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Edentulation Alters Material Properties of Cortical Bone in the Human Mandible

ABSTRACT

Ridge resorption following edentulation has been documented clinically, but the effects of tooth loss on the material properties of mandibular cortical bone have received little study. Material properties and their structural basis are essential for our understanding of bone quality in the edentulous mandible and are of interest as a tissue-level model for functional adaptation. This study's aim was to determine material property variability in the edentulous mandible, and to compare it with data from a previous study of dentate mandibles. Forty-four cortical samples were removed from each of 10 adult fresh edentulous mandibles. Cortical thickness and density were measured. Material properties were calculated from ultrasonic velocities. Mandibular cortical bone in the edentulous mandibles differed from that of dentate mandibles in cortical thickness, elastic and shear moduli, anisotropy, and orientation of the axis of maximum stiffness. These results suggest that cortical microstructural changes accompany ridge resorption following edentulation.

KEY WORDS: ultrasound, cortical bone, biomechanics, function.

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A supplemental appendix to this article is published electronically only at http://www.dentalresearch.org.

INTRODUCTION

Despite advances in caries prevention and periodontal disease treatment, tooth loss and the edentulous state remain significant health care issues. Many studies report the consequences of tooth loss and associated residual ridge resorption (Jaul *et al.*, 1980; Hirai *et al.*, 1993; Klemetti, 1996). However, little is known about the impact of edentulation and residual ridge resorption on changes in mandibular cortical structure, material properties, and biomechanics.

In general, material properties and their variation, which are important indicators of bone quality, have not received much systematic analysis in individual bone organs. A recent study (Schwartz-Dabney and Dechow, in press) demonstrates significant regional material property variation in human dentate mandibles, some of which is associated with function. Although geometry changes are reported following edentulation, nothing is known about changes in other material properties, such as elastic and shear moduli. The two previous studies that measured material properties in both dentate and edentulous mandibles had sample sizes insufficient for statistical evaluation (Carter, 1989; Arendts and Sigolotto, 1990). Some information is available for bone density, but these data are largely derived from radiographs and other scans that do not allow density to be calculated as a true volumetric measurement.

Our aim was to examine regional material property differences of edentulous mandibular cortical bone and to compare these with known properties of dentate mandibles. We hypothesized that edentulous mandibles, like dentate mandibles, differ regionally.

Regarding the potential differences between dentate and edentulous mandibles in material properties, our null hypothesis was that there were no differences. An alternate hypothesis was difficult to formulate, given the lack of information in the literature on differences in material properties resulting from bone adaptation. In experimental studies of post-cranial bone, it is widely recognized that loss of or reduction in function may lead to loss of bone mass (for review, see Martin *et al*., 1998). However, little is known about changes in elastic properties, especially if their three-dimensional characteristics are considered. Likewise, most studies of density are radiographic and fail to separate differences due to apparent bone density from those due to thickness. Nevertheless, the important issue of bone quality in the edentulous mandible, especially given the increasingly widespread use of implants for dental restoration, led us to test whether edentulation results not only in alveolar bone loss, but also in changes in the material properties of the remaining basal bone.

MATERIALS & METHODS

Specimen Selection and Preparation

Ten fully edentulous human mandibles were selected for dissection from unembalmed (fresh or frozen) cadavers donated to The University of Texas

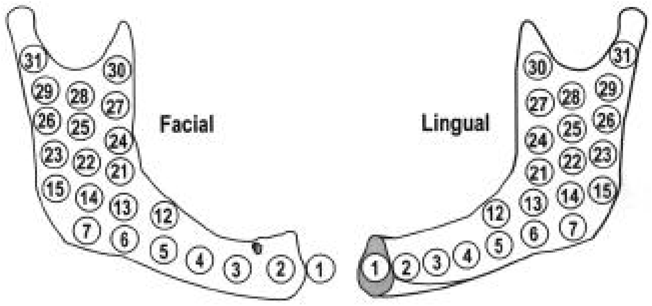

Figure 1. Location of the 22 sites on each side of the edentulous mandibles. Note that the numbering is not sequential, to allow for site correspondence with a previous study (Schwartz-Dabney and Dechow, in press) in dentate mandibles.

Southwestern Medical School willed body program. This study was exempt from IRB review because used tissues were from deceased individuals who had donated these tissues prior to death in accordance with the laws of the State of Texas.

All mandibles had intact alveolar ridges with no evidence of open or healing sockets. Residual ridge height was significantly reduced in all mandibles, averaging between 14 and 15 mm along the corpus. Age at death ranged from 58 to 88 yrs and was not significantly different between three males (69.7 yrs, SD = 10.4) and seven females (72.1 yrs, SD = 12.6). Mandibles (1) were from Caucasian donors, (2) did not have a documented history of bone disease, and (3) possessed an indication of denture use by the presence of dentures with most cadaver remains. Craniometric dimensions of the mandibles are given in the Appendix, Table 1 (www.dentalresearch.org).

All bone preparation was carried out under a hood, with a sterile technique and continuous water drip for coolant. Specimens from 22 sites were harvested on both facial and lingual cortices (Fig. 1). (Numbering is not sequential, to maintain labeling consistent with that in our dentate study [Schwartz-Dabney and Dechow, in press].) Sites were marked with a graphite line parallel to the superior surface of the alveolar ridge in the molar region and with an arrowhead indicating the anterior. Bone cylinders were harvested by means of a slow-speed dental handpiece and trephine burs (inner diameter, 4.0 mm). Endosteal cancellous bone was removed with a miniature lathe equipped with grinding wheels until there was no visible porosity perpendicular to the endosteum. Samples were stored in equal proportions of 95% ethanol and isotonic saline, which maintained the elastic properties over time (Ashman *et al.*, 1984; Zioupos *et al.*, 2000).

Measurement Technique

We measured all bone cubes with a digital caliper to the nearest 0.01 mm to verify diameter (4 mm) and determine cortical thickness, which is defined as the distance from the periosteum to the cortical-trabecular interface. Apparent density calculations, based on Archimedes' principle of buoyancy, were measured to the nearest 0.001 g with a Mettler-PM460 analytical balance (Mettler, Toledo, OH, USA) and densitometry analysis apparatus.

The principal axes of each specimen were identified by an ultrasonic technique (Schwartz-Dabney and Dechow, in press) with a Hewlett-Packard (Hewlett-Packard, Palo Alto, CA, USA) pulse generator, 2 mounted piezoelectric transducers (2.25 MHz longitudinal, Panametrics V323-SU, and 5.0 MHz shear, Panametrics V156-RM, Panametrics, Inc., Waltham, MA, USA), and an oscilloscope (Tektronix TDS-420, Tektronix, Inc., Beaverton, OR, USA). The arrowhead served as the origin for 9 measurements at rotations of 22.5°. The direction with the highest longitudinal velocity corresponded to the direction of maximum stiffness (D_3), since ultrasonic velocity increases linearly with stiffness (Ashman *et al.*, 1984; Kohles *et al.*, 1997). The direction of minimum stiffness in the plane of the cortical plate (D_2) corresponded to the slowest velocity and was 90° to the direction of maximum stiffness.

Material property testing used the pulse transmission technique (Ashman *et al.*, 1984; Ashman and van Buskirk, 1987; Schwartz-Dabney and Dechow, in press). Both longitudinal and transverse ultrasonic waves were passed through the principal axes (D_2 and D_3) and the cortical thickness (D_1) of each specimen. We measured time delays to make a phase comparison of the signals before and after transmission. We calculated ultrasonic velocities by dividing the thickness or diameter by the time delay. Elastic properties were calculated from ultrasonic velocities according to standard techniques (Ashman *et al*., 1984; Dechow *et al*., 1993; Kohles *et al*., 1997). Young's elastic modulus (E) measures a structure's ability to resist deformation along an axis, indicated by subscripts as in E_1, E_2, or E_3. Shear modulus (G) measures a structure's ability to resist angular shear stresses in a plane between 2 axes indicated by subscripts as in G_{12}, G_{31}, or G_{32}.

Principal axes could be calculated for all specimens (N = 440). However, ultrasonic velocities in the D_1 direction could not be obtained in 25 specimens, which were too thin (< 0.1 mm) for repeatable measurements to be obtained, and thus elastic properties could not be calculated. Half of these specimens came from 3 sites on the lingual ramus (#14, 15, 26). Differences between sides could not be tested at some sites (#27, 30) on the coronoid process, due to confluence of the cortical plates.

Analysis

Data from 10 dentate mandibles, previously described (Schwartz-Dabney and Dechow, in press), were used as a comparison with data from the edentulous group in relevant statistical tests. Average mandibular height (inferior border to alveolar crest) along the corpus averaged between 25 mm (symphysis) and 33 mm (molars) and was approximately double the residual ridge height in the edentulous sample (difference was significant at F = 45.6, $p < 0.001$). Analysis of variance indicated that the dentate sample was not significantly different in age, although mean values (males = 64.2, SD = 11.7; females = 62.0, SD = 17.1) and range (48-81) were slightly less. The proportion of males (seven) and females (three) was also different in the dentate sample, but tests of differences in material properties by gender for both groups did not show significant differences.

Minitab Software (Minitab Software, Pittsburgh, PA, USA) (release 13.3) was used for most statistical calculations. Data were checked for normality and hypotheses were tested with a balanced, unrestricted ANOVA with a repeated-measures design and mandible as the repeating factor. The repeated-measures design accounts for the lack of independence between multiple samples taken from a single mandible (Zar, 1996; Minitab User's Guide 2, Release 13, pps. 3-31–3-33, Minitab, Inc., 2000). Statistical p-values were presented where differences existed between (1) sites, (2) facial and lingual cortices, or (3) dentate and edentulous mandibles.

Directions of maximum stiffness, because of their unique angular distribution, required circular statistics (Zar, 1996), which we calculated with Oriana for Windows Version 1 (Kovach Computing Services, Anglesey, Wales, UK). We used Raleigh's uniformity test (Zar, 1996) to determine whether the means themselves were significant, meaning the distribution of orientations was different from a random collection of angles. If angular means were significant, we tested differences between them with a generalization of the Watson-Williams test adapted for circular distributions (Zar, 1996).

RESULTS

Principal Axis Orientation

The direction of the axes of maximum stiffness varied significantly between sites ($p < 0.05$), although several sites had no significant orientation (Fig. 2 and Appendix, Table 2 [www.dentalresearch.org]). Sites with the least variation were at the inferior corpus and posterior ramus on both cortices. Sites with the most variation were near the coronoid and condylar processes and sigmoid notch area. There were 5 paired edentulous sites with significant differences ($p < 0.04$) between facial and lingual sides (#3, 12, 25, 27, 31).

Between paired dentate and edentulous sites, two facial sites (#13, 28) differed significantly at $p < 0.01$. One site (facial #6) differed in that it was oriented in the edentulous but not in the dentate mandibles, while two sites (facial #24 and lingual #13) were oriented in the dentate but not edentulous mandible. Four sites (facial #12, 21, 26, and lingual #12) approached significance ($p < 0.1$) and are interesting because they were adjacent to sites with significant differences, suggesting a difference in a larger region of the mandible than that indicated by a single site.

Cortical Thickness

Cortical thickness in edentulous mandibles was not significantly different between facial and lingual sides, but was significantly different among sites within each cortex ($p < 0.001$). Cortical bone was thicker in the corpus than ramus (Fig. 3 and Appendix, Table 2 [www.dentalresearch.org]). Except for one anterior border site, the thickest ramus sites were along the posterior border.

Throughout most of the edentulous mandibles, cortical bone was significantly thinner ($p < 0.05$) than in dentate mandibles. Facially, only 2 sites were thicker on average in the edentulous mandible (#2, 3). Lingually, the edentulous corpus tended to be thicker than that of the dentate, while much of the ramus was thinner, except for the angle and the condylar neck.

Density

Edentulous cortical density was not significantly different between facial and lingual sides, but was significantly different among sites within each cortex ($p < 0.01$) (Appendix, Table 2 [www.dentalresearch.org]). Lingual ramus sites and facial masseteric and condylar sites were the least dense. There were no significant differences between edentulous and dentate mandibles.

Elastic Moduli

Edentulous elastic moduli were not significantly different between facial and lingual sides, but were significantly different among sites on each cortex ($p < 0.01$) (Appendix, Table 3 [www.dentalresearch.org]) and between directions (E_1, E_2, and E_3) ($p < 0.001$). The grand mean elastic moduli for edentulous mandibles were 12.5 GPa (SD = 2.3) for E_1, 17.9 GPa (SD = 3.3) for E_2, and 26.6 GPa (SD = 5.9) for E_3.

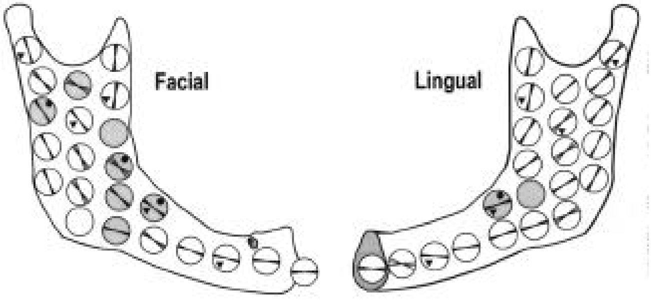

Figure 2. Means and 95% confidence intervals for the directions of the axes of maximum stiffness for edentulous mandibles (N = 10). The direction of maximum stiffness varies regionally in orientation and in the amount of variability. The central line in each circle indicates the direction of maximum stiffness (D_3). The lines on each side of the central line represent the 95% confidence intervals. Sites with no lines lack significant orientation. Shading indicates a difference between edentulous and dentate mandibles, which is significant at $p < 0.05$ (no mark in upper right of circle), or approaches significance at $p < 0.10$ (solid dot in the upper right of the circle). An inverted solid triangle (▼) indicates a significant difference between facial and lingual cortices.

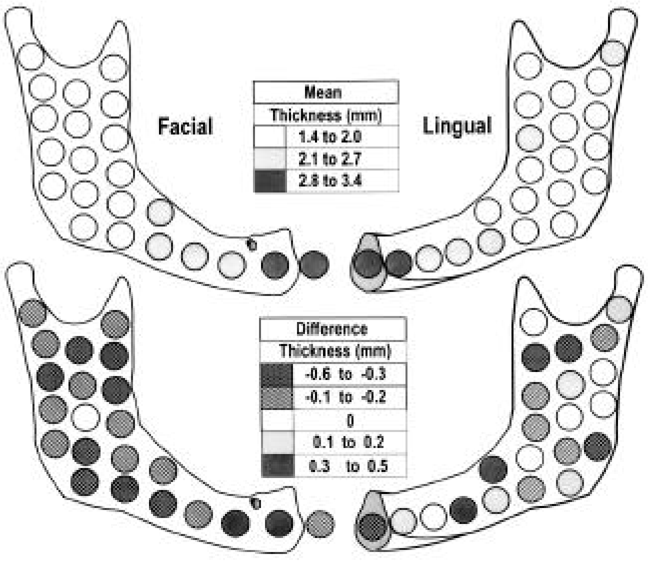

Figure 3. Average cortical plate thickness in the edentulous mandible (upper Figs.) and differences compared with dentate mandibles (lower Figs.). Cortical thickness is greatest anteriorly and is the least in the ramus. Thickness is less in most regions of the edentulous compared with the dentate mandible, except anteriorly on the facial side, and along the corpus, at the angle, and at the condylar neck on the lingual side.

E_3 values in edentulous mandibles were, on average, significantly stiffer ($p < 0.04$) than in dentate mandibles (22.8 GPa, SD = 5.4). Only 6 sites, all in the ramus (facial #13, 14, 21 and lingual #16, 24, 27) (Fig. 4), were, on average, less stiff. Average dentate E_1 values (12.7 GPa, SD = 1.8) and E_2 values (17.9, SD = 2.5) were essentially identical to those of edentulous mandibles, and no significant differences were found.

Shear Moduli

Edentulous shear moduli were not significantly different between facial and lingual sides, but were significantly different among sites within each cortex ($p < 0.01$) and

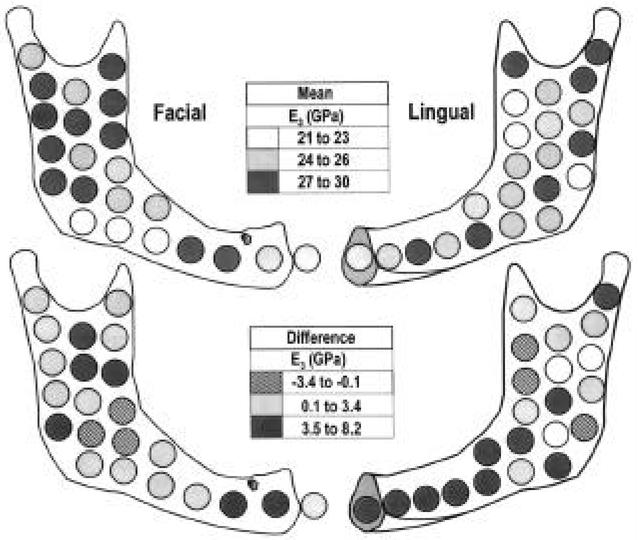

Figure 4. Average elastic moduli (E_3) in the direction of maximum stiffness (upper Figs.) and differences compared with dentate mandibles (lower Figs.). The edentulous mandibles are stiffer facially than lingually, especially in the ramus. Edentulous mandibles were stiffer over most of their cortical surface than dentate mandibles, except for several sites, mostly in the anterior part of the ramus.

between directions (G_{12}, G_{31}, and G_{23}) ($p < 0.001$) (Appendix, Table 4 [www.dentalresearch.org]). The grand means for edentulous shear moduli were 7.1 GPa (SD = 1.1) for G_{23}, 5.3 GPa (SD = 1.0) for G_{31}, and 4.5 GPa (SD = 0.9) for G_{12}.

G_{12} values in edentulous mandibles were, on average, modestly but significantly less stiff (10%, $p < 0.01$) than in dentate mandibles (5.0 GPa, SD = 0.6). Only 2 sites (#1, 2) on the facial cortex were stiffer. Average dentate G_{23} values (7.4 GPa, SD = 0.8) and G_{31} values (5.5 GPa, SD = 0.7) were not significantly different from those of the edentulous mandible.

Other Elastic Properties

Poisson's ratios, elastic coefficients, and anisotropy ratios are given in the Appendix (Tables 5-7) (www.dentalresearch.org).

DISCUSSION

Principal Axis Orientation

Our results show orientation differences between dentate and edentulous mandibles in the retromolar and superior ramus regions. For edentulous mandibles, the direction of maximum stiffness of retromolar sites is less oblique, being about 15-30° closer to the inferior border orientation. The structural significance of these differences is difficult to determine, since little is known about the internal arrangements of osteonal bone in these regions. Likewise, functional correlates cannot be inferred, because we have inadequate knowledge of *in vivo* deformations of the relevant mandibular regions during oral activities.

Ogata and Satoh (1995), in a clinical study, demonstrate one functional difference between dentate and edentulous individuals that may be important. A small sample of edentulous subjects exhibited increased bilateral occlusion compared with the more prevalent unilateral chewing and biting of the dentate. Bilateral occlusion reduces the transfer of masticatory and bite forces across the symphysis and mandibular twisting moments, which would increase the relative amount of bending during chewing and biting. Since an effective way for bone to resist deformation is for the direction of maximum stiffness to be aligned with the direction of load (principal stress) (Dechow and Hylander, 2000), then the less oblique direction of maximum stiffness may be a structural adaptation to resist relatively greater amounts of bending and decreased shear in the retromolar region.

Other than our work on dentate mandibles (Schwartz-Dabney and Dechow, in press), no measurements of the direction of maximum stiffness are available for any bones. It is interesting that the direction of maximum stiffness deviates from the anatomical axes of the mandible at many sites. This may differ from diaphyses of the post-cranial skeleton, where the stiffest directions are thought to parallel the long anatomical axes.

Also of great interest is the variation in the direction of maximum stiffness between sites. Some sites have a more constant orientation, while other sites have no statistically significant mean orientation between individuals. If material orientation is functionally related, this suggests that variations in loading may correspond to individual differences in mandibular form and muscular function.

Cortical Thickness

Our results show that differences in cortical thickness between edentulous and dentate mandibles vary regionally. The most pronounced difference is the general tendency for cortical thickness to be greater in the corpus, especially lingually, and lesser in the ramus. We hypothesize that the thicker cortical bone of the edentulous corpus represents a secondary adaptation to relatively larger strains due to a reduction in alveolar height and corpus cross-section, despite overall reduced muscular and biting loads. We also hypothesize that the cortical bone of the ramus is thinner secondary to decreased muscular loading (Raustia *et al.*, 1996). Modeling studies of function in edentulous mandibles could be used to test the mechanical effects of ridge reduction and reduced muscular load, but such information is currently unavailable.

A possible functional corollary in dentate mandibles is the relationship between mandibular cortical thickness and facial form. Cortical thickness beneath the molars varies from thicker in short-faced subjects to thinner in long-faced subjects (Masumoto *et al.*, 2001). This difference may be directly related to masticatory loads, which are greater in short-faced individuals (Throckmorton *et al.*, 1980).

Density

Controversy exists regarding the effects of tooth loss on mandibular density. Many of the differences among studies are methodological. Most studies assess density with two-dimensional scanning techniques (Horner and Devlin, 1992; Klemetti *et al.*, 1994; Ulm *et al.*, 1994), which are unable to remove the effects of thickness from material density and may be assessing primarily cortical thickness. Other studies use histological or microscopic techniques (Kingsmill and Boyde, 1998), which show cross-sectional density variations on an osteonal scale, but do not given volumetric measurements.

Our results are apparent volumetric representations of density at an intermediate tissue level, and they may differ from the results of density studies on a microscopic scale, since they are influenced by the amounts of both microporosities, such as resorption spaces, and mineralization in bone. Our results agree with those of Henrikson and Wallenius (1974), who use a technique similar to ours and find no differences in densities between dentate and edentulous individuals, or between genders. Our study extends these results to other regions of the mandible, where likewise no significant differences are found. The lack of differences suggests that cortical bone density following edentulation is maintained despite changes in structure, stiffness, and anisotropy.

Elastic Properties

The most interesting findings of this study are the significant differences in maximum stiffness (E_3) between edentulous and dentate mandibles, despite the lack of significant differences in density, and other elastic moduli. The overall positive correlation between cortical bone density and stiffness is well-known. However, these correlations are generally moderate and explain only a portion of the variance in either variable. The differing results for density and maximum stiffness suggest that three-dimensional structural changes can occur within cortical bone, while density changes little.

The regional differences in maximum stiffness are also of great interest. In much of the mandible, cortical bone may partially compensate for a thinner cortex with increased stiffness. However, this increase in stiffness may come at a cost. While the mandible may deform less for a given load, the cortex may be more brittle and thus fail more quickly under the largest and most rapidly applied loads.

On average, the edentulous mandible compared with the dentate mandible has (1) greater maximum stiffness coupled with thicker bone in the lingual corpus, (2) greater maximum stiffness anteriorly in the facial corpus and at the lingual condylar neck, (3) lesser maximum stiffness and thickness in portions of the ramus, and (4) different directions of the axes of maximum stiffness at some sites, especially in the buccal retromolar region. These differences imply adaptations to altered patterns of regional loading and deformation. In the ramus, these differences correspond to decreased EMG activity, muscular atrophy, and (presumably) muscle load in edentulous individuals (Raustia *et al*., 1996).

An understanding of these differences and their impact on clinical restorations of the mandible and its dentition requires greater knowledge of oral function in the edentulous, as well as the links among material properties, the intermediate or microstructure of cortical bone, and the processes of bone adaptation. These findings also suggest the importance of considering the three-dimensional aspects of cortical bone structure and material properties in studies of patterns and mechanisms of bone adaptation.

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APPENDIX

Material Properties of the Edentulous Mandibles by Site AQ

Table 1. Craniometric Measurements of Human Edentulous Mandibles

Craniometric Measurement (mm)	Mean	SD
Bicondylar distance: between lateral poles	116.7	5.0
Bigonial distance: between left and right gonions	94.0	5.4
Bicoronoid distance: between lateral surfaces of the coronoid	97.7	11.8
Bimental foramen distance: between mid-foramen **AQ**	42.7	2.3
Condylar height: gonion to most superior condylar point	57.5	3.3
Sigmoid height: gonion to most inferior point in sigmoid notch	42.7	4.2
Coronoid height: gonion to highest point on coronoid process	58.7	6.0
Molar height: inferior border to alveolar crest distal to 2nd molar	14.2	4.0
Premolar height: from inferior border to alveolar crest, a complete measure in the area of the mental foramen	14.5	8.1
Alveolar height: only from mental foramen to alveolar crest	4.4	5.7
Symphysis height: at midline from menton to infradentale	15.5	8.2
Mandibular length: from pogonion to condylion	122.0	5.3
Inferior corpus length: from pogonion to gonion	85.3	2.5
Sigmoid notch length: from condylion to gonion	40.2	3.1
Condylar head length: from anterior to posterior condylar pole	8.8	1.3
Condylar neck length: minimum A-P condylar neck length	7.6	1.3
Coronoid length: A-P length of coronoid process, midway from notch	9.5	1.1
Ramus length: minimum A-P ramus length, perpendicular to posterior border	27.8	4.4
Condylar head width: from lateral to medial condylar pole	18.9	2.5
Condylar neck width: minimum transverse condylar neck width	11.6	2.3
Coronoid width: maximum transverse width of the coronoid process, midway up from the sigmoid notch	3.0	0.7
Ramus width: maximum transverse width of the corpus at the level of the inferior alveolar foramen	8.6	0.9
Molar width: maximum transverse width, just distal to 2nd molar	10.3	1.8
Premolar width: maximum corpus width at the mental foramen * **AQ**	9.8	1.1
Symphysis width: maximum A-P width at midline	13.4	1.2

Table 2. Principal Axes, Cortical Thicknesses, and Densities for Human Edentulous Mandibles

		Principal Axes (°)		Thicknesses (mm)		Densities (mg/cm^3)	
Site	Area	Mean	SD	Mean	SD	Mean	SD
				Facial			
1	sym	0.0	14.3	3.1	0.6	1873	52
2	sym	4.5	13.5	3.1	0.4	1942	104
3	infbor	13.2	18.1	2.7	0.5	1961	89
4	infbor	20.3	6.7	2.5	0.3	1971	63
5	infbor	24.7	12.1	2.1	0.5	1933	95
6	angle	15.3	24.8	1.9	0.5	1864	99
7	angle	*	32.2	1.6	0.4	1807	145
12	midbod	37.5	10.6	2.3	0.6	1950	90
13	midram	42.7	15.8	1.8	0.3	1910	111
14	angle	56.6	21.3	1.7	0.3	1982	136
15	posbor	67.5	14.3	1.9	0.6	1871	107
21	midram	42.2	27.6	1.7	0.4	1973	111
22	midram	61.9	20.5	1.7	0.4	1985	99
23	posbor	65.3	6.7	2.0	0.6	1945	140
24	midram	*	44.6	1.9	0.4	1934	110
25	midram	63.2	19.6	1.7	0.4	1909	174
26	posbor	56.4	15.1	1.9	0.5	1924	138
27	cor	98.9	18.0	1.8	0.8	1982	81
28	midram	25.9	26.0	1.5	0.3	1930	101
29	cond	45.4	20.1	2.0	0.8	1978	88
30	cor	92.2	12.1	1.8	0.6	1940	131
31	cond	72.5	14.2	1.8	0.5	1842	130
				Lingual			
1	sym	-2.4	23.5	3.4	0.6	1936	42
2	sym	-8.9	31.7	3.1	0.7	1988	55
3	infbor	-4.4	9.0	2.5	0.4	2003	52
4	infbor	11.1	15.1	2.3	0.2	1975	68
5	infbor	17.9	16.9	1.9	0.4	1982	52
6	angle	20.2	15.8	1.7	0.4	1931	146
7	angle	29.6	27.8	1.8	0.6	1840	156
12	midbod	15.2	18.4	1.7	0.4	1911	113
13	midram	*	33.5	1.4	0.4	1959	100
14	angle	39.4	9.8	1.4	0.3	1958	75
15	posbor	59.6	21.4	1.4	0.2	1810	252
21	midram	36.0	20.7	1.7	0.5	1991	101
22	midram	40.3	27.6	1.4	0.3	1872	191
23	posbor	61.8	14.9	1.5	0.4	1751	239
24	midram	58.5	11.1	1.8	0.5	1831	236
25	midram	41.7	18.9	1.7	0.7	1834	229
26	posbor	49.4	9.0	1.5	0.4	1816	159
27	cor	77.1	11.2	1.5	0.3	1814	165
28	midram	42.2	13.5	1.4	0.4	1949	154
29	cond	45.0	19.7	1.5	0.4	1945	107
30	cor	78.8	11.3	1.4	0.3	1998	113
31	cond	49.3	19.6	1.9	0.7	1879	53

Abbreviations: Symphysis (sym), Inferior border (infbor), Mid-body (midbod), Coronoid process (cor), Condylar process (cond), Mid-ramus (midram), Posterior border (posbor).

* No significant orientation.

Table 3. Elastic Moduli (in GPa) for Human Edentulous Mandibles (abbreviations as in Table 2)

		Facial					
		E_1		E_2		E_3	
Site	Area	Mean	SD	Mean	SD	Mean	SD
1	sym	13.2	2.6	15.4	3.8	24.1	7.9
2	sym	13.8	2.5	15.8	3.8	26.2	7.5
3	infbor	13.6	2.6	17.5	4.1	29.5	7.9
4	infbor	13.6	1.5	16.9	3.0	27.4	6.3
5	infbor	12.0	2.7	17.4	3.5	22.9	6.6
6	angle	11.0	1.6	17.4	3.8	21.7	4.9
7	angle	10.6	1.9	17.4	2.8	23.6	5.6
12	midbod	13.3	2.2	18.8	2.5	26.9	7.1
13	midram	11.6	2.3	17.8	3.4	25.2	5.4
14	angle	12.7	2.6	18.4	3.7	27.7	6.6
15	posbor	12.3	2.9	17.7	3.2	30.4	5.5
21	midram	12.3	1.7	20.1	3.1	24.6	4.1
22	midram	12.5	1.5	19.8	2.8	26.3	5.7
23	posbor	12.9	2.5	18.5	4.8	30.3	4.6
24	midram	13.2	2.0	20.3	2.2	27.3	5.7
25	midram	13.1	2.2	20.0	3.3	29.1	6.4
26	posbor	13.0	2.5	17.4	3.3	28.6	7.2
27	cor	12.6	2.9	19.9	1.9	30.5	5.1
28	midram	11.8	2.2	19.4	2.9	26.7	5.6
29	cond	13.1	2.5	18.3	3.3	28.2	4.1
30	cor	13.6	2.5	18.3	3.5	30.5	4.1
31	cond	12.3	3.0	16.7	2.1	25.9	5.4
				Lingual			
1	sym	13.9	2.6	17.5	3.3	24.5	5.5
2	sym	13.3	2.2	17.8	2.6	25.6	4.6
3	infbor	13.4	0.7	17.8	2.3	28.1	4.5
4	infbor	13.3	1.5	18.2	2.0	26.4	6.9
5	infbor	13.7	1.4	18.4	2.1	28.9	5.6
6	angle	12.5	2.6	16.7	3.5	26.2	6.2
7	angle	11.8	2.3	18.9	3.8	26.6	3.6
12	midbod	12.0	1.8	18.6	1.1	24.9	4.0
13	midram	11.8	2.1	18.3	2.7	25.3	5.5
14	angle	12.3	1.0	19.3	1.9	27.2	4.4
15	posbor	10.6	1.7	15.9	3.6	23.3	5.7
21	midram	13.1	2.7	19.7	3.3	25.5	5.2
22	midram	11.8	1.2	16.0	2.0	25.5	7.1
23	posbor	10.9	2.3	15.3	4.9	27.2	8.2
24	midram	11.4	2.7	16.9	3.4	23.0	5.6
25	midram	11.2	2.4	17.4	6.1	25.4	4.9
26	posbor	10.2	2.8	14.6	3.9	24.1	6.5
27	cor	9.6	1.5	17.6	3.5	23.7	4.8
28	midram	12.6	1.7	17.9	3.0	26.5	5.5
29	cond	11.6	1.5	17.1	2.3	27.5	5.7
30	cor	12.3	2.3	15.4	1.8	29.1	5.7
31	cond	12.5	1.8	16.7	2.6	27.4	3.8

Table 4. Shear Moduli (in GPa) for Human Edentulous Mandibles (abbreviations as in Table 2)

		G_{12}		G_{31}		G_{23}	
Site	Area	Mean	SD	Mean	SD	Mean	SD
				Facial			
1	sym	5.0	1.2	5.7	1.3	6.2	1.0
2	sym	5.5	1.4	6.2	1.4	6.8	0.9
3	infbor	4.9	1.1	6.0	1.6	7.1	0.9
4	infbor	5.0	0.6	5.7	0.6	7.4	0.7
5	infbor	4.6	1.1	5.3	1.0	7.1	0.9
6	angle	4.1	0.6	4.8	0.7	7.0	1.0
7	angle	3.9	0.8	4.6	0.7	6.6	1.0
12	midbod	4.9	0.8	6.0	1.2	7.2	0.8
13	midram	4.3	0.7	5.2	1.0	6.9	0.8
14	angle	4.5	0.9	5.6	0.9	7.4	1.0
15	posbor	4.4	0.9	4.9	1.1	6.9	0.9
21	midram	4.4	0.7	5.0	0.7	8.1	1.1
22	midram	4.6	0.7	5.3	1.0	7.7	1.2
23	posbor	4.4	1.0	5.3	1.1	7.7	1.7
24	midram	4.8	0.9	5.6	1.0	7.4	0.6
25	midram	4.5	0.9	5.4	1.1	7.3	0.9
26	posbor	4.5	1.0	5.6	1.2	7.1	1.1
27	cor	4.5	0.8	5.3	0.8	7.6	0.7
28	midram	4.4	1.0	5.1	1.0	8.1	1.0
29	cond	4.8	1.0	5.4	1.1	7.5	1.0
30	cor	4.6	1.1	5.1	1.0	7.3	1.1
31	cond	4.4	1.1	5.2	1.3	6.6	0.9
				Lingual			
1	sym	5.0	1.2	5.7	1.3	6.9	0.5
2	sym	5.1	1.0	6.2	1.4	7.3	0.8
3	infbor	4.7	0.9	6.0	1.6	7.9	0.8
4	infbor	4.9	0.6	5.7	0.6	7.6	0.6
5	infbor	4.9	0.9	5.3	1.0	7.6	0.8
6	angle	4.7	1.0	4.8	0.7	7.3	1.0
7	angle	4.4	0.9	4.6	0.7	7.1	0.8
12	midbod	4.5	1.1	6.0	1.2	6.8	0.9
13	midram	4.2	0.9	5.2	1.0	7.3	0.9
14	angle	4.3	0.8	5.6	0.9	7.2	0.7
15	posbor	4.1	0.7	4.9	1.1	6.3	1.2
21	midram	4.7	0.8	5.0	0.7	7.5	1.0
22	midram	4.1	0.7	5.3	1.0	7.3	0.6
23	posbor	4.3	1.1	5.3	1.1	6.1	1.3
24	midram	4.1	0.8	5.6	1.0	6.4	1.3
25	midram	3.8	0.8	5.4	1.1	6.7	2.1
26	posbor	3.7	0.6	5.6	1.2	6.3	1.4
27	cor	3.6	0.7	5.3	0.8	6.2	1.0
28	midram	4.7	0.9	5.1	1.0	7.4	0.9
29	cond	4.1	0.6	5.4	1.1	7.3	0.6
30	cor	4.2	0.8	5.1	1.0	7.0	1.5
31	cond	4.4	1.0	5.2	1.3	6.6	0.7

Table 5. Poisson's Ratios for Human Edentulous Mandibles (abbreviations as in Table 2)

		υ_{12}		υ_{13}		υ_{21}		υ_{23}		υ_{31}		υ_{32}	
Site	Area	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
						Facial							
1	sym	0.29	0.13	0.22	0.12	0.32	0.12	0.21	0.11	0.37	0.15	0.31	0.13
2	sym	0.26	0.16	0.23	0.11	0.28	0.16	0.23	0.11	0.41	0.14	0.35	0.11
3	infbor	0.28	0.11	0.20	0.08	0.35	0.13	0.18	0.08	0.42	0.14	0.30	0.11
4	infbor	0.28	0.09	0.23	0.08	0.34	0.08	0.21	0.07	0.44	0.13	0.33	0.09
5	infbor	0.18	0.09	0.30	0.10	0.26	0.13	0.27	0.11	0.55	0.13	0.34	0.11
6	angle	0.18	0.08	0.29	0.08	0.29	0.14	0.25	0.09	0.55	0.11	0.31	0.12
7	angle	0.19	0.09	0.21	0.10	0.30	0.13	0.17	0.08	0.45	0.19	0.23	0.09
12	midbod	0.22	0.09	0.25	0.11	0.31	0.11	0.22	0.11	0.46	0.15	0.29	0.09
13	midram	0.21	0.11	0.25	0.09	0.32	0.14	0.21	0.09	0.54	0.14	0.29	0.09
14	angle	0.25	0.11	0.23	0.10	0.35	0.14	0.20	0.10	0.48	0.18	0.28	0.10
15	posbor	0.24	0.13	0.15	0.07	0.33	0.17	0.13	0.07	0.36	0.18	0.21	0.09
21	midram	0.21	0.10	0.27	0.08	0.34	0.15	0.23	0.07	0.53	0.12	0.27	0.06
22	midram	0.21	0.13	0.25	0.10	0.32	0.16	0.22	0.10	0.49	0.14	0.26	0.08
23	posbor	0.31	0.14	0.15	0.07	0.41	0.13	0.13	0.06	0.35	0.17	0.20	0.07
24	midram	0.22	0.10	0.22	0.10	0.34	0.13	0.19	0.10	0.43	0.14	0.23	0.08
25	midram	0.25	0.10	0.19	0.08	0.37	0.12	0.16	0.07	0.40	0.13	0.22	0.06
26	posbor	0.28	0.13	0.20	0.11	0.38	0.16	0.17	0.12	0.41	0.15	0.26	0.13
27	cor	0.22	0.12	0.16	0.08	0.32	0.15	0.14	0.07	0.39	0.20	0.20	0.09
28	midram	0.18	0.08	0.23	0.09	0.30	0.14	0.21	0.10	0.51	0.15	0.27	0.10
29	cond	0.25	0.10	0.22	0.05	0.34	0.10	0.20	0.05	0.48	0.13	0.30	0.05
30	cor	0.31	0.09	0.15	0.07	0.42	0.10	0.13	0.06	0.32	0.14	0.20	0.10
31	cond	0.26	0.12	0.20	0.08	0.34	0.15	0.20	0.08	0.43	0.17	0.29	0.08
						Lingual							
1	sym	0.30	0.11	0.25	0.08	0.37	0.13	0.22	0.08	0.42	0.12	0.30	0.09
2	sym	0.22	0.13	0.28	0.08	0.28	0.15	0.26	0.08	0.53	0.13	0.36	0.06
3	infbor	0.31	0.15	0.23	0.09	0.40	0.18	0.20	0.09	0.46	0.11	0.30	0.07
4	infbor	0.24	0.16	0.27	0.13	0.31	0.18	0.24	0.13	0.49	0.17	0.31	0.11
5	infbor	0.28	0.11	0.20	0.10	0.37	0.14	0.18	0.10	0.40	0.16	0.26	0.11
6	angle	0.25	0.15	0.24	0.07	0.31	0.17	0.22	0.07	0.49	0.15	0.33	0.09
7	angle	0.20	0.13	0.18	0.08	0.30	0.15	0.16	0.07	0.41	0.19	0.21	0.08
12	midbod	0.19	0.11	0.24	0.07	0.29	0.16	0.21	0.07	0.50	0.12	0.27	0.06
13	midram	0.23	0.13	0.24	0.10	0.35	0.19	0.20	0.10	0.49	0.18	0.26	0.10
14	angle	0.24	0.11	0.20	0.08	0.37	0.16	0.17	0.07	0.42	0.12	0.22	0.07
15	posbor	0.19	0.16	0.22	0.11	0.26	0.18	0.20	0.11	0.45	0.18	0.27	0.10
21	midram	0.23	0.09	0.25	0.08	0.34	0.11	0.22	0.08	0.48	0.10	0.27	0.07
22	midram	0.30	0.14	0.18	0.10	0.39	0.18	0.15	0.10	0.35	0.19	0.22	0.10
23	posbor	0.22	0.15	0.14	0.10	0.27	0.19	0.13	0.10	0.33	0.21	0.21	0.14
24	midram	0.23	0.11	0.23	0.09	0.32	0.14	0.20	0.09	0.46	0.17	0.26	0.08
25	midram	0.29	0.17	0.20	0.08	0.39	0.17	0.18	0.07	0.47	0.20	0.26	0.09
26	posbor	0.24	0.14	0.19	0.07	0.33	0.18	0.17	0.07	0.46	0.21	0.27	0.09
27	cor	0.16	0.09	0.21	0.10	0.28	0.12	0.18	0.09	0.48	0.21	0.23	0.10
28	midram	0.22	0.12	0.19	0.12	0.30	0.15	0.17	0.12	0.39	0.22	0.24	0.15
29	cond	0.27	0.18	0.19	0.10	0.37	0.19	0.17	0.09	0.43	0.20	0.24	0.10
30	cor	0.33	0.02	0.07	0.02	0.41	0.00	0.06	0.02	0.16	0.06	0.11	0.06
31	cond	0.29	0.12	0.17	0.08	0.38	0.13	0.15	0.08	0.36	0.13	0.24	0.07

Table 6. Elastic Coefficients for Human Edentulous Mandibles (abbreviations as in Table 2)

Site	Area	C_{11}		C_{22}		C_{33}		C_{44}		C_{55}		C_{66}		C_{12}		C_{23}	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	v	SD	Mean	SD
								Facial									
1	sym	18.4	1.7	20.7	1.8	31.8	4.4	6.2	1.0	5.7	1.3	5.0	1.2	8.4	2.6	9.7	4.2
2	sym	19.0	1.6	21.1	3.3	35.1	5.3	6.8	0.9	6.2	1.4	5.5	1.4	8.1	2.7	10.7	3.7
3	infbor	18.3	1.7	22.6	2.9	37.2	4.1	7.0	0.9	6.0	1.6	4.9	1.1	8.4	2.2	10.0	2.9
4	infbor	19.2	1.3	22.8	2.5	36.9	4.5	7.4	0.7	5.7	0.6	5.0	0.6	9.2	2.0	11.5	3.6
5	infbor	17.6	2.8	23.4	2.8	34.5	3.6	7.1	0.9	5.2	1.0	4.6	1.1	8.3	1.9	12.4	3.3
6	angle	15.9	2.3	22.7	4.2	31.8	4.0	7.0	1.0	4.8	0.7	4.1	0.6	7.7	2.4	11.2	2.9
7	angle	13.8	2.9	21.2	4.0	29.8	5.9	6.6	1.0	4.6	0.7	3.9	0.7	6.1	2.9	7.9	3.9
12	midbod	18.2	2.3	24.2	2.2	35.9	4.5	7.2	0.9	6.0	1.2	4.9	0.8	8.3	1.9	11.0	4.1
13	midram	16.2	2.5	22.7	3.2	34.3	3.2	6.9	0.8	5.2	1.0	4.3	0.7	7.7	2.1	10.4	2.3
14	angle	17.6	3.0	24.0	4.4	36.6	3.8	7.4	1.0	5.6	0.9	4.5	0.9	8.7	2.0	10.7	3.7
15	posbor	15.2	3.9	21.3	4.1	34.5	4.3	6.9	0.9	4.9	1.1	4.4	0.9	6.4	3.2	6.3	2.7
21	midram	17.6	2.0	26.0	3.4	34.1	2.0	8.1	1.1	5.0	0.7	4.4	0.7	8.8	2.4	11.5	2.5
22	midram	17.4	2.7	25.3	3.6	34.9	3.6	7.7	1.2	5.4	1.0	4.5	0.7	8.3	2.4	10.7	3.2
23	posbor	16.9	2.6	23.1	4.4	34.8	4.7	7.7	1.7	5.3	1.1	4.4	1.0	8.1	2.2	7.2	2.8
24	midram	17.3	2.5	25.0	2.8	33.9	3.3	7.4	0.6	5.6	1.0	4.8	0.9	7.8	1.7	9.2	3.1
25	midram	17.0	2.3	24.5	3.4	34.6	4.9	7.3	0.9	5.4	1.1	4.5	0.9	7.9	1.9	8.4	2.3
26	posbor	17.8	2.7	22.9	3.2	35.7	5.2	7.1	1.1	5.7	1.2	4.5	1.0	8.7	2.0	9.4	3.8
27	cor	15.7	4.1	23.7	3.1	35.5	4.2	7.6	0.7	5.3	0.8	4.5	0.8	6.7	3.3	7.2	3.6
28	midram	15.7	2.7	23.9	3.7	35.1	5.1	8.1	1.1	5.1	1.0	4.4	1.0	6.9	2.0	9.9	3.7
29	cond	17.7	2.8	23.3	3.1	36.5	3.5	7.5	1.0	5.4	1.1	4.8	1.0	8.2	1.7	10.6	1.7
30	cor	17.6	3.1	23.1	3.7	35.1	4.7	7.3	1.1	5.1	1.0	4.6	1.0	8.5	1.8	7.4	3.7
31	cond	16.5	3.3	21.5	2.2	32.8	3.8	6.6	0.9	5.2	1.3	4.4	1.1	7.7	2.0	9.4	1.7
								Lingual									
1	sym	20.4	2.3	24.5	2.4	33.5	3.3	6.9	0.5	5.5	1.1	4.9	1.2	10.5	3.0	11.7	3.7
2	sym	19.3	1.9	24.2	1.5	37.8	3.7	7.3	0.8	5.7	0.8	5.1	1.0	9.1	2.5	13.4	2.6
3	infbor	19.9	1.0	25.0	2.7	37.7	3.2	7.9	0.8	5.6	0.8	4.7	0.9	10.6	2.4	12.2	2.5
4	infbor	19.4	1.2	24.7	1.7	36.9	1.9	7.6	0.6	5.8	0.9	4.9	0.6	9.5	1.7	12.1	3.7
5	infbor	18.9	2.0	24.2	1.8	36.5	2.9	7.5	0.8	5.6	1.1	4.9	0.9	9.2	2.6	10.1	4.4
6	angle	17.6	3.0	22.3	3.7	35.7	5.1	7.3	1.0	5.4	0.8	4.7	1.0	8.3	3.0	11.1	2.5
7	angle	14.8	3.0	22.3	4.2	31.8	4.2	7.1	0.8	5.3	1.0	4.4	0.9	5.9	2.6	7.3	3.1
12	midbod	16.0	1.9	23.1	2.0	32.6	2.6	6.8	0.9	5.1	0.8	4.6	1.1	6.9	2.4	9.6	2.4
13	midram	16.7	1.9	23.9	3.4	33.5	2.9	7.3	0.9	4.9	0.6	4.1	1.0	8.4	2.9	10.1	3.2
14	angle	16.5	2.5	24.2	3.6	33.4	2.8	7.2	0.8	4.9	0.6	4.3	0.8	7.9	3.4	8.8	3.4
15	posbor	14.2	3.6	19.8	4.7	29.9	6.0	6.3	1.2	5.0	1.2	4.1	0.8	6.0	3.4	8.0	4.1
21	midram	18.3	4.3	25.6	4.5	34.1	4.2	7.5	0.9	5.4	1.1	4.6	0.8	9.0	3.3	11.1	3.3
22	midram	16.0	2.2	20.9	3.3	30.6	6.1	7.3	0.6	4.6	0.8	4.1	0.7	7.9	2.8	7.4	3.7
23	posbor	13.3	2.8	18.0	4.9	30.9	7.5	6.0	1.3	5.0	0.9	4.2	1.2	4.8	3.1	5.2	3.2
24	midram	15.5	4.0	21.5	4.7	29.9	6.2	6.4	1.3	4.9	1.1	4.1	0.8	7.3	2.9	8.9	3.5
25	midram	15.7	3.0	22.6	6.8	32.6	6.9	6.7	2.1	4.5	0.9	3.8	0.8	8.1	2.5	9.2	3.1
26	posbor	13.7	4.3	18.5	5.7	30.2	8.1	6.2	1.5	4.5	0.6	3.7	0.6	6.4	3.5	7.6	3.3
27	cor	12.3	2.3	20.8	3.2	29.8	3.7	6.2	1.0	4.2	0.6	3.6	0.7	5.1	2.2	7.4	3.5
28	midram	16.1	2.2	21.9	2.9	33.0	6.8	7.4	1.0	5.6	1.3	4.7	0.9	6.6	1.7	7.9	5.0
29	cond	16.2	2.9	22.2	1.7	34.0	3.9	7.3	0.6	4.9	1.2	4.1	0.6	7.9	3.3	8.3	3.9
30	cor	14.5	3.1	18.1	2.6	30.1	6.4	6.9	1.5	5.3	1.2	4.2	0.9	6.1	1.4	3.0	1.8
31	cond	16.4	2.9	21.2	3.4	32.4	3.4	6.6	0.7	5.1	0.9	4.4	1.0	7.6	2.4	7.8	3.0

Table 7. Anisotropies in Human Edentulous Mandibles (abbreviations as in Table 2)

				Facial					
		C_{22}/C_{33}		C_{11}/C_{22}		C_{11}/C_{33}		E_2/E_3	
Site	Area	Mean	SD	Mean	SD	Mean	SD	Mean	SD
1	sym	0.66	0.05	0.89	0.09	0.59	0.09	0.66	0.11
2	sym	0.60	0.04	0.91	0.08	0.55	0.05	0.63	0.15
3	infbor	0.61	0.04	0.81	0.07	0.50	0.05	0.60	0.07
4	infbor	0.62	0.02	0.85	0.10	0.52	0.07	0.63	0.08
5	infbor	0.68	0.04	0.76	0.10	0.51	0.05	0.78	0.11
6	angle	0.72	0.10	0.71	0.10	0.50	0.04	0.81	0.09
7	angle	0.72	0.08	0.65	0.03	0.47	0.06	0.76	0.10
12	midbod	0.68	0.05	0.75	0.05	0.51	0.04	0.73	0.15
13	midram	0.66	0.05	0.72	0.08	0.47	0.05	0.72	0.13
14	angle	0.65	0.09	0.74	0.07	0.48	0.06	0.68	0.15
15	posbor	0.61	0.05	0.72	0.10	0.44	0.08	0.59	0.09
21	midram	0.76	0.08	0.68	0.08	0.52	0.06	0.83	0.14
22	midram	0.73	0.08	0.69	0.08	0.50	0.06	0.78	0.19
23	posbor	0.66	0.08	0.75	0.12	0.49	0.06	0.61	0.13
24	midram	0.74	0.07	0.69	0.07	0.51	0.05	0.77	0.16
25	midram	0.71	0.07	0.69	0.05	0.49	0.03	0.71	0.15
26	posbor	0.64	0.06	0.78	0.09	0.50	0.04	0.63	0.11
27	cor	0.67	0.08	0.66	0.13	0.44	0.09	0.66	0.10
28	midram	0.68	0.09	0.66	0.10	0.45	0.06	0.74	0.10
29	cond	0.64	0.05	0.76	0.09	0.49	0.07	0.66	0.10
30	cor	0.66	0.05	0.76	0.07	0.50	0.06	0.60	0.08
31	cond	0.66	0.06	0.76	0.09	0.50	0.07	0.67	0.14
				Lingual					
1	sym	0.74	0.07	0.84	0.07	0.62	0.09	0.73	0.08
2	sym	0.65	0.06	0.80	0.07	0.51	0.07	0.71	0.12
3	infbor	0.66	0.05	0.81	0.07	0.53	0.04	0.65	0.15
4	infbor	0.67	0.05	0.79	0.07	0.52	0.02	0.73	0.19
5	infbor	0.66	0.07	0.78	0.05	0.52	0.06	0.65	0.12
6	angle	0.63	0.09	0.80	0.14	0.50	0.07	0.65	0.12
7	angle	0.70	0.08	0.67	0.10	0.47	0.08	0.71	0.13
12	midbod	0.71	0.06	0.69	0.06	0.49	0.06	0.76	0.13
13	midram	0.71	0.06	0.70	0.07	0.50	0.05	0.74	0.11
14	angle	0.72	0.07	0.68	0.04	0.49	0.05	0.72	0.13
15	posbor	0.66	0.07	0.72	0.09	0.48	0.07	0.70	0.17
21	midram	0.75	0.06	0.71	0.08	0.53	0.08	0.79	0.11
22	midram	0.69	0.06	0.78	0.09	0.53	0.06	0.66	0.15
23	posbor	0.58	0.05	0.77	0.17	0.44	0.08	0.57	0.12
24	midram	0.72	0.05	0.72	0.09	0.52	0.07	0.75	0.14
25	midram	0.69	0.12	0.73	0.17	0.49	0.09	0.67	0.14
26	posbor	0.61	0.07	0.75	0.10	0.46	0.08	0.61	0.07
27	cor	0.70	0.06	0.60	0.09	0.42	0.09	0.75	0.09
28	midram	0.68	0.10	0.74	0.11	0.50	0.11	0.68	0.08
29	cond	0.66	0.04	0.73	0.11	0.48	0.08	0.64	0.14
30	cor	0.61	0.05	0.80	0.06	0.48	0.00	0.53	0.04
31	cond	0.65	0.07	0.78	0.10	0.51	0.08	0.63	0.16