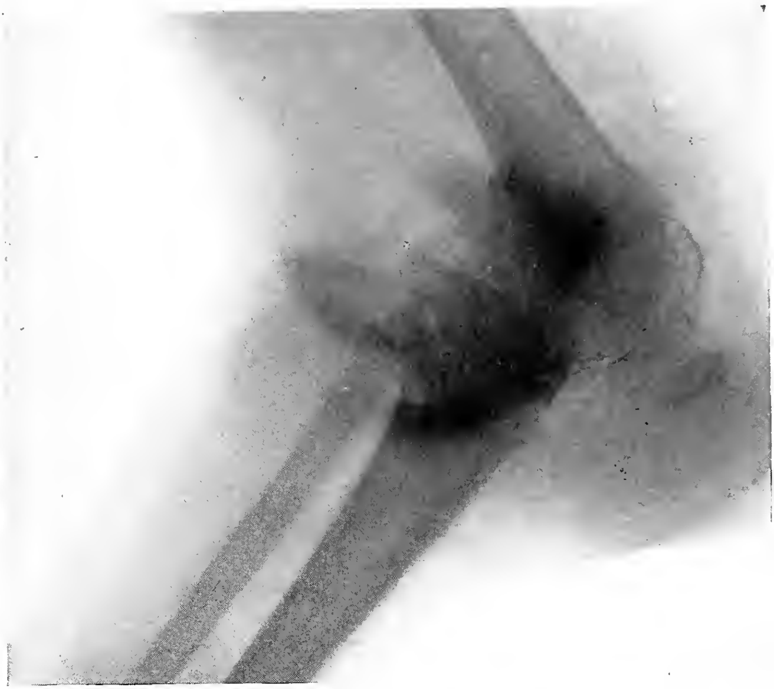

FIG. 196.—TUBERCULOUS FOCI IN AND AROUND THE KNEE-JOINT. (See Fig. 195.)

ular, some parts of it being hard, while others appeared soft to the touch. The centre of the tumour was occupied by a large ulceration, which was surrounded by several fistulous tracts, from which turbid sero-pus issued. The first impression was that the tumour represented an osteosarcoma, and it was feared that speedy amputation would be indicated. It was decided to make use of the Röntgen rays, which proved to be a valuable means of information, since the true condition was at once precisely defined. A skiagraph, which was taken with a tube of medium hardness (Fig. 201), showed that the third metacarpo-phalangeal joint was the seat of a focus of inflammation. The phalanx was grown together with the metacarpus. The cortex of the condylar side was totally destroyed, appearing as if scooped out with a gouge. By irradiation with a soft tube the limits of the tumour were well outlined. A third skiagraph, taken with a hard tube, showed the bones faintly, but permitted distinct recognition of the various shadows of the tumorous portions. The light areas represented the suppurating portions, while the dark shadows corresponded to the calcareous areas. These, as shown also by subsequent operation, were the predominating elements of the tumour. It now became evident that there was a chronic inflammatory process, the character of which was not recognized.

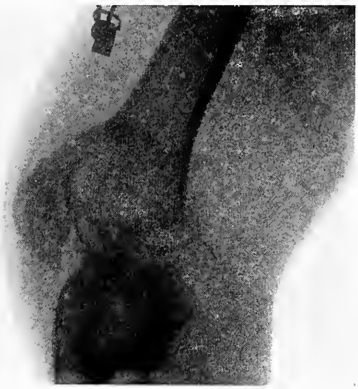

FIG. 197.—SYNOSTOSIS BETWEEN PATELLA AND FEMUR, BEFORE OPERATION.

Extirpation showed the defect of the bone filled with yellow cheesy masses, the synovial membrane being partially destroyed at the same time. But the most surprising feature of the condition was that the extensor tendons of the digits, excepting the thumb, appeared as if cemented into one mass of mortar. In dividing this mass the knife caused a loud grating sound. Of the tendon on the third finger only a few rudimentary fascicles had remained, so that it had to be sacrificed entirely. The fascicles of the second and fourth extensor tendons were kept apart by the concre-

FIG. 198.—EXOPHTHALMUS CAUSED BY TUBERCULOUS DESTRUCTION OF SKULL.

tions. They were, in fact, so much encrusted that only a small portion could be felt. The weight of the whole amount of calcareous mass removed proved to be 80 grammes.

The bones of the forearms showed considerable translucency, which suggested the presence of an atrophic state in the osseous system.

Microscopical examination showed round-cell granulations and the presence of staphylococci, but no evidence of tubercle bacilli. There were also deposits of phosphates and carbonates of calcium.

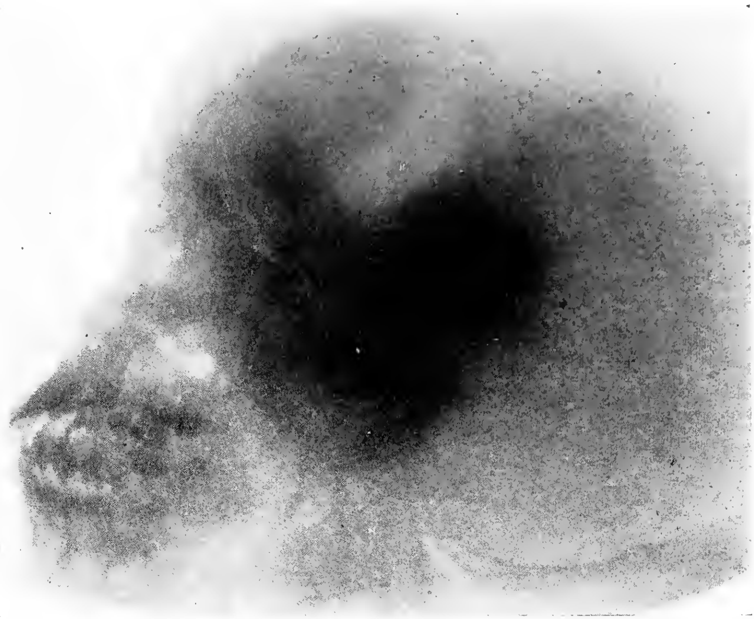

FIG. 199.—SKIAGRAPH OF CASE ILLUSTRATED BY FIG. 198.

The decalcified fragments of the tendons showed granulation of the circumfascicular and intrafascicular connective tissues, also partial necrosis. Hæmatoxylin stained the degenerated tissue dark brown violet, and picrocarmine changed it to red. Recovery was slow and was not perfect until six months after the operation.

Now, what was the integral character of the disease? There was a much degeneratel (cheesy) tissue in the state of necrobiosis, which seemed to have a sort of magnetic effect, so to speak, on the dissolved calcareous salts, inducing them to amalgamate. Such

FIG. 200.—SWELLING OF HAND IN TENONTITIS AND TENONTOTHECITIS PROLIFERA CALCAREA. (See Fig. 201.)

petrifications are found in tuberculous (cheesy) foci of the lungs, and not infrequently in endocarditis, pericarditis, old pleuritic bands, uterine myomata, and renal epithelium. As to definition

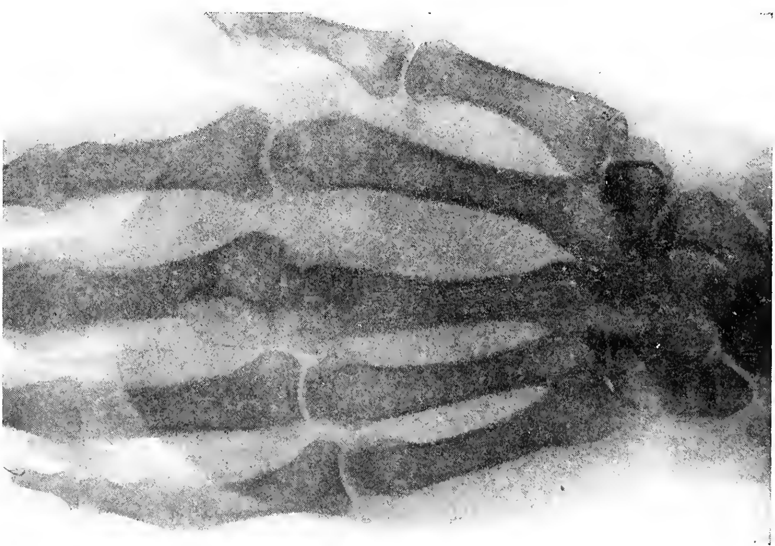

FIG. 201.—TENONTITIS AND TENONTOTHECITIS PROLIFERA CALCAREA. (See Fig. 200.)

by means of the Röntgen rays to the mode of petrification in the walls of blood-vessels as well as in the degenerated thyroid gland, see the respective sections.

The tendons and their sheaths seem to be but seldom the seat of predilection for calcareous deposits. Still, with the increasing popularity of the Röntgen rays, more light may also be thrown upon the pathology and significance of this hitherto unknown disease, for which the term "tenontitis and tenontothecitis prolifera calcarea" is suggested.

Wolff (Archiv für klinische Chirurgie, 67 Bd., Heft 2, 1902) reports a similar observation, calcareous deposits being found in the tendon and fibrous portions of the semitendinosus muscle. His patient being sixty years of age, he regards the case as one of senile calcification. The author, however, does not believe that the age is of material influence upon the production of calcareous matter in this connection.

RHACHITIS (RICKETS)

Rhachitis, while frequently found in Europe (in the old university town of Halle, which is situated in midst of the German potato district, 47 per cent of all children suffer from rhachitis), is but seldom observed in the United States. Nothing, in fact, demonstrates the prosperity of this country more markedly than the absence of this disease, which owes its origin mainly to poor nutrition.

As is well known, the characteristic features of rhachitis consist in a change of the composition, form, and texture of the bone, due to the absence of the normal amount of calcareous deposits during the period of development. This is recognised macroscopically by the development of more or less deformity (Fig. 202). The cartilaginous substance proliferates to such an extent that the epiphyses become more or less enlarged. The calcification line, characteristic of the normal osseous growth, is found to be entirely changed. While the areas of cartilaginous and osseous proliferation in a normal individual show regular lines, which run parallel to each other, they appear irregular and zigzag-shaped in a rachitic. These changes appear like indentations in the longitudinal section of a rhachitic epiphysis. The different degrees of

Fig. 202.—Rhachitic Deformity of Lower Extremities.

density caused by such changes can be well reproduced by the rays. Besides its characteristic architecture the bone shows some marked peculiarities. The abnormality of the process of calcification is most evident at the femur, the tibia, and fibula, the lower end of radius and ulna, the metacarpal bones, and the ribs.

Fig. 203 shows the deformed tibia of a child of four years. The homogeneous structure and the normal density of the middle of the diaphysis point to sufficient percentage of calcareous matter, while the lower third shows considerable lacking of these elements. The changes in rachitis slightly resemble those of osteomalacia. But in rachitis the area lacking the calcareous matter is represented by newly formed and osteoid tissue, while in osteomalacia it is formed by decalcified bone. Rachitis

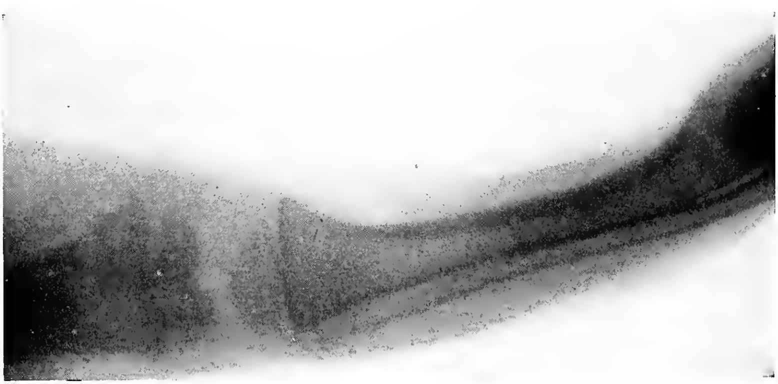

Fig. 203.—Rhachitic Tibia.

is, however, mainly distinguished from osteomalacia by the irregular arrangement of interspersed osseous structures as well as by the deformed shape of the bones.

OSTEOMALACIA

As alluded to in the foregoing section, there is a great resemblance between rachitis and osteomalacia. Still, while rachitis is a disease of infancy and childhood, osteomalacia is found in adult life only, especially in puerperal women. It consists in a progressive softening of the osseous tissues. In rachitis the growing bone is not supplied with a sufficient quantity of lime-salts; in osteomalacia the normal amount of lime-salts, present originally, becomes gradually absorbed, thus causing deformities and sometimes even fractures of the area involved.

The deformity generally begins in the os ilii in puerperal cases. Later on the spine becomes involved, the vertebræ being compressed against one another, promontory and symphysis also approximating. The extreme preponderance of the substance of the bone naturally impairs its density, so that the degree of translucency shown by the rays indicates the degree of the disease. It must be considered, however, that an overexposed skiagraph may leave the erroneous impression that there is a lack of the normal amount of calcareous matter. This will occur so much easier, since so large a bone-mass as the pelvis must generally be reproduced, which would suggest a long exposure and a hard tube. But if the deformities, especially the course of the linea innominata and the typical kink of the pubic bone are well recognised, no misinterpretation can occur.

ARTHRITIS

In acute arthritis no anatomical changes may be revealed by the rays except that the presence of an effusion may cause distention of the joint. This fact is recognised by the increasing gap between the articulating epiphyses. Later on the contours of the bone epiphysis appear irregular, and show indentations on some portions, while others are veiled. The arthritic deposits are recognisable as light shadows of the deformed epiphyses, as they consist of translucent uric-acid salts, while their periphery is distinguished by a dark sphere.

The deposits can be represented only by using a soft tube, since

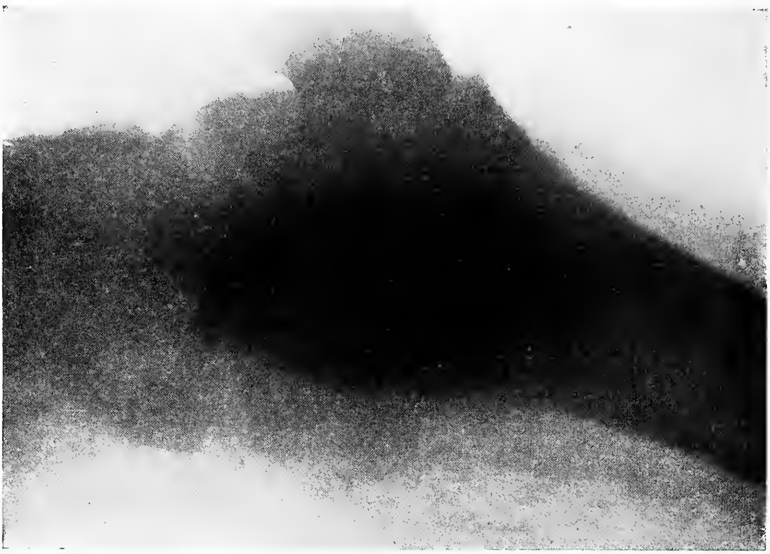

FIG. 204.—ARTHRITIS.

the rays from a hard one penetrate them to such an extent that they would leave no impression on the photographic plate.

In *gonorrhœal arthritis* the epiphyses, the affected joint, and sometimes their vicinity appear rarefied, so that they resemble the pathological changes occurring in acute inflammatory atrophy (see the section page 260). Rapid and intense absorption of calcareous matter takes place, the osseous texture in general becomes confused, the contours as well as the structures of the spongiosa appearing blurred.

In all cases of gonorrhœal arthritis of the wrist observed by the author, the carpus appeared extremely light and the contours somewhat irregular. The carpal bones are not well defined individually, but produce the impression of a confluent mass, and the radio-carpal joint shows a great tendency to ankylosis, because later even the surfaces of the cartilages become eroded. In more advanced stages the whole hand may be shortened. In arthritis of the elbow, knee, or hip the anatomical changes appear less marked, of course, than in the wrist. In order to represent the spongiosa trabeculæ well, tubes of medium hardness must be chosen. The distance should be about 10 inches between the tubal wall and the plate.

The effect of the therapy (internal treatment, immobilisation and counter irritants at the beginning) should be controlled by skiagraphy. When the inflammatory process begins to subside, massage and exercise should be advised in order to counteract

FIG. 205.—FRACTURE OF THE CORONOID PROCESS OF THE ULNA, FOLLOWED BY ARTHRITIS.

synostosis, which is especially apt to form between radius and scaphoid bone. When the stiff joint will not be made movable by massage and electricity, a chisel operation is the only effective procedure under such circumstances.

Fig. 206. — Luetic Destruction of Frontal Bone.

ARTHRITIS DEFORMANS

The nature of arthritis deformans is virtually the same as that of arthritis, the

Fig. 207.—Destruction of Frontal Bone. (Compare Figs. 206 and 208.)

cartilaginous surfaces breaking up into very fine filaments, because the substance which keeps the fibrillæ together undergoes the proc-

Fig. 208.—Skiagraph of Necrotic Fragments after Removal. (See Figs 206 and 207.)

ess of absorption. Then the cartilage becomes gradually softened down, and at last eroded through the friction of the articulating

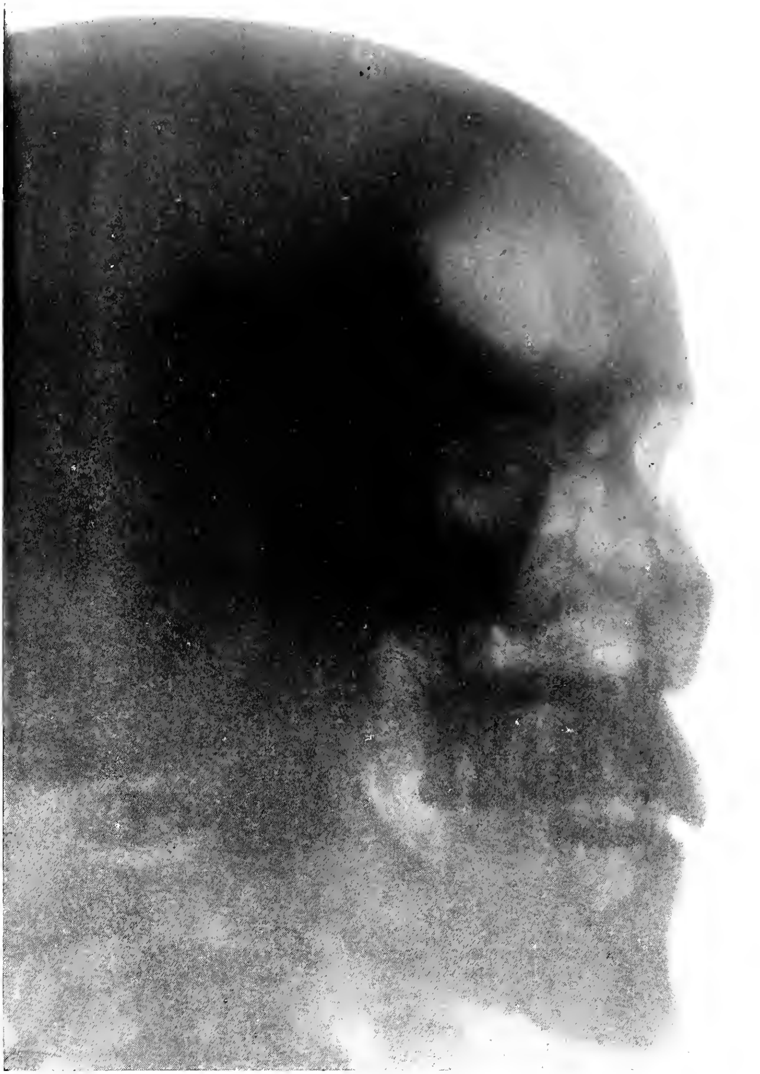

FIG. 209.—CASE ILLUSTRATED BY FIGS. 206, 207, AND 208, AFTER OPERATION.

surfaces. The underlying bone-tissue may finally be exposed, which would favour proliferation of its surface, thus causing hyperostosis. The spongiosa undergoes absorption, and, just like in acute inflammatory atrophy, the trabeculæ disappear, so that the whole area becomes rarefied.

These anatomical changes could not be diagnosticated before the Röntgen era except by dissection, the soft areas not appearing any softer to the touch than normal bone-tissue. The skiagraph, of course, reveals the osteitic proliferations as well as the rarefaction in a most marked manner. Sometimes there is perfect synostosis, at other times the joint seems to have disappeared entirely.

FIG. 210.—DESTRUCTION OF NOSE AND LEFT FRONTAL SINUS. (Compare Fig. 211.)

Fig. 204 illustrates the arthritic knee of a man of forty-four years. The osteitic proliferations are abundant and well marked. There is synostosis, which explains the complete osseous ankylosis. In a case of this kind the removal of the proliferations by the chisel is advisable, provided the patient's age and constitution justifies the interference.

Fig. 205 (see chapter on Medico-Legal Aspects) shows abundant osseous proliferation as well as rarefaction of the elbow-joint in a man of fifty years. Its complication with fracture of the coronoid process of the ulna makes it especially interesting, and shows the great difficulties of a correct ætiological appreciation.

SYPHILIS

Osseous changes may take place during all stages of syphilis, but as a rule only the tertiary stage is fit for skiagraphic representation, the ossifying periostitis of that period being well representable. In rare instances the secondary stage also shows marked signs. The seat of predilection in this type of ossifying periostitis, as is well known, is the skull. But the technical difficulties, alluded to in the General Part, prevent its clear skiagraphic representation in the great majority of cases. The extremities are a much more desirable object for skiagraphic study, and it is especially the tibia, another favourite seat of syphilitic periostitis, which shows skiagraphic signs well.

At the early stage the periosteum ossifies to a great extent, which finds its skiagraphic expression in the presence of well-marked and regular shadows, extending parallel to the normal cortex. This may become so dark that the periosteal and cortical shadow merge into each other, it being much darker than the shadow in tuberculous periostitis, because the deposition of calcareous matter in syphilitic periostitis is much more abundant. Differentiation from osteomyelitis is somewhat more difficult because this affection is also characterized by the abundant deposition of calcareous salts. But in osteomyelitis there is nearly always the distention of the bone.

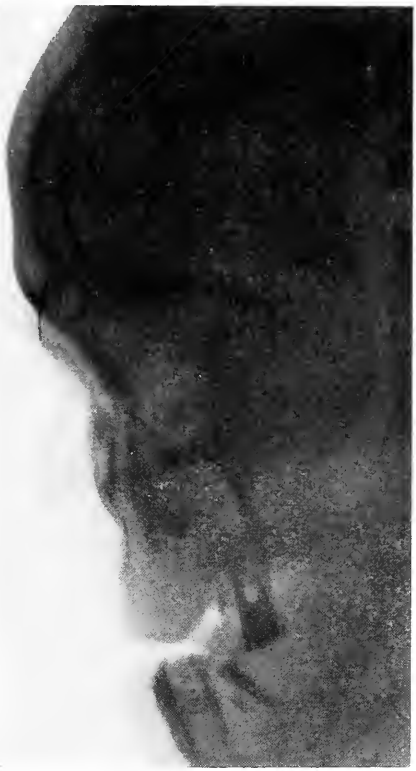

Fig. 211.—Luetic Destruction of Nose. (Compare Fig. 210.)

In order to interpret correctly it is, of course, necessary to know the skiagraphic features of the normal bone, the main characteristics of which are the regularity of its shadows.

Figs. 206 and 207 illustrate the skull of a woman of thirty-five years, who gave a history of infection. Clinical examination had revealed the presence of a sequestrum at the frontal bone, but the skiagraph (Fig. 208) showed that there were two large necrotic fragments. After their removal recovery took place (Fig. 209).

Fig. 210 illustrates complete destruction of the nose. The extent of the deficiency is evident from Fig. 211. The destruction of the left frontal sinus required removal of a small necrotic

Fig. 212.—Luetic Osteoperiostitis of Tibia.
(Compare with Fig. 218, illustrating periosteal sarcoma.)

area there. After an effort to create a new osseous support by transplantation had failed, injections of paraffin oil were resorted to. After twelve injections, made at intervals of three to four days, were administered, a sufficient amount of tissue was obtained to enable the author to form the nostrils.

Fig. 212 illustrates the periostitic proliferation of the tibia in a woman of forty years. The clinical diagnosis oscillated between tuberculosis and osteomyelitis, but the skiagraph pointed to specific nature. Recovery took place after exposure and scraping in combination with mixed treatment.

FIG. 213.—SYPHILITIC DACTYLITIS OF THE PHALANGEAL JOINT OF THE THUMB.

Fig. 213 illustrates syphilitic dactylitis in a woman of thirty-five years. Fracture, contusion, rheumatism, and tuberculosis had been thought of before the skiagraph suggested the advisability of an antiluetic therapy.

CHAPTER XIV

NEOPLASMS

Osteosarcoma.—By realizing that osteosarcoma is the most frequent of morbid osseous growths, and that of all tumours sarcoma offers the gravest prognosis, the importance of a thorough

FIG. 214.—RECURRENT PERIOSTEAL SARCOMA OF HUMERUS. (See Fig. 215.)

diagnosis need not be emphasized. The matrix of osteosarcoma, like that of all osseous growths, is either the periosteum or the medulla, in combination with the tissue originating from the proliferation.

Periosteal sarcoma is of a moderate hardness, and contains either round, or spindle, or polymorphous cells. It attaches itself

FIG. 215.—PERIOSTEAL SARCOMA OF HUMERUS. (See Fig. 214.)

to the bone laterally, but may in its further development encircle it entirely. It may develop into real osteosarcoma at a later stage, when osseous trabeculæ are formed. The skiagraph of periosteal sarcoma is characteristic, since it shows fine spiculated trabeculæ which radiate from the surface. Periosteal sarcoma spreads rapidly and is highly malignant. Whenever the diagnosis is made, amputation should be insisted upon.

Fig. 214 illustrates the rapidly developing periosteal sarcoma in a boy of fifteen years.

Fig. 215 shows the resected head of the humerus skiagraphed. The degree of translucency as well as the periosteal proliferations appear well marked.

FIG. 216.—OSTEOSARCOMA OF HUMERUS.

Fig. 216 illustrates the

same type in a boy of twelve years. The rapid growth of the tumour and its destructive character were a sad feature of this case.

Fig. 217 illustrates the periosteal type in the tibia of a man of sixty years. The spiculated trabeculæ radiating from the surface into the surrounding soft tissues can be distinctly recognised in the front as well as in the rear of the bone. Amputation was advised at once. Microscopical examination proved the tumour to be a giant-cell sarcoma.

Fig. 217.—Periosteal Sarcoma of the Tibia Radiating into the Surrounding Tissues. (Compare with Fig. 212, illustrating lues.)

Fig. 218 represents osteosarcoma of the right elbow in a man of thirty years. The skiagraph, Fig. 219, shows the bone proliferation at the inner point of the ulna, which points to the periosteal character. The extirpation verified the diagnosis.

Sarcoma originating from the *medulla* is called myelogenous, and is of a less malignant character. It may be classified as soft, hard, alveolar, and multiple. The soft myelogenous variety shows the ordinary texture, the predominating feature being the presence of round cells. It has a decidedly more benign character than the periosteal type, and therefore justifies a conservative attempt—that is, extensive extirpation. Thus the great practical value of skiagraphic differentiation is established.

Spontaneous fracture may be produced by the carious destruction of the spongy portion. At a later stage the osseous shell will yield, the sarcomatous tissue spreading in every direction.

This variety has a predilection for the long bones, especially their ends, and predominates at the lower epiphyses of the femur, tibia, humerus, and radius. Skiagraphs of the soft myelogenous variety show the absence of osseous tissue, although small fragments of it are sometimes left here and there.

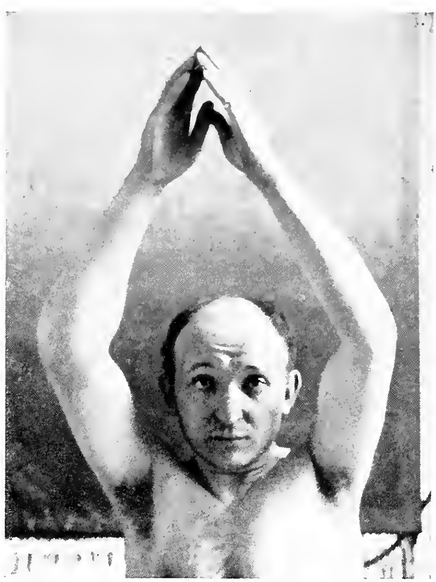

Fig. 218.—Osteosarcoma of Right Arm. (See Fig. 219.)

Fig. 220 illustrates the faint outlines of bone shell in the soft myelosarcoma of a woman of twenty-eight years who had fallen on her hand while it was in dorsal flexion. The swelling resulting from the fall produced the impression that a fracture of the lower end of the radius had been sustained. Three months after the injury, when the author saw the patient for the first time, a small deformity was noticed, just as it is observed in badly united fracture of the lower radial end; but the consistency of the epiphyseal end was soft. The skiagraph failed to show the evidence of bone tissue, only one small remnant being left at the outer aspect of the radius. Resection was advised first, but before the patient

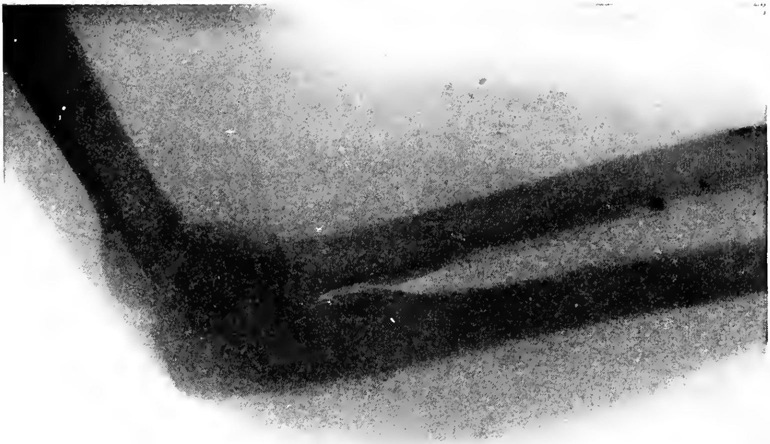

Fig. 219.—Skiagraph of Arm Illustrated by Fig. 218.

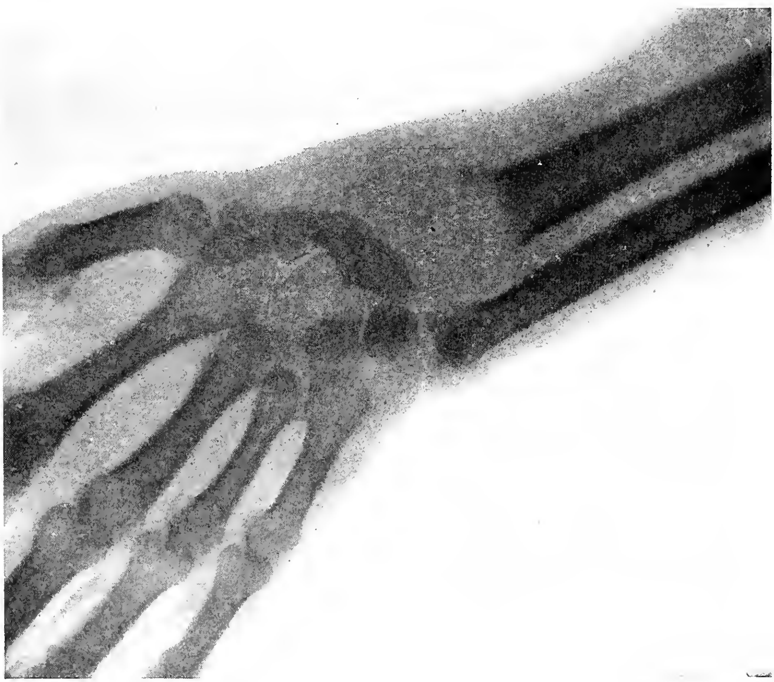

Fig. 220.—Myelogenous Osteosarcoma of Lower End of Radius. (Compare Fig 221.)

could make up her mind, another month elapsed, during which time the neoplasm had grown to the extent illustrated by Fig. 221. In spite of the extensive propagation resection could still be done. No recurrence had been reported eighteen months after the operation.

Fig. 222 shows osteosarcoma proper in a woman of forty years. The destruction of the lower third of the radius and of a large portion of the carpus is seen. Resection was performed more than four years ago. The perfect result was illustrated by a later skiagraph, which showed a slight and most uniform atrophy of the

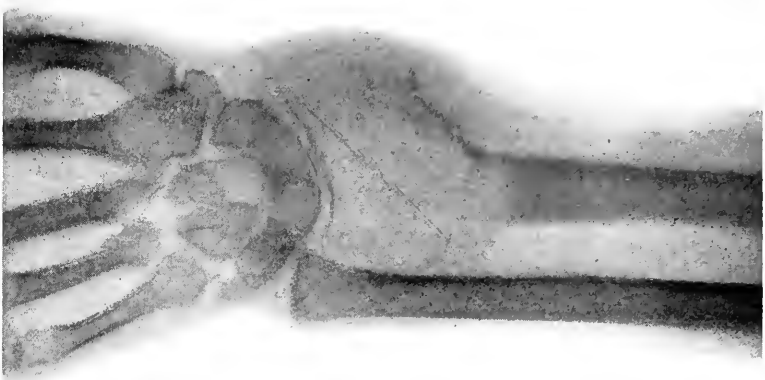

Fig. 221.—Myelogenous Osteosarcoma of Lower End of Radius. (Compare Fig. 220.)

whole left hand. In a third skiagraph, which was taken four years after the operation, the regeneration of the osseous tissue can be well studied.

Fig. 223 illustrates the same type in a woman of twenty-nine years. A conservative operation was proposed a year ago. So far no recurrence is observed.

The hard myelogenous variety, generally called endosteal or central sarcoma, also shows the ordinary sarcomatous structure. But its distinguishing feature is its fibrous texture and the presence of spindle cells. Some portions contain various tissues, the spindle-cell tissue often containing giant cells. If smaller or

FIG. 222.—OSTEOSARCOMA OF RADIUS.

FIG. 223.—OSTEOSARCOMA OF RADIUS.

larger bone trabeculæ are produced, it is called osteosarcoma proper; if there are calcareous deposits, petrifying sarcoma. If the tissues become vascular, telangiectatic sarcoma will develop, which may be mistaken for an aneurysm. In later stages, when there is a regressive metamorphosis, fatty or cystic degeneration may take place. Then neoplasms, which occur especially in the femur, tibia, and inferior maxilla, may attain an enormous size. The skiagraph of osteosarcoma proper shows more osseous tissue

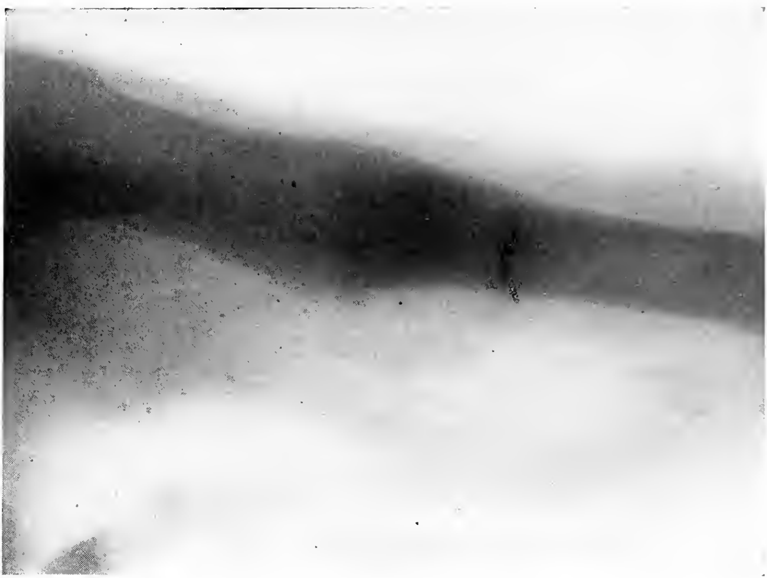

FIG. 224.—OSTEOSARCOMA OF FEMUR.

than the periosteal variety, but its outlines are very irregular. They usually commence near the epiphysis of a long bone.

Fig. 224 illustrates the cystic osteosarcoma of the femur in a man of forty-eight years. The first signs of the swelling were observed three months before the skiagraph was taken, but there were vague symptoms, especially pain in this region and disturbance of function, about nine months before that time, which were interpreted as muscular rheumatism. Inspection and palpation revealed the presence of a cyst, filled to half of its extent with serum, the microscopical examination of which proved to be negative. The skiagraph revealed the presence of bone-proliferation around the whole circumference of the middle of the femur, surrounded by a very light area. The latter indicated the cystic fluid. The knowledge that the sarcoma was of a myelogenous

FIG. 225.—LARGE LIPOMA OF THIGH.

nature induced the author to make an attempt to resect the sarcomatous area, in which he succeeded so far, as no recurrence was observed a year after operation. Further observation, of course, must show whether amputation can finally be avoided. The microscope demonstrated the presence of giant cells.

To illustrate the value of the rays in differentiation, Fig. 225 may serve as a counterpart. It concerns a lady of forty-nine years who noticed a slowly growing tumour in her thigh. When the author examined her, a globular tumour of a soft consistency was found to occupy the larger half of the thigh. Some portions appeared to be fibrous, while others showed pseudofluctuation. The history, especially the painless onset and the location, gave the author the impression that a malignant growth, perhaps a cystosarcoma, was developing. Aspiration was suggested, but the patient, whose domicile was at a great distance from New York, gave the author no chance for this procedure. A skiagraph, however, was obtained which proved two points at least. In the first place the integrity of the bone was evident, thus excluding osteosarcoma; and secondly the shadow of the tumour was so regular, and so opaque, in contradistinction to the light cystic area of the case illustrated by Fig. 224, that a solid tumour, independent from the bone, had to be assumed. The operation revealed the presence of a large lipoma, as the author learned later on by the courtesy of the surgeon who removed it.

Fig. 226.—Sarcoma of Superior Maxilla Extending to the Os Frontis.

The alveolar variety is characterized by its alveolar stroma, which contains nests of large cells. This form has a predilection for the bones of the skull and the trunk.

The multiple variety (so-called myeloma), characterized by the presence of numerous whitish foci, consists of small round cells. It has the same structure as the lymphoid sarcoma. It is nearly exclusively found in very old individuals, for whose skull and trunk it shows the same predilection as the former variety.

The skiagraph of the alveolar as well as that of the multiple type shows the foci as light irregular shadows. Their structure, their manner of destroying the pre-existing bone tissue, their thin osseous walls, and their trabecular formation furnish the stand-point for their skiagraphic study. Osteoporosis of the trabeculæ means decalcification of the bony portion affected, which explains their foggy shadows. Intraosseous tension is responsible for the expansion of the compact osseous layer, which is thus made gradually weaker, and at last almost entirely disappears. Thus we see that it is the abnormal and indefinite outline or even the entire absence of the osseous cells, the cortex especially disappearing, which is more or less characteristic of the various types of osseous sarcoma in contradistinction to other bone diseases.

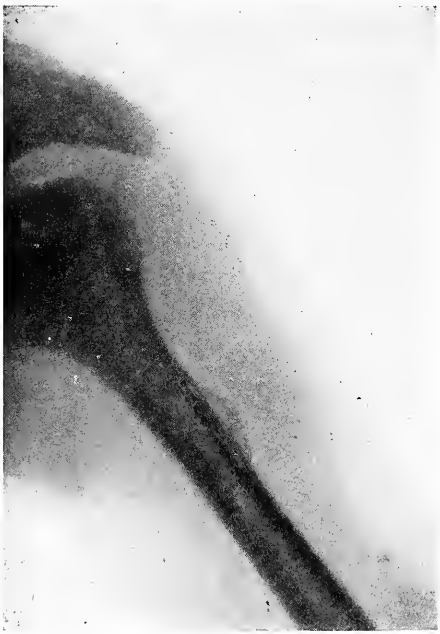

Fig. 227.—Osteoma of Humerus.

Fig. 226 shows skiagraph of alveolar sarcoma of superior maxilla and os frontis.

In chronic osteoperiostitis the walls appear irregular, too, but the irregularity is one-sided, and there is a globular or spindle shape. In tuberculosis the shadow would be cloudy or shaggy. In osteomyelitis the cortex shows nearly normal outlines.

Osteoma, of course, shows the shape of the osseous deformity, but there is the normal architectonic structure. Fig. 227 illustrates osteoma at the outer aspect of the upper third of the humerus in a boy of five years. His history showed that there was a fall more

FIG. 228.—MULTIPLE EXOSTOSES (HUMERUS, SCAPULA AND RIBS).

than a year before the development of the bony projection. The normal osseous structure, as it was evident from the skiagraph, proved the absence of a malignant growth. The same applies to *exostosis*.

Fig. 228 illustrates multiple exostosis in a boy of five years who is perfectly normal otherwise.

In *chondroma* there is a regular light-shade area in accordance with its cartilaginous character.

Fig. 229, for instance, illustrates a chondroma at the outer aspect of the first phalanx of the middle finger. The microscopical examination made after the removal of the tumour corroborated the correctness of the skiagraph (Fig. 230).

Fig. 231 shows the remnant

FIG. 229.—OSTEOMA OF FINGER. (See Fig. 230.)

FIG. 230.—CHONDROMA OF FIRST PHALANX OF MIDDLE FINGER. (See Fig. 229.)

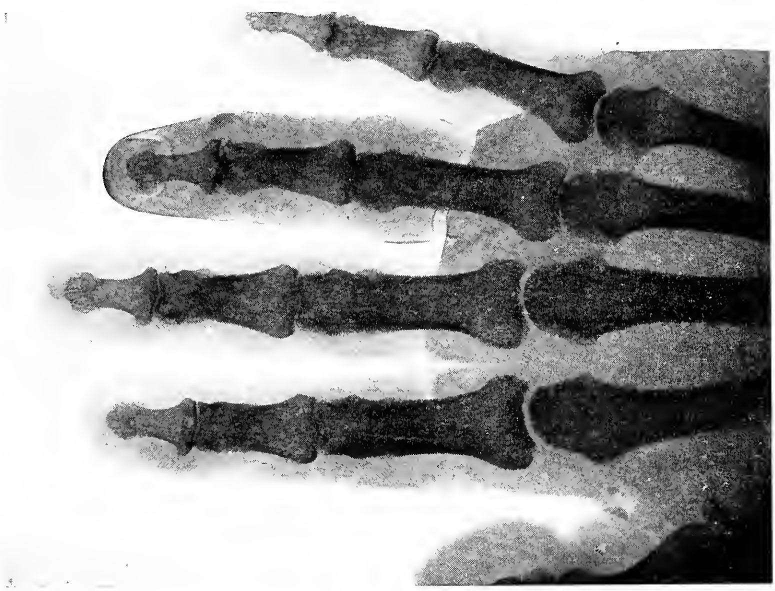

FIG. 231.—FIBROMA OF FOURTH FINGER.

of a small fibromatous growth at the outer aspect of the second phalangeal joint of the fourth phalanx. The growth was believed to be a simple wart, therefore it was cut off flush with the skin and cauterized. But the wound did not heal. The skiagraph of course suggested extirpation of the remaining portion of the fibroma.

In *acromegaly* the phalanges of the hand are broader than normal, and show no osteophytes, while their epiphyseal ends are thickened, the long bones appearing straighter and broader than

FIG 232.—FOOT IN ACROMEGALY.

normal (Fig. 232). Some of the carpal as well as tarsal bones are distinguished by the presence of exostoses.

Similar osseous and articular changes are found in the so-called osteoarthropathie hypertrophiante pneumique.

In myxœdema the epiphyseal lines of the long bones are hypertrophied and show rich osseous proliferations, which, however, contain but few calcareous salts.

In the obscure vaso-motoric lesion, called *Raynaud's disease*, the nutrition of the bones is also disturbed, slight proliferations and rarefaction being observed by the author. (See Report of Literature.)

OSSEOUS CYSTS

Cysts of the long bones are of a decidedly benign character, and consequently they are accessible to conservative surgical treatment. But, unfortunately, their signs resemble those of osteosarcoma so much that the temptation to treat them alike is not small. In view of its malignant character, osteosarcoma justifies the most radical steps, while osseous cysts demand simple opening and emptying of the cavity.

The grave prognosis of sarcoma arms the surgeon against any feeling of sentimentality. Under the circumstances he will not shrink from urgently advising one of the most multilating operations, because he knows that otherwise not only a limb, but also life will be lost.

On the other hand, how painful must it be for a surgeon to find that because of his error of diagnosis such radical steps have been taken unnecessarily; that, in other words, an extremity was amputated where only an osseous cyst existed, which could have been cured by simple incision.

Indeed, it is not very difficult to confound the two diseases. Osseous cyst resembles osteosarcoma in its slow and painless onset, often preceded by an injury, in the gradual bulging of the area involved, and in its preference for youthful age. The differential diagnosis therefore can neither be made by simply considering the history, nor by inspection, nor by palpation.

The fact that the interior of the cyst is filled with opaque bloody serum, and that its walls are lined with a smooth coat, while in osteosarcoma solid masses are formed, indicates that an exploratory incision combined with microscopical examination would clear the question of diagnosis.

But here, also, as in many other obscure ailments, the Röntgen rays have shown their usefulness. Not only do they differentiate well, but they even give us more valuable information than the exploratory incision itself, which, therefore, should always be preceded by skiagraphic examination; and for the patient a skiagraphic exposure is certainly more agreeable than an exploratory operation. After a conservative operation has been decided upon the microscopical examination may well be made after the operation.

From a skiagraphic study of 107 cases of osteosarcomas, the writer feels justified in saying that in osteosarcoma the outlines of the bone always appear more or less abnormal and indefinite, some areas even appearing entirely translucent; while in osseous cyst the cortex appears thin and narrow, but well marked and regular. The fluid centre of the bone is entirely translucent, the light shadow showing the same regularity. The adjacent epiphyses are normal. Only in the rare event of cystic degeneration at the upper epiphysis of the femur it must be considered that the regularity of the translucent (cystic) area is somewhat impaired by the anatomical peculiarities of the trochanter major.

It is especially the regularity of the texture of the walls of the cavity as they appear on the skiagraph which seem to be the characteristic skiagraphic features of osseous cyst in contradistinction to the irregular texture of osteosarcoma. It may be added that the vicinity of the epiphysis is also in favour of osseous cyst for histological reasons, as will be explained below.

The following cases may serve as a practical illustration of the value of the Röntgen rays in differentiation:

Case I, presented to the surgical section of the Academy of Medicine, March 11, 1901. H. C., a well-nourished boy, aged ten years, emigrated from Russia several months ago and presented himself on November 18, 1900. His family history is good. He was always well until eleven months ago, when he fell into an excavation on the street. On account of the intense pain in the upper portion of his right tibia and the functional disability a fracture was thought of at first, but after having remained in bed for two days he was able to walk around again. Four weeks later he fell again on the street, showing the same symptoms as on the previous accident, but this time he had to stay in bed for four weeks. It was then that a swelling of the size of a large filbert was detected at the spine of the right tibia.

Three months before the demonstration he fell for the third time, then being confined in bed for six weeks. When he got up he was free from pain, but he limped, and the swelling below his right knee had increased markedly. Walking had become more and more difficult.

The mother reported that she had sought surgical advice and that the tumour had been pronounced to be a malignant growth, which demanded immediate operation to save the boy's life.

Inspection revealed a normal and freely movable knee-joint. Nearly the whole upper half of the tibia was occupied by a painless swelling, which had the shape of a spindle, and was most pronounced anteriorly. It began at the epiphyseal line, reached its height at the upper third of the tibia, and merged gradually into the normal features of the tibia at its middle. The fibula appeared to be entirely normal. The circumference of the leg at the most prominent point was 30 centimetres, while that of the left leg measured 25 centimetres. The surface of the tumour was smooth. Its consistency was hard; a few areas appeared slightly softer. Forcible pressure revealed the presence of œdema. There was neither pulsation nor fluctuation. The skin was normal and movable. The inguinal region did not show the presence of swollen glands.

Fig. 233.—Osseous Cyst of Tibia.

It was no more than natural, in view of these facts, to think that an osteosarcoma had to be dealt with; but before arriving at a definite conclusion the writer consulted the Röntgen rays, which revealed the presence of a large triangular shape, the base of which corresponded to the epiphyseal line. The triangle was surrounded by a narrow dark and regularly arranged shadow, which represented the distended but otherwise normal cortex of the tibia. The light shadow was interpreted as a cavity, presumably containing a fluid of some kind. The normal outlines of the fibula could be distinctly recognised through the light area, although the inner surface of the leg rested on the photographic plate (Fig. 233).

The marked regularity of the texture of the cortex, as well as the uniformity of the light shadow representing the cavity, convinced the writer that osteosarcoma was not present in this case, therefore he advised conservative operation. This was performed at St. Mark's Hospital, November 21, 1900.

The anterior surface of the tumour was first exposed. After having incised the thin bone shell with a bone-knife bloody serum escaped through the opening made. Now an elliptic portion was removed from the osseous shell in order to get access to the large cavity, which was filled with black, bloody, viscid serum. There were no coagula. The osseous walls were lined with a thin membrane, and the cavity was traversed by a few fibres of osseous remnants, arranged like network, but not much thicker than a thread.

After having scooped out the cavity thoroughly its osseous wall were so thin that by pressing them together forcibly—infracturing them, in fact—their inner surfaces could be well approximated, so that no more cavity existed, so to say. Instead of packing the cavity, the writer preferred to resort to this unusual procedure, analogous to the principles of approximation of the chest-wall in old pyothorax. Only in the lower edge of the bone wound a small iodoform wick was introduced. There was considerable bloody oozing until five days after the operation, when the secretion became serous. Recovery was uninterrupted. Only a small sinus, discharging a few drops of serum in a day, is still present. The patient has now been up for two weeks and walks well. The repair was also well illustrated by a skiagraph taken two months after operation. At the present writing the patient is well. The microscopical examination of the exsected bone-fragment and its membrane, made by the courtesy of Prof. Henry T. Brooks, showed the presence of many round cells, espceially around the blood-vessels. There was no epithelial stratum nor any evidence of bacteria.

Case II.—E. T., a girl, aged thirteen years, born in New York city, presented herself to the writer on April 4, 1899. Eight months ago she slipped on a stairway and was unable to stand on her feet again. The left ankle became swollen and painful. Fomentations were applied for several weeks. No medical advice was sought until the swelling, which, after four weeks' rest, had become painless, increased.

The family history of the patient was good. Inspection revealed a movable ankle-joint. The lower third of the tibia was occupied by a painless tumour, which appears like exuberant callus formation. The external malleolus is normal. The circumference of the leg at the most prominent point is 22 centimetres, while that of the right leg measures 18 centimetres. The surface of the tumour is smooth; the consistency is hard. A skiagraph taken at once revealed the same condition present in Case I, with the difference that the shadow of the cortex is somewhat larger. (The American Journal of the Medical Sciences, June, 1901.)

The operation was the same as in Case I. The cavity contained the same black, viscid serum; the walls of the cavity, however, were thicker than those of Case I, and to their inner surface a stratum of grayish-white tissue was attached. It had the appearance of enchondromatous masses and proved to consist of cartilaginous tissue. The microscopical examination revealed an abundance of nuclei, especially of round cells, surrounded by myxomatous and disintegrated tissue. The walls could not be approximated as well as in Case I by forcible compression. The remainder of the cavity, therefore, was packed with iodoform gauze. Recovery was perfect after four and a half months. The patient has remained well ever since.

The ætiology of osseous cysts is still *sub judice*. Virchow [1] maintains that all osseous cysts are the softened products of degeneration of such growths that were solid formerly. Such solid tumours should have originated from erratic cartilaginous fragments left from the epiphyseal line.

Schlange, according to his excellent monograph, observed cartilaginous fragments in the tissues of the cyst-wall. Similar observations were made by Franz Koenig, by Deetz, and Koch.

At the early stage osseous cysts, be they in the tibia or in the femur, are easily overlooked, the symptoms being insignificant. Sometimes there is very slight intermittent pain. The joints are freely movable, and neither inspection nor palpation reveal any abnormality. After months the circumference of the extremity may appear very slightly enlarged, but the symptoms may not be fully appreciated until a fall on the thin shell of the cortex produces a fracture. Whether in our cases fracture had occurred could not be elicited. Relying upon the Röntgen rays, the writer

[1] Virchow: Ueber Bildung von Knochencysten, Monatsbericht der Berliner Akademie der Wissenschaften. Mathematisch-physikalische Klasse, 1876.

was inclined to believe that the previous injuries had the character of severe contusions. In view of the difficulty of differentiating between a benign cyst, accessible to conservative surgery, and osteosarcoma, demanding the most radical measures, the writer advocates exposing all osseous growths to the Röntgen rays before passing a final judgment in a matter of such grave importance.

Case III.—A girl of eleven, born in Germany of weakly parents, noticed a diminutive swelling on the upper third of the tibia about a year ago, shortly after a heavy substance had fallen on the leg. It caused her no pain at the time. But as the swelling increased considerably in size, a dull pain with some loss of function set in. The patellar reflex was exaggerated. The region of the swelling is painful on pressure. The swelling can be indented and a crackling sound can be heard.

The patient shows evidence of enlarged glands in the neck, and adenoid growths in the nasopharynx. When a child she had measles and scarlet fever.

The Röntgen picture shows a regular and sharply outlined cortical line of the thickness of a playing card. It represents the boundary of a transparent oval space and spindle-shaped form. The cohesion of the sheath is not severed at any point. The epiphyses are normal.

The diagnosis of osseous cyst was made accordingly, and an incision made at St. Mark's Hospital. The diagnosis was verified by the operation.

The smooth walls of the cavity, which was about the size of an apple, were lined with connective tissue. The contents consisted of a thin, sanguineous fluid. The microscopical examination of the cyst-wall, composed of several lamellæ, showed trabeculæ of bone as well as marrow substance transformed into fibrous tissue. In between granulation tissue was found, as was the case in the other specimens. Around the blood-vessels many round cells and large polynuclear cells were found. As in the other cases an epithelium stratum was not found.

The walls of the cavity were approximated by strong compression, which allows to diminish the size of the cavity perceptibly. A knife-point of granular iodoform is dropped into the depth of the cavity and wicks of iodoform gauze are placed in the upper and lower wound margins. Recovery was perfect in three months.

Case IV.—The same conditions were found in the head of the humerus of a Russian girl of nineteen years, who gave a history of an injury there which was treated for fracture during five months until the rays revealed the nature of the swelling of her shoulder. The cystyc area was of globular shape.

The literature on osseous cysts is still very scant. It is to be hoped, though, that with the ever-increasing interest and recognition of the Röntgen-ray diagnosis the number of the cases observed will grow larger and larger, so that we may look forward to a solution of the question of ætiology. As yet it is still *sub judice.* Virchow's idea that osseous cysts are the softened product of the degeneration of tumours cannot be upheld in the light of clinical experience. It is true that cystic degeneration may take place in myxoma, fibroma, myxofibroma, osteofibroma, chondroma, and sarcoma. Even multilocular cysts may arise from the degeneration of large sarcomata. They show a malignant character, however, their anamnesis is different, and the Röntgen picture shows an irregular shape, which is due to the fact that the ensheathing walls consist not only of tumourous or connective, but also of bone tissue. Again, the true osseous cyst is a disease of the period of development. The author looks upon them as the product of an inflammatory atrophy, which bears relation to the rarefying diseases as represented by osteomalacia, and especially rhachitis. Similar to the latter the osseous cyst denotes a disturbance of nutrition which is characterized by an increased absorption of bone, finally leading to a disappearance of a part of the bone tissue. That portion of the bone cortex which lies nearest the periosteum resists the absorption of the calcium salts the longest, and this is the explanation of the very thin, but still plainly visible bone-line on the Röntgen picture. The spongeous portion which lies nearest the epiphyseal cartilage forms the seat of cartilaginous deposits, which show a decided tendency to spread. Any irritation, especially trauma, will increase this tendency, and an inflammatory atrophy sets in. It resembles that which we see following phlegmonous or arthritic processes or extensive fractures. Gradually the bony structure of the spongiosa disappears until only a few lamellæ are left.

Not only the age, but also the unexceptional preference of the osseous cysts for the epiphyseal region, speak in favour of the relationship with rhachitis. Another striking factor is that all of the author's cases have been born in regions in which rhachitis is endemic.

Some one may criticise that the author is not justified in drawing up general diagnostic rules, having only four cases to fall back upon. But to this is to be responded in advance that for the last seven years it has been customary in the writer's three clinics to skiagraph every bone affection. Owing to the courtesy of his professional friends the author was able to represent 107 cases of osteosarcoma up to the present time. These cases were studied thoroughly, and as the majority was operated upon, the microscopical diagnosis could be added in most cases. In none of these cases were *these* three found:

Regularity of the thin cortex, parallel with the oval, spindle-shaped or trianguar transparency of the distended cavity. Of course there are some cases among these which simulate the typical osseous cyst, but on closer examination we find an insufficient transparency or severing of the cortical line. The author regards himself justified, therefore, to impress the importance of these points of differential diagnosis upon his colleagues.

Tubes of medium hardness must be used. If hard tubes are selected the thin cortex becomes transparent also, and the same conditions as in osteosarcoma may be produced on the plate.

CHAPTER XV

UTILIZATION OF THE RÖNTGEN RAYS IN FRACTURES

As is well known, the first object of a rational therapy of all fractures is the consolidation of the fractured ends without any displacement and without injuring the adjacent tissues, or the function of the limb. It is evident that if there is no *dis*placement no *re*placement (or, better said, reposition) will be necessary. All that is then required is to protect the injured limb in its normal position. This is done by proper immobilization.

In the great majority of cases, however, more or less displacement follows the fracture. In such an event, of course, the displaced fragments must be reduced to their normal position. After exact reposition has been attained, proper fixation in the normal position is in order. These doctrines are so simple that it seems almost unnecessary to repeat them. Yet they are frequently violated. The functional impairment following non-reduced fractures, especially the formation of adhesions, has led a number of surgeons to enunciate the dogma that the treatment of the soft tissues is the most important part in the treatment of fracture. They claim, in other words, that because the function of the soft tissues, for instance, of the tendons, is impaired after an unreduced fracture, the soft tissues should have received more attention, instead of the displaced fragment having simply been reduced to where it belongs. Nothing, in fact, is more contrary to common sense than this dangerous maxim, which is partially based upon correct observation, but entirely upon incorrect interpretation. It should always be considered that the relations of the soft tissues to the bones are like those of the clinging vine to the sturdy oak.

Galen says that the bones give the human body form, erectness, and firmness. It is evident that an injury of the bones impairs these three fundamental factors. The most important step towards repair must thus be taken in the foundations rather than in the superimposed structures.

If there is displacement of the bone fragments, undue pressure must necessarily be made upon the soft tissue; non-reduction means persistence of pressure, the fatal consequences of which are well known. Reduction means the relief of pressure. If in the frequent fracture of the carpal end of the radius the lower fragment is displaced upward (compare Fig. 248) the extensors are unduly stretched, as they are upheld like the strings of a violin by the bridge. Of course, the act of injury to the soft tissues cannot be undone by the mere cessation of pressure—that is, by reduction—but the influence of the injury on the soft tissues—the influence of the pressure, in fact—lasts only a short time, and is insignificant after early reduction, and therefore repair is easy. This means that the main premise of adhesion—formation, is wanting. And clinical observation shows that with perfect reposition the joints as well as the sheaths of the tendons are found free, provided the immobilization has not lasted for an extraordinary length of time.

A fracture is a solution in the continuity of the bone, just as a wound is a solution in the continuity of the tissues in general. The aim of modern wound treatment is union by first intention. The most important requirement for this end is, besides aseptic precautions, the thorough adaptation of the wound surfaces.

No surgeon would expect agglutination if there be displacement, diastasis, or overlapping of the wound margins. The same principle applies to the treatment of the margins of the bone fragments. It is true that manual coaptation is a little more difficult than suturing; still, under the guidance of the Röntgen rays it can always be accomplished if there are no extraordinary circumstances. Before their advent it was usually the final result alone which told of the success or failure of treatment. That result was then a *fait accompli*, and the time for proper correction had passed.

Now, with our Röntgen-light mentor we can tell from the very beginning what the result will be. If the "Röntgen mirror" reflects perfect coaptation of the fragments underneath the dressing, the final result must be good. There will be hardly any reaction; no exudation will form around the agglutinating surfaces, and consequently there will be no adhesions. Even in those cases in which considerable displacement, or comminution, or both, have injured the soft tissues, little reaction follows within them, if reduction be thorough. And if reduction is impossible, the Röntgen rays point to those fragments which are to be removed shortly after the injury. This is preferable to waiting for months, exhausting all mechanical means, and finally arriving at the conclusion that the deforming fragments had better be removed. What many of us have in former years regarded as a callus was nothing but a projecting piece of bone-fragment in a displaced position. It may, perhaps, be a pardonable policy to adhere to this most euphonic term in the presence of the inquisitive and criticising patient, who has a dangerous desire of learning the cause of his gibbous joint. But a scientific forum cannot ignore this frequent failure to reduce.

The regular scar of a well-united wound must be the model of our therapeutic efforts. Direct union is to be striven for. What is termed ensheathing callus-formation means union by second intention; this is certainly undesirable as long as union *per primam* can be well accomplished. Ensheathing callus is the compensating effort of nature to overcome the unreduced deformity and to bridge over the hiatus made by irregular adaptation.

In order to accomplish exact reposition, the degree and the direction of the displacement, as it is shown by the Röntgen rays, must be first considered. It is true that an experienced surgeon will often *guess* right, but he will never *know*, except by his infallible adjunct, the Röntgen rays. The only safe method is the self-control by the Röntgen rays. It may appear to be unjust to demand of the struggling practitioner that he should supply himself with an expensive Röntgen apparatus, but after all there will hardly be any other choice. The public is cruel, and the patient's interest concentrates itself almost entirely in his own welfare. These principles apply especially to fractures situated near a joint. Contusion and distortion are sometimes taken for fissure and often for non-displaced fracture, and *vice versa,* as the symptoms—local pain and enlargement—are common to all. Crepitus and false motion are absent, and this is not surprising, if there is much swelling or impaction.

If the principles of immediate reduction are adhered to, the "gibbous wrist" will cease to be counted among the inevitable inventory of surgical clinics. Still, the author is afraid, this is a pious wish as long as there are surgeons who imagine that by virtue of their own especially developed palpatory talent they can judge the details of any fracture without the aid of the Röntgen rays. Some are willing to use them in "obscure" cases, but they do not realize that the cases which they regard as "non-obscure" would appear in a different light when skiagraphed. In other words, what they regard to be a simple fracture often turns out to be a complicated condition. The paradox may be justified here, that if they would see this complicated condition or the fractured type in its proper light, it would then seem obscure to them.

As said above, if there is no displacement, no effort of reposition should be made. How absurd then to subject the patient, as is often done, to painful procedures. In simple fissure, union may be perfect under any, or even in spite of any, form of treatment. If the surgeon, led by anatomical knowledge, does practically the same as the quack does on account of his ignorance—namely, leave the healing process to nature—the same good result may finally be obtained. The scientific treatment of fissure or non-displaced fracture in which portions of the periosteum still maintain slight cohesion of the fragments, viz., slight immobilization, will not alter any of its mechanism, but it will at least have the value of a greater or lesser comfort for the patient; and in cases of this kind we must be warned against scientific nihilism.

CHAPTER XVI

THE OPERATIVE TREATMENT OF DEFORMED FRACTURE AS INDICATED BY THE RÖNTGEN RAYS

How often reposition is imperfect if not controlled by the Röntgen rays has repeatedly been shown in the author's own cases. Fig. 234 shows fracture of the fibula in malposition through a plaster-of-Paris dressing. The dressing was applied after the reposition was thought to have been perfect by an excellent surgeon. Of course the dressing was removed again when the surgeon saw his error. If malunion occurs, there are such changes in the direction, shape, and length of a limb, that its function becomes impaired or annulled. Impairment of shape is generally not so grave as that of length, especially when the lower extremity is concerned.

The projecting ends of fragments, when united in a false position, frequently produce irritation of the neighbouring tissue. It may be a sharp-pointed fragment, which, if not reduced at once, may put the overlying skin under such extreme tension that gradual penetration will take place. This event, changing a simple fracture into a compound one, is favoured where bone surfaces are located superficially, as at the tibia and the lower third of the radius and ulna.

Or the displaced fragments may be situated in the neighbourhood of a joint, one riding upon the other, so that extreme protrusion of one of the fragments is caused. This would render the motion of the joint painful or even impossible. If the fragments protrude far, as often happens when they are in juxtaposition, there is compression of the soft tissues. A nerve passing over this region will then be dislocated or unduly stretched, so that atrophy or inflammatory irritation may result. In the latter instance neuritis, in the first paralysis, may be expected. Among all nerves the radial is the one most frequently concerned. The author has described cases of this kind in previous publications (see Fig. 142

and 113, and Fortschritte auf dem Gebiete der Röntgenstrahlen, Band v, Hamburg). The axillary plexus may be injured in fractures of the clavicle followed by backward displacement and by that of the neck of the humerus; the ulna by fracture of the ulna or the lower end of the humerus; the median nerve in compound fracture of the humerus and radius; the tibial nerve after fracture of the tibia; and the peroneal after fracture of femur and fibula.

Up to the present time the correction of these deformities has not been frequently undertaken, although the Röntgen rays now

Fig. 234.—Fracture of Tibia and Fibula taken through Plaster-of-Paris Dressing.

enable us to make a thorough diagnosis of the anatomical relations of the fragments as well as to outline our operative steps in advance. The author has taken every opportunity to criticise the deplorable indifference and to emphasize the feeling of security the surgeon enjoys now while proceeding under the mentorship of the skiagraph. The direction of the displacement can easily be ascertained, and if two or three weeks only have elapsed, the refracture under anæsthesia at the edge of the table will often suffice to correct the malunion.

Fig. 235 shows a case of fracture of the surgical neck of the humerus, in which the diaphysis had slipped upward alongside the head of the humerus, so that union had taken place in juxtaposition. Although five weeks had elapsed, refracturing the fragments by bending them over the edge of the table was successful. Without the guidance of the rays, which showed the anatomical

FIG. 235.—FRACTURE OF THE SURGICAL NECK OF THE HUMERUS—JUXTAPOSITION.

relations most clearly, the author would have had neither the courage nor the ability to perform the correction, which, in fact, was done easily enough, since it could be estimated exactly how to direct the force of the manipulations. In transverse fractures refracture may even be tried months afterward, provided there is axial displacement (see Figs. 33, 34, 35).

If such procedures fail, the only remedy consists in osteotomy in the fracture-line. This is especially indicated when the fragments are in juxtaposition (Fig. 246). If thorough aseptic precautions are taken, tearing of the wound edges especially being avoided, and the wound itself coming in contact with the hands of the surgeon as little as possible, no reaction will take place.

In fracture of a single bone, such as the femur or humerus, a longitudinal incision should, as a rule, be made over the most prominent part of the displaced fragment, except it be in the immediate neighbourhood of a large vessel, which is to be avoided. In fracture of the femur, for instance, the exterior or posterior surface should be preferred.

In fracture of two bones (tibia and fibula or radius and ulna) a semilunar incision, preferably on the extensor surface, is recommended, since it exposes both bones simultaneously. The periosteum is divided longitudinally and shifted aside by the use of a periosteal elevator. Old adhesions are thoroughly freed with the bone knife, and the united ends separated with hammer and chisel (linear osteotomy). Then the fragments are bent, the whole limb being folded, so to speak. An assistant steadies the two folded portions after they are encircled with a strong bandage, so that the bone ends can be trimmed properly. This can be accomplished in various ways, the author's own experience being in favour of triangular indentation. This mode of procedure permits of a most accurate adaptation and immobilization, and seldom requires the use of foreign bodies for fixation. A wedge is removed from one end of the fragments, into which the other end is made to fit by the use of a saw (preferably a wire saw). In bones presenting broad transverse surfaces the adaptation may be made still more intimate by creating two triangular tips fitting into two proportional wedges. After the fragments are well approximated, the periosteal margins, as well as the fasciæ, are united separately. If aseptic precautions, hæmostasis, and coaptation are perfect, no reaction follows. The wound is simply protected by iodoform gauze and a piece of moss board, and a fenestrated plaster-of-Paris dressing is applied over the wound dressing. In operations on the femur such immobilization may be combined with an extension

Fig. 236.—Fracture of Tibia Wired, and Double Fracture of Fibula in Mal-union.

apparatus. Since the Röntgen rays permeate even the plaster-of-Paris dressing, the immediate result of the coaptation is easily studied, and modified if necessary.

Approximation and fixation can also be accomplished by the use of silver wire, which is drawn through holes bored in the end of each fragment. In oblique fractures wiring is indispensable. The irritation of the wire, however, is a disadvantage, and its use should be avoided whenever possible. If a wire must be used it should not be buried, the ends being led to the surface and enveloped in iodoform gauze. Screws, clamps, and similar appliances should be resorted to under extraordinary circumstances only.

Fig. 236 illustrates the case of a man of thirty years who sustained a compound fracture of the leg. Wiring of the tibial fragment was undertaken, as is evident from the skiagraph. Although the same process was repeated three times, the wire sutures always yielded, so that the fragments separated again. This was caused by the fact that the fibula was ignored during the operative steps. If the operation had not been undertaken until after first consulting the Röntgen rays, it would have been found that the fibula was fractured twice and that its fragments were united in false positions. To avoid tension in the suture line of the tibia, the fibula had to be exposed and adapted. If the surgeon could have seen the skiagraphic result of his case he would surely have shortened the fibula in proportion.

As the skiagraph, taken six months after the injury was sustained, indicated, the two wire sutures are at the point of separation again.

This case is reported to show how much unnecessary trouble and disappointment to the patient as well as to the surgeon can be avoided by a simple glance with the rays.

When there is much loss of bone tissue, implantation of a parallel bone may be recommended, a fibular fragment, for instance, being inserted into the medullary canal of the tibia. After successful union, the formerly thin bone sometimes reaches a con-

FIG. 237.—WIRE LEFT IN SITU AFTER SUTURING THE RADIUS—RELATIONS ANALOGOUS TO FIG. 236.

siderable size. Thus the author has observed development of the fibula to such an extent that the circumference of its middle portion became even larger than that of the tibia.

Similar conditions are illustrated by Fig. 237, which shows the ulna to be shorter than the radius, which was wired. No union took place, therefore. The silver wire was buried in this case—a procedure not to be advised.

In deformities of the diaphyseal ends a wedge must sometimes be exsected, in order to secure perfect apposition. Especially in deformed union of the malleoli, causing abduction of the foot, this procedure must be resorted to. Prominent bone portions which offer an obstacle to perfect reposition must be removed by the chisel. Such fragments often cause pressure upon an adjacent nerve, the relief from which may cure neuritis or paralysis. The protruding portion is chiselled off after the periosteum is carefully lifted from it. Then the compressed nerve must be freely exposed and properly replaced. The periosteum is united with thin catgut. Conclusions upon the anatomical condition of the compressed area can be drawn by the faradic test, which, by proving the integrity of the nerve below the injured portion, promises restoration. In the course of time, however, degenerative processes may be expected. Still, even under such circumstances, restoration is observed after the relief of pressure.

Fig. 238.—Diastasis of Fragments Causing Pressure upon the Musculospiral Nerve.

Pressure may also be caused by the formation of callus or fibrous adhesions. In the great majority of cases the radial nerve is compressed. Sometimes the nerve is found embedded in a regular osseous canal or tunnel, in which case Nature had admirably tried to create a special protection against compression. In a case of this kind surgical interference appears necessary only when the nerve is kinked at its entrance or exit.

Interposition of a nerve between the ends of the bone fragments is another cause of neuritis or paralysis. Its frequency seems to be entirely underestimated. The musculospiral (radial) nerve, especially, shows a great tendency to interposition, which finds its explanation in the spiral track in which it winds around the bone (compare Figs. 142, 143, and 238). Similar dispositions are shown by the peroneal nerve.

If the contusion of the nerve is not severe, and the incarceration insignificant at the time the fracture is sustained, symptoms of neuritis or paralysis may be postponed until further consolidation of the fragments includes the nerve in callous tissue.

Nerve interposition may be suspected whenever there is intense pain or numbness in the range of its course. By pushing the lower fragments towards the upper in a vertical direction the symptoms are markedly increased.

In fractures of the lower half of the humerus or the upper end of the fibula the possibility of nerve interposition should never be lost sight of.

The Röntgen rays give us no direct information. Still, if they show diastasis of the fragments within the area of the nerves mentioned, interposition of some kind must be assumed. If, in longitudinal displacement, the diastasis does not disappear, no matter how the position of the fragments be changed, and if crepitus cannot be perceived during these manipulations, the assumption of interposition becomes a certainty. This interposition may be simply muscular and no nerve may be inclosed; but in the majority of cases nerves are drawn in with the muscular tissue.

The skiagraph Fig. 238 illustrates a condition of this kind, which, however, was not recognised in its initial stage. The patient, a man of fifty years, sustained a subcutaneous fracture of the humerus and a multiple compound fracture of the forearm by extreme violence. Amputation of the forearm had to be performed, while the fracture of the humerus was treated by splints. A few days after the accident intense pain around the amputation wound was complained of, which radiated upward alongside the arm. When the patient was seen for the first time the thin, irregular, and fibrous cicatrix appeared to be immovable. Manipulations were painful. This suggested that there was pressure of the nerve ends requiring secondary amputation. The bone ends, after being trimmed, were covered with periosteum and a thick musculocutaneous flap. Four weeks thereafter there was perfect mobility, the pain around the stump had lessened, but still persisted alongside the arm. From the diastasis between the fragments of the humerus, as it is shown by the skiagraph, it was concluded that the source of this pain was at the fractured area, pressure being exercised upon the musculospiral nerve by interposition. This proved to be true when the author made an incision upon the fractured area, in which he found a small bone splinter shifted between the two diaphyseal fragments and overbridged by ensheathing callus. The front view of the skiagraph showed this splinter only indistinctly, but a side view proved its existence. Fibres of the biceps muscle as well as a portion of the musculospiral nerve were pulled into this conglomerated area by the small splinter. The splinter, as well as the ensheathing callus, which formed a superficial bridge, was removed, the muscular fibres pushed backward, and the nerve dislodged laterally. The fragments, after being trimmed, were united with silver wire. The pain decreased considerably, but continued in a moderate degree for three months thereafter.

Another result of the intervention of muscle, as well as of nerve tissue, is the development of pseudo-arthrosis.

If the efforts at reposition of the fragments fail to free the interposed tissues, the injured area must be extensively exposed. The compressed nerve is then lifted and displaced laterally from the fragments, which are eventually put in apposition by wiring. If the nerve is lacerated, it must be properly trimmed. If it is separated in its continuity, neurorrhaphy must be undertaken. In the latter event, which is rare, the symptoms are, of course, well marked, the power of conduction within the extent of the nerve below the fractured area being suspended.

In studying the ætiology and the mechanism of deformed fractures and their sequelæ the question is obvious, *Why not prevent them at the start?* Since we can, with more or less accuracy, estimate the result, why wait till the tissues degenerate and the deformity becomes established? Before the advent of asepsis the *laissez aller* policy was defended through the fear of wound complications, and before the Röntgen era the uncertainty of a detailed diagnosis offered a more or less justifiable excuse. These times had passed even before the discovery of the rays, and later the genius of Kocher emphasized the need of treating irreducible fractures by early operation. Helferich, McBurney, Bull, Berger, and Ransohoff followed his teachings. But they did it spasmodically, without following a logical and discriminate manner, while skiagraphy shows whether a displaced bone fragment can be reduced or not on the day it is fractured. If reduction under anæsthesia cannot be accomplished, reposition by open exposure must be attempted. If this is omitted, the fragments may present an obstacle to important functions. In deformities caused by diaphyseal fractures much interference is but seldom indicated. But in

FIG. 239.—FRACTURE OF RADIAL HEAD, SHOWING CONSIDERABLE OUTWARD DISPLACEMENT. (Compare Figs. 240 and 241.)

spiral-shaped and multiple fractures situated in the immediate vicinity of joints, it is a necessity, if the function of the joint is to be preserved.

The question whether there should be an operation or not is sometimes settled only after several attempts at reposition, controlled by the skiagraph, have been made, as is illustrated by the following case:

A girl, twenty-three years of age, fell downstairs. The family physician, who was called immediately, found considerable deformity, which he corrected to a great extent. There was an impression at first that backward dislocation had taken place, but when, after a week, the swelling surrounding the whole elbow did not subside, the patient was referred to the author for examina-

Fig. 240.—Fractured Radial Head Illustrated by Fig. 182 after a Futile Effort at Reduction. (Compare Figs. 239 and 241.)

tion. Before resorting to skiagraphy the author examined the swollen area after the usual methods without being able to recognise any marked symptoms of fracture, except at the outer aspect of the external condyle. But the skiagraph revealed the presence of the fracture of the head of the radius (Fig. 239), associated with considerable displacement, infraction of the external, and fracture of the internal epicondyle, the latter injuries without displacement. Since the author could locate the displaced radial fragment so well by the rays, he assumed that he could now also succeed in reducing it. But he was not able to palpate it. A fairly large number of physicians tried the same, but none could feel it. So the author marked the position of the fragment as his anatomical knowledge indicated it, and pressed inward. Now he applied a fenestrated plaster-of-Paris dressing, through which he took the skiagraph. This showed most impolitely that he had not only failed in his efforts at reposition, but had even made it worse (Fig. 240). But when he tried to reduce it in the extended position, he could press the fragment nearer to its normal position. Then it was that he was encouraged to make a fourth attempt in the same position of the arm, and this time he succeeded fully, as skiagraph Fig. 241 shows. The result is a good one. Had the author not succeeded in reducing the fragment, he should have exposed it freely without any further delay, and have attempted to reduce it unless it showed so little cohesion that the scant blood supply might have cut off nutrition, in which case he would have preferred to remove it.

Skiagraph Fig. 241 was taken by means of a very powerful hard tube, which permitted of such thorough permeation of the plaster of Paris that wherever the layer of the dressing was thin complete translucency was obtained.

Another instance of conservative advice was given by the Röntgen rays in the case of a lady, aged thirty years, who was thrown

Fig. 241.—Radial Head Reduced. Taken Through the Plaster-of-Paris Dressing. (Compare Figs. 239 and 240.)

against a stony prominence in a runaway accident. An enormous hæmatoma developed in the region of the elbow, considerable œdema at the same time extending from the middle of the humerus to the tips of the fingers. This, of course, caused marked deformity. There were crepitus and complete loss of power at the same time. When the author saw the patient in a country town, far from where a Röntgen apparatus could be secured, he succeeded

FIG. 242.—DIASTASIS OF FRAGMENTS IN FRACTURE AT THE ULNA. (Compare Fig. 226.)

in making the diagnosis of the presence of fracture of the olecranon followed by considerable forward displacement of the ulnar diaphysis. The decision of the question whether there were any other bone injuries was left to subsequent irradiation. After several unsuccessful attempts had been made under anæsthesia to disentangle the diaphyseal fragment, which, in overlapping the radius, was caught in the muscular tissue, the author succeeded, and his impression was, that perfect approximation between the diaphyseal fragments and the olecranon process was obtained. The arm had been kept in rectangular position for nearly three days, and the immense swelling of the whole limb seemed to be a contra-indication for an effort to apply an extension splint. After a week, when the patient, who had sustained various injuries besides that of the elbow, was able to travel, a skiagraph was taken which revealed the normal direction of the diaphyseal fragments, but a diastasis between it and the olecranon process (Fig. 242). An effort was made to shift the latter towards the diaphysis, which, after a palpatory examination, seemed to have been successful. A plaster-of-Paris dressing was applied, therefore, in the rectangular position. Irradiation through the dressing showed that the author had erred, and that the same amount of diastasis existed as before. It seemed to him that the gap was filled with muscular tissue, therefore he was unable to palpate the hiatus between the bone fragments. This could happen so much more easily since there was still considerable swelling. He removed the dressing again, repeating the efforts at reposition in the extended position, a manœuvre which was easier than a week before. Through the new plaster-of-Paris dressing, applied in the extended position, the irradiation was again tried, which proved the fragments to be in perfect apposition. Another skiagraph (Fig. 243), taken after the removal of the plaster, showed ideal union four weeks after the injury. It would be impossible, in fact, to infer from the study of this skiagraph that there ever had been a fracture, a point not to be underestimated from a medico-legal point of view. The inability of finding any evidence by palpation and the perfect function of the arm would lead to doubt as to the serious nature of

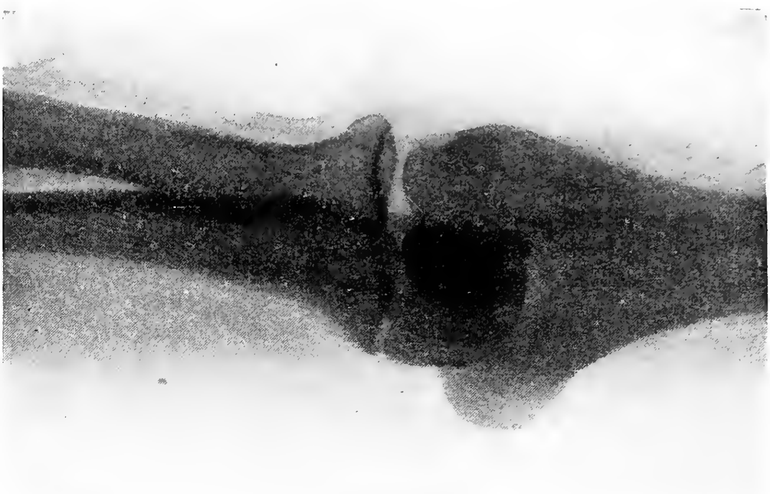

FIG. 243.—IDEAL UNION AFTER FRACTURE OF THE OLECRANON, THREE WEEKS AFTER THE INJURY. (Compare Fig. 242.)

the injury had not a skiagraph been taken at a time when the diastasis furnished such a distinct proof.

There are more instructive points in this case. The successful final reposition decided whether suturing of the olecranon should be resorted to or not. We have learned, furthermore, that the Röntgen control shows distinctly whether the dressing is better applied in the extended or in the rectangular position. The latter is the more comfortable, but if it does not permit reduction, while the less comfortable position does afford it, the point of comfort should not receive much attention, at least not for the short space

FIG. 244.—OBLIQUE FRACTURE OF OLECRANON WIRED.

of time during which the extended position would be indicated. If coaptation is perfect, the position can, as a rule, be changed into the rectangular after two or three weeks.

Skiagraph Fig. 244 may serve as a counterpart of this case. It represents an oblique fracture of the olecranon by a fall upon the elbow.

The patient, a girl of twenty-three years, was treated in the extended position by a most competent physician. Six weeks after the injury there was still a moderate amount of swelling in the region of the olecranon. Palpation revealed the presence of a gap and mobility of the lower triangular fragment. Any effort at motion was accompanied with intense pain. The skiagraph showing but little diastasis, the author advised immobilization in the overextended position, expecting that a late union would take place. But, when ten weeks after the injury, union failed to occur, although the extreme extension seemed to have held the fragments in very close apposition, the author exposed the fractured area by incision. The surfaces of both fragments were covered with fibrous tissue where they had been separated, which permitted of free motion. By excising the fibrous layers fresh bony surfaces were obtained, which the author brought into close approximation by silver wire. No reaction followed, and the result was perfect in four weeks. The method by which the holes were bored and the wire passed are shown by the skiagraph.

In a man of twenty-two years an enormous degree of displacement in osteo-epiphyseal separation of the head of the humerus was observed. The diaphyseal end was shifted alongside and in front of the head and forced between it and the skin. The projecting fragment lifted the skin at the anterior aspect of the shoulder. The accident happened during wrestling six weeks before a skiagraph was taken. Subcoracoid dislocation had been thought of first; later on, symptoms of compression of the brachial plexus (paralysis) had developed. Refracturing under anæsthesia being impossible after so long a time, reposition by osteotomy had to be resorted to. A longitudinal incision, beginning at the acromion, was made, which extended straight downward to the upper third of the arm. To this a transverse incision was added at the upper portion, which reached the inner margin of the diaphyseal fragment. After severing the periosteal adhesions with the bone knife, and the fragments which had united in juxtaposition with the chisel, it was tried to approximate them. This was made possible only after the diaphyseal end was shortened. The head of the humerus presented a thin bone shell, which could not be sewed to the diaphysis in the usual manner. The author therefore excavated the head with the bone spoon still further, trimming the diaphyseal end at the same time in such a manner that it fitted into the excavation. No wiring was done. The fragment could be kept *in situ* by immobilizing the arm in the elevated position by means of a humerothoracic plaster-of-Paris dressing. Although there was some swelling, combined with a slight elevation of temperature, for the first few days, the wound healed by first intention. The paralytic symptoms have greatly improved, still there is some loss of power.

While, as referred to before, articular fractures often demand early operative interference, for the purpose of proper reposition, fractures of the diaphyses very seldom require such procedures.

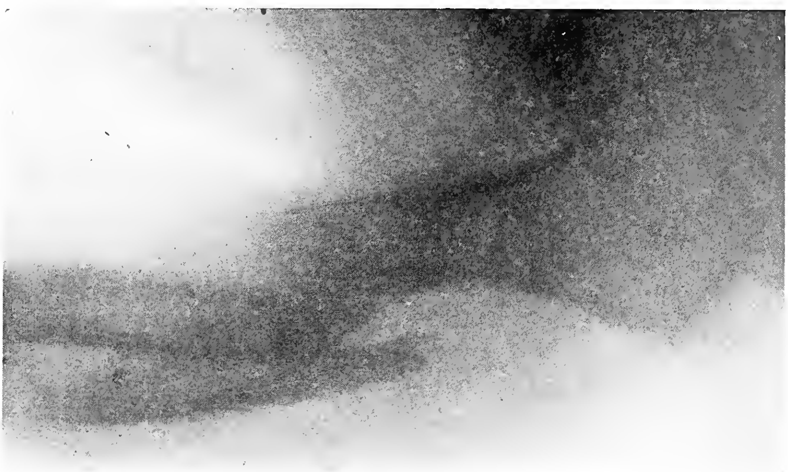

Fig. 245.—Fracture of Diaphysis of Humerus Associated with Separation of Fragment.

It may happen in the multiple type that bone splinters are so far separated from the fractured area that their reposition is impossible. If they, as the Röntgen examination will determine, are liable to offer an obstacle to the functional ability of the limb, they must be exposed. If there is sufficient periosteal coherence warranting proper nutrition of the fragment, it may be replaced and fixed by wiring. If not, it had better be removed.

Fig. 245 illustrates the spiral-shaped fracture of the humerus in a stout man, aged forty-six years, sustained by severe violence four days before the skiagraph was taken (patient presented to the New York State Medical Association, October, 1902). The slight shortening of the arm was explained by the juxtaposition of the fragments, as is evident from the skiagraph. There was an enormous swelling, which, in connection with the panniculus adiposus of the patient, rendered palpation so much more difficult. False motion, of course, crepitus also, being well marked, the diagnosis of the presence of a fracture of the upper third of the humerus could easily be made without the rays. But the presence of a large isolated bone splinter was not disclosed before skiagraphy was resorted to. From the study of the skiagraph it could be presumed that reposition of the fragment, embedded in an area of bloody effusion and lacerated and inflamed tissues, could not be attained by simple manual apposition. It was easy to persuade the patient that the operation was a necessity by simply showing him the loose splinter on the skiagraph. On the sixth day after the injury the author exposed the fractured area by an incision alongside the outer margin of the biceps muscle. The site, as well as the length, of the incision was determined by measuring the distances in the skiagraph and transferring their relations to the patient's arm. The large splinter proved to be entirely detached from the diaphyseal fragments, and as there was no periosteal cohesion, it seemed to the author risky to leave it, although there was no obstacle to reducing and fixing it by wiring. The removal was certainly safer and would not interfere with the apposition of the fragments. After the portions of the biceps and triceps muscles, which had intervened, were disengaged from the diaphyseal fragments, they were brought in apposition. No wiring was done. A humerothoracic dressing of plaster-of-Paris, applied immediately after the operation, was left *in situ* for three weeks. Recovery was uninterrupted.

As another skiagraph, taken four months after the operation, showed, union was faultless, and the deficiency caused by the removal of the isolated fragment was filled up by callus. Functional ability was perfect. If the bone splinter had not been recognised at an early stage, and had consequently been left, it would have served as an impediment between the biceps and triceps muscles, thereby arresting their contractibility. Thus we see that the question of shortening in fracture of the diaphysis of the humerus is of less importance than that of the special deformities which may disturb the functional ability of the extremity.

On the contrary, in fractures of the femoral diaphysis, the question of the shortening is more important than that of the deformity itself. Of course, if there is considerable projection of the overlapping fragment, undue pressure upon the soft tissues may produce symptoms at the point of fracture which demand interference. But, as a rule, it is the shortening which suggests operative interference, when the fragments, after being slipped by each other, become united in juxtaposition. If, in fracture of the femoral diaphysis, therefore, the fragments have only been put in the proper direction, without regard to whether there is also a lateral deviation or undue prominence of one of the fragments, the function of the leg is, as a rule, but little disturbed. This, in fact, is the least which can be expected of a physician who attempts the treatment of fractures. Juxtaposition can, therefore, never be pardoned. And this is nearly the only condition which demands osteotomy, and which cannot be remedied by any other procedure. In juxtaposition the attempt at bloodless refracture appears to be a most adventurous undertaking, if one simply looks at the skiagraph of a condition of this kind. It is unwise to attempt it, because the artificial fracture-line would not separate the fragments where they are attached to each other by sideward union, but would run through the fragments in a transverse direction (compare Fig. 246). And then extension would not elongate the shortened thigh. But osteotomy permits of separation alongside the line of false union, and extension will bring the lower fragment down, provided too much time has not elapsed since the fracture was sustained.

FIG. 246.—JUXTAPOSITION IN FRACTURE OF FEMUR.

As to old dislocations, the respective chapters are referred to. After a few weeks have elapsed bloodless reduction is rarely possible. In a case of backward dislocation of the forearm, which on account of the enormous swelling around the elbow was taken for a fracture, four months had elapsed after the injury. Reposition after so long a period could not be expected, but a semilunar incision should be made, the convexity of which would be directed upward around the olecranon, exposing it as well as the radius and liberating them by excising the capsular fragments and the cicatricial tissue. Whatever tissue present an obstacle must either be divided or removed. There is no need for resecting any bone portions.

Fig. 246 illustrates the femur of a boy of nine years, taken three months after it was fractured. The union in juxtaposition explains why there was shortening to the extent of nearly three inches. After the fragments had been separated by the chisel, forcible extension succeeded in restoring the limb to its full length.

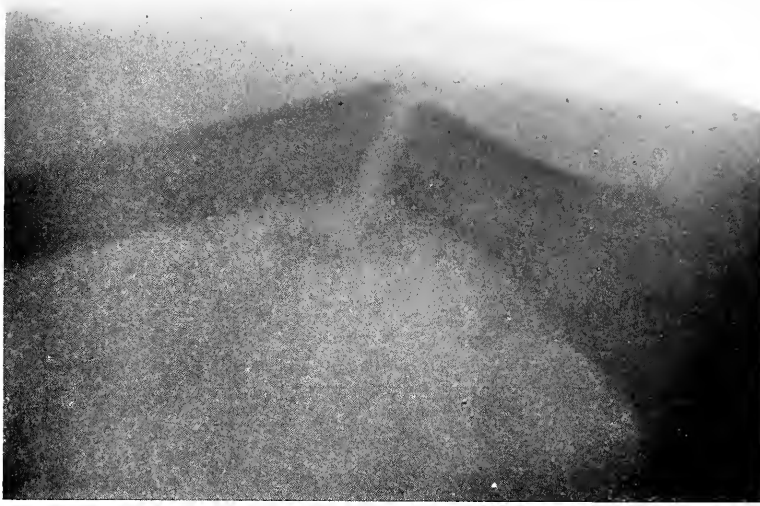

FIG. 247.—TRANSVERSE FRACTURE OF FEMUR NON-UNITED. ANGULAR DEFORMITY CORRECTED ELEVEN WEEKS AFTER THE INJURY.

The ends were trimmed and adjusted by a thick piece of silver wire. Recovery was uneventful, and the result perfect.

It is needless to say that such operations are an absolute necessity, not so much because of the undue pressure at the area of faulty union, as on account of the shortening, because such may destroy the chances of a successful career for the unfortunate patient.

Of course, such deformities should not occur at all. It is the duty of the surgeon who is called to correct them to answer the

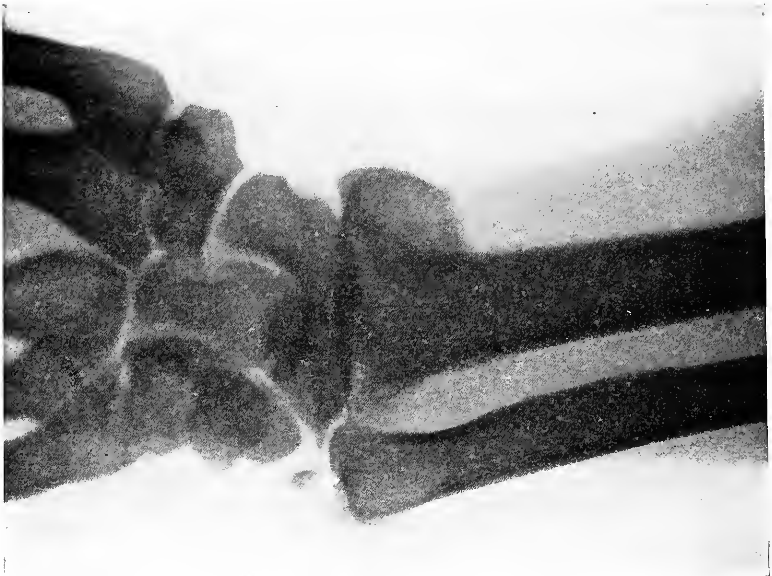

Fig. 248.—Fracture of Lower End of Radius followed by Upward and Sideward Displacement.

question of the crippled patient why his limb was not put into the proper position at once, by defending his brother, because we all are liable to err. Still it would be "a consummation devoutly to be wished" that crippled conditions of this kind should be due exclusively to the disobedience of the patients to the surgeon's directions.

Figs. 33 and 35 illustrate similar cases, the correction of which fortunately could be done by simple osteoklasis. Fig. 247 illustrates the case of a boy of sixteen years who sustained an infratrochanteric fracture. The extensive angular deformity was not reduced. Union did not take place because the outer margins of the fragments did not touch each other, so that a gap was the consequence. Nature tried to correct this condition by throwing out a large amount of callus at the adjoining margins of the inner aspect, but this did not suffice. Osteoklasis resulted in perfect recovery.

While in articular fractures reposition is often a very difficult procedure and failure a most excusable occurrence in non-complicated fractures of the diaphyses, reduction, if attempted with a minimum dose of common sense, must always be successful.

Figs. 248, 249, 250, and 251, for instance, represent very severe fracture-types in a man of thirty years who had fallen from a considerable height. Fracture of the upper end of the ulna associated with sideward dislocation of the radius of the right arm, and fracture of the lower end of the radius associated with upward dislocation of the lower fragment, were sustained (Fig. 248). No effort at reduction was made for four weeks. The author tried to reduce

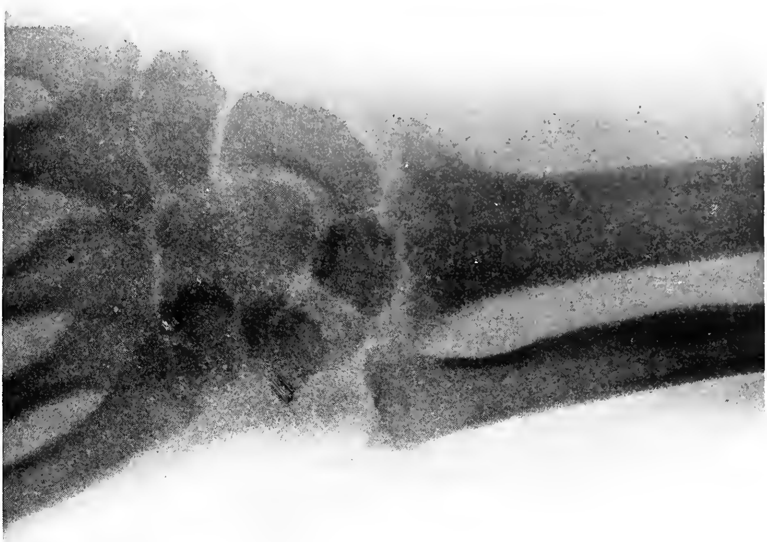

FIG. 249.—WRIST AFTER REMOVAL OF DISPLACED FRAGMENT. (Compare Fig. 248.)

the displaced fragment after having it exposed, but this being impossible it was exsected (Fig. 249). The result was good.

Reposition of the displacement of the elbow (Fig. 250) would certainly have been successful if attempted shortly after the injury, while that of the radial end would probably have been

Fig. 250.—Fracture of Upper End of Ulna Associated with Sideward Dislocation of Radius. (Compare Figs. 251 and 252.)

impossible. But an effort should at least have been made. If unsuccessful, it should have been reduced by open incision or removed.

When it was done five weeks after the injury ligamentous remnants had to be exsected in order to permit of downward pressure of the prominent diaphysis. At first it was tried to reduce the displacement in a bloodless manner. But while it was possible to lacerate the adhesions, so that the arm could be brought into the rectangular position (Fig. 251), the fragments could not be approximated. The elbow was exposed then five days after the osteotomy

Fig. 251.—Elbow After an Effort to Reduce the Fragments. (Compare Figs. 250 and 252.)

of the wrist. After the fibrous adhesions were dissected the displaced ulnar diaphysis could be approximated to the fragment, which consisted mainly of the olecranon. The radius followed its fellow then without much difficulty. The ulnar fragments were kept together by a silver-wire suture (Fig. 252). The result was nearly perfect. The author is convinced that if the Röntgen method had been used early in this case the skiagraph would have appealed strongly to the medical conscience.

Fig. 253 illustrates the *modus operandi* in the osteoplastic operation of Pirogoff. The patient, a girl of six years, whose skiagraph was taken three weeks after the operation, sustained a compound fracture of the foot, a heavy iron bar having fallen on it. Expectant treatment was resorted to for two weeks until the foot became black. There was a small area of vital tissue at the heel which in connection with a fragment of the calcaneum could be utilized for the Pirogoff method. Thus the shortening of the foot was practically overcome. The author favours inserting a screw in order to secure approximation, especially under such circumstances.

In a severe injury of this kind a skiagraph should be taken at once in order to ascertain the extent of the injury. Bone-splin-

Fig. 252.—Case Illustrated by Fig. 250, after Bloody Reposition. (Compare Fig. 251.)

ters may be reduced if in connection with the periosteum, or removed if there is no more hope for agglutination. In the case described a partial resection, performed in time, and under the guidance of the Röntgen rays, might have saved the foot.

Fig. 254 shows the effect of a compound fracture of the lower end of the ulna, which was produced by machine force in an engineer of thirty-three years. Two ulnar splinters were shifted over the anterior surface of the radius, which caused a prominence there. On palpation this prominence left the impression of the presence of callus-formation as it is observed after badly united fractures of the lower end of the radius, this fact being responsible for the pessimistic advice given by the various surgeons who thought the "callus" to be ample proof for their diagnosis: fracture of the lower end of radius associated with compound fracture of the ulna—no skiagraphic corroboration being sought. The function of the hand was totally destroyed by the defect in the ulna, and furthermore by the intervention of the two splinters which served as foreign bodies between the radius and the extensors. The skiagraph suggested to the author that he should utilize one evil for the compensation of the other, viz., displacing the splinters and implanting them into the defect.

FIG. 253.—FRAGMENT OF CALCANEUM ADJUSTED TO THE TIBIA BY A SCREW AFTER PIROGOFF'S AMPUTATION.

This was done by first chiselling off the smaller of the two fragments. When an attempt was made to displace it toward the ulnar defect, the small periosteal bridge yielded so that nutrition seemed to be too much impaired to warrant successful agglutination. It was removed therefore. The larger bone-fragment could be displaced in such a manner that a large periosteal flap remained in cohesion with the radius. At the same time the remnant of the ulnar end, mainly consisting of its head, was mobilized from its synostosis with the inner surface of the radial end and turned in the longitudinal direction. There was no reaction, and eight weeks after the operation skiagraphic evidence showed that the splinter had established itself fully in the defect. It had been fastened there by a few periosteal sutures consisting of

FIG. 254.—COMPOUND FRACTURE OF ULNA.

thinnest catgut, but at the same time it was held *in situ* by a rubber drainage-tube, pressed into the interosseous space and held by two narrow strips of adhesive plaster, after the principle of the au-

FIG. 255.—MULTIPLE FRACTURE OF THE LOWER END OF THE RADIUS.

thor's metacarpal dressing, illustrated by Fig. 167. In harmony with the perfect restoration of the anatomical condition, the functional result was perfect.

The detailed description of this case, which must be regarded

Fig. 256.—Tibia Fractured by Gun-shot.

a surgical triumph of skiagraphy, and the illustrations, will be found in the Fortschritte der Röntgenstrahlen—Hamburg.

Fig. 255 illustrates a multiple intra-articular fracture of the lower radial end in a man of fifty years. Under the guidance of the rays the author succeeded in reducing the fragments, which were upwardly and sidewardly displaced, so that the normal wrist action was nearly restored.

As to the principles of correcting deformities at the lower end of the radius, see page 231.

The fallacy of the theory that the thinness and the great force of the modern bullet would cause a clean canal-like foramen was proved by the author in March, 1896, when the commander at Governor's Island was courteous enough to permit the following experiment: A freshly amputated leg was fired at from a distance of 50 yards with the Kräg-Jörgensen rifle. This showed the most destructive effect upon the tibia, as is evident from the skiagraph No. 256, taken immediately afterward. It is the lateral transmission of the energy of the new projectile which is so destructive, at a distance up to 350 metres, at least. As is generally known, the size of the army bullet was reduced from 0.7 to 0.3 inch, and its rapidity increased from 400 to 600 inches per second, its penetrating force being about six times more. (See the Röntgen Rays in Surgery, International Medical Magazine, June, 1897.)

CHAPTER XVII

THE MEDICO-LEGAL ASPECTS OF THE RÖNTGEN RAYS

Even the most skilful experts in fractures have ceased to deny that there is an enormous number of bone injuries, which, in former years, could not be properly recognised, the general symptoms being either obscure or veiled by the swelling of the surrounding tissues. The mistakes made in differentiating fractures from dislocations, contusions, distortions, or tumefactions were innumerable; but they could be proved as such only under extraordinary circumstances. The Röntgen rays have brought about a revolution. They show the conditions as they are, and are impolite enough to do this without the slightest regard for great authorities. No wonder that such brusque information was received with a feeling of uneasiness, often by the very men who should have been but too glad to learn of their diagnostic errors in order to correct them. As is known, the errors made in the interpretation of skiagraphs, of which so much was then heard, supplied a favourite argument in defence of their procrastination.

We have learned now that our misinterpretations were caused by insufficient anatomical knowledge, as well as by technical shortcomings with which the rays had nothing to do. Officious friends, inconsiderate and malicious *confrères,* and shyster lawyers heralded and misapplied the great discovery and succeeded for a while in discrediting it even among those members of the medical profession who had begun to appreciate its great value. But these times have passed. The Röntgen rays no longer need a gladiator in the medical arena, but their recognition in the courts leaves much to be desired.

Since it is accepted by the medical profession that a plate, which is accurately made by a physician specially trained in skiagraphy, and interpreted by an expert, gives most valuable information which cannot be obtained otherwise, the court should regard it its duty to acknowledge this fact, and avail itself of it in the interest of justice. Especially the judge of the modern era of humanity in contrast to the obsolete representative of the old dogma "*Fiat justitia, pereat mundus!*" must see a valuable ally in this most wonderful discovery of the last century.

What a triumph for suffering mankind are the numerous cases in which veteran soldiers, contemptuously treated as malingerers before the courts, can now show their skiagraphic proof of the presence of foreign bodies. A patient whose body harbours a bullet, has, indeed, a very good reason to complain. The number of patients who submitted to unnecessary surgical operations because foreign bodies were suspected, but not found, and the still larger number of those who were not advised to submit to operations, although they were needed on account of the non-suspected presence of foreign bodies, is legion.

Long before the Röntgen-ray era, when the author was a young assistant, a woman was referred to him for an obscure swelling along the first phalanx of the left index-finger. The anamnesis revealed that the swelling had come on slowly after she had wounded herself with a needle. She reported that the needle had broken, but that the fragment was pulled out by herself. There was but little pain, but much functional disturbance. The impression prevailed that there was an inflammatory process caused by an infected needle. Later, when fomentations and immobilization were of no avail, rheumatism, osteitis, and then tuberculosis was suspected, and, besides the application of tincture of iodine, internal medicines were administered. No improvements being obtained, all the text-books available for information were studied, but scientific thirst was not quenched. The old routined chief whose advice was then sought suggested that an exploratory incision should be made. How great was the surprise when a small needle-fragment buried alongside the phalanx was found! The author has never forgotten the feeling of humiliation which overcame him then in the presence of the patient. But he believes he did not stand alone in this experience. *Solamen miseris, socios habuisse malorum!* To-day a simple glance with the fluoroscope would press the extraction forceps into the hands of the surgeon.

Years ago the author demonstrated a man before the Surgical Section of the New York Academy of Medicine who carried a thick glass splinter underneath his zygoma for thirty-eight years, experiencing but little pain, until, shortly before Röntgen's discovery, a swelling below his eye led him to seek medical care. The swelling was regarded as a malignant growth. He lived in a country town, and was advised to go to New York and have his superior maxilla resected. On making an incision the author found the glass splinter, and when the patient saw it, he remembered that when a boy he was wounded in his face by the explosion of a glass bottle containing gunpowder. The facial wound had healed without reaction. In this case also the Röntgen rays would have made the nature of the growth clear at once.

An odd pendant to the needle case is illustrated by the skiagraph of the foot of a dwarf (Fig. 257) made two years ago. For about two years the hero of the tragic comedy had been a round-trip patient in most of the reputed clinics of New York city. He showed a slight swelling at the outer aspect of his foot, which was diagnosticated as periostitis, osteitis, osteoma, osteosarcoma, beginning tuberculosis, rheumatism, arthritis, syphilitic proliferation or exostosis, badly united fracture, etc. Later on amputation, as well as exploratory incision, was advised. After having suffered for more than two years, he was ready now to submit to anything which would relieve him from the pain he suffered while walking. The author was unable to make a diagnosis with the usual methods, but the Röntgen rays cleared up the situation at once, showing a needle in the sole of his foot. When the patient was informed of this fact, he remembered that about two years ago, while sleeping on a lounge, he fell on the carpeted floor and noticed a sharp pain in his foot, which he explained by the fall itself. He had undoubtedly fallen on a needle sticking out of the floor, and by walking he had shifted it up into the joint, from which it was removed under considerable technical difficulties. It is needless to say that his "rheumatism" disappeared at once.

Much more serious, from the standpoint of humanity, is the following case, reported by Dr. L. Passower, Riga (Aerztliche Sachverstaendigen Zeitung, No. 15, 1901). In November, 1897, a young farmer, suffering from a swelling of his foot, was admitted to the surgical division of the army hospital of Riga (Russia) for observation. Being a recruit he was expected to serve his military term. But a year before a mass weighing 35 pounds had fallen on his leg, causing an injury which compelled him to stay in bed for three months. It was reported that during that time the foot had appeared much swollen and ecchymotic. When admitted to the service of Dr. Passower at the military hospital he was limping and complained of a continuous pain in his foot.

He was assigned a bed among old soldiers, who were requested to watch him closely, as he was suspected to be a malingerer. Three days after admission Dr. Passower received an anonymous

FIG. 257.—NEEDLE IN THE FOOT OF A DWARF.

letter, signed by "a friend of the recruit," which contained the information that the patient had produced the swelling himself, constricting his thigh and injecting medicamentous substances underneath his skin. Dr. Passower stated that he did not pay much attention to this communication, but deemed it his duty to order a still closer watch by adding a subaltern medical officer (Feldscheer) and a professional nurse to his outpost. Besides this, he as well as his assistants, visited the poor victim repeatedly and unexpectedly during night time, but were never able to discover anything wrong. After two weeks the œdema had subsided, but the tarsus still remained thickened, motion of the ankle-joint also remaining painful. Especially pressure on the scaphoid bone produced intense pain. As soon as the bandages were removed the œdema returned. So Dr. Passower came to the conclusion that the patient suffered from a chronic inflammatory process of his tarsal bones, produced by an injury. The possibility of a fracture of one of the bones was also duly considered.

After four weeks' observation he was presented to the medical board of the hospital, which suggested that he should be exempt from military service for a year. It was expected that the swelling would gradually disappear if the patient could enjoy rest at home and regular treatment. But the military commission at Riga did not accept this suggestion, because one of its physicians insisted upon the theory of the artificial origin of the swelling. So the unfortunate candidate was sent to the city hospital of Riga, where, after a second examination, he was accused of having injured himself by constriction and puncture in order to get rid of his military obligations. So he was delivered to the public prosecutor, but set free after a long trial, and especially through the efforts of Dr. Passower.

A few weeks later he was again arrested and sentenced to three months' solitary imprisonment for self-mutilation. Now Dr. Passower recommended transferring the criminal to the clinic of Prof. W. W. Koch in Dorpat, in order to obtain a skiagraph. This was at last permitted, and so Professor Koch had a chance to ascertain that there was a fracture of the astragalus, which had caused sinking of the sustentaculum of the astragalus. The patient appealed to a higher court, which dismissed the previous sentence. At the end of February, 1900, the Government referred him back to the military hospital in Riga, where he was skiagraphed. (It seems that a Röntgen apparatus was not obtained in this university town until then.) The evidence in favour of the "criminal" was too overwhelming, and so he was declared unfit for military service.

Thus an honourable man was virtually imprisoned during a period of three years. If a skiagraph had been taken at the time of his admission to the military hospital (fully two years after the publication of Röntgen's discovery), the whole procedure of ignorance and malicious arrogance would not have been set in motion, and the psychical torture of another poor individual would have been rendered impossible. In the face of the skiagraphic illustration of the fracture of the most important bone of the foot-skeleton, no judge and no jury would have dared to dispute the claims of the patient.

The counterpart is represented by a case reported several years ago (Medical Record, August 17, 1901) which showed how important for proper interpretation the knowledge of anatomical details is. It has occurred to the author as well as to others that the normal os intermedium cruris (os trigonum tarsi) was, after a single exposure, taken for a fragment severed from the astragalus. In the author's case a fracture of the fibula was present, but the first skiagraph suggested the presence of a tibial fragment also. But this was cleared up by a subsequent exposure in a different projection-plane, as mentioned previously. As mentioned in the section on the foot (page 170), the os intermedium cruris is a typical part of the tarsus of all mammals (Fig. 119).

The practical significance of this bone is evident from a case described by Wilmans, of Hamburg. A labourer claimed that he was injured by an iron bar on January 20, 1897, but was able to work during the whole day. On the following day he called on Dr. Wilmans, complaining of intense pain at his internal malleolus. He limped and asserted his inability to work. Wilmans found a slight swelling below the right internal malleolus. Ecchymosis of the skin being absent, the swelling was attributed to the presence of a considerable degree of talipes, from which the labourer suffered at the same time. The leg was elevated and fomentations were applied for several days. The patient still complaining of great pain, it was decided to transfer him to a hospital for observation. When discharged, after several weeks of treatment, the labourer made an effort to resume work, but at once declared that he was unable to keep it up. He was therefore admitted to another hospital, where he repeated this manœuvre several times during a period of six months. Finally, he claimed damages for having been crippled by the injury sustained on January 20, 1897; but in view of the negative objective condition found by Dr. Wilmans, the society decided not to grant any claim. The consequence was that the man was transferred to the surgical division of a third hospital for further observation. There he complained that he had continuous pains below the right external malleolus, even while in the recumbent position. The pain increased during walking or sitting. Stepping on the right heel he also declared to be impossible. By distracting his attention, however, it was noticed that he could stand well on his heel, and he would doubtless have been declared a malingerer had not the X-rays come to his rescue—at least temporarily. A skiagraph showed a bone-fragment at the junction of the astragalus with the posterior surface of the calcaneum. On the strength of this skiagraphic "proof" Dr. Wilmans, although still mistrusting, was forced to modify his original opinion and certified that the patient suffered from "fracture of the astragalus, in consequence of which he was damaged for life." The labourer therefore received an annuity of 30 per cent, in proportion to the estimated curtailing of his wages. Soon afterward the labourer was seen by Dr. Wilmans carrying a heavy load without any apparent pain, while formerly he had claimed to be unable to walk without a cane or crutch. Now Dr. Wilmans insisted upon a second irradiation, this time also skiagraphing the uninjured left foot. The skiagraph showed the "severed bone-fragment," which had first been regarded as a sesamoid of the musculus flexor longus hallucius, but which now was recognised as a normal os intermedium cruris. The society, of course, refused the annuity, and the German supreme assurance court, to which the man had appealed, not only sustained the verdict of the society, but also decided that the labourer must return the annuity which he had unjustifiably enjoyed for eighteen months.

In this case the Röntgen rays were very near becoming—the contrary of what they are expected to be—a protector of dishonesty. But the fault would have lain with the insufficient anatomical knowledge and not with the rays themselves, which reproduced the condition exactly as it was. The repetition of such cases, however, is highly improbable.

A complicated medico-legal question will arise when chronic diseases develop after an injury. Osteitis, arthritis deformans, and even malignant growths are not infrequently observed in this connection. If such injuries are sustained in factories, a suit for negligence is generally brought against the owner. The amount of damages, of course, depends largely upon the duration of the healing process and the degree of functional disturbance. This will vary greatly, as from a case of simple fracture, which may be accurately united in a few weeks, to an injury followed by the development of a malignant growth, which will finally cause the death of the patient.

Fig. 205, for instance, illustrates the case of a labourer fifty years old, who sustained an injury of his elbow eleven years ago (compare page 209). He reported that recovery took place after months, and that the elbow had remained stiff ever since. During the last few years inflammatory signs had manifested themselves, which were regarded as rheumatic. No other joints were involved. Since then he also had repeated attacks of pain in the elbow-joint.

When first examining the patient it was found that the elbow was very much thickened and fixed in a sharp angle. Pressure below the external condyle caused intense pain. Crepitus, so often found in old arthritic processes, could not be produced in this instance, as the joint permitted no motion at all. There were no indications of tuberculosis, syphilis, or gonorrhœa.

The skiagraph revealed the presence of malunion (sideways displacement) of the coronoid process of the ulna. This probably had given the first impetus for the development of the arthritis deformans, which is especially well marked in the external condyle of the humerus. The left condyle showed synostosis with the olecranon. Removal of the projecting fragment by the chisel, separation of adhesions, and the partial resection of the external condyle, the seat of predilection for the acute attacks, were advised as therapeutic means.

It was promised the labourer, who sustained his fracture in a factory, and who did not show any signs of ill health before, that he could use his arm again a few weeks after the accident. After ten weeks he was able to resume light work; then the swelling became gradually worse, and the diagnosis of arthritis was made. He has remained a cripple ever since, and his wages were cut down considerably. He might have claimed damages, but in view of the presence of arthritis he realized the difficulty to prove that there was a fracture originally. The Röntgen rays would have furnished this proof for him.

The development of malignant growths after an injury is illustrated by skiagraphs No. 220 and 221, which show the faint outlines of bone-shell in the soft myelosarcoma of a woman of twenty-eight years, who had fallen on her hand in dorsal flexion (compare page 287). The swelling resulting from it gave the impression that a fracture of the carpal end of the radius was sustained. Three months after the injury, when the author first saw the patient, he noticed a small deformity, just as it is observed in badly united fracture of the carpal end of the radius; but the consistency of the epiphyseal end was soft. The skiagraph failed to show the evidence of bone tissue, only one small remnant being left at the outer aspect of the radius. Resection was advised; but before the patient submitted to it another month elapsed, during which time the neoplasm had grown to twice its size. The result was reported fair eighteen months after the operation. But the chances for a permanent recovery are poor. (See The Differentiation between Inflammatory Processes and Neoplasms. Annals of Surgery, December, 1901.)

It is not always possible to show the evidence of a fracture as long as twelve years after its occurrence, as in the case of the labourer described, in which the displacement proved that there was fracture of the coronoid process of the ulna. The older the fracture, the less the fracture-line will appear. In case of the entire absence of displacement it is only a very distinct skiagraph that shows the line clearly. It is natural that in such cases there is no skiagraphic evidence after recovery—that is, from four to ten weeks, according to the type of the fracture. Should a jury in such an event doubt that there was a fracture, a skiagraph taken after such a period will show a negative result, although there surely was a fracture. At one of his demonstrations the author showed a boy whose fracture of the femur could not be shown by a very distinct skiagraph taken two months after the injury, because there was a faultless union. Had the thigh not been skiagraphed shortly after the injury, no evidence of the fracture could have been obtained subsequently.

Fig. 147 illustrates the case of the girl who sustained a fissure of the head of the radius followed by considerable functional disturbance. Another perfect skiagraph, taken four weeks after the accident, showed ideal union, so that no fissure-line could be recognised. This also shows how quickly the evidence of the presence of a fissure-line becomes lost if there be perfect approximation (compare page 206).

This experience suggests that a mediocre or even indistinct plate should never be admitted into court. It has repeatedly occurred to the author that he was not able to discover a fissure or fracture in a mediocre skiagraph, which appeared well marked in a faultless one. Such facts explain very well why some surgeons have disputed the reliability of other fellow-observers. Dr. A, for instance, insisting, and properly, upon his own diagnosis,

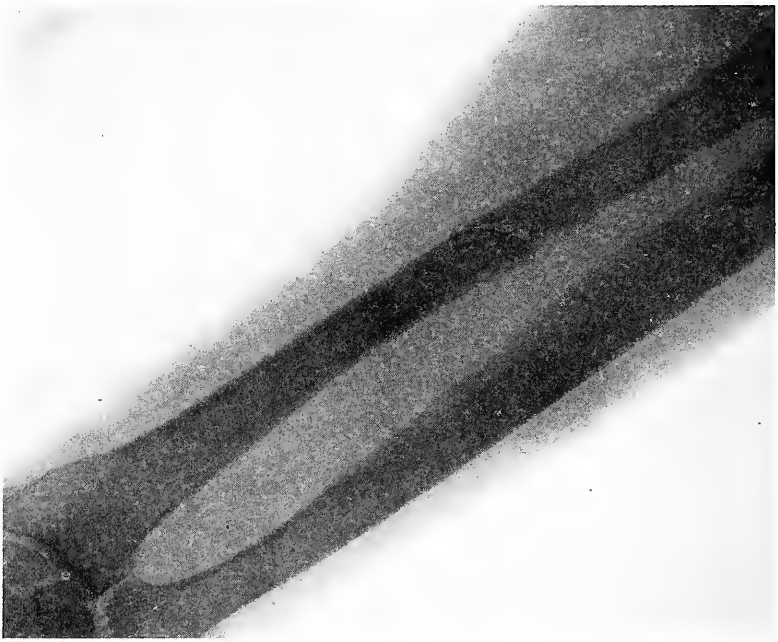

Fig. 258.—Fracture of Radial Diaphysis, Overlooked first by Fluoroscopic Examination as well as in a Mediocre Skiagraph.

while Dr. B, with his poor skiagraph, ridicules Dr. A's imagination, and sneeringly asserts that he could find no fissure-line. Of course, Dr. B's opinion is thoroughly honest, but absolutely erroneous, nevertheless. It should also be considered that during the first days of the injury the presence of a fissure is more easily overlooked than later, when callus-formation begins.

But that even in a fairly good skiagraph a fracture, followed by no displacement, can be overlooked, is illustrated by Fig. 258, which illustrates the case of a bricklayer who sustained a fracture of the middle of the radius three weeks ago, a heavy brick having fallen on his outstretched arm. He had great pain at the seat of the fracture, his hand was slightly swollen, and there was disturbance of function. Crepitus could not be elicited. A fluoroscopic examination made by the author as well as by a number of physicians revealed nothing abnormal. A fairly good skiagraph made at the time proved negative. Another one, taken in the opposite direction, gave the same result. But the suspicion that a fracture was present was so strong that a third exposure was made, this time long enough to bring out the bone-texture, the result of which was the faint representation of an oblique fracture-line at the point of tenderness. A fourth skiagraph, taken from the extensor side, revealed the fracture-line still more distinctly.

When in this case the author was at first unable to represent the fracture, some of the physicians present suggested that this was a proof of the integrity of the bones, and that the soft tissues, perhaps a nerve, were injured. But, as a rule, injuries of this kind are only found in nerves, when there is a synchronous injury of the trauma of the soft tissues. In a case of this kind a difference of opinion between experts may happen in court, and the patient may become the victim of an imperfect technique.

A counterpart to this case is the one of a boy who was under the author's treatment after extirpation of his cervical glands, and who sustained a contusion of the forearm, while the author happened to be absent from the city. So he was referred to a brother physician, who was supposed to be an expert in Röntgen science. Relying entirely upon the fluoroscopic screen, he claimed to have seen the fracture-line and declared a photograph to be unnecessary. A plaster-of-Paris dressing, extending over wrist and elbow, was applied in consequence. A few days later, when the patient was referred back to the author, he made a fluoroscopic examination of the arm, and as he could see no fracture-line he took a skiagraph through the plaster-of-Paris dressing. No evidence of fracture being found, the plaster-of-Paris dressing was removed, although the bones presented themselves distinctly. This third skiagraph proved that there was absolutely no fracture, a fact which was corroborated by the perfect function of the arm.

These two cases afford further support for the demand that only faultless skiagraphs should be admitted as evidence in court.

While we can readily see that a skiagraph furnishes the most convincing proof of the extent of the bone injuries, it does not show the injuries of the soft tissues, at least not directly. Therefore a skiagraph alone is not conclusive for the purpose of esti-

Fig. 259.—Fracture of Tibia. The same as Fig. 260. Lateral Exposure.

mating the degree of functional disability. A non-medical skiagrapher will, therefore, never be able to give expert testimony in any case of injury. If there is only one skiagraph taken the injury may appear at its worst, and *vice versa*. So a skiagraph may show a considerable degree of bony deformity, and still the function may be but little disturbed. Even fair results show, especially when displacement of the fragments or other unfortunate complications were present, no ideal union, and still the function may be good. An unscrupulous patient, who secures possession of a skiagraph of his own case, which shows considerable deformity, may strongly appeal to a jury on the strength of this deformity, especially if he succeeds in simulating great disturbance of function. On the other hand, there may be but little evidence of bone injury on the skiagraph, but there may be severe impairment of function on account of the injury of the soft tissues (circulatory, trophic, or inflammatory disturbances), which can be produced only faintly, if at all. Thus we see that in a given case the skiagraph must be considered in connection with all the clinical symptoms, and this can, of course, only be done by an experienced medical expert. As alluded to, a thorough anatomical knowledge is required. But it is also necessary to know the different modes of delineations and various projection planes.

The history revealed that the patient, a boy four years of age, fell against an iron bar while playing. Being unable to rise again, he was taken up and carried to St. Mark's Hospital, where, in the first instance, moderate pain was noted besides the functional disturbance in the left leg. There was neither any difference in level nor any other deformity, nor any shortening, nor the equinous position, but only a very moderate and uniform swelling of the leg. Abnormal mobility and crepitus could be produced only by very rough manipulations.

On the day following the injury two skiagraphs were taken in different positions, one of them on the dorsal and the other in the lateral position. The one, made by antero-posterior irradiation, the platinum disk of the tube being perpendicular to the anterior surface of the leg, did not show any indications of a fracture-line (see illustration in New York Medical Journal, January 6, 1900), while the other, obtained by lateral irradiation, shows the fracture distinctly (Fig. 259). A third exposure, made on the fifth day after the injury, in antero-posterior projection, but very slightly bent laterally, also shows the fracture-line beyond doubt (Fig. 260).

The fracture presented the typical oblique type in the middle of the tibia (fracture *à la bec de flûte*), the fracture-line running from below anteriorly to above posteriorly, and the upper tapering fragment overlapping the lower end. No lateral displacement having been present, it will be understood why the rays, reaching the long axis of the tibia in a perpendicular direction, did not show the fracture-line. A very slight change in the position, where the inclination towards the fibular direction amounted to less than a millimetre, brought out the fracture distinctly. If this skiagraph, however, is not studied very carefully, the transparency of the thinnest portion of the fragment might create the erroneous impression that the lower portion overhung the upper one.

Now, if, as is usually done, a skiagraph had been taken in the antero-posterior direction only, and if the manipulations made during the first examination had been carried out as gently as they properly should be, the fracture might have been overlooked entirely. And if, in view of the local pain and tenderness, the swelling and the functional disturbance, the possibility of a fracture had been seriously considered, the first skiagraph might have silenced the uneasy conscience.

This experience also teaches the necessity of always taking at least two skiagraphs in different positions in all cases of suspected fracture.

If this case were brought before a jury, an expert might there, on the strength of the first skiagraph taken in the antero-posterior projection, have testified, in good faith, that there was no fracture. With the diaphragm, however, even in this position, at least a faint indication of the fracture-line is shown.

In a case of osteo-epiphyseal separation of the radius in a lad of sixteen years, who had fallen from a stone staircase, the first skiagraph gave the impression of normal, non-ossified epiphyseal ends. A second skiagraph, taken with the ulnar margin of the hand slightly lifted, showed the presence of the fracture-line beyond doubt, while the third skiagraph, taken in the lateral position, markedly illustrated the displacement of the fragments. (Compare Fig. 162.)

These cases are another proof of the absolute need, as stated on previous occasion, of taking at least two exposures in different positions in all fracture cases. In joint injuries it is often neces-

FIG. 260.—FRACTURE À LA BEC DE FLÛTE OF THE MIDDLE OF THE TIBIA. (Compare Fig. 259. Anterior Exposure)

sary to make a skiagraph of the healthy joint at the opposite side at the same time, in the same position, and in the same projection.

Sometimes it is also advisable to compare a normal skeleton with a skiagraph, since some pathological conditions like rachitis, syphilis, etc., influence the outlines of the bones and may deceivingly be supposed to represent a portion of an injury. The fact that in children the epiphyseal tissues are not sufficiently ossified to produce a shadow on the plate has caused many but unjustifible errors at the early Röntgen era.

In many fractures the destruction was so extensive that a good result could not be expected under any circumstances. Then the patient may be tempted not only to claim damages from his employer, but also from his physician. In such a case, a skiagraph taken as early after the accident as possible will be the best protection for the physician. It would be a document showing that the physician knew well the serious nature of the injury. The skiagraph Fig. 261, for instance, illustrates a multiple fracture of the elbow. Splinters of bone are scattered, and are shown embedded in the soft tissues. None but a fool would, on the strength of this skiagraph, have expected the surgeon to restore the lower end of the humerus, which was almost completely shattered, to a normal condition. Or if a deformity is caused by excessive callus-formation, the skiagraph will be the surgeon's advocate. In one case considerable deformity of the wrist was present, which caused disturbance of function. The skiagraph showed the fragments in splendid apposition, proving that the deformity was produced by excessive callus-formation, for which, of course, nobody can be made responsible. The patient who accused his physician of malpractice could, when he saw the skiagraph, be easily convinced by the author that he had done great injustice to his physician.

In the case of the girl, illustrated by Figs. 239, 240, and 241, a diagnosis without the Röntgen rays was simply impossible, and without the diagnosis the patient would surely have been crippled. It was not until weeks had passed and the swelling had subsided that the author was able to grasp the radial fragment, which is of such great importance in view of its joint surface. Would the court have the right to censure the physician if he had not advised skiagraphy? If litigation ensued, would the other party have had the right from the beginning to insist that a skiagraph be taken? And if we had not succeeded in reducing the fragment, would we have been criticised?

A delicate medico-legal question is: What secures the identity of the patient who is skiagraphed? Is it sufficient that he signs his name on the envelope of the plate with a pencil containing impermeable substances, so that his signature is photographed together with the limb, or is it necessary to have a witness present, or both?

This brings us in touch with another question, which is a burning one in the full sense of the word: Is the physician responsible for an injury burn, caused by the peculiar influence of the rays, if they are used for diagnostic purposes? As described in the following chapter, it seems that in some individuals a susceptibility

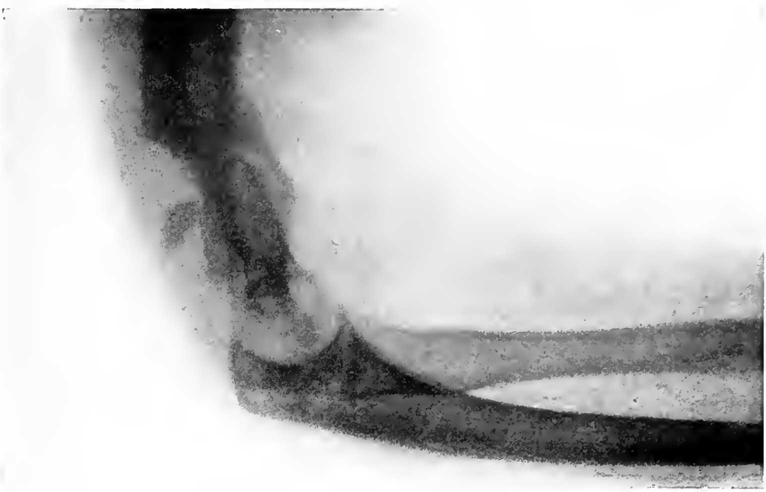

FIG. 261.—SHATTERED ELBOW.

exists which can be compared with the so-called iodoform idiosyncrasy. This susceptibility cannot be recognised except after the burn has established itself, when, in other words, it will be too late for prophylaxis. All we know is that blonde individuals are more susceptible than others. There are no means at all which protect the body from this except by a hasty examination. Since the time of exposure has, thanks to our improved apparatus, been considerably diminished, the danger of burning the patient during a thorough diagnostic exposure is extremely small.

As the Röntgen rays have also shown therapeutic properties, this question has reached a new phase. In order to exert a curative influence frequent and powerful exposures are required, and consequently the patient must, in the end, risk burning, as described in Chapter XVIII. In some instances, a protection can, especially in non-malignant skin diseases, be obtained by lead masks. But if malignant growths like cancer or sarcoma are treated, too much irradiation can hardly be done. In view of the fact that the cancer cells are not confined to the growth itself, but are also found in the adjacent tissues, it is necessary to irradiate as large an area as possible. Where ulcerations already exist, as often happens in carcinoma, and where new ulcerations as well as inflammatory processes may originate every day, an unscrupulous patient may claim that they were caused by the injudicious use of the rays. Can a physician protect himself against such allegations by simply stating that the risks of the Röntgen-ray therapy were explained to him? or are further ceremonies required? Numerous medico-legal questions have come up with this wonderful discovery, which have not yet been satisfactorily answered.

In severe cases of dermatitis, especially if there are necrotic areas, it appears to be natural that the patient is only too much inclined to blame his examiner. Whether the operator was negligent or not seems to be immaterial to the great majority of the injured; all they see are the sad consequences. In the court cases in which the author was called up as an expert, he was shocked by the unjust if, indeed, he may not say the felonious attitude of the plaintiffs. Although with our present means it should not appear very difficult to settle the question whether the physician has committed any negligence or whether he or his patient is the victim of unfortunate circumstances, there is hardly any subject in the wide field of medical jurisprudence where the juries, judges, and experts disagree as much as in this. The decisions of the courts in this country as well as in Germany, England, France, and the Netherlands illustrate a most deplorable state of affairs in this matter. French courts have excelled in decisions against physicians, especially in all cases where the corpus delicti had consisted in injury to the complexion of the fair sex.

Some time ago in New York State a suit was dismissed which had been brought against a dentist of good repute who had suspected the neuralgia of his patient, a young lady, to be caused by a foreign body in her jaw. The dentist very properly recommended that a Röntgen-ray photograph should be taken in order to verify his suspicion. At that time very few physicians were familiar with the technic of the new method, wherefore an electrician was recommended who had the reputation then of being an "X-ray specialist." The result after repeated exposures was an extensive burn of the third degree around the neck of the patient. The patient claimed that "a million volts of electricity were used," undoubtedly a somewhat excessive voltage, and one which should justify the large amount of damages demanded. The court upheld the defendant's contention, that the patient had voluntarily submitted to the Röntgen ray exposures upon the advice of the dentist, and as he had not administered the treatment, he was not liable. The dentist, in fact, would deserve high praise in seeking the best information for the cause of this patient's ailment. The question of the responsibility of the electrician is still left open.

In this country several cases are on record in which burns were caused by searching for renal stones, the examination being done by experienced physicians. Only in one case, as far as the author knows, the patient commenced suit against one of the best experts in Röntgengraphy. The suit was dismissed by the judge.

The suit against Professor Hoffa, of Berlin, the famous orthopedist, became widely known, not only because of the prominence of the defendant, but more so for the complicated etiology of the injury. The patient suffered from ankylosis of his hip, presumably after coxitis, for which he was treated by the Röntgen rays under the supervision of an "X-ray specialist." Altogether he was exposed 36 times. No change for the better taking place the patient consulted Professor Hoffa, who advised a diagnostic exposure in order to ascertain the condition of the hip-joint. The distance of the tube from the abdominal integument was 30 cm., the length of exposure 25 minutes. Ten days later extensive dermatitis set in, which induced the patient to bring charges of criminal negligence in the treatment. Professor Hoffa, in defense, claimed that the exposure was made according to the principles adopted by the medical profession, and that furthermore the sensitiveness of the skin was increased by the previous irradiations. The district attorney, after having called upon an expert, who sustained Professor Hoffa, dismissed the claim.

Nowadays, by our greatly improved means, Hoffa would not have burned his patient, even in spite of the preceding irritation, because he would not have exposed for 25 minutes. It is only a few months ago that the author had an opportunity to see Professor Hoffa take a beautiful Röntgen plate of a hip in three minutes.

We may safely expect that damage suits for Röntgen-ray burns, caused during diagnostic exposures, will become very infrequent. But with the employment of the Röntgen rays for therapeutic purposes this question of injuries has entered into a new phase. Burns have now become a rather common accident. In several instances suits were brought against physicians, especially on the ground that they did not use the necessary means of protection. In most of these instances the severe character of the diseases demanded a severe treatment, so that burning had to be risked. This fact alone is sufficient proof of the perfidious nature of the suits. In cases where only cosmetic considerations are concerned, such risky therapy is unnecessary of course, the diseased area alone requiring irradiation, and the healthy vicinity demanding protection. If in cases of this kind the patient is promised that no burning could take place, he feels justified to find fault with his physician when the promise is not fulfilled, when, in other words, dermatitis, followed by ugly cicatrization, is exchanged for a few superfluous hairs.

An illustration of the deplorable consequences of omission is the suit brought against a prominent physician in Germany, who treated a lady for hypertrichosis of the chin for several months. After repeated reactions of a slight nature were observed, the face showed signs of dermatitis of the second degree while the anterior aspect of the chest developed a burn of the third. After five months cicatrization had taken place in the face. But the chest still showed a large ulceration. At that time the patient brought charges against the physician for criminal negligence.

The court called upon various experts. One was the official "Court physician," who admitted that he did not understand anything of the Röntgen rays, but, strange to say, gave his official opinion nevertheless.

Besides this the expert testimony of the "Governmental medical board of the province" was obtained. None of these testimonies was favorable for the defendant. The third was that of the "Royal medical deputation" of Berlin, which was in favor of the defendant. The plaintiff recovered judgment to the amount of \$75. The points of the complaint were, first, the insufficient information of the patient in regard to the possible consequences of the treatment; second, the insufficient protection of those areas which did not require irradiation; third, the continuation of the treatment after redness had appeared.

The court disregarded the first two points but sustained the third, viz., negligence. This judgment is based on an error. If the court had held that the chest should have been protected it might have been more correct, but it could not have found fault with the continuation of the treatment after slight reaction had shown itself.

How far the beneficial influence of inflammation produced by the Röntgen rays goes is also illustrated by Figs. 266, 268, 271 and 274.

As to the etiology of Röntgen-ray dermatitis, its course and significance, the reader is referred to the following chapters. The proper means of protection are also discussed there.

In the meanwhile another miraculous phenomenon makes its appearance on the medical horizon. Little as we know of the practical utilization of *radium*, yet it marks a new era in electrical science. Its influence upon diseased tissue is undisputed, and consequently we shall soon hear of accidents caused by its therapeutic use. (Further particulars are found in Chapter XX.)

SECTION III

EFFECTS OF THE RÖNTGEN RAYS

CHAPTER XVIII

RÖNTGEN THERAPY

Physiological.—Soon after the discovery of the rays it was found that they had a marked influence on the protoplasm of the irradiated cell. Especially the peculiar changes which manifested themselves in the skin of persons who were exposed to the rays for a long period, called attention to this fact, which suggested that they were due to a specific influence. To define their influence the various phenomena emanating from the tube must be known. In the first place, it must be considered that there are different kinds of rays generated in the vacuum as well as at the surface of the tube—namely, Röntgen, cathode, ultra-violet rays, and those of an unknown character. There are also spark and brush discharges, and electric and electrodynamic waves.

The heat and ozone which are produced at the same time apparently do not participate in that specific influence. The ultraviolet rays cannot be of any practical importance, since they are absorbed by the glass of the tubal wall, after being generated in the vacuum.

The cathode rays show similar conditions, inasmuch as they permeate thin layers of aluminum only and are extensively absorbed by glass.

Therapeutic Effects.—The fact that the wall of the tube becomes blackened after long use gave the impetus to the theory of the direct bombardment with particles from the electrodes. But it has neither been proved that they ever passed the tube, nor has the microscopical examination of the injured integumental area shown any evidence of the presence of such elements.

Direct electric discharges cause an influence on the skin similar to that produced by the Röntgen rays. An exposure to the brush discharge of a generator capable of a spark length of two inches may cause a burn. But that electricity alone could not cause that specific influence which is observed after irradiation with the Röntgen rays, hardly needs further discussion nowadays.

It is, however, only partially explained in what manner this specific influence exerts itself. Analogous to the integumental changes produced by sunlight, heat, caustics, and acids, it is largely dependent upon the strength and the amount of the Röntgen rays. The tissues are influenced differently by different rays, just as the photographic plate is impressed differently by various kinds of light. The sensitized coating of a photographic plate not only reacts the more intensely the stronger and longer it is exposed to the light, but it also shows different impressions, according to the different refrangibility of the rays. Thus the solar spectrum, even in long exposure, scarcely affects that portion of the plate where red is projected, while the blue and violet light leave intense impressions. Green and yellow light produce stronger impressions than the red. The more refrangible the rays are, the more they are absorbed by the bromide of silver of the photographic plate.

No doubt there is some chemical action which causes metabolic disturbances. It seems most plausible that the Röntgen rays induce fluorescence in those cells which possess fluorescent properties, whereby chemical changes take place. The glue-producing tissues, of course, would be pre-eminently concerned, and the relationship to the gelatine of the bromide of silver is obvious. It is a characteristic feature of the Röntgen rays that their effects do not show before a long period of incubation. This stage, which may be properly called the latent, lasts between ten to twenty days. The nature of this reaction, generally called Röntgen-light dermatitis, will be described in the following chapter. The general symptoms reported of some patients as the consequences of moderate irradiation resemble those of sunstroke, the predominating sign being dizziness.

The prolonged influence of the Röntgen rays surely produces a more or less intense hyperæmia in any part of the human body. In experiments of long duration, conducted by reliable investigators, not only hyperæmia and swelling of the conjunctivæ, but also retinitis and contraction of the pupils have been observed. Thus we can readily understand that hyperæmia takes place in internal organs, if the powerful influence lasts long enough.

Segny and Quénniset observed intense and irregular palpitations of their heart when irradiating themselves for a greater length of time. Destot found that when he irradiated his own hand for an hour by a static machine, the tubal wall being two inches distant from the skin, the pulse became fuller after ten minutes. But there was no change in the number. The examination was done by a Marcy sphygmograph.

If a coil was used under the same conditions, the pulse showed a greater tension at first, which then disappeared gradually; finally arrhythmia was observed.

Attempts have been made to approach this important question by experiment on the lower animals. Thus Tarkhanoff (Gazetta degli Ospedali, March 4, 1897) observed that irradiation of the cerebral hemispheres of the frog inhibits reflex movements. The colour of the batrachian integument appeared much darker when the frogs returned to their moist element after being irradiated. Rivière's experiments on the hearts of frogs revealed no influence upon their rhythm after long exposure. After prolonged irradiation, frogs, mice, guinea-pigs, rabbits, and birds, died, mostly with paralytic symptoms.

How far the eye is influenced by the rays is not yet definitely settled. Among 204 blind children De Courmelles found that nine of them felt a marked perception of the rays. The experiments of Galli, Fuchs, and Kreidl point to indifference of the retina. But Wild reports a case of panophthalmitis after excessive irradiation which required enucleation of the eyeball. The anterior media show decided reaction. Photophobia is not infrequently observed after irradiation of the face. After long *séances* the author, with very few exceptions, always noticed a burning sensation of his eyelids.

Chalupecky, after irradiating the eye of a rabbit for twenty-four hours, found depilation, conjunctivitis, and infiltration of the cornea, followed later by the formation of pseudomembranes.

That the Röntgen rays exert a powerful influence upon the action of the skin, upon metabolism, and the temperature of the blood has been demonstrated by Lecercle. In one of the author's experiments made on dogs, alopecia of the area, which was irradiated for three hours, developed as early as the fifth day. The hair bulbs showed no atrophy, but the epidermis and the skin follicles were destroyed. Microscopical examinations of an excised piece of integument showed the usual signs of inflammation.

The author's experiments on mice (see Medical Record, June 18, 1902) showed that depilation began on the fifth day on an average, where irradiation was done three hours a day. The first symptoms showed at the forehead. During the time of observation the animals exhibited no disturbing symptoms—only one among nine died after being exposed to the Röntgen light for twenty-three hours. This mouse was irradiated one-half hour daily for one week, one hour daily for one week, one hour daily for a second week, and two hours daily for the third week. Depilation took place over the dorsum then. Soft tubes had been used for this case exclusively. The autopsy showed slight congestion of the viscera. Microscopical examination revealed the general signs of inflammatory changes. In two of the animals which were treated in the same manner, but in which high-vacuum tubes were used, the integumental changes were slight, but the viscera, especially the intestines, were much more hyperæmic. This would also be in favour of the assumption that the soft tubes affect the integument more intensely than the viscera, while the hard ones affect the skin to a slight degree only, but by their greater power of penetration still exert their effects on the viscera. Intense iradiation showed marked reaction at the opposite side of the body (abdomen, for instance, when the dorsum was exposed). The signs of reaction at the opposite side appeared a week later, on an average, than those of the area directly exposed. In men, visible effects on the opposite side have not been observed.

The microscopical examination of extirpated tissues, when irradiated after excision, was always negative. An extirpated testicle of an animal, for instance, showed the same structure after prolonged irradiation as the other, which was not exposed.

So much for observed facts. The question how these inflammatory processes are originated cannot be easily answered, because it touches not only physics and chemistry, but also presents physiological, pathological, and even bacteriological factors. It seems, however, that it can be answered best on the basis of clinical observation. While experiment on the lower animals is extremely useful for comparison, thereby suggesting new ways for investigation on the human body, it cannot be conclusive for the pathology of man. The thick hairy coat of the animal reacts to burns in a way different from that of the human integument. The same must be considered in connection with the effects of the Röntgen rays upon the skin. It will therefore be more proper to compare our knowledge of the conditions produced by ordinary burns of the human skin with those caused by the Röntgen rays. In both a disturbance of nutrition in the walls of the blood-vessels and its consequences become at once apparent. By considering, for instance, the consequences of a simple burn of the second degree, it will be found that the destruction of the red blood-corpuscles, described by Fraenkel, Lesser, Pavlovsky, Ponfick, and Wertheim, is of no significance even in extensive burns of this kind. According to Hoppe-Seyler, even in fatal burns of the second degree the maximum of the destroyed blood-corpuscles did not amount to more than 2.4 per cent. The products of tissue change, resulting from the pathological disintegration of the tissues, are much more detrimental. They originate, according to Fraenkel, in the same manner as they do in the digestion of albumin. The albumin is split, absorbs water, and is finally transformed into albumose and peptones. Krehl and Mathews examined these disintegration products of albumin within the human body. From the results of their investigation we may conclude that in burns of the second degree there is, besides destruction of the red blood-corpuscles, disintegration of albumin. The consequence of this latter and most important change is the formation of exudates, which produce albumoses during the process of absorption. And albumose, not being a product fit for assimilation, is eliminated from the organism by the way of the kidneys.

The greater or lesser severity of the clinical symptoms seems to be dependent upon the various degrees of toxicity of these substances. In this way the fatal outcome of extensive burns of the second degree is also explained. In addition, the large loss of fluid (blood plasma) must be considered, which is also the larger the more widely the burned surface extends. The waste of fluid causes a loss of the natural resistance in the organism, so that these toxic products find a much more favourable soil.

In burns of the second degree the destruction of the red blood-corpuscles is of much greater importance, since the elimination of a large quantity of them has effects similar to those of carbonic-acid poisoning. To this is added the result of absorption of the products of the disintegrated tissue (toxæmia).

The difference between an ordinary burn and the changes of tissue caused by Röntgen light consists, as has been alluded to above, in the slow development of the process. The peculiar chemical influence of the Röntgen light on the tissues is exerted in such a manner that the nutrition of the cells is impaired. It is only when this impairment has reached a greater degree that the signs described above manifest themselves. And these signs are again influenced by the strength and the amount of the Röntgen light. A greater or lesser degree of predisposition is also of significance. Effluvium capillorum is explained by inflammatory processes in the matrix cells.

That the Röntgen rays possess *bactericidal* properties cannot be doubted any longer, although the various reports on this subject differ widely. The antibacterial effect of sunlight is an illustrative analogy. "Where the sunlight has no access, the physician will soon appear," is an old and significant Italian proverb. In harmony with this consideration, derived from the observation of the development of tuberculosis, is the fact that cultures of the tubercle bacillus die after exposure to sunlight for three hours. When we consider the great similarity between the effect of sunlight and that of the Röntgen rays, the bactericidal property of the latter appears to be evident. And in fact the experiments of Lortet, Genoud, Fiorentini and Luraschi, Frantzius, Mühsam, Rieder and Holzknecht not only showed that the rays exert a direct bacteriodal influence on the cultures, but also arrest further development of bacterial infection. That it is not the electricity, but a specific agent of its own which is responsible for the antibacterial influence of the rays, is evident from the fact that the growth of the same cultures was not impaired if any other electric means were used.

Rieder used a Voltohm tube and an induction-coil with a spark length of ten inches, permitting of 3,000 interruptions per minute. He placed the cultures in Petri dishes at a distance of three inches from the target. They were protected by a perforated sheet of lead. It is evident that if irradiation took place through the hole made in the centre and covered with black paper which was not permeable by daylight, the pure effect of the Röntgen light could be studied, while if the opening was left free, the influence of daylight would have come into consideration. In most cases, however, the result was the same, whether daylight had had access or not.

Lortet and Genoud, after inoculating animals with the bacillus of tuberculosis, irradiated some of them daily for a period of seven weeks. None of the irradiated animals showed any signs of infection, while the non-irradiated ones developed abscesses and showed rapid emaciation. Fiorentini and Luraschi found that irradiation influenced the infected tissues considerably, thus corroborating the observation of Lortet and Genoud. Mühsam, who inoculated guinea-pigs, found that general tuberculosis was not influenced by the rays, but that the local process was either inhibited or diminished.

As this most important question stands at the present time, it seems that a powerful effect on the bacillus tuberculosis is not exerted by the rays, at least not sufficiently powerful as to be utilized in practice. That an influence exists can hardly be doubted, and to the author this seems to be less of a bactericidal than of an inflammatory nature. It is always well to remember that in tuberculosis not only the bacillus, but also that product of metamorphosis, which we know as the tuberculous nodule, is to be considered. Artificial hyperæmia, as has been shown by Rokitansky, may also arrest the development of tuberculosis. If it is appreciated that tuberculosis is still the most important of all diseases, it appears to be well worth while to investigate this province still more thoroughly.

Potato-cultures of the *Bacillus prodigiosus* exposed by von Wolfenden and Ross in test-tubes (Lancet, 1898, p. 1752) showed stimulation of their growth after an hour's irradiation. Their inductive coil had a spark length of 18 inches, their voltage amounted to 6, and the ampèrage to about 10.

It seems that the glass of the test-tubes offered an obstacle to the permeation by the rays.

Cultures of the *Staphylococcus pyogenes aureus* on gelatin, when exposed for an hour, showed diminishing of their growths under the hole in the centre. The same result was obtained in cultures of the *Bacillus coli communis*. The vibrio of cholera placed on agar responded very readily after an exposure of forty-five minutes only. In fact, the whole area corresponding to the opening in the centre was practically free from any colonies.

The same result was obtained in agar-culture of the *Typhoid bacillus,* while blood-serum cultures of the *Klebs-Loeffler bacillus* required longer irradiation until their further development was arrested.

From these observations it may be learned that especially the staphylococcus, Bacillus coli communis, vibrio of cholera, and the Typhoid bacillus were destroyed if grown in gelatin, agar, or blood-serum. It would be a consummation devoutly to be wished if these bacteria could also be reached by the rays when developing inside of the living body. But our present means do not permit an effect so powerful that the developing process of bacteria *in vivo* would be inhibited.

It seems that the various reactions shown by the various bacterial types are in proportion to the different qualities of their plasma.

The great technical difficulties connected with the study of the details of intercellular life naturally suggested approaching some of these problems by experiments on the lower animals, like the protozoa, which permit of a closer study of their protoplasma. Schaudinn (Pflueger's Archiv für die gesammte Physiologie, Band lxxvii), for instance, found that among the protozoa, *Labyrinthula dacryocystis Cienth*, showed no changes at all. The plasma of these types is viscid and inert. It is indifferent to all kinds of irritation, while the lively Amœba princeps (Ehrbg.), the liquid plasma of which contains large quantities of water, shows considerable change, and dies after being irradiated for ten hours. All kinds of infusoria perish after being irradiated for six hours.

Maldiney and Thouvenin found that the seeds of the morning-glory (*Convolvulus arvensis*) and of the watercress (*Lepidium sativum*) showed the signs of sprouting much more rapidly when they were irradiated for an hour.

All their experiments point to the fact that the rays, if used moderately, have an exciting and invigorating effect upon the organism, while when used excessively are apt to exert a destructive or paralyzing influence. This is in entire accord with clinical observation.

RÖNTGEN-RAY DERMATITIS

The pathological changes of the skin, called Röntgen-ray dermatitis and generally known as X-ray burns, resemble those in ordinary burns. Just as in ordinary burns, these different degrees should be distinguished.

The first degree is characterized by the symptoms of hyperæmia. Epidermis and cutis are infiltrated and the temperature is somewhat higher. Exfoliation takes place in small scales. The most pronounced subjective symptom is a tormenting itching in the skin. Effluvium capillorum, which manifests itself, as a rule, without producing any visible signs in the integument, belongs in the same category. It seems that there is a regressive metamorphosis (atrophy) of the differential elements—viz., the glands, hairs, and nails. Most cases of Röntgen-ray dermatitis belong to this category.

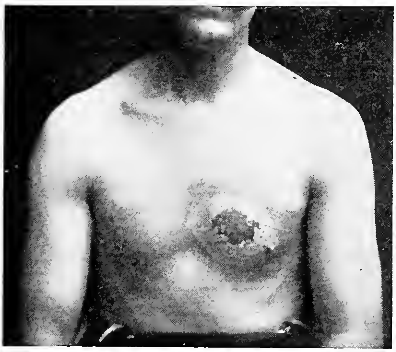

Fig. 262.—Röntgen Light Burn of the Second Degree.

The first symptom used to be the turgescence of the skin, which may appear as early as three days after the exposure. In the majority of cases the unmistakable signs do not show before the tenth day.

The main feature of the second degree consists in the formation of blisters, the clear or yellowish contents of which lift the corneal from the mucous stratum of the rete Malpighi (Fig. 262). The inflammatory signs are well pronounced, the tension is considerable, and the pain is intense. After the removal of the blisters, the corium is exposed as a red and sore surface (bullous form of Röntgen-ray dermatitis). The excoriated surface shows a yellowish-red appearance. Some cases look like having been varnished. In the further course some portions show a fibrinous cover like croup-membranes, which adhere tightly. The abundant secretion from the coarse granulations is of a sero-purulent character.

The third and gravest degree is characterized by the escharotic destruction of the irradiated tissues. They show the signs of dry gangrene, and their appearance is brownish black. There are intense inflammatory signs and the temperature rises accordingly. The patient suffers considerably. If the necrotic area exfoliates by a slow suppurating process, or if it, as it should properly be, is removed by the surgeon, a granulating ulcer remains, the cicatrization of which may take months (necrotic form of Röntgen-ray dermatitis) (Fig. 293).

Then the integument becomes hyperæmic, erythema of a light red appearance develops and changes like pigmentation set in. If the irradiation is discontinued in this stage, these signs, especially erythema and pigmentation, disappear in two or three days. The integumental turgescence lasts somewhat longer. After depilation the first signs of the recurrence of the hair show in five to nine weeks. After a few weeks there is complete recovery, though sometimes slight pigmentation of the integument remains.

If the irradiation is continued the skin may become burned and scaly; or the bullous type of the Röntgen-light dermatitis sets in. In this form intense reaction takes place after an incubation of about two weeks. This is of a subjective as well as of an objective character, and lasts about as long as the period of incubation did. Then cicatrization follows. If the area of irradiation was covered with hairs, depilation takes place. The process of regeneration of hair is slow, and pigmentation and teleangiectasis nearly always remain.

The necrotic state of the Röntgen-ray dermatitis develops a few days later than the bullous form as a rule, and requires months for its cure. This type reminds one of the stationary form of gangrene, which is known as "glacier-gangrene" in Europe. The antediluvian face of the old inspector of the ice-grotto at the Eiger glacier in Switzerland, well known to many medical tourists, affords a real study of this interesting tissue change.

There is a type of chronic Röntgen-light dermatitis which is especially found among physicians who devote a great deal of time to irradiation. Fig. 263 shows the wrinkled, shrivelled, vulnerable, and partially cracked terra-cotta hand of a physician, who had done daily skiagraphic work since the early Röntgen era. It represents the dorsal surface, which he turns against the Röntgen tube in order to ascertain, by the study of the bones of his own hand, what degree of translucency exists. The tip of the fourth finger was the most exposed target, which finds its conspicuous expression in the black colourization of the nail and the onychia. Next to it the little finger suffered most, which is illustrated by the deep black of its nail. The nail of the middle finger is less blackened, and the index still less, while that of the thumb, which is held sidewardly, is fairly normal.

FIG. 263.—RÖNTGEN-HAND.

The hands of Röntgo-active physicians show the integument wrinkled and shrivelled; the nails horny and cracked, and the phalanges thickened, so that there is tension during movement. The elasticity is lessened and the sensibility increased. Effluvium capillorum is an invariable accompaniment. In some cases the formation of warts and rhagades is observed. Undoubtedly there is a cumulative influence.

Experience has taught us that in all cases of Röntgen-light dermatitis, other circumstances being equal, long exposures had taken place; and it is therefore obvious that short exposures are the best safeguard against injury. But then the question is: Shall we reach the desired result, whether for diagnosis or therapy, by a short exposure? If not, what kind of prophylaxis must be used?

In order to appreciate this important point thoroughly we must also consider some contributing factors—viz., the construction of the tube, the penetration power of its light, the distance from the irradiated body, the position of the object, the number of interruptions, and the size of the secondary.

Whether an accumulator, a static machine, or a coil be used seems to be irrelevant. But, as mentioned in the author's previous publications on this subject, we have to reckon with Röntgen light susceptibility, existing in some individuals, just as much as we have to do with iodoform idiosyncrasy. The author's statistics at the German Poliklinik of New York, which are based upon twenty years of continuous observation, show that about every fiftieth individual becomes affected with dermatitis when treated with iodoform. Since such idiosyncrasy cannot be diagnosticated before the dermatitis makes its appearance, we shall never be able to prevent it. But what we can do is to recognise it in its early stage, and if this is done, further spreading can be arrested by simply discarding its further use.

There are, however, two points of difference between the iodoform and the Röntgen-light susceptibility. In the first place, a non-susceptible patient will not show any signs of iodoform dermatitis, no matter how long he may iodoformize himself, while there is no individual who would not be burned by the Röntgen light if its influence is kept up long enough. And, secondly, the Röntgen dermatitis will not stop as soon as further irradiation is discontinued. The peculiar features of the Röntgen rays not to show the injurious effects as a rule before the tenth, sometimes not before the twentieth day after the first exposure, stands in the way of an early and rational prophylactic therapy. The only method by which we may so far determine whether a susceptibility exists or not is by tentative exposures. So it may sometimes be a chain of little causes, long exposures, short distances, powerful apparatus, condition of patient, and weather, which in their entirety may be the stimulus for the reaction. Besides this susceptibility, which is born with the individual, and is to be regarded as an *imponderabilium*, temporary susceptibility exists, which may be attributed to temporary bodily conditions, to pathological changes, or to climatic influences. The author has repeatedly called attention to his observation that when suffering from a slight Röntgen-light dermatitis himself he could note a marked increase of the symptoms during sultry weather. The patients treated on such days had a similar experience.

He does not, however, believe that the question of susceptibility requires much consideration, as far as exposures for diagnostic purposes are concerned, since, with our present methods, the length of time needed is very much shorter. Even if repeated exposures have to be taken the author has, so far, not seen a Röntgen-light dermatitis before the fifth repetition, the intervals having been from two to three days. And these cases were slight, the first or second degree. Still, as already said, with our present apparatus, a certain length of exposure invariably causes burning, whether the individual be susceptible or not. If long exposures are responsible in nearly all cases of Röntgen-light dermatitis, we shall naturally try to shorten them, as emphasized above. This we can do only to a certain extent, if we are seeking full and distinct diagnostic information. Unfortunately, the best skiagraphs are obtained by long exposures, made with tubes of low vacuum. This, in addition, requires the use of a strong current. So, in order to get out the structural details, three irritating factors unite their influence, the long exposure, the soft tube, and the intense current. A tube with a high vacuum requires only a short exposure, but the details of the skiagraph are by no means brought out as well. So, theoretically, if the question of dermatitis did not exist, we would, as a rule, combine very low vacua, very long exposures, and currents of high intensity.

Fortunately, the longest exposure (the pelvis) does not now, with the aid of the Wehnelt interrupter, require more than four to five minutes' exposure, and this will be tolerated even by a susceptible individual. So, practically, we do not need to fear much in our diagnostic efforts, and if we could make the rays still more powerful, in order to get more differentiation, we would not hesitate to do it.

But when repeated exposures of ten minutes time are necessary, the question of susceptibility, as well as of ordinary cumulative irritation, should be considered, and therefore the intervals between the exposures should be made long—a week on an average.

None of the severe disturbances, however, reported in literature were due to short exposures, most of them being observed in professional electricians. A tube-maker in a Hamburg laboratory, for instance, by testing the tubes with his own hands, sustained a burn of the third degree, the treatment of which was apparently neglected. Over the basis of the deep ulceration an epithelioma formed and metastasis in the glands developed, so that disarticulation in the shoulder-joint had to be undertaken.

Lloyd (Medical Record, April 4, 1903, p. 554) reported the case of a tube-maker in Edison's laboratory who had received very severe burns on his hands and head. Finally he lost all the skin of his hands. He was skin-grafted in two or three hospitals, and finally returned to New York with an epithelioma developed on the Röntgen-ray burn of the right hand. This epithelioma grew rapidly while he was under Röntgen-ray treatment, and finally amputation had to be performed. By the courtesy of Mr. Thomas A. Edison the author learned that the other arm of his unfortunate assistant began to show such aggravated pathological changes that its amputation has also become necessary.

Tuttle (*ibidem*) referred to a man whose thigh he had to amputate because of the result of an X-ray burn. A careful pathological and microscopical study of the X-ray burn as well as of the parts around it had been made by William Vissman, whose conclusion was that it was the result of the production of an endarteritis and a periarteritis.

As far as the author could ascertain, extremely long exposures had preceded the injury. The pathological changes in the tissues were studied by Unna, Gilchrist, Kienboeck, Darier, Jutassy, Kibbe, Gassmann, Scholz, Oudin, and the author. Unna found a slight increase of the nuclei in the papillary body as well as around the blood-vessels. At the same time there was more pigment in the upper layer of the cutis.

Kibbe found dilatation of the blood-vessels and rich cellular proliferation.

Gilchrist noticed abundant brown pigment in the mucous stratum, and dilated vessels in the corium, while the corneal structure was thickened.

Darier observed enlargement of the reticular cells, thickening of the epidermis and atrophy of the hair and its follicles, and of the glands.

Examination of burned tissue made by the author (see The Pathology of the Tissue Change caused by the Röntgen Rays, etc. Transactions of the Medical Society of the State of New York, January 28, 1902) showed a large amount of dense connective tissue and marked vascularity. The epithelial cells of the skin were diminished in size. The tunica intima of the small blood-vessels was thickened, their calibre thus becoming narrower. The muscularis and adventitia appeared to be affected in the same manner. The muscularis may thus become atrophic. All this points to a process of constriction of the vessels. Some of the areas show still greater degeneration, the tunicæ of the small vessels being converted into a colloid mass and the intima being entirely severed from the muscularis.

In the case of Tuttle, described above, endarteritis was observed, which had extended nearly four inches underneath the burned area.

The hair extracted after prolonged irradiation is found to have lost its structure. It ends in a point instead of showing a root. Zehmann found that the bulb at the end of the root often showed slight swelling.

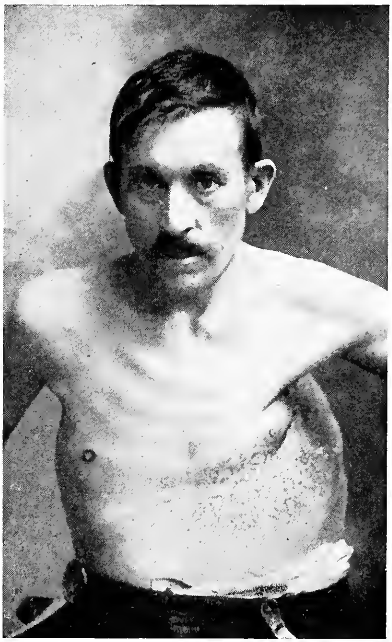

Fig. 264.—Telangiectasis two years after Röntgen Light Dermatitis.

The course of the Röntgen-light dermatitis is dependent, of course, upon the intensity and extent of the irradiation, and upon the kind of affected tissues. The prognosis of the second and first degree is extremely favourable. The integumental area situated directly above the bone, as on the skull, chin, thorax, spinal column, tibia, etc., is especially unfavourably located. The necrotic form naturally represents the severest type.

The more intensely the dermatitis sets in, the more the tissues are affected and the more marked the sequelæ appear. The following cases observed by the author may serve as illustrations. The bullous form of Röntgen-ray dermatitis was observed in a man of thirty-eight years, who in the course of two years had to submit to five thoracotomies for pyothorax. In view of the thickened pleura, which lined the immense thoracic cavity, the author had resorted to pleurectomy, and a few weeks later the Röntgen rays were expected to give information as to the extent of the cavity as well as of the previous rib-resection.

At first soft tubes were employed, the use of which gave but little contrast. This phenomenon was erroneously explained by the reason that, in spite of the removal of a large pleural portion, still a considerable part of thickened pleura had remained, which might have veiled the image of the ribs. When resecting the ribs shortly after the last exposure the author found them to be of very soft consistency, which showed the absorption of calcareous matter on account of the long duration of the inflammatory process (inflammatory atrophy). After having repeated his unsatisfactory efforts seven times, harder tubes were resorted to in combination with a high current and longer exposure, which caused a bullous dermatitis. The incubation lasted ten days, the skin was light-red first and then dark-red. Later on a blister the size of a large hand formed, the contents of which consisted of serum. After the blister was removed an excoriated surface was exposed, which cicatrized under a xeroform dressing in three weeks. Fig. 264 illustrates the pigmented integument and indicates the presence of a telangiectatic area two years after healing of the dermatitis. The patient was of blond complexion.

The same accident happened in a blond man of twenty-five years, who had suffered from traumatic lung abscess for three years. In trying to measure the various distances of the walls of the cavity five exposures were made. A soft tube was used. Thirteen days after the last exposure a blister of the size of the palm of the hand appeared on the anterior thoracic wall, opposite the opening of the cavity. The contents of the blister consisted of serum of light yellowish colour. After the opening and removal of the blistered tissue a superficial non-suppurating excoriation remained, which cicatrized under the application of a 10-percent xeroform lanolin ointment. Fig. 262 shows the excoriated surface three days after the first symptoms of dermatitis had appeared.

In both cases individuals were concerned the vitality of whose tissues had been lowered by exhaustive processes which had lasted for several years. In both instances suppurating cavities were irradiated which seemed to be apt to impart a resistance of the superimposed structures. A current of high intensity was employed, and the exposure was from five to six minutes each time.

In a third case the long-continued influence of a plaster-of-Paris dressing in connection with axillary folliculitis was sufficient reason for the lowering of the vitality of the integument. If the integument is in a stage of irritation on account of the presence of sykosis, favus, or similar skin affections the predisposition is naturally more marked.

The treatment of the inflammation caused by the Röntgen light is virtually the same as that of ordinary burns. In simple dermatosis (burn of the first degree) warm applications of Burow's solution are most comfortable for the patient. For the bullous form (second degree) a 10-per-cent xeroform-gauze dressing, after the blisters are opened and removed, is indicated for the first few days. Later on a dressing of a 10-per-cent xeroform-lanolin ointment is recommended, which is changed daily, provided there is but scant secretion. The necrotic form (third degree) requires speedy removal of the mortified tissues, the after-treatment is conducted on the ordinary principles of wound treatment, xeroform or iodoform gauze being used, the latter being preferred if there is much secretion. Torpid granulations are stimulated by an 8-per-cent solution of chloride of zinc. Skin-grafting is often indicated in obstinate cases. In the chronic form moisture must be avoided. Temporary bathing in a normal salt-solution, however, is recommended.

The Method of Therapeutic Irradiation.—The effect of irradiation depends mainly upon the intensity of the Röntgen rays and the vacuum of the tube, the size of the induction coil, the strength of the primary current, the number of interruptions, the frequency and duration of the *séances*, the distance of the tube, and last but not least, the individuality of the irradiated tissue are also factors well to be considered. As a rule, an induction coil which gives a spark-length of ten inches answers the purpose well, an ampèrage of three being sufficient on an average. A dosage of five to six ampères should be resorted to early in the treatment of malignant growths. As alluded to in the foregoing section, soft tubes exert a stronger influence upon the skin than the hard ones. Irradiation with a hard tube may, however, be followed by intense integumental reaction, if it is used in connection with a very powerful induction coil. The number of interruptions also represents a contributing factor. It is assumed that the intensity is the greater the more frequent the interruptions are. Tubes provided with an attachment for regulating the vacuum are best fitted for therapeutic purposes. The author employs the same kind of tubes which he found most useful for diagnosis. For static machines the same principles hold good. Various efforts to ascertain and regulate the degree of penetration have been made. The radiochromometer of Benoist and the *ampoule à osmo-régulateur* of Villard represent some of the efforts to solve this question.

The principle of the apparatus of Holzknecht, called chromoradiometer, is based upon the property of various salts to be more or less colourized by the influence of the rays. Such salts after being deeply colourized by the rays are made up in a scale, which also contains the same salts, not yet influenced by the rays. If the fresh salt, placed at the object to be irradiated, shows the same degree of colourization which its colourized companion has, sufficient influence is exerted, and further irradiation would better be stopped. Ingenious as the apparatus is, which is especially recommended in the treatment of lupus, it has, in its present stage, only a very limited field of usefulness. For the experienced operator the colourization of the tubal light indicates the degree of the vacuum, yellow saturated colour pointing to a soft state, and a green aqueous light being characteristic for the hard. If the operator uses the osteoscope (see Fig. 12) he will find the bones black if a soft tube, and gray if a hard one is selected.

As to the question of idiosyncrasy, reference is made to the foregoing chapter. From a strictly practical standpoint the possibility of susceptibility deserves attention only as far as cosmetic considerations are concerned. In other words, we should make clear to ourselves first what the object of our therapeutic measures is. Little stress is laid upon this point in the many valuable publications on this important subject. It is not customary to shoot at sparrows with cannon-balls. Why, if we treat a hairy surface on the face of a fair lady, for instance, resort to means as powerful as those we employ in carcinoma? And, on the other hand, if dermatitis occurs in the face of a fair lady, who simply wanted to be treated for hypertrichosis, the cure proves to be worse than the disease. In other words, when treatment for non-malignant diseases is intended, careful tentative exposures should precede it. If, then, erythema should appear after one short exposure, thus proving the presence of susceptibility, further treatment must be taken up only under extraordinary circumstances, and after the patient has been fully informed of the risks. For such purposes a first exposure of five minutes is advised. A soft tube should be selected. After a week the same procedure, now lasting ten minutes, is to be repeated. If, after a third exposure, and two weeks after the first one, no reaction has shown up, the patient is apparently not susceptible. Then he may on an average be irradiated every second or third day, and at last daily, until reaction manifests itself. Each exposure may last from ten to fifteen minutes.

During the tentative exposures the distance of the tubal wall from the skin should be four inches, later on it may be reduced to one inch. The vicinity of the irradiated area must be protected. This is done by a thick shield of lead, which, if moulded properly, attaches itself to the area selected; if not, it must be fastened to it by a bandage. If the face is concerned, a sheet of lead, into which a hole is cut to correspond with the area to be irradiated, may be bent over it. During the intervals xeroform salve (1 to 10 lanolin) should be employed.

In treating malignant diseases, we should be governed by entirely different principles. That it is absurd to protect the areas which demand the influence of a sort of destroying agent will be explained in the chapter on the treatment of malignant growths. The fact that the cases of Röntgen-ray dermatitis reported were invariably observed after long exposures, shows that the length of exposures is the most prominent causative factor.

The question how many minutes we should expose our patient at each *séance*, and how many times and in what intervals, in order to obtain the desired result, is not easily answered. After irradiating a patient for a whole hour the reaction will be a great deal more intense than if the same dosage is given during a ten minutes' *séance* on six successive days. On an average the natural limit of each exposure should be fifteen minutes. It is much more troublesome to reach the desired result after exposing ten times for ten minutes than once for an hour, but it is a great deal safer.

As to the distance of the tube, it appears to be natural that the nearer the tube, the greater the intensity of the light is, a factor which must be considered in connection with the lengths of exposures as well as with the intensity of the current and the height of the vacuum. For comparison, it is well to remember that the bromide of silver of the photographic plate shows an intense reaction at a certain distance, while after increasing it to its double extent but one-fourth of that effect is shown. In most cases the distance of the tubal wall from the skin should be four inches.

As to the modification of this rule, see chapter on Malignant Growths.

A most important factor is the character of the tissues irradiated. Different tissues react differently, as emphasized in the foregoing chapter. Different regions of the body show marked predilections, the hairy part of the skull, for instance, and those integumental portions which are immediately situated above a bone, being especially inclined. The face, the dorsum of the hand, and the mucous membranes are also more sensitive. Children and weak individuals seem to react quicker and more intensely, especially after exhaustive processes have lowered the vitality of the irradiated tissues, as, for instance, in the case of abscess formation, described in the foregoing chapter.

The same tissues, when undergoing tuberculosis, carcinomatous, or sarcomatous degeneration naturally react differently than they do in their normal state. Whether the colour of the hair, complexion, etc., furnish a predisposition, is still *sub judice.* Blond individuals seem to show a special susceptibility. All the author's cases were of light complexion. As described in the foregoing chapter, the first signs of reaction are of a subjective as well as of an objective nature. The subjective symptoms are those of burning and itching, especially at night. The feeling of extreme tension is also complained of by the patient as a most distressing sensation. In the beginning, however, these symptoms may be so slight that the patient may ignore them. It is necessary therefore to distinctly call his attention to this possible eventuality.

The objective symptoms are integumental tumescence and change of pigmentation, effluvium capillorum and erythema. The tumescence is of a diffuse character, and if it makes its appearance in the face, the patients, especially ladies, enjoy it, on account of its favourable influence on the irregularities of the skin surface, and because it clears the complexion somewhat.

According to Scholz and Behrend, histological investigation shows these symptoms to be produced by the infiltration of the integumental tissue by serous exudations which permeate the lymph-spaces situated between the elements of the stratum spinosum first, and dilates them. Sometimes the skin shows a light yellowish or brownish colour of a diffuse nature, which, as a rule, disappears shortly after irradiation is stopped. Sometimes early decolourization of the hair is observed, especially of brown individuals. In the majority of cases, pigmentation as well as decolourization appears as a late symptom of superirradiation.

Pigmentation is due to the hyperæmic condition caused by the influence of the rays on the capillaries, diapedesis of blood-corpuscles through their walls is rendered possible then in a moderate extent. Extravasation of blood-plasma containing hæmoglobin in the dissolved state, takes place at the same time. To this process the yellow tint of the hyperæmic skin is due. When the irradiated integument is covered with hair, effluvium capillorum may be observed at an early stage. At first the hair becomes loose only, so that a gentle effort suffices to pull it out. This early symptom can be recognised only if the hair is not cut or shaved away during the period of treatment. Erythema due to irradiation differs somewhat from the ordinary type. It resembles the form of erythema that is caused by sunburn. Its tints are light at first, turning into a diffuse or spotted red-brown later on.

A *résumé* of the points and principles emphasized may be condensed into the following rules: The tubal light emanating from the anticathode of a soft tube strikes the centre of the area to be irradiated at a distance of the tubal wall from the skin of four inches first, later on it is gradually decreased to one inch. In malignant diseases the exposure may last longer—that is, if the tissues do not react after an exposure of ten minutes, they may be prolonged to fifteen, and in obstinate cases may be intensified by the use of the author's diaphragm (compare Treatment of Malignant Growths). The *séances* are repeated every second or third day, and if no reaction shows, daily, until the desired result is accomplished or reaction manifests itself in the shape of turgescence or intumescence of the skin. Then irradiation must be stopped until the disappearance of these symptoms. The patient's attention must be called to the fact that those signs as well as the sensation of itching, burning, or tension may occur any time during treatment, so that he will be able to report at once to his physician. An induction coil giving a spark length of 10 to 15 inches, either in connection with an accumulator or the street current, and a Wehnelt interrupter answers all therapeutic purposes. An ampèrage of 2 to 3 is used on an average for non-malignant affections.

CHAPTER XIX

SPECIAL INDICATIONS

The first methodical experiments in the treatment of hypertrichosis were made by Freund and Schiff. The production of an inflammatory process in the integument, observed in their cases, suggested the use of the Röntgen rays in lupus. Soon afterward favourable results were reported by Kuemmell, Albers-Schoenberg, Ziemssen, Hahn, Gocht, MacIntyre, Pratt, Gilman, and the author. While at the present time the experimental stage has not been passed, yet sufficient evidence of the effect of the rays is accumulated now in hypertrichosis, sycosis, favus, blepharitis, alopecia, acne, psoriasis, eczema, prurigo, nævus vasculosus, lupus, carcinoma, and sarcoma. Even in Hodgkin's disease, rheumatism, tuberculosis, and neuralgia favourable results are reported.

HYPERTRICHOSIS

The general principles emphasized in special indications hold good in the treatment of hypertrichosis. If the chin or the cheeks are to be irradiated, the head must be thrown far back, non-affected areas of the face as well as the chest are protected by a lead mask. If only the upper lip is to be treated, a lead mask covering the whole face is chosen and an opening corresponding to the lip is cut in it. The rays are directed vertically on the area. After the tentative exposures (see foregoing chapters) were not followed by any reaction, the diseased area is irradiated ten minutes on three-day intervals at a distance of four inches (110 volts, 3 ampères). Reaction takes place after twelve to twenty days, the first signs being light red or brownish decolourization of the skin and loosening of the hair. The patient feels a slight burning sensation. Further treatment is stopped now. During the next week the hairs fall out gradually. If left alone the hair is again restored in five to eight weeks. In order to prevent this a second course of irradiation is necessary, which must begin four weeks after the signs of reaction have disappeared, this time only four to five *séances* being necessary, as a rule, to induce a lasting alopecia. In case of recurrence the same mode of treatment is repeated.

In young persons reaction is more rapid and intense than in middle-aged people. If irradiation was continued after reaction was well marked, teleangiectatic areas may remain (compare Fig. 264). Disfiguration of this kind exchanged for hypertrichosis is of course sorely felt by the patients, who generally belong to the fair sex. The growing of hair on skin-flaps after transplantation may be an obstacle for complete union, so that the result of the operation may be jeopardized. In an event of this kind depilation by the Röntgen light becomes one of the most important healing factors.

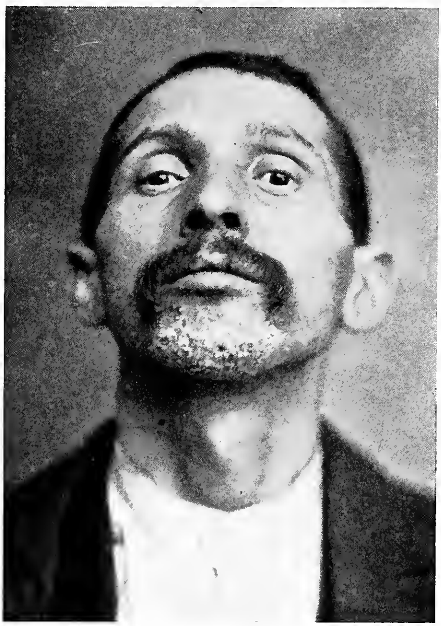

Fig. 265.—Sykosis. (Compare Fig. 248.)

SYKOSIS

Where blisters and excoriations are present a few exposures suffice as a rule. As soon as the diseased area assumes tints of darker red further treatment is to be suspended. The principles of the technique are the same as described for hypertrichosis.

Fig. 265 illustrates the case of a man of thirty years who had been treated in vain for several years. Fig. 266 shows the remarkable effect of one exposure of ten minutes at a distance of four inches a week afterward. The blisters were dried up after ten days, the secretion and crust formation stopped, and the sensation of itching and tension disappeared a few hours after irradiation.

After three to four weeks a recurrence may be observed, in which case short irradiation must be taken up again. Sometimes, however, the reaction is intense, new blisters forming, and the pain increasing. In an event of this kind irradiation must, of course, be stopped, and warm applications of Burow's solution be made.

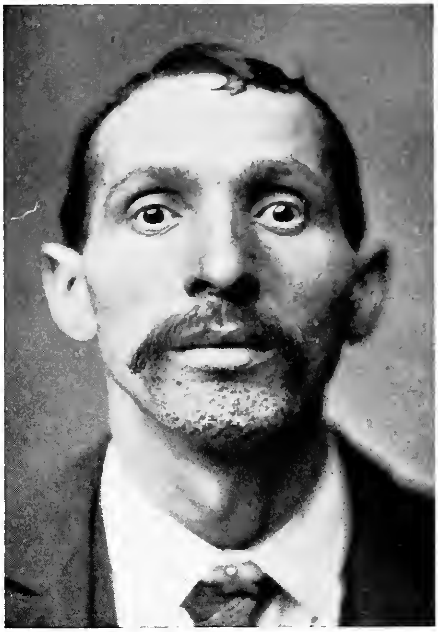

Fig. 266.—Case of Sykosis, Illustrated by Fig. 247 after one Exposure.

If sykosis localizes at the hair follicles only, small red nodules developing (folliculitis barbæ), treatment is best continued until the hair becomes lessened and falls out. By eliminating the hair every possible exciting factor is removed from cutis and papillæ.

In order to control the process of depilation, the advice must be given to the patient to leave the hair untouched, and espepecially not to be shaved.

In trichophytosis (sykosis parasitaria hyphogenes) the same good results may be obtained after only one *séance*.

FAVUS

Favus requires the most energetic treatment. Complete depilation of the skull is necessary to obtain the desired effect. To this end the tube is placed above the anterior portion of the skull first, then above the lateral parts, and finally over the middle of the occiput. In order to be able to irradiate as large an area as possible at the time, the distance should be from eight to ten inches. The *séances* should take place daily, and their length should never be less than ten minutes. Soft tubes are used. After two to three weeks the integument becomes red and the hair begins to fall out. The curative influence of the rays in favus does not seem to be of a bactericidal nature, since the vitality of the parasites found after depilation did not appear to be impaired. The elimination of the hair, which may be viewed as a kind of foreign body, permits of extensive removal of the parasites, which are sheltered by the roots as well as by the outer follicular tissues. At the same time degeneration of the cellular elements, between which the parasites propagate, is induced. The stimulatory effect of nutrition may also be regarded an important factor in the healing process.

BLEPHARITIS

Schiff and Freund reported that in ulceration and squamous inflammatory processes of the lid-margins four to nine weak exposures sufficed to separate the crusts. The excoriations became covered with normal skin tissue and the diffuse reddening disappeared. The ciliæ did not fall out as a rule. The irradiation was done while the eyelids were closed.

ALOPECIA AREATA

Kienboeck, Holzknecht, Freund, Schiff, and Ehrmann observed that after the slight quantity of hair present was removed by irradiating new hair was gradually restored in much larger quantities. The irradiation should be repeated every three days at a distance of six inches (two ampères), and must not last longer than six minutes. The result is hardly due to the bactericidal influence of the rays, but rather to the stimulating effect of weak Röntgen light. Tubes of medium hardness should be selected. During the intervals 10-per-cent xeroform-lanolin is to be used. In young individuals the prognosis is favourable, especially if there be only small areas. But in universal alopecia and in aged persons no positive results could be reported yet.

ACNE VULGARIS AND ROSACEA

In obstinate cases of acne irradiation may be resorted to. Pokitonoff and Gautier reported cures in 17 cases of acne vulgaris and rosacea. The *séances* took place daily at a distance of 7 inches. They lasted four minutes (4 ampères and 18 to 20 volts). After the sixth exposure the pustules and vascularization disappeared. Similar observations were made by Jutassy, Hahn, Schiff, and Freund.

It seems that the effect is less due to the bactericidal properties of the rays than to their inhibiting influence on the secretion of the follicles. Freund believes that the desquamation of the epidermis, following irradiation, is the most important healing factor.

PSORIASIS

Albers-Schoenberg and Hahn reported that the red plaques became lightened up after four to five *séances*, and that at the same time scales could be pulled off without the characteristic bleeding. Different areas were exposed during one sitting. At first irradiation was kept up daily, after the third exposure every two, later every third day. Freund advised an exposure of ten to twelve minutes at a distance of 7 to 8 inches if the affection is of a diffuse nature, while small areas require only four minutes time at a distance of 4 to 5 inches. Recurrence takes place frequently, therefore it is advisable to take up slight irradiation four weeks after recovery for a short period.

ECZEMA

Grunmach, Hahn, Ziemssen, Jutassy, and Schiff observed ceasing of the exudation in acute as well as in chronic eczema, after a few *séances*. The epidermis peeled off and the itching disappeared. Irradiation, however, should, just as in psoriasis, be resorted to only in such cases, where the well-tested old methods proved to be inefficient. The therapeutic technique is practically the same as in psoriasis.

26

NÆVUS VASCULOSUS (FLAMMEUS)

Jutassy (Fortschritte der Röntgenstrahlen, Band ii, Heft 5) reports a case of this congenital condition in which a perfect cure was obtained. The telangiectatic area occupied the right half of the face of a young man. The exposures lasted four and a half hours in all during six days. The healthy parts of the face were protected by a lead mask. In spite of this most energetic treatment the reaction was only slight. At first hyperæmia was noticed around the diseased area. After two weeks the epidermis peeled off in small scales. Three weeks after the last exposure the nævus had become paler. A more severe inflammation was produced then. During eleven *séances* the tumorous area was exposed to intense light at a short distance for ten hours. Twelve days after the last sitting a severe dermatitis developed, apparently of the necrotic type, the healing of which took two months. Then the nævus had disappeared.

In *elephantiasis* and *urticaria pigmentosa* good results were observed by Sorel and Toeroek.

LUPUS VULGARIS

The fact that lupus vulgaris is curable by the Röntgen rays cannot be disputed any longer. To Kuemmel belongs the credit for advising the new therapy for this gravest and most obstinate skin affection (Twenty-sixth Congress of the German Surgical Society, 1897). Later on Schiff, Freund, Albers-Schoenberg, Neisser, Gocht, and the author published favourable results. The advice given by the author in regard to ulcerative processes—namely, to remove all broken-down tissue by the scissors or the sharp spoon, if it can be easily done, before irradiation is begun, also applies to the treatment of lupus. The final result is obtained more quickly and safely then. Whatever can be done better and more efficient by the scalpel or the cautery should not be left to the rays. Thus slight operative interference, followed by irradiation, often represents a happy combination. When no detritus is present, irradiation is started without resorting to any preliminary procedures.

No tentative exposures are required. The sittings should not last longer than fifteen minutes at a distance of 4 inches for the first 6 *séances,* and then of 2 inches only. They may be repeated daily until reaction shows. The Röntgen light should be intense, a tube of medium hardness being best selected (4 ampères at 110 volts). Mucous membranes are irradiated through Ferguson specula, the interior of which is lined with lead. Into the nose a special speculum of this kind must be introduced. As soon as reaction is observed, the signs of which are dark swelling of the lupus area and reddening of the nodules, the treatment is temporarily stopped. If the mucous membrane is concerned, the first symptom of reaction consists in a marked increase of the secretion. As a rule the ulcerated portions cicatrize then, the scabs dry up and fall off, and the skin is peeling. The nodules shrink, the hyperæmia disappears, and whitish scar-tissue forms. Four weeks after apparent recovery slight irradiation must be taken up again for a short period in order to prevent recurrence. It is the neglect of this precaution which is mainly responsible for the speedy recurrence reported by various observers. During the intervals 10-per-cent xeroform-lanolin is applied to the diseased area. Before irradiation the ointment is carefully removed again.

The process of healing seems to be induced by the degeneration of the cellular elements, especially of the giant and epithelioid cells of the nodules, followed by inflammatory reaction and hyperæmia. That hyperæmia is a most important factor in the cure of tuberculosis was demonstrated by Rokitansky more than fifty years ago. It presents in fact the most unfavourable condition for the development of tuberculosis. This dictum is corroborated by the observation that tuberculosis of the lungs rarely occurs if there are congestion processes in the thoracic organs (heart lesions, asthma, etc.).

The favourable influence of artificial hyperæmia in tuberculosis of joints was proved by Bier. On the other hand, clinical observation shows that anæmia offers the most favourable condition for the development of tuberculosis, therefore it must be combated energetically. Those biologic considerations should not be lost sight of when we try to understand the mode of healing. (Compare chapter on Physiological Effects of the Röntgen Rays above.)

Lupous tissue, removed after irradiation, shows the homogeneous epithelium permeated by very small openings on microscopical examination. The corium tissue as well as the cells of the connective tissues appear to be shrinking. The giant cells as well as the epithelioid cells are of smaller size and have lost their normal shape, so that they also show a shrinking and homogeneous appearance. This indicates that epithelium, a part of the corium, and the lupous nodules gradually become necrotic and dry up finally.

Fig. 267 illustrates the case of an Armenian of thirty years who suffered from lupus vulgaris of nose and face since eleven years. He was always under medical care. Two years before irradiation was begun, extirpation of the nodules had been undertaken. This was followed by great temporary relief, but the lupous areas in both nostrils resisted the therapy, which consisted mainly in the application of caustics. At the time the Röntgen-ray treatment was begun extensive recurrence had taken place. Irradiation was started in a tentative manner—that is, first an exposure of ten minutes was given at a distance of 4 inches (4 ampères at 110 volts). The second sitting took place a week afterward, and the third after another week in the same manner.

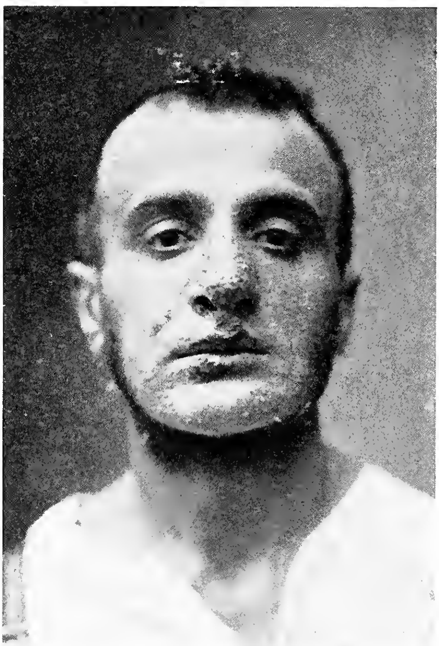

Fig. 267.—Lupus Simplex. (Compare Fig. 268.)

No reaction showing after the tentative exposures, irradiation was tried every second day for ten minutes. After the eighteenth exposure excoriations appeared, therefore the *séances* were discontinued. The dermatitis healed in two weeks, and with the exception of the intranasal nodules all signs of lupus had disappeared with it. Irradiation was taken up now in a more energetic manner, the sittings taking place daily at a distance of an inch only and lasting fifteen minutes. No protection was used except that the eyes were kept closed. After the eighth irradiation intense dermatitis set in. At the distant areas the inflammatron was of the second and at the upper lip of the third degree. The face was held upward, so that the rays could reach the intranasal nodules. Under warm applications of Burow's solution the reaction disappeared in three weeks. During the after-treatment salicyl-lanolin (1 per cent) was employed. Four weeks after the reaction had set in recovery was perfect. The intranasal nodules were cicatrized. Fig. 268 shows the result of cicatrization, one of its effects being the narrowing of the left nostril. The patient was irradiated again six times in the same manner in which he was treated at first. No recurrence was observed.

Fig. 268.—Case of Lupus Simplex, Illustrated by Fig. 267, Cured by Irradiation.

If a mask is used, gauze covered with five thicknesses of tinfoil is best selected into which a hole corresponding with the part irradiated is cut. The mask is fastened to the head by a bandage. A considerable portion of the healthy tissue must, however, always be left free.

LUPUS ERYTHEMATODES

Hahn, Schiff, Scholtz, Jutassy, Woods, Taylor, and the author reported the most satisfactory results. In most cases, however, speedy recurrence was observed, which yielded only to repeated exposures. Otherwise the mode of treatment is the same as in lupus vulgaris. The reaction causes hyperæmia and swelling, followed by exudation and crust-formation.

Fig. 269 illustrates the case of a woman of twenty-four years who suffered from lupus erythematodes nasi et faciei since she was five years old. The facial lesion had the appearance of a butterfly. Although being treated with caustics and the Paquelin's cautery the disease was disseminated. The patient gave a history of tuberculosis. A brother as well as a sister died from pulmonary tuberculosis. She had three children, one of which was still-born, and another died from meningitis (tuberculous). The third is healthy. No tentative exposures were given. Irradiation was tried every second day for ten minutes at a distance of an inch. A soft tube was selected. After the fifteenth exposure the infiltration began to disappear. After the twentieth exposure the crusts came off and the nodules showed the signs of shrinking. After the twenty-fifth exposure the nodules had disappeared, the skin appeared smooth (Fig. 270). For six weeks slight redness persisted. The after-treatment consisted in the application of salicyl-lanolin.

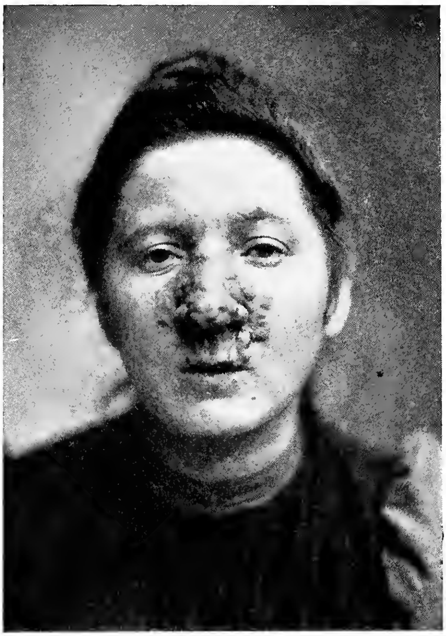

Fig. 269.—Lupus Erythematodes. (Compare Fig. 270.)

CARCINOMA

The treatment of external forms of carcinoma, including those of breast, tongue, and cervix uteri, by the Röntgen rays has become a recognised method. In fact, all integumental types are accessible to Röntgen-ray therapy. In the deep-seated forms the strength of the rays decreases so much that only a limited influence is exerted. There is, of course, a regressive metamorphosis observed in the deeper tissues of the body, but only under extremely favourable circumstances a cure would be expected. That even carcinoma of the stomach, liver, or of the corpus uteri may be influenced is not denied, but such influence is not intense enough to promise more than a slight amelioration. *Ne quid nimis!* Extravagant promises will discredit the new and delicate field of Röntgotherapy. In spite of the fact, however, that integumental carcinoma yields to the Röntgen therapy, the author would regard it extremely unwise to leave to the rays what can be done much quicker and more effectively with the scalpel—namely, extensive removal.

FIG. 270.—CASE OF LUPUS ERYTHEMATODES, ILLUSTRATED BY FIG. 269, CURED BY IRRADIATION. (Compare Fig. 269.)

But irradiation should be considered in the after-treatment as well as in inoperable cases. Even after a thorough operation of carcinoma, cells are often left in the deeper strata which cannot be reached by the surgical knife. We must consider that in the majority of cases the recurrence of carcinoma is caused by the epithelial cells of the primarily affected area, and but rarely by those of the secondary foci. Local recurrence, the most frequent form, is always produced by the carcinomatous cells which were left back, at the operation, while the indirect type originates from neighbouring tissue, which at the time of the operation appeared to be normal, but in fact carried the embryonic elements of carcinomatous infection.

A carcinomatous portion, however, left at the time of operation must not necessarily always be the cause of further infection. The *vis medicatrix naturæ* often attempts to secure a natural protection by surrounding the cancer alveoli with giant cells, which, as microscopical examination shows, starts a regressive metamorphosis analogous to the well-known healing processes in tuberculosis. It is the abundance of the epithelial toxines which prepares the soil for the new invasion and further development of the carcinoma cells. This also explains the rare occurrence of blood metastasis in carcinoma. If these cells could not really be destroyed, but if only a regressive metamorphosis was induced by the rays, a great advance in the treatment of this horrible disease would be made. The pioneer work in this direction was done in the United States, Gilman, Williams, Pusey, Grubbé, Morton, Allen, Johnson, Skinner, and the author having been early advocates of the new method in carcinoma. As a rule the induration disappeared after 15 to 30 *séances*. Crusts disappeared and cicatrization of ulcerated areas began. In epithelioma (*ulcus rodens*) the hard margins of the ulcerated area soften, the adjacent tissues becoming erythematous. Later on granulations appear on the surface of the ulcus, which brings it on a level with the normal integument. Epidermization soon follows then. The subjective condition often improved after one exposure. In fact, one of the most striking signs of improvement was the prompt relief from pain. Truly, if the rays would do no more than to give relief, where strong narcotics failed, they would be a blessing. Microscopical examination shows gradual destruction of the epithelial cells. Nucleus and protoplasm undergo lysis. In some cells fatty degeneration is observed. At the same time there is a stimulatory effect on the connective-tissue elements.

In the exposures examined by the author, the irradiated areas showed colloid degeneration, the character of the tumorous texture having disappeared. It seems that this colloid change is characteristic for the mode of cell-metamorphosis after irradiation. Fig. 271 shows the tumourous area in adenocarcinoma of the breast before irradiation, while Fig. 272 demonstrates the same area after slight reaction had set in. In the latter colloid degeneration is beginning. A resemblance to glandular structure is shown. In most parts the alveoli are completely filled with epithelial cells, so that in some places they appear like alveolar carcinoma. Some areas have undergone degeneration, their epithelial cells not taking on the stain the same as others. The cells have diminished in size, and the degenerated area, except the nuclei, appears coarsely granular. Changes of the same nature are observed in the epithelium of the skin covering the tumour (also due to the action of the rays). In some parts of the necrotic area a large amount of dense connective tissue and marked vascularity are noticed.

In the treatment of the skin diseases described above, tentative exposures, and protection of the vicinity of the affected area were

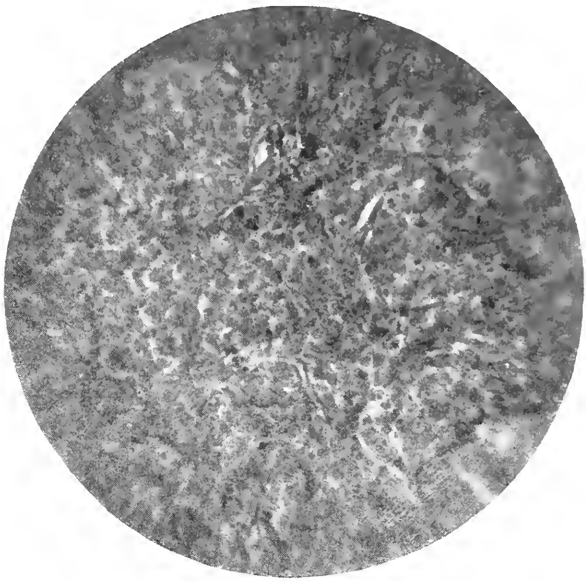

Fig. 271.—Carcinomatous Area, not affected by the Rays. (Compare Fig 272.)

advised. The distance of the tube was not less than 4 inches in the beginning, the duration ten minutes, and the intervals two to three days on an average.

In treating malignant diseases we should be governed by entirely different principles. The author has emphasized repeatedly that nothing appears more absurd than protecting the area which demands the influence of a sort of destroying agent. Since Volkmann found, on microscopical examination, that even in small and superficially located carcinomatous growths of the mammary gland, the fascia was generally involved, he was naturally led to the conclusion that removal of the tumour alone was an insufficient procedure. The correctness of his investigations was corroborated by Heidenhain, who found carcinomatous cells in the superficial layer of the pectoralis major muscle, even when the breast was only superficially involved. From these observations we learned that, at least, the superficial layer of the pectoralis major muscle

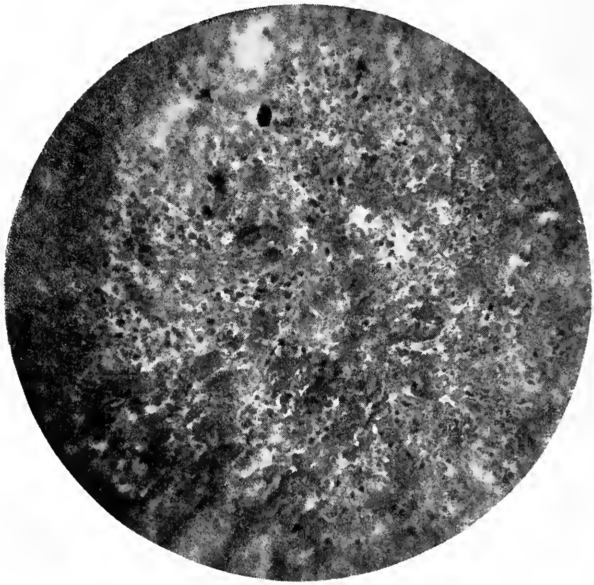

Fig. 272.—Carcinomatous Area after Irradiation, Showing Colloid Degeneration. (Compare Fig. 271.)

should be dissected away in all cases, when the carcinomatous nodule was but of small size.

It did not take long for the conclusions of Volkmann and Heidenhain to bear rich fruits. The surgeons who followed Volkmann's example were soon able to report cases which showed no signs of recurrence until after more than a year. Kuester, Senn, Halsted, Weir, Meyer, and the author (Medical Society of the County of New York, November, 1892) advised still more radical steps, with more or less modification of the original method.

The motto "Better too much than too little" must be adhered to in malignant disease, as emphasized in the author's previous publications. It is better, therefore, to suffer from slight functional disturbances after sacrificing the whole pectoralis major and minor muscles than to attain a good functional result followed by speedy recurrence.

Even if a limited area is involved only, as in the case illustrated by Fig. 275, a most extensive removal is required.

Now, if we are convinced of the fact that, even when there is only a small carcinomatous nodule in the mammary gland, the superficial layer of the pectoralis major muscle contains, or may contain, carcinoma cells, why restrict ourselves then, if we attempt to treat a nodule of this kind by the Röntgen rays? Is it not exactly the contrary of what we wish to achieve, if we then prevent distant carcinoma cells from being reached by covering the vicinity with some impermeable metal? We want to reach *all* carcinoma cells if we can, and the so-called shield does not shield the patient, but the carcinoma cells. Therefore, shields off in malignant disease! If we have made up our mind to influence the carcinoma cells, we must employ sufficient energy to enforce this result.

This does not imply, however, that the other extreme should be striven for. We must follow our therapeutic strategy in a determined but carefully observant manner. The practical *modus operandi* is, therefore, about the following:

The patient suffering from malignant disease is irradiated without first submitting to tentative exposures. The tube should be as near the tumorous area as possible, the distance of the tubal wall from the skin never exceeding 2 inches.

This is done for the purpose of influencing the growth itself as powerfully as possible. After there is a slight erythematous reaction, within the immediate vicinity of the growth, the distance is increased for the following *séance*. Thus the rays reach a larger surface. In mammary carcinoma, for instance, the area between the sternum and axilla must be fully exposed. When this wider field becomes erythematous also, the irradiation must be stopped for a few days until it shows signs of disappearance. It is not advisable to wait until the last little sign of dermatitis has vanished, because much valuable time may be lost by waiting. Repeated attacks of dermatitis may thus be endured.

It seems to the author that the further the carcinomatous infiltration has extended, the more resistance to dermatitis exists, and consequently the less reaction takes place, the cell-metamorphosis lowering the irritability of the skin. This non-susceptibility, of course, varies with the different types of malignancy. It seems to be greatest in the fibrous variety of carcinoma.

In severe cases and when there is little reaction the author's diaphragm may be used in order to concentrate the rays on the tumorous area. (Fig. 25.)

If there be extensive ulceration, causing retention of pus, irradiation should not be continued until the area is exposed fully, and any necrotic tissue removed by the scalpel or sharp spoon. If this is omitted, the power of the rays is not only inhibited, but at the same time, toxæmia from local decomposition is added to cachexia, a very dangerous association, indeed.

If the integument is concerned, soft tubes must be employed, but deeper infiltration requires tubes of medium hardness. It is obvious that for very deep-seated growths hard tubes should be employed, in view of their greater penetration power. But the rays do not in their present capacity possess so much force in the deeper tissues of the body as to induce a complete regressive metamorphosis.

The author does not maintain that the production of dermatitis in the treatment of malignant disease is desirable or a *conditio sine qua non.* But, with our present means, he regards powerful and long irradiation a necessity, and this, unfortunately, entails the provocation of the dermatitis.

The author's experience shows that whenever a dermatitis has appeared the size of the growth has diminished, œdema and pain have decreased, and the general condition of the patient has improved.

In spite of extensive dermatitis, which causes a most distressing burning and itching sensation, all patients suffering from malignant disease were anxious to undergo irradiation again as soon as possible. If the *raison d'être* is thoroughly explained to the patients, they will certainly not make their physicians responsible for excessive burns. A patient afflicted with carcinoma, especially if it is inoperable, has indeed nothing to lose, and can well afford the risk of being burned. Will he act like the boy who threw rotten eggs at the man who pulled him out of the water and saved him from drowning, because in doing so he had pulled out a lock of hair? And in any case the physician is a soldier and must do his duty unconcerned, whether he is applauded or insulted.

Of course, the purely cosmetic standpoint is entirely different. If dermatitis, as alluded to above, occurs in the face of a fair lady, who simply wanted to be treated for hypertrichosis, the cure proves to be worse than the disease.

As a rule a *séance* of ten minutes, repeated every second or third day, suffices. Extensive and deeper-seated growths should be irradiated daily for the same length of time, and if no intense reaction appears, for twenty minutes.

As soon as improvement is noted, the exposures should for a while be shorter and the intervals longer. Six weeks after recovery irradiation must be taken up again for a short period. The views of Volkmann and Heidenhain are strikingly illustrated by the observation of the two following cases:

FIG. 273.—EPITHELIOMA OF LOWER LID AND CANTHUS. (Compare Fig. 274)

Fig. 273 illustrates a patient of ninety-one years of age who suffered from epithelioma of the eyelid for four years. He was treated chemically, especially with caustics. No attempt at excision was ever made. The patient was greatly disturbed by the excruciating pain in and around the deep ulcer. All efforts to give relief proved to be failures until an attempt was made with the Röntgen rays. After the first exposure, which lasted five minutes, the pain was considerably lessened, and after the second exposure, two days thereafter, it disappeared entirely. No protection was given, except that the patient closed his eyes during the *séance*. Sometimes the distance of the tubal wall from the skin was not more than half an inch.

Although, after the nineteenth exposure, slight erythema developed, the *séances* were not stopped until, after the twenty-second, painful dermatitis showed over the face. Further irradiation was stopped then for two weeks, when all signs had disappeared. The remainder of the ulcer was dusted with xeroform, which was also used in the intervals. After three more exposures the epithelioma had fully cicatrized (Fig. 274). At the same time an epithelioma showed its first signs at the lower lip. It is at present being treated with Röntgen light. The eye is in no way affected.

Fig. 274.—Case of Epithelioma, illustrated by Fig. 273, Cured by Irradiation.

It must be assumed that while the macroscopical evidence of carcinoma was concentrated upon the eyelid, the cells must have been spread around the lymph-vessels of the whole face, thus, finally, establishing a focus in the lower lip.

The case illustrated by Figs. 275 and 276 is analogous. It concerns a man of fifty years, whose epithelioma of the lower lip (Fig. 275) was cured, no signs of recurrence showing until eighteen months afterward. Then a small nodule appeared in the left submaxillary region, the removal of which was refused by the obstinate patient. No treatment of any kind was submitted to until the tumour reached the size illustrated by Fig. 276. It extended then from the genio-hyoglossus muscle up to the parotid gland. As could be ascertained by skiagraphy, as well as by subsequent resection, the bone showed slight erosion at its lower anterior border. The microscopical examination, made by Dr. R. H. Buxton, revealed the presence of a large number of cell nests in the epithelioma. An extensive operation consisting in the exsection of the left half of the mandible and removal of the parotid gland, the temporal, the masseter, and the sterno-cleido-mastoid muscles was done. Recovery was uninterrupted.

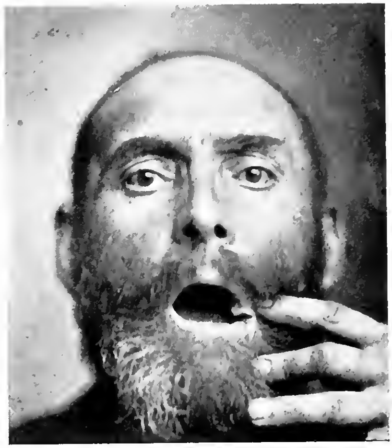

Fig. 275.—Epithelioma of Lower Lip. (Compare Fig. 276.)

Fig. 277 illustrates analogous conditions. The patient's breast was amputated by the author for fibrocarcinoma. Two years afterward a carcinomatous growth appeared in the inguinal region, while the area of mammary amputation remained normal.

From the observations of the case illustrated by Figs. 278 and 279 valuable information can be gained. At the time the patient was presented to the American Therapeutic Society, May 15, 1902, she was fifty-nine years old. She began to suffer from carcinoma of the breast ten years before. After having been operated upon ten times she enjoyed fairly good health (Fig. 278). The result of the author's first operation, performed in February, 1894, was illustrated in the Clinical Recorder, October, 1896 (Fig. 279).

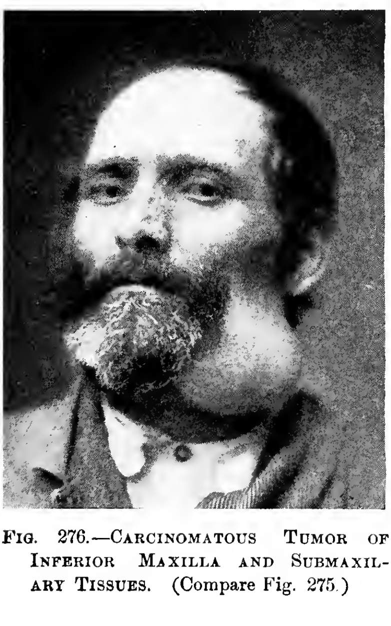

Fig. 276.—Carcinomatous Tumor of Inferior Maxilla and Submaxillary Tissues. (Compare Fig. 275.)

She had not asked medical advice until a year after the first signs had shown themselves. There was an extensive carcinomatous area then of the left breast, the axillary glands also being involved. The extensive destruction and the pain appealed to her at last. It is self-evident that under the circumstances the author had to perform a very extensive operation, not only removing the pectoralis major muscle, together with the axillary glands, but also exsecting so large an area of adjacent integument that a plastic operation had to be undertaken (see Fig. 279). Recovery was perfect until six months later, when a small nodule appeared at the anterior axillary fold. This was again extensively removed. Then a period of euphoria followed for a whole year. In September, 1896, a hard nodule originated near the sternum, which was also extirpated. Then there was no disturbance until June, 1897, when a small nodule appeared in the axilla, which was extirpated by Dr. F. Torek, to whom the author is indebted for the following report:

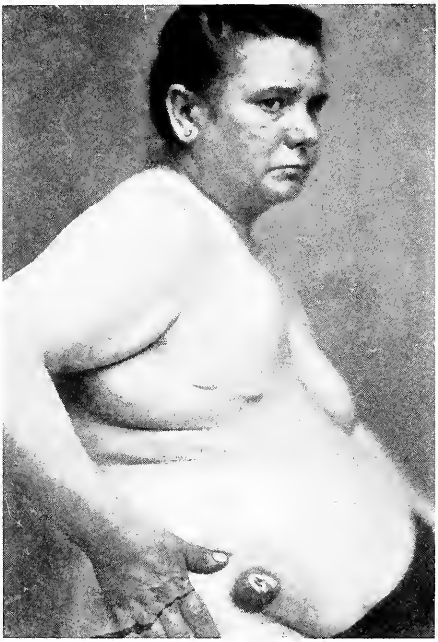

Fig. 277.—Carcinomatous Growth in the Inguinal Region, two years after Removal of Mammæ.

On August 7, 1897, there was a pain at the site of the past operation. No recurrence. March 7, 1898, recurrence in posterior axillary line; extirpation April 11, 1899; another recurrence, the tumour showing about 3 centimetres in diameter; ichthyol-vasogen treatment. On January 16, 1900, the immovable tumour has grown to the size of 8 to 9 centimetres in diameter. Dissection of axillary artery and ligation of the axillary vein. Microscopical examination by Prof. Henry J. Brooks; carcinoma, with much fibrous tissue. February 14th, wound perfectly healed. February 14, 1901, another recurrence in axilla, tumour being about the size of an egg. February 19th, operation. Discharged from hospital cured March 8th. August 21, 1901, another large node, probably starting from the stump of the pectoralis major muscle, is removed. Primary union. October 31, 1901, another operation is made in the pectoral region, and two nodules removed in the axillary region. January 13, 1902, another recurrence in the axilla of the size of a filbert; also one tumour below the clavicle, of the size of a walnut. A third neoplasm is observed in the left arm, in the former region of the pectoralis major muscle, and alongside the biceps muscle. None of the recurrent tumours is movable. Medication: Thyreoid extract. In view of this enormous extent of the growths, the arm also being extremely œdematous, a tenth operation seemed to be inopportune, therefore the Röntgen therapy was considered now.

Still, it seemed to be more preferable to extirpate the tumourous portions, as far as it was possible, before resorting to irradiation. The author succeeded in removing the whole biceps muscle, and a part of the axillary region.

FIG. 278.—CARCINOMA MAMMÆ AFTER OPERATION FOR NINTH RECURRENCE. (Compare Fig. 279.)

The infraclavicular tumour could not be removed in its entirety. The patient left St. Mark's Hospital eleven days afterward. The general condition had remarkably improved after ten irradiations, each one lasting about thirty minutes. The infiltration below the clavicle and along the triceps muscle, as well as the œdema, did not disappear until extensive dermatitis of the first degree had set in.

In spite of its imperfect recovery, this case must be regarded a triumph of surgery. Ten years have now elapsed since the first sign of carcinoma was observed, and nearly eight years since the first operation, which was performed under the most unfavourable circumstances, due to the patient's own procrastination. The patient still appears well.

The author expects no recovery, but believes that under the Röntgen treatment her condition will, at least temporarily, improve further.

Another case, also presented to the Therapeutic Society, may be mentioned in view of a few interesting peculiarities. It was one of adenocarcinoma of the breast, recurring three months after the most skilful removal.

FIG. 279.—CASE OF CARCINOMA MAMMAE AFTER FIRST OPERATION. (Compare Fig. 278.)

Within another three months a large infiltrated mass, reaching from the sternum to the axilla, had formed. The supraclavicular region, the shoulder, and the whole upper extremity of that side were œdematous to the utmost degree. Near the sternum a small ulcerating area was noticed. The patient suffered temporary pain of great intensity. The husband was told then that there was hardly a possible chance even of improvement, but he urged the author to try irradiation nevertheless. The whole area was exposed, first at intervals, and then every day, for an average of twenty minutes. There were sixteen exposures altogether before the presentation. After the fourteenth exposure the infiltrated area began to shrink and the œdema disappeared entirely. The recurring growth had reached the pleura, as was evident from the presence of pleuritic effusion, which was aspirated. A specimen taken from the irradiated area showed colloid degeneration, the adenoid character having disappeared. This seems to some extent to show the mode of cell-metamorphosis which the cells undergo after irradiation. (Compare section on Pysiological Effects.)

FIG. 280.—RECURRENT CARCINOMA MAMMÆ. (Compare Fig. 281.)

The patient was at the time of presentation free from pain and her appetite had increased. A few days later the superficial layers around the ulcerating area shed themselves as scabs.

Even in this desperate case the temporary influence of the rays was well marked. The patient after a long period of euphoria succumbed to pleuropneumonia three months later. The author's observation suggests that irradiation should be begun as soon as union is perfect after the removal of the neoplasm, and should be kept up for a period of several weeks.

FIG. 281.—CASE ILLUSTRATED BY FIG. 280, RECOVERING.

Another case, presented to the American Therapeutic Society, is that of an unmarried lady of forty-seven years who noticed a small nodule in her left breast in June, 1896, which caused slight pain. In October of the same year she consulted a reputed clinician, who advised immediate *amputatio mammæ.* But she procrastinated until December 21, 1897, when she submitted to extensive operation. Recovery was speedy, and it was not until August, 1898, when recurrence took place near the sternum. In November of the same year a second extirpation was successfully performed. Another recurrence took place March, 1900, but no operation was attempted then, the treatment consisting especially in local application of antiseptics and in the administration of Fowler's solution. On March 17th the author saw the patient for the first time. Then there was a large hard mass of the size of a fist, covering the manubrium sterni and a large ulcerated area in the left mammary region (see Fig. 280). Considerable œdema was also present. After twenty-four irradiations, which on the average lasted twenty minutes at each time, the large mass above

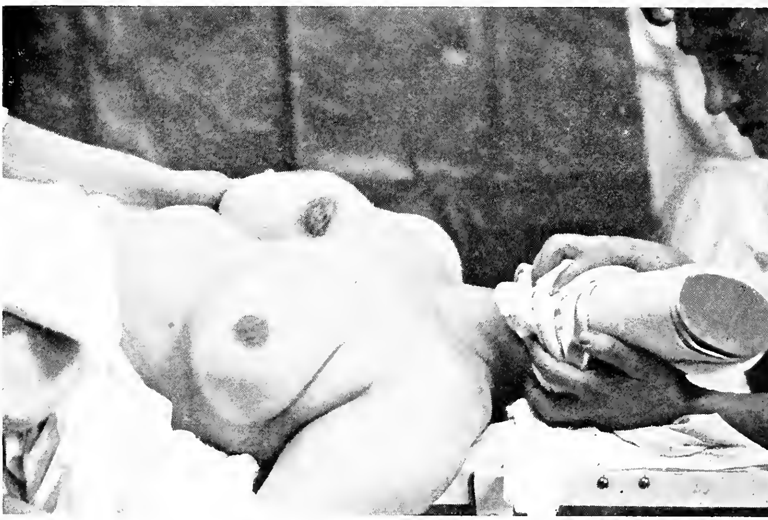

Fig. 282.—Fibrocarcinoma Mammæ, a year after its onset.

the sternum shrank almost entirely and much of the ulcerations cicatrized. The œdema disappeared completely (Fig. 281).

After an interval of three months slight recurrence took place. Irradiation was done again for ten minutes each time. After the seventeenth *séance* dermatitis set in, so that the treatment was stopped. This case is still under observation.

Fig. 282 illustrates the case of a woman of forty-five years who did not submit to operation until a year after the onset of the disease. Recurrence took place four months after thorough removal. Partial extirpation was performed again, and frequent irradiation was done until intense reaction took place. After the reaction was over, the patient improved considerably. A second recurrence took place six months after the partial extirpation, to which the patient succumbed.

As to further statistics, reference is made to the author's previous publications, New York Medical Journal, May 24, 1902, Review of Reviews, August, 1902, and Medical Record, February 14, 1903.

FIG. 283. — RECURRENCE OF CARCINOMA MAMMÆ.

As emphasized above, the Röntgen rays should not be substituted for the surgical treatment of carcinoma. It should not even be tried, because a carcinomatous area if often irradiated becomes degenerated, and when operation is submitted to then union by first intention is not obtained. Excessive hæmorrhage may also occur in the metamorphosed tissues.

It should also be kept in mind that partial operations, which in former years were regarded unscientific, are indicated if the after-treatment is carried on by irradiation. In deep-seated carcinoma an attempt should be made to remove as much as possible of the outer portion in order to enable the rays to get better access to the deeper-seated strata. For this end it is sometimes even advisable not to unite the wound margins, but to keep them open and separated, so that the rays do not need to penetrate the overlying tissues first, but attack the diseased area directly.

Ordinarily prophylactic irradiation should be begun as soon as union of the wound is obtained, and continued until slight reaction shows itself.

Fig. 283 illustrates the case of a woman of twenty-eight years, whose small mammary tumour was thought to be an adenoma, whereupon extirpation was performed. Three months thereafter recurrence took place, but no surgical steps were undertaken. When the author saw the case, the tumour, which proved to be of a carcinomatous nature, had gone beyond the possibilities of surgical technique. Irradiation was tried therefore, which improved the condition remarkably. At the present writing there is only a small cancerous area, and the general health of the patient is good.

Fig. 284.—Infraclavicular Carcinoma in a Woman of Seventy Years.

Fig. 284 illustrates an inoperable carcinomatous tumour of the infraclavicular region in a woman of seventy years. In cases of this kind the Röntgen-ray treatment must at least be tried in a palliative sense.

Fig. 285 shows carcinoma of the skull in a woman of sixty-eight years, which was extensively extirpated by the author. Recurrence took place two years afterward.

In Fig. 286 adenocarcinoma developing after the removal of an old suppurating sebaceous cyst is recognised. After thorough extirpation of the growth, irradiation was done prophylactically. No recurrence was observed two years thereafter.

The same observation was made in a man of forty-five years, whose large epithelioma of the lower lip (Fig. 287) was thoroughly removed a year after its onset, the patient having treated himself by ointments. Irradiation was taken up at once, recurrence having been observed.

In the case of a lady of sixty-seven years, suffering from carcinoma of the vaginal introitus (Fig. 288), the same good result was observed after the combined treatment—viz., extirpation followed by irradiation.

Fig. 285.—Carcinoma of Skull.

SARCOMA

It was the privilege of the author to show the first case of sarcoma successfully treated by the Röntgen method. In view of the good results obtained in

Fig. 286.—Carcinoma Developing from an old Sebaceous Cyst.

Fig. 287.—Epithelioma of Lower Lip.

the treatment of carcinoma, it was obvious to think of giving the rays a trial in sarcoma. The first patient, presented to the German Medical Society of New York City on May 6, 1901 (Muenchener medicinische Wochenschrift, No. 32), suffered from melanosarcoma. He was a strongly built cooper of thirty-six years. He remembered that for fifteen years he had observed a small black speck (mole?) at the region of his external malleolus. About one year ago it assumed the appearance of a common verruca. A continuous increase of size was observed then. In November, 1900, the "verruca" became sensitive and the surface began to excoriate. Carbolic-acid baths were now prescribed by the patient himself, and faithfully used, until, about

Fig. 288.—Carcinoma of Vaginal Introitus in a Woman of Sixty-seven Years.

Fig. 289.—Melanosarcoma.

Christmas, the growth had reached the size of an apple. It was not until then that the patient became afraid and consulted his family physician, who referred him to the author's department at St. Mark's Hospital.

On December 24, 1900, the author found the following state present: The strongly built patient shows a healthy appearance. He admits being a free drinker. The family history is good. At the region of his left external malleolus a tumour of the size of an apple is noticeable (Fig. 289). Its consistence is moderately hard, its surface of a smoky gray colour, and it seems to have originated from the confluence of small warts. It cannot be dislodged from its base. The inguinal region contains a gland of the size of a walnut.

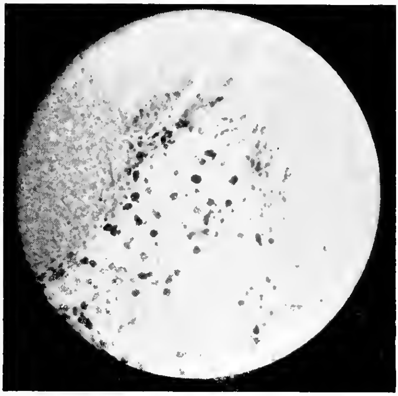

FIG. 290.—SPECIMEN OF CASE OF MELANOSARCOMA ILLUSTRATED BY FIG. 289.

At first the diagnosis of lymphosarcoma was made, and amputation considered accordingly, but the patient refused to submit to it. His family also being adverse to such a radical step, the author contented himself with extirpation of the tumour and of the inguinal gland. The apparently healthy periosteum of the external malleolus was removed, together with the neoplasm. Recovery being perfect in a week the patient left the hospital.

FIG. 291.—MELANOSARCOMA. (Compare Figs. 289 and 290.)

Microscopical examination of the growth revealed the presence of pigment, which proved that we had to deal with melanosarcoma, the most malignant type of sarcoma (Figs. 290 and 291).

The patient returned to the hospital six weeks afterward. The same tumour showed at the outer malleolus again, but it was somewhat broader and flattened. Its margin was encircled by a few bluish-black nodules, of the size of a pea, which could be compared to hæmorrhoidal nodules. A glandular convolution of the size of a goose's egg had developed in the inguinal region in the meantime. Extirpation was performed again. The patient withdrew from treatment two weeks afterward, his excuse being that he felt perfectly well again. Four weeks thereafter he presented himself again with a relapse. This time there were about thirty dark bluish-black grape-like nodules of various size. The largest nodules bled easily on touch. The inguinal region showed a tumour of the size of the head of a new-born child. On the inner surface of the leg, especially alongside the inner border-line of the calf, several dozens of nodules had originated, which resembled those of the tumour itself closely. Their size varied between that of the head of a pin and that of a cherry. Extirpation was done once more. The microscopical examination of the removed portion, made by Dr. H. Kreuder, showed well-developed large sarcoma cells. The pigment is chiefly seen in the form of streaks, but by higher magnification it can be recognised as fine granules which are contained in cells in the connective-tissue framework of the tumour. In some places they

Fig. 292.—Appearance after Seventh Irradiation. (Compare Figs. 289, 290 and 291.)

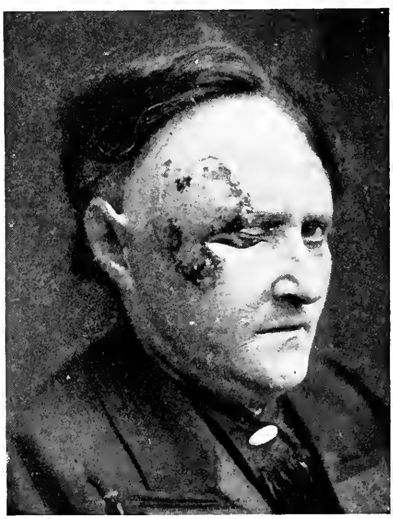

Fig. 293. — Osteosarcoma of Orbit showing Necrotic Röntgen-Ray Burn.

resemble a netting. Few cells in the alveoli of the sarcoma cells are pigmented. But some portions of the section, especially the necrotic areas, show a great amount of pigment. One of the specimens was coloured with hæmatoxylin and eosine, and a second with Van Gieson's fluid.

The patient would now have submitted to amputation, but considering metastasis, the prospects of such operation at this late stage would not have appeared promising. Serum treatment was now considered first. Although the author himself so far did not experience much benefit in a fairly large number of his malignant cases, he still regards its use indicated in such desperate cases. But at the same time the thought of Röntgotherapy suggested itself.

Fig. 294.—Osteosarcoma illustrated by Fig. 293, one year later.

Without entertaining audacious hopes irradiation of the defect left after the last extirpation was begun. The time of exposure was at first ten, then twenty and thirty, with moderate light, and at last once even forty-five minutes. While the exposure lasted forty-five minutes the patient felt an itching sensation over the whole leg, which lasted for several hours after the *séance*. Up to the time of presentation irradiation had been done seven times. After six weeks there was not only no trace of relapse, but a number of the metastatic nodules of the calf, especially those near the area of irradiation disappeared, while others have shrunk (Fig. 292).

The inguinal tumour became larger during the time of this treatment.

Three weeks after the demonstration the defect at the outer aspect of the malleolus had cicatrized perfectly. After three months no recurrence had been observed. The inguinal tumour was removed on the day after the demonstration as intended, and now the inguinal area was also irradiated every second day for ten minutes. Two weeks after the removal a derma-

Fig. 295.—Skiagraph of Case illustrated by Figs. 293 and 294.

titis set in, which prevented further irradiation. The patient succumbed suddenly to metastasis of the lungs. The disease had reached a stage in which final recovery could hardly be expected, and it is to be regretted that the thought of the Röntgotherapy did not suggest itself to the author at an earlier stage, as treatment might then have effected a local cure before metastasis could have taken place. But the course proved the efficiency of the rays, because the fact cannot be denied that, in great contrast to the former course, after the preceding extirpation no relapse was observed. The fact that well-developed sarcomatous tissue shrank and cicatrized is also beyond doubt.

FIG. 296.—GLIOMA.

Similar experience was gained in the case of a lady of forty-two years, who showed the signs of sarcoma of the orbit in the fall of 1901. Enucleation of the eyeball had to be undertaken, but recurrence in the frontal bone took place three months thereafter, and reached such an extent that it was regarded inoperable.

After having ascertained the extent of the growth by a skiagraph the author removed the diseased bone portions. Three weeks thereafter, when cicatrization had taken place, irradiation was begun three times a week, exposing ten minutes each time. No change during two months' treatment was observed. But when irradiation was stopped for three weeks, the signs of recurrence showed up again, the vicinity of the orbit projecting far. Now irradiation was resorted to every day at small distance, low vacuum and high current being chosen. After eleven exposures extensive dermatitis developed, which proved to be of ulcerative type, within the centre of the irradiated area. At the same time complete alopecia at the diseased side set in (Fig. 293). The patient suffered considerably for a week, then the symptoms gradually subsided. The treatment consisted in the application of Burow's solution at first, and in the use of xeroform gauze later. Three weeks after the beginning of the vehement dermatitis all signs of the sarcomatous infiltration had disappeared, especially the projection, and the general condition of the patient improved remarkably. There is, in fact, no abnormality noted at present. This state of euphoria has continued up to the present time.

Fig. 294 shows the normal condition of the patient a year afterward. The skiagraph indicates the removed bone portions (Fig. 295). Alopecia is still well marked (Demonstrated to the Surgical Section of the New York Academy of Medicine, March meeting, 1903). Whether it will continue indefinitely is at least doubtful; nevertheless, the entire disappearance of the recurrent growth is to be regarded as a most important fact. (At the present writing the patient still enjoys perfect health.)

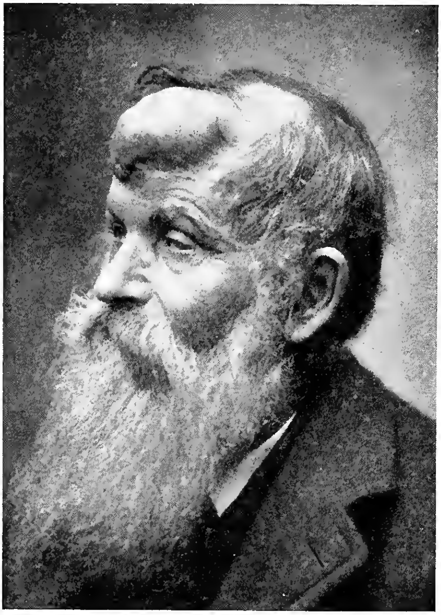

FIG. 297.—OSTEOSARCOMA OF SKULL. (Compare Figs. 299 and 300.)

Fig. 296 represents a counterpart to this case. It illustrates a glioma, which necessitated enucleation of the eyeball in a girl of two years. Even in this desperate case great temporary improvement at a late stage was observed.

Fig. 297 illustrates osteosarcoma of the skull in a man of sixty-six years. A skiagraph obtained then showed arrosion of the frontal bone. Extensive extirpation was performed by the author at St. Mark's Hospital. Microscopical examination proved it to be a round-cell sarcoma of the ordinary type (Fig. 298). After removal there was an immense defect which was filled by flaps taken from the vicinity. The process of cicatrization occupied two months. Then irradiation was done for a month at intervals of three days. The patient did very well for two years. Then a small nodule showed in one of the scars which had formed by cicatrization. After a few weeks a second one formed (Fig. 299). It was only then that the patient presented himself again to the author. Irradiation was taken up at once, the intervals being short and the exposures long. After three weeks intense reaction set in, blisters forming within the area of cicatrization. At first warm Burow's solution was applied, a few days later xeroform gauze was used. Two weeks after the reaction had set in, the two large nodules had completely disappeared (Fig. 300). Four days after the onset of the dermatitis a piece was exsected from one of the irradiated nodules.

According to the laboratory report made by the courtesy of Dr. Henry Kreuder, this specimen showed the following changes: An abundance of fibrous connective tissue, which appears very dense and wavy, showing exceptionally few nuclei and being almost structureless. On first sight the sarcoma cells are scattered throughout this new connective tissue, and only in some places small

FIG. 298.—ROUND CELL SARCOMA.

areas of sarcoma cells can be encountered. Fig. 301 shows dense connective tissue with sarcoma cells scattered through it, also an area of myxomatous tissue changing into dense connective tissue.

Upon closer study one notices that on the surface of the tumour (epithelium wanting, Fig. 302) a very marked necrosis and an inflammatory process are going on, which does not take place only in the sarcomatous, but also in the newly formed dense connective tissue. This necrosis and inflammation are probably the result of the irradiation, which is so powerful as to cause a complete disintegration of the superficial tissue.

FIG. 299.—CASE ILLUSTRATED BY FIG. 297, TWO YEARS AFTER EXTIRPATION.

The deeper parts of the specimen (Fig. 303) do not show any areas of necrosis, but the formation of a great deal of myxomatous tissue everywhere in the growth, and this seems to be the origin of the dense fibrous connective tissue which is so abundant throughout the specimen. Fig. 301 shows this quite distinct. Besides the changes above one notices that the walls of the small blood-vessels have become thickened on account of the formation of connective tissue in the intima and media. The change in the vessel walls are not shown in the photographs.

The specimens were prepared by being fixed in a mixture of Müller's fluid and formalin, hardened in alcohol, and embedded in clove-oil celloidin.

The staining was done with alum-hæmatoxylin and eosin and picric-acid fuchsin and thionin.

Figs. 304–314 show various kinds of sarcoma treated after the same principles, all of them being operated. In most of them recurrence took place.

Fig. 304 shows round-celled sarcoma, originating from the superior maxilla, in a child of six months. Moderate irradiation of the operated area (Fig. 305) was begun a week after operation. Recurrence took place two months after extirpation. The patient died from metastasis.

Fig. 306 illustrates osteosarcoma of superior maxilla (spindle-celled) in a man of thirty-six years. Moderate irradiation was begun three weeks after operation. Recurrence took place nine months after the operation. The patient died from metastasis.

Fig. 307 shows a spindle-celled osteosarcoma, originating from the inferior maxilla, in a woman of sixty-two years. Moderate irradiation was begun two weeks after operation. Recurrence took place four months afterward, death being due to the erosion of the external carotid artery.

Figs. 308–313 illustrate cases in which no recurrence has taken place up to the present time, in all of them powerful irradiation having been employed. In all cases intense reaction took place.

Fig. 308 shows the round-celled sarcoma of a man of seventy years, which originated from the periosteum of the sternum and the second rib. A large defect remained after extirpation, which was partially covered by a plastic operation.

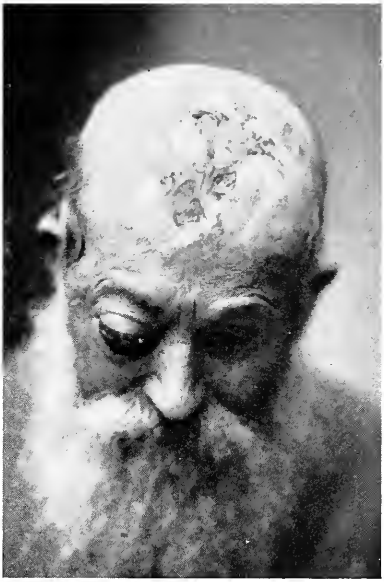

Fig. 300. — Recurrent Sarcoma of Skull, Treated by Irradiation. (Compare Figs 297 and 299.)

Fig. 309 illustrates the spindle-celled fibrosarcoma in the mamma of a woman of twenty-three years. Extensive removal was undertaken.

Fig. 310 shows round-celled sarcoma in the groin of a man of forty years. The operation was done in the same way as in the case illustrated by Fig. 289.

Fig. 311 indicates round-celled periosteal sarcoma, originating from the condylus femoris externus, in a man of thirty-three years. Amputation being refused, extirpation was undertaken. Irradiation was begun seven days after operation.

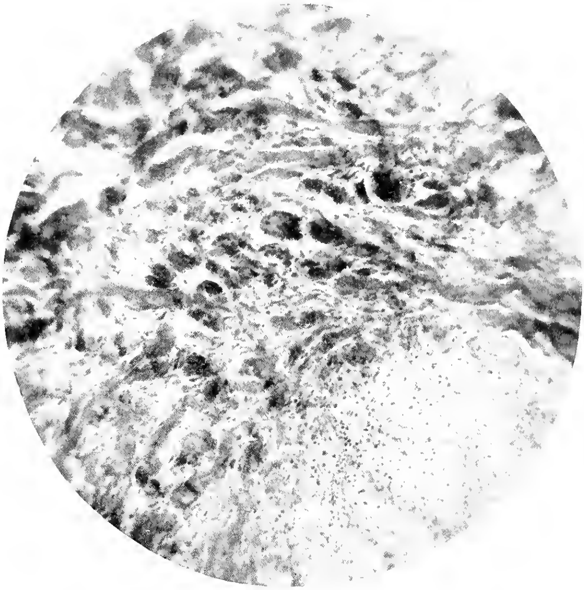

Fig. 301.—Sarcomatous Tissue after Irradiation.

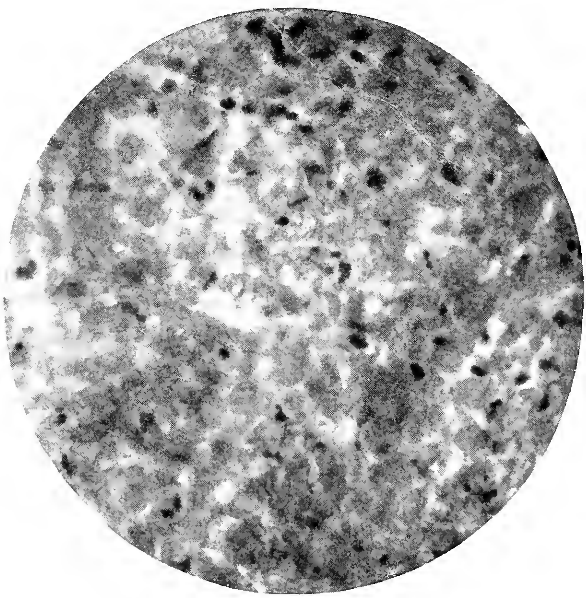

Fig. 302.—Sarcomatous Tissue after Irradiation (epithelium wanting).

Fig. 312 shows a case of the same nature in a man of sixty-four years.

Fig. 313 illustrates a round-celled sarcoma in the leg of a woman of fifty years.

Even in the deplorable case of a man of twenty-eight years, illustrated by Fig. 314, temporary improvement was obtained, the extensive œdema disappearing as soon as the ulcerated area cica-

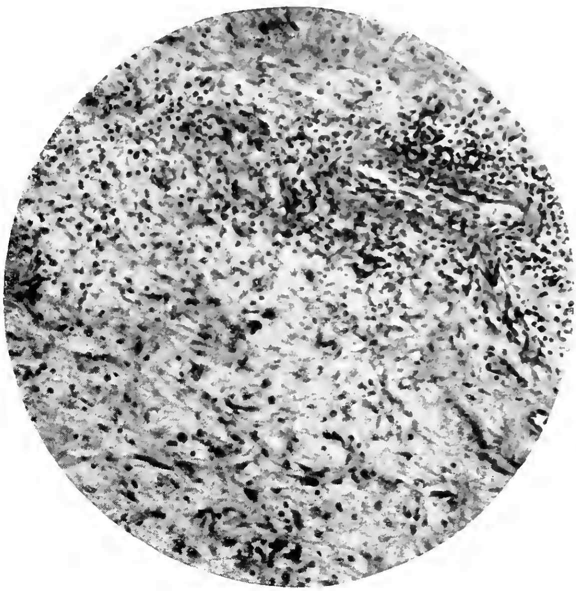

FIG. 303.—SARCOMATOUS TISSUE, DEEP STRATUM, AFTER IRRADIATION.

trized. The patient had previously submitted to extirpation, and succumbed four months afterward to the recurrence.

The statements of the author were corroborated later by the observation of Williams, Pusey, Coley, Morton, Allen, Skinner, and others. Even in deep-seated tumours an inhibitory action could be noticed.

The superficially located growths, of course, yield most readily to the Röntgen-ray therapy. Next to it tumours primary in the lymph-glands may be considered.

The observations of William P. Coley (Medical Record, March 21, 1903), to whom science is greatly indebted for his indefatiga-ble investigations in this important field, are noteworthy. He

Fig. 304.—Osteosarcoma Originating from Superior Maxilla. (Compare Fig. 305.)

treated 24 cases of the various types of sarcoma, among them were 17 round-celled, 3 spindle-celled, and 1 melanotic round-celled.

In 4 the variety was doubtful. Of the 3 cases of spindle-celled sarcoma, one, recurrent sarcoma of the superior maxilla, showed no improvement. A recurrent sarcoma of the chest wall, as well as a spindle-celled sarcoma of the chest, was still under treatment, with slight improvement. Another case, formerly under Coley's care, a spindle-celled sarcoma of the abdominal wall and pelvis, the size of an eight months' pregnant uterus, was treated for seven months by Skinner, with general improvement, but slight local diminution.

Of the 17 cases of round-celled sarcoma, all inoperable, four have disappeared entirely, yet in every case a recurrence has taken place in less than a year. In all of these cases the Röntgen-ray applications were made four times a week, and continued over a period of many months.

Among these was a very extensive recurrent round-celled sarcoma of the neck, both sides, superior and infraclavicular, pectoral, and axillary regions on one side and mediastinal glands. (The early history of this case is given in full in the Transactions of the

Fig. 305.—Case of Osteosarcoma of Superior Maxilla, illustrated by Fig. 304, after removal.

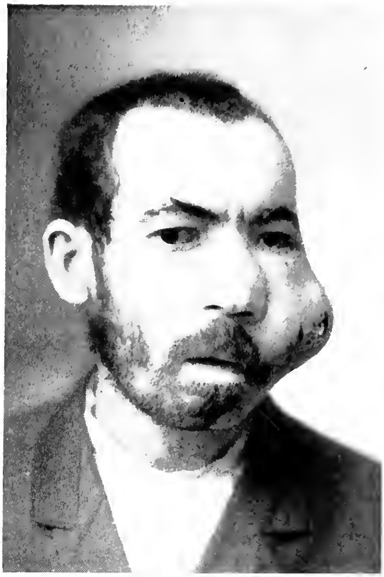

Fig. 306.—Osteosarcoma of Superior Maxilla.

Fig. 307.—Osteosarcoma Originating from Inferior Maxilla.

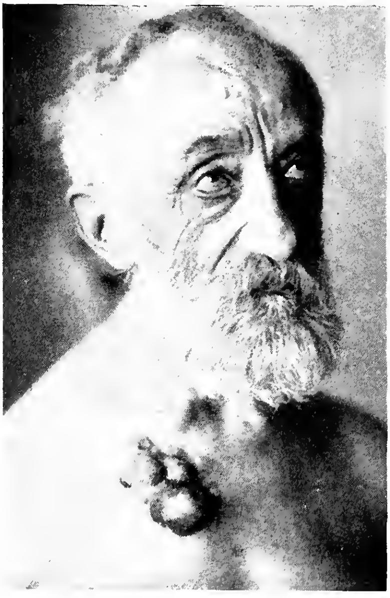

Fig. 308.—Sarcoma Originating from the Periosteum of the Sternum and the Second Rib.

Fig. 309.—Fibrosarcoma Mammæ in a Woman of Twenty-three Years.

American Surgical Association, 1902.) The patient, aged forty-five years, was confined to bed and in such a hopeless condition that she was not expected to live more than two months. The toxine treatment had been used and abandoned. On February 10th Coley began the Röntgen-ray treatment purely as an experiment. The improvement was more striking and rapid than in any other case that he had observed. The tumours steadily disappeared, and by July 1 there remained only a small nodule the size of an almond anterior to the sternomastoid muscle. This he removed under ether purely for pathological study, and the examination by Dr. George Biggs confirmed the original diagnosis. The patient had regained her normal strength, and went to the country for the summer. She returned on September 24th with a local recurrence the size of an English walnut in front of the ear in the lower portion of the parotid. Both groins were filled with multiple tumours, varying in size from a hen's egg to a pigeon's egg. In addition, there was an intra-abdominal tumour smooth, globular, fairly movable, apparently originating in the ascending colon or its mesentery. There was undoubted constriction of bowel at this point. Her condition again seemed hopeless, but Coley resumed the Röntgen-ray treatment, and in three weeks the nodule in the parotid region had entirely disappeared. At present the groin tumours have entirely disappeared, and the tumour in the abdomen has decreased about one-half. January 19, 1903, the abdominal tumour is steadily decreasing, and

Fig. 310.—Sarcoma of Groin in a Man of Forty Years.

Fig. 311.—Periosteal Sarcoma of External Condyle.

FIG. 312.—SARCOMA OF LEG SHOWING GANGRENE IN ITS CENTRE.

the patient's general health is good.

Coley's experience showed that in several cases of inoperable round-celled sarcoma in which his toxine-treatment had been tried and failed, the Röntgen-ray caused entire disappearance of the tumours. Yet all of these cases are of recent date, and in all there has been a speedy recurrence.

In a larger number of his cases of inoperable sarcoma, the tumours disappeared entirely under the toxines, and remained well from three to ten years after treatment. In all he had 20 patients with inoperable sarcoma remain well from two to ten years after the disappearance of the tumour under the mixed toxine treatment. Of these, 15 patients were well from five to ten years.

In observing the effect of the Röntgen ray upon 3 cases of spindle-celled sarcoma, it was found to be exceedingly slight. Yet just in this class of cases—the spindle-celled—the result of the toxine treatment has been by far the most satisfactory, nearly 50 per cent of the cases of inoperable, spindle-celled sarcoma having disappeared under the treatment in his own experience. In the round-celled variety, however, upon which the influence of the toxines is much less pronounced, the immediate results from the Röntgen-ray treatment seem to have been best. In a very large inoperable round-celled sarcoma two-thirds of the growth had disappeared under the toxine treatment, and at this point the Röntgen-ray was used in addition to the toxines with the result

FIG. 313. — PROLIFERATING SARCOMA OF LEG.

Fig. 314.—Periosteal Sarcoma of Leg.

that the entire tumour disappeared three months later.

Coley concludes, therefore, that in deep-seated and inaccessible growths the results from the toxines will probably prove better than from the Röntgen-rays.

The author agrees with Coley that there is no objection to using both methods of treatment at the same time, and that there is reason to believe that the combined treatment will give better results than either used alone. There are a larger number of cases of inoperable sarcoma treated either with the Röntgen-ray or the toxines, in which inhibitory action is almost, but not quite, sufficient to check the growth, and it seems but reasonable to suppose that the combined action of the Röntgen-rays and toxines might be sufficient not only to check the growth, but to cause it to disappear.

The principles as well as the technique of this treatment are the same as described for carcinoma (see foregoing sections). Just as in carcinoma, irradiation should not be substituted for operative treatment in operable tumours, and prophylactic irradiation should be begun as soon as union of the wound is obtained. It must also be continued until slight reaction shows itself.

Fig. 315.—Osteosarcoma of Frontal Bone and Orbits.

But in inoperable growths, like the case of a boy of eighteen years, illustrated by Fig. 315, the Röntgen rays are the therapy *par excellence*. The large extent of the round-celled sarcomatosis is indicated by skiagraphic examination.

HODGKIN'S DISEASE (PSEUDOLEUCÆMIA)

Hodgkin's disease bears a strong resemblance to sarcoma. Of the ætiology and essential pathology of this obscure affection very little is known yet. Its characteristics are an enlargement of the lymphatic glands, lymphatic tissues forming in internal organs like the lungs, the liver, kidneys, spleen, and intestines. As a rule the swelling begins in the glands of the neck, one side of which is soon filled up by a mass of glands. Probably the nature of Hodgkin's disease is infection, the specific effect of the alleged bacterium being caused by its predilection for lymphoid tissues. No permanent therapeutic results have been obtained so far, extirpation as well as administration of arsenic, bone-marrow, and toxine treatment having given only temporary benefit.

Irradiation tried recently has given much more satisfactory results. N. Senn (New York Medical Journal, April 18, 1903) reported two cases, in which a perfect cure was effected. One of the cases was that of a farmer of forty-five years whose glandular affections dated back a year. It had commenced in the cervical region almost simultaneously on both sides, and involved very extensively the glands of these localities as well as the axillary and inguinal region. As Senn stated, there was a macular eruption of the skin all over the chest, back, and abdomen. The increased respiratory movements and dulness over the anterior mediastinum indicated the extension of the disease to the bronchial and mediastinal glands. Spleen considerably enlarged. Liver dulness slightly increased. No tenderness over the junction of the gladiolus with the ensiform cartilage of the sternum or epiphyses of the long bones. He was anæmic, but not emaciated. The blood examination showed anæmia, but no abnormal blood-cells. At the examination, made at 11 A. M., the pulse was 78, respiration 22, and temperature 99° F. Senn prescribed arsenic and iron, and, in view of the heretofore hopelessness in such case, advised in addition the use of the Röntgen ray. The Röntgen therapy was referred to Dr. W. F. Buttermann, in charge of this department at the St. Joseph's Hospital. As this was the first case of pseudoleucæmia in the institution to be subjected to the Röntgen-ray treatment, Dr. Buttermann took the precaution to inform the patient that in all probability the treatment would result in more or less severe burns, owing to the fact that glands in the chest would make it necessary to resort to somewhat vigorous use of the rays. Patient received 34 treatments as follows: Right side of neck one minute, left side of neck one minute, neck from before backward one minute, each axilla one minute, neck from behind forward one minute, each groin one minute, spleen one minute. Daily sitting for the first ten days; 60 volts 8 ampères were used each day; distance of tube from surface 12 inches, a medium vacuum tube being used. The treatment was commenced on March 29, 1902. On April 7th, after ten treatments had been given, the glands had undergone a noticeable reduction in size. At this time the patient made complaint of an intense itching all over the chest and a uniform redness made its appearance over the chest and axillary regions. The voltage and ampèrage were reduced to 42 and 6 respectively. After the next six treatments the voltage was again reduced to 28, ampèrage remaining the same. April 15th: The itching became so severe that it kept the patient awake all night. The skin of the chest blistered. The skin of the neck, naturally very dark, turned dark brown. A 5-per-cent boric-acid-vaseline ointment, applied twice a day, relieved the itching.

From April 16th to 23d the exposures were limited to the neck, back, and groins, as the chest and axillæ were the seat of quite an extensive burn. April 24th: All of the glands subjected to the Röntgen-ray treatment have nearly disappeared. The face and part of scalp exposed to action of the Röntgen-ray are devoid of hair. Axillary and pubic hair has also disappeared. Skin of neck dark brown and blistered. The skin of the chest from the neck down to about 4 inches below the nipples exfoliated in several places. The nipples were very sore, discharging pus. The treatment was suspended, and the patient discharged from the hospital with instructions to continue the use of the salve and internal medicine. Two weeks later he returned to the hospital for more medicine, and expressed himself as feeling well. His appetite was good, and he was able to attend to his duties. No enlarged glands could be discovered. No elevation of temperature. Breathing much improved. The dermatitis had improved. He returned a second time on August 1st, as he had recently noticed a slight enlargement of the cervical and axillary glands. He is feeling well, and is able to attend to all of his business. Dermatitis has disappeared. Return of hair growth. Patient received daily ten treatments, 28 volts 6 ampères; each group of glands was exposed for two minutes at a distance of 12 inches; tube the same as before. The glands disappeared promptly. No return has taken place since, the patient being in perfect health, with the exception of a joint affection, which has no connection whatever with the pseudoleucæmic process.

Senn maintains that there could be but very little doubt that the constitutional disturbances which followed the prolonged use of the Röntgen-ray in his second case, and which set in simultaneously with the progressive diminution in the size of the glands, were due to a toxæmia caused by the absorption of the products of degeneration of the pseudoleucæmic product. This toxic condition unquestionably was likewise the cause of the increased enlargement of the spleen noted after the second series of applications. This patient has been heard from very recently, and it is believed that there are no indications of the return of the disease, and he is considered in perfect health.

The eminent success attained in these two cases by the use of the Röntgen ray can leave no further doubt of the powerful influence of the Röntgen therapy in the treatment of Hodgkin's disease. Williams also reported 3 cases, which improved greatly under irradiation, only recently.

RHEUMATISM

Sokolow (Wratsch, 1897, No. 46) reported 4 cases of acute rheumatism in children with astonishing results. The patients, after being protected with woollen clothes, were irradiated for ten to twenty minutes. In one of the patients, a girl of nine years, the pain and swelling in the wrists, fingers, and knees disappeared after the second *séance*. The distance of the tube amounted to 15 inches. After each irradiation the mobility of the joints was increased.

Fig. 316.—Tuberculosis of Thumb.

Fig. 317.—Adenoma of Tongue.

TUBERCULOSIS

Southgate Leigh, reported by Werner (Fortschritte auf dem Gebiete der Röntgenstrahlen, Band iii, Heft 3), observed the cure of tuberculosis of the elbow. The exposures lasted two hours, and were reported two or three times a week. The total length of the period of irradiation was twelve hours. Then the swelling had disappeared and no relapse occurred. The time of observation was eighteen months at the date of the report.

Kirmisson (Société de chirurgie, February 2, 1890) reported a case of tuberculosis of the wrist, which was much benefited by 65 daily *séances,* each one lasting ten minutes. The cure became perfect under Bier's compression-treatment. Similar results were reported by Bazy, Lancaster, Sainton, and Escherich.

In pulmonary tuberculosis good results are claimed by Rendu and Du Castel, Bergonié and Mongour, Sinapius, Chanteloube, Descamps, and Rouilliés, Destot and Dubard. Sinapius (Die Heilung der Lungentuberculose durch Röntgenstrahlen, Leipzig, 1897) claimed that he obtained a number of excellent results. In seems, however, that the diagnosis was not thoroughly established in these cases, therefore the deductions have to be taken *cum grano salis.* In tuberculosis of the larynx the prospects of irradiation seem to be more promising.

The influence of the Röntgen-rays was tried experimentally by the author in the case of a boy of ten years, who suffered from tuberculosis of the thumb (Fig. 316). Although there was intense irradiation, the improvement was only slight. Irradiation in combination with injections of iodoform glycerine seem to give the best results, as was also shown in this case.

FIG. 318.—MALIGNANT LYMPHOMA.

Lymphoma has also been treated successfully by the Röntgen method. The author, however, advises irradiation after removal. Considerable influence is also observed in adenomatous conditions (see Fig. 317). The same applies to the treatment of *malignant lymphoma.* In the case of a woman of twenty-five years suffering from this disease (Fig. 318) improvement was obtained by irradiation.

NEURALGIA

The value of the Röntgen-rays as an analgesic has been demonstrated in connection with the treatment of malignant growths.

Gocht (Fortschritte auf dem Gebiete der Röntgenstrahlen, Band i.) obtained prompt relief from trigeminal neuralgia after the second exposure. Freund observed similar results.

Stembo (Die Therapie der Gegenwart, 1900, No. 6) reported a permanent cure in 21 cases of neuralgia. Grunmach (Deutsche medicinische Wochenschrift, 1899, No. 37) claims that neuralgia of the face, occiput, and of the intercostal nerves disappeared.

In one of the author's cases slight relief was obtained. The patient, a man of forty years, suffered from infraorbital neuralgia. After extensive resection of the nerve the author observed a temporary cure. Nine months afterward the same pain recurred. Irradiation was tried now until reaction showed up. While the dermatitis lasted slight relief was obtained.

Fig. 319.—Noma after Scarlet Fever.

It seems that the electric irritation of the peripheric nerves inhibits their function, so that there is no sensation. Whether the disappearance of colicky pains observed in some of the author's cases of cholelithiasis was due to irradiation seems to be doubtful.

NOMA (CANCRUM ORIS)

Recently the author also tried to study the influence of the rays on noma (cancrum oris). Fig. 319 is an illustration of this horrible disease in a girl of six years. The gangrenous process followed a severe attack of scarlet fever. In spite of using the most radical means (exsection of the necrotic area, followed by use of Paquelin's cautery, antiseptic spray, necrotic foci formed again. It seemed that after strong irradiation the process was checked.

CHAPTER XX

BECQUEREL RAYS AND RADIUM

It appears quite natural that as the direct consequence of Röntgen's discovery other rays were detected. The *Becquerel rays*, for instance (discovered by Becquerel in 1896), may be regarded as Röntgen rays of small intensity.

Uranium was discovered by Klaproth, a German chemist, more than a hundred years ago. Peligot isolated the metallic uranium from the chloride in 1840.

Becquerel showed that especially uranium and its salts are capable of exciting fluorescent screens. Without being stimulated by any form of electricity, light, or heat, the Becquerel rays can be transmitted through wood, pasteboard, and even thin metal. They seem to be identical with the Röntgen rays in that they discharge electrified bodies, generate ozone in the atmosphere, are deflected by the magnet, and are capable of exerting chemical action.

The Becquerel rays have less penetrative power than the Röntgen rays, and also show poor contrasts; so that in their present shape they cannot be utilized for diagnostic purposes.

Uranium is found in very small amounts. It forms various minerals, the commonest of which is the uraninite, better known as Pitschblende, a compound oxide which also contains barium, iron, and other metals, and is found in Saxony, Bohemia, England, and Colorado.

In 1896 Professor Pierre Curie and Mrs. Curie, of Paris, succeeded in extracting the polonium from the uranium. Polonium shows greater radio-activity than the uranium, and penetrates aluminum to a much greater extent. The polonium rays can be deflected by a magnet and lose their power very rapidly. It is characteristic for uranium as well as for polonium that they cannot impart radio-activity.

Shortly after the discovery of polonium Mr. and Mrs. Curie gave the world the most mysterious substance called radium. This remarkable metal was isolated from the barium also found in the pitschblende. Mr. Curie regards the radium to be a new element. Of the polonium a sufficient quantity has not yet been obtained to give a spectrum, wherefore the proof as to whether it be a pure element is not brought yet.

Although the radium is called a metal it does, in fact, not exist in a metallic form, as it is generally secured as a bromide or a chloride.

The rays of radium are capable of reducing peroxide of iron, bichromate of potash, and the salts of silver in presence of organic substances. They furthermore colorize white paper, glass, and porcelain, change the greenish-yellow color of platino-cyanide of barium into a brownish variety, and transform white into red phosphorus. It was only natural to expect that they would likewise act on the silver gelatine-bromide of photographic plates.

So far the radium could be procured only from the pitschblende found in Saxony. The greatest obstacle to the practical utilization of the radium is its enormous price. This deplorable fact is well explained by the technical difficulties connected with its separation from the uranium residues. To produce only two pounds of the costly substance 8,000 tons of uranium residue are required.

The activity of radium as well as of polonium and actinium is a million times greater than that of uranium. It is most remarkable that the temperature of radium is always one and one-half centigrade over that of the surrounding atmosphere. Thus it may be calculated that one hundred small calories are set off by fifteen grains of radium per hour. There are various theories on the unknown source of this wonderful energy, but so far none of them has proved to be satisfactory, the most plausible one being that there is a property of capturing peculiar radiations which are covering the space continuously without being noticed by us.

Another marvelous property of radium is that its activity can be imparted to other substances which may retain this activity for varying periods of time. Curie reported that he could not go near to his electrometer to make measurements for hours after having been near radium. Geitel and Elster (Physikalische Zeit, II, p. 590) observed that a thin wire of any metal which was charged negatively from some source of a current became radio-active. The same applies to lightning-rods, leaves of trees, falling rain or snow, at least for a time.

It is natural that a substance which excels by such marvelous powers must also have some marked physiological effects. They made themselves severely felt when Becquerel carried some radium in his pocket and sustained a deep burn on his abdomen.

Danyoz and London found that mice were killed within four to five days by the influence of radium, even if this substance was kept at a distance. At first hyperæmia of the ears was observed; later on there was indifference to mechanical irritation, and finally coma and paralysis supervened. It seems that the function of the cerebral nervous system is disturbed first. Autopsy showed profuse hyperæmia of the subtegumental tissues and of the dura mater. The size of the spleen was greatly reduced.

FIG. 320.—SKIAGRAPH OF A KEY—BY BROMIDE OF RADIUM.

Another property of radium is that a tube containing two or three milligrams of this wonderful product held near one's temple causes the sensation of a flash of light. If held there for a few hours, dermatitis will be evoked. When applied to the nerve-centers, a paralyzing effect is produced. This may be so strong that it may kill organisms when inflicted upon them.

Two milligrams of radium inserted near the vertebræ of a mouse caused death in three hours by paralysis, according to Professor Curie. That the radium rays also possess bactericidal properties is evident from the experiments of W. Caspari, Asch, and Kinass, who observed that the cultures of the bacillus prodigiosus were destroyed in three hours.

Blind people experience a sensation of light as soon as radium is brought near the eyes.

M. Javal (Revue Internationale de l'électrotherapie et de la radiothérapie, November and December, 1902) finds that patients afflicted with glaucoma or corneal opacity are able to see radium well, while in case of blindness due to changes in the retina, no vision is obtained from it.

It was obvious to utilize the physiological properties of radium for therapeutic purposes. Undoubted success has been obtained in various diseases, especially in lupus, carcinoma, and sarcoma. Some investigators claim that the rays of the radium show even a greater therapeutic effect than the Röntgen rays, and that they reduced the extent of malignant growths in cases where the Röntgen rays had been tried in vain.

Fig. 321.—Skiagraph of Hand—by Bromide of Radium.

An undoubted advantage of the radium over the Röntgen rays is that it can be placed into mucous cavities, like the nose, œsophagus, stomach, uterus, urethra, etc. The small size of the tubes also permits of embedding them within the tumourous tissue through an opening made by puncture.

The radium treatment may also be tried in all cases in which irradiation by the Röntgen rays proved to be unsuccessful.

In regard to the diagnostic utilization of the radium rays it must, however, be said that while there is considerable permeation, the contrasts are poor. Another disadvantage is that it takes hours to represent an image.

Figs. 320 and 321, for instance, are skiagraphs made by the aid of radium. Fig. 320 (key) was taken with 30 milligrams of bromide of radium, the time of exposure lasting one hour. Fig. 321 (hand) is the result of six hours' exposure, 10 milligrams of bromide of radium only being used.

The intense illuminating effect of the radium is illustrated by the fact that a sufficient amount of it permits of microscopical examination in a dark room.

Radium must be kept free from moisture. It cannot be handled in a loose condition, and is therefore best kept in a sealed glass tube. While a higher degree of temperature increases the luminosity of radium, moisture reduces it considerably.

There are other radio-active substances which were separated from pitschblende, as for instance *thorium*, which stands next to radium as far as radio-activity is concerned, and *actinium*, a substance which possesses the characteristics of its associate, the thorium.

CHAPTER XXI

FINSEN METHOD AND ULTRA-VIOLET RAYS

The observations of Professor Niels R. Finsen, of Copenhagen, on "Concentrated chemical light rays in medicine," and especially the remarkable results he obtained in the treatment of lupus, startled the medical world. Since this preliminary report, published in December, 1896, the number of cases of lupus vulgaris subjected to his method by Finsen swelled up to 800.

Originally Finsen simply utilized the rays of the sun, employing the chemical or actinic rays only and excluding the caustic.

As is well known, a large quantity of the most effective radiation, *viz.*, that of the ultra-violet, becomes absorbed in passing the atmosphere. It is furthermore appreciated that the sun-rays cause radiant heat which must be filtered off. These difficulties Finsen tried to overcome by utilizing a solution of ammonio-sulphate of copper as a ray filter.

It soon became evident, however, that the chief result was produced just by these ultra-violet rays, which become absorbed to so large an extent in passing the atmosphere. Therefore Finsen selected the electric arc in place of the sun-rays, also substituting quartz as the transmitting medium. Between the quartz lenses a stream of running water served to absorb the heat-rays. Thus the intensity of the therapeutic effect was increased while the time of exposure was shortened.

The fact that the common arc-light gives off a much larger amount of ultra-violet rays than the sun was known before it was practically utilized. That it is still far surpassed by the condenser, was discovered only recently by Görl, of Nuremberg (see Zur Lichtbehandlung mit ultravioletten Strahlen, Muenchener Medicinische Wochenschrift, May 8, 1901), who made use of the actinic qualities of the condenser-spark by constructing the lamp which is now commonly known as the "Görl lamp."

Besides being actinic the ultra-violet rays are characterized by their power of fluorescence. Their effect on the integument of higher animals and their bactericidal properties are also well marked.

Finsen's important observation that anæmic tissues are permeated more readily by the ultra-violet rays than those in which normal blood circulation takes place induced him to advise compression of the integumental area, in order to render it as bloodless as possible (see also Bie, British Medical Journal, September 30, 1899. Thus a higher degree of translucency was obtained); and, the greater the transparency of the tissues is, the more powerful the therapeutic effect will be. It is well to remember, as shown in the division on the physiological effects of the Röntgen rays (p. 360), that the ultra-violet rays present inside of a Röntgen tube do not penetrate the glass, wherefore they need no practical consideration in the question of Röntgen irradiation. In other words, glass must be considered to be opaque, just like bones, paper, rubber, and ebonite, while substances like quartz, ice, grape-sugar, and pure polished rock-salt are transparent to the ultra-violet rays. Polished rock-salt is the most transparent substance of all, and consequently best fitted for the purpose of compression.

Görl very properly, therefore, utilized this substance for his lamp, which he attached with its condenser to the secondary terminals of a Ruhmkorff coil. This modus operandi simply consisted then in pressing the open end of the Görl lamp, which is fitted with a piece of rock-salt against the area to be treated.

While, with the ingenious apparatus of Finsen, as well as of Lortet and Genoud, a cooling medium is required in order to reduce the radiation of heat, by which the ultra-violet rays are always more or less intercepted, the Görl lamp, by virtue of its feeble radiation of heat, can be used as it is.

Piffard, who deserves credit for having called attention to the therapeutic properties of sun-light years ago, modified the Görl lamp in such a manner that its employment became extremely simple.

As alluded to before this method of treatment proved to be especially successful in lupus vulgaris. But also in lupus erythematodes and other superficial lesions of a benign as well as of a semi-malignant character; furthermore in its influence upon the vesicles of small-pox it also showed marked effects. This naturally brings up the question, what advantages the Röntgen ray therapy possesses over the method of Finsen. Of the physical nature of the latter we surely know more than of that of the first. We know that the ultra-violet rays are composed of the blue, violet, indigo, and ultra-violet portions of the spectrum, while the nature of the Roentgen rays is still X, that is unknown.

The ultra-violet rays, by virtue of the short length of their waves and by their high frequency, cause no sensation of light, like the Röntgen rays. Neither can the Röntgen rays be polarized or reflected and refracted like the ultra-violet light. As alluded to in the general part (p. 61) the opacity of the Röntgen rays depends upon the density or atomic weight of the objects, a factor which does not influence the penetration power of the ultra-violet rays. In proportion to the difference in the physical manifestations of the two kinds of light there is a marked dissimilarity in the character of the inflammatory and congestive reaction. In great contradistinction to the Röntgen light the ultra-violet rays cause but a slight hyperæmic condition, which disappears rapidly. It is furthermore a special feature of the ultra-violet rays, that these symptoms appear immediately after the exposure. Pigmentation may be produced, but no destruction of healthy tissue, especially no burns of the third degree as in Röntgen irradiation.

The fact that there is so little power of penetration shows that the ultra-violet rays can not be considered as effective means in the treatment of malignant growths.

In integumental affections of a cosmetic character the ultra-violet rays show an advantage over the Röntgen rays, because there is no fear of intense reaction. They may, therefore, also be substituted in such cases, where great vulnerability is shown under Röntgen ray treatment.

The firm pressure which is necessary to keep up anæmia of the irradiated skin-area is a most tiresome procedure, and it requires a great deal of patience to submit to many daily séances of an hour's duration.

All in all, this mode of treatment can not, ingenious as it is, in its present state, compete with the Röntgen method. Fig. 322 illustrates the modus operandi at the Finsen Institute in Copenhagen. The light is thrown through large telescopes and concentrated on the diseased areas which are compressed by nurses.

In this connection attention is called to the great credit due to Dr. William J. Morton, of New York City, who not only published the first book on the Röntgen rays in this country, but also called attention to the therapeutic properties of a form of electricity called "high frequency current" as early as 1881. This current is characterized by its alternating or oscillating at the rate of about one million times a second, and its powerful effect on metabolism. The principle of Morton was utilized and modified by d'Arsonval of Paris.

In the original Morton arrangement there is a spark gap of an inch, while in that of d'Arsonval one of about ten inches is used.

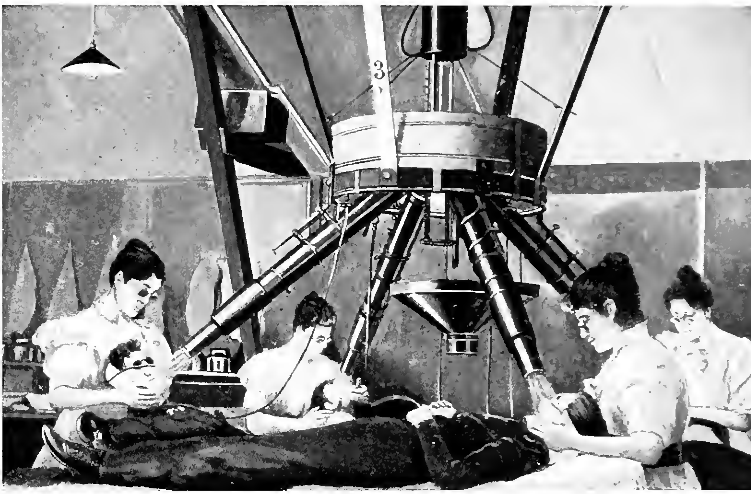

Fig. 322.—Irradiation by Finsen Light.

When the d'Arsonval current passes, the patient feels a vibrating sensation first and his hair stands out from the scalp. Then there is a feeling of exhilaration and increasing energy.

What changes the passing currents induce in the tissues is still unknown. Mysterious as the Röntgen rays and the radium are, their discovery meant only another new riddle, which may never be solved.

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