*International Journal of Dentistry Research 2022; 7(3): 73-77*

International Journal of Dentistry Research

***Research Article***

ISSN: 2581-3218
IJDR 2022; 7(3): 73-77
Received: 22-10-2022
Accepted: 18-12-2022

www.dentistryscience.com
doi: 10.31254/dentistry.2022.7307

# Evaluation of the Buccal Cortical Bone Thickness in Class II Malocclusion for Mini-Implant Insertion: a CBCT Study

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## Abstract

**Background:** This study aimed to evaluate the buccal cortical bone thickness of the Iraqi population for mini-implant insertion using cone-beam computed tomography (CBCT). **Methods:** This cross-sectional study was conducted on maxillary and mandibular CBCT scans of 40 patients (14-25 years). One examiner measured skeletal parameters at 4, 6 and 8 mm apical to the cementoenamel junction (CEJ). **Results:** the largest buccal cortical bone thickness in the maxilla was between the first and second molar (1.36mm for males, 1.24mm for females) and in the mandible was between the first and second molar (2.17mm for males, 2.37 for female). **Conclusions:** The buccal cortical bone thickness varies in different individuals. In the mandible, the buccal cortical bone thickness was increased as we move from the anterior to the posterior area. The buccal Cortical bone thickness is thicker in the mandible compared to the maxilla.

**Keywords:** Cone-beam computed tomography, Mini-implant, Orthodontic anchorage procedures, Buccal cortical bone thickness.

**INTRODUCTION**

Orthodontic mini-implants have gained popularity in recent years that are supported by the bones[1]. One of the continuing difficulties for orthodontists is the preservation of the anchorage unit. Intra-oral or extra-oral locations are used in traditional procedures. Extraoral methods are used to provide the best therapy results, however, extra oral Anchorage is difficult to use and usually requires the patient's compliance[2]. Mini implants provide several advantages, including ease of placement and removal, quick loading, use in a variety of sites, absolute anchorage, cost-effectiveness, and reduced patient cooperation[3].

The thickness of the cortical bone is important because it is the primary predictor of a mini implant's initial stability. In the posterior dentition, approximately 1 mm or more of cortical bone thickness can be expected in the alveolar process[4].

Finite element analysis suggested that the cortical bone received the majority of the force when a lateral force was applied to the mini implant[5]. The primary stability of the mini implant depends on mechanical retention between it and bone. Cortical bone thickness is important in the success of mini implant because insufficient cortical bone thickness often causes inadequate primary stability[6]. To achieve sufficient primary stability, Motoyoshi et al. discovered that cortical bone thickness should be greater than 1 mm and is deeply linked with the success rate of mini implant[7].

Two important components define the stability of orthodontic mini-implants: Primary stability is accomplished through mechanical attachment between the bone and the mini-implants, and secondary stability is produced by continued bone remodeling surrounding the implant[8]. Since cortical bone has a greater bone-implant contact area than the trabecular bone of bone marrow, dental implants performed better when implanted in a location with higher bone density (cortical bone) rather than in a region with less bone density (bone marrow)[9].

When a mini-implant is clinically movable at the time of placement, it is considered a primary failure. This is related to insufficient cortical bone support in terms of thickness and density, or the closeness of a mini-implant to a neighbouring tooth root. Secondary failure is a situation in which a mini-implant is initially stable but subsequently becomes mobile after 1–2 months. Bone necrosis surrounding the mini-implant threads causes delayed instability, which can be caused by thermal bone injury (during pilot drilling), high

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insertion torque, extremely close contact to a tooth root, traction overload, or a combination of these factors[10].

When the Cortical Bone Thickness is lowered, oblique insertion offers proper cortical bone engagement. The cortical bone had a high-stress distribution, while the cancellous bone had a low-stress distribution. It was also concentrated at the apex of the threads that come in contact with the cortical bone[11]. To increase the contact area between the implant and the cortical bone when the cortical bone thickness is lowered (1 mm), 30 degrees of insertion is recommended. When the cortical bone thickness is adequate (2 mm), a 90-degree insertion angle is recommended, as a 30-degree insertion angle might create microcracks and necrosis in the cortical bone, resulting in mini-implant failure[12].

The role of the mini-implant in Class II correction procedures is recommended to begin after the permanent dentition has erupted, and include En masse retraction, Fixed functional appliances, Molar distalization and Support for retraction after extraction. Mini implant anchorage has enhanced predictability for the correction of Class II malocclusions. Whether using direct anchorage retraction or indirect anchorage retraction[13].

## MATERIAL AND METHOD

### Sample

The sample was obtained from records at al Noor specialized dental centre, in Mosul, Iraq. The study included participants who were referred for CBCT assessment in Radiology Unit for different dental procedures. The records were collected between April and June 2022. All of these images were taken by using the same CBCT machine and the same technician. We informed the patient that CBCT information will include in my research. The study protocol was approved by the ethics committee of the college of dentistry, Mosul University and also by the ethics committee of Nineveh health directorate, Iraq. The study involved a total of 40 individuals (19 male, 21 female) who met the following research requirements: males and females with ages ranging (from 14-25 years old), CBCT scans with all maxillary and mandibular teeth, CBCT images of good quality without artefacts, Complete eruption of second permanent molars[14], No missing, rotated, malformed teeth[14], No orthodontic treatment before[14], no periodontal disease and alveolar bone loss, absence of severe skeletal discrepancy, no congenital missing (except for third molars), absence of severe crowding, No dental spacing, absence of developmental anomalies such as cleft lip and palate, or syndrome[15], no rotations and developmental malformations[16]. Any patient who did not meet any of the aforementioned criteria was ruled out.

The cone beam computed tomography apparatus used was 8100carestream (Carestream Health, Inc.) the scanning was at dual jaw used for all patients at 90 kV, 2.5mA and exposure time 15 seconds and voxel size 150um and software used for taking image was Acquisition Interface that designed and developed specifically for the CS 8100. CS 3D Imaging v3.8.7 software was used to perform CBCT analyses. Using measuring software tools millimetric ruler was provided with the software to measure the buccal cortical bone thickness in the maxilla and the mandible[16].

### Patients, Materials, and Methods

Image acquisition: Before radiation exposure, the patient was instructed to remove any metal object that could interfere with imaging like hairpins, jewelry, eyeglasses, etc. Ask the patient to wear a lead apron. The patient then stood inside the CBCT unit and bite on the bite block (supply with CBCT machine) with new cleared protective sheaths. The head position is adjusted from the positioning panel so that the area of interest is centred in the beam (patient midline will coincide with machine midline). The head was stabilized with a headrest and chin rest so that the Frankfort horizontal plane is parallel with the floor. The patient's head was located between the X-ray source and the late panel detector. Hand's patient Grip both the lower handles of the head and chin rest. The patient was instructed to avoid any head movement, don't open their mouth with mild breathing during the exposure time. Scanning is started with an X-ray tube- flat penal sensor rotation 360 degrees around the patient's head. we informed the patient that the machine will be rotated during the scan which is normal, and instructed the patient to remain stable

Image analysis: The CBCT images were evaluated by the CS 3D Imaging V3.8.7 software program. To reduce measurement errors caused by nonstandard head postures, all images were oriented according to a standardized procedure, The horizontal axis was parallel to the palatal plane. The nasal septum was aligned parallel to the vertical axis. The angle of slicing would be changed as a result[17].

Detection and measurement: CBCT images were analyzed on The axial, sagittal and coronal sections to describe the buccal cortical bone thickness (from the second molar on one side to the second molar on the opposite side) for both maxillary and mandibular arches at 6 inter radicular sites for each side at 3 levels (4mm, 6mm, 8 mm respectively from CEJ).

At sagittal view: we determine the three levels for measurements for each tooth. The cementoenamel junction act as a referenced point because it is more reliable to detect in the radiograph, so the levels were at 4mm, 6mm, and 8mm from CEJ [14] as shown in figure 1.

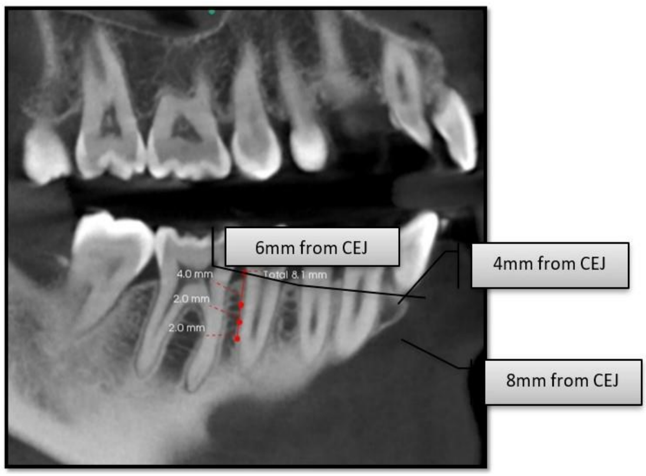


**Figure 1:** Radiophotograph shows levels for measurement

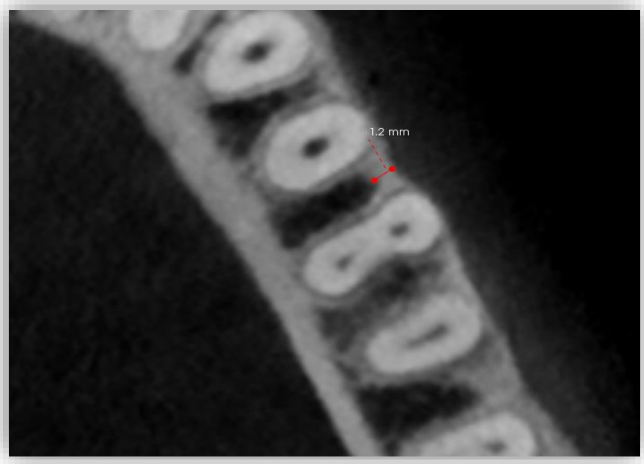


**Figure 2:** Radiophotograph show the buccal cortical bone thickness between lower premolar and molar

After we decided on the levels we go to the axial view. At axial view, we measured the buccal cortical bone thickness for each level. we measured the distance between the internal and external aspects of the buccal cortex in the middle of the inter-radicular distance between every two adjacent teeth [17] as shown in figure 2.

**Reliability of measurement**

To assess measurement reliability, 10 randomly selected cases were used to measure the buccal cortical bone thickness at randomly selected sides and levels.

Intra-examiner reliability was tested by repeating the measurements after 2 weeks intervals. Statistical comparison of the measurements obtained in these 2 periods using paired t-test showed no significance.

**RESULTS**

We calculated the means and standard deviations of the buccal cortical bone thickness. Shapiro-Wilk's test revealed a normal distribution of the data. We used Paired Samples Test to compare between right and left sides. One Way Analysis of Variance (ANOVA) and Duncan's multiple range analysis tests were used to compare 3 levels of the buccal cortical bone thickness. All statistical analyses were carried out by the SPSS software program (version 20; SPSS Inc., Chicago, IL, USA). The Comparison between the right and left side was no significant differences either in maxilla or mandible, so we deal with it as one side in statistic and display the date, one for the maxilla and one for the mandible.

**Buccal cortical bone thickness in maxilla for males:**

Buccal cortical bone thickness showed an increased value on moving from 4 mm level to 8 mm level in all sites and the degree of differences was small between levels, so this increase was not significant at p-value< 0.05 except there were significant differences at the site (1-2), (2-3) between level 4mm from CEJ and level 8mm from CEJ as shown in table 1.

**Table 1:** Comparison between buccal cortical bone thickness for maxilla in male

| Maxilla measurement for male | | | | | |
|---|---|---|---|---|---|
| Site | Levels | Mean | F-value | P-value | Duncan grouping |
| 1-2 | 4mm | 0.85 | 3.744 | 0.029 | A |
| | 6mm | 1.00 | | | AB |
| | 8mm | 1.05 | | | B |
| 2-3 | 4mm | 0.85 | 2.958 | 0.059 | A |
| | 6mm | 0.95 | | | AB |
| | 8mm | 0.85 | | | B |
| 3-4 | 4mm | 1.08 | 0.623 | 0.539 | A |
| | 6mm | 1.09 | | | A |
| | 8mm | 1.18 | | | A |
| 4-5 | 4mm | 1.04 | 0.432 | 0.651 | A |
| | 6mm | 1.06 | | | A |
| | 8mm | 1.13 | | | A |
| 5-6 | 4mm | 1.06 | 0.007 | 0.993 | A |
| | 6mm | 1.07 | | | A |
| | 8mm | 1.07 | | | A |
| 6-7 | 4mm | 1.27 | 0.248 | 0.781 | A |
| | 6mm | 1.28 | | | A |
| | 8mm | 1.36 | | | A |

**Buccal cortical bone thickness in maxilla for females:**

Buccal cortical bone thickness showed an increased value on moving from 4 mm level to 8 mm level in all sites and the degree of differences was small between levels, so this increase was not significant at p-value< 0.05 except there were significant differences at the site (1-2), (2-3) between level 4mm,6mm from CEJ and 8mm from CEJ and site (3-4) between level 4mm from CEJ and level 6mm, 8mm from CEJ as shown in table 2.

**Table 2:** Comparison between buccal cortical bone thickness for maxilla in female

| Maxilla measurement for female | | | | | |
|---|---|---|---|---|---|
| Site | Levels | Mean | F-value | P-value | Duncan grouping |
| 1-2 | 4mm | 0.83 | 7.781 | 0.001 | A |
| | 6mm | 0.90 | | | A |
| | 8mm | 1.03 | | | B |
| 2-3 | 4mm | 0.87 | 8.061 | 0.001 | A |
| | 6mm | 0.93 | | | A |
| | 8mm | 1.07 | | | B |
| 3-4 | 4mm | 1.13 | 3.281 | 0.041 | A |
| | 6mm | 1.26 | | | B |
| | 8mm | 1.27 | | | B |
| 4-5 | 4mm | 1.03 | 1.127 | 0.327 | A |
| | 6mm | 1.10 | | | A |
| | 8mm | 1.25 | | | A |
| 5-6 | 4mm | 1.06 | 0.027 | 0.973 | A |
| | 6mm | 1.06 | | | A |
| | 8mm | 1.07 | | | A |
| 6-7 | 4mm | 1.16 | 0.584 | 0.559 | A |
| | 6mm | 1.17 | | | A |
| | 8mm | 1.24 | | | A |

**Buccal cortical bone thickness in the mandible for males:**

Buccal cortical bone thickness showed an increased value on moving from 4 mm level to 8 mm level in all sites and the degree of differences was small between levels, so this increase was not significant at P-value < 0.05 for most sites except in males there was significant differences at the site (1-2) between level 4mm from CEJ and level 8mm from CEJ and also the site (4-5) between 4mm,6mm from CEJ and level 8mm as shown in the table 3.

**Buccal cortical bone thickness in the mandible for female**

Buccal cortical bone thickness showed an increased value on moving from 4 mm level to 8 mm level in all sites, and there were significant differences at all sites except in sites (1-2) and (6-7) for all levels as shown in table 4.

**DISCUSSION**

From the biomechanical consideration, the range of buccal cortical bone thickness values between 1.0 to 2.0 mm will be appropriate for mini implant therapy.

For mini-implant stability, the cortical bone thickness of at least 1 mm is required. Sawada et al. proposed that There was a tendency for the superior part of the alveolar process to be thicker than the inferior part of the maxilla when assessed cortical bone thickness. Therefore, insertion in the region above the alveolar process is recommended whenever it is possible. However, the nasal cavity, maxillary sinus, and transitions from the attached gingiva to the alveolar mucosa must all be considered. In order to ensure safe insertion[18].

**Table 3:** Comparison between buccal cortical bone thickness for mandible in male

| Mandible measurement for male | | | | | |
|---|---|---|---|---|---|
| Site | Levels | Mean | F-value | P-value | Duncan Group |
| 1-2 | 4mm | 0.79 | 6.331 | 0.003 | A |
| | 6mm | 0.91 | | | AB |
| | 8mm | 1.03 | | | B |
| 2-3 | 4mm | 1.00 | 0.175 | 0.840 | A |
| | 6mm | 1.04 | | | A |
| | 8mm | 1.12 | | | A |
| 3-4 | 4mm | 1.24 | 2.099 | 0.130 | A |
| | 6mm | 1.33 | | | A |
| | 8mm | 1.49 | | | A |
| 4-5 | 4mm | 1.37 | 3.604 | 0.032 | A |
| | 6mm | 1.44 | | | A |
| | 8mm | 1.72 | | | B |
| 5-6 | 4mm | 1.47 | 2.069 | 0.134 | A |
| | 6mm | 1.52 | | | A |
| | 8mm | 1.79 | | | A |
| 6-7 | 4mm | 1.91 | 1.000 | 0.373 | A |
| | 6mm | 1.97 | | | A |
| | 8mm | 2.17 | | | A |

**Table 4:** Comparison between buccal cortical bone thickness for mandible in female

| Mandible measurement for female | | | | | |
|---|---|---|---|---|---|
| Site | Levels | Mean | F-value | P-value | Duncans group |
| 1-2 | 4mm | 0.94 | 0.489 | 0.615 | A |
| | 6mm | 1.01 | | | A |
| | 8mm | 1.07 | | | A |
| 2-3 | 4mm | 0.91 | 8.722 | 0.000 | A |
| | 6mm | 1.04 | | | B |
| | 8mm | 1.17 | | | C |
| 3-4 | 4mm | 1.23 | 6.876 | 0.001 | A |
| | 6mm | 1.31 | | | A |
| | 8mm | 1.47 | | | B |
| 4-5 | 4mm | 1.36 | 8.516 | 0.000 | A |
| | 6mm | 1.48 | | | A |
| | 8mm | 1.65 | | | B |
| 5-6 | 4mm | 1.46 | 6.296 | 0.002 | A |
| | 6mm | 1.68 | | | B |
| | 8mm | 1.79 | | | B |
| 6-7 | 4mm | 2.18 | 1.410 | 0.248 | A |
| | 6mm | 2.25 | | | A |
| | 8mm | 2.37 | | | A |

In our study, the buccal cortical bone thickness was more than 1mm in most sites except (1-2) sites has less than 1mm.

there is a linear increase of cortical bone thickness from level 4mm to level 8mm from CEJ, This agrees with Alrbata et al., 2014 [19] but disagrees with Baumgaertel et al. who found that cortical bone thickness values were at the minimum in the middle and at the greatest in apical and coronal regions from CEJ[20, 21] this may be the difference in the methodology used and sample selected and included in studies. Baumgaertel and Hans measured 30 dry skulls whereas Kim et al. measured cortical bone thickness on 23 Korean cadavers. there is a linear increase in cortical bone thickness from anterior to posterior regions in both arches. In some sites and levels, the increase was not in an organised pattern, this may be due to occlusion force distribution, the thickness of cortical bone increase under functional occlusion because of the increase in the mechanical strain, which causes to increase in the response of alveolar bone, An experimental animal study stated that bone formation will happen in areas subjected to high strain and changing at fast rates[22].

The buccal cortical bone thickness in the mandible was greatest in the posterior region between the first and second molar (2.17 in males, 2.37 in females) and decreased progressively toward the anterior region between the central-lateral site that was (1.03 in males, 1.07 in female) this result consistent with Al Amri et al. [23]and also reported with Fayeda et al. 2010[17].

The highest buccal cortical bone thickness in the maxilla was(1.36 mm in males and 1.28 in females) at an 8 mm level from CEJ between the first and second molars. Generally, The buccal cortical bone thickness in this study increase when we move from (level 4mm from CEJ) to (level 8mm from CEJ) toward the apical area, this result agrees with Fayeda et al. 2010[17].

In our study, the cortical buccal bone thickness was higher in the mandible than maxilla in most sites this agrees with (Baumgaertel, 2007) who measured the cortical bone thickness at 2, 4, and 6 mm from the alveolar crest and said that Buccal cortical bone thickness was greater in the mandible than in the maxilla[20].

## CONCLUSION

A previous investigation is needed before mini-implant insertion. Buccal cortical bone thickness showed an increase in value on moving from coronal to the apical area in all sites and the degree of differences was small between levels, so this increase was not significant statistically. In mandible, the buccal cortical bone thickness was increased as we move from the anterior to the posterior area. The buccal Cortical bone thickness is thicker in the mandible compared to the maxilla.

**Conflict of Interest**

None declared.

**Financial Support**

None declared.

## REFERENCES

1. Ohiomoba H, Sonis A, Yansane A, Friedland B. Quantitative evaluation of maxillary alveolar cortical bone thickness and density using computed tomography imaging. Am J Orthod Dentofac Orthop [Internet]. 2017;151(1):82–91. Available from: http://dx.doi.org/10.1016/j.ajodo.2016.05.015
2. Johns G. Orthodontics mini implants – A brief review. Int Dent J Student's Res. 2022;9(4):176–80.
3. Jaradat M. Orthodontic Mini Implants, an Update. EC Dent Sci 2010. 2021;(October):107–16.

4. Park J, Cho HJ. Three-dimensional evaluation of inter-radicular spaces and cortical bone thickness for the placement and initial stability of microimplants in adults. Am J Orthod Dentofac Orthop [Internet]. 2009;136(3):314.e1-314.e12. Available from: http://dx.doi.org/10.1016/j.ajodo.2009.01.023
5. Cha JY, Kil JK, Yoon TM, Hwang CJ. Miniscrew stability was evaluated with computerized tomography scanning. Am J Orthod Dentofac Orthop [Internet]. 2010;137(1):73–9. Available from: http://dx.doi.org/10.1016/j.ajodo.2008.03.024
6. Pan CY, Liu PH, Tseng YC, Chou ST, Wu CY, Chang HP. Effects of cortical bone thickness and trabecular bone density on primary stability of orthodontic mini-implants. J Dent Sci [Internet]. 2019;14(4):383–8. Available from: https://doi.org/10.1016/j.jds.2019.06.002
7. Veli I, Uysal T, Baysal A, Karadede I. Buccal cortical bone thickness at miniscrew placement sites in patients with different vertical skeletal patterns. J Orofac Orthop. 2014;75(6):417–29.
8. Redžepagić-Vražalica L, Mešić E, Pervan N, Hadžiabdić V, Delić M, Glušac M. Impact of implant design and bone properties on the primary stability of orthodontic mini-implants. Appl Sci. 2021;11(3):1–10.
9. Tseng YC, Wu JH, Chen H Sen, Chen CM, Ting CC. Effects of gripping volume in the mechanical strengths of orthodontic mini-implant. Kaohsiung J Med Sci [Internet]. 2017;33(11):578–83. Available from: http://dx.doi.org/10.1016/j.kjms.2017.03.010
10. Ludwig B. The Orthodontic Mini-Implant Clinical Handbook (2013). Vol. 35, The European Journal of Orthodontics. 2013. 852–852 p.
11. Deguchi T, Nasu M, Murakami K, Yabuuchi T, Kamioka H, Takano-Yamamoto T. Quantitative evaluation of cortical bone thickness with computed tomographic scanning for orthodontic implants. Am J Orthod Dentofac Orthop. 2006;129(6):721.e7-721.e12.
12. Popa A, Dehelean C, Calniceanu H, Watz C, Brad S, Sinescu C, et al. A custom-made orthodontic mini-implant—effect of insertion angle and cortical bone thickness on stress distribution with a complex in vitro and in vivo biosafety profile. Materials (Basel). 2020;13(21):1–16.
13. Bowman SJ. Settling the Score with Class IIs. 2014;57–69.
14. Pan F, Kau CH, Zhou H, Souccar N. The anatomical evaluation of the dental arches using cone beam computed tomography - an investigation of the availability of bone for placement of mini-screws. Head Face Med. 2013;9(1).
15. Amin Golshah et al. 2021. Interradicular distance and alveolar bone thickness for miniscrew insertion: a CBCT study of Persian adults with different sagittal skeletal patterns.
16. Moslemzadeh SH, Sohrabi A, Rafighi A, Kananizadeh Y, Nourizadeh A. Evaluation of interdental spaces of the mandibular posterior area for orthodontic mini-implants with cone-beam computed tomography. Vol. 11, Journal of Clinical and Diagnostic Research. 2017. p. ZC09-ZC12.
17. Fayeda MMS, Pazerab P, Katsarosc C. Optimal sites for orthodontic mini-implant placement assessed by cone beam computed tomography. Angle Orthod. 2010;80(5):939–51.
18. Sawada K, Nakahara K, Matsunaga S, Abe S, Ide Y. Evaluation of cortical bone thickness and root proximity at maxillary inter-radicular sites for mini-implant placement. Clin Oral Implants Res. 2013;24(A100):1–7.
19. Alrbata RH, Yu W, Kyung HM. Biomechanical effectiveness of cortical bone thickness on orthodontic microimplant stability: An evaluation based on the load share between cortical and cancellous bone. Am J Orthod Dentofac Orthop [Internet]. 2014;146(2):175–82. Available from: http://dx.doi.org/10.1016/j.ajodo.2014.04.018
20. Baumgaertel S, Hans MG. Buccal cortical bone thickness for mini-implant placement. Am J Orthod Dentofac Orthop [Internet]. 2009;136(2):230–5. Available from: http://dx.doi.org/10.1016/j.ajodo.2007.10.045
21. Won HL, Soo KL, Ulf MW, Youn SC. A descriptive tissue evaluation at maxillary interradicular sites: Implications for orthodontic mini-implant placement. Clin Anat. 2007;20(7):760–5.
22. Mavropoulos A, Ödman A, Ammann P, Kiliaridis S. Rehabilitation of masticatory function improves the alveolar bone architecture of the mandible in adult rats. Bone [Internet]. 2010;47(3):687–92. Available from: http://dx.doi.org/10.1016/j.bone.2010.06.025
23. Al Amri MS, Sabban HM, Alsaggaf DH, Alsulaimani FF, Al-Turki GA, Al-Zahrani MS, et al. Anatomical consideration for optimal position of orthodontic miniscrews in the maxilla: A CBCT appraisal. Ann Saudi Med. 2020;40(4):330–7.



**HOW TO CITE THIS ARTICLE-**
Gasgoos SS, Alshamma MT. Evaluation of the Buccal Cortical Bone Thickness in Class II Malocclusion for Mini-Implant Insertion: a CBCT Study. Int J Dent Res 2022; 7(3):73-77. doi: 10.31254/dentistry.2022.7307