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Cover Page Footnote

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ORIGINAL ARTICLE / ARTICLE ORIGINAL

***Orthodontics** / Orthodontie*

ASSESSMENT OF MANDIBULAR CORTICAL BONE THICKNESS FOR MINISCREW PLACEMENT IN RELATION TO THE VERTICAL FACIAL PATTERNS USING CBCT : A CROSS-SECTIONAL STUDY

Rima Daoui[1] | Aly Ossman[2]

Introduction: The need of more anchorage in the orthodontic daily practice has introduced the use of temporary anchorage devices (TADs). Cortical bone thickness has been one of the major factors on the success rate of the stability of TADs. Different vertical dimension patterns can be found among orthodontic patients with potentially variable cortical bone thickness.

Aim of the study: to assess the cortical bone thickness in the posterior region of the mandible in relation to different vertical facial patterns using Cone-beam computed tomography (CBCT) and to evaluate the progressive change in the thickness of cortical bone from 4,6 to 8 mm from the crest of the alveolar bone toward the apical region.

Methods: Thirty-six participants were selected and their cephalometric x-rays and CBCTs were analyzed and compared. Vertical facial pattern was measured with the use of the mandibular plane angle and participants were grouped in 3 categories according to the measures. On the CBCTs, buccal and lingual cortical bone thickness were measured from 4,6 and 8 mm from the alveolar crestal bone and compared. All analyses were conducted using IBM SPSS Statistics for Windows, v.26 (IBM Corp., Armonk, NY, USA). The significance level was set at $\alpha = 0.05$ for all statistical analyses.

Results: There was no statistically significant differences were observed between the vertical dimensions groups in terms of buccal and lingual measurements at 4, 6, and 8 mm from cemento-enamel junction (CEJ) between 44/45, 45/46, and 46/47 ($P>0.05$).

Conclusions: There was a progressive increase in cortical bone thickness in most of the studied groups from the alveolar crest to the apical region.

Keywords: CBCT, Cortical bone thickness, Mandible, Vertical dimension pattern.

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Conflicts of interest:
The authors declare no conflicts of interest.

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ORIGINAL ARTICLE / ARTICLE ORIGINAL

***Orthodontics** / Orthodontie*

ÉVALUATION DE L'ÉPAISSEUR DE L'OS CORTICAL MANDIBULAIRE POUR LE PLACEMENT DE MINIVIS PAR RAPPORT À DIFFÉRENTES DIMENSIONS VERTICALES À L'AIDE DE CBCT : UNE ÉTUDE TRANSVERSALE

Introduction: Le besoin d'ancrage maximal dans la pratique orthodontique quotidienne a introduit l'utilisation de dispositifs d'ancrage temporaires (TAD). L'épaisseur de l'os cortical a été l'un des principaux facteurs du taux de réussite et de la stabilité des TADs. On peut trouver différents modèles de dimensions verticales chez les patients orthodontiques avec des épaisseurs d'os cortical potentiellement variable.

Objectif de l'étude: évaluer l'épaisseur de l'os cortical dans la région postérieure de la mandibule en relation avec différents schémas faciaux verticaux à l'aide de la tomodensitométrie à faisceau conique (CBCT) et évaluer le changement progressif de l'épaisseur de l'os cortical de 4,6 à 8 mm de la crête de l'os alvéolaire vers la région apicale.

Méthodes: Trente-six participants ont été sélectionnés et leurs radiographies céphalométriques et CBCT ont été analysées et comparées. Le modèle facial vertical a été mesuré à l'aide de l'angle Frankfort-plan mandibulaire et les participants ont été regroupés en 3 catégories selon les mesures, normo, hypo et hyperdivergent. Sur les CBCT, les épaisseurs osseuses corticales vestibulaire et linguale ont été mesurées à partir de 4, 6 et 8 mm de l'os crestal alvéolaire et ont été comparées. Toutes les analyses ont été effectuées à l'aide d'IBM SPSS Statistiques pour Windows, v.26 (IBM Corp., Armonk, NY, USA). Le niveau de signification a été fixé à $\alpha = 0,05$ pour toutes les analyses statistiques.

Résultats: Aucune différence statistiquement significative n'a été observée entre les groupes des différentes dimensions verticales en termes de mesures buccales et linguales à 4, 6 et 8 mm de la jonction cémento-amélaire (CEJ) entre 44/45, 45/46 et 46/ 47 ($P>0,05$). **Conclusions**: Il y avait une augmentation progressive de l'épaisseur de l'os cortical dans la plupart des groupes étudiés, allant de de la crête alvéolaire à la région apicale.

Mots clés: CBCT; épaisseur de l'os cortical; mandibule; type de croissance vertical.

Introduction

Temporary anchoring devices (TADs) were not so long ago launched into the orthodontic field to provide maximal anchorage with simple procedures. TADs can be positioned in many bony sites in the arches and are characterized by their straightforward and simple placement methods and easy loading [1]. Many considerations define TAD's success rate and stability, but the most important determinant is the cortical bone thickness. According to a research even 0.5 mm changes in the thickness of cortical bone might have a significant influence on TAD's success rate [2]. Primary stability is accomplished by the mechanical interdigitation instead of TADs to bone contact at the initial stage of healing, the thickness of cortical bone has been the major component for stability [3]. Miniscrews can be placed in different locations away from the cemento-enamel junction (CEJ), according to the type of tooth movement to be accomplished usually ranging from 2, 4, 6, 8 and 10 mm. These locations have different cortical bone thickness that need to be analyzed to obtain a good primary stability of the TADs. Vertical facial dimension is critical for orthodontists because it affects growth forecast, biting force, anchoring system and function. Vertical facial morphology is linked to bony morphological changes influenced by functions and genetics during early ages. Therefore, it is rational to expect that cortical bone thicknesses in both arches would be variable in patients with different vertical facial dimensions [4]. Cone-beam computed tomography (CBCT) has been recently introduced to evaluate efficiently the three dimensions (3D) structures, the bony morphology and architecture of the cortical bone in the mandibulo-maxillary complex. To date, there has been not enough data available for the best posterior sites of placement of TADs in the mandible and the relation between the alveolar cortical bone thickness and different skeletal vertical dimension patterns. Hence, the present study was to assess the cortical bone thickness in the mandible for ideal success of placement of miniscrews using CBCT in different vertical facial dimensions. The null hypothesis is there is no significant difference between various vertical facial dimensions and the cortical bone thickness in the mandible.

Materials and Methods

The study design consists of a cross-sectional, comparative and descriptive study. Patients were selected from the archived records at the Outpatient Clinics of the Division of Orthodontics in the Department of developmental Sciences, Faculty of Dentistry, Beirut Arab University, Lebanon who had pretreatment CBCT scans with age ranged between 18 to 35 years. The CBCT scans had been taken for purposes not related to this study (such as preoperative assessment for third molar extraction). The following study was approved by the scientific and ethical review committee and institutional review board at Beirut Arab University with IRB code: 2023-H-0103-D-M-0518).

The sample size estimation was performed using 80% power of the study and sample size using G*power software (ver. 3.1) at alpha= 0.05. The estimated sample size is calculated by taking the mean and standard deviation from a similar study conducted by Sadek et al, [5]. The calculated sample size was 28 CBCT scan. Therefore, 36 pretreatment CBCT scans were taken for more valid results.

The selected patients were fulfilling the following inclusion and exclusion criteria according to Sadek et al, [5]. As for the inclusion Criteria, there should be no history of previous orthodontic treatment, patient's age ranging between 18 and 35 years old with fully erupted permanent dentition (except for third molars). Whereas for the exclusion criteria, patients with pathologies or radiolucency in the areas of measurement were excluded. There shouldn't be periodontal bone problems like severe periodontitis, nor extreme cranio-facial disorders.

Once selected, the pretreatment radiographs were divided first into three groups according to the vertical skeletal pattern based on the measurement of mandibular plane angle. This angle is measured between the mandibular plane (Me-tangent to the lower border of the mandible) and the anterior cranial base (S – N); which is equivalent to 32° ± 3° in individuals with normal growth patterns. That said, individuals below the average angle were grouped as hypodivergent and the ones above as hyperdivergent participants. As a total, the following distribution was set in 3 groups: hypodivergent = 11 (30.6%), normo-divergent = 13 (36.1%) & hyperdivergent = 12 (33.3%). Each group was then subdivided according to the gender (Fig.1).

CBCT (Carestream Kodak 9000c, USA) using 5 cm x cm field of volume (FOV) with exposure factors of 76 kV, 5–6.3 mA and 32.4 sec were obtained. A 3D image was reconstructed by 3D software and saved in digital imaging and communications in medicine (DICOM) format. Cephalograms generated from these scans were used to identify the patients' facial type.

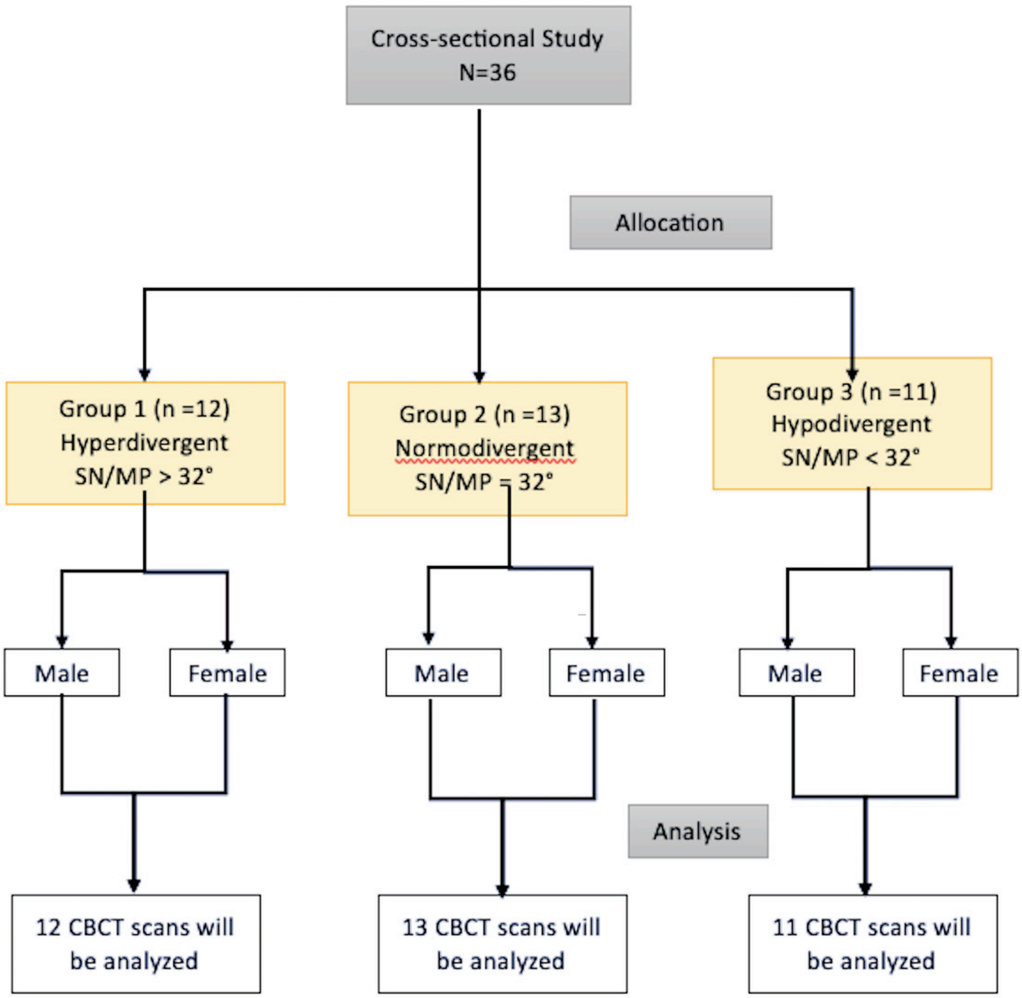

Figure 1: Cohort Flow Diagram.

The area of interest on CBCT scans was the right posterior mandible from the first premolar till the second molar. Using a digital software, a two dimensional (2D) slices were created of 0.3 mm thickness, at the midline between each contact area. Before measuring, each site was oriented in all 3 planes of space. Starting with the sagittal slice as shown in Fig. 2, the mid inter-radicular area was detected.

Then, this slice led to the axial slice, which was positioned in a way that the vertical reference line and the long axes of the roots formed a diagonal across the inter-radicular region (Fig.3). The horizontal reference line was then oriented to cut through the thinnest portion of cortical bone and bisect the inter-radicular region (Fig. 4). Finishing with the coronal slice, to determine the measurement value in respect to the crestal alveolar bone, the reference line was adjusted.

For each inter-radicular space in the mandible, from the distal of first premolar to the mesial of the second molar, the following measurements were conducted: buccal cortical bone thickness at 4, 6 and 8 mm apical to the CEJ. Same measurements for the lingual cortical bone were done (Fig. 5). All of the interradicular locations chosen for measurement had previously been utilized for TADs employment clinically. Therefore, the thickness of the buccal and lingual cortical bone was established by measuring them perpendicular to the bone surface.

One certified orthodontist (R.D.) took all measurements for this study to minimize variations in measurement accuracy. The intra-operator error was determined by repeating measurements on ten randomly chosen participants by the same observer, two weeks apart.

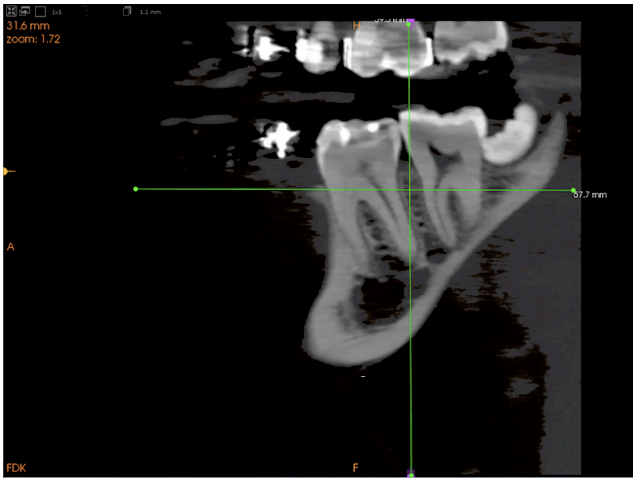

Figure 2: Sagittal slice.

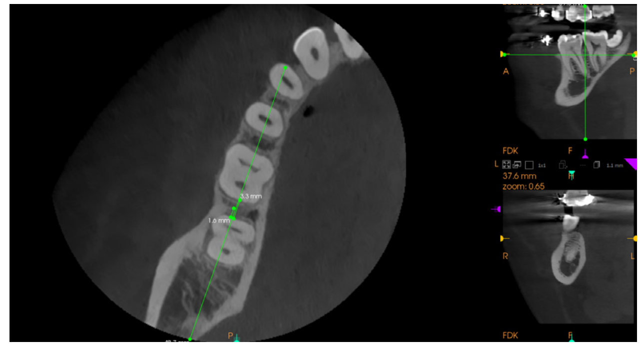

Figure 3: Axial slice.

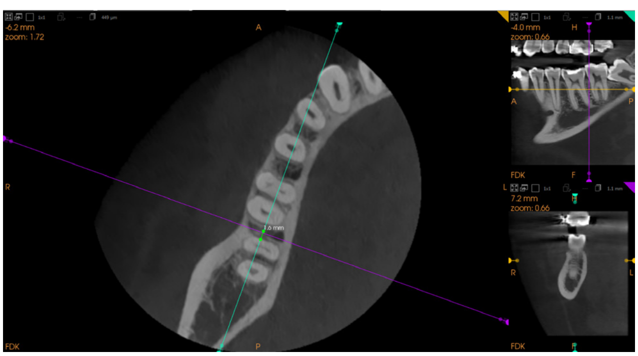

Figure 4: Horizontal reference line.

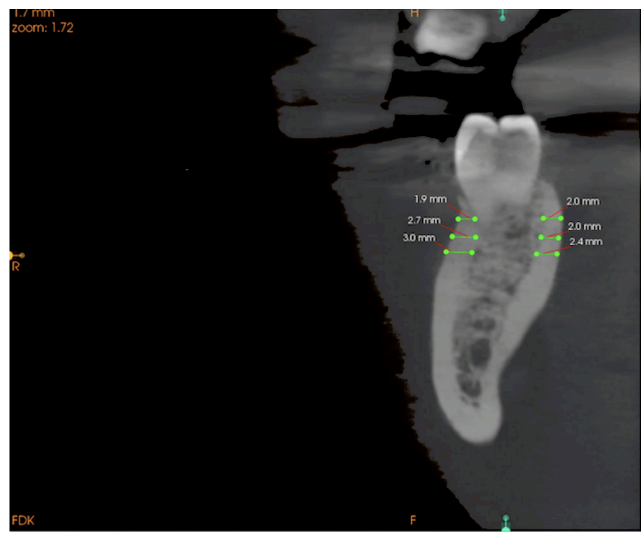

Figure 5: Buccal and lingual cortical bone thicknesses at 4, 6 and 8 mm from the CEJ.

Statistical analysis

All analyses were conducted using SPSS Statistics for Windows, v.26 (IBM Corp., Armonk, NY, USA). The alpha error was set at p-value < 0.05. The normality of distribution for the quantitative variables was evaluated using the Shapiro-Wilk test. To compare means of buccal or lingual bone thickness between the different levels (4, 6 and 8 mm), the repeated-measures analysis of variance ANOVA was used, followed by the Bonferroni post-hoc test for multiple pairwise comparisons. The level of significance was set at 5% and all tests were two-sided.

Results

The distribution according to sex was almost equal, embracing 17 (47.2%) males and 19 (52.8%) females. In addition, the distribution according to the vertical facial pattern consisted of three equivalent groups: the hypodivergent = 11 (30.6%), the normodivergent = 13 (36.1%) and the hyperdivergent = 12 (33.3%). The mean age was 21.03 ± 3.39 years (minimum = 18 years, maximum = 29 years). The mean mandibular plane angle was 33.04 ± 5.66 degrees (minimum = 21.77, maximum = 45.05).

According to the table 1 and 2, no statistically significant differences were observed between the three vertical dimension groups in terms of buccal or lingual measurements at 4, 6, and 8 mm from CEJ between 44/45, 45/46, and 46/47 (P>0.05).

Table 1: Measurements of buccal interradicular bone thickness at 4, 6, and 8 mm from the cemento-enamel junction according to the three vertical groups regardless of gender.

		Groups	Mean ± SD	*P*-value
At 4 mm from CEJ	Between 44/45	Hypodivergent Normodivergent Hyperdivergent	1.36 ± 0.21 1.38 ± 0.47 1.21 ± 0.34	0.292
	Between 45/46	Hypodivergent Normodivergent Hyperdivergent	1.72 ± 0.47 1.68 ± 0.51 1.32 ± 0.55	0.091
	Between 46/47	Hypodivergent Normodivergent Hyperdivergent	2.17 ± 0.58 2.39 ± 0.65 1.89 ± 0.60	0.139
At 6 mm from CEJ	Between 44/45	Hypodivergent Normodivergent Hyperdivergent	1.47 ± 0.26 1.46 ± 0.47 1.34 ± 0.46	0.449
	Between 45/46	Hypodivergent Normodivergent Hyperdivergent	1.70 ± 0.50 1.86 ± 0.51 1.47 ± 0.53	0.073
	Between 46/47	Hypodivergent Normodivergent Hyperdivergent	2.5 ± 0.80 2.58 ± 0.60 2.11 ± 0.64	0.204
At 8 mm from CEJ	Between 44/45	Hypodivergent Normodivergent Hyperdivergent	1.54 ± 0.40 1.62 ± 0.45 1.49 ± 0.48	0.820
	Between 45/46	Hypodivergent Normodivergent Hyperdivergent	2.00 ± 0.74 1.87 ± 0.60 1.58 ± 0.53	0.285
	Between 46/47	Hypodivergent Normodivergent Hyperdivergent	2.65 ± 0.61 2.95 ± 1.01 2.32 ± 0.66	0.332

*Statistically significant at p<0.05

Table 2: Measurements of lingual interradicular bone thickness at 4, 6, and 8 mm from the cemento-enamel junction according to the three vertical groups regardless of gender

		Groups	Mean ± SD	*p*-value
At 4 mm from CEJ	Between 44/45	Hypodivergent Normodivergent Hyperdivergent	2.34 ± 0.93 1.96 ± 0.88 1.84 ± 0.66	0.340
	Between 45/46	Hypodivergent Normodivergent Hyperdivergent	1.82 ± 0.54 1.68 ± 0.68 1.77 ± 0.71	0.714
	Between 46/47	Hypodivergent Normodivergent Hyperdivergent	1.78 ± 0.58 1.57 ± 0.42 1.87 ± 0.52	0.330
At 6 mm from CEJ	Between 44/45	Hypodivergent Normodivergent Hyperdivergent	2.45 ± 0.72 2.31 ± 0.61 2.02 ± 0.60	0.367
	Between 45/46	Hypodivergent Normodivergent Hyperdivergent	1.94 ± 0.53 1.98 ± 0.59 1.99 ± 0.56	0.840
	Between 46/47	Hypodivergent Normodivergent Hyperdivergent	1.97 ± 0.52 1.96 ± 0.39 2.02 ± 0.45	0.934
At 8 mm from CEJ	Between 44/45	Hypodivergent Normodivergent Hyperdivergent	2.28 ± 0.56 2.31 ± 0.64 1.93 ± 0.40	0.426
	Between 45/46	Hypodivergent Normodivergent Hyperdivergent	2.01 ± 0.45 2.07 ± 0.55 2.02 ± 0.38	0.967
	Between 46/47	Hypodivergent Normodivergent Hyperdivergent	2.12 ± 0.50 2.02 ± 0.31 2.18 ± 0.41	0.619

*Statistically significant at p<0.05

According to table 3 and 4, no statistically significant differences were observed between groups in terms of buccal or lingual measurements at 4, 6, and 8 mm from CEJ between 44/45, 45/46, and 46/47 (P>0.05) for males and females separately. For every facial pattern and in terms of buccal or lingual measurements at 4, 6, and 8 mm from CEJ between 44/45, 45/46, and 46/47, no statistically significant differences were observed between males and females (P>0.05).

Table 3: Measurements of buccal interradicular bone thickness at 4, 6, and 8 mm from the cemento-enamel junction according to the three vertical groups and gender

		Groups	Males	Females	*p*-value
At 4 mm from CEJ	Between 44/45	Hypodivergent	1.38 ± 0.17	1.34 ± 0.26	0.748
		Normodivergent	1.4 ± 0.58	1.34 ± 0.26	0.724
		Hyperdivergent	1.23 ± 0.25	1.20 ± 0.38	0.891
	Between 45/46	Hypodivergent	1.8 ± 0.50	1.62 ± 0.46	0.552
		Normodivergent	1.81 ± 0.51	1.46 ± 0.47	0.240
		Hyperdivergent	1.13 ± 0.42	1.38 ± 0.59	0.600
	Between 46/47	Hypodivergent	2.32 ± 0.74	2.00 ± 0.29	0.392
		Normodivergent	2.46 ± 0.56	2.28 ± 0.83	0.680
		Hyperdivergent	1.93 ± 0.35	1.88 ± 0.68	0.897
At 6 mm from CEJ	Between 44/45	Hypodivergent	1.53 ± 0.31	1.40 ± 0.19	0.428
		Normodivergent	1.54 ± 0.56	1.34 ± 0.29	0.622
		Hyperdivergent	1.40 ± 0.10	1.32 ± 0.54	0.813
	Between 45/46	Hypodivergent	1.92 ± 0.51	1.44 ± 0.39	0.123
		Normodivergent	2.00 ± 0.51	1.64 ± 0.48	0.234
		Hyperdivergent	1.33 ± 0.35	1.51 ± 0.59	0.641
	Between 46/47	Hypodivergent	2.67 ± 1.06	2.30 ± 0.27	1.000
		Normodivergent	2.75 ± 0.56	2.30 ± 0.62	0.204
		Hyperdivergent	2.00 ± 0.82	2.14 ± 0.62	0.751
At 8 mm from CEJ	Between 44/45	Hypodivergent	1.70 ± 0.44	1.36 ± 0.28	0.169
		Normodivergent	1.71 ± 0.51	1.48 ± 0.34	0.524
		Hyperdivergent	1.60 ± 0.17	1.46 ± 0.55	0.670
	Between 45/46	Hypodivergent	2.25 ± 0.87	1.72 ± 0.46	0.247
		Normodivergent	2.01 ± 0.65	1.64 ± 0.49	0.354
		Hyperdivergent	1.43 ± 0.32	1.63 ± 0.60	0.599
	Between 46/47	Hypodivergent	2.80 ± 0.82	2.48 ± 0.19	0.662
		Normodivergent	3.17 ± 1.19	2.58 ± 0.54	0.354
		Hyperdivergent	2.23 ± 0.86	2.34 ± 0.64	0.814

*Statistically significant at p<0.05

Table 4: Measurements of lingual interradicular bone thickness at 4, 6, and 8 mm from the cemento-enamel junction according to the three vertical groups and gender

		Groups	Males	Females	*p*-value
At 4 mm from CEJ	Between 44/45	Hypodivergent	1.90 ± 0.49	2.88 ± 1.10	0.126
		Normodivergent	1.65 ± 0.62	2.46 ± 1.06	0.093
		Hyperdivergent	1.67 ± 0.50	1.90 ± 0.7	0.618
	Between 45/46	Hypodivergent	1.55 ± 0.27	2.14 ± 0.63	0.068
		Normodivergent	1.49 ± 0.37	1.98 ± 0.98	0.435
		Hyperdivergent	1.93 ± 0.42	1.71 ± 0.80	0.660
	Between 46/47	Hypodivergent	1.75 ± 0.43	1.82 ± 0.78	0.855
		Normodivergent	1.50 ± 0.37	1.68 ± 0.51	0.435
		Hyperdivergent	2.03 ± 0.35	1.81 ± 0.57	0.547
At 6 mm from CEJ	Between 44/45	Hypodivergent	2.25 ± 0.48	2.70 ± 0.93	0.327
		Normodivergent	2.11 ± 0.39	2.62 ± 0.81	0.222
		Hyperdivergent	1.93 ± 0.30	2.04 ± 0.68	0.796
	Between 45/46	Hypodivergent	1.73 ± 0.31	2.20 ± 0.66	0.153
		Normodivergent	1.86 ± 0.43	2.18 ± 0.80	0.435
		Hyperdivergent	2.03 ± 0.25	1.98 ± 0.64	0.890
	Between 46/47	Hypodivergent	1.87 ± 0.42	2.10 ± 0.65	0.491
		Normodivergent	1.91 ± 0.48	2.04 ± 0.21	0.589
		Hyperdivergent	2.07 ± 0.30	2.01 ± 0.50	0.862
At 8 mm from CEJ	Between 44/45	Hypodivergent	2.17 ± 0.48	2.42 ± 0.68	0.486
		Normodivergent	2.20 ± 0.47	2.50 ± 0.89	0.724
		Hyperdivergent	2.03 ± 0.29	1.90 ± 0.44	0.864
	Between 45/46	Hypodivergent	1.88 ± 0.32	2.16 ± 0.58	0.429
		Normodivergent	1.96 ± 0.38	2.24 ± 0.77	0.622
		Hyperdivergent	2.03 ± 0.25	2.01 ± 0.43	0.936
	Between 46/47	Hypodivergent	2.07 ± 0.40	2.18 ± 0.64	0.729
		Normodivergent	2.01 ± 0.37	2.04 ± 0.22	1.000
		Hyperdivergent	2.33 ± 0.21	2.13 ± 0.46	0.494

*Statistically significant at $p<0.05$

According to table 5, for the buccal bone thickness, between 44/45, 45/46, and 46/47, and for the lingual bone thickness between 46/47, there was a significant difference between 4, 6, and 8 mm. At 8 mm from CEJ, thickness was significantly greater than that measured at 6 mm, and greater than that measured at 4 mm ($P<0.05$). At 6 mm from CEJ, thickness was significantly greater than that measured at 4 mm from CEJ as well ($P<0.05$).

For the lingual bone thickness, between 44/45 the greatest mean was observed at 6 mm from the CEJ followed by 8 mm and 4 mm. No significant differences were observed between 8 and 6 mm, and between 8 and 4 mm ($P>0.05$); however, at 6 mm thickness was significantly greater than that measured at 4 mm ($P<0.05$).

For the lingual bone thickness, between 45/46, the greatest mean was observed at 8 mm from CEJ, followed by 6 and 4 mm. No significant difference was observed between 8 and 6 mm ($P>0.05$); however, significant differences were observed between 8 and 4 mm, and 6 and 4 mm ($P<0.05$).

Table 5: Measurements of buccal and lingual interradicular bone thickness at 4, 6, and 8 mm from the cemento-enamel junction regardless of facial pattern and gender

		Levels	Mean ± SD	*p*-value
Buccal bone thickness	Between 44/45	At 4 mm from CEJ At 6 mm from CEJ At 8 mm from CEJ	1.32 ± 0.36 1.42 ± 0.41 1.56 ± 0.44	<0.001*
	Between 45/46	At 4 mm from CEJ At 6 mm from CEJ At 8 mm from CEJ	1.57 ± 0.53 1.68 ± 0.53 1.82 ± 0.63	0.001*
	Between 46/47	At 4 mm from CEJ At 6 mm from CEJ At 8 mm from CEJ	2.16 ± 0.63 2.40 ± 0.69 2.65 ± 0.81	<0.001*
Lingual bone thickness	Between 44/45	At 4 mm from CEJ At 6 mm from CEJ At 8 mm from CEJ	2.04 ± 0.83 2.26 ± 0.65 2.18 ± 0.56	0.031*
	Between 45/46	At 4 mm from CEJ At 6 mm from CEJ At 8 mm from CEJ	1.75 ± 0.64 1.97 ± 0.55 2.03 ± 0.46	<0.001*
	Between 46/47	At 4 mm from CEJ At 6 mm from CEJ At 8 mm from CEJ	1.73 ± 0.51 1.99 ± 0.44 2.11 ± 0.40	<0.001*

*Statistically significant at $p<0.05$

Discussion

Among many characteristics, the site's architecture, particularly the cortical bone's thickness, appears to have a direct bearing on success. This is because, rather than osseointegration, the micro implant's principal stability comes from its close contact with the cortical bone [6]. Cortical bone thickness has been the subject of several studies in an effort to forecast the stability of miniscrews [2,7]. For that reason, it is crucial to adopt a precise and repeatable approach to evaluate cortical thickness, taking mini-screw insertion sites into account, since it is claimed to be a key determinant in the success of TADs. Due to multiple benefits including the evaluation of structures in 3D, low radiation dosage, rapid collection time, high spatial resolution, gray density range, and contrast, CBCT, has been widely used by orthodontists [7,8]. Hence, the best methodology in this study was to appraise each potential insertion location by the mean of CBCT.

The forms of the maxilla and the mandible adjust to masticatory forces, particularly, the thickness and density of the cortical bone. Less stress may hence be anticipated to result in less pronounced bone adaptations [9]. Facial divergence has similarly been related to the masticatory muscles. Subjects with muscular dystrophy provide a naturally appearing example. Garc et al, [10] conducted a study which have showed a positive correlation between reduced muscle function and greater facial divergence.

In this study, mandibular buccal and lingual cortical bone thicknesses were assessed at 4, 6 and 8 mm from the CEJ were TADs are frequently inserted clinically, starting from 4mm where usually attached gingiva starts to 8mm where generally its far from anatomic sites; since caution should be exercised beginning at 9 mm from the bone crest to minimize nerve injury [11]. In this study, here was no significant difference between the cortical bone thickness and the vertical dimension patterns. Hence the null hypothesis was accepted.

Mini-implants implanted in areas with cortical bone thickness less than 1 mm have worse success rates [2]. Whereas, zones characterized by very thick cortical bone could amplify the chances of mini-screw breakage and damage the bone by inducing micro-breakages [12].

In this study, there was no significance difference between the two opposite sex in cortical bone thickness at all the measured sites (p-value > 0.05). This comes in agreements with Farnsworth et al, [12] study was there were no difference between females and males at inter-radicular sites where TADs implantation is frequent. Our findings are further in accordance with the results done by Ono et al, [13] Chun and Lim, [14] and Schneider et al, [15] who also testified non-significant correlation linking sex to cortical plate thickness. Maximum biting force might not be predicted to result in sex variations in cortical thickness because it is not a regular or habitual activity, like, mastication. Even though, men typically consume more foods with a greater fat content and meat than do females, these dietary variations may not automatically correspond to differences in functional capacity [16].

Kuroda et al, [17] conducted a retrospective study and averred that no correlation between the mandibular plane angle measurements and TADs success rate were found. This agreed with our results. Our results are further supported by Schneider et al, [15] who stated that for persons with skeletal face patterns that are hyperdivergent, hypodivergent or normodivergent, bone parameters (density and thickness) are analogous. Similarly, our results are in agreements with in Akbulut et al, [18] article where 66 CBCT scans of participants were included and grouped according to their facial vertical patterns using frankfort-mandibular plane (FMA) angle.

Controversially, it was shown Miyawaki et al, [19] research that the hypodivergent group had lingual & buccal cortical plates significantly thicker than those of normal or hyper divergent groups. Nevertheless, this study was conducted clinically, and no cortical bone thickness was measured on CBCT scans and clinically many factors could have contributed to this conclusion, like the use of 3 types of TADs, examiner surgical skills, and so on.

Gaffuri et al, [20] specified that the maxilla's anterior region and nearly all of the mandible's sites had weaker cortical bone in hyperdivergent participants. Although in their study, no interradicular cortical bone thickness were measured, instead the cortical thickness of the long axis midroot of each 12 teeth was measured. Hence, these results are not reliable to ours.

Menezes et al, [21] performed a research where 56 mini-implants were placed in the posterior buccal region of the maxilla in 30 participants to study TADs stability and success rate. Participants were classified in 2 groups only: horizontal grower vs. vertical grower depending on their cephalometric FMA measures. Moreover, cortical bone thickness was measured using CBCT images. It has been shown that greater cortical thickness of the alveolar bone was seen in several particular areas in participants who had horizontal development, including the labial anterior maxillary region and the labial anterior and buccal posterior mandibular regions. Nonetheless, the success rate and stability of mini-implants in the buccal maxillary posterior area were unaffected by growth pattern.

Finally in this study, high-angle subjects when compared to the other two groups tended to have more sites with cortical bone thickness less than 1 mm, which according to Motoyoshi et al, [2] can raise the possibility that mini-screws inserted at these locations will fail. On the contrary, the cortical bone of some hypodivergent subjects was more than 3.5 mm thick. Thick cortical plate could be problematic for mini-screws placement because of potential implant fracture and increased bony minor breakages. Therefore, the thicker does not always mean the better. The amount of force produced by the insertion of self-drilling mini-screws has the capacity to fracture cortical bone in places with thick cortical bone. Pre-drilling has been recommended as a result for the dense cortical regions [22]. Augmenting the mini-screw diameter or placing it in an oblique pathway have both been suggested as ways to improve the stability of the mini-screws in areas with thin cortical bone thickness [23].

As for the difference in cortical bone thickness between 4, 6 and 8 mm regardless of the facial patters, between all the interradicular sites measures, all buccal bone thickness (BBT) and lingual bone thickness (LBT) between only 46/47 increased from the CEJ towards the apex. Whereas, lingually between 44/45 and 45/46 there were some variations. This comes in agreement with Cassetta et al, [24] Khumsarn et al, [25] and Al-Hafidh et al, [26] who all found that as mini-screws are inserted more apically, more cortical bone thickness is expected regardless of vertical facial patterns. Whereas Fayed et al, [27] discovered that the maxillary BBT reduced apically at a distance of 6 mm but grew as the distance from the CEJ increased.

The fact that the architecture of alveolar bone is dependent on functional load and the shape of roots may help to explain the variation in cortical bone thickness [28]. As the roots erupted and lengthened, the alveolar bone persisted to take shape around them and remodel. Alveolar bone develops with apical bone deposition, which results in an increase in the depth of the socket. Alveolar bone is very adaptable and capable of remodeling [29]. Under effective occlusion, mechanical stress tends to rise, which increases the reaction of the alveolar bone and tends to result in a rise in cortical bone thickness [30]. This data would suggest that cortical bone's apical areas experience more mechanical stresses and have a propensity to become thicker.

Future research should ideally take into account additional aspects, such as the subjects' diets and masticatory forces, since these may contribute to the variation in bone thickness and density. Additionally, only bone quantity was evaluated. The stability of a mini-screw may also be influenced by the quality of the bone around it. To assess the integrity of the bone around mini-screws, more clinical research is required.

Conclusion

There was no significant difference between the skeletal vertical dimension and the thickness of cortical bone thickness whether it was buccally or lingually in the posterior right mandible. There was no significant difference between females and males regarding the cortical bone thickness measures. Finally, there was a progressive increase in the thickness of cortical bone from the alveolar crest towards the apex between in most studies sites.

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