

THE EVOLUTION OF FRACTURE TREATMENT

ISIDORE COHN, B.S., M.D., F.A.C.S., New Orleans, Louisiana

THE evolution of fracture treatment has necessarily been a slow process. The story of fractures through the ages is a definite challenge to the industry and enthusiasm of the present and future generations. As we read yesterday's record preserved by faithful historians, we cannot help but marvel at the powers of observation which enabled the master surgeons of the past to diagnose and treat fractures without the aid of modern scientific adjuncts. One wonders at the temerity of surgeons prior to the introduction of anesthesia. How they were able to reduce deformity caused by fractures without the benefit of anesthesia, will always remain a tribute to the heroism of patients. How simple, in a way, this particular great gift has made the management of these cases is not appreciated by our generation.

From Hippocrates through Galen, de Chauliac, even down to the latter part of the nineteenth century, there were lengthy discussions about matters which today even a first year medical student would consider primary information. This information was not available to the greatest surgeons of the past; they had to depend on their knowledge of anatomy and of logic, and based on these alone we find great treatises written on the subject as to whether one position or another was better, or whether one splint or another was preferable. To the credit of the ancients we should say without hesitation, that many of the things which are being rediscovered today were utilized by our forefathers, if not entirely, certainly in principle, and in many instances they all but stumbled on the things which seem so important today.

"Hundreds of the profession have derived their celebrity from our general ignorance of the learning and attainments of Galen, by stripping the laurels from his honored brow, from which they unduly

From the Surgical Department, Touro Infirmary and Charity Hospital.

Fracture oration before the Clinical Congress of the American College of Surgeons, New York, October 17-21, 1938.

weaved a wreath to place around their own, altogether undeserving of it."¹

Each generation looking back at the history of the past speaks of itself as modern and the older generation as ancient. It is probable that the next generation will think in terms of ours with the same attitude as we look on those of the past. We trust that they will show as much respect for us as we must show to those who preceded us.

Our respect is due to Galen, de Chauliac, Paré, and a host of others who accomplished so much with the only means available, their powers of observation and anatomical knowledge. Their example should stimulate us to emulate them.

It becomes our duty to insist on a greater amount of practical application of the anatomical information which is available.

Our own generation should avoid making use of short cut methods and special gadgets.²

"The very facilities we possess are among the chief causes of our imperfection. Like the hero in the fable, we lie down in repose in full persuasion that the hours of indolence may be easily regained."²

It is our duty to teach fundamental principles, as principles alone should guide us in the management of fractures. We will discuss evolution in terms of principle and not in terms of particular apparatus or particular fractures. If we were to attempt to discuss evolution of the treatment of any one fracture, it would carry us too far afield. This discussion will be limited to principles which have to do with the diagnosis and treatment of fractures, bacteriological principles, x-ray, and industrial developments, which have done so much toward making our present methods possible.

Let us not think in terms of what a man calls himself, whether he calls himself a gen-

¹The writings of Hippocrates and Galen. Epitomized from the Latin and translated by John Redmond Cox. Published in Philadelphia, 1846.

²Magnuson, Paul. Fundamentals versus gadgets in the treatment of fractures. Fracture Oration. Delivered before the Clinical Congress of the American College of Surgeons, 1935.

eral surgeon, fracture surgeon, bone and joint surgeon, orthopedist, or what not. It is fundamentally important that the surgeon, who is best prepared to treat fractures, should treat the injuries of our race. They are those who have given of themselves and who are willing to continue to give service and time in order to study and prepare themselves to bring back the disabled individual to his normal capacity as quickly as possible. Names should be disregarded; a common cause—the individual who has been injured—is to be considered primarily. "Disown not your own offspring, yet be not disavowed by your progeny." This may well be the attitude of surgeons toward those of special groups who attempt to cast out the parent body. They have forgotten or do not know to whom they are indebted for the present high position of the surgeon in relation to fractures. If we were to think in terms of one of Shakespeare's great plays, the surgeon might be compared to King Lear, who provided for the offspring and then was cast aside as unfit. This seems to be the attitude of some branches of surgery today toward the general surgeon.

FRACTURE SURGERY

Let us consider surgery as the application of one's knowledge of anatomy for the relief or cure of a pathological condition. Let us remember, too, that today's axioms were mysteries beyond the horizon of yesterday. The horizon had enshrouded the x-ray, bacteriology, and anesthesia. Therefore, surgery could not progress. The evolution of knowledge had not reached out into the field so clearly defined for us today. Surgery of fractures had to stagnate.

With all of our good fortune have we attained the heights which we should have, or have we followed too closely the dictates of the past? Having defined surgery as the application of one's knowledge of anatomy for the relief or cure of a pathological state, we cannot help but think of surgery as manual in its conception. Fracture surgery is not different from other surgery. It is distinctly, not merely, the treatment of broken bones.

The treatment of fractures implies the utilization of the best knowledge of the sur-

geon, as well as the application of the minute knowledge of our forefathers of surgery. They passed from the degraded position of "barber surgeon," through the stage of consort to "sack-em-up men," until today they are the high priests of the suffering, the sculptors repairing the finest work of the Great Architect.

Who were the ancestors of the fracture surgeons of today? In this survey of the evolution of fracture treatment we have elected to begin with the writings of Guy de Chauliac. No matter where one attempts to make his initial investigation he will find literature of value antedating the entrance of his earliest hero on the scene. If we were to accept Hippocratic writings as a starting point, we would become disillusioned immediately. In an epitomy of Hippocrates and Galen, published in 1846, by Coxe, we find:

"We cannot in full force of the term admit, that the title of Father of Medicine is justly his due without encroaching on the rights of others; especially since it is incontestably proved by many that these treatises, we admire as his, have really emanated from other sources."

Hippocrates would not have claimed originality for himself:

"People rather admire what is new, and what is strange they prefer to what is obvious." (Hippocrates.)

As a warrant for electing to begin with de Chauliac, I quote from Desault:

"Celsus only copied Hippocrates, adding nothing to his mode of practice. No new method distinguished the surgery of the Arabians. It is necessary to come down to the time of de Chauliac before we meet with the method which is almost universally adopted at present."

What were the diagnostic signs by which the fathers of surgery recognized fractures, and what were the principles of treatment? de Chauliac taught:

"The signs of fracture are manifest to the senses. If the hand is placed on the region and touches the limb, it finds the part of the bone separated one from the other, and variable, and the figure of the limb abnormal. In palpating with the hand a crackling is heard in the bone, and pain when the spot is touched, and lack of power to sustain it in place."

Already the pioneer was teaching the value of inspection, palpation, manipulation, and

mensuration, the importance of pain, change in the axis of the limb, loss of function, abnormal mobility, and crepitus.

As one further reviews the literature he finds that he has to go down the ages to 1758, to the epoch-making work of Heister:

"It is no difficult matter to examine fractures of the bone:

"1. By the eye, when the injured part is apparently shorter than the sound, or when you see that the patient cannot make use of it.

"2. By the touch, when you perceive a preternatural inequality of the bone, or that it bends in a part where nature never intended it should; and here by the way, we must recommend it to surgeons, if it be possible to fix the patient immediately at the first searching of the fracture, where he is to lie during the course of the cure.

"3. By the ear, when we hear the ends of the broken bones crush against each other upon moving the limb."

In 1832, Sir Astley Cooper stated:

"Some of the symptoms of fractures are nearly conclusive. The crepitus, the change in the form of the limb, and the shortening of it, are circumstances communicating the most certain information."

America's own William Gibson, in 1832 believed:

"In general crepitation is more to be relied on than any other sign, and is an almost certain indication of fracture. Added to this there is usually more or less deformity, pain, swelling, inability to use or move the limbs."

Malgaigne, speaking for French surgeons in 1859, stated:

"The phenomena to which fractures give rise are crackling, heard by the patient at the time of the accident, pain, loss of power in the limb, contusion of the skin, swelling, or subsequent preternatural mobility at the seat of the injury, deformity from displacement of the fragments, and crepitation. If the finger be passed slowly and carefully over the whole length of the suspected bone, unless it has been subjected directly to external violence, the absence of all pain and pressure will prove its integrity; on the contrary, the existence of pain more or less severe at a circumscribed spot would afford strong presumption of a fracture. More than once from this sign alone, I have ventured to diagnose 'fracture.'"

This attitude on Malgaigne's part of recognizing the importance of localized pain is probably one of his greatest contributions. If that particular teaching were more generally

followed, there would be fewer patients treated today for so called sprains.

In 1866, Hastings Hamilton published his remarkable work, the first of its kind in the United States. From this the following is quoted:

"In proceeding to establish a diagnosis in any case, the surgeon should sit down quietly and patiently with the sufferer, so as to inspire in him from the first, the confidence that he is not to be hurt or at least not unnecessarily.

"He ought then to inquire of him minutely as to all the circumstances immediately relating to the accident, in order that he may determine as nearly as possible its cause, which alone to the experienced surgeon, often affords presumptive if not conclusive evidence as to the nature and precise point of the injury.

"From this, he should proceed to examine the disabled limb; removing the clothes with the utmost care, by cutting them away rather than by pulling, and when completely exposed, should notice with his eye, its position, its contour, the points of abrasion, discoloration, or of swelling, and not until he has exhausted all of these sources of information ought the surgeon resort to the harsher means of touch and manipulation.

"Nor will his sensations guide him to the point of fracture by any other methods so accurate as when, the patient being composed and his muscles at rest, he moves the fingers lightly along the surface of the limb, pressing here and there a little more firmly according as a trifling indentation or elevation may lead him to suspect this or that to be the point of fracture.

"The limb may now be measured with a tape line and compared with the opposite limb, having first marked with a soft pencil or with ink, the several points from which the measurements are to be made.

"Finally, if any doubt remains the limb must be firmly but steadily held while the necessary manipulations are performed for the purpose of ascertaining the existence of mobility and of crepitus."

Samuel D. Gross, or the elder, in 1882 stated:

"There are only 3 symptoms which are at all reliable evidence of existence of fractures, namely, crepitation, deformity, and preternatural mobility. The co-existence of these symptoms is unmistakably denotive of the nature of the accident. Too much stress cannot be placed upon preternatural mobility as a sign of fracture. Next to crepitation it is unquestionably the most important diagnostic symptom.

"The physiognomy, or general expression of the affected part, often affords valuable diagnostic aid. The deformity for example of the hand and wrist in fractures of the lower extremity of the radius, the eversion of the toes in intercapsular fractures of the

femur, and the shortened and retracted appearance of the arm in fractures of the humerus are generally unmistakable evidence of the nature of the accident. The manner in which the patient inclines his head and supports the elbow and forearm in fractures of the clavicle, is too significant to be overlooked by anyone who has ever witnessed it. The peculiar aspect and the attitude of the broken thigh, conjoined with the utter helplessness of the muscles, or the absence of voluntary power are signs which seldom admit of misinterpretation."

It is interesting to compare the careful inspection, palpation, mensuration, advocated by Heister, Cooper, Malgaigne, Desault, Hamilton in 1866, and Gross in 1882, with the hurried advice, "have an x-ray picture taken," so often heard today. These instructions might well serve as a summary of all that was known up to 1895. To our diagnostic armamentarium was added the x-ray in 1895 by William Roentgen.

A review of the literature from de Chauliac to the latter part of the nineteenth century, reveals several salient facts: (1) Diagnosis was based on clinical signs and symptoms, pain, loss of function, crepitus, abnormal mobility, and physiognomy of the part; (2) a knowledge of anatomy was depended upon; and (3) painstaking observations were made. At this point they were forced to stagnate. For nearly 600 years no progress could be made.

Like a beacon across a storm-tossed sea, the light of opportunity burst upon us with the advent of the x-ray. What were some of the results of the introduction of the x-ray? It no longer was necessary to resort to manipulation, for the purpose of eliciting abnormal mobility and crepitus to satisfy one's self that the injured individual had a fracture. In fact, it then became the duty of the teacher, to insist that the traditional crepitus and preternatural mobility should not be sought. Unfortunately, diagnostic acumen seems to have fallen to a low ebb. The surgeons trained before the advent of the x-ray merely used the x-ray as an adjunct and as an essential, added factor, and they trained their students to do likewise.

The powers of observation from which one could note the loss of active motion, the change in the attitude of the limb, plus local-

ized pain, obtained by light palpation, enabled the clinician to indicate nearly accurately where the fracture was and the x-ray was and is used by this group to confirm the diagnosis. For another group, who would take the "royal road," an x-ray is ordered immediately, and action taken on the result reported by the radiologist.

This innovation laid upon us certain obligations, obligations which I fear we have not altogether accepted. The x-ray provided us with a rapid means of diagnosis, but it also directed that we evaluate data not heretofore available; and it clearly indicated that all stored up knowledge gained by experience should not be cast aside. The new data consisted primarily of the visual image. It soon became evident that the visual image of bones varies with age. It became apparent at once to Poland, that a correct interpretation was needed of the appearance of epiphyses at all ages up to adult life so that the normal would not be mistaken for the abnormal. We soon learned that fractures through the epiphyseal lines could not be diagnosed by the x-ray in young children.

In the early part of the paper a statement was made that the ancients all but stumbled on some of the things which seem so important today. One of these has to do with the so called epiphyseal separations. In 1859 Malgaigne stated:

"I rank among fractures these lesions (epiphyseal separations), which some modern authors would consider as distinct from them."

According to Malgaigne, Bertrandi established by dissection the existence of so called separations of the epiphyses. Of course, he had no x-ray, therefore could only philosophize about the nature of the lesion, but he did say:

"When the solution of continuity is on a level and in the same direction with the epiphyseal cartilage the presumption is in favor of the decollation, but certainly can only be arrived at by an autopsy. Consequently aside from the complications the prognosis is the same as for the ordinary fracture near joints."

In 1866 Hastings Hamilton stated:

"Epiphyseal separations we shall not hesitate to class with fractures, and to submit them to the same rules of nomenclature."

The discussion still goes on. It is certainly to be hoped that in the near future we will recognize that all epiphyseal separations are in reality fractures. I believe we cannot escape this solution to the problem. We believe that the prophetic statement of the older surgeons on this point might well be adopted and that the term, "epiphyseal separation," be deleted from our surgical nomenclature.

It also became apparent that the hypothetical conditions, reverently spoken of as "sprains," were in most instances fractures. It is devoutly to be hoped that this antiquated term will soon cease to occupy the position of prominence which it does at present.

TREATMENT OF FRACTURES

When considering the principles involved in the treatment of fractures, one is confronted by a situation which is well summed up in the writings of John Bell, 1826:

"Ask a young man who has studied his profession faithfully what he would do with a fractured limb? He cannot tell. Ask the same question of one who has practised it well and sensibly. He cannot tell how he himself is accustomed to manage a fractured limb. He has no rule or settled methods. Ask the man of books and study what have been the doctrines of old, or what have been the actual improvements of the modern surgeon; he also is at a loss. Theories, bandages, machines, improvements, innumerable, he can well remember, but altogether with these recollections, this conviction always rests upon his mind, that the subject which he has long regarded as the most interesting is the only one which he has in vain endeavored to understand.

"There is no rule or principle yet established; this is almost the only department of practice which has been continually changing, without ever being improved."

In looking back over the literature we find much that we might quote from the masters of the past. Sound advice given by Hippocrates might well continue to be followed by those seeking to improve methods of treatment of fractures.

"Hippocrates tells us that medicine in all of its branches had been long established; that, they had found out the principle, and the route of discovery of many excellent things which would serve for the discovery of more, provided that those who undertook the task were fitted for it, and possessing a knowledge of what had already been done, would pursue a similar route."

de Chauliac taught the following:

"The general treatment of fractures follows the general intentions of wounds, and there are 4 principal intentions: The first is to equalize the bone; the second to preserve the equalized bone; the third to bind it with callus; the fourth to remedy complications. Before all things, one should prepare all that is necessary for the reduction. The necessary things are: Let one have a cradle or suspensory in which the limb will be firmly and evenly placed; a mattress bed on which the patient sleeps, and if it is necessary let it be perforated so that he may go to stool; a cord hanging over the bed or some other thing for him to catch and help himself when he wishes to go to stool or turn himself."

Here then are the fundamentals which were possible prior to anesthesia, asepsis, and the x-ray. When we would flatter ourselves about recent developments in the general management of fractures it should take no more than the above quoted statement of de Chauliac to humble us.

Sound advice, given by Heister in 1759 with reference to treatment of fractures, is the following:

"The surgeon's principal care in fractures is to unite the broken bones to which three things are necessary: (1) That the bone be restored to its natural situation; (2) that after the bone has recovered its natural situation, it may be kept there by giving it rest, and applying proper bandages; and (3) you are to use proper means to prevent or remedy the disorders that usually attend this accident. *The knowledge of anatomy is necessary to perform these intentions.*"

As early as 1805 Desault was pleading for the application of anatomical knowledge and physical principles in reduction of deformity and the maintenance of the reduction. He says:

"All kinds of apparatus for fractures being nothing but resistances opposed by art to the powers which produce displacement, it follows that they should all act in directions precisely opposed to the directions of these powers."

If more attention were paid at the present time to such fundamental anatomical and physical principles involved in this admonition, there would be less necessity for operative procedures in the treatment of fractures.

Sir Astley Cooper, speaking for the English professor in 1832, stated:

"The general treatment of fractures embraces three principal indications: The first is to reduce the pieces of bone into their natural situation. (Cooper favored immediate reduction.) The second is to secure and keep them in this state. And, the third is to prevent any unpleasant symptoms likely to arise and to relieve them when they have come on."

The interest and enthusiasm of the surgeons of that generation to obtain every available bit of information, so that they could improve themselves in the management of fractures, may be well appreciated by visiting the collections of specimens made by Cooper, Hunter, and others, to be found in the great museums of Great Britain.

Strange as it may seem, anatomical knowledge and surgical progress were inhibited by law. Stranger still is the fact that crime paved the way for the study of anatomy. Prior to the Warburton Act of 1832, which legalized the study of anatomy in England, the only subjects legally available for dissection were the bodies of criminals who were sentenced to be "dissected and anatomized." The teachers of anatomy at that time had to purchase bodies from "resurrectionists." These unscrupulous bands of grave snatchers carried their nefarious occupation farther and murder became an active business. One visiting Edinburgh today will see reminders of the activities of this band. The mort-safes in Gray Friars Cemetery bear mute testimony to the work of the "sack-em-up men." The life and usefulness of some of the great anatomists of that day were blasted by public indignation which was aroused by the proof of their association with the purveyors of human bodies. Nevertheless, the desire for knowledge and the hope of rendering service forced the courageous group of surgical-anatomists to continue their relations, with resurrectionists.

"Sir Astley Cooper's usefulness to the world was based on his profound knowledge of anatomy, and this was gained by the careful dissection of bodies, which were supplied him by the resurrectionists. Thus did the end justify the means."¹

The modern slogan, "Crime does not pay," was proved when Burke, Bishop, and Williams, were convicted and sentenced to death. Fol-

¹Ball, James Moore. Sack-Em-Up Men. Edinburgh: Oliver & Boyd, 1928.

lowing their execution, public sentiment was sufficiently aroused to permit the passage of the act legalizing anatomical study. An act, which was thought then as now by some as a desecration, has proved to be a consecrating link of the past with the present and future welfare of the human family.

Knowledge of anatomy substitutes safety for boldness and daring. Cooper like many of his contemporaries realized difficulties incident to the management of certain fractures and the utter hopelessness of obtaining good results in certain fractures. This spurred him on in his desire to obtain specimens for study. From a report by Sir Astley Cooper, "On Fractures of the Neck of the Humerus," the following is quoted:

"Let the surgeon do what he will, the head of the humerus will probably remain in the axilla, and the upper motions of the arm will be in a considerable degree lost."

Astley Cooper proved himself more than an anatomist, more than an operator; he was a true surgical philosopher. The advice contained in the following admonition should be heeded by all who believe in the dictum that we should be generous to others and critical of ourselves, for therein lies the attitude which should characterize the unselfish seeker of knowledge:

"These cases should teach the members of our profession to be kind, generous, and liberal toward each other, and not to impute to ignorance or inattention that which is the result of a generally incurable accident. It too often happens that when every trial has been made to restore the parts and without success, the patient goes to some other surgeon to whom he shows his arm, and points out its uselessness and want of motion. A jealous and illiberal medical man might say, 'Yes, this is a dislocation which has not been reduced. I wish I had seen it at the first, but now it is too late for a successful attempt to replace it.' However, every intelligent well informed surgeon will now confess that no knowledge or exertion of skill could have prevented the deformity and loss of the natural motion which results from this formidable accident."

This eloquent plea is not only the philosophy of a generous man, but it is almost like a crying aloud in the wilderness for more help in the diagnosis of fractures. Such came with the advent of the x-ray.

We pass from England to France, from 1832 to 1859. In the preface to his treatise on fractures, Malgaigne indicates that his work is the first treatise in the French language limited to the subject of fractures. Malgaigne fulfilled his aim of, "Presenting a résumé of all the doctrines and ideas maintained from the earliest time to our own days, 1859." In vain one searches for a change of method or principle.

A brief résumé of Malgaigne's teachings follows:

"The treatment of fractures consists, generally speaking in the fulfillment of two principal indications: To reduce the broken ends and to keep them in place until consolidation is complete.

"The proper time for attempting reduction is a question that has presented itself ever since the earliest time, and has been variously solved by practitioners. According to Hippocrates, 'extension should be attempted on the first or second day.' Boyer and Larrey advocated in general immediate reduction and Velpéau also advocated immediate reduction."

Malgaigne concludes:

"It is indeed the first day that is generally the most favorable."

Anesthesia is not mentioned under the heading of treatment; and the old discussion of when to reduce was revived. On that point Malgaigne was as definite as surgeons of our own day. In Hamilton's epoch-making *Treatise on Fractures*, in 1866, the first treatise limited to the subject in America, we find several noteworthy contributions. It is the first treatise in which anesthesia is advocated for diagnostic purposes, and for treatment. He says:

"I do not often find it necessary to resort to anesthetics for the purpose of insuring quietude and annihilating pain in making these examinations, but if the examination is not satisfactory, and the diagnosis is important, I do not hesitate to render the patient completely insensible."

Hamilton is definitely committed to the plan of immediate reduction:

"Nearly all fractures present 3 principal indications of treatment, namely: To restore the fragments to their place as completely as possible; to maintain them in place; and to prevent or control inflammation, spasms, and other accidents. It ought to be regarded as a rule, liable only to rare exceptions,

that broken bones should be restored to place as soon as possible after the occurrence of the accident."

His advice with reference to transportation of the injured may well be conceded as a forerunner to the instructions given by our transportation committee; namely, "Splint them where they lie," and "gentleness of handling."

Hamilton states:

"All that has been said in relation to the propriety of handling a broken limb gently when the surgeon is examining the position and character of the fracture, is equally applicable to the lifting and transporting of the patient to his bed, to the removal of his clothing, and to the general management of the limb before it is dressed. Rude or awkward manipulations by which needless pain is inflicted are not simply acts of wanton cruelty, but they are sources of inflammation, suppuration, and gangrene. It is difficult to state the precise manner in which the surgeon ought to proceed. Much will depend upon the circumstances of the case, something upon one's natural tact, and upon the amount of experience, but more, I think upon the natural kindness of heart, and social education. The man of refinement and sensibility will know instinctively how to proceed, and needs no instructions. They who lack these qualities can never learn, and it would be quite useless to undertake to teach them. I sincerely wish such men as these latter would find some more suitable employment than the practice of a humane art."

Those who believe that the so called Balkan frame and suspension methods are of recent introduction, would do well to note the Jenks fracture-bed frame described in Hamilton's text, as well as other suspension frames. The after-care of fractures with fracture beds containing provisions for bed pans was advocated by Hamilton, and he describes the Daniels fracture bed with such a provision.

In the section devoted to fractures, by Samuel D. Gross the elder, in his *System of Surgery*, published in 1882, we find the indication for treatment of fractures briefly summed up:

"The leading indications in the treatment of fractures are to procure reunion and to prevent deformity. It has been a much mooted question whether as a general principle a fracture should be set as soon as possible after its occurrence, or whether time should be allowed for the subsiding of the resulting inflammation. It certainly requires no great knowledge of the nature of the accident to discover that such cases should receive the earliest possible attention."

The first reference in a text on the subject of fractures to the Listerian method, we find in Gross's work:

"Whether carbolic acid, apart from the other means, recommended by Lister, is really any benefit in the treatment of those injuries is still a mooted question. A modification of the Lister treatment was introduced a few years ago in the New York Hospital by Professor Markoe, and has given most flattering results, only 1 death resulting in nearly 200."

More important, however, than any detail of treatment one can find is the advice of Gross with reference to fractures:

"There is no class of injuries which a practitioner approaches with more doubt and misgiving than fractures. They frequently involve consequences hardly less serious and disastrous to the surgeon than to the patient himself. If I were called upon to testify what branch of surgery I regarded as the most trying and difficult to practice successfully and creditably, I should unhesitatingly assert that it was that which relates to the present subject.

"I certainly know none which requires a more thorough knowledge of topographical anatomy. As for myself I never treat a case of fracture, however simple, without a feeling of the deepest anxiety in regard to its ultimate issue; without a sense of discomfort, as long as I am conscious that despite the most assiduous attention and the best directed efforts the patient is likely to be lame and deformed for life. A crooked limb, whether rendered so by injudicious treatment or not, is an unpleasant sight to the sensitive surgeon, in as much as it continually reminds him of his bad luck or want of success. I do not wish to be understood to say that it is always in his power to cure these accidents without deformity or impairment of function. Such a view would be contrary to experience and common sense. There are many cases of fracture which do not admit of any other results, however attentively or skillfully they may be treated."

The dissatisfaction expressed by Gross, Hamilton, and others led just a few years later to efforts to improve results. There appeared on the scene Arbuthnot Lane who Moynihan said was, "A man whose mind easily moves along new paths." As early as 1865, Lane began operating on fresh fractures, and for this purpose he used wire. His boldness is an inspiring example of an individual with courage to break away from tradition. He at least had the bolstering influence of the epoch-making work of the pioneers who had introduced anesthesia and of those who had paved the way for a clean surgical wound.

Surgical approach to the subject of fracture diagnosis and treatment had reached an *impasse* prior to the time of Crawford W. Long, in 1842, at which time he introduced ether anesthesia. We marvel at the heroism of the patients and the temerity of the surgeons of the past, who with brute force and "blind flying" attempted reduction of deformities following fractures in the days before anesthesia, and before the introduction of the x-ray. We also marvel at the boldness of the surgeons who before Pasteur and Lister attempted operative treatment of fractures.

As early as 1854 we find that Brainard condemned the use of wires and foreign bodies of every description as a means of promoting the formation of callus: He said: "It is a practice not founded on correct principles and is often dangerous." It should be recalled that this statement was made several years before Lister's application of Pasteur's discovery. Brainard however proved the greatness of his mind in the following statement: "Every method of treatment for ununited fractures appeals to experience in proof of its success."

Time marched on and Lane and Lambotte continued their pioneering break with orthodox methods. What reasons did Lane give for his desire to seek a change? From his own works published in 1905, we quote:

"Experience has taught me to regard the statements in anatomical and surgical work with strong suspicion. It was evident that the displaced fragments of a broken bone were never or hardly ever restored to their normal position, and the so called 'setting of fractures' was a myth. I made very extensive inquiries of medical men, and I was satisfied that the teachings contained in the text books, as to the possibility of restoring the form of broken bones, and the satisfactory results of their treatment were absolutely false."

These words of Lane were written in 1905, but he had evidenced his unrest as early as 1885. This was 10 years before Roentgen's discovery of the x-ray.

THE X-RAY

Evolutionary processes go on in the natural order. Man's appreciation of them waits for the unfolding of the secrets in the world about us, and for the practical application of the

scientific information thus unfolded. Within 1 year of Roentgen's discovery 49 books and more than 1000 scientific and clinical papers were published. The profession had been waiting for someone to lead them from darkness to light. Methods of reduction, which up to the advent of the x-ray had been dependent on accurate clinical observation, now had a valuable adjunct. American surgeons, like surgeons in all parts of the world, were quick to realize potentialities of x-ray for diagnostic purposes. The effect of the introduction of the x-ray on the professional mind is clearly stated by Cattell in 1896:

"No discovery in medicine has equalled its importance, since Pasteur, Lister, and Koch placed bacteriology on a scientific basis. Who a year ago would have dreamed of being able actually to see the displaced fragments in a Colles' fracture, to set the bone, to dress the arm and then examine the bone again through the wooden splint and bandages, and note whether or not the broken bones had been correctly approximated? The imagination of the reader is left to discover new fields of usefulness for this most wonderful and practical discovery of Professor Roentgen."

On April 8, 1896, in the *Electrical Engineer*, published in New York, the following announcement was made, with reference to the opening of the Post Graduate Hospital X-ray Department:

"Doctors to become cathodographers. Cathodography will shortly become one of the regular features of the Post Graduate Hospital, 20th Street and Second Avenue.

"The utility of taking x-ray pictures in surgery has been demonstrated so often, that hospital authorities have decided to set aside one of the smaller wards for that purpose; and they will equip it with Crookes tubes, Ruhmkorff coils, sensitized plates, and all other paraphernalia of the new art."

According to Glasser this was the first special Roentgen Department in the United States.

Philip Mills Jones, of San Francisco, and Edward A. Tracy, of Boston, expressed the sentiments of various sections of this country with reference to the new discovery and its usefulness:

"With no discovery within my recollection has the immediate and general excitement been so intense. The application of the x-rays in medicine has thus far been confined almost entirely to surgical

diagnosis. Fractures and dislocations, though easy of diagnosis, are sometimes very puzzling. No matter what the natural ability, education or experience of the fingers, they may often be at fault; here, we have an agent that cannot err.

"The fractures and dislocations that have been examined with much profit by this means includes almost every large bone, almost every joint in the body, and no man who has availed himself of this aid in such cases will speak of it in any terms save those of the highest praise."

Edward A. Tracy, in 1897, said:

"The application of Roentgen's discovery necessitates the rewriting of the textbooks on fractures and dislocations. Facts, heretofore 'smothered by surmise,' are clearly set forth by the radiographs."

The United States Army made the x-ray an integral part of the Army medical equipment before 1898. In an article by W. C. Borden, published under the direction of the Surgeon General, George M. Sternberg, we read:

"Soon after the discovery by Professor Roentgen the Surgeon General of the Army supplied Roentgen-ray apparatus to several of the larger post hospitals. On the outbreak of the war with Spain and the establishment of the general hospitals, the most prominent and important of these hospitals and the three hospital ships, 'Relief,' 'Missouri,' and 'Bay State,' were supplied with similar appliances. The use of the roentgen ray has marked a distinct advance in military surgery."

One can say that the golden age of fracture diagnosis and treatment was born with the advent of the x-ray. After the advent of the x-ray reduction could be carried out with an accuracy not possible before. Let it be remembered that the x-ray did not add a principle but an aid in the carrying out of the fundamental conception of treatment.

That our predecessors realized their limitations is adequately expressed by Cooper, Malgaigne, Hamilton, Gross, Lane, and a host of others. The x-ray provided the opportunity for the surgeon to express himself either conservatively or radically. Conservatively, by the application of anatomical knowledge and physical principles, he could reduce a deformity definitely. When this was not accomplished he could safely apply direct exposure of the fracture site and make use of internal fixation for the purpose of assuring the reduction which was thus accomplished.

CONCLUSION

The discussions which have arisen since 1900 with reference to operative or non-operative treatment have had only one objective, to obtain the earliest and safest method of returning the injured to economic efficiency. In order to establish the truth, statistical studies had to be made, since none were available. These were not easily obtained. Statistics, which were presented in the early days, were favorable to one or the other method depending on the source and ability of the surgeons compiling them. It soon became evident that certain fundamental principles had to be applied if the greatest good was to be done. These principles are:

1. In general, conservative treatment applied along anatomical lines was the most successful in the average hands.
2. Certain fractures have to be operated upon routinely.
3. Direct surgical treatment of fractures should be done only by those qualified by training to operate and equipped with adequate armamentarium.
4. Proper hospital facilities are essential.

Improvements in x-ray facilities, better surgical technique, and new anesthetic agents have all contributed to the safety of surgery whenever indicated.

From the earliest times we find that the masters of surgery taught the value of reduction and immobilization. When to reduce, whether immediately or after variable periods of waiting for the swelling to subside, has provided many arguments. The gist of all discussions at the present time is that attempts at reduction should be made as soon as possible after the accident in simple fractures.

In compound fractures the debate still goes on. Some advocate immediate internal fixation and others direct skeletal traction and suspension. This is a question of experience and not evolution. The evolutionary step is the question of operation as an addition to our portfolio of safe procedures. The safety of this progressive step is dependent upon the

qualifications of the surgeon and the environment provided. This question has been presented admirably by William O'Neill Sherman in a recent fracture oration. It need only be pointed out that direct, operative attack, which resulted from dissatisfaction, was a step in the development of fracture treatment.

In the evolution of the operative procedures by internal fixation many materials have been used and each lauded by enthusiasts. Time alone will answer all of the questions whether absorbable or non-absorbable material should be used, whether autogenous grafts of one kind or another are best; whether grafts are absorbed and act only as a splint and scaffold, or whether they remain permanently; whether one material is irritant, electrolytic, or not. All of these represent the passing show.

The principle of operating in selected cases is, however, a definite stage in the evolution of fracture treatment. Factors, which have made this step possible, are industrial developments, particularly chemical and metallurgical, as well as scientific achievement along bacteriological lines.

It should not be forgotten that fundamental principles of fracture treatment remain the same. They are early reduction and adequate immobilization. The axiom with reference to anatomical knowledge necessary for reduction must not be overlooked.

Will observers in the future credit our generation with progress in principles and practice or will we be charged with having spent our time idly discussing the polemics of who should treat fractures? Traumatic surgery is demanding more and more of our efforts, due to the ever increasing hazardous occupations and modes of transportation. The evolution of the fracture problem depends on continued search for truth and the utilization of all of the aids that scientific achievements place at our disposal for the benefit of the suffering mass of the human family. Let it not be said of our generation that we stagnated, or that we were bound by the adamant force of the authorities of yesterday.