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THE CLINICAL SIGNIFICANCE OF THE OSSEOUS SYSTEM

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MONROVIA

According to Webster's International Dictionary, the skeleton is "the bones of a human being or other vertebrate collectively; the bony or more or less cartilaginous framework supporting the soft tissues and protecting the internal organs." Such is the general concept of the skeleton. The skeleton is much more than this. It is a dynamic structure which functions throughout life. Its physiologic functions are multiple and have been long recognized, but they have failed to impress clinicians as they should.

The skeleton is a mineral storehouse. This fact is well understood by toxicologists as in case of lead poisoning.[1] The elimination of such poisons from the body requires that the osseous system receive due consideration. Its function as a blood building organ is well known. The fluidity of its mineral content, and its relationship to the electrolytic, hence physiologic balance is of prime importance.[2, 3] But to many, the dictionary definition of its being a supporting tissue states its most important function, and fractures and their repair are apt to overshadow its important medical aspects.

In this discussion I wish to lay particular stress on the bones as living organs. They possess not only the function of being supporting tissues for the muscles and organs, but they are also dynamic units whose biological efficiency must be in proportion to the functional activity of the body as a whole. The size of the skeleton, as compared with the size of the body, the density of the bones and the appearance and time of closure of the epiphyses is of great clinical significance.

From anthropologists standards of size for bones of the ancient Peruvians are obtainable,[4] and are relatively constant for a given age and sex. Data are available for other primitive people;[5] but for the optimum size of growing bones of American boys and girls, reliable figures are surprisingly lacking. In considering the size of bones at the present time, it is necessary to speak more from clinical impressions than from the actual data of controlled statistical analyses.

If we were to compare two children of the same age, one born under best obtainable rural conditions and breast-fed, and the other a bottle-fed infant whose formula has been relatively high in starches and low in heat labile activators, we would find two children whose skeletal development is materially different. The rural baby nursed by a mother whose food is freshly produced and rich in the proper activators develops a relatively large skeleton, with compact bones. The facial development is broad and regular. If satisfactory living conditions are maintained, with open air life, physical exercise, and ample, fresh, nutritious food, the eruption of the teeth takes place within narrow time limits, and they are well calcified. The facial development continues throughout childhood, and when adult age is reached, the skull is relatively large. On the other hand, the skeleton of the infant from the city is apt to be smaller and the bones softer.

The development of the skeleton is accepted as being closely associated with the activity of the thyroid.[6, 7, 8, 9] The cause may come either from the secretion of the thyroid itself, or because of the fact that the same factors which control the activity of the thyroid also influence skeletal growth.

In case of a child with a defective thyroid, physiologic balance is disturbed, and disturbance in the osseous system is also seen.[6] This may be illustrated by the changes which take place in facial development,[10] which primarily show as an interference with the forward movement of the inferior and middle third of the face. Oftentimes this failure in forward movement gives a long appearing face, instead of the square jaw with adequate room for the teeth, broad interpupillary distance, and other features which belong to the child who has had an adequate supply of growth promoting factors. Not infrequently there is an absence of some of the teeth.

The effect of skeletal development on the physiological and psychological state of individuals is a study in itself. Wherever there is a disturbance in skeletal development, it is almost a corollary that there is, or has been, interference in the physiology and psychology of the individual.

The density of the bones of children may be taken as an index of the amount of minerals available for physiologic processes. The child who has a compact cortex and trabeculation of his bones has a much higher electrolytic reserve than the child who has the same size bone, with relatively coarse mesh. That the minerals in the bones are relatively labile has been pointed out by Aub and others.[3]

In our work in allergy we have found that allergic paroxysms such as asthma cause a drop in the blood chlorides. Todd pointed out that scorings are noted in the long bones of growing children corresponding to upset mineral metabolism. These represent definite arrestments of skeletal growth which result from changes in the availability of minerals. It has been observed that the mineral stores in the bones are depleted during recurrent spells of high summer temperatures lasting several days and causing profuse perspiration. It is difficult to control their elimination, even by the administration of large quantities of calcium and other salts.

The fact that salts are withdrawn from the bones can at times be ascertained by x-ray studies of the trabeculae in some definite area such as the carpal bones, the distal end of the clavicle, or the jaw. It can be especially shown in pregnancy and in the preparation for lactation which makes a heavy drain on the calcium stores of the body.

The size of the shaft of the bones, when considered in relation to their mineral density, gives definite prognostication as to the possible muscular strength which an individual can attain. It is impossible to place on a fine framework the heavy musculature necessary for the individual to do heavy physical work. Although Wolff's law states that function determines structure, it is as impossible to create a heavy gymnast from a child with a small body framework as it is to make a percheron out of a race horse.

Lack of mineralization is playing an ever-increasing rôle among the aged.[11] Spontaneous crushing of vertebrae, particularly those of the lower thoracic and lumbar areas, now and then occurs because of the inability of the soft bones to bear the weight of the body. Likewise, fractures of the neck of the femur are frequently the precipitating cause of death among elderly people. The crushing type of fractures is occasionally seen in comparatively young and middle-aged people—some even in childhood. These fractures in children may result from a trivial accident in the gymnasium or on the playgrounds.

Predisposition to fractures of this type is recognized as due to disturbed mineral metabolism, but it has not received the attention it deserves. The importance of hard bones to cattle is thoroughly understood by those interested in animal husbandry, but application of the same principles to human beings has not been generally made. It is well known to herdsmen that a soft boned cow cannot long withstand the stress of calf bearing and lactation. Likewise, they know that the calf of such a soft boned cow does not have the physical stamina of the calf of a cow with bones of greater density.

The bones, besides being an index of the ability of the cow to produce milk and give birth to normal or deficient calves, also may be considered as an index of her resistance to infectious diseases. Cows presenting soft bones are less resistant by far to infections from streptococci in the form of mastitis than those presenting a denser ossification. This may likewise be said to be true of all other forms of infectious diseases common to cattle.* Cats with deficient bone calcium also suffer from an unusual number of infections.

A year ago we reported before this Society[12] that diet definitely affects the mineralization of the bones as determined by a study of the femur of the cat; and that the effects of disturbed mineralization are transmitted to the offspring in an intensified form. If the offspring from a second generation deficient litter are placed in the same pen with the offspring from a second generation normal litter, we note the following: 1. The diet adequate to maintain the animal of healthy parentage in good health is not sufficient to regenerate the deficient animal. 2. The deficient animal will be subject to infectious diseases which may involve any organ of its body. 3. Its fur will be rough, and the animal will suffer from many fleas. On the other hand, the healthy animal in the same pen, living under the same conditions, is not so susceptible to infectious diseases, its fur will be softer, and it will not harbor many fleas. 4. The femurs of the second generation deficient animals will be soft, and average approximately 60 to 80 per cent of the percentage of calcium and phosphorus found in adequately mineralized animals.

The bones of experimental animals which fail to develop full mineralization may have a relatively long shaft with a cortex thinner than normal, and an apparent hyperplasia of the connective tissue cells of the bone marrow with lessening of the density of the bony trabeculae. Animals presenting these disturbances in mineralization show a certain degree of anemia, and although there is suggestive evidence that this is true in human beings, we have no conclusive proof.

The development of the osseous system may be used as an index of the general health of the individual.[13] Study of the contour of the face provides a measuring stick by which we can determine the periods of life in which disturbances of growth and development have taken place. The study of the appearance of the centers of ossification and the fusions of the epiphyses with the diatheses is usually considered as being controlled by hormones. In them we can study the relative activity of factors which control calcification of the body as well as deformities which may result from dysfunction of the endocrine glands. We can also gain information with reference to skeletal abnormalities which may or may not be primarily endocrine in character.[14] In stressing the fact that abnormalities of fusion have largely been due to dysfunction of the glands of internal secretion, we have failed to give proper weight to nutrition and other influences.

The question may properly be raised, "Is it not equally logical to assume that the glandular deficiencies and the disturbances and distortions in skeletal and body configurations may be evidence of the working of the same formative forces, rather than standing definitely in the position of cause and effect?" For instance, we have shown in our second generation cooked meat cats that there is a high percentage of animals that show a tendency to too rapid growth of the long bones at the expense of the size of the animal's body and the

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diameters of the shafts of these bones. This configuration compares favorably with the so-called hypogonadal syndrome, of the underweight type found in human beings. We likewise find on pathological examination of the gonads of these animals that there is definite evidence of deficiency.[15] Their reproductive function is materially lessened. Furthermore, we find a structural disturbance and functional hypoactivity in the thyroid of many of this group. These disturbances appear along with changes in many other structures. Inasmuch as these changes are produced both by disturbance in maternal nutrition and in the nutrition of the individual after birth, can the skeletal and organic changes be logically attributed solely or primarily to gonadal deficiency?

Much of the nutritional history of the child can be told from the study of the face, jaws and teeth.[16, 17] Here we have osseous structures visible to the naked eye. The teeth and the manner of their eruption are particularly important. They represent in their eruption, alignment, size and contour the result of many nutritive and physical forces that have been exerted on the child. But if the factors essential to the proper laying down of calcium are lacking, preparation frequently fails to take place, and the teeth erupt in an irregular manner.

In case the primary teeth are not properly spaced, malalignment of permanent teeth occurs, and if the permanent teeth are not directly in line with the primary teeth, serious deformity of the face may take place due to the primary teeth being shifted in or out, and the permanent teeth in the opposite direction. As a result, the primary teeth may not be shed on time, and the permanent teeth may be materially delayed.

These same general factors are operative from the time of the preparation for the child's first deciduous incisors to the time of the eruption of the third molars. A temporary upset such as influenza, or other acute illness or a surgical operation can interrupt the progress of facial structures. When the vault of the mouth fails to grow in its transverse and antero-posterior diameters, so do the nasal passageways, turbinates, and sinuses lag in their development.

If the normal growth of these structures is interfered with, not only do the bony structures suffer, but also the soft structures upon the bony framework. This produces abnormal physiological reactions in these structures.

When the clinician understands the phases of development which belong to the various age periods, he may be able to form an opinion of the general physiologic reactions and stability of individual patients at different periods of life.

The fact that material changes can be made in the skeletal trends of growing children has been recognized by the orthopedic surgeons and the orthodontists, who by various appliances have learned to correct many bony deformities. The orthodontist is able to make profound changes in the facial contours of his patients. However, whether or not the patient will maintain the improved facial configuration, or whether the patient may lose his or her teeth at an early age is not a matter of purely external mechanical forces. This depends upon the inherent physiology of the osseous structures with which he is dealing. A low calcium content produces a soft bony bed which may be unable to maintain the teeth in position.

Little attention has been paid to the possible effect of improved physiology upon facial growth. Yet we have found that when additional growth stimulation is applied to certain deficient children at the right time, before they have attained complete facial growth, material changes in the contour of their faces can be brought about without the application of surgical appliances. The medical approach to the problem, however, requires a great deal of patience, a conviction on the part of the physician that he can accomplish changes, and the meticulous attention to details on the part of the patient over a sufficient length of time to produce the result.

The factors which control the growth and development of the face are, as far as we have been able to judge, similar to the factors which control general reproductive efficiency. Apparently the laying down of body tissues and the ability to reproduce are functions controlled by related, if not identical, forces. The clinician must look upon the skeleton as a dynamic structure which reflects the efficiency of the life processes as a whole. This is recorded in the scorings of the bones,[18] in their size, contour and structure, in the growth of the face as a whole, and in the relative length of the long bones when compared with the body.

Deviations from the standard anthropological prototype should not be merely passed off with a word, but should be carefully considered, because they tell us a story—possibly a story which we cannot fully understand—nevertheless a story of the forces which have directed and modified body structure and function. They are concrete evidence of either the normal or abnormal action of important activators necessary for physiologic stability.

In summary, the skeleton is a living structure acting as a storehouse for minerals necessary to the physiologic functions of the body, housing the blood forming organs, acting as a support for the soft tissues, and reflecting deviations from the normal growth rate of the body.

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