The Mineralization Problem in Orthodontia*

T. WINGATE TODD, M.B., Ch.B., Manc.; F.R.C.S., Eng.; C.M.Z.S., London.
Cleveland, Ohio

Introduction

The mineralization problem of the orthodontist implies much more than the provision of an adequate mineral ration for the child. Stated very baldly it means that the orthodontist must be able to rely upon the mineral of the jaws securely fixing in their new alignment the teeth which he has rearranged. But teeth are not posts sunk in solidifying cement. They are more correctly likened to a team of horses whose efficient cooperation depends on the bridle of occlusion as much as on the harness of jaw mineral. Obviously, this harness must be strong enough to hold the teeth in position, but it must also be resilient enough to ease off here and there as the strain of work shall require. It must be pliable, not brittle, or it will break down under stress. One must then realize that in mineralization one is not studying the construction of a permanent substance but rather the fabrication of a supporting framework, the pattern of which may indeed be permanent but the constituent parts of which are constantly undergoing change and reconstruction to meet the needs of the moment in alignment and activity. Our problem then divides itself into estimations of two features: namely, adequacy of structure and adequacy of response. The discussion of these will bring forth all understanding of the process of mineralization on which we can rely in our management of malocclusion.

Mineralization and Growth

Total deprivation of mineral, like total deprivation of any other nutritional essential, will ultimately prohibit growth. But partial deprivation to a minimal or even subminimal level differs from deprivation of protein in that it will not adversely affect growth which will continue as before though the animal grows up mineral-poor. It is understood, of course, that several minerals enter into the composition of skeletal tissue but since the bones contain ninety-nine percent of the calcium of the body we shall consider calcium the chief of these minerals, the more particularly since diet which, under ordinary circumstances could scarcely be deficient in phosphorus, is very apt to be subminimal in calcium. Distinction between the calcium-poor animal and the protein-poor animal is then very important. An animal, the

*Presented before the 28th annual meeting of the Eastern Society of Graduates of the Angle School of Orthodontia, at cleveland March 15-16, 1937.

food protein of which lacks the amino-acid lysine, will not grow up. It simply stops growing altogether or grows only at such a rate as it is able to make new body material of normal lysine content from the reduced lysine ration provided. An animal on a food ration lacking calcium, on the contrary, does grow and may even grow at a normal rate, developing a body so calcium-poor that its legs are unable to bear the weight of the body. Yet the bones are not pathological: they show no rickets at the growing ends and they readily undergo repair after fracture. This means that the bones merely lack mineral. From a functional point of view they are normally healthy. This is the antithesis of the animal in which bones are well mineralized but show ununited fractures despite careful nursing. Roentgenograms of such bones show that no rarefaction has taken place near the site of fracture in the bone from which the mineral of the repair callus is obtained. Such bones likewise may be brittle but they present a totally different problem from that of the demineralized bone which is ready enough to deploy its substance appropriately but does not possess enough to make its functional response effective. For information on the chemical and nutritional aspects of growth one may consult the clear and simple account in Sherman's book (Sherman, H. C. 1937 Chemistry of Food and Nutrition, 5th ed. Macmillan Company, New York, pp. 482-499).

The Texture of Bones

All bones possess an outer shell of compact tissue, or cortex and an inner substance of spongy or cancellous tissue. Encroaching on the spongiosa to a different extent in different bones is the yellow marrow of the shaft. The red marrow or blood-forming organ of the metaphyses or growing ends of long bones and of the spongy substance in the short and flat bones, is of significance in childhood and youth but after the beginning of the third decade these blood-forming organs are confined to sternum, ribs, ossa innominata and vertebral column, the only bones in which growth potentiality is not yet terminated.

That the thickness of the campacta cylinder of the shaft is liable to vary considerably is merely a matter of observation: it is not a subject of particular significance in our present problem where interest necessarily centers on the spongiosa. In order to learn quantitatively the mineral content of a bone one must make an adequate chemical analysis. This we have done and are describing our procedure elsewhere. But before making our analysis we took roentgenograms of the bones so that our chemical analysis might find its counterpart in the roentgenographic record of texture. Thus Figures 1 and 2 are roentgenograms of the calcaneus or heel bone from young men of twenty-three and twenty-four years respectively, the first having a well mineralized and the second a poorly mineralized skeleton. Analysis of the middle phalanx of the fifth finger of each of these skeletons gives mineral determinations of 1.03 grams and 0.73 gram mineral per 1 cubic centimeter of bone respectively. That the depletion of the calcaneus parallels that of the finger is, of course, too much to ask but the comparison of the roentgenograms of Figures 1 and 2 indicates sufficiently clearly the usefulness of the roentgenogram as a rough measure of mineralization. Figure 3 shows very clearly the difference between the well mineralized hand and the poorly mineralized hand in adolescent girls. I have already described the textural features of a normal healthy bone but will recapitulate them here because of their appropriateness in this discussion.

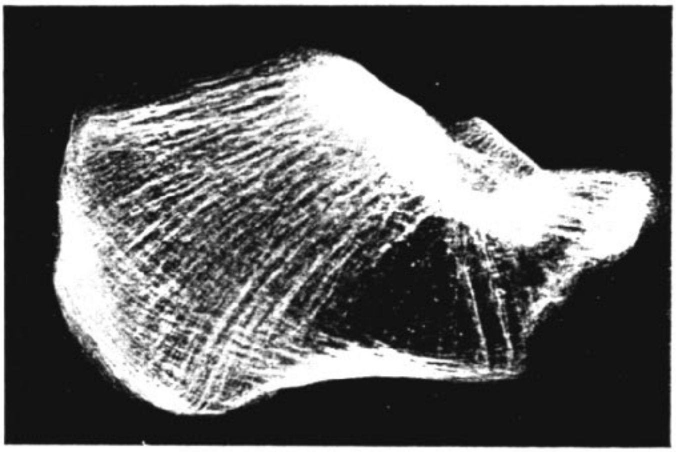

Fig. 1
Calcaneus male, white (dead), 24 years. Close striae; dense mineralization.

The roentgenographic shadow of a bone should show a dense well-defined compacta with a spongiosa in which the trabeculae, especially at the metaphysis near the growing end, are partially obscured by a gray film of labile mineral forming the store from which the blood mineral is replenished. When the demands for mineral are great in consequence of rapid growth, as in infancy and preadolescence, this labile store may be temporarily diminished resulting in a clearer tracery of trabeculae. Children of impoverished constitution, whether from prolonged toxemia, protracted ill-health or inability to utilize mineral, show a more pronounced reduction of the labile mineral with encroachments even on the trabeculae themselves which become thinner or fragmented.

Anomalies of Mineralization

In one of these children the gray sheen obscuring well-formed and unbroken trabeculae is clearly demonstrated. In the other the gray sheen is missing, "washed out" as it were, leaving thin and fragmented trabeculae to contrast with the sturdy healthiness of the other hand.

Demineralized bones of this type are not defective in their potentiality for repair. They fracture easily, it is true, but they form callus, though of a similar demineralized type. Bones such as these are simply inadequate, not perverted in functional character. They differ profoundly in structure and function from those bones which throw out no callus after fracture. In

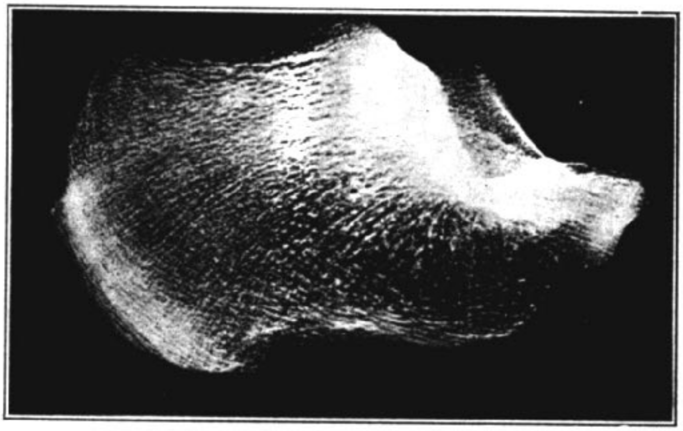

Fig. 2
Calcaneus male, white (dead), 23 years. Thinning and fragmentation of striae with compensatory thickening in others; light mineralization.

them texture is dense, the mineral stable, repair power is lost and ununited fracture is the rule.

It is the demineralized bone which so impedes the work of the orthodontist. There is in the jaw no efficient response which the orthodontist can call to his aid in fixing the realignment of the teeth brought about by the expenditure of the orthodontist's time and the patient's patience.

The question arises whether a special roentgenogram of the hand is essential for a diagnosis of demineralization. It is not essential but it is helpful. The same demineralization can be seen in a roentgenogram of the jaw but it is not so clearly defined nor so easily identified as in the hand.

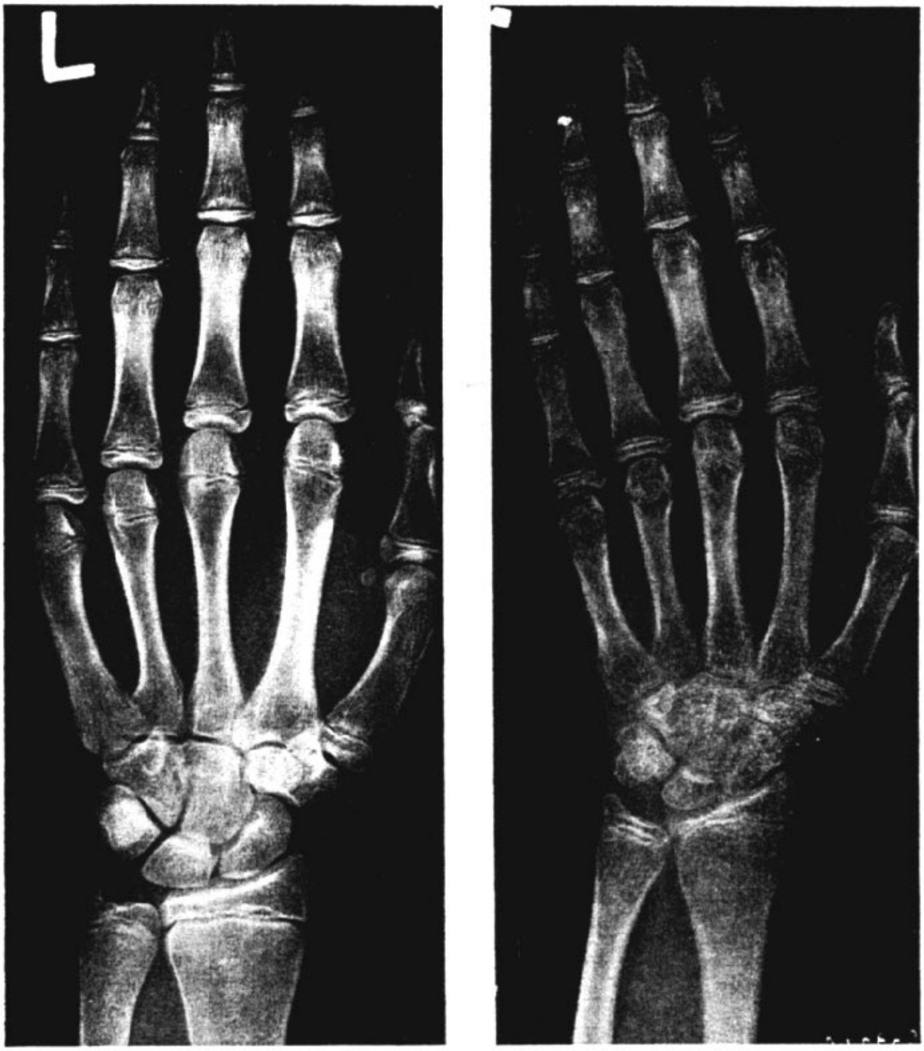

Fig. 3
Contrast in mineralization. SS 171 H female, white (living), 13 years (left) SS 3327 A female, white (living), 19 years (right). Both at a maturation age of 13 years 6 months. Note the "washed out" appearance of the carpals and ends of shafts of long bones in SS 3327 A (right) in contrast with the uniform gray sheen over carpals and ends of shafts in SS 171 H (left). The figure on the right is an example of pronounced demineralization.

The state of demineralization of one bone does not give an exact and reliable estimate of the demineralization of another bone in the same person. Demineralization is first seen in the phalanges of fingers and toes. It spreads to metacarpus and metatarsus, to carpals and tarsals and last into the shafts of the bones of forearm and leg. For the reason that it gives an estimate of the extent of demineralization a roentgenogram of the hand is most useful. Demineralization of the jaws accompanies demineralization of the rest of the skeleton and by the time demineralization can be identified in the bones of forearm or leg that of the jaws will be quite marked.

Now the processing of roentgenograms so that the degree of mineralization can be readily identified requires care. It is for this reason that we devised the density gauge (Figures 4 and 5), which is a simple instrument

Fig. 4
Line drawing of W.R.U. density gauge

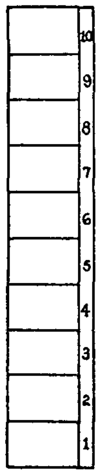

Fig. 5
Line drawing of density gauge to demonstrate the method of guaranteeing uniformity in standardization of the instrument

built of aluminum carefully calibrated in steps, each one millimeter in thickness, so that the gauge registers from one to ten millimeters. This instrument is laid on the film-holder close to one edge and roentgenographed with the hand. The following principles governing use of the gauge are sent out with each example distributed from the laboratory.

"The Western Reserve University Density Gauge is built of a series of 10 plates of pure hard aluminum, each one millimeter in thickness. It is used solely for comparison of density of roentgenograms. When there is not uniformity of result the difference between two roentgenograms can be assessed in millimeters of aluminum.

"The instrument is not devised for the direct assessment of density of bone shadows. A bone shadow is not structureless or uniform but is a network of trabeculae in the interstices of which 'labile' mineral is deposited and reabsorbed. The simple figure of the chicken-wire upon which snow descends and melts away in the sunshine is the best metaphoric illustration of this phenomenon. An appraiser of mineralization must know what bone texture looks like and must appraise the bone texture as a structural pattern.

"Comparison of texture is a simple matter when uniformity of processing is proven by the Density Gauge. When uniformity is not attained, experience alone will guide the observer who is then compelled by circumstances to rely upon his uncontrolled assessment of mineral accumulation upon trabeculae and mineral retention in interstices.

"The difficulty encountered in interpretation of assessment is that in periods of rapid growth it is entirely 'normal' to have a rather light texture in the spongiosa. Lightness of texture is found in infancy and during the rapid growth of adolescence. Hence what is reasonable mineralization at one period of childhood is not reasonable mineralization at another."

It will be apparent from the above paragraphs that the gauge is not used to check directly the mineral density but to control the processing so that the bone texture of one roentgenogram can be checked against that of another.

The Clinical Problem of Demineralization

Long-continued illness such as chronic tuberculosis of the lungs will bring about skeletal demineralization, but the chief cause of this disability is not to be sought at the clinical level. The majority of women on our preconceptional series show mild demineralization: their husbands rarely do. A large minority of our adolescent girls show demineralization, the boys less frequently. Fractures in adolescence are due less to excess of violence than to ineffective resistance on the part of the skeleton. That fifty percent of all fractures of the clavicle occur before the age of five years is not so much a result of imperfect balance as of imperfect mineralization. The growing child is specially susceptible to mineral impoverishment of the skeleton.

The rapid growth of infancy, the metabolic changes entailed by adolescence and the strain on resources inevitable in pregnancy demand a high calcium intake. If this is lacking demineralization rapidly ensues. Increase of the calcium ration in any form, natural or synthetic, organic or inorganic, quickly replenishes the skeletal store. These are the only periods of life when, in our experience, simple administration of calcium is effective therapeusis.

The main cause of demineralization is to be found in unacknowledged handicaps to health which steadily drain the skeletal stores and by some mechanism, as yet unknown to us, prevent the utilization of the mineral in the food. Administration of calcium to these people will have no effect whatever on the skeletal store.

It is probably significant that children retarded in physical maturation during the second decade very frequently show inadequate mineralization. Sensitivities to food or air-borne particles are prone to be accompanied by demineralization. The roentgenogram readily detects large alterations in skeletal mineral and by careful analysis, and use of the aluminum gauge in processing, lesser changes can be quantitatively distinguished.

The correct therapeusis for depleted mineral is detection and correction of unheeded, unacknowledged deficiencies of diet and health, not the overloading of the system with calcium given in medicinal form.

2109 Adelbert Road

The material presented by Dr. B. Holly Broadbent, completing the publication of the scientific program of the 28th Annual Meeting of the Eastern Society of Graduates of the Angle School of Orthodontia, will appear in the October issue of The Angle Orthodontist.