THE YEAR BOOK *of* ORTHOPEDICS *and* TRAUMATIC SURGERY

(1958-1959 YEAR BOOK *Series)*

EDITED BY

EDWARD L. COMPERE, M.D., F.A.C.S., F.I.C.S.

Professor and Chairman, Department of Orthopedic Surgery, Northwestern University Medical School; Chairman, Department of Orthopedic Surgery, Chicago Wesley Memorial Hospital

With a Section on

PLASTIC SURGERY

EDITED BY

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PLASTIC SURGERY

INTRODUCTION

"Organized negligence is the cause of most hospital infections." This was the challenging opening statement of one member of a Panel which discussed antibiotics as related to surgery at the Southeastern Regional Assembly of the United States Section of the International College of Surgeons meeting in Miami Beach January 4-7, 1959. The alarming increase in the incidence of infections of the wounds following elective operations of supposedly "clean cases" has demanded careful study of all operating room technics. The tragedy of bacterial invasion of the wound after open reduction of a fracture or any other operation on the bones or joints of a patient almost defies description. Most of these infections are caused by antibiotic-resistant staphylococci which are more often found in the nose or throat than on the skin of the patient or of a member of the surgical team.

Greater care must be taken to cover adequately the nose and mouth of each person who enters an operating room. This must include the patient, the surgeon, the anesthesiologist, residents, interns and nurses. Cultures should be made of the nose and throat of each patient and, at regular intervals, of each member of the operating room teams. Those who are found to be persistent carriers of strains of virulent streptococci or staphylococci should be barred from the operating room until it can be shown definitely that they are no longer harboring these organisms which have proved to be so grave a threat to the life or limb of patients.

Improved prostheses of vitallium or stainless steel, better operative technics and more careful selection of cases for prosthesis arthroplasties of the hip appear to be the answers to the question of how to obtain a high percentage of satisfactory end results. An accurate fit of the metal femoral head in the acetabulum has been shown to be a primary factor in preventing erosion and wearing away of the weight-bearing area of an acetabulum.

Care of the diseases or injuries of elderly patients requires more and more time of the orthopedic surgeon. Senile osteoporosis of the spine and malignant tumor metastases to the weight-bearing bones produce pain and pathologic fractures. The great decrease in the number of patients crippled by tuberculosis, pyogenic osteomyelitis, nutritional deficiency diseases and poliomyelitis has been compensated for many times over by the greatly increased number of patients with fractures and other injuries of the spine and extremities resulting from accidents on the highway, in the factory and in the home. The orthopedic surgeon, reluctantly or willingly, is ever increasingly becoming a surgeon of trauma.

This is the twelfth volume of the YEAR BOOK OF ORTHOPEDICS AND TRAUMATIC SURGERY that I have been privileged to edit. For me, this has been a most wonderful and valuable experience. Only because of increasingly heavy commitments in connection with my duties as Professor and Chairman of the Departments of Orthopedic Surgery at Northwestern University Medical School, Chicago Wesley Memorial Hospital and the Veterans Administration Research Hospital, and as an officer of various surgical societies, have I decided that I must relinquish this editorship. It gives me much pleasure to be able to announce that my successor will be Dr. Ralph K. Ghormley, Emeritus Professor of Orthopedic Surgery of the University of Minnesota and Emeritus Chairman of the Division of Orthopedic Surgery of the Mayo Clinic. Dr. Ghormley is a world-renowned orthopedic surgeon and scholar. I predict that under his direction this YEAR BOOK will become the most widely read reference book of the orthopedic surgeons of the world.

I again call to the attention of our readers the excellent section on Plastic Surgery edited by Dr. Neal Owens, Professor of Clinical Surgery at Tulane University School of Medicine. This is the second volume in which this section has been added to the YEAR BOOK OF ORTHOPEDICS AND TRAUMATIC SURGERY. Comments received about this section have been most favorable.

EDWARD L. COMPERE

ANATOMY, EMBRYOLOGY, PHYSIOLOGY AND PATHOLOGY

Anatomy of Joints of Spine is reviewed by Walter M. Dörr[1] (Univ. of Heidelberg). The ligamentum flavum connects the vertebral arches which support the articular and other processes and have a characteristic structure in the lumbar area. Between the lateral margin of the yellow ligament and the margin of the vertebral arch there is a recess which is connected with the joint space and is actually an extension of it. The recess is bordered by the yellow ligament anteriorly and by the vertebral arch and its margin posteriorly and superiorly, respectively; laterally it is closed by fatty tissues. These recesses are located along the lumbar spine and on the lowest thoracic vertebra. They measure about 4-6 mm. in height. Besides this superior recess of the joint space, there is often an inferior recess in the upper or lower lumbar area or along the entire lumbar spine.

In the cervical spine, a mucous sac stretches between the vertebral arches from the vertebral joint to the interspinous ligament. About 3-4 mm. in height, it is bordered superiorly and inferiorly by the vertebral arches, anteriorly by the yellow ligament and posteriorly by a membrane covered with fatty tissue. On the side facing the vertebral joints there is a thin membrane between the joint cavity and mucous sac. This membrane usually contains a pinpoint opening through which the joint cavity and mucous sac communicate. No mucous sac was found between the occiput and atlas or between the atlas and axis.

The author found three types of articular disks. The first type was coarse, poor in vessels or even avascular; the second was loosely built, fatty and vascular; and the third type, found in the lumbar area, was larger than the other two and contained vessels and vascular tissues. In addition to these disks, there were small, barely visible villi in the joint recesses. It is suggested that the first type be named menisci, the second either meniscus-like structures or simply joint folds and that the third type be known as fat bodies similar to those found in the knee joint.

(1) Arch. orthop. u. Unfall-Chir. 50:222-234, 1958.

The joint disks are believed to have two functions: mechanical protection of the joint surfaces and volume equalization by space variations in the joint cavities.

Histologic Changes in Joint Capsule in Congenital, Traumatic and Paralytic Dislocation of Hip were studied by Margret Lange[2] (Univ. Orthopedic Clinic, Munich). The capsule of the hip joint is subject to various influences and changes. It may elongate and assume the form of an hourglass or may appear flat and stretched. It may also contract, shrink and shorten. Its inner surface may enlarge by increased villus formation, leading to increased exudation and resorption.

The rich vascularity of the synovia explains the effective response of the joint capsule to inflammatory or chronic, mechanical stimuli (pressure, traction and shearing). In the fibrous layer, and especially in the synovial layer, perivascular lymphocytic extravasations and localized and diffuse accumulation of lymphocytes were often seen. The capillary network of the joint capsule usually responds to irritation by increased vascularization. In capsular degeneration, the vessel walls often show fatty degeneration of the intima. Endangiitis obliterans of the arterioles, leading to histolysis, was seen in several capsules.

The many nerve endings in the joint capsule account for pain in joint injuries and in certain diseases of the capsule. In long-standing and severe injuries, fatty degeneration takes place in both parts of the capsule. In paralytic hip dislocations, the normal tissue structure is replaced almost completely by severe fatty degeneration.

Several capsules showed implants of cartilage and bone trabeculae, proving the ability of the capsular connective tissue to turn into cartilage and bone.

The capsule of the hip joint is able to compensate strongly by increasing its thickness four or five times. Its regenerative power is also pronounced.

Electron Microscope Studies of Crystal-Collagen Relationships in Bone: IV. Occurrence of Crystals within Collagen Fibrils was investigated by Huntington Sheldon and Robert A. Robinson[3] (Johns Hopkins Univ.). Earlier electron microscope studies revealed the existence of crystals

(2) Ztschr. Orthop. 90:270-299, 1958.
(3) J. Biophys. & Biochem. Cytol. 3:1011-1016, Nov. 25, 1957.

within the collagen fibrils of bone matrix. In fully calcified bone matrix there are no areas which are not replete with crystals. This finding indicates that there should be a deposition of crystals not only at the periphery of the fibrils but also within them. The position of the crystals along the collagen fibrils was shown by Jackson in sections from incompletely calcified embryonic avian bone. Referring to the longitudinally oriented collagen fibrils with attached crystals, she suggested that the section plane may pass through the fibrils. This implies that crystals could lie within the fibrils.

In studying calcifying mouse bones with cancellous bone spicules, the authors found that new calcification of bone matrix occurs at the periphery of bone spicules in normal animals. A layer of osteoblasts overlies the calcified spicule and the layer of calcifying bone matrix. In hematoxylin-stained sections for light microscopy osteoblasts are seen to have an intensely basophilic cytoplasm. In the electron microscope this cytoplasm appears to contain densely packed, lamellated intracellular membranes, most of which appear to have small granules attached to their outer surfaces. Such membrane systems have been variously referred to as ergastoplasmic sacs, rough-surfaced elements of the endoplasmic reticulum and alpha cytomembranes. These membranes have been reported as a cytoplasmic component of most cell types and seem to be most prominent in cells that elaborate protein. The arrangement and abundance of these granular membranes in the osteoblast most nearly corresponds to the appearance of this component in the acinar cells of the pancreas. The space between the smooth appositive surfaces of the granular membranes appears to contain an amorphous substance which is more dense than the embedding medium. The relation of the cell surface membranes to the amorphous substance between the appositive surfaces of the granular membranes and to the extracellular collagen fibrils is particularly difficult to delineate.

The osteoblast is invariably separated by a small distance from the calcified matrix. This area contains physiologic osteoid or matrix which is becoming calcified. In this area there are varying amounts of collagen fibrils and of opaque interfibrous substance and varying numbers of crystals indicating calcification. In normally calcifying bone matrix, collagen fibrils appear to be vested with an opaque coating a short distance (less than 0.5 μ) from the osteoblast. Then within an exceedingly short distance these coated fibrils appear associated with inorganic crystals, and the matrix is calcified. This has been referred to as the calcification front.

Occasionally two osteoblasts may overlie one another. Between such cells collagen fibrils are seen. In such an area, separated by one cell from the calcification front, small crystals may be seen occasionally. Near the calcification front crystals are seen most commonly at the periphery of fibrils, between tangential fibrils or in crystal aggregates sufficiently large to obscure underlying fibrils.

Ultrastructure of Bone: Technic of Microangiography as Applied to Study of Bone: Preliminary Report is presented by Lowell F. A. Peterson, Patrick J. Kelly and Joseph M. Janes.[4] Injection into the specimen must be as nearly complete as possible. The injected material must have sufficient contrast on the x-ray film to be easily distinguishable, and there must be no disturbance from the bursting of small vessels caused by excessive pressure. Once the injection is made, the contrast medium must remain in the vessels instead of diffusing through the vessel wall. This requirement cannot be met, of course, where the endothelial lining is incomplete. Appropriate fixatives limit diffusion of very fine injection mediums to a tolerable level for many tissues. With large specimens, diffusion is marked when a medium such as a 25% suspension of thorium dioxide (Thorotrast) is used. In general, varying forms of barium sulfate, e.g., Micropaque, or freshly precipitated barium sulfate suspended in gelatin solution, have been most useful for study of the vascularity of cancellous bone, and Thorotrast has worked best in the study of cortical bone. A microangiogram made by the following method is shown in Figure 1.

TECHNIC.—Animals are prepared for injection by anesthetization with pentobarbital (Nembutal®), heparinization and exsanguination through the carotid artery. The hindquarters are perfused with an isotonic solution to which a vasodilator has been added. When the perfusion is seen to have removed the blood adequately from the hindquarters, as determined by the character of the outflow, the contrast medium is injected. When Thorotrast is used, the limbs are not perfused before injection. Runoff of the injection medium into the venous side of the circulation may be prevented by ligation of the outflow at the desired time before completion of the injection. Injection pressures are measured continuously; no one pressure is suitable for

(4) Proc. Staff Meet. Mayo Clin. 32:681-686, Nov. 27, 1957.

all purposes. In general, though, physiologic pressures are often sufficient. When heavier concentrations of barium sulfate are used, it is at times necessary to exceed physiologic pressures somewhat to achieve more constant filling of the vessels.

When suspensions of barium sulfate are employed as the injection medium, 10% formalin is used as the fixative. After thorough fixation the bone is cut on a milling machine in sections 1 mm. thick and decalcified in 15% formic acid. Thereafter, the sections may be kept in 10% formalin. The frozen-section method is used in making slices

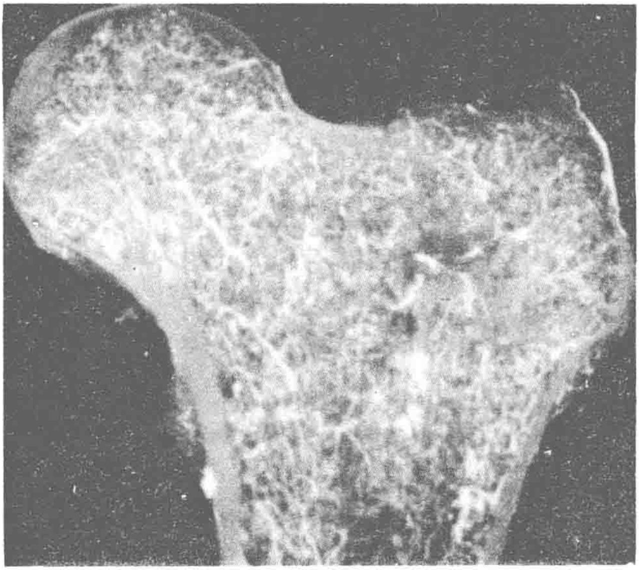

Fig. 1.—Microangiogram of section 1 mm. thick from femur of dog showing epi- and metaphysial arteries, epiphysial scar and vascular arcades in head of femur. (Courtesy of Peterson, L. F. A., *et al.*: Proc. Staff Meet. Mayo Clin. 32:681-686, Nov. 27, 1957.)

of soft tissue or of decalcified bone into which injection has been made.

Target-film distances vary from 14 to 22 cm. Empiric determination of exposure data is essential; however, at a distance of 14 cm. with a specimen of decalcified bone 1 mm. thick, generally an exposure of 7-8 minutes is required at 20 kv. and 25 ma. Kodak high-resolution plate or spectroscopic plate, 649-GH, is the film used. The specimen is placed between two layers of Mylar, a Du Pont plastic available in varying thicknesses, to prevent curling of the specimen due to drying and also to provide close contact by means of a vacuum between the specimen and the photographic emulsion. The plastic layer on the top portion of the specimen is the layer that applies the pressure to the specimen holding it against the photographic emulsion.

The films are developed according to the manufacturer's directions with D-19 developer and acid fixative. Slight overexposure of the film is attempted; it is underdeveloped to keep grain size minimal. This has not resulted in marked decrease in contrast. After the films are washed the emulsion is immediately covered with a glass cover slip in a manner similar to that used for histologic sections. This protects the emulsion and aids cleaning of the slides. Best results are obtained when all solutions are filtered and kept in clean, covered, glass utensils. Constant agitation during development is helpful in reducing adjacency effects of the photographic emulsion. Stereoscopic views can be produced by taking microradiograms or microangiograms at two different angles and then viewing these with a microstereoscope or enlarging them by photomicrographic methods and viewing with a prismatic stereoscopic apparatus.

Ultrastructure and Function of Bone are discussed by Franklin C. McLean[5] (Chicago). The unit of bone structure at the microscopic level is the haversian system, or osteon. This is an irregular cylindric, branching structure with thick walls and narrow lumen known as the haversian canal. This canal carries one or more capillaries and venules. The cylindric osteons are usually oriented in the long axes of bones. Their basic structure consists of concentric layers, or lamellae, the fibrils of each lamella extending spirally to the axis of the canal. The osteon, in addition to its canal and fibrillar structure, includes many lacunae that house the cells of bone (osteocytes) and interconnect with one another and with the lumen by branched canaliculi. In cross-section, the osteons average about 150 μ in external diameter, whereas the canal may not measure more than 20 μ in diameter. In length, the osteons commonly extend several millimeters.

An osteon is formed by deposit of layers or lamellae of fibrillar bone matrix on the walls of a cylindric cavity or tunnel, with subsequent mineralization of the lamellae. After an osteon has been fully mineralized, it loses some of its ability to react with body fluids, mainly because its constituents are less accessible to the circulating fluids. Throughout life, compact bone undergoes a process known as haversian remodeling. This insures a constant supply of reactive bone accounting for less than 1% of the total bone mass. This reactive bone gives the skeleton its function as a tissue.

Electron microscopy of bone is aided by both high and low angle x-ray diffraction. High-angle diffraction, particularly with microdiffraction technic, lends valuable assist-

(5) Science 127:451-456, Feb. 28, 1958.

ance to the study of crystallographic properties of bone tissue. Low-angle diffraction reveals information about the dimensions of the particles and their orientation. Microradiography requires the passage of x-rays through thin sections so that differences in absorption of radiation can be recorded on photographic film. Whereas ordinary histologic sections of bone do not show differences in the density of individual osteons, differences are clearly demonstrated in microradiograms. The younger osteons appear less mineralized and, consequently, less dense than the older ones. Attention has thus been focused on the mineralization of osteons, for it is readily demonstrable that the new and less dense osteons account for most of the uptake of radioactive calcium, strontium and phosphorus.

Results obtained in the study of normal bone tissue by microradiography have been confirmed by microinterferometry. Also, microinterferometric measurements made on decalcified sections have shown that the content of organic material varies little in osteons, indicating that the differences seen on microradiographs depend solely on degree of mineralization. The polarizing microscope also gives new and valuable information about the ultrastructural organization of calcified tissue.

Most protein present in bone is collagen, which is responsible for about 95% of the dry fat-free organic content. It occurs in fibers about 800 A. wide, of indeterminate length, characterized by dense cross-banding at intervals averaging about 640 A. and is generally oriented in the long axes of bones. It is in an organic crystalline form capable of refracting x-rays.

The other organic material of bone, about 5%, is termed "ground substance" and fills the spaces between the collagen fibers and crystals of bone mineral. Electron microscopic observations indicate that the ground substance has its own organization and ultrastructure. The interconnection of the ground substance with tissue fluid, by virtue of which the two exist as a continuum, permits exchange of ions and other substances with the blood. Chemically, the ground substance consists of protein and carbohydrates. The crystals of bone mineral are hexagonal tabular forms, a few hundred angstroms in length and breadth, with a thickness of only a few unit cells.