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THE EFFECT OF TUBE CURRENT OF THE CONE-BEAM COMPUTED TOMOGRAPHY (CBCT) ON THE ACCURACY OF MEASURING DIFFERENT GINGIVAL THICKNESSES OF THE MANDIBLE. (IN VITRO STUDY)

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ABSTRACT

Background: CBCT is a 3D scan designed for head and neck imaging. This technology offers advantages over traditional CT in dentistry, including a limited radiation dose, cost, and a more reliable method for linear measurements. However, CBCT has poorer contrast resolution, so a soft tissue cone-beam computed tomography (ST-CBCT) was created to enhance the quality of soft tissue images.

Purpose: Evaluation of the effect of tube current on the precision of measurement of different gingival thicknesses of the mandible.

Material and Methods: The graduated periodontal probe was utilized by two examiners to measure the thicknesses of 1 and 3 mm of baseplate pink wax, which was applied as a soft tissue simulation in various regions of a dry mandible in this in vitro investigation. These thickness measurements were obtained twice, perpendicular to the bone surface and one week apart. CBCT scans with 4 and 10 mA and a FOV of 50 × 100 mm were used to scan the dry mandible, and the results were evaluated against gold standard measures.

Results: There is a significant statistical difference between the CBCT measurements and the physical measurements using 4 mA and 10 mA and FOV 50 × 100 mm in detecting 1 mm thickness of wax; however, no significant difference is discovered when the thickness was 3 mm.

Conclusions: Both 4 mA and 10 mA with a small FOV of 50 × 100 are more recommended for measuring gingival thickness of 3 mm but less recommended for measuring gingival thickness of 1 mm.

KEYWORDS: Cone beam computed tomography; gingival thickness; measurement accuracy; tube current.

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INTRODUCTION

Cone beam computed tomography (CBCT) is used to generate three-dimensional (3D) scans of the maxillofacial skeleton using a specialized extraoral imaging scanner, similar in size to a panoramic X-ray machine, as opposed to the two-dimensional (2D) planar detector of conventional CT scanners that require multiple rotations and a linear detector array for narrow slices. This allows a single rotation to capture data over a larger volume, allowing for 3D and 2D reconstruction at multiple levels. CBCT reduces exposure to X-rays, making it an efficient and safe imaging technology for head and neck applications. **(Nasseh & Al-Rawi, 2018, and Ylisiurua et al., 2024).**

CBCT has abundant benefits over traditional CT in dentistry, like reduced radiation exposure and lower cost. Its submillimeter resolution is perfect for implant site evaluation and orthodontic assessment. CBCT is considered somewhat more trustworthy for linear measures than conventional CT (**Patcas et al., 2012, and Venkatesh & Elluru, 2017**).

Mostly, due to noticeable and high noise levels, image quality of CBCT deteriorates, including contrast resolution with dose reduction causing soft tissue detection limitation (**Moudi et al., 2019, and Iskanderani et al., 2020**).

Cross-sectional imaging approaches are used in dentomaxillofacial imaging to handle complex diagnostic and treatment planning challenges like endodontics, implantology, restorative dentistry, periodontics, forensic dentistry, and surgery (**Miracle & Mukherji, 2009, and Alamri et al., 2012**).

There are various procedures for measuring gingival thickness, including invasive procedures, such as needles, periodontal probes, or endodontic files, which are used trans-gingivally; all are noted for their accuracy, and CBCT, which allows analysis of gingiva and alveolar bone, however, it involves radiation exposure. In contrast, ultrasonic devices yield a non-invasive option for evaluating gingival dimensions **(Schwarz et al., 2024).**

To enhance the quality of soft tissue images, a soft tissue cone-beam computed tomography (ST-CBCT) was created. The patients' tongues were retracted toward the floor of their mouths during ST-CBCT scans while they were wearing plastic lip retractors **(Januário et al., 2008).**

Many researches have also been done to use CBCT to determine the oral cavity's soft tissue thickness, but not many have assessed how accurate CBCT is at doing so. This study attempted to estimate the precision of CBCT in determining the thickness of soft tissues in the oral cavity.

MATERIALS AND METHODS

Study Design

From the Department of Anatomy, Faculty of Medicine, Minia University in Egypt, one dried mandible was obtained. There was no indication of the age, sex, or race of this dried human mandible. The study was carried out at the Oral and Maxillofacial Radiology Department, Dental Hospital, Faculty of Dentistry, Minia University, Egypt.

Sample preparation

A dry mandible was selected from the Department of Anatomy, Faculty of Medicine, Minia University.

1. Two thicknesses (1 mm and 3 mm) of pink baseplate wax were used to simulate gingiva **(Moudi et al., 2019, and Mostafa, 2020)** in different regions of a dry mandible in:

a- Anterior of the mandible: labial and lingual areas.

b- Posterior of the mandible: buccal and lingual area.

The wax was uniform and free of bubbles, with different thicknesses determined by William's graduated periodontal probe in a perpendicular direction to the bone surface and evaluated by 2 observers.

2. Regular human cheek soft tissue can be simulated with 13–17 mm of wax in vitro radiographic studies **(Schropp et al., 2012)**, to simulate the interaction with X-ray photons with facial tissues.

Image acquisition

The prepared sample and simulated facial soft tissue were imaged by the SCANORA® 3Dx CBCT scanner (Soredex, Tuusula, Finland) with high-resolution scans of FOV of 50 × 100 mm with 2 tube currents of 4 and 10 mA.

Image evaluation and data analysis

Individually, for analysis, each CBCT data set was transfered in DICOM (Digital Imaging and Communication in Medicine) format to the OnDemand3D® software (CyberMed, Seoul, Korea) for viewing; the cross-sectional cuts with thickness and interval of 0.1 mm were selected. A total of 14 holes for each wax thickness were analyzed individually. The thicknesses of base plate wax were measured at mark areas (standardized hypodense marks) made by the William's graduated periodontal probe that were done after adjusting each standardized mark in a non-orthogonal sagittal cut; a line connecting the upper and lower outer borders of each hypodense area is drawn, and the wax thickness was measured by a line bisecting the corresponding hypodense area and perpendicular to this drawn line (**figure 1**).

To improve viewing, various changes were made to the contrast and brightness, and 1 cm magnification was applied.

These measurements were checked by two oral and maxillofacial radiologists with at least 5 years' experience, and the result was recorded after their consensus in an Excel sheet

Statistical analysis

Numerical data were checked for normality by analyzing the data distribution and utilizing tests of normality (Kolmogorov-Smirnov and Shapiro-Wilk tests). Gingival thickness measurements data revealed normal (parametric) distribution. Data were introduced as mean, standard deviation (SD). Repeated measures ANOVA test was utilized to compare between FOVs as well as currents. Bonferroni's post-hoc test was done for pair-wise comparisons when ANOVA test is significant. The significance level was set at P ≤ 0.05. Statistical analysis was done by IBM SPSS Statistics for Windows, Version 23.0. Armonk, NY: IBM Corp.

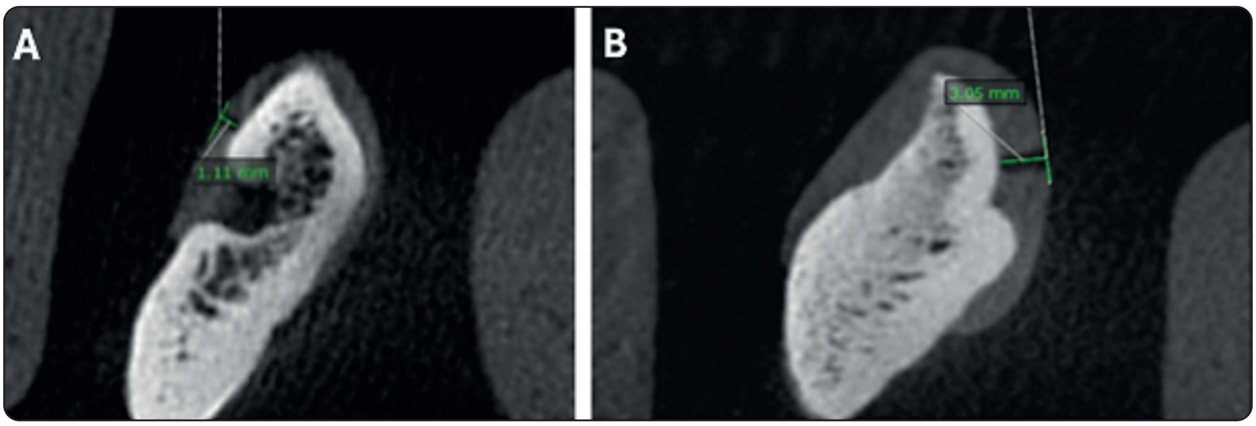

Fig. (1) Shows (A) the thickness of 1 mm pink baseplate wax measured with the OnDemand3D software in the buccal region of the mandible's premolar area. (B) the thickness of 3 mm pink baseplate wax measured with the OnDemand3D software in the lingual region of the mandible's midline area. Both images' measurements are taken with OnDemand3D software. Note simulation of cheek and tongue on both images.

RESULTS

This table shows that with a FOV of 50 × 100 mm and a gingival thickness of 1 mm on both the buccal and lingual sides, there was no statistically significant variation between the 10 mA and 4mA currents; both exhibited statistically significantly higher measurements than the gold standard. However, for a gingival thickness of 3 mm on the buccal and lingual sides, there was no statistically significant variation in gingival thickness measurements between the 10 mA and 4 mA currents and the gold standard.

TABLE (1) Descriptive statistics and results of repeated measures ANOVA test for comparison between gingival thickness measurements of 1 and 3 mm with different currents of 4 and 10 mA.

Thickness	Side	50×100 mm FOV				Gold standard		P-value
		10 mA		4 mA		Mean	SD	
		Mean	SD	Mean	SD			
1 mm	Buccal	1.091	0.03	1.067	0.04	1	0	<0.001*
	Lingual	1.107	0.044	1.067	0.042	1	0	<0.001*
3 mm	Buccal	2.976	0.036	3.006	0.053	3	0	0.128
	Lingual	3.019	0.017	3.037	0.026	3	0	0.054

: Significant at $P \leq 0.05$, Different superscripts in the same row indicate statistically significant difference between currents.

DISCUSSION

CBCT can be used as a non-invasive manner to visualize the gingiva and detect the gingival thickness. Intrinsic image quality of CBCT has a significant impact on diagnostic accuracy. There is a direct correlation between image quality and tube current.

In this study, when 1 mm < 2 mm wax thickness in the buccal and lingual sides was scanned with 4 and 10 mA currents and FOV 50 × 100, it showed statistically significantly higher measurements than the gold standard, which is compatible with **Latifi et al., 2023** who assessed the precision of assessing the soft tissue thickness by CBCT utilizing a FOV of 8 × 11 cm and a current of 3 mA. They detected significant differences between digital caliper measurements and CBCTs for thicknesses of less than 2 mm. The accuracy of measurements varied according to gingiva thickness, with a digital caliper being more accurate for thinner tissue and high-resolution CBCT imaging for thicker tissue.

In addition, these results are compatible with **Gkogkos et al., 2020** who used FOV 8 × 9 cm and a 5-mA tube current. CBCT measurements were higher than trans-gingival probing at the left central incisor.

In contrast, **Gupta et al., 2024 and Gürlek et al., 2018** used 4 mA and FOV 100 × 100 mm; FOV 100 × 120 mm and 75 mA, respectively; they found there was no significant variation in measurements between transgingival probing and CBCT. The difference in results may be attributable to variations in other CBCT settings like voxel size and exposure time, observer performance, and software used. In addition, all these studies didn't compare CBCT accuracy among different gingival thicknesses or exposure parameters.

As a result of past research considering different gingival thicknesses, CBCT performance decreased in measuring soft tissue as gingival thickness reduced, which can be attributed to observer performance that relies on the sub-millimeter measurement sensitivity of tools of CBCT software. So thin gingiva to be correctly measured necessitates a high-resolution screen and user-friendly measuring software **(Shao et al., 2018 and Sönmez et al., 2021).**

In this study, 3-mm (>2 mm) wax thicknesses on the buccal and lingual sides showed no statistically significant variation between gingival thickness measurements and the gold standard when scanned by FOV 50 x 100 mm and 4 and 10 mA tube currents. These results are compatible with **Sönmez et al., 2021** who used limited FOVs with 5 and 7 mA, and **Moussa et al., 2024** who used FOV 80 × 80 mm and 8 mA. They found there was no significant variation between CBCT and transgingival measures.

CONCLUSIONS

Both 4 and 10 mA with a small FOV of 50 × 100 mm are more recommended for measuring gingival thickness of 3 mm but less recommended for measuring gingival thickness of 1 mm.

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