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CONE BEAM COMPUTED TOMOGRAPHY EVALUATION OF ALVEOLAR BONE THICKNESS AND ITS CORRELATION WITH DIFFERENT MUCOGINGIVAL HEIGHT: CROSS SECTIONAL STUDY

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ABSTRACT

Objectives: To evaluate the average alveolar buccal cortical bone thickness using Cone beam computed tomography (CBCT) at different clinical mucogingival junction heights (MGJ), and to provide the correlation between the alveolar bone thickness and clinical MGJ.

Methods: The study was carried on 89 patients having CBCTs recruited in the orthodontic clinic. The MGJ were measured clinically in both upper and lower arches using digital caliper. Then, using CBCT at the same length to measure the corresponding alveolar buccal cortical bone thickness. Analysis of the data was performed using Pearson's correlation coefficient and Student's t-test.

Results: At the upper side, there was a statistically significant direct correlation between length and thickness measurements at MGJ, MGJ + 2 mm as well as MGJ – 2 mm (P-value <0.001), (P-value <0.001) and (P-value <0.001), respectively. Similarly at the lower side, there was a statistically significant direct correlation between length and thickness measurements at MGJ, MGJ + 2 mm as well as MGJ – 2 mm (P-value = 0.039), (P-value = 0.001) and (P-value <0.001), respectively.

Conclusions: There was a direct correlation between average clinical MGJ obtained through clinical measurement and the corresponding alveolar buccal cortical bone thickness calculated through CBCT measurement.

KEY WORDS: CBCT, alveolar cortical bone thickness, mucogingival junction height, clinical measurement.

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INTRODUCTION

Cone beam computed tomography (CBCT) imaging has been recommended for head and neck applications since it is less cost and radiation exposure relative to conventional CT technology. Assessing the position and placement of teeth, their developmental stage, and the condition of neighboring teeth are some of the benefits of CBCT [1].

The evaluation of gingival dimensions, such as the thickness of keratinized tissue (KT) and apico-coronal dimension, is crucial for making decisions on the design of periodontal therapy, particularly in determining the necessity and nature of periodontal surgery. Moreover, it serves as a landmark for measurements in periodontal evaluations [2]. The mucogingival junction can be identified using three different methods: the visual method (VM), which involves identifying the line by comparing the colors of the gingiva and alveolar mucosa; the VM following histochemical staining (HM); and the functional method (FM), which involves using a periodontal probe to apply light pressure to distinguish the boundary between stable and immovable tissues [3].

The patient's anatomical characteristics should be taken into consideration while choosing the miniscrew's insertion site and angulation prior to implantation. The danger of root perforation rises if the quantity, inclination, and closeness of interradicular bone to the roots are not accurately measured [4].

Previous studies evaluated the ideal alveolar bone thickness and width for miniscrew insertion, some studies evaluated the bone quality in different sites. However, the purpose of this study is to evaluate the alveolar buccal cortical bone thickness at different lengths using CBCT and correlate it with the clinical mucogingival heights to provide a guideline for implant site selection and placement. The null hypothesis was that there is no correlation between the clinical mucogingival heights, and the corresponding alveolar cortical bone thickness measured by CBCT.

MATERIALS AND METHODS

Ethical approval and informed consents

This clinical study was conducted according to the Declaration of Helsinki of the General Assembly, October 2013[5]. The current study was approved by the Research Ethical Committee of Faculty of Dentistry, Cairo University, Egypt (Reference number: 13223).

Study design and setting

This study was designed as an observational, cross sectional clinical study was performed on 89 patients having CBCTs for any purpose were recruited from the clinic of orthodontics at the Faculty of Dentistry, Cairo university, Cairo, Egypt.

Eligibility criteria

inclusion criteria; gender: males and females, age: adult age, dentation: permanent dentition, good general health with absence of any nutritional problems or bony disease, no usage of any anti-inflammatories or antibiotics in the month preceding the study. Exclusion criteria; periodontal and/or gingival disease, systemic and/or bone disease, and growth abnormality.

Sample size calculation

Using G.Power®: a statistical calculator software with a power of 85%, level of significance of 5% (two sided), an assumed medium effect size of 0.3, the study would require a sample size of 89 patients to test the correlation between the distance from midpoint between buccal cusp of second premolar and mesio-buccal cusp of first molar to the mucogingival junction and corresponding thickness of alveolar buccal cortical bone on CBCT in the upper and lower jaws in both sides.

Measurement procedure

Patients whose CBCT scans retrieved were clinically examined. The position and height of the mucogingival junction was identified in the four quadrants; upper left, upper right, lower left, lower right. For clinical measurement a digital caliper was used (Digital Vernier Caliper, Mitutoyo, Japan). In maxillary arch on each side, we measured the distance between midpoint between buccal cusp of upper second premolar and mesio-buccal cusp of upper first molar to the mucogingival junction using digital caliper. While in the mandibular arch, we measured the distance between midpoint between buccal cusp of lower second premolar and mesio-buccal cusp of lower first molar to the mucogingival junction using digital caliper as shown in Figures (1-3).

After the length of the mucogingival junction height was determined, radiographic analysis on the CBCT (Planmeca, Promax® 3D Mid, Helsinki, Finland) was performed using Planmeca software (Planmeca Romexis, Version 6.0, Helsinki, Finland). The exposure settings were adjusted to 0.4 mm isotropic voxel size, 13.5 s exposure period, 90 kVp, and 8 mA. The areas examined in each CBCT scan were performed to measure the alveolar buccal cortical bone thickness through the whole dimension of the alveolar bone at the height of the mucogingival junction determined clinically and at 2mm higher than this height, and 2 mm lower than this height as shown in Figures (4 and 5).

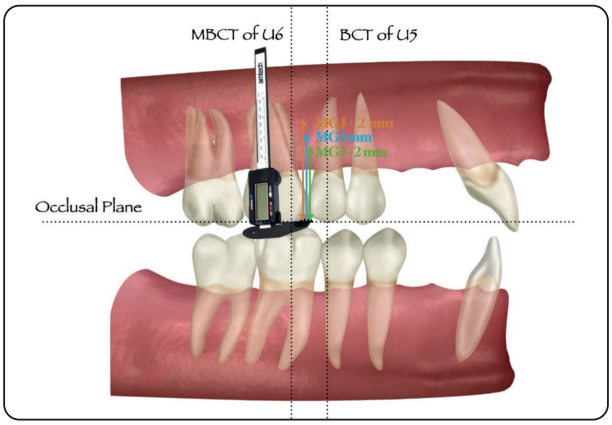

Fig. (1). Diagram illustrating the use of caliper for clinical measurement of height of MGJ in maxillary arch

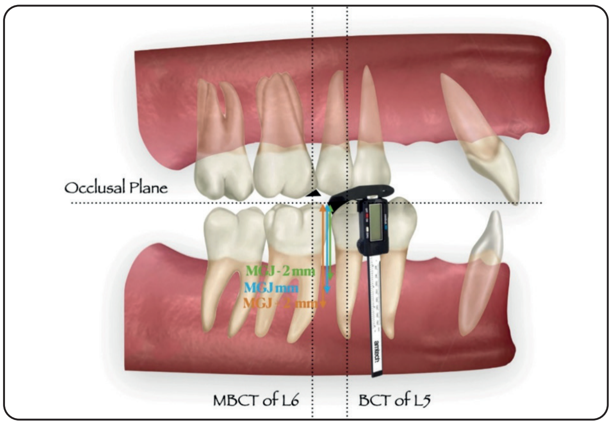

Fig. (2). Diagram illustrating the use of caliper for clinical measurement of height of MGJ in mandibular arch

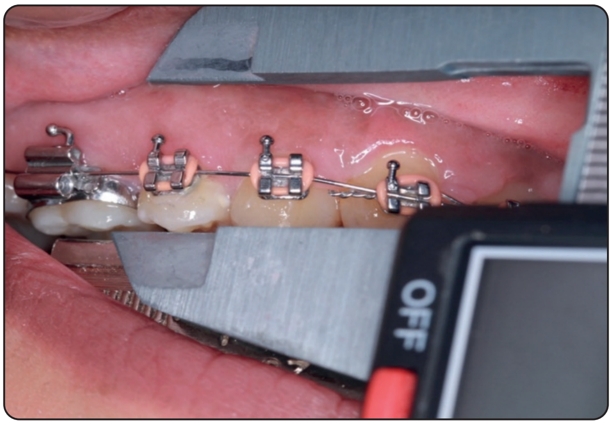

Fig. (3). Clinical measurement of MGJ height length in maxillary arch.

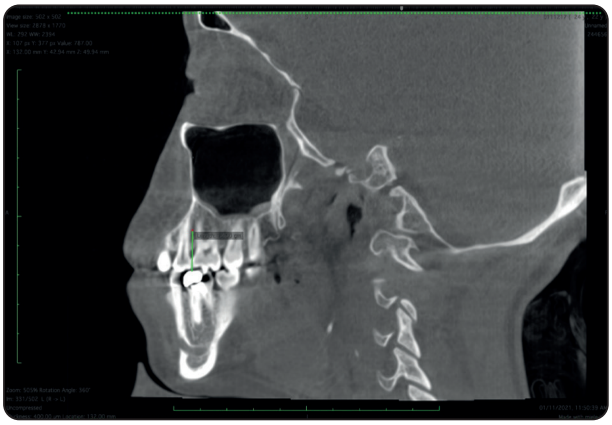

Fig. (4). Drawing the line of length measured clinically on CBCT scan on sagittal view.

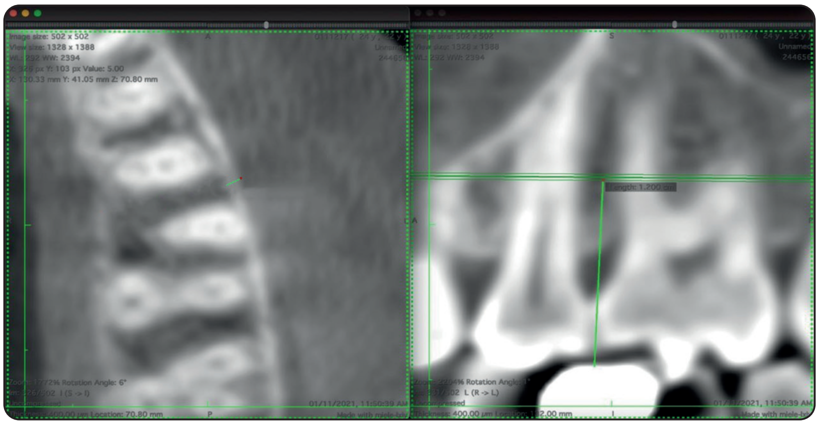

Fig. (5). Measurement of alveolar buccal cortical bone thickness on CBCT scan.

Statistical analysis

Quantitative data were explored for normality by checking the distribution of data and using tests of normality (Kolmogorov-Smirnov and Shapiro-Wilk tests). All data showed normal (parametric) distribution. Descriptive statistics included the mean, standard deviation (SD), 95% Confidence Interval (95% CI), median and range values. Pearson's correlation coefficient was used to determine correlations between different variables. Student's t-test was used for comparisons between length and thickness measurements in males and females. The significance level was set at $P \leq 0.05$. Statistical analysis was performed with IBM SPSS Statistics for Windows, Version 23.0. Armonk, NY: IBM Corp.

RESULTS

Descriptive statistics for the study sample

Base line characteristics

The present study was conducted on 89 subjects, 59 females (66.7%) and 30 males (33.3%). The mean and standard deviation (SD) values for age were 20.6 (4) years old with a minimum of 17 and a maximum of 33 years old.

Length measurements (mm)

Descriptive statistics for length measurements are presented in Table (1).

Thickness measurements (mm)

Descriptive statistics for thickness measurements are presented in Table (2).

Comparison between right and left sides

Length measurements (mm)

Measurements on the right and left sides were the same for all measurements except at MGJ – 2 mm level. However, at this level, there was no statistically significant difference between the two sides. Therefore, mean of the two sides will be used for further comparisons and correlations as shown in Table (3).

TABLE (1) Mean, standard deviation (SD), 95% Confidence Interval (95% CI) for the mean, median and range values for length of MGJ measurements (mm).

Location	Level	Mean	SD	95% CI for the mean	Median	Minimum	Maximum
Upper right	MGJ	12.24	0.83	12.07-12.42	12.44	10	13.68
	MGJ + 2 mm	14.24	0.83	14.07-14.42	14.44	12	15.68
	MGJ - 2 mm	10.24	0.83	10.07-10.42	10.44	8	11.68
Upper left	MGJ	12.24	0.83	12.07-12.42	12.44	10	13.68
	MGJ + 2 mm	14.24	0.83	14.07-14.42	14.44	12	15.68
	MGJ - 2 mm	10.24	0.83	10.07-10.42	10.44	8	11.68
Mean of the two sides	MGJ	12.24	0.83	12.07-12.42	12.44	10	13.68
	MGJ + 2 mm	14.24	0.83	14.07-14.42	14.44	12	15.68
	MGJ - 2 mm	10.24	0.83	10.07-10.42	10.44	8	11.68
Lower right	MGJ	9.96	0.5	9.86-10.07	10.02	8.77	11.38
	MGJ + 2 mm	11.96	0.5	11.86-12.07	12.02	10.77	13.38
	MGJ - 2 mm	7.96	0.5	7.86-8.07	8.02	6.77	9.38
Lower left	MGJ	9.96	0.5	9.86-10.07	10.02	8.77	11.38
	MGJ + 2 mm	11.96	0.5	11.86-12.07	12.02	10.77	13.38
	MGJ - 2 mm	7.98	0.57	7.86-8.1	8.02	6.77	10.55
Mean of the two sides	MGJ	9.96	0.5	9.86-10.07	10.02	8.77	11.38
	MGJ + 2 mm	11.96	0.5	11.86-12.07	12.02	10.77	13.38
	MGJ - 2 mm	7.97	0.52	7.86-8.08	8.02	6.77	9.55

TABLE (2) Mean, standard deviation (SD), 95% Confidence Interval (95% CI) for the mean, median and range values for corresponding alveolar buccal cortical bone thickness at different MGJ heights measurements (mm).

Location	Level	Mean	SD	95% CI for the mean	Median	Minimum	Maximum
Upper right	MGJ	0.94	0.3	0.93-0.94	0.92	0.94	0.96
	MGJ + 2 mm	0.95	0.2	0.94-0.95	0.94	0.95	1
	MGJ - 2 mm	0.94	0.4	0.93-0.94	0.92	0.94	0.96
Upper left	MGJ	0.94	0.3	0.93-0.94	0.92	0.94	0.96
	MGJ + 2 mm	0.95	0.2	0.94-0.95	0.94	0.95	1
	MGJ - 2 mm	0.94	0.4	0.93-0.94	0.92	0.94	0.96
Mean of the two sides	MGJ	0.94	0.3	0.93-0.94	0.92	0.94	0.96
	MGJ + 2 mm	0.95	0.2	0.94-0.95	0.94	0.95	1
	MGJ - 2 mm	0.94	0.4	0.93-0.94	0.92	0.94	0.96
Lower right	MGJ	0.85	0.5	0.84-0.85	0.82	0.85	0.86
	MGJ + 2 mm	0.86	0.6	0.84-0.86	0.82	0.85	0.86
	MGJ - 2 mm	0.84	0.4	0.83-0.84	0.8	0.84	0.86
Lower left	MGJ	0.85	0.5	0.84-0.85	0.82	0.85	0.86
	MGJ + 2 mm	0.86	0.6	0.84-0.86	0.82	0.85	0.86
	MGJ - 2 mm	0.84	0.4	0.83-0.84	0.8	0.84	0.86
Mean of the two sides	MGJ	0.85	0.5	0.84-0.85	0.82	0.85	0.86
	MGJ + 2 mm	0.86	0.6	0.84-0.86	0.82	0.85	0.86
	MGJ - 2 mm	0.84	0.4	0.83-0.84	0.8	0.84	0.86

TABLE (3) Descriptive statistics and results of paired t-test for comparison between length of MGJ measurements (mm) on the right and left sides.

Side	Level	Right side		Left side		P-value
		Mean	SD	Mean	SD	
Upper	MGJ	12.24	0.83	12.24	0.83	NC
	MGJ + 2 mm	14.24	0.83	14.24	0.83	NC
	MGJ - 2 mm	10.24	0.83	10.24	0.83	NC
Lower	MGJ	9.96	0.5	9.96	0.5	NC
	MGJ + 2 mm	11.96	0.5	11.96	0.5	NC
	MGJ - 2 mm	7.96	0.5	7.98	0.57	0.320

: Significant at P ≤ 0.05, NC: Not computed because values are the same on both sides.

Thickness measurements (mm)

Measurements on the right and left sides were the same for all measurements. Therefore, mean of the two sides will be used for further comparisons and correlations.

Correlation between length and thickness measurements

At the upper side, there was a statistically significant direct correlation between length and thickness measurements at MGJ, MGJ + 2 mm as well as MGJ – 2 mm (Correlation coefficient = 0.842, *P*-value <0.001), (Correlation coefficient = 0.834, *P*-value <0.001) and (Correlation coefficient = 0.911, *P*-value <0.001), respectively. An increase in bone length is associated with an increase in thickness and vice versa. Similarly at the lower side, there was a statistically significant direct correlation between length and thickness measurements at MGJ, MGJ + 2 mm as well as MGJ – 2 mm (Correlation coefficient = 0.218, *P*-value = 0.039), (Correlation coefficient = 0.359, *P*-value = 0.001) and (Correlation coefficient = 0.683, *P*-value <0.001), respectively. An increase in bone length is associated with an increase in thickness and vice versa as shown in Table (4).

TABLE (4). Results of Pearson's correlation coefficient for the correlation between length of MGJ and corresponding thickness measurements.

Location	**Level**	***Correlation coefficient (r)***	***P*-value**
Upper	MGJ	0.842	<0.001*
	MGJ + 2 mm	0.834	<0.001*
	MGJ - 2 mm	0.911	<0.001*
Lower	MGJ	0.218	0.039*
	MGJ + 2 mm	0.359	0.001*
	MGJ - 2 mm	0.683	<0.001*

: Significant at P ≤ 0.05.

Correlation between age and length measurements

At the upper as well as lower sides, there was no statistically significant correlation between age and length measurements at MGJ, MGJ + 2 mm as well as MGJ – 2 mm levels as shown in Table (5).

TABLE (5) Results of Pearson's correlation coefficient for the correlation between age and length of MGJ measurements.

Location	Level	Correlation coefficient (r)	P-value
Upper	MGJ	0.095	0.372
	MGJ + 2 mm	0.095	0.372
	MGJ - 2 mm	0.095	0.372
Lower	MGJ	-0.072	0.498
	MGJ + 2 mm	-0.072	0.498
	MGJ - 2 mm	-0.056	0.598

: Significant at P ≤ 0.05.

Correlation between age and thickness measurements

At the upper as well as lower sides, there was no statistically significant correlation between age and thickness measurements at MGJ, MGJ + 2 mm as well as MGJ – 2 mm levels as shown in Table (6).

Correlation between gender and length measurements

There was no statistically significant difference between mean length measurements in males and females at MGJ, MGJ + 2 mm as well as MGJ – 2 mm levels as shown in Table (7).

TABLE (6) Results of Pearson's correlation coefficient for the correlation between age and alveolar buccal cortical bone thickness measurements.

Location	Level	Correlation coefficient (r)	P-value
Upper	MGJ	0.107	0.316
	MGJ + 2 mm	0.127	0.232
	MGJ - 2 mm	0.165	0.121
Lower	MGJ	-0.029	0.789
	MGJ + 2 mm	0.050	0.641
	MGJ - 2 mm	-0.079	0.460

: Significant at P ≤ 0.05.

TABLE (7). Descriptive statistics and results of Student's t-test for comparison between length of MGJ measurements (mm) in males and females.

Location	level	Males (n = 30)		Females (n = 60)		P-value	Effect size (d)
		Mean	SD	Mean	SD		
Upper	MGJ	12.38	0.68	12.18	0.89	0.271	0.248
	MGJ + 2 mm	14.38	0.68	14.18	0.89	0.272	0.247
	MGJ - 2 mm	10.38	0.68	10.18	0.89	0.271	0.248
Lower	MGJ	9.94	0.47	9.97	0.52	0.775	0.064
	MGJ + 2 mm	11.94	0.47	11.97	0.52	0.775	0.064
	MGJ - 2 mm	7.97	0.55	7.97	0.52	0.992	0.002

: Significant at P ≤ 0.05.

DISCUSSION

A proper treatment plan is essential for appropriate orthodontic treatment. One of the most crucial instruments for diagnosis and treatment planning in the head and neck region is the imaging systems [6]. The traditional 2-dimensional systems had a limited analytical capacity because they compress the two-dimensional anatomy of the region. Therefore, development of 3-dimensional imaging system is widely used today [7].

Miniscrews have become more popular in recent years because they are easy to apply in a short amount of time and may be utilized in different parts of the mouth, indicating great patient comfort and affordability [8]. The success and failure of Miniscrews depends on the presence of a sufficient bone thickness and gingival height [9,10].

It is suggested that sufficient attached gingiva is necessary for maintaining gingival health and promoting appliances to deliver orthodontic treatment without causing bone loss or gingival recession[11]. In the fields of orthodontics, periodontology, implantology, and oral surgery, the study of bone thickness in the maxillary and mandibular dentition has drawn increasing interest[12]. In this study, CBCT was used to assess the alveolar buccal cortical bone thickness because it is a very accurate and successful technique commonly utilized to assess the alveolar buccal cortical bone thickness [7], and employed to evaluate alveolar buccal bone measurements [13]. Measurement was done using CBCT and digital calipers.

The MGJ was interpreted clinically as the distance between midpoint between buccal cusp of upper second premolar and mesio-buccal cusp of upper first molar to most apical point of mucogingival junction using digital caliper. While in the mandibular arch, we measured the distance between midpoint between buccal cusp of lower second premolar and mesio-buccal cusp of lower first molar to most apical point of mucogingival junction using digital caliper[14]. This study assessed the average clinical mucogingival heights through clinical measurement on the maxillary and mandibular arches on both sides from the midpoint between the buccal cusp of the upper second premolar and the mesio-buccal cusp of the upper first molar to the mucogingival junction using a digital caliper, and determined the corresponding alveolar buccal cortical bone thickness through CBCT measurement to evaluate their correlation.

There hasn't been any recorded quantitative data on mucogingival heights till now. Considering this, the current study used an intraoral caliper to examine the mucogingival heights of young individuals in good periodontal health.

The mean mucogingival heights level through clinical measurement for maxillary arch on both sides was (12.24 mm). While, the mean clinical mucogingival heights through measurement for mandibular jaw of both sides was (9.96 mm). The measurements on the right and left sides were the same for all measurements, which denote symmetrical pattern of the mucogingival heights in healthy periodontium.

Generally, the mucogingival heights distribution pattern in this study was consistent with other investigations [3]. The mucogingival heights in maxillary teeth was higher than in mandibular teeth in the same position, according to a comparison of the maxilla and mandible. The average for all teeth in maxillary was found to be 4.77 mm compared to the corresponding in lower arch which was found to be 3.50 mm. By tooth type, the mucogingival heights in both jaws displayed comparable variation tendencies.

On the current study, the corresponding alveolar buccal cortical bone thickness through CBCT measurement showed that the mean alveolar bone thickness for maxillary arch on both sides was (0.94 mm). While, the mean alveolar cortical bone thickness for mandibular arch on both sides was (0.85 mm).

From the collected results of average mucogingival heights through clinical measurement and the corresponding alveolar buccal cortical bone thickness through CBCT measurement, a direct correlation can be recognized. There was an increase in alveolar buccal bone thickness is associated with an increase in height level and vice versa was noticed.

The results obtained by Ganji et al. come against the results of the current study, as they showed that; in the maxillary right first premolar, the relationship between buccal bone thickness and gingival thickness is independent of one another. However, in the maxillary left first premolar, maxillary left second premolar, and maxillary right second premolar, there is a moderate correlation with a dependent relation [15]. Moreover, Wang et al. concluded that thick gingiva does not essentially correspond to a thick underlying alveolar bone .

Andrade et al. obtained a similar conclusion about the relationship between the gingival margin heights and bone thickness. They investigated the relationship between the alveolar bone and gingival dimensions in the maxillary anterior teeth. Cone-beam computed tomography images of 160 maxillary anterior teeth were evaluated. They concluded that the greater bone thickness was associated with a higher gingival margin level at the lateral incisor, but not with bone crest level [17].

La Rocca et al. discovered no significant link between gingival probing and CBCT scan results in an in vivo evaluation of 90 maxillary teeth in 15 patients. Additionally, comparisons were not conducted at the same levels in their study. In order to compare and contrast with earlier research, the correlation between the gingiva's thickness and the labial alveolar bone's thickness at each depth level was computed [18].

No correlation was observed between age or gender with the measured mean clinical mucogingival heights for both maxillary and mandibular arches nor the mean alveolar buccal bone thickness measured through CBCT. The results came in accordance with previous study by who showed no significant difference between the attached gingival width assessed visually and age or gender [19]. Zweers et al. found correlation between soft and hard tissues at the same level was investigated. The results showed no significant correlation was discovered. Gingival thickness at the alveolar crest level (G0) and bone thickness at all levels, especially at the lateral incisors and canines, were found to be significantly correlated when the range was expanded to compare tissue thickness at all levels. This finding adds to the findings of earlier research that suggested a moderate relationship between alveolar buccal bone thickness and supra-crestal gingival thickness [20].

CONCLUSIONS

There was a direct correlation between average clinical MGJ obtained through clinical measurement and the corresponding alveolar buccal cortical bone thickness calculated through CBCT measurement. These correlations may be beneficial for predicting the most likely sites for miniscrew insertion. No correlations were observed among age or gender.

List of abbreviations:

CT: Computed Tomography; CBCT: Cone Beam Computed Tomography; MJG: Mucogingival junction heights; KT: Keratinized tissue; VM: Visual method; HM: Histochemical staining; FM: Functional method

Declarations:

Ethics approval and informed consent to participate

This study received ethical approval from the Research Ethical Committee of Faculty of Dentistry, Cairo University, Egypt (Reference number: 13223). All methods were performed in accordance with the Declaration of Helsinki. The legal guardian of each participant signed a written informed consent form.

Consent for publication

Not applicable.

Availability of data and materials

The datasets used and/or analyzed during the current study available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

Funding

Not applicable.

Authors' contributions

MZ, SM, and FF designed the study. MZ, SM, and FF collected data. MZ, SM, and FF analyzed data. MZ, SM, and FF checked the data and the results. MZ, SM, and FF interpreted data and wrote the report. MZ, SM, and FF revised the report from preliminary draft to submission. MZ, SM, and FF modified the language, revised, and modified the final manuscript. SM, and FF supervised the study. All authors have read and approved the manuscript.

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