Henry Ford Hospital Medical Journal

Volume 9 | Number 1 Article 23

3-1961

Human Haversian System Measurements

Harold M. Frost

HUMAN HAVERSIAN SYSTEM MEASUREMENTS

HAROLD M. FROST, M.D.

INTRODUCTION

An attempt to calculate the physical parameters of the diffusion pathway between osteocytes and Haversian canals created the need for measurements of Haversian system and Haversian canal diameters and their average separation. The majority of such measurements done elsewhere have been on animal rather than human bone. The current measurements are published because they are of some histological interest and because they supply some figures for use in attempting to understand diffusion dynamics in bone's physiological spaces.

METHODS

Fresh, undecalcified sections were made and stained with basic fuchsin by methods published elsewhere.[3,4] Sections prepared by these methods have a shrinkage in the radial and tangential axes of about 2% in adult bone. Accordingly correction for shrinkage is not necessary but if it should be it is readily made. Sections prepared as recommended by Enlow are also satisfactory for this type of work.[2]

Measurements of length were made with a calibrated eyepiece micrometer using fully illuminated apochromatic optics. Magnification was selected so that the majority of the measurements of a given feature involved use of more than half of the micrometer eyepiece scale.[1,6] Orientation of Haversian systems and canals being measured was randomized by arbitrary rotation of the micrometer eyepiece before the measurement and by measurement of structures in all quadrants of the cross section being measured, the exception being the child's rib which did not contain Haversian structures in the pleural cortex. Measurements were made after the line of measurement was made to pass through the center of the Haversian canal by positioning the section for this purpose.

Measurements of area were made with a Zeiss Integrating Eyepiece. This device provides a simple, rapid, and effective means for making area measurements with a microscope to nearly any desired degree of precision and its use is outlined by Hennig.[5]

RESULTS

The measurements are tabulated in Table I.

Note that there is no significant difference in the various measurements with age or sex, in view of the small number of cases measured, and that there is little difference among the various bones measured, the exception being the child's rib.

Note also that the measurements do not reflect the elliptical cross-section geometry of Haversian systems and Haversian canals. These structures are uually ellipses on cross section and the younger the individual the more pronounced is the ellipticity. The measurements listed in Table I are means, due to the randomization of the measurements, and thus are midway between the mean major and mean minor axes of the ellipsoidal configuration of the structures measured.

Table I

Case	Bone	Age	Sex	Average Diameter H.S. u	Average Diameter H.C. u	Average Distance Between H.C. u	Vascular Area In Cortex % of Whole
06 20 70	Clavicle	56	F	258 | 42	57 | 38	346 | 39	6.3
24 30 10	Clavicle	68	F	180 | 15	60 | 12	350 | 19	5.6
38 21 44	Clavicle	57	F	230 | 30	70 | 34	340 | 23	
83 68 47	Femur	53	M	256 | 20	97 | 20	296 | 40	6.15
87 93 01	Clavicle	13	F	300 | 20	69 | 20	385 | 30	12.5
01 18 85	Tibia	90	F	232 | 20	72 | 20	390 | 20	12.4 (a) 39.0 (b)
30 20 60	Tibia	14	M	266 | 20	76 | 30	310 | 20	11.9
94 77 60	Rib	½	F	No H.S.	46 | 20	143 (c) 197 (d)	6.06
Means (94 77 60 excluded)		50		246 | 167	71 | 174	345 | 190	

H.S. = Haversian System.

H.C. = Haversian Canal.

a = outer 1 mm. of cortex.

b = 1 mm band, 1 mm deep to cortical surface (Vascular area in other cases listed is average for entire cross section.)

c = Fetal bone (pleural cortex).

d = Lamellar bone (cutaneous cortex).

The figures in boxes at the lower right of the mean values are the number of measurements averaged to obtain the mean values. Vascular area is the proportion of the total cross section area comprising vascular channels of all types; 11885 excepted as noted in text.

The extremes of the measurements are not tabulated. For the interested reader the minimal diameters of Haversian systems and canals were 30 and 10 micra respectively while the maximal diameters were 550 and 300 micra respectively. The distances between nearest vascular canals on cross sections ranged from 90 to 800 micra.

On the average, in adult cortical bone, the farthest an osteocyte would be from an Haversian canal is half the average distance between Haversian canals, or 172 micra.

Case 11885 is interesting in that this tibia was obtained from a woman with severe osteoporosis. While the outer millimeter of the cortex contained only a slightly increased vascular area, the deeper portions of the cortex contained an increasing area of vascular channel and a decreasing area of bone. This is one of the physical types of osteoporosis, the other being thinning of the cortex without significant enlargement of the vascular channels in the cortex that is present.

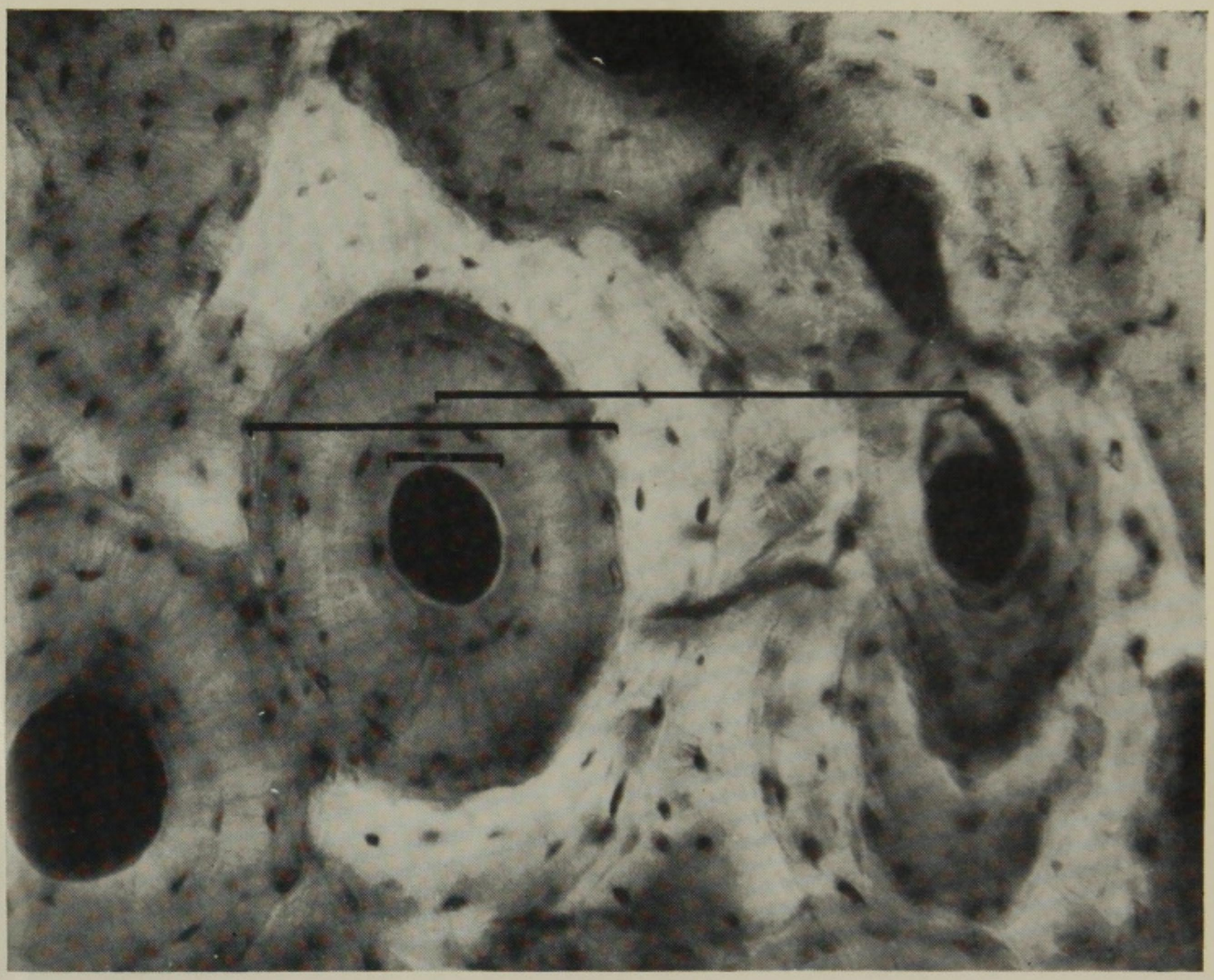

Figure 1

Photomicrograph of cross section human tibia, undecalcified, basic fuchsin. Several Haversian canals and Haversian systems are illustrated. The Haversian system just to left of center is a concentric one, the inner one being the more recently formed. The outer one is larger and appears clear because it is micropetrotic so that most of its canaliculae and some of its lacunae are filled with mineral and unstained.
Diameter of Haversian canal is the feature under the shortest India ink line.
Diameter of the Haversian system is the feature under the middle length India ink line.
Distance between Haversian canals is the feature under the longest India ink line.

SUMMARY

The average diameters of Haversian systems and canals (as measured on 7 human bones) are 246 and 71 micra respectively. The average distance between vascular channels in these same bones is 345 micra.

REFERENCES

1. Allen, R. M.: The Microscope, New York, D. Van Nostrand Co. Inc., 1940.

2. Enlow, D. H.: A plastic-seal method for mounting sections of ground bone, Stain Technol. 29:21, 1954.

3. Frost, H. M.: Preparation of thin undecalcified bone sections by rapid manual method, Stain Technol. 33:273, 1958.

4. Frost, H. M.: Staining of fresh undecalcified, thin bone sections, Stain Technol. 34:135, 1959.

5. Hennig, A.: Critical survey of volume and surface measurement in microscopy, Zeiss Werkzeitschrift, No. 30, Dec. 1958, p. 78.

6. Needham, G. H.: The Practical Use of the Microscope, Including Photomicroscopy, Springfield, C. C. Thomas, 1958.