# Maxillary and Mandibular Cortical Bone Thickness in Anterior Dentate Region: a Cone-Beam Computed Tomography Analysis

Abstract

**Aim**
The present study aims to measure the thickness of cortical bone buccally, palatally/ lingually in anterior dentate sites in maxilla and mandible.

**Materials and Methods**
Cone-beam computed tomography images of 480 patients (240 males and 240 females) aged 25 to 65 years were analyzed to measure the thickness of the buccal and palatal/lingual cortical bones for both maxillary and mandibular anterior teeth on the right and left sides. The measurements were made at following levels: the crest, the middle third of the root and the apex. The data was collected and statistically analyzed using the independent t-test for the differences between the male and female groups and between the buccal and palatal/lingual sides at each level. Pearson's correlation was used to assess the association between gender and bone thickness.

**Results**
The buccal cortical bone thickness was least in canines followed by central incisors. Whereas, the highest palatal/lingual cortical bone thickness was seen in canines followed by central incisors. The palatal/lingual bone thickness was higher than the buccal bone thickness at each level ($p<0.05$).
The mean buccal and palatal/lingual bone thickness at each level was significantly larger in males than females and the difference was statistically significant ($p<0.05$). Also, gender was significantly associated with the buccal and palatal/lingual bone thickness ($r=0.58$, $p=0.04$).

**Conclusion**
The present study suggests that the cortical bone thickness in maxilla and mandible varies with respect to location of the teeth and gender.

Authors

**Mukhopadhya P.**[1]
**Rajasekar A.**[2*]

1
Postgraduate, Department of Implantology, Saveetha Dental College and Hospitals, Saveetha Institute of Medical and Technical Sciences (SIMATS), Saveetha University, Chennai, India

2
Reader, Department of Periodontology, Saveetha Dental College and Hospitals, Saveetha Institute of Medical and Technical Sciences (SIMATS), Saveetha University, Chennai, India

*
Corresponding author

Keywords

**Alveolar bone, Bone thickness, Cortical bone, Imaging, Surgical anatomy.**

DOI

10.23805/JO.2025.682

## INTRODUCTION

Cortical bone thickness is an indicator of overall bone health. Thicker cortical bone generally suggests better bone quality and density, which is crucial for dental procedures. Studying the cortical thickness of the maxilla and mandible is important for several reasons, particularly in the field of dentistry.

The thickness of the cortical bone in the maxilla and mandible is critical for the primary stability of dental implants. Understanding cortical thickness helps in selecting the appropriate implant size and shape and in planning the placement to maximize bone contact and stability (1). The mechanical interaction between the dental implant fixture and the surrounding bone determines implant primary stability, which is thought to be the first prerequisite for the success of dental implant treatment (2). Implant primary stability is significantly influenced by both bone density and cortex thickness (3,4). Preoperative evaluation of the characteristics of the bone can be used to predict the stability of the implant, especially immediate implants (5).Preoperative bone evaluation can also help in avoiding certain complications that could affect the success of a dental implant, like perforation and damage to anatomical structures (6). Moreover, to create dental implant restorations that are aesthetically pleasing, adequate alveolar bone volume, thickness and height are crucial (7).

Furthermore, cortical bone thickness can affect the rate and extent of tooth movement. Thicker cortical bone may resist orthodontic forces, necessitating adjustments in treatment plans (8). In orthodontic treatments, mini-implants or temporary anchorage devices are often used. Knowing the cortical bone thickness helps in determining the best placement for these devices (9). According to Miyamoto I et al. (10), cortical bone thickness has a greater impact on initial stability during implant installation than does implant length. Determining the bone condition is crucial for the success of implant treatment and cortical to cancellous bone ratio is crucial for implant stability during surgery. A recent systematic review established a relationship between the implant's primary stability and the thickness of the cortical bone at the insertion site (11).

Dental professionals are becoming more interested in studying the thickness of bone in the maxillary and mandibular dentition. Basal bone and alveolar bone, which are created by the alveolar process, make up the maxilla and mandible. The mandibular and maxillary bones are not structurally similar; cancellous bone typically makes up a larger portion of the former (12). For evaluating bone, cone-beam computed tomography (CBCT) is thought to be an effective three-dimensional imaging technique. Since its introduction in 1982, CBCT has been a crucial diagnostic and imaging tool because it produces clear images devoid of nearby structures superimposing on them. When comparing it to panoramic radiographs, it was superior at displaying anatomical structures (13). It takes minimal scanning time and produces extremely valuable information in all multiple planes with a low radiation dose (14).

Due to the variability in cortical bone thickness, it is crucial to perform a detailed preoperative assessment, often using CBCT scans, to measure bone dimensions accurately at the planned implant site. Understanding these nuances and the anatomical differences between buccal and palatal/lingual cortical bone in the anterior maxilla and mandible is essential for achieving successful esthetic outcomes especially in immediate implant placement. Thus, this study was done to: (a) measure cortical bone thickness in maxillary and mandibular regions - buccally, palatally/lingually in anterior dentate sites; and (b) determine whether gender had an impact on cortical bone thickness.

## MATERIALS AND METHODS

480 patients (240 males; 240 females) aged 25 to 65 years were included in this study. This study involved dentate adult patients who were referred for a head and neck CBCT scan between January 2024 and May 2024 to the Department of Radiology, Saveetha Dental College and Hospitals, Chennai, India. The study was carried out in compliance with 1975 Helsinki Declaration, as amended in 2013, with approval from Saveetha Dental College and Hospitals' Institutional Ethical Committee (IHEC/SDC/MSIMPLANT-2305/24/052).

Every participant gave their informed consent. G*Power Software, Version 3.0 was used to calculate the sample size based on the mean and standard deviation values from a prior study (15). 80% power and an $\alpha$ of 0.05 were chosen. The target sample size was 478 subjects.

This study included patients who were completely dentate and free of periodontal disease; they ranged in age from 25 to 65; they had fully formed apex in both maxillary and mandibular teeth; they had no crowns, root canal therapy, resorbed roots, congenital anomalies and periapical infections. Patients with impacted/supernumerary teeth; history of maxillary or mandibular surgery; tooth misalignment were excluded.

CBCT (Sirona Orthophos XG SD System, NC, USA) was utilized to measure the thickness of buccal and palatal/lingual cortical bones. For the right and left maxillary (Figure 1) and mandibular (Figure 2) teeth, thickness measurements were taken at the central incisor (CI), lateral incisor (LI) and canine (C). The thickness of the buccal and palatal/lingual cortical bones was determined from the distance of the outer cortex to the tooth root at following levels: crest, middle third and apex. All measurements were performed by one investigator (PM).

### Statistical Analysis

The Statistical Package for Social Sciences (SPSS Software, Version 23.0; IBM Corp., Armonk, NY, USA) was employed to conduct the data analysis. The Shapiro-Wilk test of normalcy and the Kolmogorov-Smirnov test were used to assess the results. Results were found to follow a parametric

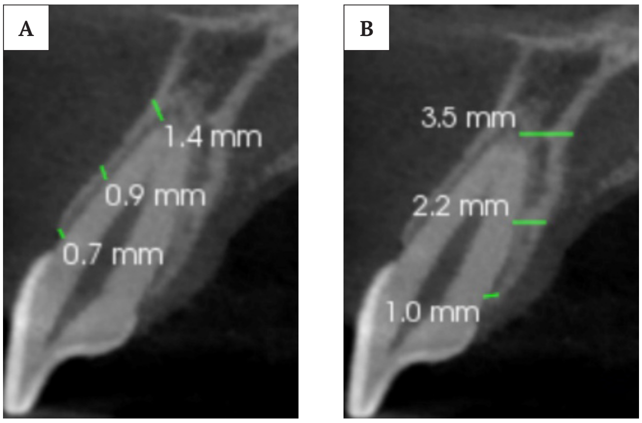


**Fig. 1** CBCT measurement of maxillary cortical bone thickness at three levels on the (**A**) buccal aspect and (**B**) palatal aspect

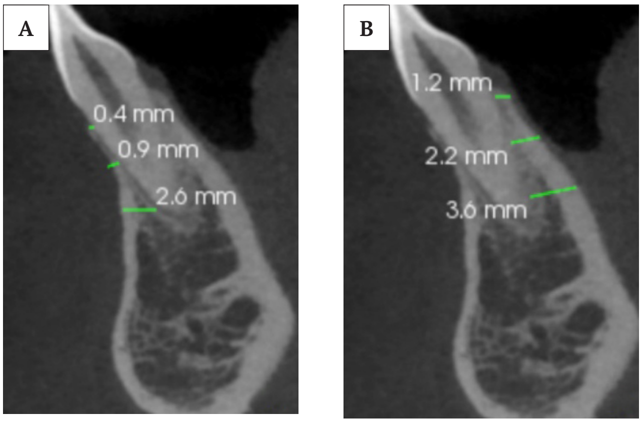


**Fig. 2** CBCT measurement of mandibular cortical bone thickness at three levels on the (**A**) buccal aspect and (**B**) lingual aspect

distribution based on the data. The mean and standard deviations were used to display the data. The differences between males and females and between buccal and palatal/lingual sides at each level were analyzed by independent t-test. Pearson's correlation coefficient was calculated to examine association between variables. A p-value of less than 0.05 indicated statistical significance for the results.

## RESULTS

This study involved a total of 480 CBCT examinations (240 males and 240 females) with a mean age of 45.26 years. Table 1 displays the mean thickness of the buccal and palatal/lingual bone in the maxillary and mandibular anterior teeth. Canines had the lowest mean buccal bone thickness at all three levels in maxillary and mandibular anterior teeth, followed by central and lateral incisors. Whereas regarding the palatal/lingual bone thickness, the highest mean value was observed in canines followed by central incisors and lateral incisors at all the three levels. Also, the palatal/lingual bone thickness was higher than the buccal bone thickness at each level ($p<0.05$). Additionally, the thickness of the bone increased steadily on the buccal and palatal/lingual sides from the crestal level to the apical level. Every tooth's buccal and palatal/lingual sides differed significantly at each level ($p<0.05$).
Table 2 displays the mean thickness of the buccal and palatal/lingual bone in the maxillary and mandibular anterior teeth for both males and females. On the buccal and palatal/lingual sides, there was a consistent rise in bone thickness for both sexes from the crestal level to the apical level. Regarding the differences between females and males,

| Maxillary Buccal Side | | | | | | |
|---|---|---|---|---|---|---|
| Measured areas | 13 | 12 | 11 | 21 | 22 | 23 |
| At crest | 0.46±0.28 | 0.6±0.21 | 0.56±0.27 | 0.50±0.21 | 0.79±0.35 | 0.46±0.26 |
| At middle third | 0.82±0.27 | 1.0±0.21 | 0.9±0.12 | 0.98±0.33 | 1.02±0.09 | 0.76±0.38 |
| At apex | 1.5±0.06 | 1.64±0.78 | 1.30±0.48 | 1.44±0.59 | 1.52±0.70 | 1.27±0.36 |
| Maxillary Palatal Side | | | | | | |
| Measured areas | 13 | 12 | 11 | 21 | 22 | 23 |
| At crest | 1.29±0.02 | 0.84±0.10 | 1.08±0.44 | 1.11±0.62 | 0.96±0.46 | 1.24±0.23 |
| At middle third | 2.30±0.89 | 1.80±0.48 | 2.21±0.63 | 2.10±0.70 | 1.90±0.90 | 2.38±0.28 |
| At apex | 3.6±0.90 | 3.09±0.38 | 3.26±0.33 | 3.10±0.94 | 2.74±0.10 | 3.72±0.88 |
| Mandibular Buccal Side | | | | | | |
| Measured areas | 43 | 42 | 41 | 31 | 32 | 33 |
| At crest | 0.33±0.19 | 0.56±0.22 | 0.44±0.10 | 0.57±0.26 | 0.63±0.24 | 0.42±0.20 |
| At middle third | 0.86±0.19 | 0.92±0.16 | 0.89±0.11 | 0.80±0.13 | 0.83±0.09 | 0.60±0.13 |
| At apex | 1.64±0.01 | 1.95±0.24 | 1.69±0.91 | 1.39±0.62 | 1.54±0.97 | 1.36±0.66 |
| Mandibular Lingual Side | | | | | | |
| Measured areas | 43 | 42 | 41 | 31 | 32 | 33 |
| At crest | 1.16±0.15 | 0.81±0.20 | 0.86±0.25 | 0.92±0.29 | 0.74±0.28 | 1.23±0.28 |
| At middle third | 1.88±0.49 | 1.66±0.18 | 1.67±0.31 | 1.37±0.19 | 1.28±0.13 | 2.24±0.41 |
| At apex | 2.79±0.81 | 2.48±0.48 | 2.69±0.34 | 2.1±0.08 | 2.01±0.04 | 3.14±0.76 |

**Tab. 1** Cortical bone thickness in maxillary and mandibular anterior teeth

males had significantly larger mean buccal and palatal/lingual bone thickness at each level than females and the difference was statistically significant ($p<0.05$). Moreover, there was a significant correlation ($r=0.58$, $p=0.04$) between gender and the thickness of the buccal and palatal/lingual bones.

## DISCUSSION

Research in implantology is primarily focused on improving success rates by enhancing osseointegration between the implant and surrounding bone (16-20). All such efforts aim to optimize bone–implant integration, which forms the cornerstone of long-term stability and function (21,22). In this context, advancements in imaging technology, particularly CBCT, have greatly strengthened the clinician's ability to accurately assess cortical bone thickness in the maxilla and mandible. This precision has translated into improved treatment outcomes and patient care in the field of dentistry. Accordingly, the present study was designed to quantify bone thickness in the buccal and palatal/lingual regions of maxillary and mandibular teeth. The results of our study showed that the canines had the lowest buccal cortical bone thickness among the maxillary and mandibular anterior teeth, followed by the central incisors. On the other hand, canines had the thickest palatal/lingual cortical bone, followed by central incisors. These results are consistent with a study by Porto OCL et al. (23), where the authors noted that the palatal aspects of the canines and central incisors of the maxilla and mandible presented the highest mean values of bone thickness, while the buccal cortical bone of the maxillary and mandibular teeth, particularly in the anterior canines, central incisors, first premolars, and first molars, had the lowest mean values. Similarly, Farmosa J et al. (24), measured the thickness of the mandibular alveolar bone and found that the mandibular canines had thinner buccal alveolar bone. Vakil JK et al. (25), Park J et al. (26), and Miyamoto I et al. (10) reported similar results. Furthermore, in a study using cadavers that sought to estimate the average thickness of cortical bone at various tooth locations revealed that both maxilla and mandible presented higher palatal/lingual cortical bone thickness as compared to buccal cortical thickness (27). Braut V et al. (28), also highlighted that the measurement of lingual bone width was significantly greater than that of buccal bone width, which may be one of the main causes of the minimal resorption that occurs on the lingual aspects following tooth extraction.

In this study, we noticed a notable increase in thickness of bone on the buccal and palatal/lingual sides from the crest to the apex, which aligned with a similar study by Kolte AP et al. (29), where the bone thickness at the dentate sites showed a consistent rise from crest towards apex on buccal and lingual aspects in female and male patients. Also, the authors demonstrated that there was statistical significance in the bone width at various levels on the buccal and palatal/lingual aspects, which is in accordance with the present study findings. Braut V et al. (28), also reported thicker and pronounced lingual inclinations of the alveolar process which exhibited a consistent increase from marginal bone level to the apical level.

The current study also showed that males had statistically significant differences in mean buccal and palatal/lingual bone thickness at each level, with the differences being larger than those of females. Additionally, the thickness of the buccal and palatal/lingual bones was significantly correlated with gender. Kim HJ et al. (30), evaluated the cortical bone thickness with respect to gender and reported

| Maxillary Buccal Side | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Measured areas | 13 | | 12 | | 11 | | 21 | | 22 | | 23 | |
| | Male | Female | Male | Female | Male | Female | Male | Female | Male | Female | Male | Female |
| At crest | 0.61±0.12 | 0.51±0.13 | 0.90±0.36 | 0.70±0.30 | 0.70±0.30 | 0.68±0.11 | 0.84±0.36 | 0.7±0.2 | 0.9±0.37 | 0.8±0.1 | 0.5±0.26 | 0.1±0.30 |
| At middle third | 0.91±0.12 | 0.72±0.29 | 1.20±0.10 | 0.90±0.20 | 1.10±0.30 | 0.80±0.20 | 1.3±0.3 | 0.94±0.3 | 1.66±0.55 | 1.57±0.08 | 0.8±0.2 | 0.6±0.09 |
| At apex | 1.53±0.95 | 1.32±0.10 | 1.7±0.5 | 1.5±0.2 | 1.6±0.4 | 1.4±0.1 | 1.6±0.9 | 1.4±0.8 | 1.7±0.1 | 1.64±0.09 | 1.4±0.5 | 1.14±0.06 |
| Maxillary Palatal Side | | | | | | | | | | | | |
| Measured areas | 13 | | 12 | | 11 | | 21 | | 22 | | 23 | |
| | Male | Female | Male | Female | Male | Female | Male | Female | Male | Female | Male | Female |
| At crest | 1.9±0.4 | 0.6±0.2 | 1.0±0.3 | 0.63±0.15 | 1.7±0.41 | 1.3±0.9 | 1.5±0.99 | 1.01±0.9 | 1.08±0.76 | 0.8±0.02 | 1.6±0.3 | 1.2±0.31 |
| At middle third | 2.9±0.8 | 2.7±0.2 | 2.1±1.0 | 2.05±1.02 | 2.4±1.01 | 2.1±0.6 | 2.2±1.06 | 2.2±0.7 | 2.1±0.7 | 2.0±0.01 | 2.8±0.3 | 2.5±0.2 |
| At apex | 4.0±1.2 | 3.9±1.1 | 3.84±1.04 | 3.0±1.04 | 3.9±0.2 | 3.84±0.94 | 3.7±1.4 | 3.6±0.06 | 3.4±1.95 | 2.4±0.95 | 4.1±0.8 | 3.9±1.4 |
| Mandibular Buccal Side | | | | | | | | | | | | |
| Measured areas | 43 | | 42 | | 41 | | 31 | | 32 | | 33 | |
| | Male | Female | Male | Female | Male | Female | Male | Female | Male | Female | Male | Female |
| At crest | 0.42±0.15 | 0.23±0.01 | 0.71±0.2 | 0.62±0.21 | 0.36±0.11 | 0.27±0.01 | 0.52±0.04 | 0.33±0.09 | 0.67±0.25 | 0.61±0.30 | 0.34±0.10 | 0.29±0.55 |
| At middle third | 0.84±0.21 | 0.71±0.12 | 0.95±0.19 | 0.8±0.21 | 0.9±0.18 | 0.78±0.14 | 0.67±0.2 | 0.65±0.04 | 0.68±0.16 | 0.66±0.12 | 0.63±0.18 | 0.64±0.03 |
| At apex | 1.6±0.04 | 1.05±0.12 | 1.7±0.21 | 1.6±0.17 | 1.67±0.18 | 1.5±0.01 | 1.3±0.5 | 1.29±0.2 | 1.4±0.85 | 1.3±0.50 | 1.31±0.20 | 1.17±0.33 |
| Mandibular Lingual Side | | | | | | | | | | | | |
| Measured areas | 43 | | 42 | | 41 | | 31 | | 32 | | 33 | |
| | Male | Female | Male | Female | Male | Female | Male | Female | Male | Female | Male | Female |
| At crest | 1.6±0.2 | 1.0±0.13 | 0.9±0.2 | 0.7±0.1 | 1.07±0.14 | 0.8±0.01 | 0.98±0.11 | 0.62±0.31 | 0.76±0.01 | 0.5±0.01 | 1.31±0.68 | 1.11±0.2 |
| At middle third | 2.1±0.40 | 1.7±0.2 | 1.7±0.21 | 1.2±0.2 | 1.9±0.5 | 1.6±0.16 | 1.01±0.16 | 0.9±0.2 | 0.9±0.05 | 0.8±0.2 | 2.17±0.04 | 2.03±0.01 |
| At apex | 2.97±0.81 | 2.1±0.5 | 2.6±0.21 | 1.8±0.4 | 2.9±0.01 | 1.9±0.15 | 2.1±0.2 | 1.8±0.1 | 1.97±0.02 | 1.5±1.01 | 3.04±1.01 | 2.86±1.21 |

**Tab. 2** Comparison of cortical bone thickness in maxillary and mandibular anterior teeth among males and females

that in maxilla and mandible, males exhibited significantly higher buccal, lingual and palatal cortical thickness than females. Furthermore, Abbas SA et al. (31), demonstrated that in both jaws, the cortical bone thickness in males was significantly higher than in females at 4, 6, and 8 mm from crest and also reported that gender was significantly associated with cortical bone thickness. Ono A et al. (32), and Goyushov S et al. (33), reported findings that were comparable. Collectively, the present study suggests that thickness of cortical bone varies with respect to location of teeth and gender. Nonetheless, a couple of limitations in the present investigation should be taken into account when evaluating the data's clinical significance. Firstly, even though CBCT is a widely used imaging technique in dental and maxillofacial radiology due to its high-resolution 3D imaging capabilities and lower radiation dose, the spatial resolution of CBCT is determined by the voxel size, which might not always be sufficient for accurately measuring very thin cortical bone (34). Thus, it's possible that the alveolar bone thickness was underestimated in the current study. Also, in the current study, patients of varying age ranges were enrolled and were not evenly distributed and divided into groups. Future research examining the variations in alveolar bone thickness across diverse populations, age groups and treatment response patterns on different alveolar bone thickness would therefore be extremely important from a clinical standpoint.

## CONCLUSION

With regard to the maxillary and mandibular anterior teeth, the current CBCT analysis indicates that,

(a) Canines had the thinnest buccal cortical bone, followed by central incisors. On the other hand, canines had the thickest palatal/lingual cortical bone, followed by central incisors.
(b) Compared to the buccal bone, the palatal/lingual bone thickness was noticeably greater.
(c) Thickness of the bone on buccal and palatal/lingual sides increased significantly from crest to apex.
(d) Men exhibited a statistically significant difference in the mean thickness of their buccal and palatal/lingual bones at each level compared to women.

## REFERENCES

**1.** Marquezan M, Osório A, Sant'Anna E, Souza MM, Maia L. Does bone mineral density influence the primary stability of dental implants? A systematic review. Clin Oral Implants Res. 2012 Jul;23(7):767-74.
**2.** Mathieu V, Vayron R, Richard G, Lambert G, Naili S, Meningaud JP, et al. Biomechanical determinants of the stability of dental implants: Influence of the bone–implant interface properties. J Biomech. 2014 Jan 3;47(1):3-13.
**3.** Padmaja S, Rajasekar A. Correlation between primary stability of dental implants and bone density: A retrospective analysis. J Long-Term Eff Med Implants. 2024;34:65-70.
**4.** Bhattacharya D, Ponnanna AA, Jingade RR, Maiti S, Rai N, Gopalkrishna M. An in vitro assessment of optimizing implant positions in bilateral distal extension implant-assisted removable partial dentures: A microstress analysis. Journal of Indian Prosthodontic Society. 2024 Jan 1;24(1):82-7.
**5.** Durrani F, Karthickraj SM, Imran F, Ahlawat S, Kumari E, Vani SG. Comparative evaluation of hard and soft tissue parameters by using short implants and standard long implants with sinus lift for prosthetic rehabilitation of posterior maxilla. Journal of Indian Society of Periodontology. 2024 Jan 1;28(1):106-12.
**6.** Gaêta-Araujo H, Oliveira-Santos N, Mancini AX, Oliveira ML, Oliveira-Santos C. Retrospective assessment of dental implant-related perforations of relevant anatomical structures and inadequate spacing between implants/teeth using cone-beam computed tomography. Clin Oral Investig. 2020 Sep;24:3281-8.
**7.** Buser D, Martin W, Belser UC. Optimizing esthetics for implant restorations in the anterior maxilla: anatomic and surgical considerations. Int J Oral Maxillofac Implants. 2004 Nov 2;19(7):43-61.
**8.** Chang HW, Huang HL, Yu JH, Hsu JT, Li YF, Wu YF. Effects of orthodontic tooth movement on alveolar bone density. Clin Oral Investig. 2012 Jun;16:679-88.
**9.** Sivakumar N, Shantha Sundari KK, Chandrasekar S, Santhosh Kumar MP. Orthodontic implants-A review on biological and mechanical considerations. Drug Invent Today. 2018 Dec 1;10(12):2636-40.
**10.** Miyamoto I, Tsuboi Y, Wada E, Suwa H, Iizuka T. Influence of cortical bone thickness and implant length on implant stability at the time of surgery-clinical, prospective, biomechanical, and imaging study. Bone. 2005 Dec 1;37(6):776-80.
**11.** Di Stefano DA, Arosio P, Capparè P, Barbon S, Gherlone EF. Stability of dental implants and thickness of cortical bone: clinical research and future perspectives: A systematic review. Materials. 2021 Nov 25;14(23):7183-9.
**12.** Monje A, Chan HL, Galindo-Moreno P, Elnayef B, Suarez-Lopez del Amo F, et al. Alveolar bone architecture: A systematic review and meta-analysis. J Periodontol. 2015 Nov;86(11):1231-48.
**13.** Veerappan RR, Gopal M. Comparison of the diagnostic accuracy of CBCT and conventional CT in detecting degenerative osseous changes of the TMJ: A systematic review. J Indian Acad Oral Med Radiol. 2015 Jan 1;27(1):81-4.
**14.** Scarfe WC, Farman AG. What is cone-beam CT and how does it work?. Dent Clin N Am. 2008 Oct 1;52(4):707-30.
**15.** Fuentes R, Flores T, Navarro P, Salamanca C, Beltrán V, Borie E. Assessment of buccal bone thickness of aesthetic maxillary region: a cone-beam computed tomography study. J Periodontal Implant Sci. 2015 Oct 1;45(5):162-8.
**16.** Maiti S, Dhakshinya M, Nallaswamy D, Jessy P. Comparative analysis of surface characteristics and hardness of three dimensional printed PEEK vs PEKK-as implant biomaterial. Journal of Osseointegration. 2024 Mar 5;16(1):16-22.
**17.** Nahata B, Maiti S, Ganesh MK, Heboyan A, Sai L, Paulraj J. Sulfonated polyether ketone ketone (SPEKK) implant as an alternative to titanium implant-in vivo study on Wistar Albino rat mandible. BMC Oral Health. 2025 Apr 13;25(1):557.
**18.** Yadalam PK, Sharma S, Natarajan PM, Ardila CM. Gradient boosting-based classification of interactome hub genes in periimplantitis with periodontitis–an integrated bioinformatic approach. Frontiers in Oral Health. 2024 Nov 26;5:1462845.
**19.** Yadalam PK, Ardila CM. Deep Neural Networks Based on Sp7 Protein Sequence Prediction in Peri-Implant Bone Formation. International Journal of Dentistry. 2025;2025(1):7583275.
**20.** Biju D, Arumugam P, Kannan S, Yadalam PK, Ronsivalle V, Cicciù M, Minervini G. Development, characterization, and biocompatibility and corrosion analyses of a silver-decorated graphene oxide and chitosan surface coating for titanium dental implants: A preliminary report. Dental and Medical Problems. 2024;61(4):627-32.
**21.** Baltazar CM, Salinas BG, Franco NR, Sandoval GM, González GM, Whitney AB, Baltazar-Ruiz A. Root morphology and angulation analysis of mandibular first molar for the planning of immediate implants. A cross-sectional study using CBCT. Journal of Osseointegration. 2023 Sep 27;15(4):233-7.
**22.** Scavia S, Maddalone M. Total flapless split-crest technique with tunnel connective graft using microspire conical connection implants: a 3-year retrospective study. Journal of Osseointegration. 2023 May 26;15(3):189-96.
**23.** Porto OCL, Silva BS de F, Silva JA, Estrela CR de A, Alencar AHG de, Bueno M dos R, et al. CBCT assessment of bone thickness in maxillary and mandibular teeth: An anatomic study. J Appl Oral Sci. 2020 Feb 7;28:e20190148.
**24.** Formosa J, Zou M, Chung CH, Boucher NS, Li C. Mandibular alveolar bone thickness in untreated Class I subjects with different vertical skeletal patterns: a cone-beam computed tomography study. Angle Orthod. 2023 Nov 1;93(6):683-94.
**25.** Vakil JK, Sable RB. A retrospective study on Indian population to evaluate cortical bone thickness in maxilla and mandible using computed tomography images. J Indian Orthod Soc. 2014 Jul;48(3):149-55.
**26.** Park J, Cho HJ. Threedimensional evaluation of interradicular spaces and cortical bone thickness for the placement and initial stability of microimplants in adults. Am J Orthod Dentofacial Orthop 2009 Sep;136(3):314-9.
**27.** Katranji A, Misch K, Wang HL. Cortical bone thickness in dentate and edentulous human cadavers. J Periodontol. 2007 May;78(5):874-8.
**28.** Braut V, Bornstein MM, Lauber R, Buser D. Bone dimensions in the posterior mandible: a retrospective radiographic study using cone beam computed tomography. Part 1-analysis of dentate sites. Int J Periodontics Restorative Dent. 2012 Apr 1;32(2):175-80.
**29.** Kolte AP, Kolte RA, Pakhmode RAV. Assessment of buccal and lingual alveolar bone width in the posterior region at dentate and edentulous sites: A cone-beam computed tomography study. J Indian Soc Periodontol. 2020;24(1):26-31.
**30.** Kim HJ, Yu SK, Lee MH, Lee HJ, Kim HJ, Chung CH. Cortical and cancellous bone thickness on the anterior region of alveolar bone in Korean: A study of dentate human cadavers. J Adv Prosthodont. 2012 Aug 1;4(3):146-52.
**31.** Abbas SA, Alhuwaizi AF. Buccal cortical bone thickness in Iraqi arab adults by cone beam computed tomography for orthodontic mini-implants. J Baghdad Coll Dent. 2017 Mar 13;29(1):183-7.
**32.** Ono A, Motoyoshi M, Shimizu N. Cortical bone thickness in the buccal posterior region for orthodontic mini-implants. Int J Oral Maxillofac Surgery. 2008 Apr 1;37(4):334-40.
**33.** Goyushov S, Dursun E, Tözüm TF. Mandibular cortical indices and their relation to gender and age in the cone-beam computed tomography. Dentomaxillofac Radiol. 2020 Mar 1;49(3):20190210.
**34.** Kiljunen T, Kaasalainen T, Suomalainen A, Kortesniemi M. Dental cone beam CT: A review. Physica Medica. 2015 Dec 1;31(8):844-60.