ORIGINAL ARTICLE

Anthropometric Evaluation of Labial Alveolar Bone Dimension of Maxillary Anterior Teeth in Kuantan Population: A Cone-Beam Computed Tomography Study

Chu Seng Boon[1], Farah Elyna Bahdun[2], Aina Qasrina Ahmad[2]

[1] Department of Prosthodontics, Kulliyyah of Dentistry, International Islamic University Malaysia, Bandar Indera Mahkota, 25200 Kuantan, Pahang, Malaysia.
[2] Kulliyyah of Dentistry, International Islamic University Malaysia, Bandar Indera Mahkota, 25200 Kuantan, Pahang, Malaysia.

ABSTRACT

Introduction: Labial bone with adequate height and width is crucial for an implant to be successfully placed and ensure the stability of treatment outcome in the long term. The objective of this study was to employ cone-beam computed tomography (CBCT) assessment in evaluating the differences in labial alveolar bone morphology among the Kuantan population in Malaysia. **Methods:** A total of 60 images taken from Kulliyyah of Dentistry, International Islamic University Malaysia, between 2009 and 2019 were analysed. The root diameter, labial and palatal plate thickness, the labial bony curvature angle beneath the root apex, and the distance from the deepest point of labial bony curvature to the root apex were all measured on each of the maxillary anterior teeth. **Results:** At 3 mm below the cementoenamel junction, the mean (± standard deviation; SD) thickness of the labial plate for maxillary anterior teeth was 1.45 ± 0.62 mm, 1.38 ± 0.50 mm, and 1.61 ± 0.66 mm for the lateral incisor, central incisor, and canine, respectively. Below the root apex, the labial bony curvature angle was 233.63 ± 17.74 for the central incisor, 235.68 ± 17.74 for the lateral incisor and 233.81 ± 11.09 for the canine. Discussion: The result revealed a favourable labial plate in the Kuantan population when implant in the aesthetic zone is planned. **Conclusion:** Labial alveolar bone thickness of the Kuantan population was thin within 1.5 mm while the palatal plate was thick. Overall, labial alveolar bone was present within 3 mm below the cementoenamel junction. The labial bony curvature was highest and most curved for the central incisor compared to the lateral incisor and canine.
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Keywords: Labial alveolar bone, Thickness, Anterior teeth, Cone-beam computed tomography

Corresponding Author:
Chu Seng Boon, MClinDent(Pros)
Email: chusengboon@iium.edu.my
Tel: +6019-9810975

INTRODUCTION

An implant-supported restoration is a treatment option that aims to provide support and retention for prosthetic replacement of teeth that have been lost. Nevertheless, the placement of an implant in the anterior maxilla is a challenging procedure given its anatomic limitation and high aesthetic demands (1,2). Maxillary teeth are often surrounded by a very thin and friable labial plate, which may be deformed or weakened after extraction. To achieve predictable results, it is required to use a labial alveolar bone thickness of at least 1 to 2 mm (3). Therefore, bone augmentation may be needed before the implant can be positioned in the best possible location inside the bone. This highlights the importance of examining the anatomy of the orofacial ridge, crestal width and height, and labial bone before implant placement.

Irrespective of the implant system used, labial bone with sufficient height and width will ensure good implant placement in the aesthetic zone with stability in the long-term (1). Despite having a thicker palatal plate, Swasty et al. found that Korean adults' maxillary anterior labial plate was usually very thin below 1 mm (4). They further elaborated that the most angled region is the labial bony plate beneath the root apex of the central incisor, whereas the depth of the lateral incisors is smaller compared to the bony curvature beneath the root apex of the central incisors. Hence, it is recommended to place implants palatally in the anterior maxilla to avoid complications. Also, it is important to ensure that the labial alveolar plate and the long axis of the surgical implant drill are parallel. These steps prevent the labial plate from perforation when the central incisor is subjected to osteotomy. This is because the central incisor's labial bony plate is the most angled.

Cone-beam computed tomography (CBCT) are clinically

sound and sophisticated radiographs that assist clinicians in diagnosing bony dimension deficiencies before placing an implant. Recent evidence suggested that there is no significant difference between utilising CBCT to measure the alveolar bone thickness and the gold standard references, which applies to the direct measurement of human skulls or live patients (5). Furthermore, the labial bone thickness and height of the labial bone can be measured quantitatively using the CBCT with high accuracy and precision (6).

A recent study reported that conservative treatment is indicated for most adolescent and adult patients. In contrast, elderly patients had a significant requirement for prosthodontics, which were classified as a restorative treatment (7). Restorative treatments are designed to replace missing teeth and restore functional occlusion, which is in line with the function and purpose of dental implants. However, there are limited studies regarding the morphological differences of the labial bone in the Malaysian population. Given the research gap, the objective of this study was to employ CBCT in assessing the variations in labial alveolar bone morphology among Malaysians by focusing specifically on the state of Kuantan, Pahang.

MATERIALS AND METHODS

Subjects

The study protocol was approved by the IIUM Research Ethics Committee (ID: IREC 2020-098). A total of 60 Malaysian adults who had their CBCT photos taken at the Kulliyyah of Dentistry, International Islamic University Malaysia (IIUM) between 2009 and 2020 participated in this study. The inclusion criteria entailed subjects with intact maxillary anterior teeth and having no signs of periodontal disease. CBCT images that were of poor quality or blurry were excluded. The mean (± standard deviation; SD) subjects' age was 29 (± 11.81) years old, with a minimum and maximum age of 17 and 57 years old, respectively. Most of them were females (n = 35, 58.3%) and males were 25 (41.7%). Majority of the subjects were of Malay ethnicity (n=49, 81.67%), followed by Chinese (n=9, 15%) and Indian (n=2, 3.33%).

Imaging and processing

All CBCT images were acquired retrospectively through radiology data in the Dentistry polyclinic of Kulliyyah, IIUM. Images were assessed and analysed by two operators using Planmeca Romexis® software (Version 2.1.1.R). To assess the reproducibility of measurements, intra-operator and inter-operator reliability were evaluated. 10 CBCT images were randomly selected and analysed by a single operator (F.E.B.), who repeated all the data collection after a four-week washout period. A second operator (A.Q.A) who was calibrated and trained by an experienced clinician (C.S.B) on the data collection protocol, completed the same data collection on the same CBCT images and repeated the process after four weeks. Calibration between both operators was assessed and the intraclass correlation coefficient (ICC) was calculated. The result was 0.93, indicating a highly reproducible method of assessment. Both operators worked together on data collection for each of the CBCT images.

Measurements

On each maxillary anterior tooth, five aspects of measurement were recorded based on 3-dimensional images. This included the distance from the labial bone crest to the cementoenamel junction (CEJ), labial and palatal plate thickness, the root diameter, the labial bony curvature angle beneath the root apex, and the distance between the deepest point of labial bony curvature of each maxillary anterior tooth to the root apex.

Distance between the labial bone crest and CEJ (Fig. 1a)

Perpendicular horizontal lines were drawn on each anterior maxillary tooth on the CEJ and labial bone crest, and the distance between those lines was measured.

Thickness of the labial and palatal plate (Fig. 1b)

Lines A and B were drawn 3 mm and 4.5 mm below the CEJ, respectively. Line D was drawn at the root apex, whereas halfway between the root apex and CEJ represented line C. Four guidelines perpendicular to each tooth's axis were used to measure the thickness of the labial and palatal alveolar plates.

Root diameter of the maxillary lateral incisor, central incisor and canine (Fig. 1c)

The maxillary central incisor, lateral incisor and canine labio-lingual root diameters were measured at the CEJ level and 3 mm below at the reference line A.

Labial bony curvature angle (PQR) beneath the root apex (Fig. 1d)

As a reference line to the three points that were used (P, Q and R), a line was drawn perpendicular to the apex of the root of the tooth. Accordingly, the anterior and uppermost points of the labial plate are the reference point P, point R is the location on the labial plate which coincides with reference line D. The imaginary line between points P and R intersects at point Q, which represents the maximum depth on the labial bony curvature between R and P. These points formed an angle which was then documented.

The distance from the Q (i.e., deepest point) of the labial bony curvature to the root apex (Fig. 1e)

The vertical distance between a line perpendicular to the root apex and point Q was measured.

Statistical analysis

All statistical analyses were carried out using the Statistical Package for Social Science version 25.0

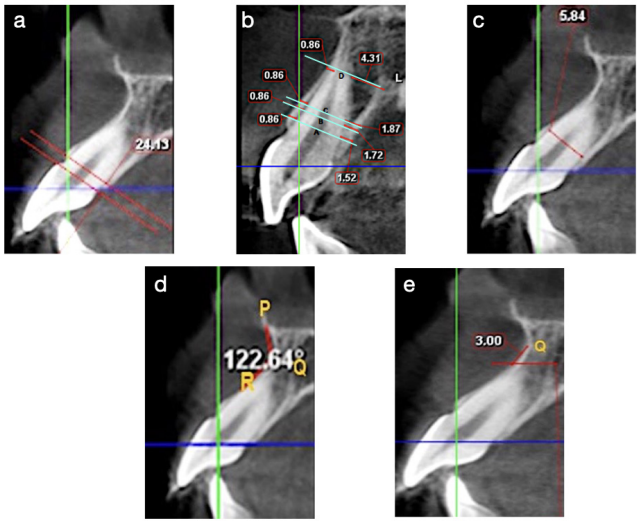

Fig. 1: (a) Perpendicular lines were drawn and the distance between the lines was measured. (b): The thickness of labial and palatal alveolar plates were measured at four reference lines. (c) Diameter of the maxillary anterior teeth on reference line A. (d) Labial bony curvature angle (∠ PQR) below the root apex of maxillary anterior teeth. (e) Distance between the root apex and the deepest point (Q) of labial bony curvature.

(SPSS, IBM Corp, Armonk, NY). Prior to data analysis, the Shapiro-Wilk test was used to check for normality. Numerical variables were presented and the mean of each variable was compared using one-way analysis of variance (ANOVA), Scheffé test and independent t-test, with the significant level set at α=0.05.

RESULTS

The mean distance (± SD) between the labial bone crest and CEJ for the central incisor was 1.55 ± 0.59 mm, 1.60 ± 0.60 mm for the lateral incisor, and 1.87 ± 0.76 mm for the canine. Comparisons between the means showed that the distance between the labial bone crest and CEJ was statistically significantly lower for the central incisor compared to that of the canine. Overall, Table I revealed that the labial bone crest of maxillary anterior teeth was within 3 mm of the CEJ.

Based on the percentage, most of the labial bone thickness was lower than 1.5 mm irrespective of the tooth and reference lines, excluding reference line D where most of the estimates were higher than 2 mm as shown in Table II. The mean thickness of the labial plate was higher in reference line D for all

Table I: The mean distance between the CEJ and labial bone crest (unit: mm)

	N	Central incisor	Lateral incisor	Canine	p-value
CEJ-labial bone crest	60	1.55 ± 0.59	1.60 ± 0.60	1.87 ± 0.76	0.018*

*$p < 0.05$, statistically significant difference exists. Post-hoc comparison (Scheffй test)

Table II: The percentage of labial bone thickness based on three different ranges (unit: %)

Reference line	Site								
	Central incisor			Lateral incisor			Canine		
	< 1.5 mm	1.5 -2.0 mm	> 2.0 mm	< 1.5 mm	1.5 - 2.0 mm	> 2.0 mm	< 1.5 mm	1.5 - 2.0 mm	> 2.0 mm
A	70.0	21.7	8.3	68.3	15.0	16.7	50.0	31.7	18.3
B	70.0	21.7	8.3	63.3	16.7	20.0	56.7	26.7	16.7
C	75.0	20.0	5.0	76.7	15.0	8.3	71.7	20.0	8.3
D	26.7	18.3	55.0	30.0	28.3	41.7	26.7	35.0	38.3

maxillary teeth compared to reference lines A, B and C. The thinnest areas were recorded at reference line C for all the samples. No significant difference was detected in the labial plate thickness between the four reference lines measured on the canine, lateral incisor and central incisor (Table III). In contrast, the mean thickness of the palatal plate was significantly different in reference lines C and D. Likewise, the mean value was significantly greater compared to that of the central and lateral incisors in reference line C. The same result was observed in reference line D, where the palatal plate was significantly thicker for the canine compared to both central and lateral incisors (Table III).

Table III: The mean thickness of the labial and palatal plate of maxillary anterior teeth (unit: mm)

	Site	N	Reference line			
			A	B	C	D
Labial plate	Central incisor	60	1.38 ± 0.50	1.39 ± 0.42	1.32 ± 0.44	2.71 ± 0.96
	Lateral incisor	60	1.45 ± 0.62	1.48 ± 0.56	1.32 ± 0.61	2.17 ± 1.16
	Canine	60	1.61 ± 0.66	1.58 ± 0.66	1.38 ± 0.56	2.04 ± 0.94
	p-value		0.095	0.162	0.793	0.363
Palatal plate	Central incisor	60	2.04 ± 0.72	2.84 ± 1.03	3.61 ± 1.29	8.31 ± 2.26
	Lateral incisor	60	2.07 ± 0.80	2.84 ± 1.16	3.65 ± 1.50	8.30 ± 2.53
	Canine	60	2.16 ± 0.82	2.92 ± 1.02	1.65 ± 1.48	11.69 ± 2.81
	p-value		0.717	0.901	0.000*	0.000*

*$p < 0.05$, statistically significant difference exists. Post-hoc comparison (Scheffй test)

The highest value was shown in the root diameter of the canine, followed by the lateral and central incisors at the CEJ's level and below 3 mm (Table IV). Below the root apex, the labial bony curvature angle (PQR) at the canine, lateral incisor and central incisor were 233.81 ± 11.09, 235.68 ± 17.74 and 233.63 ± 17.74, respectively (Table V). The distance from the deepest point (Q) of labial bony curvature to the root apex was 2.85 ± 1.38 mm, 2.89 ± 1.31 mm, and 3.05 ± 1.01 mm at the central incisor, lateral incisor, and canine respectively (Table VII).

Table IV: Root diameter of the maxillary anterior teeth (unit: mm)

Level		N	Central incisor	Lateral Incisor	Canine	P-value
CEJ	**Labio-lingual**	60	9.73 ± 0.93*	8.91 ± 0.88*	10.78 ± 0.75*	0.000
3mm below CEJ	**Labio-lingual**	60	8.45 ± 0.96*	7.97 ± 0.97*	10.10 ± 1. 20*	0.000

*$p < 0.05$, statistically significant difference exists for all pairs. Post-hoc comparison (Scheffé test)

Table V: Labial bony curvature angle below root apex of maxillary anterior teeth (unit: ^{0})

	N	Central incisor	Lateral incisor	Canine	P-value
∠ PQR (^{0})	60	233.63 ±17.74	235.68 ± 11.95	233.81 ± 11.09	0.673

Table VI: The distance between root apex and the deepest point (Q) of labial bone curvature (unit: mm)

	N	Central incisor	Lateral incisor	Canine	P-value
Root apex-Q point	60	2.85 ± 1.38	2.89 ± 1.31	3.05 ± 1.01	0.658

DISCUSSION

Recent studies, including systematic reviews and randomised controlled clinical trials, have reinstated that dental implants remain among the most popular treatment options for the replacement of missing teeth with promising success and survival rates (8–10). However, a crucial indicator of successful implant therapy is the stability in the long term, which is commonly assessed based on the availability of adequate bone volume, aesthetic alignment of natural teeth, and ability to preserve the health of tissues surrounding the implant (1,11,12). Previous studies demonstrated that the most important factor in elucidating the overall success of treatment outcome and aesthetics of peri-implant soft tissue is the morphology of the labial bone around the implant at the anterior maxilla region (13–15). It has been reported that implant survival rates are higher when the fixtures are inserted in residual bone with good bone density, width and height (16). Therefore, the labial bone thickness encompassing the implant located in the anterior maxilla is considered a critical factor for favourable outcomes. The implant is to be placed orofacially in the comfort zone, which is any site between the emerging point of the adjacent teeth and the expected reconstruction. The procedure facilitates proper restoration and preservation of the gingival margins' harmonious scalloping. Due to limited data on the analysis of alveolar bone morphology in the Malaysian population, this research was conducted to assess the variation in labial alveolar bone among the population of Kuantan, Pahang. The outcomes of this study provide important information that could be employed as a guide for treatment plans involving dental implants.

This study revealed that the labial alveolar bone crest of maxillary anterior teeth was approximately 3 mm below the CEJ. This result is consistent with the reports from a similar study conducted among the Korean population (17). Specifically, the researchers demonstrated that the head of the implant fixture should be positioned at least 3.5 mm apical to an imaginary line connecting the adjacent teeth's CEJ (17). This procedure assures that the fixture is highly protected by the alveolar bone, thereby enhancing a favourable treatment outcome by positioning the implant head in the recommended position. In addition, to minimise the change and resorption of the anterior maxillary residual bone when placing an implant in the aesthetic zone, it is required that the labial bone thickness is greater than 1.91 mm (18).

In a study on the thickness of the labial plate conducted among the Korean adult population, it was reported that less than 1 mm of bone labially was present on all maxillary anterior teeth (17). Similarly, a recent study on the Malaysian population reported similar findings where they found that the labial bone crest was predominantly thin (<1 mm) (19). However, the present study showed that the labial bone thickness of Malaysian adults was greater than 1 mm with regard to reference lines A, B, C and D. For all maxillary anterior teeth in reference line D, the labial bone thickness was greater than 2 mm. When an aesthetic zone implant is anticipated, these findings indicate the presence of a more favourable labial plate in the Malaysian population. Nonetheless, the results buttress the idea of positioning the implant platform more palatally to facilitate the placement of the implant in the correct 3D position.

The labio-lingual diameter of the root was measured at 3 mm below the CEJ and the highest value was recorded on canine (10.10 ± 1.20 mm), lateral incisor (7.97 ± 0.97 mm) and central incisor (8.45 ± 0.96 mm. These findings corroborate the study by Arief et al. where the lateral incisor had the smallest diameter among the anterior maxillary teeth (20). To have enough bony structure surrounding an implant in the lateral incisor region, it is recommended to use an implant with a narrow shoulder diameter. Buser et al. also stated that proper implant selection is critical for implant performance and a small diameter implant fixture of 3.5 mm is widely applied with at least a gap size of 5.5mm in regions of the lateral incisor (1).

When the labial bony curvature angle beneath the root apex was measured, the central incisor had the lowest curvature angle, followed by the canine and lateral incisor. A similar outcome was reported by Arief et al., who found that the maxillary central incisor recorded the smallest labial bony curvature while the bony plate below the root apex had the largest curvature (20). Hence, it is of utmost importance to ensure the labial plate and

long axis of the implant drill are parallel during surgical osteotomy to avoid perforation. Additionally, a tapered implant is more ideal to be used in the anterior maxilla compared to a parallel-sided implant fixture. These findings are also vital in immediate implant placements after tooth extraction. Tooth extraction causes about 40 to 60% average loss of the original width and height of the alveolar bone. Therefore, the length of the implant fixture should be enough for the initial stability (21).

For the lateral incisor, a mean distance of 2.89 ± 1.31 mm was recorded between the deepest point of buccal bony curvature and the root apex, 2.85 ± 1.38 in the central incisor, whereas that of the canine was 3.05 ± 1.01 mm in the canine. These estimates are potential guidelines for determining the correct length of the implant fixture to avoid perforation of the labial plate.

One of the limitations of the present study was that no assumption was made on the influence of age, gender and ethnicity on the morphology of the labial alveolar bone. Although these factors may have a significant impact on the variables that were being investigated, the poor sample size and racial distribution have impeded the analysis of this category. Therefore, for an accurate quantifiable assessment, a future study may classify an equal gender, age group, ethnicity and type of tooth with its degree of inclination along with the medical and dental status of each subject.

CONCLUSION

This study revealed that the labial alveolar bone thickness is thin (less than 1.5 mm) and the palatal plate is thick among the Kuantan population. Overall, labial alveolar bone was present within 3 mm of the CEJ. In comparison to the lateral incisor and canine, the central incisor had the largest and most angled labial bony curvature.

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