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The Distribution of Cortical and Trabecular Bone Mass along the Lengths of the Radius and Ulna and the Implications for *in vivo* Bone Mass Measurements

R. A. Schlenker and W. W. VonSeggen

Center for Human Radiobiology, Argonne National Laboratory, Argonne, Illinois

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The amounts of cortical and trabecular bone mineral mass were measured by means of microdissection and an ashing technique at approximately 2.5 mm intervals along the most distal 12 cm of radii and ulnae from four women aged 21, 43, 63, and 85. The data show that the distributions of mineral mass and percentage of trabecular bone are similar in both bones. At sites in the radius and ulna commonly used in the photon absorptiometric method of bone mineral mass measurement the percentage of trabecular bone varies between 10% and 50%. The percentage of trabecular bone in the most distal 10% of the length of the radius and ulna remains approximately constant with age but the percentage in the segment which lies between 30% and 40% of the length, measured from the styloid process, increases with age.

Key words: Absorptiometric measurements — Bone — Bone mass — Bone loss — ^{125}I.

Introduction

Bone mass in normal and diseased persons has been studied by numerous investigators in recent years using a variety of techniques (Horsman and Simpson, 1974). Of these, the photon absorptiometric method (Cameron and Sorenson, 1963) is one of the most precise. It has been applied, mainly, to local measurements of bone mineral mass in the midshaft and distal portions of the radius. Some investigators state that the distal site is principally trabecular bone (Smith *et al.*, 1970) but there is little direct evidence to support or refute this. Measurements in our laboratory show that the percentage bone loss with age in the distal radius is no greater than in the midshaft (Schlenker and Oltman, 1973). If the distal site were predominantly trabecular, it would have a considerably larger surface area per unit mass than the midshaft site and one would expect the percentage bone loss to be greater than at the midshaft site (Jowsey and Gordan, 1971).

To resolve this apparent paradox, the present study was carried out.

Materials and Methods

Radii and ulnae from four white females aged 21, 43, 63, and 85 were obtained from a medical school gross anatomy laboratory. The causes of death were: suicide, internal hemorrhage, heart attack, and stroke respectively. The 43-year-old subject had sustained a fracture of the neck of the left femur with minimal trauma four months prior to death and the 63 year old woman was hemiplegic and confined to a nursing home for at least 22 months before she died. A radiological survey of the radii, ulnae, right femora, and mid-thoracic vertebrae

For reprints: Dr. Robert A. Schlenker, Center for Human Radiobiology, Building 203, Argonne National Laboratory, Argonne, Illinois 60439, USA.

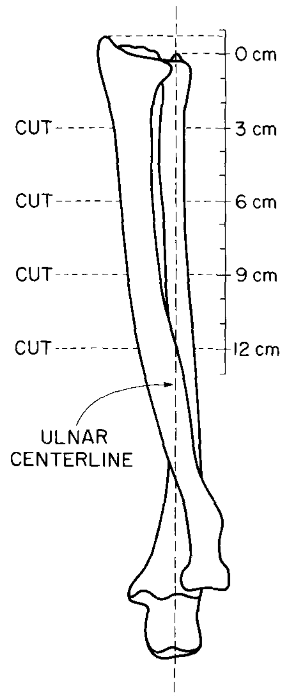

Fig. 1. Radius and ulna in the anatomical positions assumed during bone mineral measurement. The orientations and positions of hacksaw cuts used to separate the bones into pieces for embedding and sectioning are shown

Table 1. Wet weights, bone lengths and arm lengths for radii and ulnae used in this study

Subject	Weight (g)		Bone length (cm)		Forearm length (cm)	
	Radius	Ulna	Radius	Ulna	From radial tip	From ulnar tip
21 yr old	39.5	49.0	22.9	24.5	25.2	24.5
43 yr old	38.5	43.5	22.7	24.1	24.6	24.1
63 yr old	36.4	41.6	23.2	24.6	25.2	24.6
85 yr old	29.2	40.0	20.6	22.3	22.7	22.3

revealed no bone lesions but indicated moderate osteoporosis in the 63 year old. Therefore, we expect the 43- and 63-year-old subjects to have lower bone mass than individuals of comparable age.

The right radius and ulna were studied in the 21, 43, and 63 year old women and the left radius and ulna were studied in the 85-year-old woman. The wet weights (not fresh), the bone lengths and the lengths of the forearms from the radial and ulnar styloid tips to the olecranons of the ulnae are given in Table 1. These data are often used to establish measurement sites (Smith *et al.*, 1970; Heer *et al.*, 1973).

After being scraped free of soft tissue and dried in air, the radius and ulna from each subject were bound together in the anatomical positions they would assume during bone

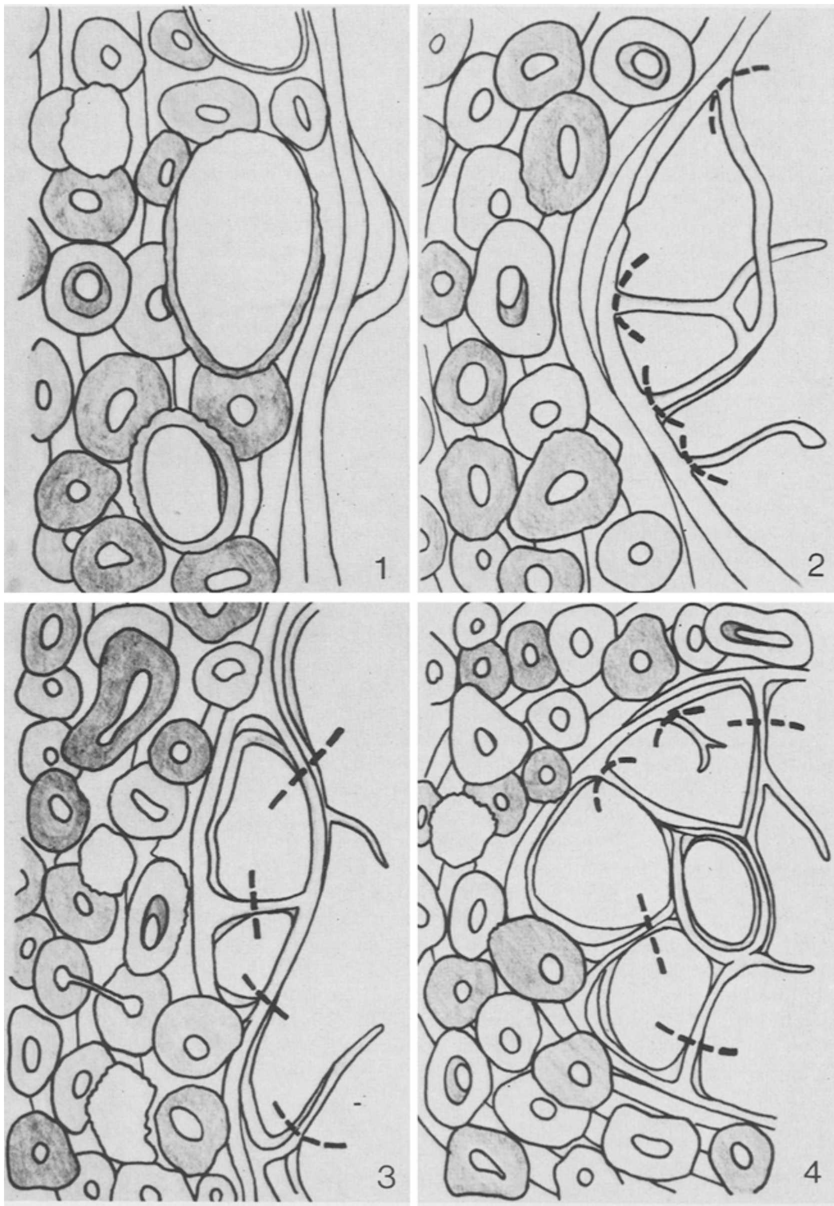

Fig. 2. Illustration of morphological criteria used to distinguish trabecular from cortical bone. Dashed lines indicate where trabecular bone was broken away. See text for full explanation

mineral measurement with the forearm lying prone. They were laid beside a ruler oriented parallel to the approximate centerline of the ulna. Lines were drawn across the bones perpendicular to the ulnar centerline at 3, 6, 9, and 12 cm from the ulnar styloid tip and each bone was cut with a hacksaw into four pieces (Fig. 1).

The bone pieces were dehydrated in alcohol, defatted in methanol-ether and embedded in polymethylmethacrylate. The resulting blocks of bone and plastic were sectioned by a circular bone saw in planes which were approximately parallel to the planes of the hacksaw cuts; the blocks were cut only part way through so that individual sections remained attached with their faces parallel to one another. Each block was mounted in an Eastman Kodak Contour Projector, Model 1, and the distances between the distal face of the first section of the piece and the distal faces of all subsequent sections were measured. The sections were then broken away from the block and section thicknesses were measured with a micrometer. The mean and standard deviation of the section thickness was 0.2010 ± 0.0023 cm. From repeated determinations of the positions of one face we estimate that the maximum error in any distance measurement is ± 0.0025 cm.

Each section was placed in a covered porcelain crucible which had been thoroughly ashed for 24 h at 600°, dried for 24 h in a desiccator, and weighed. The sections were then ashed for 24 h at 500°. This burned the methylmethacrylate away and left an intact partially ashed section. The section was viewed under a hand lens and the trabecular bone was broken away from the cortical bone using a pair of tweezers. The cortical bone was transferred to a second crucible and the two crucibles were placed side by side in the oven and ashed again for 24 h at 600°. Following this the crucibles were placed in a desiccator for 24 h and then were weighed to 0.1 mg immediately upon removal from the desiccator. The crucible weights were subtracted to obtain the ashed weights of the cortical and trabecular bone for each section.

We assessed the magnitudes of 3 sources of error in the weight measurements: inaccuracies in the balance reading, weight increases due to adsorption of atmospheric water vapor, and the ash content of methylmethacrylate. The balance error was less than ± 0.05 mg, the weight increase due to humidity was less than 0.4 mg and the weight increase due to the methylmethacrylate ash was less than 0.2 mg. On the basis of these results, we believe that all weights are accurate to better than ± 1 mg.

Differentiation of Trabecular Bone from Cortical Bone. It is often difficult to distinguish between cortical and trabecular bone microscopically. With aging, large cavities appear adjacent to the medullary canal; they may be separated from the medulla by just a few circumferential lamellae as indicated diagrammatically in Fig. 2, view 1. If the cavity surface were functionally a Haversian canal surface, the separating wall would not be considered a trabecula; if the cavity surface were functionally an endosteal surface, then the wall would be considered a trabecula. Since we did not know the functional nature of such surfaces we adopted the following morphological critera: If a piece of bone was more than 2 lamellae thick, as in Fig. 2, view 1, we assumed that it was not a trabecula. If it was 1 or 2 lamellae thick, as in Fig. 2, view 2, we called it trabecular and broke it away from the cortical bone at the points indicated by the dashed lines. If it was more than 2 lamellae thick over part of its length and 2 or less over the rest, as in Fig. 2, view 3, we called the thinner portion trabecular bone and broke it away as indicated by the dashed line. If bone 3 or more lamellae thick was completely supported by bone which was 1 or 2 lamellae thick at its narrowest point, as in Fig. 2, view 4, we called it trabecular bone and broke it away with its supports as indicated by the dashed lines.

Results

Ash weights of cortical and trabecular bone were measured in 362 sections. The data were used to compute the total bone mineral mass (ash weight divided by sections thickness) and the percentage trabecular bone for each section. These quantities are summarized in Figs. 3 and 4 and in Table 2.

The data for all sections from the 43 year old are plotted on separate graphs in Fig. 3 with the radius and ulna in the anatomical positions shown in Fig. 1. Distances are measured in the direction of the ulnar centerline which is perpendicular to the scan path of the bone mineral analyzer and also perpendicular to the sectioning plane. The distances are 2% less than if measured along the centerline of the distal half of the radius, which is not parallel to the ulnar center-

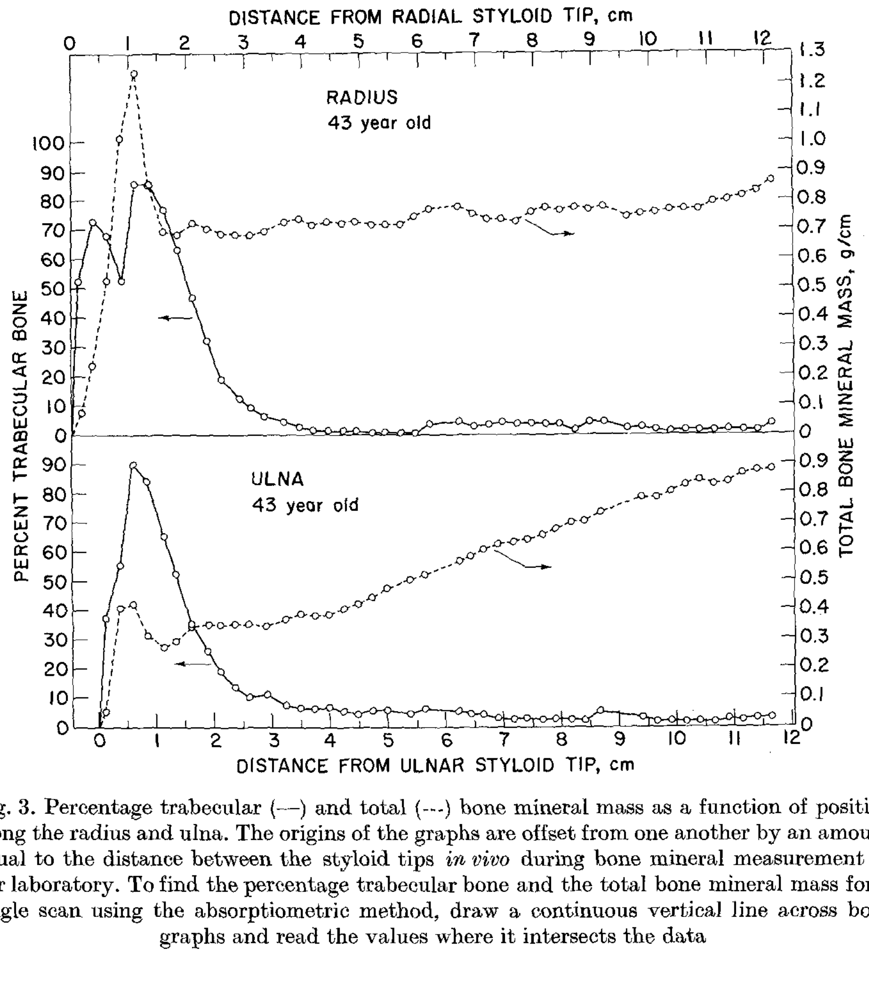

Fig. 3. Percentage trabecular (—) and total (---) bone mineral mass as a function of position along the radius and ulna. The origins of the graphs are offset from one another by an amount equal to the distance between the styloid tips *in vivo* during bone mineral measurement in our laboratory. To find the percentage trabecular bone and the total bone mineral mass for a single scan using the absorptiometric method, draw a continuous vertical line across both graphs and read the values where it intersects the data

line. Any vertical line which may be drawn across the graphs represents a scan path. The points in which such a line intersects the plotted data give the percentage trabecular bone and the total bone mineral mass for the path.

These graphs for the radius and ulna of the 43-year-old subject are typical of the graphs for the other three cases. They reveal trends common to all: A large but rapidly changing percentage of trabecular bone within the first 3 cm of the styloid tips of both bones; a small amount of trabecular bone between 3 and 12 cm from the styloid tips; an almost constant total radial bone mineral mass proximal from about 1.5 cm; a progressive increase in the total ulnar bone mineral mass proximal from about 4 cm.

These data show that at positions between about 1 and 4 cm from the ulnar styloid tip both the radius and ulna have relatively constant total bone mineral mass, but that a wide variation occurs in the percentage of trabecular bone. Thus in longitudinal studies, repositioning errors will introduce little scatter into the total

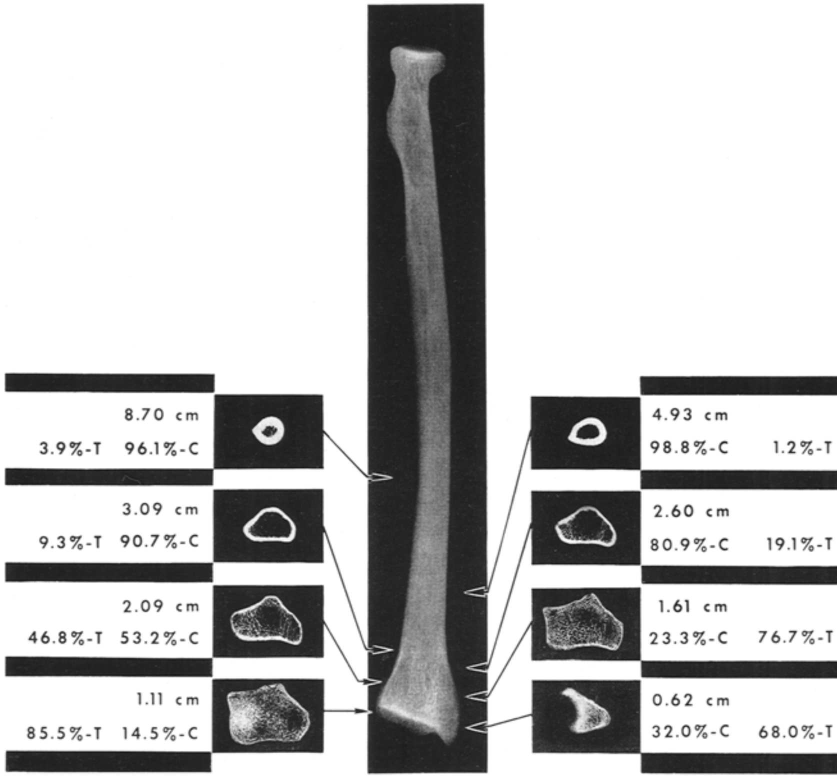

Fig. 4a

Fig. 4 a and b. Radiographs of the radius (4a) and ulna (4b) from the 43-yr-old subject showing some of the bone sections removed for study. The distance between the styloid tip and the midpoint of each section and the cortical and trabecular percentages are shown. The radial sections lie approximately opposite the corresponding ulnar sections; for example, a scan across the 0.12 cm section of the ulna would intersect the 0.62 cm section of the radius

bone mineral mass but may cause measurements to be made at points which differ widely in trabecular percentage. If the objective is to trace changes in trabecular bone then precise repositioning is essential.

Radiographs of sections from the radius and ulna from the 43-year-old subject and of the whole bones are shown in Fig. 4. Sections from the radius and ulna which are approximately opposite one another during bone mineral measurement are used in the illustration; for example, the ulnar 0.12 cm section is opposite the radial 0.62 cm section, the ulnar 0.62 cm section is opposite the radial 1.11 cm section, the ulnar 1.11 cm section is opposite the radial 1.61 cm section, etc.; a scan across a section of the ulna would intersect the corresponding section of the radius. The 2.11 cm and 8.18 cm sections from the ulna and the 2.60 cm and 8.70 cm sections from the radius correspond to the distal and midshaft scanning sites used in our laboratory. These illustrations give a visual impression of how trabecular mass changes as one moves proximally from the styloid tip and empha-

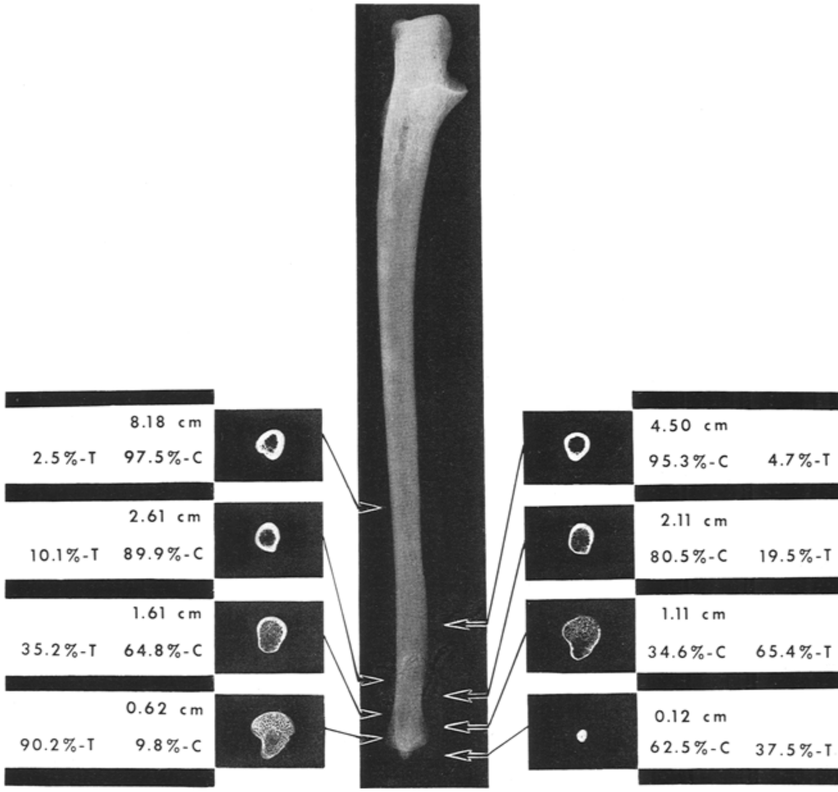

Fig. 4b

size the fact that sections which are opposite one another in the radius and ulna are similar in the percentage of trabecular bone which they contain.

Bone mineral mass and percentage trabecular bone are presented for all subjects in Table 2. Data are given for individual sections in the most distal piece from each bone, and averages are given for the remaining three pieces. The average bone mass is computed by adding the masses of all sections in the piece together and then dividing by the sum of the section thicknesses. The percentage of trabecular bone is computed by adding the trabecular bone mass in all sections and dividing by the sum of the total masses for the sections. The maximum error in the bone mineral mass data is ± 0.005 g/cm. Positions are given for the midpoints of individual sections relative to the radial and ulnar styloid tips; for bone pieces, positions are given for the midpoints of the first and last sections in the piece. Positions are expressed in four ways corresponding to the common methods of establishing the measurement site[1]. Data on radius and ulna sections or pieces

1 The four ways are: (a) by measuring a fixed distance proximal from the ulnar styloid tip or (b) from the radial styloid tip; (c) by measuring a fixed percentage of arm length proximal from the ulnar styloid tip or (d) from the radial styloid tip; when measuring from the ulnar styloid tip, arm length is defined as the distance between the ulnar tip and the ulnar olecranon; for measurements from the radial tip the arm length is the distance between the radial tip and the ulnar olecranon.

Table 2. Bone mineral mass and percentage trabecular bone for the radius and ulna of each subject. Data are given for the individual sections in the most distal piece from each bone and average data are given for the sections in the remaining three pieces. Data on sections or pieces from the radius and ulna which lie opposite one another when the forearm is in position for bone mineral mass measurement lie in the same row of the table. For a full explanation of the table and the errors in its entries, see the text

Radius				Ulna			
Position relative to styloid tip of radius/ulna		Bone mineral mass (g/cm)	% trabecular	Position relative to styloid tip of radius/ulna		Bone mineral mass (g/cm)	% trabecular
Distance (cm)	Percentage forearm length			Distance (cm)	Percentage forearm length		
a) 21 yr old							
0.196/—	0.8/—	0.083	53.0				
0.443/—	1.8/—	0.229	62.3				
0.670/—	2.7/—	0.718	40.6	0.794/0.123	3.2/0.5	0.042	57.1
0.914/0.243	3.6/1.0	1.323	42.0	1.025/0.354	4.1/1.4	0.300	28.1
1.163/0.492	4.6/2.0	1.805	50.3	1.265/0.594	5.0/2.4	0.426	73.9
1.406/0.735	5.6/3.0	0.954	72.5	1.520/0.849	6.0/3.5	0.327	78.4
1.647/0.976	6.5/4.0	0.869	58.4	1.756/1.085	7.0/4.4	0.306	57.8
1.877/1.206	7.4/4.9	0.837	48.7	1.999/1.328	7.9/5.4	0.302	42.6
2.137/1.466	8.5/6.0	0.840	36.2	2.243/1.572	8.9/6.4	0.334	32.2
2.375/1.704	9.4/7.0	0.860	23.9	2.485/1.814	9.9/7.4	0.369	25.5
2.625/1.954	10.4/8.0	0.842	18.0	2.727/2.056	10.8/8.4	0.395	18.7
2.875/2.204	11.4/9.0	0.840	12.9	2.972/2.301	11.8/9.4	0.411	13.5
3.094/2.423	12.3/9.9	0.841	8.91	3.202/2.531	12.7/10.3	0.419	10.1
3.354/2.683	13.3/11.0	0.844	7.05	3.452/2.781	13.7/11.4	0.428	10.4
3.577/2.906	14.2/11.9	0.855	4.56				
3.943/3.272	15.6/13.4	0.837	1.19	3.990/3.319	15.8/13.5	0.510	2.41
to	to			to	to		
6.362/5.691	25.2/23.2			6.413/5.742	25.4/23.4		
6.827/6.156	27.1/25.1	0.830	0.83	7.042/6.371	27.9/26.0	0.698	0.27
to	to			to	to		
9.254/8.583	36.7/35.0			9.467/8.796	37.6/35.9		
9.728/9.057	38.6/37.0	0.874	0.62	10.109/9.438	40.1/38.5	0.820	0.79
to	to			to	to		
12.153/11.482	48.2/46.9			12.544/11.873	49.8/48.5		
b) 43 yr old							
0.129/—	0.5/—	0.080	52.1				
0.370/—	1.5/—	0.239	72.9				
0.618/0.159	2.5/0.7	0.525	68.0	0.583/0.124	2.4/0.5	0.055	37.5
0.868/0.409	3.5/1.7	1.013	52.6	0.831/0.372	3.4/1.5	0.408	55.4
1.110/0.651	4.5/2.7	1.237	85.5	1.074/0.615	4.4/2.6	0.421	90.2
1.359/0.900	5.5/3.7	0.850	85.3	1.322/0.863	5.4/3.6	0.316	84.1
1.606/1.147	6.5/4.8	0.690	76.7	1.569/1.110	6.4/4.6	0.271	65.4
1.851/1.392	7.5/5.8	0.682	63.2	1.817/1.358	7.4/5.6	0.292	52.5
2.091/1.632	8.5/6.8	0.721	46.8	2.068/1.609	8.4/6.7	0.343	35.2
2.346/1.887	9.5/7.8	0.701	32.2	2.316/1.857	9.4/7.7	0.352	26.2
2.600/2.141	10.6/8.9	0.685	19.1	2.572/2.113	10.5/8.8	0.350	19.5
2.846/2.387	11.6/9.9	0.683	12.1	2.817/2.358	11.5/9.8	0.351	13.8
3.093/2.634	12.6/10.9	0.679	9.30	3.066/2.607	12.5/10.8	0.355	10.1
3.345/2.886	13.6/12.0	0.694	6.02	3.316/2.857	13.5/11.9	0.349	11.2

Table 2 (continued)

Radius: Position relative to styloid tip of radius/ulna — Distance (cm)	Percentage forearm length	Bone mineral mass (g/cm)	% trabecular	Ulna: Position relative to styloid tip of radius/ulna — Distance (cm)	Percentage forearm length	Bone mineral mass (g/cm)	% trabecular
3.690/3.231 to 6.185/5.726	15.0/13.4 to 25.1/23.8	0.728	1.87	3.718/3.259 to 6.112/5.653	15.1/13.5 to 24.8/23.5	0.428	5.86
6.707/6.248 to 9.201/8.742	27.3/25.9 to 37.4/36.3	0.758	3.59	6.638/6.179 to 9.141/8.682	27.0/25.6 to 37.2/36.0	0.648	3.47
9.614/9.155 to 12.119/11.660	39.1/38.0 to 49.3/48.4	0.788	1.75	9.874/9.415 to 12.112/11.653	40.1/39.1 to 49.2/48.4	0.818	2.36
c) 63 yr old							
0.126/—	0.5/—	0.068	20.7				
0.376/—	1.5/—	0.173	47.5				
0.627/—	2.5/—	0.470	57.9				
0.888/0.255	3.5/1.0	0.927	66.7	0.815/0.182	3.2/0.7	0.052	52.8
1.133/0.500	4.5/2.0	1.045	77.6	1.062/0.429	4.2/1.7	0.095	40.9
1.389/0.756	5.5/3.1	0.860	81.4	1.322/0.689	5.2/2.8	0.360	68.0
1.611/0.978	6.4/4.0	0.738	73.6	1.566/0.933	6.2/3.8	0.352	80.0
1.862/1.229	7.4/5.0	0.685	55.3	1.805/1.172	7.2/4.8	0.303	75.7
2.129/1.496	8.4/6.1	0.667	42.3	2.060/1.427	8.2/5.8	0.281	56.0
2.387/1.754	9.5/7.1	0.652	30.3	2.305/1.672	9.1/6.8	0.299	35.9
2.631/1.998	10.4/8.1	0.631	23.3	2.559/1.926	10.2/7.8	0.315	13.4
2.887/2.254	11.5/9.2	0.611	17.0	2.813/2.180	11.2/8.9	0.314	3.32
3.131/2.498	12.4/10.2	0.565	3.93	3.062/2.429	12.2/9.9	0.319	4.04
3.392/2.759	13.5/11.2	0.561	3.88	3.307/2.674	13.1/10.9	0.324	3.04
3.797/3.164 to 6.283/5.650	15.1/12.9 to 24.9/23.0	0.571	3.28	3.849/3.216 to 6.349/5.716	15.3/13.1 to 25.2/23.2	0.371	5.08
6.768/6.135 to 9.257/8.624	26.9/24.9 to 36.7/35.1	0.575	2.81	6.871/6.238 to 9.353/8.720	27.3/25.4 to 37.1/35.4	0.511	4.40
9.768/9.135 to 12.263/11.630	38.8/37.1 to 48.7/47.3	0.573	2.21	9.880/9.247 to 12.356/11.723	39.2/37.6 to 49.0/47.7	0.623	5.53
d) 85 yr old							
0.126/—	0.6/—	0.095	51.3				
0.381/0.007	1.7/0.03	0.298	52.9	0.495/0.121	2.2/0.5	0.102	32.3
0.619/0.245	2.7/1.1	0.656	66.8	0.742/0.368	3.3/1.7	0.328	66.9
0.867/0.493	3.8/2.2	0.840	75.8	0.967/0.593	4.3/2.7	0.356	74.7
1.119/0.745	4.9/3.3	0.646	82.4	1.213/0.839	5.3/3.8	0.310	76.1
1.358/0.984	6.0/4.4	0.620	72.0	1.439/1.065	6.3/4.8	0.280	67.8
				1.689/1.315	7.4/5.9	0.264	54.9
1.861/1.487	8.2/6.7	0.528	52.0	1.937/1.563	8.5/7.0	0.265	45.2
2.118/1.744	9.3/7.8	0.485	38.6	2.207/1.833	9.7/8.2	0.240	34.3

Table 2 (continued)

Radius				Ulna			
Position relative to styloid tip of radius/ulna		Bone mineral mass (g/cm)	% trabecular	Position relative to styloid tip of radius/ulna		Bone mineral mass (g/cm)	% trabecular
Distance (cm)	Percentage forearm length			Distance (cm)	Percentage forearm length		
2.362/1.988	10.4/8.9	0.465	30.4	2.457/2.083	10.8/9.3	0.267	28.1
2.612/2.238	11.5/10.0	0.473	23.5	2.707/2.333	11.9/10.5	0.246	23.7
2.858/2.484	12.6/11.1	0.476	21.4	2.951/2.577	13.0/11.6	0.250	19.7
3.107/2.733	13.7/12.3	0.472	15.8	3.210/2.836	14.1/12.7	0.251	21.3
3.348/2.974	14.7/13.3	0.466	11.9				
3.690/3.316 to 6.107/5.733	16.3/14.9 to 26.9/25.7	0.454	6.53	3.788/3.414 to 6.021/5.647	16.7/15.3 to 26.5/25.3	0.312	12.7
6.783/6.409 to 9.023/8.649	29.9/28.7 to 39.7/38.8	0.456	6.79	6.540/6.166 to 9.045/8.671	28.8/27.7 to 39.8/38.9	0.464	9.06
9.581/9.207 to 11.964/11.590	42.2/41.3 to 52.7/52.0	0.507	5.29	9.530/9.156 to 12.014/11.640	42.0/41.1 to 52.9/52.2	0.587	8.00

which are in the same anatomical position when the forearm is prone lie in the same row of the table. The maximum error in the distances between sections within one bone piece is ± 0.0025 cm. The maximum error in the distances measured from the styloid tip, in the distances between sections from two different pieces of the same bone, or in the distances between sections in the radius and ulna is ± 0.1 cm.

Discussion

Sites of bone mineral mass measurement in the distal radius have been described as predominantly trabecular bone (Smith *et al.*, 1970), although there is little supporting evidence. Our data give a direct quantitative measure of the relative amount of trabecular bone along the lengths of the radius and ulna and may be used to determine the percentage of trabecular bone at distal measurement sites. The precentages of trabecular bone mineral mass at five distal sites used in several laboratories (Nilsson and Westlin, 1973; Goldsmith *et al.*, 1971; Heer *et al.*, 1973; Smith *et al.*, 1970; Johnston *et al.*, 1968) are presented in Table 3.

The averages of the percentages for our four subjects and the ranges of individual values are presented. For the first site the precentage is the average over a band extending from 1 to 1.7 cm from the ulnar styloid tip. For the other sites the band was assumed to be 2 mm wide, i.e., about the width of a bone section, and centered at the scan site. The data show that at the first site the bone is approximately 50% trabecular and at the remaining four sites it is approximately 10–25% trabecular. Individual deviations from the mean are large. Most laboratories utilize the last four sites in the table; thus most distal site data reported

Table 3. Percentage of trabecular bone mass in the radius and ulna at various distal measurement sites. Percentages for all subjects have been averaged together. The range of individual values is shown also

Site description	Percentage trabecular bone	
	Radius average (range)	Ulna average (range)
A band 7 mm wide, 1 cm from the ulnar styloid tip[a]	53 (42–61)	52 (45–58)
2 cm from the ulnar styloid tip[b]	24 (17–30)	21 (11–30)
$^{1}/_{10}$ of the length of the ulna from the ulnar styloid tip[c]	13 (6–24)	13 (4–26)
$^{1}/_{10}$ of the distance between the radial styloid tip and the olecranon of the ulna measured from the radial styloid tip[d]	27 (21–34)	24 (17–33)
3 cm from the radial styloid tip[e]	13 (10–18)	12 (4–20)

[a] Nilsson and Westlin (1973).
[b] Goldsmith *et al.* (1971).
[c] Heer *et al.* (1973).
[d] Smith *et al.* (1970).
[e] Johnston *et al.* (1968).

Table 4. Average bone mineral mass and percentage trabecular bone in the most distal 10% of the radius and in the segment which lies between 30% and 40% of the total length measured from the styloid tip

Subject	0–10% segment		30–40% segment	
	Average bone mineral mass (g/cm)	Percentage trabecular mass	Average bone mineral mass (g/cm)	Percentage trabecular mass
21 yr old	0.83	50	0.83	0.6
43 yr old	0.67	68	0.75	3.4
63 yr old	0.63	64	0.57	2.7
85 yr old	0.53	67	0.48	6.9

have been measured at locations which are high in cortical bone despite assumptions to the contrary (Smith *et al.*, 1970; Heer *et al.*, 1973).

As bone ages, large resorption cavities develop in cortical bone adjacent to the medullary canal as illustrated in Fig. 2, views 1 and 3 (Arnold,1970). The resultant tendency for trabecular bone to increase is counteracted by the concurrent erosion of trabeculae. The data in Table 4 present a quantitative picture of the outcome of these opposing tendencies. The average bone mineral mass and the percentage trabecular bone in the most distal 10% of the radius and in the segment which lies between 30% and 40% of the total length measured from the styloid tip are presented for each subject. In the distal portion there is a marked decrease in mineral mass as age increases but the percentage of trabecular bone remains approximately constant. This constancy means that there is a net loss of trabecular bone and implies that new trabecular bone is produced at too low a rate to keep up with the loss of existing trabecular bone. In the 30—40% segment the average bone mineral mass also decreases markedly with age, but the percentage of trabecular bone appears to increase. The rate of increase appears to be fast enough to produce an actual increase in the total amount of trabecular bone. The results for the ulna show the same trend as those for the radius. While four cases are insufficient to define population trends precisely, it is probably safe to say that the percentage of trabecular bone in the distal end would be approximately independent of age but the precentage 30—40% segment would increase with age.

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