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CORRELATION BETWEEN DENSITY OF THE ALVEOLAR TRABECULAR PATTERN AND THE ACTUAL MINERAL CONTENT OF HUMAN MANDIBLES

by

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INTRODUCTION

Reduction in bone density caused by demineralization is reflected in changes in the morphological pattern of bone structure. These osteoporotic changes are, owing to the rapid metabolic turnover, visible earlier in the cancellous than in the compact bone (*Cooke*, 1955).

Densiometric analysis of radiograms of human finger bones in a dry, fat-free state has shown a highly significant correlation between the trabecular density of the cancellous bone pattern and the true mineral content of bone (*Virtama & Telkkä*, 1961). *In vivo*, however, the covering effect of the soft tissues has made an adequate analysis of the trabecular pattern more difficult (*Virtama*, 1961).

Alveolar bone is covered only by a thin mucous membrane and can, by using a special technique, be radiographed without cheeks included. Subsequently, densiometric studies of alveolar bone pattern have given, *in vivo* likewise, promising informations in selected cases. The purpose of this work was to establish whether the radiographic trabecular density could be used as an estimate of the true mineral content of mandibular alveolar bones.

MATERIAL AND METHODS

Twenty specimens of alveolar bone originating from 19 human mandibles removed *post portem* comprised the material of the study. All specimens,

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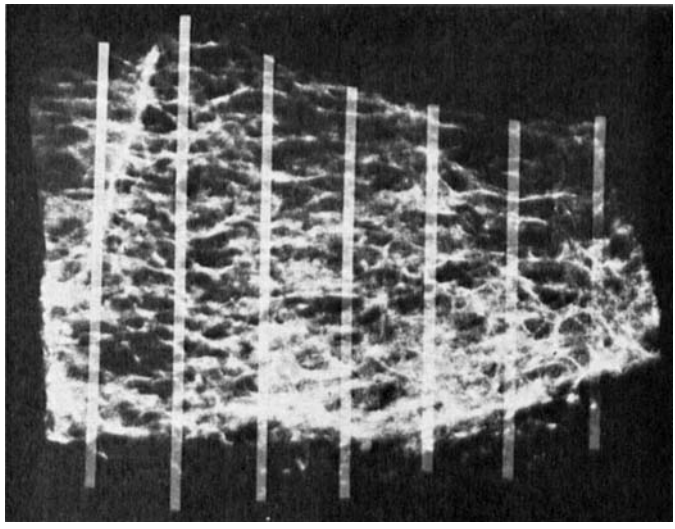

Fig. 1. Radiograph of an alveolar mandibular bone specimen showing the tracing paths of scannings.

about 1,5×2 cm in size, were taken from praemolar and molar regions. After careful removal of the soft tissues the bones were degreased with acetone and dried at room temperature. The bone pieces were then radiographed with the aid of an ordinary four-valve roentgen machine at 45 kV from a distance of one metre. The exposures were made on Kodak Crystallex finegrain non-screen film, the films were conventionally developed in Kodak Dx 80 developer and thereafter analyzed photometrically with a Joyce automatic recording densitometer. The ratio of record to sample travel was 1 to 20.

Then the bone pieces were dried in a vacuum oven at a temperature of 80°C for 48 hours and immediately weighed with a laboratory balance. The surfaces of the bones were made airtight by using lac varnish and the volumes were measured with a Beckman Air Comparison Pycnometer. By dividing the dry weights of the bone pieces by their volumes the dry densities were obtained. The calcium content of the bones was determined by means of X-ray fluorescence (*Calonius et al.*, 1965).

In each densiometric analysis, to obtain comparable results, the background density of the film was adjusted to the level of the basal line of the record by means of the base line control wedge. The scannings were carried out on linear tracing paths at 5 mm intervals across the trabecular patterns of the alveolar sections (Fig. 1). The illuminated area used was 0.02×0.5 mm

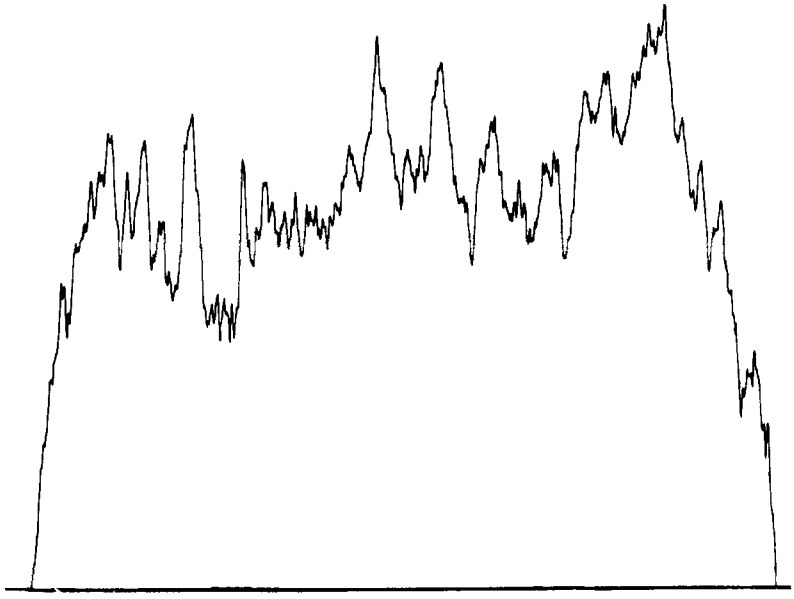

Fig. 2. Densiometric profile of an alveolar mandibular bone specimen the density of which is 1.19 gcm-^{3}. Trabecular density calculated from the profile was 1.64.

on the film. Five or six densitometric curves were thus obtained from each radiogram (Fig. 1 and 3). The number of the individual peaks of the densitometric curves was counted and their heights standing out from the basic density area were recorded. The length of each profile measured with a curvimeter was calculated per linear unit of the scanning line and this was divided by the average height of the individual peaks. The arithmetic mean of the resulting figures was considered to represent the alveolar trabecular density of the bone.

RESULTS

The correlation between the radiographic trabecular density and the dry density as well as the calcium content of the alveolar bone sections was examined by standard statistical methods. The following regression equations were obtained (Fig. 5):

$$X_D = 1.07 \,.\, X_T — 0.54 \pm 0.06;\ r = 0.96$$
$$X_C = 0.273 \,.\, X_T — 0.147 \pm 0.014;\ r = 0.96$$

where X_T represents radiographic trabecular density, X_D dry density and X_C the calcium content.

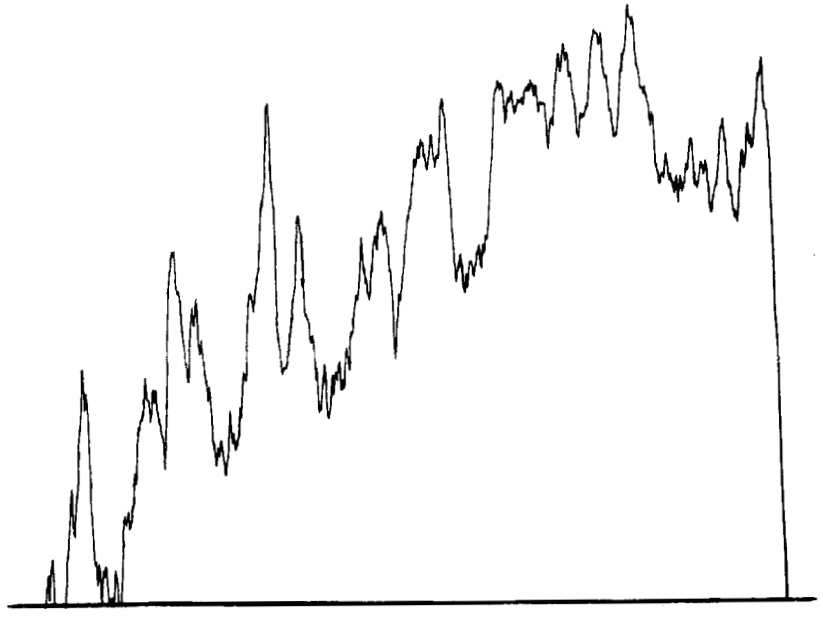

Fig. 3. Densiometric profile of an alveolar mandibular bone specimen the density of which was 1.61 gcm^{-3}. Trabecular density calculated from the profile was 2.07.

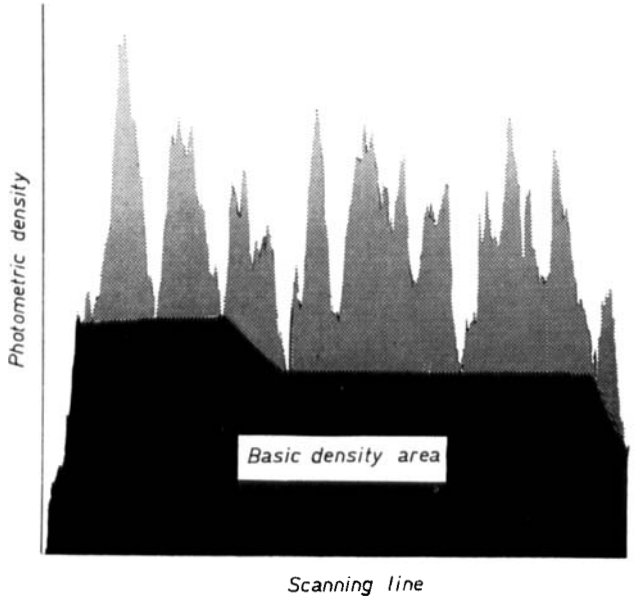

Fig. 4. Densiometric profile showing the basic density area and the length of the scanning line.

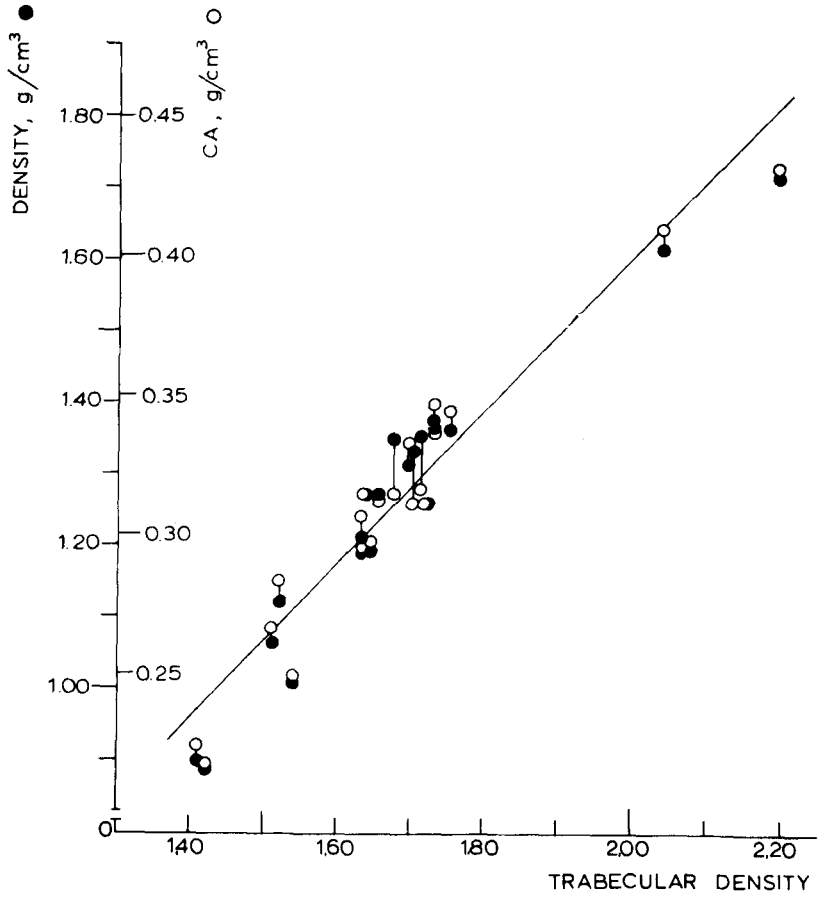

Fig. 5. Scatter diagram. The trabecular densities of the alveolar mandibular bones obtained from the densitometric curves plotted against the corresponding bone densities (dry weight per volume) and the calcium contents.

DISCUSSION

The present results correspond to the results obtained from finger bones (*Virtama & Telkkä*, 1961) and show a highly significant correlation at a level of $P < 0.001$ between trabecular density and true mineral content of mandibular alveolar bones. The trabecular ratio, the percentual ratio of the sum of trabecular peak widths as measured at a distance of 4 cm from the basal line to the length of the scanning line, used as an indicator of trabecular density of finger bones by Virtama and Telkkä, did not show a constant correlation with the dry density of the alveolar bone. This is apparently

due to the variation in thickness between marginal parts and basal parts of the alveolar bones. However, in the present study the relation between the length of a densitometric profile per linear unit of the scanning line and the average height of the peaks shown by the same profile proved roughly to indicate the relative trabecular density of bone. The denser radiographic appearance of trabeculation caused by greater bone thickness reflected in the densitometric analysis in increased overlapping of the lower parts of the individual density peaks. On the other hand, the increase of overlapping was found to be in proportion to the thickness of the alveolar bone pieces examined. Therefore, the densitometric density values obtained indicated relative, not absolute trabecular density.

The results obtained imply that the density of the trabecular pattern of alveolar cancellous bone gives representative information about true bone density. However, an almost unilinear arrangement of the trabeculae was shown to be a basic condition for a successful densitometric analysis. The applications of the method are therefore limited in the jaws to the determination of the density of the alveolar bone pattern of the mandibles. The complicity of the method makes it less statisfactory for clinical purposes. Studies for simplification are therefore under progress.

SUMMARY

Possibilities for the use of radiographic trabecular density as an indicator of bone density of human mandibles are studied. Twenty autopsy pieces of alveolar bone from the praemolar and molar regions were radiographed and analyzed densitometrically. The results obtained showed a highly significant correlation between the trabecular density, as calculated from the densitometric curves of the bone pieces, and the actual density (dry weight per volume unit) as well as the calcium content of the bones.

RÉSUMÉ

CORRÉLATION ENTRE LA DENSITÉ DE LA STRUCTURE TRABÉCULAIRE ALVÉOLAIRE ET LA TENEUR RÉELLE EN SUBSTANCES MINÉRALES DANS LA MANDIBULE HUMAINE

La possibilité d'utiliser la densité trabéculaire radiographique comme indicateur de la densité osseuse de la mandibule humaine a fait l'objet de cette étude. Vingt spécimens d'os alvéolaire des régions des molaires et des prémolaires obtenus à l'autopsie ont été radiographiés et analysés par densi-

métrie. Les résultats obtenus mettaient en évidence une corrélation fortement significative entre la densité trabéculaire, calculée à partir des courbes densimétriques des spécimens osseux, et la densité réelle (poids sec par unité de volume), ainsi que la teneur en calcium des os.

ZUSAMMENFASSUNG

BEZIEHUNG ZWICHEN DICHTE DER ALVEOLÄREN TRABECULAR STRUKTUR UND DES MINERALGEHALTS DER MENSCHLICHEN MANDIBULA

Möglichkeiten der Verwendung der röntgenographischen trabeculären Dichte als Indicator für die Knochendichte der menschlichen Mandibula werden untersucht. Zwanzig Autopsiestücke von Alveolarknochen der Praemolaren und Molaregegend wurden geröntgt und ihre Trabekelmuster densitometrisch analysiert. Die Resultate zeigten eine sehr bedeutungsvolle Korrelation zwischen der trabeculären Dichte, die von den densitometrischen Analysen erhalten wurden, und der wirklichen Dichte (Trockengewicht pro Volumeneinheit) als auch dem Kalziumgehalt der Knochen.

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