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Influence of CBCT Different Radiation Doses on Mandibular Soft Tissue Thickness Measurements

(Diagnostic Accuracy Study)

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KEYWORDS

Influence of CBCT, Radiation, Mandibular Soft Tissue

ABSTRACT:

Purposes: 1. Study the influence of changing CBCT radiation doses (using ultra low dose and high dose systems) on soft tissues thickness measurements and compare the results with the direct measurements method.2. Compare the influence of this change in the CBCT radiation doses on the hard tissues measurements

Methods: 9 fresh pig mandiblue were utilized for each of two CBCT scan systems (Planmeca Promax 3D MID). Nine disposable needles were inserted into the gingival tissue of each jaw until reaching resistance from the underlying bone. A mark on each needle at its entrance point into the soft tissue was created using a permanent marker. Jaws were scanned twice, using ultra low (Rad UL) and high (Rad H) exposure times. The needles were extruded, and an electronic caliper was used to measure the length of the penetrated portion of the needle in mm. Radiographic GT was measured on cross sectional images, produced in the axial direction of the 3D location of the needles. Statistical analysis was performed with SPSS 16 ® (Statistical Package for Scientific Studies), Graph pad prism & windows excel and presented in 3 tables and 2 graphs. Exploration of the givendata was performed using Shapiro-Wilk test and Kolmogorov-Smirnov test for normality which revealed that data originated from normal data distribution. Accordingly, comparison between different groups was performed by Repeated measures ANOVA test followed by Tukey`s Post Hoc test for multiple comparison. The significance level was set at $p \leq 0.05$.

Results: The Real Measurement group (8.61 ±1.90) was significantly the highest, then the High-Definition group (7.22 ± 2.27), while the Low-Definition group (6.99 ± 2.15) was significantly the highest with P= 0.02.In Pairwise comparison between the Real Measurement group and the High-Definition group revealed insignificant difference as P= 0.062 • Comparison between the Real Measurement group and the Low-Definition group revealed significant difference between them as P=0.08 • Comparison between the High-Definition group and the Low-Definition group revealed insignificant difference between them as p-value = 0.8574.

Conclusions: Reducing CBCT radiation may be possible without affecting accuracy of radiographic gingival thickness measurements, thus opening the way to a wider utilization of CBCT in dentistry. Clinical relevance: Reducing radiation dose may enable a wider utilization of CBCT in dentistry.

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Introduction

Periodontal biotype identification in patients has a fundamental role in optimal planning of preventive and therapeutic management in periodontology, implantology, orthodontics and dental prosthetics. Periodontium soft tissue thickness, called gingival thickness (GT) is consider an essential factor that has influence on a periodontal biotype assessment. **(Sala et al.,2018)**

The influence of the gingival thickness seems to be an important factor to take into account in determining the line of dental treatment as it plays an important role in wound healing in regenerative surgical procedures. (**Vervaeke et al. ,2014)**

Also, soft tissue thickness measurement has also been important, in periodontal plastic surgery which have been performed to correct or eliminate the traumatic, anatomic, or developmental deformities of the gingiva or alveolar mucosa. **(Gupta et al. ,2016)**

In an attempt to assist with treatment planning, less invasive techniques to determine the thickness of biotypes has been developed, transgingival probing, ultrasonic, and recently CBCT. Measurement of gingival thickness are most commonly carried out using a periodontal probe under local anesthesia, or by more precise method of transgingival probing (TGP) using an endodontic tool with a rapper stopper . **(Gupta et al. ,2016)**

Cone beam computed tomography (CBCT) is a relatively new 3D extra-oral imaging system which was specifically developed to overcome the limitations of 2D periapical radiographs as it produces undistorted 3D information of the maxillofacial skeleton with a lower radiation dose has been compared to conventional CT Consequently, CBCT has the potential to become non-invasive diagnostic instrument for various dental applications in which defect characterization, localization and volume measurements are important. **(Sala et al.,2018)**

Recently, the use of cone beam computed tomography (CBCT) has been proposed as a state of the art approach for assessing periodontal biotypes because it provides information relative to both soft and hard tissue dimensions as reported by several studies which used CBCT to assess delicate gingival soft tissue by retracting them. **(Gupta et al.,2015 , Sala et al.,2018 and panda et al.,2019)**.

In addition to accurately representing clinical measurements, data has been obtained from CBCT scans may be more accurate than that obtained from transgingival probing, because pressure from a periodontal probe or needle may cause tissue distortion during application of the technique. **(Gupta et al. ,2016)**

However, despite the abundance of literature proclaiming the accuracy of CBCT scans in determining the different linear hard tissue measurements, until recently there has been little work investigating the accuracy of CBCT imaging of periodontal biotype determination and measurements. **(Aswapati et al. ,2017)**

Barriviera et al. ,2009, recently described a technique using CBCT that accurately visualized the dimensions of the palatal masticatory mucosa, thus enabling the clinician to make linear measurements of the soft tissue covering the palate. Also **Januário and coworkers 2018,** described a novel approach for visualizing gingiva via CBCT enabling them to measure the distance between the gingival margin and the alveolar crest as well as the width of the facial gingiva (biotype).

Khateeb et al 2022, CBCT systems have predefined protocols using various exposure times; however, there is currently no data on the effect of the lower exposure setting on soft tissue measurements. The importance of the study lies in the additional benefit to patients in using reduced radiation dose for soft tissue measurements alongside the principal indication of hard tissue diagnosis Therefore, the aim of the present study was to measure gingival thickness, both directly and in CBCT using various exposure times, and compare them.

Materials and methods

For this study, Nine (9) mandibular pig jaw were used. The test sites were confined to the soft tissue around the posterior teeth. Three parameters were tested, using: a) DICOM viewer (Planmeca Promax 3D MID) using a ultra dose scan , b) DICOM viewer (Planmeca Promax 3D MID) using a high dose scan, c) Modified Trans-gingival using a needle technique and measuring caliper.

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Radiographic examination and soft tissue thickness measurements using CBCT:

Radiographic markers made of radiopaque composite (Charmfil plusA3; Dentsply, Korea) were applied to the buccal and lingual enamel cusps of each posterior tooth. Needles were inserted into the gingival tissue of the jaw until reaching resistance from the underlying bone. A mark on each needle at its entrance point into the soft tissue was made, using a permanent marker. Next, the jaws were scanned twice, using two scan protocols, defined as Ultra low exposure (Rad UL) and High exposure (Rad H) protocols. CBCT (PlanmecaRomax 3D MID) (Fig 1). CBCT (UL) using (2) mA, (100) Kvp, and effective exposure time 3.22 s,while CBCT (H) using (8) mA, (100) Kvp, and effective exposure time 3.12 s, Where upper light beam indicated the top of the field of view (FOV), and another lower light beam indicated the bottom of the FOV and reconstructed cross section CBCT images were obtained .Then Romax software was used for analysis and measurements.

Fig 1: A CBCT (Planmeca Romax 3D MID) with pig jaw

Soft tissue thickness measurements by using Romax software:

First, based on the acquired image data and following transfer into DICOM format, manipulation of CBCT data, using Planmeca software was done. A panoramic curve was drawn at the crystal end of the bone and parallel to the buccal cortical bone. Cross sectional images were obtained perpendicular to that curve. The scan orientation was prepared to adjust all the scans in the same orientation. To align CBCT section and actual measurement as close as possible, we chose a middle cross section cut. The needles were identified in the CBCT by adjusting the cross sectional view parallel to the axis of the needle.(Fig 2)

Radiographic gingival thickness (in millimeters) was measured on cross sectional images, produced in the 3D location of the needles (Rad UL and RadH). All measurements were performed twice. (Fig 2,3)

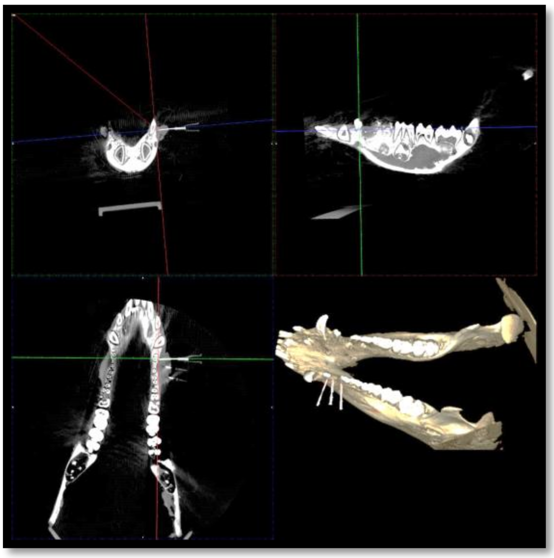

Fig 2: Adjusting the cross sectional view parallel to the axis of the needle

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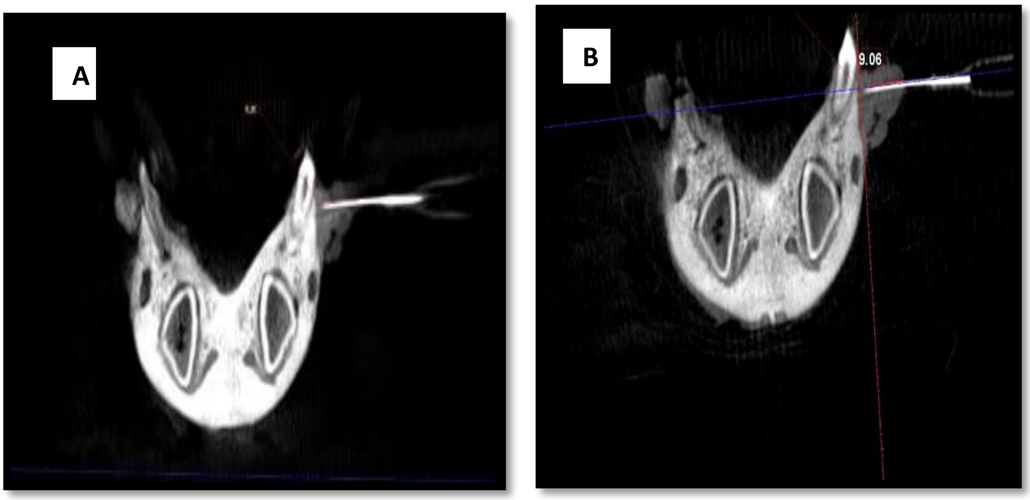

Fig3: Cross section CBCT image, Measurements were done using a Ultra Low dose (a), High dose (b)

Gold standard measurement using transgingival needle:

For the measurement of soft tissue thickness, a total of 64 selected points in soft tissue were investigated in one jaw. In order to measure the thickness of gingiva using trans-gingival Needle (TGN) direct measurements were taken by the digital caliper (Shenhan Measuring Tools Co., LTD, Shanghai].Following scanning, the needles were extruded, and an electronic caliper was used to measure the length of the penetrated portion of the needle in millimeters.(Fig 4)

Fig 4 : (B) Digital caliper was used to measure the distance represent the soft tissue thickness

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Statistical Analysis:

Statistical analysis was performed with SPSS 16 ® (Statistical Package for Scientific Studies), Graph pad prism & windows excel and presented in 3 tables and 2 graphs. Exploration of the given data was performed using Shapiro-Wilk test and Kolmogorov-Smirnov test for normality which revealed that data originated from normal data distribution. Accordingly, comparison between different groups was performed by Repeated measures ANOVA test followed by Tukey`s Post Hoc test for multiple comparison. The significance level was set at p ≤0.05.

Research Ethics Committee:

this study was approved by the ethics committee of the faculty of dentistry - Misr University for science and technology.

Results:

Table (1) and figure (5) presents descriptive statistics of real measurements, high definition , and low-definition measurements. The table displays the minimum, maximum, median, range, mean, and standard deviation values.

Table (1): Descriptive results of real measurements, high definition, and low-definitionmeasurements.

	Minimum	Maximum	Median	Range	Mean	Standard Deviation
Real Measurement	6.00	12.00	9.00	6.00	8.61	1.90
High Definition	4.62	11.40	6.40	6.78	7.22	2.27
Low Definition	4.01	10.79	7.20	6.78	6.99	2.15

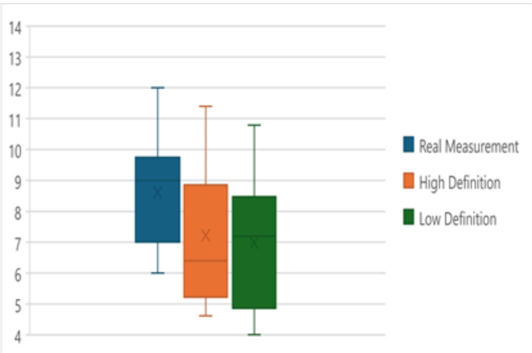

Figure (5): Boxplot representing descriptive results of real measurements, highdefinition, and low definition.

Comparison between Real Measurement, High Definition, andLow Definition (RM One Way ANOVA test):

The Real Measurement group (8.61 ±1.90) was significantly the highest, then the High-Definitiongroup (7.22 ± 2.27), while the Low-Definition group (6.99 ± 2.15) was significantly the highest with P= 0.02, as presented in table (2) and figure (6).

Table (2): Repeated measures ANOVA to compare between group:

	Mean	Standard Deviation	RM One Way ANOVA
Real Measurement	8.61	1.90	0.051
High Definition	7.22	2.27	
Low Definition	6.99	2.15	

*Significant difference as P<0.05.

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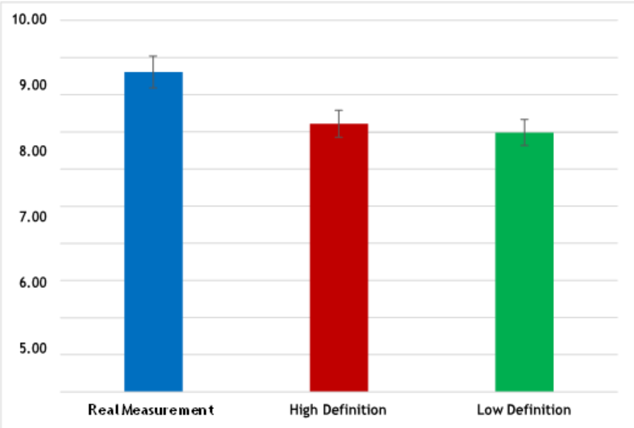

Figure (6): Bar chart represents all groups.

Pairwise comparison :

Pairwise comparison between different groups was performed by using Tukey`s Post Hoc test aspresented in table (3), and revealed that:

- Comparison between the Real Measurement group and the High-Definition group revealed insignificant difference as P= 0.062
- Comparison between the Real Measurement group and the Low-Definition grouprevealed significant difference between them as P=0.08
- Comparison between the High-Definition group and the Low-Definition group (revealed insignificant difference between them as p-value = 0.8574.

Table (3): Pairwise comparisons:

Tukey's multiple comparisonstest	Mean 1	Mean2	MeanDiff.	SE ofdiff.	95.00% CI of diff.	AdjustedP Value
Real Measurement vs. HighDefinition	8.611	7.221	1.39	0.5136	-0.07766 to 2.858	0.0625
Real Measurement vs. LowDefinition	8.611	6.987	1.624	0.6417	-0.2092 to 3.458	0.0808
High Definition vs. LowDefinition	7.221	6.987	0.2344	0.4395	-1.021 to 1.490	0.8574

Discussion:

In the present study, there was a good correlation between clinical and radiographic measurements of gingival thickness and essentially no significant difference between higher and lower doses in an experimental model consisting of pig jaws. CBCT use in the dental profession has been constantly on the growth in recent years, increasing patient exposure to radiation hazards. Therefore, the aim of reducing radiation doses is of increasing importance and the present study results present a promising opportunity. The significant associations between soft tissue thickness and outcomes of periodontal treatments such as root coverage procedures [4] and implant therapy [13,14], highlight the importance of pre-treatment soft tissue assessment. CBCT is principally used for evaluating hard tissues but may be potentially used for non-invasive soft tissue evaluation as a secondary outcome. There have been several attempts to find an alternative to the invasive trans-gingival needle technique with varying success. Poor to weak agreement was found between photo assessment, a periodontal probe inserted inside the sulcus; and the real thickness measured with a needle [15]. In a human study there were no significant differences between a digital caliper (invasive measurement) and ultrasonography [16], however, this method may be suitable only in experimental settings and not in clinical practice. Measuring radiographic gingival thickness was already shown to be accurate in a pig jaw model using a high-resolution high radiation dose [17]. In a study by Alves et al. comparing probe transparency,

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transgingival assessment (needle), photographic assessment and CT scanning in 12 patients, the best correlation was found between the CT and the trans-gingival method [18]. These results are in correlation with our study, in which differences between Cli and Rad were not statistically significant. In contrast, there were significant differences between CBCT and trans-gingival measurements with an acupuncture needle in an ex-vivo study that evaluated gingival thickness on incisors in 20 porcine mandibles [10]. The clinical significance, however, seems to be negligible (the mean difference CBCT-needle being 0.14mm). Efforts to reduce radiation dose are constantly being done in various medical disciplines such as orthopedics [19], trauma [20] as well as the dental field [21]. It seems that dose reduction is usually achieved by amperage reduction, use of partial rotations, reducing the number of projections, and increasing voxel sizes, but seldom by kV reduction or exposure time reduction [21]. In a 2016 systematic review of CBCT exposure parameters, mixed results were reported, but in the majority of studies altering the exposure parameters, including exposure time, had no impact on diagnostic accuracy or pathology detection [22]. In this review soft tissue assessment was not reported. Also, the authors graded most of the included studies as having a low/very-low GRADE score [23]. Since there is a 100 times difference in effective doses for different CBCT devices between the lowest and highest recommended doses [24], and considering all the above, further efforts should be made in low-dose radiation research. In spite of the advantage of reduced radiation caution should be exercised when interpreting the results of the present study. CBCT was performed on maxillae and not entire heads, therefore there was significantly less interference from adjacent anatomical structures. Patients, differently from pig jaws, may have metal in dental implants and restorations, which produce significant artefacts that may affect radiographic interpretation. Cheek inflation during CBCT acquisition, similar to the study of Alves et al. (the patients closed their lips together and inflated their mouth during the scan to move cheek and lips away from the jaws) may be helpful in demarcation and separation of the gingiva from other soft tissues, thus improving accuracy. Finally, considering the wide variety of CBCT devices and protocols, the results of the present study should not be directly extrapolated to other CBCT systems. Further studies on methods to reduce radiation dose should assess CBCT image quality from regarding technical image quality as well as the diagnostic point of view. The strenght of the present study is its uniform data collection while the major weakness is the in vitro nature of the study which excluded some major confounders, such as patient movement, artifacts that may affect clear identification of gingival margins (dental restorations, lips, cheeks). Therefore further clinical studies should be performed before extrapolating the results to clinical practice. In conclusion, reduction in radiation dose during CBCT scans may be possible without affecting accuracy of radiographic gingival thickness measurements and thus opens the way to a wider utilization of CBCT in dentistry

conclusion

Reduction in radiation dose during CBCT scans may be possible without affecting accuracy of radiographic gingival thickness measurements and thus opens the way to a wider utilization of CBCT in dentistry.

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this study received no external funding.

Conflict of interest:

The authors declare that they have no competing interests.

References:

1. **Aguilar-Duran L, Mir-Mari J, Figueiredo R, Valmaseda-Castellón E.(2020).** Is measurement of the gingival biotype reliable? Agreement among different assessment methods. Med Oral Patol Oral Cir Bucal. Jan 1;25(1):e144-e149.
2. **Alves PHM, Alves TCLP, Pegoraro TA, Costa YM, Bonfante EA, de Almeida ALPF.(2018)**.Measurement properties of gingival biotype evaluation methods. Clin Implant Dent Relat Res.Jun;20(3):280-284.
3. **Giannobile WV, Jung RE, Schwarz F (2018).** Groups of the 2nd Osteology Foundation Consensus Meeting. Evidence-based knowledge on the aesthetics and maintenance of peri-implant soft tissues: Osteology Foundation Consensus Report Part 1-Effects of soft tissue augmentation

procedures on the maintenance of peri-implant soft tissue health. Clin Oral Implants Res. Mar;29 Suppl 15:7-10.

4. **Goulston R, Davies J, Horner K, Murphy F(2016).** Dose optimization by altering the operating potential and tube current exposure time product in dental cone beam CT: a systematic review. Dentomaxillofac Radiol.;45(3):20150254.

5. **Guyatt GH, Oxman AD, Vist GE, Kunz R, Falck-Ytter Y, Alonso-Coello P, Schünemann HJ** (2008) GRADE Working Group. GRADE: an emerging consensus on rating quality of evidence and strength of recommendations. BMJ. 2008 Apr 26;336(7650):924-6.
6. **Holtzman LP, Blasi G, Rivera E, Herrero F, Downton K, Oates T.(2021).**Gingival Thickness and Outcome of Periodontal Plastic Surgery Procedures: A Meta-regression Analysis. JDR Clin Trans Res. 2021 Jul;6(3):295-310.
7. **Hooper T, Eccles G, Milliken T, Mathieu-Burry JR, Reed W**.(2019). Dose reduction in CT imaging for facial bone trauma in adults: A narrative literature review. J Med Radiat Sci. 2019 Jun;66(2):122-132.
8. **Lau SL, Chow LK, Leung YY** (2016). A Non-Invasive and Accurate Measurement of Gingival Thickness Using Cone-Beam Computerized Imaging for the Assessment of Planning Immediate Implant in the Esthetic Zone-A Pig Jaw Model. Implant Dent. Oct;25(5):619-23.
9. **Sharma S, Thakur SL, Joshi SK, Kulkarni SS**. Measurement of gingival thickness using digital vernier caliper and ultrasonographic method: a comparative study. J Investig Clin Dent. 2014 May;5(2):138-43.
10. **Tavelli L, Barootchi S, Avila-Ortiz G, Urban IA, Giannobile WV, Wang HL.** Peri implant soft tissue phenotype modifi cation and its impact on peri-implant health: A systematic review and network meta-analysis. J Periodontol. 2021 Jan;92(1):21-44.
11. **Yel I, Booz C, Albrecht MH, Gruber-Rouh T, Polkowski C, Jacobi M, Lenga L, Schulz M, Frank J, Marzi I, Vogl TJ, Eichler K, Kaltenbach B.** Optimization of image quality and radiation dose using different cone-beam CT exposure parameters. Eur J Radiol. 2019 Jul;116:68-75
12. **Yeung AWK, Jacobs R, Bornstein MM**. Novel low-dose protocols using cone beam computed tomography in dental medicine: a review focusing on indications, limitations, and future possibilities. Clin Oral Investig. 2019 Jun;23(6):2573-2581.
13. **Bornstein MM, Scarfe WC, Vaughn VM, Jacobs R.** Cone beam computed tomography in implant dentistry: a systematic review focusing on guidelines, indications, and radiation dose risks. Int J Oral Maxillofac Implants. 2014;29 Suppl:55-77.
14. **Sala L. , Alonso-Pérez R., Agustin-Panadero R., Ferreiroa A. & de-Albornoz a. c. (2018).** Comparative in vitro study of two methods for gingival biotype assessment;10(9): 858–863.
15. **Vervaeke S, Dierens M, Besseler J, De Bruyn H. (2014).**The influence of initial soft tissue thickness on peri-implant bone remodeling. Clinical Implant Dental Research ;16:238–47.
16. **Gupta P, Jan SM, BehalR, MirRA, Shafi M.(2015).** Accuracy of cone-beam computerized tomography in determining the thickness of palatal masticatory mucosa. Journal Indian Soc Periodontol;19:396-400.
17. **Panda M, Jalaluddin MD, & Agrawal U (2019).** Soft perspectives of mucogingival soft tissue measurement methods," Journal of Esthetic and Restorative Dentistry;23, (3) :146–156, 52.
18. **Aswapati S and Dr. Swatika K.(2017).** Soft tissue thickness determination using CBCT in periodontics: A review: ; 3(3): 05-07.
19. **Barriviera M, Duarte WR, Janua'rio AL, Faber J, BezerraAC.(2009).**A new method to assess and measure palatal masticatory mucosa by cone-beam computerized tomography. Journal Clinical Periodontol;36(7):564-568.
20. **Khateeb H, Machtei EE, Horwitz J (2022)** The effect of radiation dose on CBCT measurements of maxillary gingival thickness. Int J Oral Craniofac Sci 8(2): 026-031.