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Effect of mechanical appliances on reduction in the treatment of fractures

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THE EFFECT OF MECHANICAL APPLIANCES
ON
REDUCTION TIME IN THE TREATMENT OF FRACTURES

BY

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INTRODUCTION

The time which elapses from when a fracture occurs to the time when it is reduced and immobilized may vary from two to three hours to as many months or even longer. In the following pages I will refer to this elapsed period of time as "reduction time" and will discuss the effect of mechanical appliances on reduction time and some of the factors which may be responsible for this variation.

Because of controversial questions in the treatment of fractures and because there are so many types and varieties of fractures, as will be shown, I shall limit the discussion to those fractures of long bones, caused by external violence, and uncomplicated by septic infection, pre-existing bone pathology, or specific infectious disease.

NORMAL GROWTH OF A LONG BONE

Since the subject of fractures and their treatment includes all the different phases of medicine, I think one should have a clear idea of the fundamental anatomical principles involved in the normal bone picture. I will refer to this subject several times during the course of my discussion and, as a review, I will use material described in any standard text of Anatomy.

In a brief resume of the Embryology and growth of the long bones we find that they are at first solid cartilage, and growth takes place by a process of intercartilaginous ossification.

In the first stage the process commences in the center and proceeds toward the extremities which for some time remain cartilaginous. Subsequently a similar process commences in one or more places in those extremities and gradually extends through them. The extremities do not, however, become joined to the body of the bone by bony tissue until growth has ceased; between the body and either extremity, a layer of cartilaginous tissue, termed the epiphyseal cartilage, persists for a definite period.

The first step in the ossification of the cartilage is that the cartilage cells, at the point where ossification is commencing and which is termed the center of ossification, enlarge and arrange themselves in rows. The matrix in which they are imbedded increases in quantity, so that the cells become further separated from each other. A deposit of Calcium material now takes place in this matrix, between the rows of cells so that they become separated from each other by longitudinal columns of calcified matrix, presenting a granular and opaque appearance. Here and there the matrix between the cells of the same row also becomes calcified, and transverse bars of calcified substance stretch across from one calcareous column to another. Thus there are longitudinal groups of the cartilage cells enclosed in oblong cavities, the walls of which are formed by calcified matrix which cuts off all nutrition from the cells; the cells in consequence atrophy, leaving spaces called the primary areolae.

At the same time that this process is going on in the center of the solid bar of cartilage, certain changes are taking place on its surface. This is

covered by a very vascular membrane, the perichondrium. On the inner surface of this, that is to say, on the surface in contact with the cartilage, are gathered the formative cells, the osteoblasts. By the agency of these cells, a thin layer of bony tissue is formed between the perichondrium and the cartilage. There are then in this first stage of ossification, two processes going on simultaneously: in the center of the cartilage the formation of a number of oblong spaces, formed by calcified matrix and containing withered cartilage cells, and on the surface of the cartilage, the formation of a layer of true bone.

In the second stage there is a prolongation into the cartilage of processes of the deeper layer of the perichondrium which has now become the periosteum. These processes consist of blood vessels and cells, (osteoblasts or bone formers, and osteoclasts or bone destroyers). The latter are similar to the giant cells found in marrow and they excavate passages through the new-formed bony layer by absorption and pass through it into the calcified matrix. Wherever these processes come in contact with the calcified walls of the primary areolae, they absorb them

and thus cause a fusion of the original cavities and the formation of larger spaces which are termed the secondary areolae or medullary spaces. These secondary spaces become filled with embryonic marrow consisting of osteoblasts and vessels, derived in the manner described above, from the osteo-genetic layer of the periosteum. The walls of the secondary areolae become thickened by the deposition of layers of true bone on their surface.

This takes place in the following manner. Some of the osteoblasts of the embryonic marrow, after undergoing rapid division, arrange themselves as an epitheloid layer on the surface of the wall of the space. This layer of osteoblasts forms a bony stratum and thus the wall of the space becomes gradually covered with a layer of true osseous substance in which some of the bone forming cells are included as bone corpuscles. The next stage in the process consists in the removal of these primary bone spicules by the osteoclasts. One of these giant cells may be found lying at the free end of each spicule. The removal of the primary spicule goes on with the formation of permanent bone by the periosteum and in this way the medullary cavity of the body of the bone is formed.

This series of changes has been gradually proceeding toward the end of the body of the bone so that in the ossifying bone all the changes described above may be seen in different parts, from the true bone at the center of the body to the hyaline cartilage at the extremities.

While the ossification of the cartilaginous body is extending toward the articular ends, the cartilage immediately in advance of the osseous tissue continues to grow until the length of the adult bone is reached.¹

Bearing the above facts in mind then and remembering that the bone is an ingenious piece of architecture subject continuously to stresses and strains, we will see how these processes are concerned when a fracture or a solution in the continuity of the bone occurs.

NORMAL HEALING OF BONE

According to Stirling², the healing of a fractured bone is the outcome of several processes in which different tissues and fluids of the body bear their part.

From a radiographic point of view, when a fracture has taken place, the edges of the bone are clear cut. Providing healing proceeds satisfactorily, in a few days the edges become less definite, presenting an eroded moth-eaten appearance. This erosion may be so great that the actual fracture line itself seems to increase considerably in width. At a later date, which in children may be seen as early as the tenth or twelfth day, ossified callus is laid down around the fracture site. At the same time it can be noted that the medullary cavity is entirely obliterated with new bone, both at the line of fracture and slightly above and below it. After a period, which may be months, the medullary cavity is reformed, the excess callus is absorbed and the cortex is restored to its normal shape and density.

From a Histological point of view, when a fracture takes place, the space between the fragments is

filled with blood and the neighboring bone-cell spaces are occupied by bone cells. The periosteum is usually torn across and slightly stripped up from the bone at the edges of the fracture. There is a tear into the soft tissues which in the majority of cases includes muscles. By the eighth or tenth day the space between the bones is filled with very elementary mesoblastic tissue, which later takes the form of fibroblasts. According to Murray³ this elementary mesoblastic tissue arises from the marrow cavity, from the Haversian canals, from the endostium, from the periostium and from the mesoblastic tissue which forms the sheaths of the torn muscle bundles; in brief, from all tissues of mesoblastic origin in the area. Stirling² and Radasch⁴ maintain that Collagen fibres form in the exoplasm between the cells and here also one sees minute blood vessels with walls a single cell thick. From the tenth day onward, Calcium and other salts are deposited in the spaces between the cells. This deposition of salts is probably brought about by the Enzyme, phosphatase, and it is to be noted, as Stirling² points out, that the optimum medium for the action of this Enzyme is an alkaline one of pH 8.4. At a later date the mass of bone which fills the marrow cavity and which forms the extra cortical callus, is absorbed or remolded. The

new lines assumed by the trabeculae are largely influenced by the stresses and strain put upon the bone. This last statement is especially important to be remembered in the following paragraphs.

Murray³ states that if fluid is aspirated from between the fragments on the first day, it is largely composed of blood and has the same pH value as the blood (7.4). As the days pass the reaction becomes more acid. In some cases by the fourth day it registers a pH of 4.5. The acidity of the hematoma is brought about by the exudation of CO₂ from the dead and dying cells, from the Lactic acid in the damaged muscles and from the conversion of blood sugar. The acidity of the hematoma absorbs salt from the bone ends and gives the moth-eaten appearance seen in the xray. At certain stages the Lactic acid content is fifteen times the normal and the CO₂ which is more diffusible is twice the normal. By the tenth day the Calcium content has increased to ten times the normal.

Stirling², Murray³ and Radasch⁴ seem to think it reasonable to assume that the formation of bone is due to the action of the hypercalcemic hematoma fluid on the embryonic mesoblastic tissue. From experiments conducted it may be presumed that the chemical

alteration in the fluid around the ends of a fractured bone takes place in a sealed off cavity which has no immediate relation with the surrounding body fluid. This is another point, the importance of which will be spoken of later.

"If good reduction is carried out after a fracture, a sealed off chemical factory surrounds the ends of the broken bone and the processes indicated above take place. Anything which interferes with the reposition of the fractured bone, with the chemical activity of the factory or with the living walls of the factory will lead to delayed or non-union."²

VARIETIES AND CAUSES OF SOME OF THE COMMON FRACTURES

"A fracture may be defined as a sudden solution of continuity in a bone, usually resulting from external violence."⁵ The following varieties may exist singly or in any sort of combination depending on the particular fracture mechanism.

A Closed (Simple) fracture is one in which the skin is unbroken, or at any rate where the external air has no admission to the site of injury.

An Open (Compound) fracture is present when the skin or mucous membrane is so lacerated that there is direct or indirect communication between the fracture and the external air.

Incomplete fractures are described in various forms. A greenstick fracture is one which occurs most usually in children. Curved bones such as the Clavicle, are most frequently affected but any of the extremities may be involved. The fracture is in the convexity of the curve and the concave part is bent just as when a green bough or twig is partially broken.

Complete fractures may be transverse, if due to direct violence; oblique, arising usually from indirect violence; spiral, when the force acts in a rotary direction as well as longitudinally - it occurs most frequently in the Tibia or Femur and the

lower fragment often has a sharp triangular upper end. Not uncommonly, a second fissure runs downwards from the main line of fracture, separating off a long narrow fragment of the shaft. A longitudinal fracture is one due to fissuring or splitting of the bone in its long axis. Comminuted is a term used to describe the condition when the bone is broken into more than two pieces; impacted, when one fragment is driven into the other; multiple, when more than one fracture exists; complicated, when important structures such as an artery, nerve, or joint are damaged as well as the bone. The separation of an epiphysis results in young people, often from violence directed to the ends of the bones and is literally a separation at the epiphyseal junction.

According to Magnuson⁶ the number and varieties of fractures caused by direct violence, has increased greatly in the past few years. "When Henry Ford gave the world a new mode of locomotion he gave us a mixed blessing. Today the automobile kills 30,000 people annually in the U. S. and maims at least 300,000. Because of it and other modern hazards, fracture treatment has assumed a new and greater importance."⁶ Aeroplanes, boats, busses, trains and motorcycles with

their excessive speed necessarily lead to many accidents with consequent propensity to bodily injury. They account for most of the fractures by direct violence. The fractures usually occur in the bone at the spot struck, often being transverse, not infrequently comminuted and often complicated with injuries to the soft parts.

When due to indirect violence the accident is usually produced by the compression or bending of the bone with such force as to exceed the limits of its natural elasticity, so that it yields at its weakest spot. Thus when a person jumps or falls from a height, the leg bones are compressed between the weight of the body and the resistance of the ground, and if the violence is excessive, a fracture occurs at some point of mechanical disadvantage. If the stress falls chiefly on the shaft, an oblique fracture may ensue, often with much longitudinal displacement and possibly becoming compound; if an element of torsion is present or by forced inversion or eversion of the foot, the fracture is likely to become spiral in type. If on the other hand, the violence expends itself on a mass of cancellous tissue, such as the Os Calcis, Astragalus or upper end of the

Tibia, the bone may be fissured in various directions, or comminuted; "...such a condition is sometimes termed a compression fracture."⁵ Muscular action is most commonly the cause of fractures of osseous prominences into which powerful muscles are inserted. The Patella and Olecranon are often fractured in this way. These fractures most often occur in games of sport such as football, basketball and hockey where swift and strong muscular action is needed. Since the use of Insulin and Metrazol in Psychotherapy, many fractures have occurred as a result of the violent muscular contractions elicited by these drugs.

As stated before there are thousands of mechanisms by which fractures can be produced and it is important for the surgeon to have a thorough knowledge of these in order that the treatment can be simplified.

DEVELOPMENT OF MECHANICAL APPLIANCES

The word "reduce" as defined by Webster means to "restore a condition."⁷ At what time in medical history this word became a descriptive medical term as applied to the treatment of fractures is hard to say. In Adams' translation of Hippocrates' writings in 1886, he speaks of the "reduction of fractures."¹⁴ Dorland defines the word, "To replace in normal position."⁸ One may be presumptuous enough to assume that the word came into use as a descriptive term in medicine by virtue of its English definition.

Literally, when a bone is fractured its normal condition is altered, and by the reduction of the fracture we attempt to restore this condition. Actually, this is rather difficult because, although we may restore the bone to its former anatomical condition, it may still be far from normal because of other physical damage such as tearing, trauma, etc., and because of the physiological reactions of tissue to injury. Let us consider what may occur structurally as the result of a fracture. Angulation, offset, overriding and rotation are terms which by definition are self-descriptive and give us a definite

picture of the displacement, although the degree to which the fragments are displaced may vary. When a fracture is completely reduced, we infer that none of the above conditions exist and that perfect anatomical reduction has been effected.

The question that presents itself then is, why is it that, in one case reduction may be effected immediately, and in another case which is practically identical, reduction may not be carried out for weeks or even months. "That this does occur constantly is common knowledge among men who treat fractures."²⁶ According to Speed²⁶, Bohler²⁸ and Magnuson²¹ there are always factors in every case which require individual solutions but it is the main problem to which I refer, namely, why is the immediate and complete anatomical reduction of fractures not effected in all cases; what are the factors responsible and, how are they affected by the use of mechanical appliances?

In attempting to answer this question, we are reminded by Magnuson²¹ of the fact that this subject includes a great many controversial questions in management in the treatment of fractures, and in reviewing the literature one is greatly impressed by the countless different kinds of apparatus which have been described and the differences of opinion

which exist among surgeons as to open and closed reduction methods with the use of special apparatus.

Here then must be factors which would explain variation in reduction time, and it seems to me that an investigation of the early history and development of mechanical appliances and their use in the treatment of fractures might furnish an interesting background for study and perhaps give us a clue which will aid us in answering the above question.

Delving into the history of fracture treatment, I shall pay more attention to the development of the use of mechanical appliances than to the general history of fracture treatment. However, I shall give the outstanding discoveries and advances in as nearly a chronological order as is possible.

According to Sir Grafton Elliot Smith¹⁰, the most ancient records of the treatment of fractures are supplied by bodies found by the Hearst Expedition of the University of California excavating at Maga-el-der about one hundred miles north of Luxor in Egypt. These bodies were found in rock cut tombs which were identified as belonging to the Fifth Dynasty which, according to conservative estimates,

ruled in Egypt about 4500 years ago or about 3000 B.C. Two of these bodies had fractured limbs with splints in position. Two separate sets of splints were discovered, one applied to what was evidently a compound fracture of the femur in a girl about fourteen years old, and the other to a compound fracture of both bones of the forearm. In the former fracture four splints were applied around the circumference of the limb. They were roughly shaped of wood and about one foot four inches long and one and a quarter inches wide and reached less than three inches above the site of the fracture, but about six and one-half inches below the knee. Each of these splints was carefully wrapped in linen bandages wound around the wood in two layers obliquely, so that the obliquity of the superficial layer was at right angles to that of the deeper layer. As Smith remarks, these splints must have been useless to support the broken bone or prevent shortening; they could only fix the knee joint and afford some degree of rest to the injured limb. In marked contrast was the effective support afforded by the splints in the case of the forearm fracture, where

again a more or less complete tube of splinting invested the limb from a point about an inch below the upper end of the radius, as low as and partly including, the wrist joint. This was constructed of three pieces of rough bark and a bundle of straw and coarse grass.

H. W. Jones says, "We must not assume that the history of medicine began with the Greeks. More than 3000 years before the time of Hippocrates disease and injury had received serious study in Egypt and Mesopotamia. Excavations carried on in Egypt have shown in many of the early cemeteries that fractures of the long bones and especially the ulna were very common."¹¹

W. A. Clarke¹² brings out the fact that recorded descriptions of the methods of Egyptian physicians are very scanty but in the Smith Surgical Papyrus are found sketchy references to fractures of the humerus. "Thou shouldst make for him two splints of linen (and) thou shouldst apply one of them both on the inside of his upper arm and the other on the under side of his upper arm."²⁷ Clarke also refers to the remains of bodies with fractured limbs that had been set up in bark splints.¹²

Monroe¹³ makes the observation that a thousand years before Joseph became Governor under Pharoah, the Egyptians were using linen for splinting.

From the above evidence, probably the earliest form of mechanical appliance used in the treatment of fractures was a splint of such nature as to run parallel to the bone and to be fastened around the extremity by some means.

There are no other outstanding contributions as revealed by the literature until the time of Hippocrates. In his writings, which were very numerous, he devotes quite some time to the description of fractures and their treatment.

Hippocrates¹⁴ lived from 460 to 370 B.C. He wrote on fractures and dislocations specifically and he describes in detail the general principles of fracture treatment: first, reduction of the broken bone by traction and counter traction, stating that in the case of the forearm less force is required than in the leg and thigh, where the muscles are more bulky and strong. In the first, one assistant may be able to exert the force necessary; in the second, two strong men; while in the last, two men may not be sufficient, and he advocates the use

of special apparatus. One such for making extension by means of two windlasses at the end of a stout beam placed under the patient is an instrument called the glossocomium. Another, one of the first descriptions of an orthopedic table, is called the scamnion of Hippocrates; and, although Hippocrates' works are not illustrated, several commentators in the literature have illustrated it.

While the extension is being exerted, the surgeon places the bones into apposition with the palms of his hands. He also describes the correct posture of the limbs, stressing what he calls the natural position as that which can easily be sustained; the position of relaxation. He points out the importance of reducing the fractures in such positions so that they will need no alteration when retentive appliances are being put on, as that would tend to upset the position of the bones again. The limb was then bandaged with roller bandages. The details of the application of these rollers are fully set out, and warnings are issued about the tightness, etc. Generally, they were reapplied every three days until the seventh to eleventh day, according to the situation, when, the swelling having subsided and the

parts relaxed, splints were applied over fresh rollers. The splints are not described in any detail, but it is stated that they should be smooth, even, and rounded at the extremities, they should be somewhat shorter all along than the upper bandaging, and those parts where there are tuberosities and which are devoid of flesh, such as the ankles and fingers, should be guarded from the splints which are placed over them.

In the case of the leg and thigh he mentions gutters, and says that in the thigh it is necessary that they should reach from the nates to the foot, or should not be used. He seems undecided as to the advisability of this form of splint. He gives a full description of an apparatus for compound fracture of the leg which is most interesting. It consisted of two rings such as those of a Thomas' Splint (to be described later), but smaller, "... one to bear below the knee, the other above the ankle"¹⁴; they are kept extended by a pair of rods of suitable length on each side. He recommends also the use of gold thread around the teeth in fractures of the lower jaw.

He also states that the man who presumes to treat fractures must be equipped to do so under any conditions. The men in the larger cities should have the heavier equipment which has been described, but the men in the smaller communities and the traveling doctors must adapt whatever they have at hand to fit their needs. He describes a fracture table improvised from a ladder such as might be found in any household, by which traction and counter traction may be exerted.

- For instance, in fractures near the elbow, traction is applied by means of a clove hitch attached to the wrist. This in turn is acted on by a system of pulleys. Counter traction is maintained by a ring of the ladder pressing firmly in the axilla on the injured side. Similarly in reducing fracture of the lower extremity, the extension is applied by a clove hitch and counter extension by bands passed between the thighs and attached to the upper end of the table so the patient may not be displaced by the powerful pull necessary. It is quite evident, therefore, that even in those days there were many methods. Hippocrates urges the practitioner to use the method which is best fitted to reduce the type of fracture with which he is dealing and if one method does not

work, to try another.

Following Hippocrates, the literature mentions several men who were using mechanical appliances in the treatment of fractures. Among these is Albucasis¹⁵. In his advice on the treatment of fractures, he warns against a too strong extension and too much pressure in the reduction, as this will cause inflammation. His description of splints and bandages is minute and simple. He advises the use of liniments for the skin and soft stupes. He says the splints should be removed or loosened in three or five days. He tells us that a fracture of the radius is less serious than that of the ulna. If both bones are fractured traction will have to be strong to effect reduction. He recommends the use of the splint for twenty days after which a sling may be used. In leg fractures he uses a gutter splint with coaptation splints.

Celsus¹⁶ who lived at Rome in the reign of Tiberius Caesar describes the difficulties of reducing fractures of the clavicle and methods of maintaining the reduction with pads and bandages and even a small wooden ferrule splint not mentioned by Hippocrates.

The next outstanding work on treatment of fractures with the use of mechanical appliances was written by Guy de Chauliac¹⁷. Methods of reduction and retention are given in detail. He described coaptation splints made of willow, sword handle wood, horn, iron or leather but said they should neither touch nor injure the bone. The splints were bound with a cord with a cannula inserted so that by twisting the latter, the cord could be tightened. He advised a suspensory or cradle in which the limb could be firmly held. Splints were only to sustain during the first seven days or until the swelling subsided.

Ambroise Paré (1510-1590)¹⁸ quoted several of Hippocrates sayings. He treated reduction of compound fractures by manipulation, and he used splints of shaped metal with notches cut out so that the wound would be accessible without removing the splint.

Among the American Indians¹⁹ not only the medicine men but also the laymen were familiar with fractures and their treatment. It is significant that the splints they used were long enough to immobilize the neighboring joints, while those em-

ployed by the surgeons of medieval Europe, as before described, stopped short of the joints.

During the middle ages the treatment of fractures fell into the hands of the "bone setters", who possessed considerable skill and knowledge of the subject, for they were sought far and wide.²⁰ Magnuson²¹ states that it was an hereditary profession and the most famous family of this time is that from which Hugh Owen Thomas descended.

During the last century numerous new developments were brought out in the form of appliances. In 1827 Nathan Smith first used the long anterior leg splint in suspension treatment. Continuous traction with use of weights and pulleys was devised by Daniels in Georgia in 1827. The well known Buck's Extension appeared in 1851. This was a device designed to be used in the treatment of fracture of the thigh²¹. In brief, the leg was bandaged with moleskin to which a rope was attached. The rope then passed over a pulley and a weight exerted a pull in the long axis of the leg, and by this means tended to reduce the fracture. In 1862 Hunt applied sand bags to aid in the immobilization of fractures.²¹

Although it is believed that plaster casts were used about 1789 it was not until 1837 that Frause developed the type of plaster cast in which the patient could be ambulatory, i.e. the walking plaster cast.¹³

In the 1860's, Hugh Owen Thomas²² described the splint which is in common use today and which bears his name. Briefly, it consists of a rod bent into a long U shape with the open end attached to a ring. The ring can be slipped over the leg and comes up where it presses on the perineum. This particular splint, Thomas designated as "Knee appliance for locomotion."²² Thomas designed several kinds of splints for use in his work which consisted mainly in the treatment of diseases of the hip, knee and ankle joints. In his treatment he stressed the importance of enforced uninterrupted and prolonged rest.²²

Magnuson believes that this splint is adaptable in original or modified form to the proper treatment of more fractures of the long bones than any other splint ever invented.²¹ I will show in the succeeding pages that Hugh Owen Thomas had very definite ideas on the subject of splints and their use.

John Thompson Hodgkin of Kentucky (1826-1882) devised many instruments and much apparatus. One in particular was his wire suspension splint for the treatment of fractures of the femur and forearm of which many are still in use.²³

Sir William Arbuthnot Lane²⁴ about 1900 describes his method of holding fractures with the use of plates screwed to the bones. This method is still much in use today.

In 1909 Steinman demonstrated his famous nail, by means of which traction could be applied directly to the bone. During the first World War, however, calipers, commonly referred to as "ice tongs", were devised to take the place of the Steinman Nail. It seems that when infection occurred the hole through which the nail is driven furnishes a highway for bacteria and a situation of this type is harder to combat and may result in permanent damage. With the use of calipers, the infection, if it occurred, was usually localized at the surface points of contact.⁶

Kirschner's Wire was introduced in 1909. According to Speed²⁶, Kirschner employed steel wires which could be easily and rapidly drilled through

the soft parts and bone to give, when gripped in a proper locking device, steady pull on a part with a minimum sized wound and a greatly reduced chance of infection or possibility of bone splitting or injury. The fine wires of the Kirschner traction can sustain heavy pulls.

As suggested by Magnuson²¹ this brings us up to date in the development and use of mechanical appliances. There are countless numbers of appliances which have been devised in recent years but as he says they are but modifications or slight improvements on apparatus which has already been in use for years.

CONTROVERSIAL OPINIONS ON MODERN USE OF MECHANICAL
APPLIANCES

Thus far we have described the development of mechanical appliances in the treatment of fractures which in itself, does not begin to answer the question as stated previously. We have shown however that for hundreds of years different men have treated fractures and each man has had his own ingenious idea as to the mechanical aid he used in striving to effect reduction and immobilization. We have shown that each man named in the development of mechanical apparatus had his own ideas and methods and that he was unable or unwilling to accept the other man's method of treatment but was stimulated by the problem at hand to invent or devise a better one of his own. Here then is a factor which must be investigated from the standpoint of modern treatment of fractures with the use of mechanical appliances

First let us return to Hippocrates¹⁴ for a moment in order to examine his method. At that time in his writings he cautioned that, "A fracture should not be allowed to go to the second or third day but should be reduced, and properly reduced as soon after it occurs as it is possible to apply the reduction apparatus, which is thought out to meet the needs of that par-

ticular case"¹⁴ If we analyze this statement we find that here is a bit of fundamental advice. At that time with no knowlege of the process of normal bone healing, or the diagnostic aid of the xray, he was forced to invent an appropriate means for maintaining reduction in each individual case and this means may or may not have been effective at the first attempt which would result in variations in the "reduction time".

Hugh Owen Thomas²² discusses the merits and demerits of several mechanical appliances invented by both Europeans and Americans. In his writings on the use of weights and pulleys in the treatment of fractures he states that a fractured thigh, if treated by extension only, would be accompanied with vastly more muscular irritability than if the same case was placed in a modern appliance with retention, in which the limb was retained and fixed immovably in the strict meaning of the term fixation. In speaking of American methods he says they deserve praise for having studied diligently to improve the treatment of fractures but some of their methods are less efficacious than some of the methods already in use. In conclusion he states that

the design of apparatus which he submitted to the profession was free from all the defects of the previous appliances.

Investigating more modern opinions in the treatment of fractures, according to Stirling² when a fracture occurs, there is a tendency for the muscles to contract and immobilize the distal fragment. This is purely a protective mechanism, but often becomes a severe problem in relation to the recovery and ultimate functional result because the muscles do not pull evenly and there is a great tendency for an increase in the amount of overriding or angulation to occur, depending, of course, on those muscles which are exerting the greatest amount of pull, and on their position of attachment along the shaft of the bone. Here again then is simple but positive evidence of the purely mechanical ^{factor} /which exists in all fractures.

According to Fox²⁹, in attempting to prevent the muscle spasm which ultimately ensues if not prevented, traction and counter traction should be applied as soon as possible. If the traction is applied immediately, the muscle spasm can be eliminated and reduction can then be accomplished. Logically there are two places on a limb where a pull can be

obtained; from the skin, by appropriate means, and from somewhere along the bone by a mechanism which penetrates through the bone through which a force can be exerted.

In speaking of skin traction, Jostess says, "In strong muscular patients, skin traction is generally ineffectual. It serves only to traumatize the skin and render it indisposed to any future surgical procedure such as open reduction or insertion of a pin."³⁰ He also states that this fact must be kept carefully in mind because if surgical treatment becomes necessary, then obviously skin traction should not have been used in the first place. The skin usually becomes so traumatized that a further interval of waiting is necessary until the skin has healed. Skin traction often amounts to costly temporizing, for after from three to four weeks have elapsed and reduction has not been effected, it is necessary to break up whatever callus has formed before skeletal traction can be started.

In referring to Fox²⁹ again, he also states that in the treatment of fractures we should strive to secure anatomical reposition of the fragments in order to get good functional results. He says that everyone

knows that there is at present a failure to obtain these results in a great many cases. Of course, there are times when the nature of the fracture and injury to the soft parts makes this very difficult or impossible. The fault lies mostly in the treatment. Everyone who has used skin traction must realize its inadequacy and faults. Very often the fractures cannot be reduced even moderately well by this means and the adhesive many times slips and too often causes irritation of the skin with much discomfort to the patient.

Chenault says that, "In attempting to speak for more frequent use of skeletal traction, we are not unmindful of the fact that there are certain cardinal principles in the treatment of all fractures; namely, that first aid and subsequent treatment should not inflict additional injury; that unnecessary manipulation should be avoided; that we should splint them where they lie and transport them very carefully; treat the shock and let the fracture be reduced and immobilized at the earliest possible moment; and to seek to elicit crepitus and abnormal mobility is to produce additional injury which should be unlawful

for all bone surgeons." He also says that displacement should be completely reduced as soon as possible and this reduction maintained by the apparatus appropriate to that particular fracture, having due regard to the injuries of the skin and other soft parts. Contrary to a lot of early beliefs immediate, complete anatomical reduction is essential to functional success.

According to Dieterle³², the use of wire in the treatment of fractures has been an advantage in that trauma to tissue is reduced to a minimum. "... the indiscriminate use of wire in the treatment of fracture should be condemned."³² He also states that when skin traction is equally effective the use of other methods is not indicated. In any fracture where the chance of getting a satisfactory reduction by simple manipulation and adequate splintage is assured, the use of wire is not indicated.

Le Breton³³ asserts that the metallic ready made splints hanging in the wardrobe of the hospital, are used less and less, as they do not meet the indications. The fear of infection from the introduction of pin or wire through the bones has become less as we so seldom see it.

In a discussion following an article by Le Breton³⁴,

W. C. Payne states that a great proportion of the physicians who are called upon to treat fractures obtained their training before skeletal traction was advocated. There are a great many fractures which can successfully be treated by the splint and fixation method, but there are also a great many fractures which can be treated only by the skeletal method, and he is in favor of the Kirschner wire or the Steinman pin.

In speaking of open and closed reduction methods in the treatment of fractures, Dr. Lorenz Boehler of the University of Vienna says, "The most unfortunate innovation in the treatment of recent fractures is the routine exposure and reduction by open operation, particularly if this practice is carried out by inexperienced persons without special indications, with defective appliances and with the application of large metal foreign bodies. Thousands of human lives have been sacrificed by these procedures and many more have been crippled by them."²⁸

In reference to the application of metal foreign bodies, Haynes³⁵ says that in long experience with the use of pins to maintain skeletal fixation where rigid sepsis was observed, "....there has been no infection

of the bone in any case."

Stuck states, "New alloys have been developed, such as vitallium, which are non-electrolytic and which can be used in the bone without damage."³⁶

What Boehler may have referred to in his statement given on Page 36 is the poor judgment used in the choice of appliance, caused by the inexperience and lack of special training in the treatment of fractures. That he has no objection to the reduction of fractures by the open method is brought out by Orr who "...was impressed not so much by his special traction apparatus or his non-padded cast, but by the fact that he could put the patient on the table and that the patient did not leave the operating table till the fracture was reduced."³⁷

Dr. W. O. Sherman³⁸ of Pittsburgh, in his recent fracture oration before the Clinical Congress of the American College of Surgeons, stated that the open reduction of a fracture made by a competent surgeon who practices a rigorous sepsis, in his opinion takes no more risk than when he operates on a chronic appendix. The majority of fractures can be treated by the closed method; however, in a good number of fractures, the surgeon is unable to get a perfect reduction by the closed method. This statement agrees

with the necessity for open reduction but gives no mention of the importance of immediate reduction nor of the selection of cases for open operation. He goes on to say, "As a rule we operate between the twelfth and fifteenth day after the occurrence of the fracture. During the first two weeks we try to do a closed reduction but if we fail to obtain the proper position of the fragments we do not hesitate to operate."³⁸

The section on surgery of the British Medical Association³⁹ concludes that operative treatment should not be regarded as a method to be resorted to after failure of non-operative measures, and that to secure the most satisfactory results from operation, it should be employed as soon as possible, using post-operative fixation with the aid of adequate mechanical means.

Henderson⁴⁰ declares the fact that the elbow is a hinge joint explains why serious impairment of motion may follow these injuries if the fracture is not immediately and completely reduced. If reduction is not possible by manipulation, open reduction must be resorted to and the fragments must be held by whatever means the surgeon chooses.

SUMMARY

In summing up, we find that the question asked on page sixteen still remains unanswered. However, if we examine the evidence as presented we find the following essential facts:

1. There are as many different types of fractures as there are fracture mechanisms.
2. There are countless numbers of fracture mechanisms.
3. For hundreds of years men have designed apparatus for use in the reduction and immobilization of fractures.
4. Surgeons were not content to use the method or appliance as devised by others, but tried constantly to make their own improvements in treatment.
5. Many surgeons will not use skeletal traction until skin traction has failed.
6. Many surgeons will not resort to open reduction with mechanical fixation until all other methods have produced no results.
7. Many surgeons will attempt use of an appliance in the treatment of a fracture, which will work only in the original case.

- From the above facts it appears that we may assume the following which will answer the question. There is a wide variation in reduction time in the treatment of fractures because of either improper choice of mechanical apparatus or incorrect management due to improper method of maintaining fixation in post-operative or individual cases. In these days of mechanical advancement we see many devices of strange and wonderful design advocated for the reduction and retention of fractures. Some are very ingenious applications of standard appliances to meet a condition which has arisen in a given case. They might work if one could but apply them, with nothing to bother about but mechanics, but many devices do not take into account the Anatomy of the parts to be treated and consequently cannot be used in any case except the unusual, or the one originally intended.

In the modern treatment of fractures, it seems that frequently the essential factors have been somewhat overshadowed by the emphasis given to certain methods of technique and forms of apparatus, etc., rather than to the application of definite and well

established principles of treatment to the various conditions met with. Many men who are treating fractures today have forgotten the principles taught many years ago by Hippocrates and since used very successfully; instead they will attempt to adapt someone's method or piece of apparatus to their individual case which often may be an improper choice, leading to a greatly prolonged and unnecessary reduction time.

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