HISTORY OF ORTHOPAEDIC SURGERY

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The word Orthopedia was used for the first time as the title of a book published in 1741 by Nicholas Andry, Professor of Medicine at the University of Paris. Andry formed the word Orthopedia out of two Greek words, *orthos* meaning straight, free from deformity and *paidios,* a child. Professor Andry writes "out of these two words I have compounded that of orthopedia, to express in one term the design I propose, which is to teach the different methods of preventing and correcting the deformities of children." In the book there is depicted a crooked young tree attached to a straight staff to exemplify his philosophy. According to Andry, posture and proper muscle balance play a major role in the symmetrical development of the skeleton. Andry studied deformities of the spine, head and neck, and the extremities. "In the absence of trauma or destructive disease—he says—crookedness of the spine derives from asymmetrical pull of the muscles of the trunk." In the prevention of the deformity great attention is paid to postural training when sitting and standing. Proper posture and regular, adequate exercises are to be considered a necessary part of every child's upbringing. Andry advised parents not to bind their babies too snugly to prevent a narrow chest and short clavicles. The child should be fitted with a corset when getting up after an illness requiring prolonged bedrest. Andry observed that the proportion of the length of the trunk to the legs changes with age and that supportive apparatus may be necessary during fast growth in adolescence to prevent spinal deformities.

In the middle ages the deformed and the lame were ostracized from society and considered unfortunate incurables. A concern for the crippled developed gradually only after the radical philosophical and scientific revolutions that occurred in the Renaissance. The crippled was not considered a social problem until the 17th century. In 1601 England established the Poor Relief Act, the first statute enacted by a European government specifically mentioning the crippled and providing to some extent for his care. Thus, the crippled came into community consciousness as a public charge, and the medical profession gave its attention to the cure, prevention, or relief of the lame and deformed body.

The orthopedists of the 17th and 18th century had a large body of knowledge on crippling deformities gathered by Greeks, Romans, and Renaissance physicians. The books of the School of Hippocrates of fractures, and on atriculations contain excellent discussions on the clinical aspects and treatment of fractures and dislocation. A carefully prescribed method of traction was used for reduction of fractures of the long bones. The traction was maintained during the application of the firm bandages or splints until the part was adequately supported. It was important to obtain proper alignment and length of the thigh bone. "For the arm, when shortened,—Hippocrates said—might be concealed and the mistake will not be great, but a shortened thigh bone will exhibit the man maimed." Early mobilization of the fractured extremity was recommended. "It should be kept in mind—he added—that exercise strengthens and inactivity wastes."

The diagnosis and treatment of dislocations was as carefully studied as fractures. The descriptions of shoulder dislocations and their care have become classic. Reduction was effective by traction on the arm with counter traction applied to the axilla using the heel of the operator as we do even today.

Clubfoot was recognized as a congenital deformity and treatment was said to be most effective when applied at the earliest possible time. Repeated manual correction was attempted, with strong bandages applied during the process. Overcorrection was said to be essential and the foot was to be maintained in the position over a long period of time. Later, specially devised shoes were to be worn to prevent a relapse which they knew was more than likely to occur.

Deformities of the spinal column were intensively studied. The deformity could be caused by fractures and dislocations of the vertebrae, or by disease. A possible relationship between the spinal gibbous and pulmonary disease was first suggested in the Hippocratic text on articulations. (Final confirmation of the connection between vertebral disease and pulmonary tuberculosis, however, was to wait for the work of Delpech and the pathologists of the 19th century.) But the Greeks knew that "there are many varieties of curvatures of the spine even in persons who are in good health: for it takes place from natural conformation and from habit and the spine is liable to be bent from old age and from pains." The serious consequences and the possible progression of a spinal deformity, whatever its etiology, were fully appreciated. Although the treatment of a spinal deformity was considered to be usually ineffective, it was always assiduously attempted. Various methods were devised with a view to reducing the visible deformity. The patient was placed in traction on a bench and compression was applied on the gibbous. The extension bench described by Hippocrates has been copied and modified throughout the ages into recent times.

Galen contributed greatly to the understanding of muscle contracture and on the significance of nerve fibers entering each muscle. "The principle of motion comes from the brain and travels through the nerves," Galen said. He called the nerve impulse a vital humor. Galen's contributions to the clinical practice of orthopaedics were few and he followed Hippocrates whose practice he emulated. He's believed to have coined the words kyphosis, lordosis, and scoliosis to connote those deformities described in the Hippocratic text. After Galen there is nothing important in the orthopaedic literature until the 11th century. At that time students from all parts of Europe went to Salerno where the study of anatomy was emphasized as an essential basis for surgical practice. From Salerno came Roger of Parma who wrote near the end of the 12th century the first great book on surgery in Western Medical Literature. In it is found much of the Greek material with little trace of Arabian influence. From Salerno, surgery moved up the Italian peninsula to the newly created University of Bologna in 1113. Bologna still ranks as a foremost center of orthopedic surgery. In Bologna effective and simple braces were devised, such as spinal supports and splints for fractured femurs. Saliceto wrote in 1275 his important book on "Cyrurgia" which is considered to be the best work on anatomy before the Renaissance. Saliceto preferred the scalpel to the cautery and insisted upon cleanliness when operating and the avoidance, when possible, of trauma and manipulation. In Bologna was taught the fundamental doctrine of antisepsis as practiced by the Hippocratic school as well as the avoidance of wound contamination.

Later, Guy de Chauliac (1300–1368), a Professor at the University of Montpelier, wrote in his book "La Grande Chirurgie" on the use of weights and pulleys for continuous traction in the treatment of fractures of the femur.

During the 15th and 16th centuries there was a complete review of anatomy based upon meticulous dissection of the human body. Leonardo da Vinci (1452–1519) was the leader of the scientific method of research which culminated in the work of Vesalius. Leonardo was a student and later an instructor of anatomy, and he made many original observations concerning the origin, insertions, and functions of the muscles of the human body. He evolved two important principles of muscle function; mechanical leverage and synergistic action upon which muscle balance depends. Leonardo worked assiduously for many years with his teacher, a very prominent anatomist, Marc Antonio della Torre. Leonardo's "Quaderni dan'Anatomia" was lost for 200 years. In the 18th century William Hunter discovered portions of this work in the British libraries and more was discovered in Italy. Most are now in the Royal Library at Windsor. Great anatomists contributed to the advance of this science, among them are Vesalius, Falopius, Servetus, and Eustachio. The work of Vesalius at Padua "De humani corporis fabrica," published in 1543 is a landmark in the history of medicine; books I and II, on bones, ligaments, and muscles have figures of superlative excellence and accuracy.

Following the Renaissance many hospitals were built in Europe to house the sick and the crippled. Skeletal deformities were treated by massage, manipulation and braces. Frances Glisson wrote in 1650 an important monograph on rickets. Glisson also described patients with achondroplasia which he considered to be fetal rickets. In his monograph there is a clinical description of infantile scurvy. Spinal deformities were apparently very common and most were thought to be due to rickets. Spinal caries is often termed Pott's disease; Pott in 1779 did not describe the disease or its tuberculous nature but only the deformity and its sequelae. The tuberculous nature of the gibbous had been surmised by Hippocrates and also by Galen and was finally established by Delpech.

Although much effort was devoted to the treatment of skeletal deformities with Orthopedic apparatus, real progress would come only from the discoveries in anatomy, physiology, chemistry, pathology, and from the understanding and control of infectious diseases.

Hieronymus Fabricius studied at Padua where he succeeded his master Gabriel Fallopius as teacher of anatomy and surgery. Fabricius (1537–1619) was the author of the first illustrated work on embryology and he depicted the valves in the veins. He described an apparatus for the correction of torticollis and another for the gradual reduction of the gibbous. He did not accept the Hippocratic suggestion of forcible correction of spinal deformities, and advocated the use of gentle manipulation with repeated adjustments of the spinal brace. William Harvey studied under Fabricius. His discovery of the circulation of the blood in 1628 had been paved by the discovery of the valves in the veins by Fabricius and by that of the lesser circulation by the Catalan Servetus. Harvey's work was the basis of modern rational medicine.

With a rudimentary microscope, the Dutch Anton Van Leeuwenhoek observed the striped character of muscle and its sarcolemma. Toward the end of the 17th century, Baglivi noted the existence of two types of muscle tissue, the striped and the smooth. This century saw the rise of the physical sciences, and physicists were successful in giving mathematical expression to mechanical events. The Italian physicist Alphonso Giovanni Borelli (1608–79) was a pupil of Galileo. In his book "De Motu Animalum", published in Rome in 1608, Borelli investigated the action of muscle contraction on bones of man and animal. His analysis evolved into a system describing the mechanics of walking, running, jumping, weightlifting, birdflight, fish motion, and insect creeping. He was a representative of the iatrophysicists, who explained animal activity and physiology as rigid consequences of the laws of physics and mechanics. Thus, heartbeat was a simple muscular contraction, and the circulatory system was hydraulic in principle. Steindler, who introduced the study of biomechanics to American Orthopedics, referred to Borelli as "the real founder of modern kinetics".

Thomas Sydenham of London, in the second part of the 17th century, studied the natural history of disease, thus reviving the interest of the Hippocratic school of medicine in early Greece. He described accurately gout as well as scurvy which was frequently epidemic at that time among the crews of sailing vessels.

Clinical teaching was first instituted at the University of Leyden in 1636, and the medical school attained a reputation which rapidly surpassed even that of Padua. Herman Boerhaave was first appointed a teacher in Leyden in 1701 and established the modern method of "bedside" teaching and medical instruction.

Clopton Havers of London studied in the University of Utrecht, another famous Dutch university of that period and applied himself to the investigation of bones and joints. His book "The Osteologia Nova" contains the first description of the microscopic appearance of the articular cartilage and the internal architectural of bone, including the first account of the vascular canals of long bones known as the Haversian canals. He did not recognize, however, their vascular contents. Although he was a contemporary of Harvey, Havers did not comprehend the new theory of circulation but retained the traditional conception of animal spirits. Havers made original observations on the structure of cartilage and on the presence of mucilaginous material in the cells of the synovial membrane.

Albreght Von Haller studied at Leyden with Boerhaave in 1763 and wrote a most comprehensive treatise of eight volumes on "Elements of Physiology of the Human Body" which appeared in the middle of the 18th century. Haller investigated the tendency of the muscle fibers to shorten with any stimulus, and afterwards to expand again to their normal length. This capacity for contraction Haller called irritability: "a very slight stimulus produces a movement altogether out of proportion to itself and continues to do this repeatedly as long as the fiber remains alive." Haller noted that stimulus of the muscle contracture came by the nerves. Haller also showed that the tissues themselves are not capable of sensation, but that the nerves are the sole channels or instruments of this process. In his book "Experiments on the Formation of Bone" published in 1763, Haller describes the growth of bone in fowl embryos and young chicks. The bone forms not from the periosteum, but from the soft cartilaginous tissue and from those tissues that surround the primordial nucleus of ossification. Haller also studied healing fractures in chickens and pigeons and observed the exceptional vascularity of the reparative tissues about the fracture and finally ascribed actual osteogenic properties to the newly formed vessels. To Haller, who lived almost a century before the introduction of cellular histology, bone was a substance deposited in tissue rather than the product of local cellular activity.

In the 18th century a new chapter of physiology was opened by the extension of the knowledge of electric phenomena to the living body. Galvani of Bologna, while investigating the susceptibility of nerves to irritation in 1791, showed a correlation between muscle twitching and simultaneous contact with both iron and copper. He was, in fact, producing an electrical current. Volta of Pavia demonstrated that the muscle can be thrown into continuous contraction by repeated electric stimulations. Duchenne de Boulogne published in 1855 his basic book on "L'electrisation Localissée" where he described with utmost precision the action of muscles as detected by localized electrical stimulation. He opened a new chapter in muscle physiology, pathology, and the treatment of paralysis.

Post mortem examinations were rarely done before Giovanni Battista Morgagni who was Professor of Anatomy at Padua for 56 years. In his 79th year, in 1761, he published his vast experience on the clinical history of the patient, the history of his disease, and the events in connection with his illness and death. In his book, "De Sedibus et Causis Morbosum" (On the Seats and Causes of Disease) conditions of the organs at some 700 post mortem examination are minutely described; and the findings are correlated with the clinical history. Morgagni introduced the necessity of basing diagnosis, prognosis, and treatment on a knowledge of anatomical lesions.

The study of the anatomical specimen was introduced into surgery by John Hunter in London. With Hunter (1728–93), surgery became a "real" science, replenished with ideas drawn from comparative anatomy and pathology. Hunter's approach was based on Hippocratic principles. He stated, "the only rational means of treatment are those which are based on the natural recuperative power of the body." He ruptured his Achilles tendon while dancing and observed that the proximal portion was retracted a considerable distance and the gap between the ends became breached by simple connective tissue which supplied sufficient strength to restore good function to the ruptured tendon. His monument is the Hunterian Museum in London. It contains the few specimens which survived the German bombing in World War II.

In 1736 John Belchier reported to the London Philosophical Society that when madder was fed to pigs and their bones were later examined, newly formed bone was stained red while established bone remained unstained. Before Belchier, Duhamel had made similar observations. This experiment became fundamental to all later research on bone growth and development. In more recent times, the dye alizarine, first extracted from madder, has supplanted the root in the laboratory. While studying osteogenesis, John Goodsir from the University of Edinburg observed in 1845 that the formation of osteoid tissue and callus was a direct effect of the activity of the osteoblasts in the periosteum. Later on, William Macewen from the University of Glasgow thought that the periosteum possessed no osteogenic property, whereas Ollier in Lyon, France, in 1867 demonstrated the importance of the osteogenic property of the periosteum and thought it was important not to damage this structure during surgery for internal fixation of fractures.

Rudolph Virchow in the 19th century exerted a very important influence on medical thoughts. His achievement was the extension of the cell concept to diseased tissues. His "Cellular Pathology" published in 1858 analyzed such tissue from the point of view of cell formation and cell structure. He described the underlying genetic identity of bone, cartilage, and connective tissue cells and named "osteoid" the tissue seen in rachitic bone. Virchow's work complemented the pathological studies of Morgagni and John Hunter with histological observations.

A breakthrough in the history of medicine occurred in 1796 when Edward Jenner demonstrated that a condition known as cowpox gave immunity for smallpox. Vaccination opened a new world with the study of immunity to disease. One and a half centuries later, infantile paralysis was controlled with a vaccine and the orthopedic surgeons were freed from a great load of work in their practice.

The germ doctrine of disease has been the central triumph of medicine during the last 100 years. The work of Pasteur, Koch, Hansen, and Ehrlich as the founders of bacteriology is well known to all of us. Many infectious diseases were associated with their organisms at about the same time near the last quarter of the 19th century. It was then, too, that the scientific study of immunity took great strides, and many infectious diseases were well studied and some were controlled with "active or passive" immunity. With Lister's development of antisepsis and later on asepsis, surgery finally was made safe. The discovery of ether anesthesia in 1846 by William Morton made surgery painless. Through the centuries, orthopedic surgery has been of utmost importance to the army surgeon. Thus a treatise on the history of orthopedics must include a review of the treatment of war wounds.

The introduction of cannon shot in the 14th century marked the beginning of a new type of war wound often with extensive injuries to the skeleton. In Spain during the siege of Málaga in 1487, Queen Isabella organized the first field hospitals, known as ambulances, set up in support of armies in action. Ambrose Paré made the greatest contribution to surgery in the 16th century. He served three kings of France, and wrote an important treatise on surgery, "Ten Books of Surgery." He possessed great surgical skill. He advocated the introduction of maggots in suppurating wounds when he was acting as a surgeon in the army of Henry II. He published the first case of a bullet imbedded in the spinal cord. He described the use of ligatures of the veins and arteries when amputating an extremity. Paré insisted upon the necessity for cleanliness in all operative work and recommended the enlargement of the wounds and the removal of all foreign bodies. He used traction for reduction of fractures and splints for their immobilization. He devised a large number of corrective apparatus such as corsets and metal to be used for spinal deformities, splints for fracture work, walking splints for hip disease, and several types of shoes for clubfeet.

It was not until 1731 that Mareschal founded the Academy of Surgery in Paris, which 11 years later obtained the same rights and privileges as the Faculty of Medicine. Under his influence there was founded in Russia and Austria educational institutions for military doctors which contributed greatly to the diffusion of medical knowledge among the surgeons of that day. The medical services in the armies of Napoleon were efficiently organized by two notable military surgeons, Pierre Percy and Dominic Larrey. Larrey was gifted with great manual dexterity and operated with extreme rapidity. The wounds were debrided widely but the death rates in the hospitals in the Napoleonic Wars in 1813 and 1814 exceeded 28%. During the Franco-Prussian war of 1870 Ollier made his first observations on the treatment of wounds by the use of the occlusive method. This method was essentially the same as that which half a century later was to be made known by Winnett Orr throughout the world. About this time Joseph Lister introduced antisepsis and later asepsis and made possible the exploration of new fields of surgical technique. John Hunter considered that war wounds vary considerably. The small wound of entry of a bullet may not need to be debrided, whereas a large wound must be explored and thoroughly cleaned.

In World War I, the surgeons at first tended to make wide incisions for debridement and used a variety of antiseptics. Carrel used continuous hypochlorite irrigation by which a sterilization of the wound was achieved with a minimum of disturbance of the healing process. Secondary suture was used on a wider scale, often with disastrous results with later sepsis. In the later stages of the war, two surgeons from the United States, William Baer and Winnett Orr, began detailed studies of certain therapeutic principles which at that time were not generally known or accepted. In Spain, the war of 1936–39 made possible a large scale practical application of the suggestions put forward by these American surgeons. Orr stated that rest is as important to the healing of the wounds of soft tissue as it is for the healing of broken bones. To evacuate soldiers with open wounds and fractures from Europe to the United States, he dressed the wounds with Vaseline gauze and covered them with a plaster cast applied to the affected extremity. In most instances, when the soldiers arrived in the States, the wounds were much improved and healed. Following the war, Orr published his cases of compound fractures treated by wound excision and immobilization in plaster. He extended these principles to the treatment of osteomyelitis.

In the Spanish War, Trueta introduced Orr's technique with some modifications that decreased mortality in the hospitals to 0.6%. The wounded extremity was thoroughly washed with soap and water with a nail brush until the wound itself was bleeding. The skin edges of the wound were excised as well as old contused tissue, and the wound was widened as much as required. Nonviable muscle and connective tissues were thoroughly removed as well as all foreign organic matter. Once the fracture was reduced, the wound was dressed with gauze and the extremity was immobilized in a plaster cast including the two adjoining joints. In wounds with deep cavities, drainage was provided by opening up the aponeurotic planes and the intermuscular spaces. This drainage was maintained open by the insertion of sterile gauze or a rubber tube. Retained discharge, which is the result of bad drainage, may bring about disaster. This same treatment was widely used in World War II and in Korea and Vietnam. The use of antibiotics greatly enhanced survival rate in these wars and made successful "delayed primary wound closure" and early skin grafting of the wounds feasible. Modern vascular surgery was first applied in the Korean war and contributed greatly to the decrease of the amputation rate of severely wounded extremities.

Improved surgical techniques and applied bioengineering have changed the practice of orthopaedic in the past 50 years. Probably the most successful innovation has been the improvement of the hip arthroplasty with a total hip replacement designed by Professor John Charnley of the University of Manchester, England. Charnley replaced the head of the femur with a metallic prosthesis of small size to reduce the "moment" of frictional force. This prosthesis is used in combination with a low friction plastic socket. He developed a self curing acrylic cement to anchor both the femoral replacement and the acetabular high-density polyethylene socket. In developed countries, total hip replacement is used very often for the treatment of patients with osteoarthritis of the hip and other hip ailments. The operation has been very successful in providing relief of pain and good hip motion for several years following surgery.

Internal fixation of the skeleton for treatment of fractures has been greatly perfected with the use of plates and screws and other devices made of inert metallic alloys. The three-phlanged nail devised in 1931 by Smith Petersen of Harvard represented an important advance in the treatment of fractures of the neck of the femur. Intramedullary nailing for fractures of the shaft of the femur with the Küntscher nail was used extensively during the second World War, and it is a successful method of treatment of femoral shaft fractures in clinical practice. Internal fixation of the shaft fractures interferes, however, with the natural fracture callus formation and delays the healing of fractures. In the hands of a good surgeon, internal fixation of articular fractures greatly improves the results. Internal fixation of fractures not involving the joints is possibly not better than the judicious application of plaster of Paris bandages which can successfully immobilize the injured extremity and allow for weight bearing and functional use of the injured extremity. Plaster of Paris, by the way, was first introduced by Mathijsen in 1852, a Flemish army surgeon. Plaster of Paris successfully replaced traditional splints made of a mixture of egg white, gums, and resins.

When I came to Iowa City in 1941, a large number of patients in the Orthopaedic Department had diseases which are today practically unknown— namely residuals of poliomyelitis, tuberculosis of bones and joints, and osteomyelitis. Skeletal tuberculosis decreased considerably in Iowa during the 1930's owing to the destruction of cattle infected with tuberculosis. The disease was nearly completely eradicated in the late 1940's with the advent of streptomycin. Osteomyelitis was also controlled in the 1940's with the advent of penicillin although it is still seen, mainly as a complication of open fractures. Poliomyelitis disappeared in the early 1950's with the advent of the polio vaccine.

Originally, the orthopedist primarily was concerned with the care of the crippled child; now they have to deal with a number of poorly understood disorders of growth and development of the skeleton, degenerative arthritis, and congenital deformities. Now the specialty occupies a prominent role in all modern hospitals throughout the world. The American Academy of Orthopaedic Surgeons has over 12,000 members. The Academy defines orthopaedic surgery as "the medical specialty that includes the investigation, preservation and restoration of the form and function of the extremities, spine and associated structures by medical, surgical, and physical means." The Academy's seal of office is the crooked tree in Andry's book.

Henry Mankin, Professor of Orthopaedics at Harvard, stated that "future changes in orthopaedics will be based in biology and more specifically in our ability to understand and alter the basic unit, the cell." Much effort is being devoted to the study of the skeletal connective tissue cell and their matrices. The electron microscope, x-ray diffraction, and other instrumental analyses have allowed detailed examination of cells, cell organelles, and extracellular matrices of fibroblasts, chondrocytes, osteoblasts, and osteocytes. Much has been learned of the function of these cells and of the composition of the extracellular matrices, particularly of collagen and proteoglycans through the efforts of biologists and biochemists, but much remains to be done.

SUGGESTED READING

(These books can be found in Dr. Martin's Rare Book Room in the Hardin Medical Library at the University of Iowa.)

1. Andry, Nicolas: L Orthopédie. Paris, 1741.

2. Hippocrates: a) Opera Omnia Quae Extant. Frankfurt, 1595. b) The Genuine Works of Hippocrates, by Francis Adams, London, 1849

3. Delpech, Jacques Mathieu: De l'orthomorphie. Paris, Gabon, 1828.

4. Galen: De Ossibus. Lyon, 1549.

5. Saliceto, Gulielmus de: La Ciroxia Vulgarmenta Fata. Venice, Fide Pierto, 1474.

6. Guy de Chauliac: La Grande Chirurgie, Rouen, 1615.

7. Leonardo da Vinci: Quaderni d' Anatomia. Christiania, 1911-1916.

8. Vesalius: "De Humani Corporis Fabrica". Basel, 1543.

9. Glisson, Frances: Fractures de Rachitide Sive Morbo Puerili. The Hague, 1682.

10. Farbricius, Hierouyums: Opera Omnia Anatomica et Physiologica. Leyden, 1738.

11. Harvey, William: De Motu Cordis. Frankfurt, 1628.

12. Borelli, Alfonso Giovanni: "De Moto Animalum". Rome, 1680.

13. Sydenham, Thomas: Opera Omnia. Geneva, 1716.

14. Havers, Clopton: Osteologia Nova—or New Observations of the Bones. London, 1691.

15. Haller, Albreght von: "Experiments on the Formation of Bone". London, 1763.

16. Haller, Albreght von: Elementa Physiologiae Corporis Humani. Lausanne, 1757.

17. Duchenne de Boulogne: "De L'electisation Localisée," Paris, 1872.

18. Morgagni, Giovanni Batista: "De Sedibus et Causis Morbosum" (on the Seats and Causes of Disease). Venice 1761.

19. Hunter, John: A Treatise on the Blood, Inflammation and Gun-shot Wounds. London, 1794.

20. Virchow, Rudolph: "Cellular Pathology". Berlin, 1858.

21. Ollier, Xavier: Osteogenic Property of the Periostium. Paris, 1867.

22. Paré, Ambrose: Opera Chirurgica. Frankfurt, 1594.

23. Dupuytren, Guillaume: Clinical Lectures. Paris, 1832-1834.

24. Pott, Percivall: Some Few General Remarks on Fractures and Dislocatons. London, 1769.

25. Steindler, Arthur: Mechanics of Normal and Pathological Locomotion in Man. Springfield, Ill., 1935.

26. Orr, Winnet: Osteomyelitis and Compound Fractures and Other Infected Wounds. St. Louis, 1929.

27. Trueta, Josep: Treatment of War Wounds and Fractures. London, 1939.