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Comparison of anterior maxillary and mandibular alveolar parameters in African American and Caucasian women: A retrospective pilot study

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ABSTRACT

Purpose: The primary objective of this study was to analyze the thickness and height of alveolar bone around the maxillary and mandibular incisors. Additionally, this study aimed to compare bone parameters between Caucasian (CC) and African American (AA) female patients.
Materials and Methods: In this retrospective pilot study, 50 female subjects (25 CC and 25 AA) were included. The inclusion criteria were AA or CC women between the ages of 18 and 50 with a normo-divergent facial pattern and Angle's class I, end-on class II, or mild class III malocclusion. The distance from the cementoenamel junction (CEJ) to the buccal and lingual alveolar crest; the alveolar ridge thickness at the mid-root and apex; and the buccal and lingual bone thickness at 3, 6, and 9 mm from the CEJ were measured.
Results: No significant difference was found ($P > 0.05$) in the cortical bone thickness at 3 mm, 6 mm, or 9 mm from the alveolar crest between CC and AA populations for most measurements. A significant difference in bone thickness was found ($P < 0.05$) for the lingual surface of the central incisor, with maxillary bone thickness found to be higher than mandibular bone thickness. The measurements of lingual thickness were larger than those of buccal thickness for both races.
Conclusion: There were no differences in maxillomandibular anterior alveolar bone measurements between normo-divergent adult AA and CC women, except for a few parameters at varying locations. However, future studies can be planned based the current pilot study data, which may provide valuable information. ***(Imaging Sci Dent 2021; 51: 175-85)***

KEY WORDS: Alveolar Process; Cone-Beam Computed Tomography; Mandible; Maxilla

Introduction

Bimaxillary protrusion (BP) is a facial trait characterized by underlying skeletal prognathism, protrusive teeth and lips, and a decreased interincisal angle. These skeletal and dental traits often result in mentalis strain, lip incompetence, increased gingival display, and facial convexity. While BP can be seen in individuals of any race, it is more common in the African American (AA) population. These facial and dental characteristics are often deemed esthetically unacceptable by patients, prompting them to seek treatment from orthodontists and oral surgeons.[1-3]

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The orthodontic treatment goals for BP are decreasing lip protrusion, facial convexity, retraction, and uprighting. These goals can be accomplished by premolar extraction with orthodontics or by a combined orthodontic-surgical approach. When considering premolar extraction, first premolars are often extracted to increase the retraction of anterior teeth utilizing maximum anchorage in the posterior area.[3] The maximum anchorage can be accomplished with skeletal anchorage devices, such as mini-implants and miniplates, or intraoral appliances such as Nance appliances.[4] Previous studies have found that the extraction of four bicuspids resulted in improved dental characteristics associated with BP. Additionally, a study observed an improvement in lip protrusion following extraction with maximum anchorage space closure.[5]

When closing a large extraction space, the amount of ret-

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raction is limited by the thickness of the cortical and cancellous bone surrounding the tooth. Tooth movement occurs by widening the periodontal ligament with resorption of bone on the pressure side and apposition on the tension side. Thus, if tooth movement exceeds the biological limit of the surrounding alveolar bone, specific adverse effects such as root resorption, alveolar bone loss, gingival recession, root dehiscence, and fenestration can occur.[6]

When considering incisor retraction in cases of maximum anchorage extraction, the biological limit is the alveolar bone surrounding the apical one-third of the incisors. Thus, 3-dimensional imaging is essential to fully visualize the available bone to determine the amount of tooth movement possible. A previous study conducted by Lee et al.[7] investigated the alveolar bone of lower incisors skeletal class III adults of different vertical patterns using cone-beam computed tomography (CBCT) images. They found that skeletal class III subjects with high mandibular plane angles showed thinner mandibular alveolar bone than low-angle patients.

Most previous studies utilized CBCT and focused on the thickness of the facial bone wall surrounding the anterior dentition of the maxilla to place immediate implants. Such studies have concluded that most tooth sites in the anterior maxilla have a thin facial bone wall, averaging less than 1 mm.[8-10] This study used a similar method and techniques, but focused on both the buccal and lingual aspects of the alveolus in order to obtain a more comprehensive view of housing size for tooth retraction.

A recent study from Goshtasbi et al.[11] discovered that the heritability of alveolar bone thickness ranged from 50.3% to 58.0%. That study suggested that genetic factors play a significant role in alveolar thickness, with a moderate to high effect. If genetic predispositions are relevant for alveolar thickness, then race and ethnicity could perhaps be a determining factor for alveolar width and height.

The primary objective of this study was to quantitatively analyze the thickness and height of alveolar bone around the maxillary and mandibular incisors. Additionally, this study aimed to compare and contrast bone parameters (bone thickness and bone height) in Caucasian (CC) and AA female patients. The null hypothesis was that the bone parameters (bone thickness and bone height) of the maxillary and mandibular incisor locations would not be different between these racial groups.

Materials and Methods

An institutional review board exemption was obtained for evaluating CBCT volumes, acquired from the database of Georgia School of Orthodontics, Atlanta. Following the screening of 161 CBCT scans, this retrospective study reviewed 50 CBCT scans of female patients who were referred to the Division of Orthodontics for treatment. All CBCT scanned images were de-identified for protected health information by authorized personnel before using them as a part of the study. CBCT scans were acquired using an i-CAT CBCT unit (Imaging Sciences International, Hatfield, PA, USA), with the standard protocol of the i-CAT for an extended field of view (FOV), ranging from 21×13 inches to 30×22 inches, with 0.3-mm voxel size and 17.5-s acquisition time.

Subjects were selected based on the following inclusion criteria: female; AA or CC; between the ages of 18 and 50 at the time of the CBCT; normo-divergent; and Angle's class I, end-on class II, or mild class III malocclusion. The exclusion criteria were anterior open bite; anterior crossbite; congenitally missing, extracted, malformed, or impacted anterior teeth; generalized root resorption; periapical pathology; the presence of cleft lip or palate; history of past orthodontic treatment; periodontal disease or evidence of anterior bone loss; syndromic patients; history of skeletal or bone disorders; or poor CBCT quality. For each subject, the name, date of birth, date of CBCT, sex, race, CBCT FOV, voxel size, dental malocclusion (class I, II, or III), vertical skeletal relationship (hypo-, hyper-, or normo-divergent), and approximate dental crowding or spacing were recorded. Patients' vertical relationships were assessed qualitatively by referencing Bjork's 7 structural signs for growth rotation.[12] All CBCT scans were evaluated using a third-party CBCT reconstruction software (Dolphin Imaging version 11.9; Dolphin Imaging and Management Solutions, Chatsworth, CA, USA).

The alveolar bone surrounding the maxillary and mandibular incisors was evaluated. The measurement protocol was similar to that described by Garlock et al.[13] For each incisor examined, the volume was oriented in all 3 planes of space (sagittal, coronal, axial), as shown in Figure 1. Orientation was accomplished in order to generate a CBCT slice through the middle of the pulp canal, along the long axis of the tooth. The sagittal section was then used to generate measurements relevant to the study. Prior to measuring bone thickness, a plan was drawn at the cementoenamel junction (CEJ). Each root was measured from the apex to the CEJ and halved to determine the mid-root point. The rater then reviewed the images on a laptop screen (MacBook Air, Apple Computers Inc., Cupertino, CA, USA) under standardized conditions of ambient light and sound. The investigator had the full capability to evaluate the volumes in all

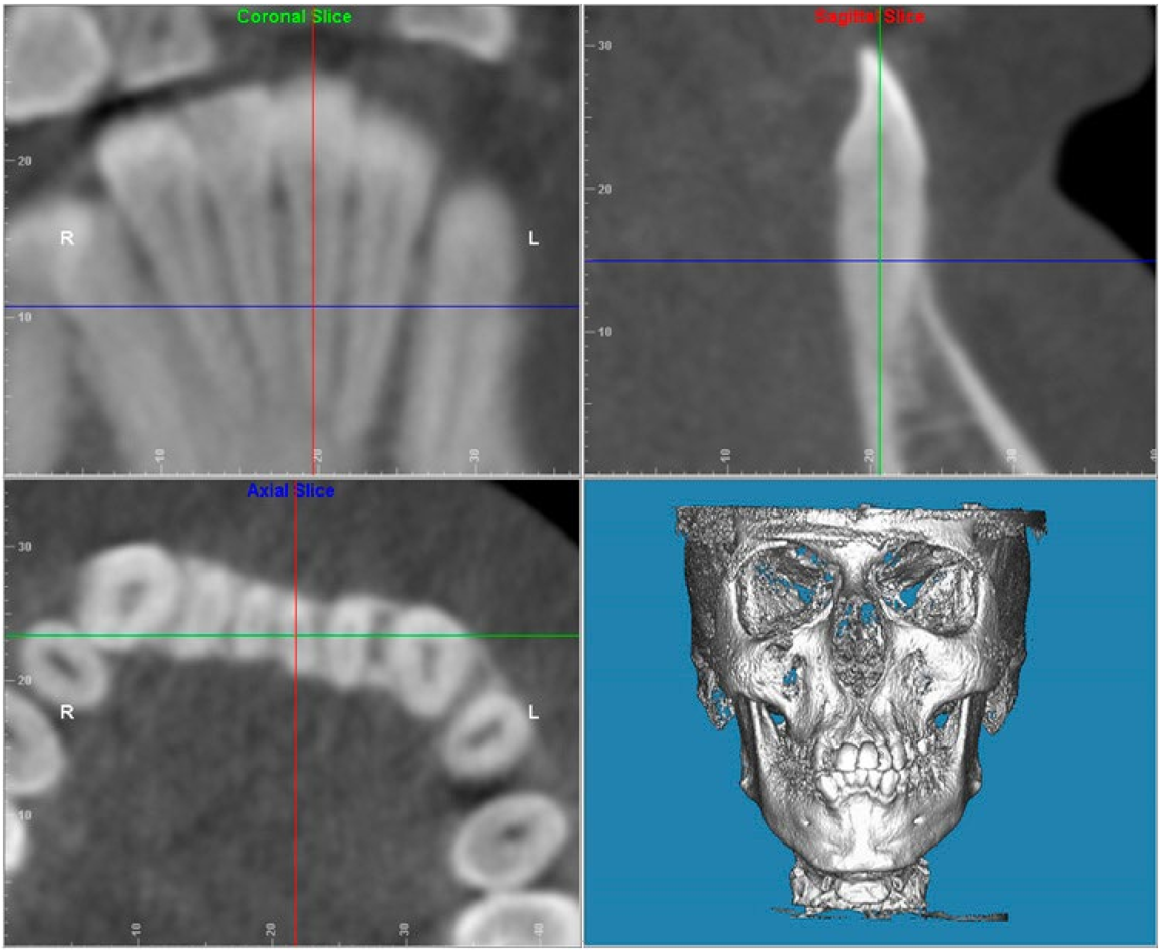

Fig. 1. Cone-beam computed tomography scan oriented along the long axis of the tooth in all 3 planes.

3 orthogonal planes and manipulate contrast and histograms. To test the intra-examiner reliability, the same person measured bone parameters on 5 randomly selected scans two weeks later.

The following measurements were recorded: 1) from the CEJ to the lingual/palatal alveolar crest; 2) from the CEJ to the buccal alveolar crest; 3) the alveolar ridge thickness at the mid-root level; 4) alveolar ridge thickness at the apex; 5) the buccal bone thickness at 3, 6, and 9 mm from the CEJ plane; 6) the lingual/palatal bone thickness at 3, 6, and 9 mm from the CEJ plane (Fig. 2). The bone thickness refers to the distance between the root surface to the outer surface of the cortical bone at a specific vertical location. The alveolar ridge thickness refers to the horizontal distance between the buccal and lingual surfaces at a specific vertical location (Fig. 2). Overall, 10 measurements were made for each incisor (80 measurements [40 maxillary and 40 mandibular] per patient), leading to a total of 4,000 measurements.

Simple descriptive statistics were used to summarize the data. Mean, standard deviation, standard error of the mean, maximum, minimum, range, and 95% confidence intervals were computed for the bone parameters of the maxillary and mandibular incisors (alveolar height: labial and lingual, alveolar thickness: mid-root and apex, and bone thickness: labial and lingual at 3 different vertical locations - 3 mm, 6 mm and 9 mm from the alveolar crest). For all outcomes, intra-examiner reliability was computed by Cronbach alpha values (intra-class correlation coefficients). The 1-sample Kolmogorov-Smirnov test was used to examine the normality of distribution for bone measurements at different locations. All the measurements were normally distributed. For the variability of the bone parameters for each incisor, between 2 racial groups (CC and AA), between the maxilla and mandible, and between labial and lingual, the independent-sample t-test was performed. All statistical tests were 2-sided, and to minimize the probability of type I errors, a P-value of <0.05 was deemed to indicate statistical significance. Statistical analyses were conducted using Graph Pad

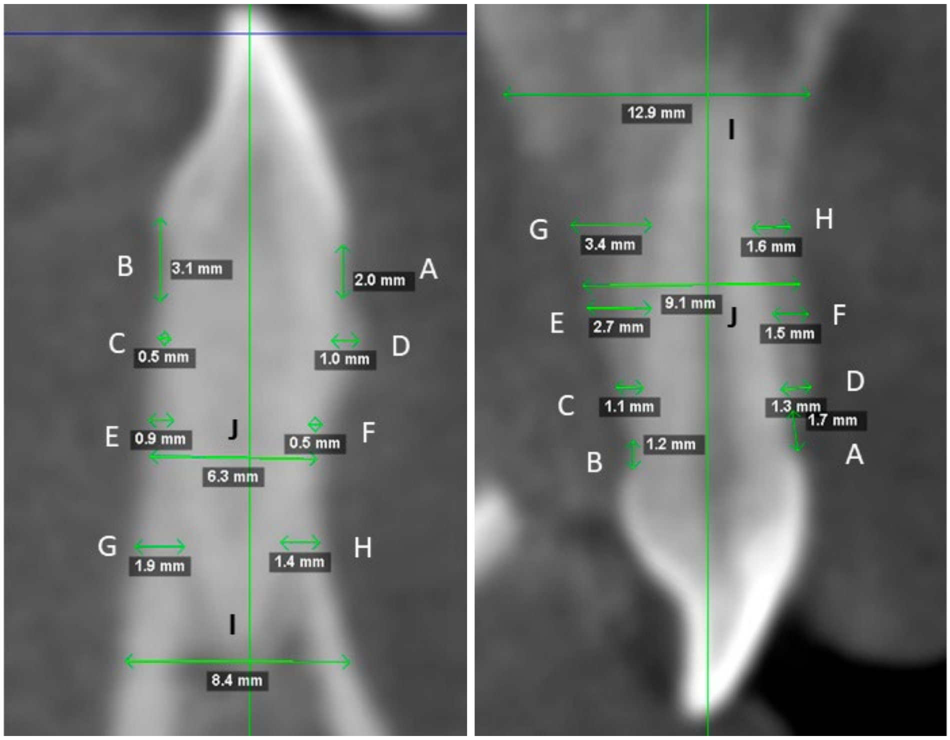

Fig. 2. Bone measurements used in the study. Alveolar height: (A) labial, (B) lingual/palatal; bone thickness at 3 mm (C and D), 6 mm (E and F), and 9 mm (G and H) from the alveolar crest: alveolar thickness: (J) mid-root, and (I) apex.

Table 1. Descriptive statistics and comparison of bone measurements of the maxillary central incisors between Caucasian (CC) and African American (AA) female patients

Location of measurement		Category	Race	Mean ± SD	95% CI
Buccal	3 mm	Bone thickness	CC	0.80 ± 0.44	0.68-0.93
			AA	0.82 ± 0.35	0.70-0.93
	6 mm	Bone thickness	CC	0.71 ± 0.35	0.61-0.81
			AA	0.60 ± 0.33	0.49-0.70
	9 mm	Bone thickness	CC	0.71 ± 0.44	0.59-0.84
			AA	0.59 ± 0.81	0.33-0.85
Lingual	3 mm	Bone thickness	CC	1.50 ± 0.59	1.30-1.60
			AA	1.40 ± 0.60	1.20-1.60
	6 mm	Bone thickness	CC	2.50 ± 1.00	2.20-2.80
			AA	2.10 ± 0.95	1.70-2.40
	9 mm	Bone thickness	CC	3.80 ± 1.50	3.40-4.20
			AA	2.90 ± 1.10*	2.60-3.30
Mid-root		Alveolar ridge thickness	CC	8.30 ± 1.60	7.80-8.70
			AA	7.90 ± 1.20	7.50-8.20
Apex		Alveolar ridge thickness	CC	9.40 ± 1.80	8.80-9.90
			AA	8.40 ± 1.70*	7.80-8.90
Labial height		Bone height	CC	1.70 ± 0.65	1.50-1.90
			AA	1.70 ± 0.71	1.50-1.90
Lingual height		Bone height	CC	1.50 ± 0.89	1.20-1.70
			AA	1.30 ± 1.10	0.97-1.70

SD: standard deviation, CI: confidence interval, *: $P < 0.05$ compared with CC

Table 2. Descriptive statistics and comparison of bone measurements of the maxillary lateral incisors between Caucasian (CC) and African American (AA) female patients

Location of measurement		Category	Race	Mean ± SD	95% CI
Buccal	3 mm	Bone thickness	CC	0.80 ± 0.56	0.64-0.97
			AA	0.64 ± 0.43	0.50-0.77
	6 mm	Bone thickness	CC	0.62 ± 0.59	0.45-0.79
			AA	0.33 ± 0.32*	0.22-0.43
	9 mm	Bone thickness	CC	0.40 ± 0.54	0.25-0.56
			AA	0.25 ± 0.38	0.13-0.37
Lingual	3 mm	Bone thickness	CC	0.84 ± 0.57	0.68-1.00
			AA	1.10 ± 0.63	0.88-1.30
	6 mm	Bone thickness	CC	1.70 ± 0.60	1.60-1.90
			AA	1.80 ± 0.84	1.60-2.10
	9 mm	Bone thickness	CC	2.70 ± 0.87	2.50-3.00
			AA	2.50 ± 0.90	2.20-2.80
Mid-root		Alveolar ridge thickness	CC	7.40 ± 0.81	7.10-7.60
			AA	7.20 ± 0.95	6.90-7.50
Apex		Alveolar ridge thickness	CC	8.20 ± 1.60	7.70-8.60
			AA	7.00 ± 1.40*	6.50-7.50
Labial height		Bone height	CC	2.00 ± 1.10	1.60-2.30
			AA	1.40 ± 0.88*	1.20-1.70
Lingual height		Bone height	CC	2.10 ± 1.20	1.80-2.50
			AA	1.60 ± 1.50	1.10-2.10

SD: standard deviation, CI: confidence interval, *: $P < 0.05$ compared with CC

software 8.4.2 (GraphPad Software Inc., San Diego, CA, USA).

Results

In this study, 161 CBCT scans were screened and after applying the selection criteria, a review of 50 CBCT scans of patients (25 CC and 25 AA) with a mean age of 32.5 years was conducted. The maxillary arch measurements of 6 patients were excluded from the statistical analysis due to the presence of cysts, an impacted canine, or the periodontal condition in those maxillary arches. The average intra-rater reliability was determined to be 0.84. The reliability was highest (≥ 0.96) for lingual bone measurements at 6 and 9 mm from the CEJ and the alveolar width at the mid-root and apex levels. The reliability was lowest for labial thickness at 6 mm and for the labial bone height.

Maxillary incisors

Bone thickness: No significant differences ($P > 0.05$) in cortical bone thickness at 3 mm, 6 mm, or 9 mm from the alveolar crest were found between the CC and AA populations for most of the measurements (Tables 1 and 2). Significant differences were observed for the bone thickness at 9 mm on the lingual surface for maxillary central incisors (CC: 3.8 ± 1.6 mm, AA: 2.9 ± 1.1 mm, $P < 0.05$), and at 6 mm on the buccal surface for maxillary lateral incisors (CC: 0.62 ± 0.59 mm, AA: 0.33 ± 0.32 mm, $P < 0.05$).

Alveolar ridge thickness: A significant difference in alveolar ridge thickness was found between the CC and AA population at the apex for both the central (CC: 9.4 ± 1.8 mm, AA: 8.4 ± 1.7 mm, $P < 0.05$) and lateral incisors (CC: 8.2 ± 1.6 mm, AA: 7.0 ± 1.4 mm, $P < 0.05$) (Tables 1 and 2). No significant difference in alveolar ridge thickness was found at the mid-root level ($P > 0.05$) (Tables 1 and 2).

Alveolar height: Except for the labial bone height of lateral incisors (CC: 2.0 ± 1.1 mm, AA: 1.4 ± 0.88 mm, $P < 0.05$), all the measurements showed non-significant findings for the labial or lingual alveolar height when the 2 racial groups were compared (Tables 1 and 2).

Mandibular incisors

Bone thickness: Except at 3 mm (CC: 0.9 ± 0.63 mm, AA:

Table 3. Descriptive statistics and comparison of bone measurements of the mandibular central incisors between Caucasian (CC) and African American (AA) female patients

Location of measurement		Category	Race	Mean±SD	SD	95% CI
Buccal	3 mm	Bone thickness	CC	0.77±0.50	0.50	0.62-0.91
			AA	0.71±0.55	0.55	0.56-0.87
	6 mm	Bone thickness	CC	0.47±0.59	0.59	0.30-0.64
			AA	0.49±0.36	0.36	0.39-0.59
	9 mm	Bone thickness	CC	1.30±0.95	0.95	0.98-1.50
			AA	1.50±0.56	0.56	1.30-1.60
Lingual	3 mm	Bone thickness	CC	0.90±0.63	0.63	0.72-1.10
			AA	0.57±0.46*	0.46	0.44-0.71
	6 mm	Bone thickness	CC	1.20±0.57	0.57	1.00-1.30
			AA	0.79±0.61*	0.61	0.61-0.96
	9 mm	Bone thickness	CC	1.80±0.74	0.74	1.60-2.00
			AA	1.70±0.72	0.72	1.40-1.90
Mid-root		Alveolar ridge thickness	CC	6.60±0.93	0.93	6.30-6.90
			AA	6.30±0.65	0.65	6.20-6.50
Apex		Alveolar ridge thickness	CC	7.00±1.80	1.80	6.50-7.50
			AA	7.70±1.60*	1.60	7.30-8.20
Labial height		Bone height	CC	2.20±1.30	1.30	1.80-2.50
			AA	2.40±1.50	1.50	2.00-2.90
Lingual height		Bone height	CC	2.60±1.40	1.40	2.20-3.00
			AA	2.80±1.30	1.30	2.40-3.10

SD: standard deviation, CI: confidence interval, *: $P<0.05$ compared with CC

0.57±0.46 mm, $P<0.05$) and 6 mm (CC: 1.2±0.57 mm, AA: 0.79±0.61 mm, $P<0.05$) from the lingual surface of the maxillary central incisors, there were no significant differences ($P>0.05$) in the labial or lingual cortical bone thickness at 3 mm, 6 mm, or 9 mm from the alveolar crest between the CC and AA populations (Tables 3 and 4).

Alveolar ridge thickness: Except at the apex of the central incisors (CC: 7.0±1.8 mm, AA: 7.7±1.6 mm, $P<0.05$), all other measurements for alveolar thickness showed a non-significant difference ($P>0.05$) between the 2 groups (Tables 3 and 4).

Alveolar height: All the labial or lingual alveolar bone height measurements showed non-significant findings when the 2 racial groups were compared (Tables 3 and 4).

Maxillary versus mandibular incisors

A significant difference in bone thickness was found ($P<0.05$) for the lingual surface of the central incisor at 3 mm, 6 mm, and 9 mm for both racial groups, with maxillary bone thickness found to be higher than mandibular thickness. For the central incisors, significantly higher maxillary alveolar ridge thickness was found in CCs at the mid-root and apex, but only at the mid-root for AAs ($P<0.05$). Significantly higher mandibular alveolar ridge thickness was found in the AA group for the mandibular lateral incisors at the apex ($P<0.05$). For the majority of bone height parameters for both CCs and AAs, a comparison of the maxillary versus mandibular arch showed a significant difference, with bone height measurements being higher for the mandibular arch ($P<0.05$). A descriptive comparison of the maxillary versus mandibular arch can be found in Table 5.

Labial versus lingual bone parameters

Table 6 shows a comparison of the bone thickness of labial and lingual surfaces. A significant difference was found for maxillary central incisors, maxillary lateral incisors, and mandibular lateral incisors at 6 mm and 9 mm, with the lingual bone thickness being higher than the labial bone thickness ($P<0.05$). No significant difference was found in bone height upon comparison of the labial and lingual surfaces ($P>0.05$).

Table 4. Descriptive statistics and comparison of bone measurements of the mandibular lateral incisors between Caucasian (CC) and African American (AA) female patients

Location of measurement		Category	Race	Mean ± SD	95% CI
Buccal	3 mm	Bone thickness	CC	0.77 ± 0.50	0.63-0.91
			AA	0.88 ± 0.51	0.73-1.00
	6 mm	Bone thickness	CC	0.40 ± 0.37	0.29-0.50
			AA	0.41 ± 0.29	0.33-0.50
	9 mm	Bone thickness	CC	0.87 ± 0.64	0.69-1.10
			AA	0.97 ± 0.55	0.81-1.10
Lingual	3 mm	Bone thickness	CC	0.89 ± 0.62	0.71-1.10
			AA	0.83 ± 0.50	0.69-0.97
	6 mm	Bone thickness	CC	1.50 ± 0.76	1.20-1.70
			AA	1.40 ± 0.95	1.10-1.70
	9 mm	Bone thickness	CC	2.00 ± 1.00	1.70-2.30
			AA	1.90 ± 0.96	1.70-2.20
Mid-root		Alveolar ridge thickness	CC	7.40 ± 0.97	7.20-7.70
			AA	7.10 ± 0.78	6.90-7.30
Apex		Alveolar ridge thickness	CC	7.70 ± 1.70	7.20-8.20
			AA	8.20 ± 1.50	7.70-8.60
Labial height		Bone height	CC	2.20 ± 1.60	1.80-2.70
			AA	2.20 ± 1.60	1.80-2.60
Lingual height		Bone height	CC	2.50 ± 1.40	2.10-2.90
			AA	2.40 ± 0.67	2.20-2.60

SD: standard deviation, CI: confidence interval

Discussion

In the present study, the height and width of the alveolar bone surrounding the maxillary and mandibular incisors were measured and the mean values were compared between AA and CC normo-divergent female populations. Significant differences were found in bone thickness, alveolar thickness, and bone height on the labial and lingual sides of the maxillary and mandibular incisors for a few of the measurements (Tables 1-4).

A clinically relevant finding of this study was that the mean labial bone thickness of all maxillary measurements was less than 1 mm (range, 0.25-0.82 mm) (Tables 1 and 2). These results are in agreement with Nowzari et al.,[10] who reported a high prevalence of thin facial bone overlying maxillary central incisors. They showed that the percentage of maxillary central incisors with a cortical thickness ≥2 mm measured at levels of 1, 2, 3, 4, and 5 mm was 0%, 1.5%, 2.0%, 3.0%, and 2.5%, respectively. The overall mean thickness of the bone was 1.05 mm for all 4 maxillary incisors. Their findings are higher than those of the current study, as the mean thickness of buccal bone was 0.68 mm in CCs and 0.57 mm in AAs (Tables 1 and 2). One reason for this disparity could be differences in study methodology and the location of measurements.

Furthermore, except for the central incisor at 9 mm ($P < 0.05$), no significant findings were found for maxillary lingual thickness. In general, the measurements of lingual bone thickness were larger than those of labial bone thickness for both races, and a significant difference was found for bone thickness at 6 mm and 9 mm for the maxillary incisors and mandibular lateral incisors ($P < 0.05$, Table 5). This suggests that following the extraction of premolars, during the retraction, incisors may remain within the alveolar housing more successfully than in non-extraction treatment with subsequent flaring of incisors, provided there is initial crowding. This hypothesis is supported by Thilander,[14] who found that bony defects could be filled by moving teeth that remain in the alveolar walls. However, during orthodontic tooth movement, if a tooth is moved through the bony plate and alveolar dehiscence is created, no bone remineralization is observed.

Table 5. Comparison of maxillary and mandibular bone measurements of the central and lateral incisors in Caucasian (CC) and African American (AA) female patients

Location of measurement		Category	Race	Maxillary versus mandibular central incisor		Maxillary versus mandibular lateral incisor	
				Mean difference	95% CI	Mean difference	95% CI
Buccal	3 mm	Bone thickness	CC	0.04	−0.6022 to 0.6745	0.03	−0.6102 to 0.6664
			AA	0.10	−0.5691 to 0.7711	−0.24	−0.9111 to 0.4291
	6 mm	Bone thickness	CC	0.24	−0.3979 to 0.8787	0.22	−0.4155 to 0.8612
			AA	0.11	−0.5631 to 0.7771	−0.09	−0.7571 to 0.5831
	9 mm	Bone thickness	CC	−0.54	−1.174 to 0.1029	−0.46	−1.102 to 0.1745
			AA	−0.86*	−1.534 to −0.1939	−0.72*	−1.393 to −0.05240
Lingual	3 mm	Bone thickness	CC	0.58	−0.05915 to 1.217	−0.04	−0.6827 to 0.5940
			AA	0.85*	0.1759 to 1.516	0.25	−0.4201 to 0.9201
	6 mm	Bone thickness	CC	1.29*	0.6481 to 1.925	0.26	−0.3752 to 0.9014
			AA	1.27*	0.5964 to 1.937	0.45	−0.2201 to 1.120
	9 mm	Bone thickness	CC	1.98*	1.344 to 2.621	0.71*	0.07501 to 1.352
			AA	1.26*	0.5884 to 1.929	0.58	−0.09110 to 1.249
Mid-root		Alveolar ridge thickness	CC	1.70*	1.061 to 2.338	−0.06	−0.6995 to 0.5772
			AA	1.52*	0.8464 to 2.187	0.06	−0.6111 to 0.7291
Apex		Alveolar ridge thickness	CC	2.33*	1.688 to 2.965	0.50	−0.1334 to 1.143
			AA	0.63	−0.03560 to 1.305	−1.15*	−1.824 to −0.4834
Labial height		Bone height	CC	−0.43	−1.073 to 0.2036	−0.27	−0.9077 to 0.3690
			AA	−0.73*	−1.402 to −0.06140	−0.76*	−1.433 to −0.09240
Lingual height		Bone height	CC	−1.12*	−1.762 to −0.4856	−0.38	−1.019 to 0.2573
			AA	−1.45*	−2.116 to −0.7754	−0.77*	−1.440 to −0.09940

CI: Confidence interval, *: $P<0.05$ for the comparison of maxillary vs. mandibular parameters

This study also evaluated mandibular bone thickness, and found significantly higher bone thickness in CCs at 3 mm and 6 mm from the alveolar crest on the lingual side of mandibular central incisors (Tables 3 and 4). However, given that width measurements were made at 8 different locations and for 4 separate teeth (a total of 32 width measurements), no direct correlation was observed regarding the relationship between alveolar bone width and race (Tables 3 and 4). Morad et al.[15] found the labial bone thickness for mandibular anterior teeth to be between 0.5 and 0.8 mm within the first 5 mm from the CEJ. Han and Jung[16] examined the alveolar crest width and height in Korean cadavers and found similarly thin bone around the mandibular central and lateral incisors, averaging 0.86 ± 0.59 mm and 0.88 ± 0.70 mm, respectively. Although the methods in these studies were not identical to those of the present study, the results are similar to the findings of the present study in an adult female population. In the current study, the mean labial bone width ranged from 0.47 mm to 1.5 mm (Tables 3 and 4).

When assessing the height of alveolar bone, the only significant finding was found for the labial height on the maxillary lateral incisor (Tables 1-4). A study conducted by Ghassemian et al.[17] found that patients 50 years or older had a 1 mm larger CEJ-bone crest distance than those 30 or younger. While the present study did not include individuals over 50 years of age, the average age of the 2 groups was very similar, with CCs averaging 33.60 years and AAs averaging 33.64 years. When evaluating the alveolar ridge thickness, significantly greater alveolar ridge thickness was found in CCs for maxillary central and lateral incisors and mandibular central incisors at the apex ($P<0.05$, Tables 1-4). This observation has specific implications for orthodontic treatment, as clinicians can utilize this evidence to predict the range of predictable root movement and torque expression without undesirable side effects.

Finally, when comparing maxillary and mandibular bone

Table 6. Comparison of labial and lingual bone measurements of the central and lateral incisors in Caucasian (CC) and African American (AA) female patients

Location of measurement	Category	Race	Maxillary: Labial versus lingual (central incisor) Mean difference	Maxillary: Labial versus lingual (central incisor) 95% CI	Mandibular: Labial versus lingual (central incisor) Mean difference	Mandibular: Labial versus lingual (central incisor) 95% CI
3 mm	Bone thickness	CC	−0.68*	−1.290 to −0.06013	−0.13	−0.7344 to 0.4704
		AA	−0.61	−1.279 to 0.06855	0.14	−0.4624 to 0.7424
6 mm	Bone thickness	CC	−1.75*	−2.365 to −1.135	−0.70*	−1.306 to −0.1016
		AA	−1.46*	−2.131 to −0.7839	−0.30	−0.9004 to 0.3044
9 mm	Bone thickness	CC	−3.10*	−3.711 to −2.481	−0.58	−1.180 to 0.02444
		AA	−2.32*	−2.996 to −1.649	−0.20	−0.8024 to 0.4024
Height	Bone height	CC	0.28	−0.3357 to 0.8940	−0.41	−1.012 to 0.1924
		AA	0.38	−0.2936 to 1.054	−0.33	−0.9364 to 0.2684
			Labial versus lingual (lateral incisor)		Labial versus lingual (lateral incisor)	
3 mm	Bone thickness	CC	−0.04	−0.5855 to 0.5064	−0.11	−0.6469 to 0.4229
		AA	−0.45	−1.119 to 0.2286	0.05	−0.5564 to 0.6484
6 mm	Bone thickness	CC	−1.11*	−1.652 to −0.5603	−1.07*	−1.601 to −0.5311
		AA	−1.52*	−2.189 to −0.8414	−0.98*	−1.580 to −0.3756
9 mm	Bone thickness	CC	−2.33*	−2.875 to −1.783	−1.15*	−1.687 to −0.6171
		AA	−2.28*	−2.951 to −1.604	−0.98*	−1.578 to −0.3736
Height	Bone height	CC	−0.16	−0.7043 to 0.3876	−0.27	−0.8049 to 0.2649
		AA	−0.20	−0.8686 to 0.4786	−0.20	−0.8044 to 0.4004

CI: Confidence interval, *: $P<0.05$ on the comparison of labial vs. lingual parameters

parameters, a significant difference was found specifically for the lingual bone width of central incisors, with the maxillary bone thickness being higher than the mandibular bone thickness ($P<0.05$, Table 5). Mid-root alveolar ridge thickness showed a similar trend for the central incisors. This information could be useful in orthodontic treatment planning and applying differential biomechanical principles for maxillary and mandibular arches.

Additionally, the quality of the CBCT images has a huge impact on the reliability and accuracy of the measurements. Molen[18] found 0.3- and 0.4-mm voxel size to be inadequate to properly visualize thin bone for various reasons. Most notably, he found that thin bone was especially susceptible to partial volume averaging, meaning that the angle at which the image plane intersects the bone wall could cause a thin bone to appear thicker or thinner than it actually was. Patcas et al.[19] suggested that a smaller voxel size (0.125 mm) was more accurate for visualizing thin bone, but with the trade-off of an increase in radiation exposure to patients. Additionally, with the decrease in voxel size, the image became more sensitive to noise, resulting in poorer spatial resolution. Güngör and Doğan[20] conducted a CBCT study evaluating the effects of 0.25-, 0.3-, and 0.4-mm voxel sizes on the accuracy of linear distance and concluded that the linear measurements were similar and reliable. Baumgaertel et al.[21] published a CBCT study evaluating the reliability and accuracy of CBCT dental measurements. They utilized a 0.28-mm voxel size and concluded that the dental measurements proved to be reliable and accurate. Based on this evidence, linear measurements made on CBCT scans with a 0.3-mm voxel size in the present study should be considered reliable and accurate.

Even though differences between the 2 racial groups were sparse and lacking in clinical applicability, it is still important to accurately assess alveolar housing dimensions when planning orthodontic tooth movement. If non-extraction treatment is anticipated, and crowding exists, the labial bone dimensions are relevant for determining how much proclination is acceptable. If a patient is protrusive to begin with, and premolar extraction/incisor retraction is planned, the abundance of lingual bone is important. Srebrzyńska-Witek et al.[22] found that mandibular anterior bone tended to be thicker on the lingual than the labial aspect (with measurements at 3 mm, 6 mm, and 9 mm). Another similar finding was that the bone increased in width from the cervical to the apical region, except at the 6-mm labial measurement point where the mean bone width was thinnest (Tables 1-4). Overall, this finding suggests that there may be more tolerance for incisor retraction than proclination. Thilander[14] found that areas of bony dehiscence did not remineralize unless the tooth was moved back within the alveolar housing. It was, therefore, deemed important to respect this boundary. Alveolar bone width might be genetically controlled, and thus does not increase when teeth are moved outside of the alveolar process.

Although the present study comprehensively evaluated the alveolar housing surrounding the maxillary and mandibular anterior teeth, the outcomes were limited by the small number of samples. Moreover, additional raters should be used for each set of data to evaluate interrater reliability to ensure a more accurate data set. Lastly, it was difficult to compare the results of the present study to those of other studies due to the lack of previous research comparing alveolar bone morphology between AAs and CCs. The majority of previous research was concerned with the labial aspect of the bone in CCs. Future studies should also include larger sample sizes for greater statistical power based on the current study data.

In conclusion, there was no significant difference in maxillomandibular anterior alveolar bone measurements between normo-divergent adult AA and CC women except for a few parameters at varying locations. However, future studies can be planned based the current pilot study data, which may provide valuable information.

Conflicts of Interest: None

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