Mandibular anterior bony support and incisor crowding: Is there a relationship?

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Introduction: The aim of this study was to test the null hypothesis that increased irregularity of the mandibular incisors is associated with a reduction in the alveolar support on cone-beam computed tomographic sections. **Methods:** From a sample of 1100 digital volumetric tomographs, 125 tomographs of subjects with Class I malocclusion (mean age, 21.6 ± 4.8 years) were selected for this study. An irregularity index was used to categorize these tomographs as having mild, moderate, or severe crowding. All tomographs were taken by using an iCAT (Imaging Sciences International, Hatfield, Pa) imaging device. The following parameters were measured on the sections corresponding to the 4 mandibular incisors with the iCAT software: height, thickness, and area of the entire symphysis; height, thickness, and area of the cancellous bone of the symphysis; and distance between the vestibular and lingual cortices. For the statistical evaluation, independent samples *t* test, analysis of variance, and the Tukey HSD test were used at an alpha level 0.05. The Pearson correlation coefficient and a simple linear regression were calculated to determine the relationship between mandibular anterior bony support and incisor crowding. **Results:** Almost all mandibular anterior bone measurements were greater in the male subjects than in the female subjects (height of the mandibular symphysis, $P < 0.001$; cancellous bone height, $P < 0.001$). Female subjects with mild crowding had higher values for cancellous bone height ($P = 0.025$) and vestibular cancellous bone thickness ($P = 0.004$) than did those with severe crowding. However, no differences were detected in the male subjects. Additionally, significant correlations were determined between incisor crowding and thickness of the mandibular symphysis, cancellous bone thickness, and the vestibular part of cancellous bone thickness in female subjects. **Conclusions:** Significant relationships were found between the measures of mandibular incisor crowding and basal bone dimensions in female subjects. Except for the vestibular part of cancellous bone thickness, all mandibular incisor bone measurements were greater in the male subjects than in the female subjects. (Am J Orthod Dentofacial Orthop 2012;142:645-53)

Crowding of the mandibular incisors is a critical issue because it has an impact on prognosis, treatment methods, and retention. Several factors can be assumed to affect the development and severity of crowding, such as the direction of mandibular growth,[1] early loss of the deciduous molars,[2] mesiodistal tooth and arch dimensions,[3] oral and perioral musculature, and incisor and molar inclinations.[4] The attempt to establish an orthodontically ideal, long-lasting, and equilibrated position of the incisors has included the possible determination of the anteriormost limit of the teeth.[5]

The mandibular symphysis is the anatomic factor that limits the movement of the incisors. The small labiolingual dimension of the alveolar process in this area implies a thin layer of bony support of the mandibular incisors.[6] Wehrbein et al[7] suggested that, in the case of a narrow and high symphysis, extensive orthodontic tooth movements during routine orthodontic treatment with a fixed appliance might be critical and lead to progressive bone loss of lingual and labial cortical plates. Fuhrmann[8] has shown that loss of thin bone plates can be induced by orthodontic tooth movement. Therefore, the choice of treatment plan should be greatly influenced by the morphology of the symphysis and the position of the mandibular incisors.[5]

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Cone-beam computed tomography (CBCT) has become a popular modality in the evaluation of orthodontic diagnosis and outcomes.[9] CBCT enables us to examine the shape and the size of alveolar bones without the disadvantages of conventional radiographs.[6,10] Unlike conventional radiographs, there is no magnification and distortion in CBCT images.

Only a few studies have evaluated the mandibular bone with computerized tomography. Gracco et al[5] evaluated mandibular incisor bony support in untreated patients with various facial types via computed volumetric tomography and found a statistically significant relationship between facial type and the total thickness of the mandibular symphysis. Siciliani et al[11] found that the symphysis is thin and elongated in patients with long faces, whereas it is thicker in those with short faces. Tsunori et al[12] established a correlation between facial type and mandibular cortical bone thickness. Yamada et al[13] indicated that the morphology of the alveolar bone in the central incisor region might be associated with the inclination of the central incisors.

Because the teeth and the neighboring bony structures are in a close relationship, a reciprocal effect can occur, and they might be affected by each other. To our knowledge, no research in the literature has investigated the correlation between mandibular bony support and mandibular incisor crowding with CBCT. Thus, the aim of this study was to test the null hypothesis that increased irregularity of the mandibular incisors is associated with a reduction in the alveolar support on CBCT sections.

MATERIAL AND METHODS

Before this study, a power analysis with G*Power (version 3.0.10; Franz Faul, Christian-Albrechts-Universität, Kiel, Germany) was performed to estimate the sample size. It showed that a total sample size of 111 subjects would give more than 80% power (actual power, 0.8034; critical F, 3.0803; noncentrality parameter, $\lambda = 9.99$), or 126 subjects would give more than 85% power (actual power, 0.8548; critical F, 3.0698; noncentrality parameter, $\lambda = 11.34$) to detect significant differences with a 0.30 effect size and at an $\alpha = 0.05$ significance level.

Permission was obtained from the Dicle University Human Researches Regional Ethical Committee after its Research Scientific Committee had approved the experimental protocol. All CBCT scans were selected from the archive of the university's Oral and Maxillofacial Radiology department. The CBCTs for these patients had been taken at their usual records appointments as a part of the necessary radiographs; therefore, the subjects were not unnecessarily subjected to additional radiation.

By September 2010, images of 1100 patients (ages, 8.5-67.3 years) were in the database. CBCT scans of subjects with syndromes, craniofacial malformations, evidence of trauma, and periodontal diseases, those who had had orthognathic surgery or previous orthodontic treatment, and those with congenitally missing or extracted permanent teeth (except third molars) were excluded from the initial sample of 1100 digital volumetric tomography scans. From the remaining tomography scans, 125 tomographs of subjects with Class I malocclusion, aged 16 to 36 years (mean age, 21.6 ± 4.8 years), were selected for this study. The subjects with Class II and Class III malocclusions were excluded to eliminate probable compensation mechanisms that might affect the inclination of the mandibular incisors. The selected patients were categorized according to Little's irregularity index as having mild, moderate, or severe crowding.[14]

All tomographs were obtained with the iCAT imaging device (model 17-19; Imaging Sciences International, Hatfield, Pa) at the following settings: the x-ray emission time was 3.5 seconds, exposures were made at 5.0 mA and 120 kV, exposure time was 9.6 seconds, and axial slice thickness was 0.3 mm. Also, primary and secondary reconstructions of the data were performed with the iCAT software. This secondary reconstruction permitted the creation of 3-dimensional maximum-intensity projection images, from which it was possible to make the linear and angular measurements.

All measurements were performed by using the distance-measuring property of the iCAT software, and the CBCT landmarks were designated by 1 author (I.V.). All landmarks used in this study are given and defined in Table 1.

To examine the osseous variables in the region of the incisors, the following measurements were calculated for all mandibular incisors on the sagittal slices (Fig 1): (1) height of the mandibular symphysis, (2) cancellous bone height of the mandibular symphysis, (3) thickness of the mandibular symphysis, and (4) cancellous bone thickness of the mandibular symphysis. We subsequently divided the cancellous bone thickness into vestibular and lingual portions. The sagittal slices were arranged so that the vertical reference line on the panoramic view passed through the central axis of the incisors. Twenty-four CBCT measurements (6 measurements for the section of each incisor level) were made for each of the 125 patients, giving 3000 measurements.

Table I. CBCT landmarks used in the study

A point: the point on the internal surface of the anterior cortex
P point: the point on the internal surfaces of the posterior cortex
As point: the most anterosuperior point of the mandibular alveolar process
Lc point: the point formed by the intersection of external surface of the lingual cortex and the line parallel to the axis of the incisors and crossing the As point
Center of rotation (C): the midpoint of the incisor root position embedded in alveolar bone
L point: the apex of the root
CH line: the line parallel to the axis of the incisor from the vestibule to the lingual cortex of the symphysis
MT line: the line perpendicular to the axis of the incisor that passes through the apex of the root between the external surfaces of the lingual and vestibular cortices
A-P size: the arc between points A and P that corresponds to the cancellous bone thickness of the alveolar process
A-L size: the arc between points A and L that identifies the vestibular portion of the cancellous bone of the symphysis
L-P size: the arc between points L and P identifies the lingual portion of the cancellous bone of the symphysis

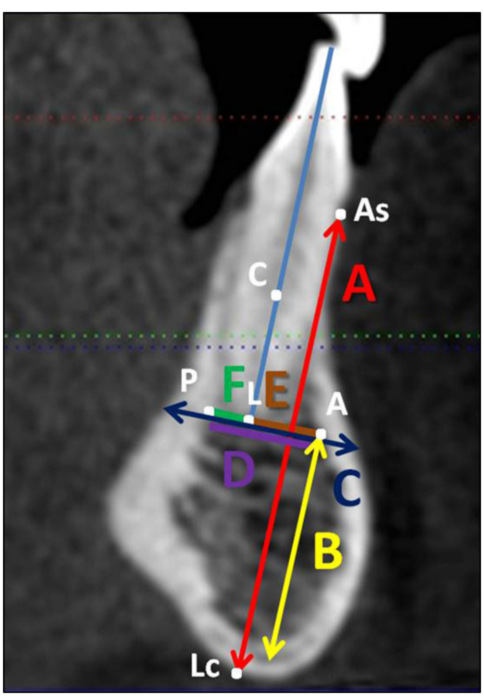


Fig 1. *A*, Height of mandibular symphysis (*As point* to *Lc point*); *B*, cancellous bone height of mandibular symphysis (*CH line*); *C*, thickness of mandibular symphysis (*MT line*); *D*, cancellous bone thickness of mandibular symphysis (*A point* to *P point*); *E*, vestibular cancellous bone thickness (*A point* to *L point*); *F*, lingual cancellous bone thickness (*L point* to *P point*).

CBCT scans were also used to evaluate crowding (Fig 2). The irregularity index proposed by Little[14] was

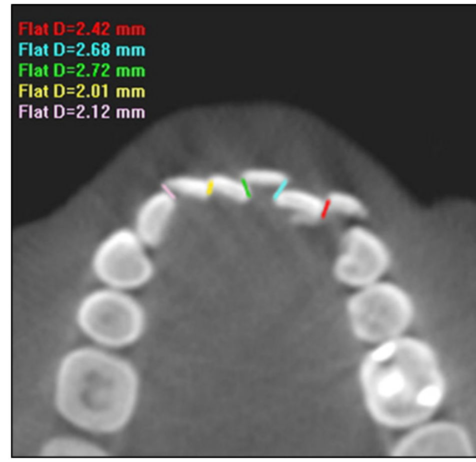


Fig 2. The irregularity index involves measuring the linear displacement of the anatomic contact points of the anterior teeth.

used to evaluate mandibular incisor crowding. The scoring method involves measuring the linear displacement of the anatomic contact points of the anterior teeth. The sum of the 5 measurements represents the subject's irregularity index value.

Additionally, to identify possible differences in bony support with different levels of the irregularity index, crowding was classified according to the following criteria: (1) mild, up to 3 mm (spacing was also included); (2) moderate, between 4 and 8 mm; and (3) severe, more than 8 mm.[15]

Statistical analysis

All statistical analyses were performed with the statistical package for social sciences (version 13.0, SPSS for Windows; SPSS, Chicago, Ill). The normality test of Shapiro-Wilks and the Levene variance homogeneity test were applied to the data. The data were normally distributed, and there was homogeneity of variance among the groups. Thus, the statistical evaluation was performed by using parametric tests. Arithmetic mean and standard deviation values were calculated.

To evaluate sex differences in mandibular bony support measurements, the independent samples *t* test was used. Statistical comparisons of mandibular bone dimensions in subjects with different severities of crowding (mild, moderate, or severe) were undertaken by 1-way analysis of variance (ANOVA) and the Tukey HSD test. To evaluate the correlation between mandibular anterior bony supports and mandibular incisor crowding, Pearson correlation coefficients were estimated, and a simple linear regression analysis was done. When the *P* value was less than 0.05, the statistical test was determined to be significant.

Table II. Descriptive statistics and comparisons of sex differences in mandibular incisor bony support measurements with independent samples *t* test

	Female			Male			
Measurement (mm)	*n*	*Mean*	*SD*	*n*	*Mean*	*SD*	*P value*
Height of the mandibular symphysis	66	21.01	3.06	59	23.26	2.81	<0.001
Cancellous bone height	66	11.60	2.03	59	13.27	1.99	<0.001
Thickness of the mandibular symphysis	66	7.79	1.80	59	8.39	1.51	0.046
Cancellous bone thickness	66	4.92	1.38	59	5.43	1.09	0.026
Vestibular part of cancellous bone	66	3.29	1.15	59	3.53	0.90	0.197
Lingual part of cancellous bone	66	1.63	0.62	59	1.89	0.56	0.015

Table III. Statistical comparisons of mandibular incisor bony support in male subjects with different severities of crowding with 1-way ANOVA

	Mild crowding (0-3 mm)			Moderate crowding (4-8 mm)			Severe crowding (>8 mm)			ANOVA
Measurement (mm)	*n*	*Mean*	*SD*	*n*	*Mean*	*SD*	*n*	*Mean*	*SD*	*P value*
Height of the mandibular symphysis	24	22.86	2.76	17	22.91	2.44	18	24.11	3.15	0.305
Cancellous bone height	24	12.87	1.74	17	12.94	2.23	18	14.11	1.93	0.099
Thickness of the mandibular symphysis	24	8.46	1.56	17	8.24	1.79	18	8.45	1.22	0.889
Cancellous bone thickness	24	5.55	1.10	17	5.15	1.27	18	5.54	0.90	0.457
Vestibular part of cancellous bone	24	3.51	0.86	17	3.44	1.08	18	3.64	0.82	0.802
Lingual part of cancellous bone	24	2.02	0.65	17	1.71	0.52	18	1.90	0.43	0.226

RESULTS

To determine the errors associated with CBCT measurements, 15 CBCT images were selected randomly. The measurements were repeated 8 weeks later by the same author (I.V.). A Bland-Altman plot was applied to assess the repeatability. The differences between the first and second measurements were not significant.

Comparisons of all bone measurements at the level of the 4 mandibular incisors were made, and no statistically significant differences were found. Thus, the bony support measurements of all incisors were pooled.

Table II summarizes the descriptive statistics and comparisons of sex differences in the mandibular anterior bony support measurements. According to the statistical analysis, only the vestibular part of cancellous bone thickness had no significant sex dimorphism ($P = 0.197$). All other measurements showed statistically significant sex differences. All measurements were greater in the male subjects than in the female subjects.

Because there was significant sex dimorphism, the relationship between bone support and mandibular incisor crowding was determined separately for each sex. Statistical comparisons of mandibular anterior bony support in male subjects with different amounts of crowding are shown in Table III. According to the ANOVA, there was no statistically significant difference for the bone measurements among the male subjects with different severities of crowding (Table III).

However, statistically significant differences were found in 2 of the 6 measurements (Table IV) for female subjects. Significant differences were found in cancellous bone height ($P = 0.017$) and the vestibular part of the cancellous bone thickness measurements ($P = 0.005$). The Tukey HSD analysis indicated that the mild group had higher values for cancellous bone height ($P = 0.025$) and the vestibular part of cancellous bone thickness ($P = 0.004$) than did the severe group.

Correlations between mandibular anterior bone support and mandibular incisor crowding values were determined for both sexes, as shown in Table V. In male subjects, no significant correlation was determined. However, in female subjects, significant correlations were found between incisor crowding and thickness of the mandibular symphysis ($r = -0.331$; $P = 0.007$), cancellous bone thickness ($r = -0.384$; $P = 0.001$), and the vestibular part of cancellous bone thickness ($r = -0.446$; $P < 0.001$). Regressions for these measurements are also shown in Figures 3 through 5. The correlation between incisor crowding and thickness of mandibular symphysis was determined in female subjects (irregularity index = 8.72 + [–0.13 * thickness of mandibular symphysis]). Moreover, a link between cancellous bone thickness and incisor crowding was seen (irregularity index = 5.78 + [–0.12 * cancellous bone thickness]). Similarly, the

Table IV. Statistical comparisons of mandibular incisor bony support in female subjects with different severities of crowding with 1-way ANOVA and the Tukey HSD test

	Mild crowding (0-3 mm)			Moderate crowding (4-8 mm)			Severe crowding (>8 mm)			ANOVA	Tukey HSD P value		
Measurement (mm)	*n*	*Mean*	*SD*	*n*	*Mean*	*SD*	*n*	*Mean*	*SD*	P *value*	*Mild-moderate*	*Mild-severe*	*Moderate-severe*
Height of the mandibular symphysis	22	21.55	3.16	20	20.80	2.64	24	20.68	3.33	0.596			
Cancellous bone height	22	12.21	2.15	20	12.05	1.78	24	10.67	1.84	0.017	0.962	0.025*	0.056
Thickness of the mandibular symphysis	22	8.29	1.90	20	8.04	1.48	24	7.12	1.80	0.064			
Cancellous bone thickness	22	5.34	1.51	20	5.03	0.86	24	4.45	1.50	0.082			
Vestibular part of cancellous bone	22	3.79	1.21	20	3.40	0.80	24	2.73	1.13	0.005	0.464	0.004†	0.103
Lingual part of cancellous bone	22	1.55	0.67	20	1.63	0.53	24	1.70	0.65	0.714			

*$P \leq 0.05$; †$P \leq 0.01$.

Table V. Correlation between mandibular incisor bony support measurements and irregularity index

	Irregularity index					
	Female			Male		
Measurements	*n*	*r*	P *value*	*n*	*r*	P *value*
Height of the mandibular symphysis	66	0.042	0.736	59	0.125	0.344
Cancellous bone height	66	−0.222	0.073	59	0.098	0.461
Thickness of the mandibular symphysis	66	−0.331	0.007	59	−0.007	0.955
Cancellous bone thickness	66	−0.384	0.001	59	−0.067	0.613
Vestibular part of cancellous bone	66	−0.446	<0.001	59	0.071	0.593
Lingual part of cancellous bone	66	−0.023	0.852	59	−0.230	0.080

r, Pearson correlation coefficient.

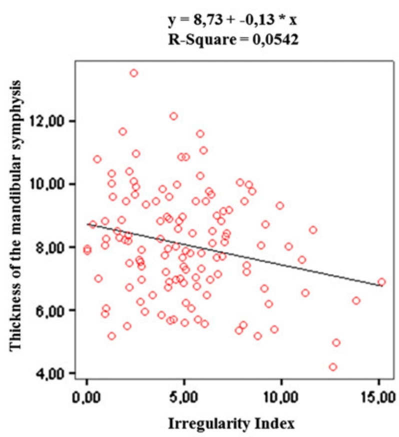
vestibular part of cancellous bone thickness and incisor crowding were associated (irregularity index = 3.87 + [−0.19 * vestibular part of cancellous bone thickness]). Multiple linear regressions were applied for incisor crowding (Table VI).

Incisor crowding = 7.608 + (0.589 * thickness of the mandibular symphysis) – (1.245 * cancellous bone thickness) – (0.259 * vestibular part of cancellous bone thickness). ($R = 0.318$; $R^2 = 0.101$; Adjusted $R^2 = 0.0785$.)

DISCUSSION

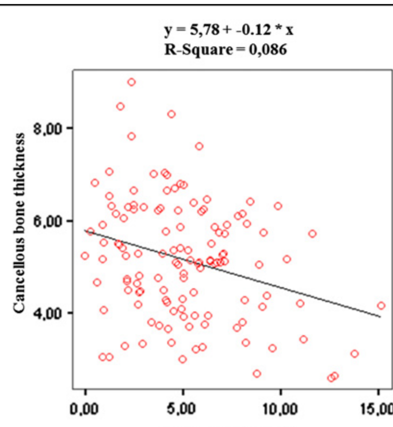
In orthodontic diagnosis, mandibular incisor crowding is critical and frequently a limiting factor when planning treatment. Decisions regarding extractions in the mandible are greatly influenced by the extent of crowding and the relationship between basal bone and incisor positions. Daskalogiannkis[16] defined basal bone as the bone that supports and is continuous with the alveolar process. Salzmann[17] documented that the size, form, and relationship of the basal bone are independent of the size of the teeth, and that tooth arrangement greatly depends on the size of the basal bone. In this respect, a reduced labiolingual size of the alveolar process in this area indicates that the layer of bone supporting the mandibular incisors is thin and liable to sustain iatrogenic damage.[5] Although the teeth are housed in bone, the role of bone in mandibular incisor crowding has not been investigated extensively. Thus, the aim of this study was to evaluate the relationship between mandibular anterior bony support and incisor crowding.

Previous attempts to measure basal bone have resulted in complicated methods that are often time-consuming to perform and variable in estimations.[18] Now, CBCT enables us to examine the shape and the size of basal bone without the disadvantages of conventional radiographs.[10,13] These images, in addition to being 3-dimensional, are not subject to distortion or superimposition, and secondary computerized reconstructions also facilitate quantitative and qualitative evaluation of the bone surfaces, quantitative evaluation of the relationship between teeth and bone,[19] and selection of the desired sections.[6] Nauert and Berg[6] indicated that only with computed tomography are accurate imaging and assessment of the labiolingual bony support of the mandibular incisors possible; this was confirmed in later studies.[20,21] In addition, CBCT can provide instant results.[22] Therefore, by considering the advantages of volumetric tomography, we preferred CBCT scans to evaluate mandibular bony incisor support.



	Unstandardized Coefficients		Standardized Coefficients	t	*p*-value
	Coefficient	*Std. Error*	*Beta*		
Constant	8,432	1,301		6,478	<0,001
Thickness of the mandibular symphysis	-0,419	0,158	-0,233	-2,655	0,009

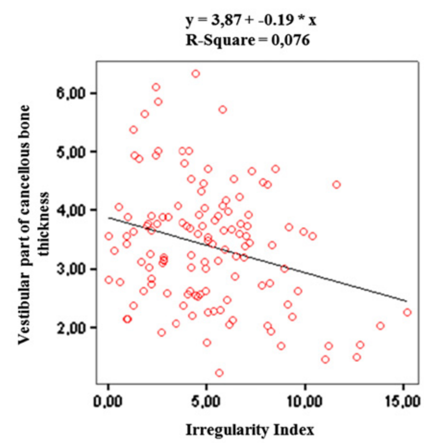
Fig 3. Scatter plot of incisor crowding and thickness of the mandibular symphysis for female subjects.



	Unstandardized Coefficients		Standardized Coefficients	t	*p*-value
	Coefficient	*Std. Error*	*Beta*		
Constant	8,655	1,094		7,910	<0,001
Cancellous bone thickness	-0,698	0,206	-0,293	-3,394	0,001

Fig 4. Scatter plot of incisor crowding and cancellous bone thickness for female subjects.

To date, previous investigators have used traditional orthodontic records, including plaster models and cephalograms, to attempt to detect relationships involving basal bone.[17] Plaster models have limitations, however,



	Unstandardized Coefficients		Standardized Coefficients	t	*p*-value
	Coefficient	*Std. Error*	*Beta*		
Constant	7,801	0,904		8,626	<0,001
Vestibular part of cancellous bone thickness	-0,810	0,254	-0,276	-3,181	0,002

Fig 5. Scatter plot of incisor crowding and the vestibular part of cancellous bone thickness for female subjects.

that include the need for accurate impressions and deep vestibular rims, especially posteriorly. Traditionally, measurements on dental casts are made with either calipers, a Boley gauge, or needle-pointed dividers. Quimby et al[23] investigated the accuracy (validity), reproducibility (reliability), efficacy, and effectiveness of measurements made on computer-based models. They found that computer-based models appear to be a clinically acceptable alternative to conventional plaster models. Baumgaertel et al[24] investigated the reliability and accuracy of dental measurements made on CBCT reconstructions. They indicated that dental measurements from CBCT volumes could be used for quantitative analysis. Similarly, Lim and Lim[25] evaluated the possibility of using digital models and CBCT images for model analysis; they found that digital models and CBCT images were clinically acceptable. Therefore instead of collecting plaster study models for this study, we preferred to use CBCT images for the measurements of the irregularity index.

When the incisors are positioned in the medullary portion of the alveolar bone, an optimal position is assumed to be obtained. A labially positioned incisor can have less bone support at the labial aspect than a lingually positioned incisor. The bone support of the symphysis at the midline might be narrower than the bone in the lateral incisor region. Therefore, central and lateral incisors might have different amounts of bone support in the labial aspects. On the other hand, in this study,

Table VI. Multiple linear regression analysis for incisor crowding

	Unstandardized coefficients		*Standardized coefficients*		
	Coefficient	*SE*	*Beta*	t	P *value*
Constant	7.607	1.322		5.753	0.000
Thickness of the mandibular symphysis	0.591	0.439	0.328	1.345	0.181
Cancellous bone thickness	−1.250	0.686	−0.524	−1.823	0.071
Vestibular part of cancellous bone thickness	−0.256	0.511	−0.087	−0.501	0.617

no statistically significant differences were determined for the bony support measurements of the 4 mandibular incisors at all bone measurements. Thus, the measurements of all incisors were pooled.

Gracco et al[5] aimed to verify a correlation between the morphology of the mandibular symphysis and the various facial types via computed volumetric tomography and used the same parameters for evaluating mandibular bony support. They compared the measurements obtained for the 4 mandibular incisors in each group and observed that the total and cancellous bone heights and the areas of the symphysis were greater at the central incisors than at the lateral incisors. However, in this study, we found no statistically significant differences regarding bone thickness among the 4 mandibular incisors. This controversy might result from the different classification patterns of patients. In our study, the patients with Class I malocclusion were classified according to the irregularity index. Gracco et al[5] used a vertical facial pattern to evaluate the patients and did not consider crowding. Also, due to a likely random pattern of irregularity, the group means for each incisor might be similar.

In this study, statistically significant sex differences were determined in all mandibular anterior bone measurements except the vestibular part of cancellous bone thickness. All mandibular bone measurements for male subjects were greater than those of female subjects. Dempsey et al[26] discovered that, overall, males have larger dimensions than females. Ursi et al[27] indicated that there is approximately a 5% sex difference in the size of the skeletal bones, with females being smaller. This sex dimorphism is also present in the dental arches and can play a confounding role in analysis. Lestrel et al[28] showed the differences between the sexes and an asymmetrical pattern of crowding in the dental arches. Also, the differences of the thickness in relation to sex and crowding can be explained by a bony compensatory phenomenon (remodeling). The bone remodels by physiologic load (strain) such as bite force. Osborne and Mao[29] measured incisive bite forces and found the average force to be 190 N in males and 50 N in females.

Miethke and Behm-Menthel[30] identified mandibular incisor crowding as a local, independent, genetically determined discrepancy between tooth width and size of supporting bone. A review of the literature indicated conflicting results about the factors contributing to mandibular incisor crowding. Sinclair and Little[31] and Howe et al[3] found no significant relationships between various mandibular parameters and incisor crowding. However, Berg[32] found that children with crowding had significantly lower mean values for mandibular length. Similarly, Leighton and Hunter[33] reported that patients with crowding had shorter posterior face heights and mandibular bodies. Türkkahraman and Sayın[34] found a significant inverse correlation between crowding and mandibular length. In this study, we found no statistically significant difference in bone measurements among male subjects with different levels of crowding. On the other hand, we observed that the mild crowding group showed higher values for cancellous bone height and the vestibular part of cancellous bone thickness than did the severe crowding group of female subjects.

We found a statistically significant inverse correlation between mandibular incisor crowding and mandibular symphysis thickness and cancellous bone thickness only for female subjects. The thickness of alveolar bone might be an etiologic factor for incisor crowding, or the smaller thickness of alveolar bone is a result of incisor crowding because, in rotated incisors, the labiolingual dimension of the root is reduced in the surrounding bone because of the oval shape of the incisor root. Female subjects with a thick bone structure demonstrated mandibular incisor crowding. Similarly, it can be hypothesized that females with thinner mandibular cortices experience greater dental crowding. It is believed that orthodontically moved teeth might not be stable if the basal arch over which they are placed is not large enough.[35] Supposedly, consistent with our results, Rothe et al[36] concluded that subjects with thin cortical bone at the lower anterior border of the mandible had more relapse of mandibular incisor irregularity, because thin cortical bone at the lower anterior border of the mandible is associated with a general reduction in bone density. Also, if the basal bone in the body of the mandible is constricted or too small, the teeth will be forced out of their normal arrangement, or if a normal arrangement is achieved, they will be proclined relative to the mandibular plane.[37] Therefore, it is logical to assume that proclination of teeth can cause side effects such as external root resorption,[38] gingival recession, and alveolar defects such as dehiscence and fenestration.[39]

Although we found statistically significant correlations in female subjects between measurements of mandibular incisor crowding and basal bone dimensions, the correlation coefficients were relatively low. We think that such low correlations will have almost no value in prediction.

CONCLUSIONS

Significant relationships were found between the measurements of mandibular incisor crowding and basal bone dimensions in female subjects. Except for the vestibular part of cancellous bone thickness, all mandibular incisor bone measurements were greater in males than in females.

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