

Comparison between Characteristics of Maxillary Right and Left Central Incisors: A Cone-beam Computed Tomography Study

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ABSTRACT

Aim: To compare the angulation of maxillary left (UL) and right (UR) incisors and the width of alveolar bone.

Materials and methods: This study was conducted using archived cone-beam computed tomography (CBCT) images of 50 male and 50 female patients. The UL and UR incisors were compared in terms of incisor/palatal plane angle, collum angle, labiopalatal crown-root position, and alveolar bone width (ABW). The comparison, with reference to gender and age, was analyzed using one-way analysis of variance and independent sample *t* test.

Results: There is no substantial variance in the average differences of the assessed variables for UR and UL central incisors ($p > 0.05$). No significant association was found between crown labial to root and root labial to crown positions for both central incisors ($p > 0.05$). Statistical analyses revealed that tooth type has no significant association with the central incisors-related variables. Alveolar bone width, at various areas assessed, showed significant relation to gender. On the other hand, incisor/palatal plane angle and ABW at the cemento-enamel junction and at level of Point A (subnasale) were significantly affected by age.

Conclusion: Gender can significantly affect the development of ABW. Also, incisor/palatal plane angle and ABW at certain areas are correlated with age.

Clinical significance: Understanding the similarities or differences between right and left maxillary central incisors may give better indication if cephalometric images are accurate in attaining such measurements. This in turn will also help orthodontist to choose the proper tool for treatment decision-making related to incisor tooth movement.

Keywords: Alveolar bone width, Collum angle, Cone-beam computed tomography, Crown-to-root angle, Incisors' characteristics.

The Journal of Contemporary Dental Practice (2020): 10.5005/jp-journals-10024-2874

INTRODUCTION

Orthodontic treatment can be attained by teeth movement in its desired place. As such, suitable support for alveolar bone is highly needed for efficient movement of teeth and steady position.¹ In order to achieve this, premolar extraction and anterior retraction are required for many malocclusion problems. Treating such cases requires controlling the torque of the incisor while retracting them.² Understanding and examining the periodontium and tooth structure of the incisors before retraction are necessary to envisage limitations and possibilities of fenestrations, loss of alveolar bone, or dehiscence during incisor retraction.¹⁻³

Accurate diagnostic imaging is an indispensable necessity in order to obtain the accurate diagnosis and ideal action as well as in monitoring the development and result of treatment.^{4,5} Cephalometric radiographs are two-dimensional projection of the facial skeleton in the mid-sagittal plane. However, it does not provide a factual scale for the incisor inclinations and alveolar bone width (ABW).^{3,6} As such, old-style radiographic images, like periapical radiographs, panoramic views, and cephalograms, are deemed less precise in assessing bone structure.^{3,7} A study conducted by Fuhrmann revealed a common overestimation of the width of labiolingual bone on the lateral cephalogram in comparison to physical dimensions of the concrete samples.^{2,3,8} Likewise, cephalometric examination has other restrictions such as 2D representation of anatomical structures as well as image distortion due to errors related to X-ray equipment or variations in

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How to cite this article: Linjawi AI. Comparison between Characteristics of Maxillary Right and Left Central Incisors: A Cone-beam Computed Tomography Study. *J Contemp Dent Pract* 2020;21(7):723-727.

Source of support: Nil

Conflict of interest: None

patient's head positioning.⁶ In the anterior region, the true scale and inclination of the right and left incisors might be misled by such overlap of anatomical structures.

In contrast, three-dimensional cone-beam computed tomography (CBCT) was described to be more accurate in assessing incisors' inclinations and morphology of alveolar bone.^{6,9} CBCT is deemed advantageous in the assessment of osseous condition around teeth due to certain factors such as low radiation dose, low cost, convenience, and accuracy.^{10,11} Cone-beam computed tomography could be utilized as a support in case analysis and treatment preparation, as it helps in minimizing difficulties in dental procedures.¹²⁻¹⁴ Cone-beam computed tomography is extensively utilized in the assessment of width and size of the bones in maxillofacial and oral areas.^{13,15}

Disparities in incisors' angulations, alveolar bone thickness, and incisive canal morphology are challenging variables that can affect the movement of maxillary incisors.^{1,13,16-18} Cone-beam computed tomography studies revealed a thicker alveolar bone on the palatal side when compared to the labial side and at the apical level than the coronal level of the central incisors.^{1,13,18} Lee et al.¹³ found that the majority of participants had <2 mm of ABW at the labial side at 3 and 5 mm apical to central incisors' cemento enamel junction (CEJ). No substantial variation in the finding among male and female in terms of ABW was reported. Several studies reported positive association between inclination of central incisor and morphology of alveolar bone.¹⁷

Given the availability of limited information on the relationship between the right and the left maxillary incisors' angulation and ABW, this study assessed the correlation between the angulation of both incisors and the width of the surrounding alveolar bone. The incisors' angulations assessed were: the incisor to palatal plane angle, the crown to root angle, which is called the collum angle, and the crown to root position. Such angulation in addition to measuring the surrounding alveolar bone are important measures to know when deciding tipping, torqueing, and bodily movement of incisors. In addition, understanding the similarities or differences between right and left maxillary central incisors may give better indication if cephalometric images are accurate in attaining such measurements. This in turn will also help orthodontist to choose the proper tool needed for treatment decisions related to incisor tooth movement.

MATERIALS AND METHODS

Study Design

This study, which utilized a cross-sectional approach, was conducted using CBCT archived records of adult patients seeking treatment at the Faculty of Dentistry of King Abdulaziz University, Jeddah, Kingdom of Saudi Arabia. Ethical approval was obtained from the ethical committee of the same institution [ethical no. 100-06-19].

Sample Characteristics

The criteria for inclusion in this study were: (1) CBCT images for at least the maxilla was taken; (2) no orthodontic treatment history; (3) no dental anomalies related to the maxillary incisors including missing or supernumerary teeth; (4) no dental treatment to maxillary incisors; (5) no maxillary incisor trauma history; and (7) no congenital abnormalities including cleft lip and palate.

The sample was grouped according to gender and age categories. Four age-groups were identified: less than or equal to 20, 20-40, 40-60, and greater than 60 years of age.

Cone-beam Computed Tomography Images

In terms of CBCT images, the subsequent settings were used: normal mode with specifications of 6.8 seconds, 4.10 mGy, 90 kV, and 4 mA; slice thickness of 0.147 mm; field of view of 81 × 74 mm; and voxel size of 0.146 mm. Image acquisition was done with the Frankfort horizontal plane parallel to the floor. Images were then saved as DICOM file, and the sagittal view was extracted as well as evaluated using OnDemand 3D Imaging software (Seoul, Korea).

Measurements

Linear and angular measurements of the maxillary left (UL) and right (UR) central incisors were assessed in the sagittal plane for the following variables (Fig. 1):

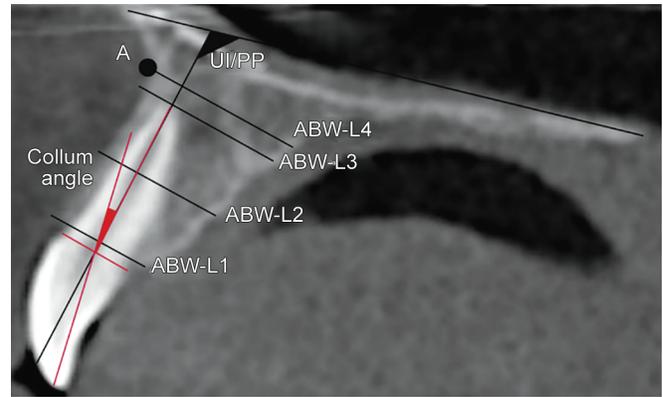


Fig. 1: UI/PP [black lines]: incisor to palatal plane angle. Collum angle [red lines]: crown-root angle. Alveolar bone width (ABW) [black lines]: lines drawn from palatal to labial surface of central incisor perpendicular to its long axis; ABW-L1: at cemento enamel junction (CEJ), ABW-L2: at mid-root level at half the distance between L1 and L3, ABW-L3: at level of the root apex and ABW-L4: at the level of Point A (subnasale)

- Incisor/palatal plane angle: the angle between the long axis of the central incisor and the palatal plane.
- Collum angle: crown-root angle is the angle created by the following two lines:
 - A line drawn from the crown tip passing through a mid-point at the cervical line of the tooth.
 - A line drawn from the root tip passing through a mid-point at the cervical line of the tooth.
- Crown-root position: to assess the crown to root position and categorized as follows.
 - 1 = crown tip is labial to the root tip.
 - 2 = crown tip is palatal to the root tip.
- Alveolar bone width: The ABW at the right and left central incisors was determined by drawing a line from the palatal to the labial perspective perpendicular to the long axis of the tooth. The ABW was measured at four levels: L1—at CEJ, L2—at mid-root level by measuring half the distance between L1 and L3, L3—at level of the root apex, and L4—at the level of Point A (subnasale).

Measurement Error

A single examiner, the author who is an orthodontist, performed all measurements, which were repeated after a 2-week break. No substantial association between the 2 sets ($p < 0.05$) as well as within-class correlation constant of 0.81, which reveals a good consistency of data, was determined after performing an independent *t* test that linked the first and second sets of the measurements.

Statistical Analysis

Calculations of mean as well as standard deviations were performed for all sets of data. Assessment concerning UR and UL incisors for all variables assessed was performed according to gender using paired *t* test. Comparison was also performed according to age categories using *post hoc* Tukey's test and one-way analysis of variance. Correlations among parameters were studied using Bonferroni correction for multiple comparisons and Pearson correlation analysis. Statistical analyses were determined via SPSS 22.0 computer software package (IBM, Armonk, NY, USA). The confidence level for analyses was set at $p < 0.05$.

Table 1: Mean and standard deviations of the assessed variable for the UR and UL central incisors (*n* = 100)

	UR central incisor, mean (SD)	UL central incisor, mean (SD)	Mean difference (right-left), Mean (SD)	<i>p</i> value
Incisor/PP	115.69 (8.07)	116.69 (9.46)	1.00 (6.76)	0.142
Collum angle	3.43 (2.50)	3.47 (2.98)	-0.04 (3.21)	0.894
ABW L1	7.58 (0.77)	7.55 (0.81)	0.03 (0.66)	0.636
ABW L2	8.24 (1.08)	8.15 (1.20)	0.08 (0.80)	0.301
ABW L3	9.03 (1.90)	8.90 (1.81)	0.13 (1.39)	0.366
ABW L4	10.49 (2.18)	10.43 (2.37)	0.06 (1.51)	0.694

UR, upper right central incisor; UL, upper left central incisor; PP, palatal plane; ABW, alveolar bone width; L1, at CEJ; L2, mid-root; L3, at root apex. Significance level at *p* < 0.05

Table 3: *p* values and significant differences in the assessed variable between the UR and UL central incisors according to gender, age, and tooth type

	According to gender	According to age	According to tooth type
Incisor/PP	0.432	0.028*	0.422
Collum angle	0.142	0.576	0.911
Crown-root position	0.151	0.818	0.841
ABW L1	0.005**	0.080	0.779
ABW L2	0.000***	0.474	0.608
ABW L3	0.000***	0.200	0.631
ABW L4	0.000***	0.032*	0.853

UR: upper right central incisor, UL: upper left central incisor
PP, palatal plane; ABW, alveolar bone width; L1, at CEJ; L2, mid-root; L3, at root apex. Significance level: **p* < 0.05, ***p* < 0.01, ****p* < 0.001

RESULTS

Archived CBCT images of 100 patients, 50 males and 50 females, were utilized in this study. Assessment of UR and UL central incisors were conducted, and mean difference was determined. Low mean differences were computed for ABW at various levels. On the other hand, the mean difference in the collum angle provided a value of -0.04. A mean difference of 1.00 was computed for incisor/palatal plane angle. At 95% confidence level, no substantial association was determined in the mean variances of the assessed variables for UR and UL central incisors, as shown in Table 1.

Crown-root position for UR and UL incisors were also assessed, with reference to age and gender. For maxillary right (UR) central incisor, crown labial to root position were present at 29%, whereas root labial to crown were common in 71% of the participants. On the other hand, 70% of the sample had root labial to crown position, while crown labial to root position was found in the remaining 30% for UL central incisor. There was no significant difference in crown-root positions between UR and UL central incisors at level of significance of *p* < 0.05, as provided in Table 2.

Age, gender, and tooth type were also considered in the assessment of UR and UL central incisors. Statistical analyses revealed that tooth type has no significant association with the variables related to UR and UL central incisors. Alveolar bone width at various areas assessed was found to be significantly related to gender. On the other hand, incisor/palatal plane angle, and ABW at

Table 2: Number and percentages of crown-root position for UR and UL central incisors with reference to gender and age (*n* = 100)

	UR central incisor	UL central incisor	<i>p</i>
Crown labial to root	29 (29%)	30 (30%)	0.819
Root labial to crown	71 (71%)	70 (70%)	

UR, upper right central incisor; UL, upper left central incisor
Significance level at *p* < 0.05

the CEJ (L1) and at level of Point A (subnasale) [L4] were significantly affected by age, as shown in Table 3.

DISCUSSION

In a related study on Chinese adults, Zhou et al.¹¹ found that the maxillary anterior labial bone was paper-thin, particularly at 3 mm beneath the CEJ and mid-root areas. Likewise, a more curved labial bone contour was present at the central incisor. In addition, the curvature angle was found to be minimal in participants with retruded maxillae as effected by the lump on the labial bone at the central incisor. As such, they suggested that angulating the implant apex to the palatal side at the upper central incisor is deemed necessary.

The relationship between thickness of alveolar and buccal bones at the central incisors were determined by Uner et al.¹⁹ using CBCT. Their study revealed that the absence of substantial association amid the alveolar bone width of the left and right central incisors. However, male participants were found to have thicker alveolar bone when compared to female counterparts. Hence, it can be suggested that gender portrays a noteworthy part in the characterization of ABW, as shown in Table 3.

However, different results on the relationship between bone thickness, age, and gender was revealed by the study of Nowzari et al.²⁰ Results showed that the preliminary maxillary bone width has substantial influence on the retorting level of soft tissue and facial bone after tooth removal and direct implant assignment. In this study, bone thickness was found to have no association with age and gender.

A related study was also conducted by Panda et al.¹⁶ which evaluated the anterior maxillary bone width as well as the incisive canal using CBCT for direct implant assignment. Results showed that gender and age were two major characteristics that affected the incisive canal as well as the amount of bone anterior to it. This study reported that males have thicker anterior maxilla when compared to female counterparts. This indicates that more precautionary procedures are deemed essential for females during surgical procedures. Anterior maxillary bone thickness also declines with progressing age as to which could be associated with anterior teeth loss upon aging.^{16,21-23}

Likewise, linear regression analysis performed by Yu et al. specified that the adjacent profile of alveolar bone is interrelated to the lower central incisor.¹⁷ This suggests that tooth inclination is marked by the morphology of the alveolar bone. In addition, increment of the lower arch length is a consequence of the proclination of lower incisors. This could generate dilemma with organization among lower and upper arches. Adequate withdrawal of the upper incisors could, in turn, be restricted in closing gaps in extraction.^{17,24}

The dimension and morphology of the alveolar ridge of anterior maxilla were also measured by Zhang et al.¹⁸ using CBCT for treatment preparation. Fifty-one participants with complete

set of teeth at right maxilla were screened for this study. They found out the increment in alveolar width from coronal to apical path for each tooth as well as the absence of substantial correlation in ridge stature between teeth. Likewise, male participants had significantly thicker ridge in comparison to female counterparts in terms of central incisors, lateral incisors, and canine teeth. This report was also consistent with the findings of Schropp et al.²⁵

The current finding showed no significant difference between the right and the left maxillary incisors in the measurement assessed. Based on that, it can be said that the cephalometric measurements on the maxillary incisors' angulations is accurate enough to make treatment decisions. Results also showed that the alveolar bone width is thinner in females than in males and is affected by age at the level of the apex. This highlights the importance of assessing the ABWs surrounding the teeth when deciding their movement. Such measurements are more clearly defined on CBCTs than cephalometric radiographs. Thus, it is recommended to use CBCT for better assessment and diagnosis of orthodontic cases.

CONCLUSION

Assessment of UR and UL central incisors were conducted, and the mean difference revealed low mean differences for alveolar bone width at various levels. Crown-root position for UR and UL incisors were also assessed, with reference to age and gender. Results revealed no substantial association between crown labial to root and root labial to crown positions for both UR and UL central incisors. Likewise, alveolar bone width at various areas assessed was found to be significantly related to gender. Related studies reported that the bone thickness of anterior maxilla in males is greater than that of females indicating the need for more precautionary procedures for females during surgical procedures. Anterior maxillary bone thickness also declines with progressing age as to which could be associated to anterior teeth loss upon aging. Based on the results, incisor/palatal plane angle and ABW at the CEJ (L1) and at the level of Point A (subnasale) [L4] were significantly affected by age.

DECLARATIONS

Ethics Approval

Ethical approval was done by the Ethics Committee of King Abdulaziz University, Faculty of Dentistry, Jeddah, Saudi Arabia [ethical no. 100-06-19].

Author's Contributions

All designed the study, collected patients' CBCT data, analyzed and interpreted the results, and wrote the manuscript.

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