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Anatomical Dimension of the Anterior Maxillary Alveolar Process: A Cone Beam Computed Tomography Study

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ABSTRACT

Background and aim: Immediate implant therapy has become a widespread technique that immediately restoration of esthetic and function. Its dimensions should be determined after the exploration of the bone around the natural tooth. This study aimed to explore alveolar bone in the maxillary anterior region using cone-beam computed tomography, including CS 3D Imaging Software.

Materials and methods: It is a retrospective study conducted in the Dental Faculty of Medicine Monastir Tunisia. It included 400 CBCT Scans checked from the radiological center. On selected CBCT, fulfilling inclusion criteria, facial alveolar bone thicknesses in the coronal (point A), middle (point B), and apical third (point C) were calculated. Alveolar height, crest height, and tooth angulations were also determined. Using SPSS 21software, descriptive statistics including the mean and standard deviation (SD) were calculated. AS well T-test, Pearson correlation, and Friedman test were used to analyze the data. The significance level was set at 95%.

Results: Mean alveolar height of maxillary central incisor, lateral incisor, and canine was respectively 20.5±3.62, 20.73±2.53, and 20.36± 2.81 mm. The difference between sites was statistically significant. Males had longer alveolar height than females. The mean facial plate thicknesses of the alveolar bone across point measurements A, B, and C were 0.86, 0.90, and 0.99mm for maxillary central incisors, 1.4, 0.80, and 0.84 mm maxillary lateral incisors and 1.08, 0.67, and 0.66mm for maxillary canines. Mean alveolar crest height (D) of the anterior maxillary teeth were 2.32 ± 1.04, 2.20 ± 0.1 and 2, 41 ±1.7 respectively at the level of maxillary central incisors, lateral incisors, and canines.

Conclusion: Facial bone is thin: lateral incisors have the most significant bone thickness, followed by central incisors, then canines with the most negligible bone thickness among the anterior maxillary teeth. Males exhibited greater facial bone heights. Facial bone thickness depends on teeth' angulations. Immediate implant placement in this area requires careful radiological exploration, taking into consideration its features.

1. Introduction

Immediate implant therapy has become a widespread technique that immediately restoration of esthetic and function.[1-4] Various studies have confirmed the validity of such treatments.[3, 4] It seems to be a promising approach that thwarts unavoidable bone crest resorption after the tooth extraction[5, 6] especially for anterior teeth, characterized by thin bone plates.[6] That is why many authors recommend immediate implant placement in anterior regions.[6] Joseph Yun Kwong Kan presents a great opportunity in esthetic dentistry, followed by an immediate prosthesis.[4] However, some information concerning bone thickness around the tooth in the anterior region is available in the literature. Thus, it is necessary to explore it.[7] Alveolar ridges and thickness should be previously evaluated when planning for immediate implant placement. Cone-beam computerized tomography (CBCT) seems to be useful and allows the preoperative investigation. Due to

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the height resolution of images on various planar with a low radiation dosage and affordable price, it was recently recommended by the American Academy of Oral and Maxillofacial Radiology (AAOMR) as the most suitable exploration for implant therapy.[1, 8, 9] Moreover, incredible accuracy in the sub-millimeter range[10] makes it reliable for crest exploration.[1] The present study was conducted to explore the alveolar ridge in the maxillary anterior region using CBCT.

2. Materials and methods

A total of 400 CBCT scans were checked from a Radiological center. The scans were not specifically performed for the study. Then, only 160 CBCT, fulfilling inclusion criteria, were selected. Concerned patients were well informed, and verbal approval was obtained. The collected CBCT belonged to 87 male and 73 female patients aged between 20 and 45 years old.

Inclusion / Exclusion criteria

The study included scans of patients with full anterior dentition. For those Scans, anterior maxillary teeth were checked. The study excluded decayed or restoration of anterior teeth, teeth with periapical images, cysts or dehiscence, teeth with prosthetic rehabilitation, or poor image definition. As well as, the Cemento Enamal junction had to be evident. Patients who underwent previous orthodontic treatments were also excluded.

Measurements

All CBCT scans were obtained using Orthophos SL 3D brand and respecting the following instructions: The patient was positioned with the patented occlusal bite block. The unit automatically determines the correct tilt of the head and indicates it using corresponding symbols and colors in order to avoid blurring images. Images were processed in axial, sagittal, and oblique sections. The measurement tools of CS 3D Imaging Software (Carestream Dental) were used. In axial views, the curvative alveolar ridge was drawn manually. Then, on sagittal sections made in the middle of each tooth (Fig. 1), six measurements were performed across the following references points (Fig. 2):

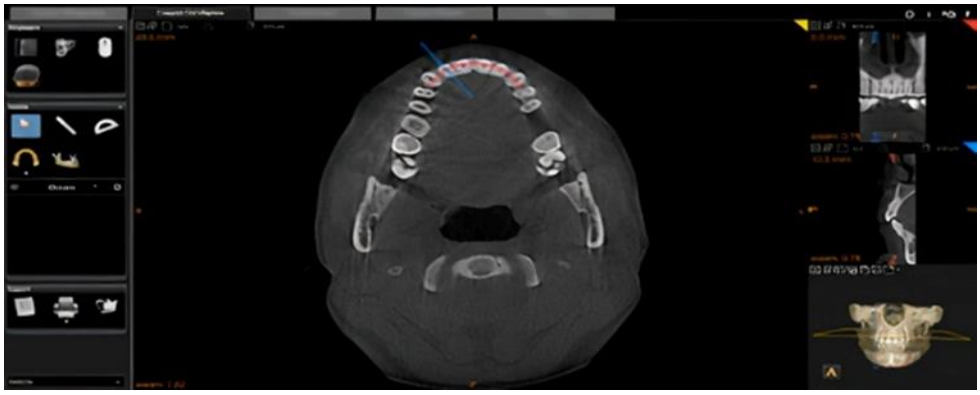


Fig. 1. Axial view at the maxillary arch. The red line indicates the curvature of the alveolar ridge. The blue line, perpendicular to the alveolar ridge, indicates where the cross-sectional view was taken.

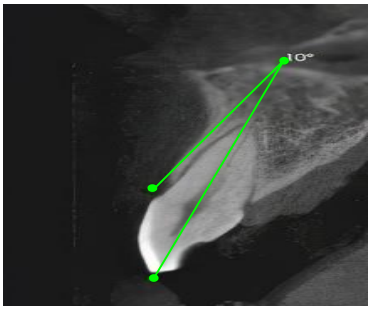
1. Alveolar height: defined as the distance measured from alveolar crest to the floor of nasal fossa respecting tooth axis[11](Fig. 2-a).

2. Facial Alveolar bone thickness: was measured across 3 fixed references points: A, B, and C. Point A were defined as the distance from the facial plate to the coronal third of the root at the level of the bone crest. Also, points B and C measured bone thickness from the facial plate to the mid and apical root third surface[11](Fig. 2-b).

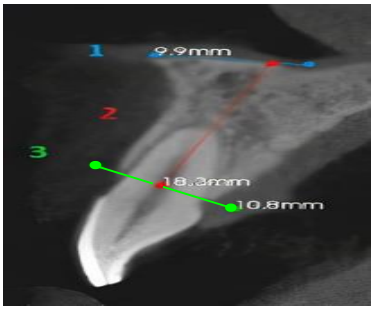
3. Crest height:(point D) was measured from alveolar bone crest to cementoenamel junction.[11]

4. Tooth Angulation (Ang): the angle measured between the coronoradicular tooth axis and the tangent to the buccal cortical bone was measured with the angle tool(Fig. 2-c).

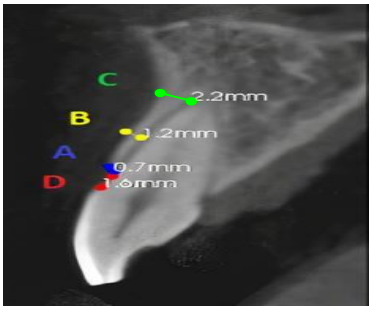
All measurements were taken in millimeters, using a digital caliper, by two qualified operators. If the differences in measures parameters were less than 2 mm, the mean value was considered. When it was more than 3mm, a third operator was invited.



a: Facial thickness across references points: A- at the level of the bone crest; B- at the mid root surface; C- at the apical root third; D-Distance between alveolar crest and cementoenamel junction.



b: Measurement of the alveolar height:
1. Nasal fossa Floor
2. Alveolar hight
3. Alveolar Crest line



c: Measurement of Angle

Fig. 1. Measurements protocole on oblique CBCT reconstructions.

Statistical analysis

Statistical analysis was performed using SPSS 21software.Data normality was tested using Kolmogorov–Smirnov and Kruskal-Wallis tests. Descriptive statistics, including the mean and standard deviation (SD), were calculated. T-test, Pearson correlation, and Friedman test were used to analyzing the data. The significance level was set at 95%, and P-values<0.05 were considered significant.

3. Results

The mean alveolar height of maxillary central incisor, lateral incisor, and canine was respectively 20.5±3.62,20.73±2.53 and 20.36± 2.81 mm. The difference between sites was statistically significant (Table 1), and Significant differences in bone ridge height between genders were also found (Fig. 3).

Table 1. Alveolar height (mm).

	Central incisor		Lateral incisor		Canine		Sig
Alveolar height	Right	Left	Right	Left	Right	Left	-----
	20.36±3.51	20.8±4.01	20.84±3,015	20.60±3	20.6±2.78	20.26±2.9	-----
Sig	0.7*		0.6*		0.4*		-----
Mean	20.5±3.62		20.73±2.96		20.36±2.81		0.00*

*Friedman Test

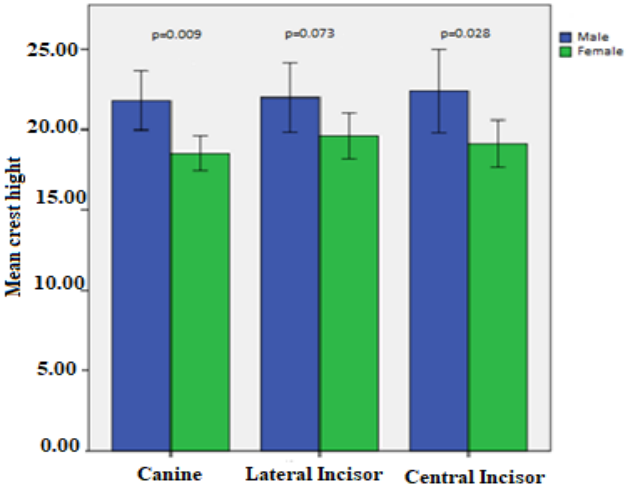


Fig. 3. Genderwise Distribution of alveolar Crest.

Males had longer alveolar height than females. The mean facial plate thicknesses of the alveolar bone across measurement points are summarized in Tables 2 and 3. Differences between sides were statistically not significant. The mean alveolar crest height (D) of the anterior maxillary teeth is presented in Table 4.

Table 2. Mean facial plate thicknesses (mm)across measurement points per side.

	Central incisor		Lateral incisor		Canine	
	Right	Left	Right	Left	Right	Left
A	0.96±0.32	1±0.31	1.15±0.5	1.1±0.41	1.07±0.47	1.05±0.44
B	0.87±0.37	0.93±0.37	0.87±0.5	0.77±0.46	0.72±0.45	0.68±0.42
C	0.93±0.52	1.06±0.69	0.90±0.44	0.79±0.53	0.67±0.41	0.7±0.46

Table 3. Meanfacial plate thicknesses(mm)across measurement points per site.

	Central incisor	Lateral incisor	Canine	Sig*
A	0.86	1.14	1.08	0.074
B	0.90	0.80	0.67	0.006
C	0.99	0.84	0.66	0.402
Sig*	0	0	0.775	-----
Mean thickness	0.92± 0.27	0.93± 0.32	0.8 ± 0.24	0.241

***:**Friedman Test

Table 4. Comparison of the means facial bone crest(mm) of anterior teeth according to the side and gender.

D*		Central incisor Mean ±Std	Sig	Lateral incisor Mean ±Std	Sig	Canine Mean ±Std	Sig
All		2.32 ± 1.04	-----	2.20 ± 0.1	-----	2,41 ±1.7	-----
Gender	Males	2.4528±1.26	0.4**	2.5105 ±1.14	0.07**	2.4 ±1.26	0.9**
	Female	2.2250±0.85		1.98 ±0.81		2.4 ±0.93	
Side	Right	2.37 ±1.1	-----	2.15 ±1.6	-----	2.35±1.2	-----
	Left	2.3±1.07	-----	2.36 ±1.13	-----	2.46±1.27	-----

*:measures in millimeters

**: Independent T-test

The difference between genders was statistically not significant. Scatterplots and correlation revealed a statistically significant positive relationship between facial plate height and the upper anterior teeth age. A moderate, positive correlation was found (Fig. 4). Mean angulations between the axis of the teeth and the alveolar process is presented in Table 5, which illustrates a positive and significant correlation between mean angulation and mean thickness.

Table 5. Mean Angulations of anterior teeth and correlation with facial bone Thickness.

	Mean Angulations(°) ±Std	Sig*	Mean thickness	
			r**	Sig**
Central incisor	14.25 ±5.87	0.00	-0.23	0.069
Lateral incisor	12.80 ±5.07	0.00	0.328	0.02
Canine	9.73 ±4.3	0.00	0.006	0.450
Average angulation	-----	-----	0.438	0.022

*:T test

** :Pearson correlation

4. Discussion

When planning for immediate Implant placement, dimensions have to be previously determined around natural teeth. That is why the available bone height and thickness should be carefully evaluated before extraction.[1] Therefore, the present study aimed to measure the facial thickness and height of the alveolar bone of anterior maxillary teeth using CBCT images. The mean alveolar height of maxillary central incisor, lateral incisor, and canine was respectively 20.56, 20.73 and 20.36 mm. Results seem to be slightly greater than those found by Zhang w et al.[1] (18.83, 19.07, 18.91mm). Therefore,

statistically significant differences between sites were not proved as in the present study.[1] Males exhibited greater facial bone heights at the maxillary central incisor, lateral incisors, and canines, as Rai S et al.[12] reported. The mean thickness of facial alveolar bone in the coronal third was 0.86, 1.14, and 1.08, respectively, for central incisors, lateral incisors, and canines.0.86, 0.9 and 0.99 mm. Foundings are close to those of those of those Sheerah H[11](1.21, 0.93 and 0.88mm), AlTarawneh S et all[7](0.73, 0.7, and 0.74 mm), Gluckman H[13](0.6 ,0.7 and 0.6), Zekry et al[14] (0.83, 0.83 and 0.77 mm), Vera et al[15](0.78, 0.8, 0.82 mm),Wang et al[16](0.8, 0.7 and 0.7 mm), and Januarioet al[17](0.6, 0.7 and 0.6 mm). In the middle third, the mean bone thickness was 0.9, 0.8, and 0.67, respectively, for central incisors, lateral incisors, and canines. Results were near to those of other studies such as AlTarawnehS[7](0.69, 0.61, and 0.53 mm), Sheerah H[11](0.96, 0.92, 0.84), Gluckman H[13] (0.5, 0.5 and 0.5) , Zekry et al[14] (0.8, 0.75, 0.68 mm), Wang et al[16] (0.8, 0.7, 0.7 mm), and Vera et al[15](0.69, 0.69, 0.72 mm). Apical third bone thickness measured 0.92, 093, and 0.8 respectively for central incisors, lateral incisors, and canines. Measures were close to Vera et al[15] (0.9, 0.8, 1 mm). However, AlTarawneh S[7] found slightly thinner thickness (0.6, 0.49, and 0.4 mm) while Sheerah H[11] and Gluckman H[13] reported respectively slightly larger thickness (1.51, 1.58 and 1.38 mm)(1.2, 1.3 and 1.4). Few discrepancies between studies may be attributed to various factors, such as population variability, sample characteristics, or measures protocols (over or underestimations). Moreover, the coronal third of the facial bone appeared to have the most favorable thickness at the canine and lateral incisor levels. Recent studies[18, 19] approved these findings. Sheerah H[11] concluded, yet, that the apical third had a thicker thickness.

The present work showed that lateral incisors have the most significant bone thickness, followed by central incisors. Canines exhibited the most negligible bone thickness among the anterior maxillary teeth. It could be explained by differences in teeth dimensions, as lateral incisors have the thinnest diameters. Founding is coherent with previous studies.[11, 20] Some others pointed out that canines had the greatest bone thickness.[19, 21] In the present investigation, the distance between the facial alveolar bone crest and the cementoenamel junction of the anterior teeth (D) ranged from 2.2 to 2.41 mm. Sheerah H[11] reported crest height from 1.74 of 3.37 mm. A positive correlation according to age was confirmed, consistent with Sheerah H et al.[11] Boskey and Coleman[22] showed a correlation between crest height and both age and gender. They explained the positive correlation between age to the nature of the aging process.[22] Sheerah H[11] attributed it to oral hygiene, Occlusion, and nutrition. According to Roopak and David[23] Insufficient crest height could influence the interproximal papilla level, from the esthetic outcome is dependent. The mean angulation was 14.25° ±5.87, 12.80° ±5.07 and 9.73° ±4.3 respectively for maxillary central incisor, lateral incisor, and canine. Dos Santos JG[6] reported angulations 12.7°, 14.8°, and 16.5° respectively for central incisor, lateral incisor, and canine. The discrepancy could be due to differences in measurement protocols. The present study pointed that facial bone thickness depends on teeth angulations through a moderate correlation. Otherwise, several factors could affect facial bone thickness.

To summarize, Facial bone thickness is thin for anterior maxillary teeth and depends on age and angulations, while alveolar height is longer for males. Some authors recommend bone augmentation.[7] Others recommend a palatal placed implant. It is the first approach to this topic in Tunisia. To Comparing of some previous studies, our sample size was larger. In addition, the present investigation used paired statistical tests, whereas other studies used unpaired tests that target the study's objective better. However, some limitations should also be noted, such as sample selection. It would be better if patients were selected, then CBCT would be performed. Some factors, thus, should be taken into consideration as oral hygiene and periodontitis, which could affect recession and bone loss. As well, Occlusion and angle class may affect angulations and facial bone thickness.

5. Conclusion

The present study has proved the accuracy of CBCT for the crest investigation. Males exhibited greater facial bone heights at the level of maxillary Teeth. Lateral incisors have the greatest bone thickness, followed by central incisors then canines. Notably, Crest height distance increases with age. As well, a positive correlation was detected between angulations and mean thickness. Future studies are useful to evaluate palatal alveolar bone thickness.

Conflict of Interest

The authors declared that there is no conflict of interest.

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