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INTRODUCTION

The preparation and trial of an action involving personal injury often presents quite a distressing problem to the general practitioner—he must deal with, examine and cross-examine practitioners of a complex science foreign to his own; he must be able to evaluate medical data as evidence; he must be able to glean knowledge from hospital charts, medical records and X-rays; all this when the very texts to which he turns for information are written in a language that is probably strange to him.

It is toward the lawyer's practical problem with respect to the trial and preparation of cases involving skull fractures that this article is directed, with the hope that it will provide to the reader a sufficient basic knowledge to enable a more confident approach to such cases.

The preparation and trial of a negligence action involving a head injury presents the following problems for primary consideration: is there or is there not a fracture present? If a fracture is present, is it accompanied by brain damage? If the fracture is excluded, are brain alterations nevertheless present? This paper is limited to a consideration of the first problem.

Although the X-ray as a method of investigation in head injuries is valuable, many limitations that tend to limit its usefulness are present which unless understood may lead to serious error. The following are some of the circumscribing factors: inadequate familiarity with the normal anatomical structures of the skull and brain and the shadows they cast; a superficial grasp of the healing periods in skull fractures; the presence on X-ray films of numerous confusing shadows which resemble fractures; the occasional great resemblance on X-ray films between fracture lines and normal skull shadows frequently making a differentiation between the two most difficult.

ANATOMY OF THE SKULL

The skull is composed of twenty-two distinct and separate bones, eight comprising the cranium (brain case), and fourteen, the face. The eight bones of the brain case are flat in form, bound to each other by fixed joints known as sutures. The borders of these bones are serrated or saw-like in appearance, the teeth of one fitting into the indentations of those contiguous to it. Thus, powerfully locked joints of considerable width are formed. Each flat bone is composed of three tables or layers: an outer layer (called the "outer table") of thick, dense, compact bone, to which the scalp is fixed, a

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layer of soft spongy bone between the outer and inner tables, traversed by thin-walled, inter-communicating veins, and an inner layer called the "inner table" of thick, dense, compact bone which is separated from the underlying brain by the coverings of the latter, called the meninges.

For descriptive purposes the cranium is divided into the vault, which is also called the dome or calvaria, and the base or bottom. The vault forms the top front-mid-back aspects of the skull and protects the brain beneath. The base of the cranium supports the brain and extends from the bones of the face in front, back to the upper end of the spinal column where the latter makes contact with the back of the head. It is exceedingly irregular, presenting numerous deep and superficial pits and elevations and large and small apertures. The deep depressions support the brain and the elevations provide sites for the attachment of the meninges. The apertures transmit the arteries, veins and nerves coursing to and from the brain. All these structures may cast confusing shadows which are frequently mistaken for fractures or which obscure those fractures that are present.

Middle and Inner Aspects of the Vault

The middle and inner aspects of the vault normally present numerous grooves, elevations and depressions which cast X-ray shadows, which also are often mistaken for fractures.

Diplöe. Within the soft, spongy middle table are numerous thin-walled intercommunicating veins, along the course of which are distributed small irregular lakes or pools of venous blood. The venous elements and the spongy bone together constitute the diplöe.

Meningeal Grooves. The coverings of the brain are composed of three membranous layers closely approximated to each other. Collectively they are known at the meninges. The outer layer, closely applied to the inner table, is the dura mater; immediately beneath the dura mater, is the arachnoid; directly below the latter and intimately adherent to the brain is the pia mater. Coursing within the dura are the meningeal arteries and veins which are housed in branched narrow, non-tapering and non-tortuous grooves. In addition, there is located within the top-mid aspect of the dura, a large venous channel.

Pacchionian Depressions. Small oval pits called the Pacchionian Depressions are located in the top-mid aspect of the vault, housing small, fleshy, oval meningeal projections. They vary in number and consistency. Their function is to discharge cerebro-spinal fluid into the large venous channel coursing in the dura mater over the top of the brain.

Convolutional Imprints. The upper aspect of the cerebrum, or brain proper, is composed of numerous coils or convolutions, finger-wide in diameter. Their pressure upon the inner surface of the vault produces finger-wide shallow imprints, which are seen more frequently in children than in adults and usually disappear between the ages of twelve and fifteen.

SHADOWGRAMS

The X-ray was discovered by Professor Roentgen in 1896. Unaware of the nature of these rays, he named them X-rays. Since these rays have the quality of penetration and cast shadows of what they penetrate upon a photographic film, they are also known as shadowgrams or roentgenograms. An X-ray representation is, therefore, a record of shadows cast by an object upon a photographic film. A photograph, unlike a shadowgram, is a relatively exact reproduction or copy of what the lens of a camera sees and transmits to the negative in the dark chamber. However, no lens or dark chamber is utilized in the taking of an X-ray.

Physics of the Shadowgram

X-rays, like light waves, are electromagnetic vibrations, differing from light waves only in the size of their wave lengths. Light waves vary from 400 to 700 millimicrons (1 micron equals 1 millionth of a millimeter). When they strike the eye, different visible color sensations are produced which are determined by the lengths of the light wave, as, for example, violet, blue, green, yellow, orange, red. The wave lengths of the X-ray vary from .01 to 3 millimicrons, which upon striking the eye produce no color sensations. They are thus said to be invisible. Like light rays, the rays of the X-ray travel in straight lines and affect a photographic film in the same manner. X-rays, however, have the additional quality of penetration. Their power of penetration is in proportion to the intensity or wave length of the rays and the density of the object through which they pass. Those that are blocked in their passage are converted into heat and are said to be absorbed.

The X-ray film is composed of celluloid, both sides of which are covered by a thin layer of gelatin impregnated with silver salts. When the film is exposed to the X-rays, chemical changes occur in the silver salts, producing a latent or invisible image, which after being immersed in the developing solution is converted into a manifest or visible image. The effect of the X-ray upon the silver salt is to convert it into a black metallic silver, rendering the film more or less opaque. The degree of opacity is determined by the amount of radiation acting upon the sensitive photographic film. After the developer has acted, the film is placed in a fixer (hypo). The fixer removes any of the silver salt unaffected by the X-ray, leaving fine particles of metallic silver suspended in the gelatin. The fixing process destroys the sensitivity of the film to light and makes the image permanent. When the X-ray is directed through an area of the body in which several contiguous structures of varying densities are present, the film is affected, according to the amount of X-rays actually reaching it; the denser the object, the less the penetration and the lighter the representation upon the film; the less dense the object, the greater the penetration and the darker the representation upon the film. X-ray representations, therefore, are studies in shadow variations determined by density variations; they are not photographic reproductions or copies.

Where reference is made to "greater density," it is implied that the shadow cast is lighter because of interference presented by the part X-rayed to the passage of the X-ray on its way to the film. The concept of "lesser density" indicates that the shadow is dark because there is less interruption to the passage of the X-ray. Thus, bone structures will appear lighter on an X-ray film than muscle tissue.

Necessary Exposures

In proper preparation of a head injury case, the following X-ray exposures of the skull should be made: one for each side of the skull (laterals); one over the front of the skull (frontal); one over the back of the skull (occipital); and one for the base of the skull.

Stereoscopic investigation, which is described below, should not be omitted, for it may very well reveal a fracture not detectable in ordinary exposures or exclude a shadow mistakenly interpreted as a fracture. A negative report unchecked by such a study might result in embarrassing error. The use of portable X-rays, on the other hand, should be avoided, if possible. Technical difficulties not encountered in the X-ray laboratory frequently tend to make such studies unsatisfactory.

Stereoscopic Films

When the eyes are focused upon an object, each eye receives the impression separately. The impressions thus received are conveyed to the brain, and there the two are fused into a single, three-dimensional perception. Thus, normal vision is said to be stereoscopic vision. The same principle is utilized in the production of stereoscopic X-rays. The films used and their development and fixation are the same as in the making of an ordinary X-ray except that two exposures of the part under investigation are made. The second film is taken after the X-ray tube is moved one and one-quarter inches to the side of the center of the object. After the films are developed and fixed they are placed in the viewing apparatus, one on each side of the examiner's head. The apparatus merges the two images into one and a perception of three-dimensional solidity results. In effect, the stereoscopic apparatus performs the function of brain-merging. The use of stereoscopic X-ray films in court has several disadvantages. First, the viewing apparatus can be used only by one person at a time; second, the apparatus is large and cumbersome and does not lend itself to easy transportation; third, considerable experience is necessary in operating the apparatus and visualizing the images. Even physicians inexperienced in its use, not to speak of laymen, would see little of significance when using the stereoscopic equipment.

A new method has recently been developed in which many people at the same time can see three-dimensional images. Images of the two films are projected upon a polarized screen. All those looking at the screen are provided with special polarized spectacles, and the image seen under such circumstances is stereoscopic.

With either method a minute analysis of anatomical relations in depth becomes possible. In all doubtful instances of fractures the study is invaluable.

Identification of Shadowgrams

The identification of the film should be permanent and ineradicable. Proper identification includes the name of the subject, the date when the plate was made, the number of the films and the initials of the radiographer. Letters and numbers impervious to the X-ray are placed on a corner of the film at the time it is exposed to the X-ray. After the film is developed and fixed these identifying marks will be permanent. The side of the body X-rayed should also be permanently marked on the plate by the letters R (right) and L (left). At times this is very important, for in double-coated films identification may be rendered impossible in the absence of such markings.

Problems of Technique

A proper technique in the actual taking of the film and in its development is essential. The further the object is from the plate and the closer the source of the X-ray to the object, the larger is the image. Thus, in the case of a fracture, a faulty location of the object or tube may cause the shadow representation to be grossly exaggerated. The part to be X-rayed must be properly centered so as to avoid improper angles which may obscure a fracture or cast shadows resembling a nonexistent fracture. In order to avoid such distortion, the object must be in direct line between the source of the X-ray and to the center of the film; the rays must be perpendicular to the film and the plane of the object. Even with the best of the techniques the shadows cast are always slightly magnified. Over-exposure or under-exposure may obliterate an existing fracture, or cast confusing shadows, called "artefacts." An insufficient number of exposures or the omission of stereoscopic studies may lead to errors. Negative lateral films without confirmation by stereoscopic views also frequently result in serious error. Failure to compare a suspected shadow with the corresponding opposite side is another failure in technique.

Legal Aspects

Admissibility of the Shadowgram. As has already been stated, the shadowgram portrays shadows cast by body structures. In and by itself, it has no diagnostic meaning and must be interpreted by one "learned in the art." They are not like photographs which speak for themselves. Although a photograph is the best evidence of what it portrays, the X-ray is meaningless to a layman or even to a physician untrained in the interpretation of X-rays. Unexplained by an expert they have no probative value and indeed may tend to mislead rather than aid. The opinion of the expert supplementing the X-ray record is the only evidence. Before the expert may interpret the film, it must be properly identified and authenticated. The following identification and authentication is sufficient to establish a foundation: (a) testimony by a physician that he was present when the film was taken; that he saw it taken and developed and that he examined the exposure immediately thereafter;[1] (b) where the physician does not personally make the film, but was present and directed its making;[2] (c) where a technician positively identifies the film by his own notations or markings thereon, the fact that he is unable to identify the subject does not render the identification insufficient.[3]

Identification, however, is insufficient where an attempt is made to do so by marks or notations not made by the witness and he is unable to identify the film as being that of the subject without relying upon the identifying markings.[4]

Persons Who May Interpret the Shadowgram. An X-ray technician generally is so adequately trained in anatomy, physiology, pathology, chemistry, physics and photography as to be able to take X-rays accurately, and he may testify to the conditions under which they were taken.[5] Ordinarily, however, he is not qualified to interpret them. There should be some proof, if he is to render an opinion on the X-ray, that he is qualified by training and experience to do so. This is equally true with respect to physicians, who must satisfy the court that they possess the specific learning and skill.[6] A license to practice medicine is only prima facie evidence of such specialized competency. If the witness is in fact qualified by training and experience, his opinion may be received, even though he is not licensed to practice medicine. The opinion of a non-professional expert, however, is received with great caution. Only if the court is fully satisfied with the expertness of the witness will his testimony be received.[7] Thus an X-ray technician testifying to causes and conditions as shown on a shadowgram without preliminary proof that he is an expert in the art of interpretation is legal error.[8] It is a matter of preliminary proof as to whether or not the witness is in fact an expert. The discretion of the court determines the competency of the witness to give an expert opinion. The disqualification of such a witness is not error unless such discretion is arbitrarily exercised.[9] The party calling the witness must establish the qualifications of the witness before he is examined. The question of competency should not be deferred to the cross examination.[10]

1. Marion v. B. G. Coon Construction Co., 216 N.Y. 178, 110 N.E. 444 (1915).
2. Arkansas Amusement Corp. v. Ward, 204 Ark. 130, 161 S.W.2d 178 (1942).
3. Beard v. Turritin, 173 Miss. 206, 161 So. 688 (1935).
4. Clark v. Reising, 341 Mo. 282, 107 S.W.2d 33 (1937).
5. Krauss v. Ballinger, 171 Ill. App. 534 (1912); Ehrenheim v. Yellow Cab Co., 239 Ill. App. 403 (1926); Covington v. Bowen, 191 Ky. 376, 230 S.W. 532 (1921).
6. Croley v. Huddleston, 301 Ky. 580, 192 N.W.2d 717 (1946).
7. Robertson v. Aetna Life Ins. Co. Inc., 37 Ga. App. 703, 141 S.E. 504 (1928); Whipple v. Goodchamp, 261 Mass. 40, 158 N.E. 270 (1927); see 3 WIGMORE, EVIDENCE § 795 (3d ed. 1940).
8. Saas v. Hindmarsh, 184 N.Y. Supp. 467 (Sup. Ct. 1920).
9. Pope v. Ryals, 232 Ala. 260, 167 So. 721 (1936); Liles v. Hannah Picket Mills, 197 N.C. 772, 150 S.E. 363 (1929).
10. Dolan v. Herring-Hall-Marvin Safe Co., 105 App. Div. 366, 94 N.Y. Supp. 241 (1st Dep't 1905).

Necessity for the Production of the Shadowgram. It is error to permit an expert to render an opinion over objection to matters shown in the X-ray without the introduction of the plate into evidence.[11] In view of this holding, it seems certain that a hospital record containing written interpretation of an X-ray would also be excluded. It should be noted with respect to this problem that no case in point has been found.

The admission into evidence of an improperly identified X-ray over objection, even if not shown to the jury, but which is referred to by the expert in his opinion, is error which is not cured by subsequent instructions to the jury to disregard the testimony relating thereto.[12]

Stereoscopic Shadowgrams. The limitations in the use of these films in court have already been discussed. In a Texas case[13] the court refused to allow stereoscopic films to be taken from court for the purpose of viewing them in a stereoscopic viewing apparatus, because the expert testified that the films could be adequately read in court without the use of the apparatus. Whether the Florida courts would permit such removal for study where the expert states that without such an opportunity he is unable to read them properly remains open, especially in light of the fact that recent developments in polarized viewing makes it possible to conduct a stereoscopic examination in court.

Prints. Prints of X-rays are made from the X-ray film in the same manner as a photograph is made from the photographic negative. In general, prints are not as accurate as the actual X-ray film itself. Therefore, it is not error for the court to exclude them upon objection. They may be admitted, however, where the proof establishes that the original cannot be produced and that the print is verified as being accurately made from the X-ray of the subject in question. Without such foundation the print is inadmissible.[14]

Shadowgrams as Models. The right to use and introduce maps, diagrams and models to illustrate and explain the testimony of witnesses is unquestioned.[15] X-rays are included under this rule. Where an X-ray is duly authenticated as a correct representation of a normal human part, it is admissible to aid the court in understanding in what respect the X-rays of the injured part show a deviation from the normal.[16] In fact it is error to exclude such films where it appears that without them the jury would get

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11. Gay v. United States, 118 F.2d 160 (7th Cir. 1941); Gursslin v. Helenboldt, 259 App. Div. 1064, 21 N.Y.S.2d 269 (4th Dept. 1940); Marion v. B. G. Coon Construction Co., *supra* note 1.

12. Walsh v. Frankenthaler, 186 App. Div. 62, 173 N.Y. Supp. 764 (1st Dep't 1919).

13. Hicks Rubber Co. v. Harper, 134 Tex. Civ. App. 89, 131 S.W.2d 749; *error dismissed*, 132 S.W.2d 579 (1939).

14. Beach v. Chollett, 31 Ohio App. 8, 166 N.E. 145 (1928).

15. State v. Knight, 43 Me. 11 (1857); see 3 WIGMORE, *op. cit. supra* note 7, § 791.

16. Bruce v. Western Pipe and Steel Co., 177 Cal. 25, 169 Pac. 660 (1917); McGrath v. Fash, 244 Mass. 327, 139 N.E. 303 (1923); Torelli v. Eastman Kodak Co., 260 App. Div. 553, 23 N.Y.S.2d 895 (4th Dep't 1940).

a false impression of the injuries in question, or where[17] the expert testifies that without such "model" films he is unable to properly demonstrate his opinion with respect to the X-rays of the person whose injuries are in issue.[18]

Normal Cranial Shadows

Many structures within the cranial bones normally cast shadows which are frequently mistaken for fractures. So too fracture lines may be confused for normal shadows.

Suture Shadows. After middle life sutures tend to become obliterated making their identification on the film troublesome and may at times be confused with fracture lines, for at times they appear as more or less whitish bands (increased density). This difficulty is not common, for the shadow cast consists of regular teeth-like shadows of considerable width, which rules out any confusion in diagnosis. When the interpretation is in doubt, an X-ray of the injured side is indicated for purposes of comparison or a stereoscopic investigation should be made.

Vascular Shadows. The vascular grooves and diplöe cast shadows which are often mistaken for fracture lines.

Groove Shadows. The channels housing the meningeal blood vessels cast shadows on the X-ray film. These nontortuous and nontapering channels may appear larger on one side of the skull than on the other, a finding by itself not indicative of an abnormality. With age the channels tend to become deeper and more distinct. The shadows cast by the grooves are frequently misinterpreted as fractures and fractures mistaken for grooves. The following characteristics differentiate one from the other: groove shadows are more hazy and light than fracture lines; grooves do not present evidence of splintering and irregularity which is so characteristic of fracure lines; grooves spread out fan-wise like the branches of a tree. Only occasionally are grooves as fine as fracture lines.

Fractures within a groove may be easily overlooked where only a flat (nonstereoscopic) plate is made. Under such circumstances repeated X-ray at periodic intervals may solve the problem. If subsequent X-rays reveal the shadow becoming lighter and more irregular, it is indicative of the fact that the healing process is under way, since the gradual lightening and increasing irregularity indicate a deposit of bone-rebuilding calcium. Such an observation is conclusive that the shadow is a fracture shadow and not a normal groove. Stereoscopic studies may also be helpful in this connection.

Diplöic Shadows. Diplöic shadows may be confused with grooves and fracture. These shadows appear as a network of somewhat dark indistinct panels. Their X-ray appearance differs from that of the grooves in that the latter are straighter and more sharply defined. The diplöic blood lakes or pools cast dark irregular shadows (1.5 mm. in diameter). They may be mistaken for depressed fractures. Diplöic X-ray representations are differ-

17. McIlwain v. Gaebe, 128 Ill. App. 209 (1906).
18. Virginian Ry. vs. Bell, 188 Va. 492, 87 S.E. 570 (1916).

entiated from fracture lines by the absence of splintering, by their greater width and by their greater indefiniteness and irregularity. Where the diplöic veins radiate from a common center in a stellate (starlike) form, there is danger that an erroneous interpretation of fracture will be made. Stereoscopic investigation is again indicated in aid of the solution of this problem.

Pacchionian Pits. Pacchionian pits cast darkish shadows simulating bony defects. They have at times been confused with shadows cast by depressed fractures.

Convolutional Shadows. Convolutional imprints on the inner aspect of the vault cast finger-wide shadows of increased density. If unusually marked and enlarged after 12-15 years of life, they may be indicative of increased intracranial pressure, provided there is also clinical evidence of brain pathology.

Bony Thickening Shadows. The skull bones are not uniform in thickness. Thus shadows of varying densities are cast. Frequently after middle life the inner table of the cranium, especially in its front third, exhibits bony thickenings. These are as a rule present on both sides of the skull. So too irregular indentations may be present. Such normal irregularities are not often confused with fractures.

Normal Intracranial Calcific Shadows

Normal brain structures, being soft, are permeable to the X-ray and therefore cast no shadows. However, at various stages of life structures within the brain become impregnated with lime. Such calcific formations, like bone, throw shadows which may be mistaken for fractures. The following discussion covers several of the principal structures so involved.

Pineal Gland Shadows. The pineal gland is a small, conical, reddish gray structure about 8 millimeters long, located in the mid-underpart of the brain. Its function has as yet not been determined. When this structure becomes impregnated with lime, the calcific shadow varies from the size of a dot to that of a hazel nut, appearing on the film singly or in groups of two or three. They are not caused by a fracture.

Choroid Plexus Shadows. The choroid plexus is a highly vascular, fringe-like body within the hollow interior of the brain. It manufactures cerebral spinal fluid. Frequently, after twenty-five years of age and occasionally earlier, clusters of lime are deposited within it. In stereoscopic views they have the appearance of an equilateral triangle.

Dura Mater Shadows. The outer covering of the brain after middle life is often the seat of a calcific deposition. The shadows cast may be round, oval or sickle-shaped.

Arterial Shadows. With advanced life, the walls of the arteries within the cranial contents may be the seat of lime impregnation. Under such circumstances whitish linear shadows, simulating fracture lines, may be noted.

Fractures of the Cranium

The general practice in medicine is to X-ray all skulls following a head injury, even if the trauma is apparently trivial, so as to eliminate any likelihood of overlooking fracture. The presence of a fracture and its extent is in no wise a measure of the presence of brain damage or its severity, for trifling fractures may cause profound intracranial alterations and extensive fractures may be relatively harmless. In evaluating the effects of a head injury with respect to partial or total temporary and partial or total permanent disability, the problem is to be determined, not by the nature and extent of the fracture, but rather by the nature and extent of the brain damage. An X-ray of a fracture taken months and even years after injury is of equal value to one taken immediately after the injury in determining the presence or absence of a fracture. This point is amplified in a subsequent section of this paper.

Fractures of the skull may involve the vault, the base or both. They may be simple (closed) or compound (open). A simple fracture is one in which no communication exists between the interior of the cranium and the outside air; a compound fracture implies the existence of such a communication.

Linear or Fissure (crack) Fractures. Both compound and simple fractures may be linear, depressed or comminuted from violence applied to the outside of the skull or a rupture of the middle ear. The presence of air within the skull is known as a traumatic pneumocoele. Ten to twenty days elapse before symptoms related to this disorder appear.

The terms linear and fissure fracture are synonymous terms. These fractures resemble a line. They occur mostly in the vault, two-thirds of them continuing into the base. Such fractures may be complete, in that the break in the bone passes through its entire thickness, i.e., the three bony tables, or incomplete, involving only one of the tables. The fracture line in the complete type may take a vertical, horizontal or oblique course. The fracture may be single or multiple, long or short. The incomplete variety may be of several kinds: the outer table may be intact and the inner one fractured (rare), or the outer one fractured and the inner one spared. Linear fractures without brain involvement are relatively harmless.

Shadowgrams. A linear fracture casts a black or dark linear shadow three to five millimeters in diameter. Its margins are sharp and clean cut; the course irregular; its terminal end tapers; and its origin is broad. The shadow line is black or dark because the X-rays coursing through the bone to the film below pass unimpeded between the crack. At times the shadow resembles a scratch on the film. Many such fractures on a lateral film are overlooked. Stereoscopic studies generally should not be omitted, especially in problem cases. Linear fractures frequently must be differentiated from normal suture lines or grooves. Stereoscopic studies may be the only means of establishing whether a fracture or a normal suture or groove is present. In fractures involving the inner or outer tables, dark lines of slight irregular density are cast. This appearance results from the fact that the X-ray succeeds in only partially penetrating the break.

Fissure fractures in the base of the skull are the most difficult to demonstrate. The bottom of the skull is highly irregular in outline, its unevenness being due to the presence of numerous grooves, elevations and depressions. All these cast shadows of varying sizes and shapes, causing a multitude of interlacing lines at all angles and planes. These may either obscure an existing fracture or create shadows which are mistaken for them. A negative finding without corroboration by a stereoscopic study is incomplete and even large fractures may be missed. Although the film may be negative as to fracture, this does not categorically exclude its presence if the examination of the patient reveals findings consistent with fracture.

Healing. The process of healing is recognized by the narrowing of the fracture and by a progressive loss of its clear definition due to the deposition of lime into the fracture defect. The younger the individual the more rapidly does the evidence of fracture disappear, provided the blood supply to the damaged bone remains adequate. In children, even when the fragments are widely separated from each other, the fracture line may disappear in four to twelve months; in adolescents about twelve months; in adults from eight to thirty-six months. In the latter when the fragments are widely separated, five years may elapse before fracture obliteration is indicated. In elderly people the fracture defect may never disappear.

Comminuted Fractures

Comminuted fractures are those in which the bone is splintered into many fine particles. Such fractures are limited mostly to the vault and are rarely found in the base. A fragment of the splintered bone is often depressed and encroaches upon the brain beneath. The existence of the depression and the extent of its downward displacement can, as a rule, be determined by stereoscopic examination. Manifestations of severe brain disturbance is often present in such cases, since a depression of .5 centimeters is sufficient to produce signs of brain compression.

Shadowgrams. These will be discussed under the heading of depressed fractures.

Healing. Comminuted fractures heal more slowly than linear cones. At times, for one of several reasons, they never unite. Interference with the blood supply, undue separation of the fragments, interposition of a portion of the underlying dura mater between the fragments are amongst the more prominent causes for retarded healing, or absolute failure to heal. In the young, when union takes place, repair is effected by the formation of new bone.

Depressed Fractures

A depressed fracture is one in which a fragment of bone is driven down towards the brain. The shape of the fragment and the depth of the depression varies. Depressed fractures are often compound. This condition is grave, since the danger of meningitis or brain abscess is ever present.

Shadowgrams. In depressed or comminuted fractures, where the fragments overlap each other, or where a fragment overlaps the contiguous unaffected bone, or where it is turned sidewise, whitish shadows of increased density are produced. The increased density results from the fact that the overlapping of the fragments doubles the thickness of the bone. Thus the passage of the X-ray is prevented from reaching the film. The area subjacent to the comminution is often relatively translucent due to the presence of air or blood beneath it.

Healing. The presence of air spread over the surface of the brain is revealed on the film by a dark shadow, oval or circular in appearance, and establishes a radiographic diagnosis of a compound fracture.

Depressed fractures which have not been surgically elevated may consolidate within one year leaving a rounded depression in the skull. The bone at the side of the depression is occasionally thickened and hardened. Where the blood supply is damaged, the fracture lines may never disappear.

Operative Defects

When a fragment of bone is driven down towards the brain there is danger of brain compression. When compression is present, the lifting or the removal of the compressing fragment is indicated. Various operative procedures are available.

Simple Decompression. In this operation the fragment is lifted into its original site or is removed. If it is removed, the resulting space is never filled in. Where a bone graft is implanted to eliminate the defect, the transplant may in some cases be successful if new bone forms over the graft. In other cases the graft fails as a result of its being absorbed. The X-ray appearance of the defect is a dark shadow clearly defined against the surrounding normal bone. Where the fragment is merely lifted into place, evidence of the fracture disappears in two to four years.

Bone Flaps. Here a large section of bone is cut through and flapped down. After the brain under this artificial window is examined and treated, the bone is replaced. In some instances where the blood supply to the flap has been damaged, the bony structure may disintegrate after several months; in others union takes place by the formation of fibrous tissue and not by bone. The outline of the bony window has been observed for as long as ten years after the operation.

Determination of the Age of Fractures

The age of a fracture may be of extreme importance in medico-legal problems. Old linear fractures are characterized by their indefiniteness and indistinctness resulting from the deposition of calcum during the process of healing. In depressed fractures thickening of bone adjacent to the site of the fracture is often present. The thickening is revealed on the film by a light shadow indicating increased bony density due to the deposition of lime during the process of healing. At times the margins of the bone adjacent to the fractured defect are thinned because of calcium absorption. Often such X-ray findings are interpreted as normal anatomical shadows.

CONCLUSION

A proper preparation for the trial of the X-ray phase of a negligence action involving a head injury is dependent upon a grasp of several phases of medicine as well as an awareness of the many limitations encountered in the interpretation of a film. This is particularly true with respect to the cross examination. The latter may proceed from two levels; one on a learned comprehension of the subject matter, with an objective of ascertaining the truth with a minimum of confusion; the other is to proceed upon an unwarranted assumption that expert witnesses are, as a class, untruthful and therefore the method of choice is to discredit them. The ultimate effect of the latter approach is a highly charged and disorderly cross examination leading only to confusion. As one meets students in the classroom and lawyers actually at work in the courts, the impression is gathered that the attack upon veracity is the method of choice. It seems that the cross examination of medical experts has deteriorated into maligning of professional character. Although it may be true that on occasion, medical witnesses have played fast and loose with their opinions, such conduct is by far the exception. It is quite understandable in light of the many limitations of the X-ray that respective experts would differ in their interpretations. Attorneys who proceed upon the premise that medical experts are in general untrustworthy might indeed by suspected of a rationalization covering their own intellectual sloth. A scientific curiosity and diligent preparation might dissipate such psychological attitudes and thus lead to an improvement of the standards of trial practice.