https://doi.org/10.35845/kmuj.2025.23618

ORIGINAL ARTICLE

CBCT-based morphometric assessment of the mandibular second premolar region: implications for implant placement and perforation prevention

Naauman Zaheer [1], **Saira Atif** [1], **Musa Ejaz Farrukh** [1], **Mustafa Qadeer** [1]

1: CMH Lahore Medical College & Institute of Dentistry, National University of Medical Sciences, Lahore, Pakistan

Email: naauman20@gmail.com
Contact #: +92-321-4440283

Date Submitted: February 27, 2024
Date Revised: October 15, 2024
Date Accepted: October 16, 2024

ABSTRACT

Objective: To study the mandibular second premolars relation to alveolar bone and provide clinical guidelines for implant fixtures to prevent buccal and lingual perforations.

Methods: This cross-sectional analytical study evaluated cone-beam computed tomography (CBCT) records from Jinnah MRI, University of Lahore, and Fatima Memorial Hospital. CBCT (n=164) scans were selected via purposive sampling per defined inclusion and exclusion criteria. The scans were used to measure alveolar process height and width, basal bone width, and the angles between the long axes of the alveolar and basal bones in the mandibular second premolar region. Measurements were performed using the Ginifab web-based application. Ethical approval was granted by the Institutional Review Board of CMH Lahore Medical College.

Results: Measurements of mandibular second premolars revealed that the alveolar process height (EF) and width (AB) and basal bone width (CD) were 20.3±1.1 mm, 52.2 (49.3–53.7) mm, and 53.0 (50.2–54.5) mm for females, and 20.8±1.2 mm, 53.1 (51.8–55.0) mm, and 54.0 (52.8–55.8) mm for males. Age distributions were similar (females: median 32.5 years; males: median 33.0 years, p=0.151). Males showed significantly greater crest distance (20.8±1.2 vs. 20.3±1.1 mm; p=0.013) and wider alveolar processes (53.1 vs. 52.2 mm; p=0.003) and basal bones (54.0 vs. 53.0 mm; p=0.006). No gender differences in tooth-to-bone angles were observed. Oblique morphology predominated (70.1%, p=0.865), thus ultimately informing implant placement strategies.

Conclusion: The proposed classification guides mandibular second premolar implant selection and design. The oblique type may pose the highest risk of buccal perforation according to this study.

Keywords: Bicuspid (MeSH); Mandible (MeSH); Mandibular premolar (Non-MeSH); Bone and Bones (MeSH); Alveolar bone (Non-MeSH); Bone morphology (Non-MeSH); Cone-Beam Computed Tomography (MeSH); Dental Implants (MeSH).

THIS ARTICLE MAY BE CITED AS: Zaheer N, Atif S, Farrukh ME, Qadeer M. CBCT-based morphometric assessment of the mandibular second premolar region: implications for implant placement and perforation prevention. Khyber Med Univ J 2025;17(1):65-70. https://doi.org/10.35845/kmuj.2025.23618

INTRODUCTION

Bone anatomical morphology plays a significant role in the success of dental implant placement, particularly in the mandibular region. Variations in bone density, structure, and morphology directly affects the stability and longevity of dental implants. Implant dentistry, a practice with ancient roots, has evolved considerably over time, with modern dental implants revolutionizing the replacement of missing teeth.[1] The success of these implants depends on factors such as their positioning and angulation, which must align with the long axis of the restoration to ensure long-term stability and minimize mechanical complication.[2] Proper treatment planning for implant placement requires careful assessment of bone ridge size and morphology, which is often achieved through clinical examination and radiographic techniques.[3] The complexity of dental implantation in the mandibular region is heightened by anatomical variations, such as the mental foramen's size and shape.[4] Furthermore, accurate localization of the mandibular canal is critical to avoid complications like nerve damage during implant placement.[5,6] The thickness of cortical bone also impacts implant success, with thicker bone providing better initial stability.[7] Mandible resorbs downwards and outwards to become wider, meaning that the buccal part of the alveolar bone resorbs faster than the lingual part of the alveolar bone.[8] Hence, the pattern of resorption in the mandible is a major component that can affect the success of an implant placement. Therefore, there are more chances of buccal perforation in cases where buccal resorption of alveolar bone is fast, and the alveolar process is buccally angled. Among the available imaging techniques, cone-beam computed tomography (CBCT) has emerged as the most effective tool for evaluating bone anatomy, offering detailed 3D images of the maxillofacial skeleton, which aids in implant planning.[7,9]

While considerable research has examined the role of bone morphology in implant success within the mandibular molar region, limited data exist regarding its impact in the mandibular premolar area. This gap is clinically significant, as the premolar region is crucial for mastication and facial aesthetics and may present distinct anatomical challenges. In particular, the influence of parameters such as bone density and trabecular patterns on implant stability and osseointegration remains underexplored. Addressing this gap is vital for refining implant placement strategies and improving success rates across various mandibular regions.

This study was undertaken to reveal the relationship between alveolar bone morphology and implant success in the mandibular premolar region, a subject that has received relatively little attention in existing literature. By employing CBCT imaging to assess the anatomical characteristics of the mandibular second premolars, we aimed to inform clinical guidelines for optimal implant positioning. The primary objective was to analyze the alveolar bone surrounding the mandibular second premolars and determine its influence on implant placement and subsequent clinical outcomes.

METHODS

The CBCT records from Jinnah MRI, Body Scan Center, University of Lahore and Fatima Memorial Hospital were obtained in accordance with the specified standards between December 2021 and May 2022. Informed consents for documentation and public presentation were obtained from all patients. The images came from a Promax 3D CBCT machine (Planmeca, Finland) with Romexis software, featuring a minimum filtration equivalent of 84 Kvp, 4mA, and 8x8 cm FOV. The standard CBCT protocol involved fixing the patient's head using a head frame to align the horizontal and vertical reference lines with the patient's eye level and facial midline. All CBCT records were evaluated by the principal investigator (NZ) and the third co-author (MEF). The sample size of 164 patients was determined using a 95% confidence level, 7% margin of error, and 0.5 expected proportion, as calculated using the WHO sample size calculator (Gallucci GO et al., 2017).[10]

Ethical approval for this study was obtained from the Institutional Review Board of the Institute of Dentistry, CMH Lahore Medical College, Lahore, Pakistan (Case No: #638/ERC/CMH/LMC) prior to commencement. A purposive (non-probability) sampling technique was employed in the study design.

Inclusion criteria

1. Persons whose teeth are completely erupted from the left mandibular second premolar to the right second premolar.

2. Absence of any visible deformities.

3. Mandibular posterior teeth exhibit no defects or deformities in their development.

4. Mandibular posterior teeth were found to be in good oral health, showing no signs of dental caries, triangular flaws, worn out or scraped off.

5. Non resorbed alveolar ridges.

6. The absence of degenerative illnesses and malformations in the mandible.

7. CBCT images were easily interpretable.

Exclusion criteria

1. Individuals who have a congenital or acquired absence of mandibular premolars.

2. Individuals with mild to intense or advancing periodontitis.

3. Irregular tooth maturation like radicular cysts etc.

4. Background of teeth and jaw injury.

5. Orthodontic treatment's record.

6. Incomplete radiographic images or small field of view (FOV) scan showing only one arch.

Adjustments were made along the tooth's neck to the horizontal plane; the tooth's midpoint mesiodistally was cut by the transverse plane. By joining the tip of the root to the centre of the occlusal table (Point A to Point B), the long axis of the tooth was calculated.

In order to measure the alveolar process, the buccal line (BL1) which refers to the contour line on the buccal surface of the tooth, and runs along the buccal alveolar surface, and the lingual line (Ll2), which runs along lingual alveolar surface. By cutting the surface in half, the alveolar line (L2) was marked, indicating angulation of the alveolar process. The measurement of the basal bone's major axis involved connecting BL3, representing the buccal line along the outer surface, with LL4, and denoting the lingual line along the inner surface of the basal bone. The basal line (L3) which refers to the line that represents the junction between the tooth's crown and root, marking the base of the crown, was identified by cutting both lines in half in the selected measured plane (Figure 1).

The software tool used to measure the angles and lengths was a web based application https://www.ginifab.com/feeds/angle_measurement/) (https://www.ginifab.com/feeds/cm_to_inch/actual_size_ruler.html.

Angle measurement: The long axis of the 2nd premolar (L1) and the long axis of the alveolar bone (L2) came together to form the upper internal angle (<a). The result was positive when the long axis of L1 was positioned buccal to L2, and negative when L1 was situated lingual to L2.

The upper internal angle (<b) was created by the intersection of the long axis of the alveolar bone (L2) and the long axis of the basal bone (L3). When L1 was positioned buccal to L2, the angle was positive, and when L1 was lingual to L2, the angle was negative (Figure 2).

Length measurement: At the lowest point of the alveolar bone, perpendicular to L2, the width AB represented the distance between the buccal and lingual alveolar plates. Conversely, at the highest point of the basal bone, perpendicular to L3, the width CD denoted the space between the buccal and lingual basal plates. The distance EF would be measured between the buccal and lingual alveolar crests. Additionally, the distance XY corresponded to the span between the midpoint of EF and AB (4,11) (Figure 3). Based on the cross-sectional morphology of the mandible, the second premolars were classified into two main categories, each containing two subcategories.

The straight type: The basal bone and alveolar process exhibited a close alignment, with L2 and L3 overlapping or nearly overlapping. There is a clear linear alignment of these landmarks without significant deviation or curvature. The upper internal angle (<b) appeared small, which suggests that the alveolar process is more upright, with less divergence from the basal bone, depicted in Figure 4A & B. **The oblique type:** The alveolar process exhibited a buccal angulation in

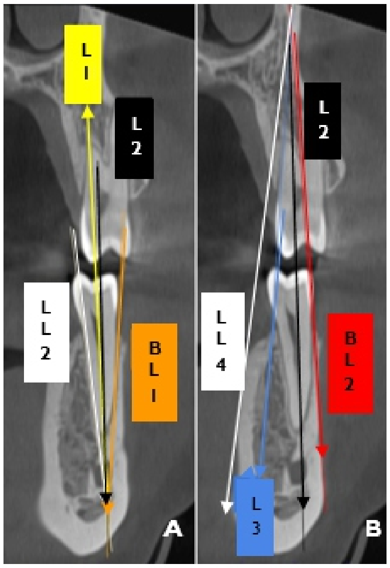

Figure 1: The buccal line refers to the contour line on the buccal surface of the tooth. The lingual line runs along the lingual (inner) surface of the alveolar process, representing the contour of the bone on the side of the tooth facing the tongue. The long axis **(L1)** of the tooth is established by joining the root apex and the midpoint of a line originating from the occlusal counterpart's abrupt point **(A)**. The long axis of the alveolar process **(L2)** is defined by cutting the buccal line of the alveolar process into half **(BL1)** and lingual line of the alveolar process **(LL2)** **(A)**. The long axis of basal bone **(L3)** is defined by cutting the buccal line of the alveolar process into half **(BL2)** and lingual line of the alveolar process **(LL4)** **(B)**.

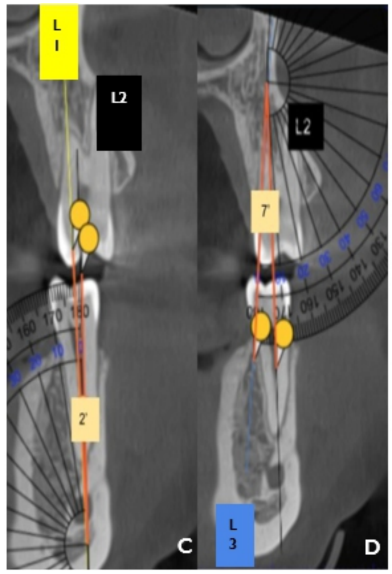

Figure 2: **L1** and **L2** formed the upper internal angle (a) **(C)**. **L2** and **L3** formed the upper internal angle (b) **(D)** which is positively large in this case (Oblique type).

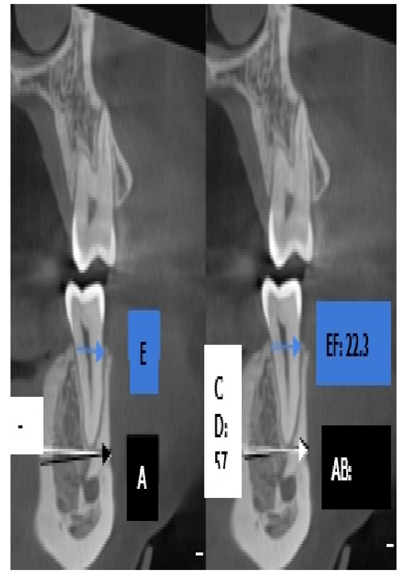

Figure 3: The measurement **AB** correspondsto the width between the buccal and lingual alveolar plates at the lowest point of thealveolar bone perpendicular to **L2** (representedas **EF)**. he width **CD** representsbuccal and lingual basal plates at the highest part of the alveolar bone, perpendicular to **L3 (EF)**. Meanwhile, the distance **EF** is measurebetween the buccal and lingual alveolar crest **(EF).**

relation to the basal bone, resulting in a significantly large positive angle (angle b), which shows that the basal bone and alveolar process are not closely aligned or parallel (Figure 2C and 2D).

Statistical analysis: Data was analyzed using Statistical Package for Social Sciences (SPSS) version 23.0. Chi square tests were employed to compare the percentage of successful implants in each bone type. Statistical significance was set at $p > 0.05$. The kappa statistics were employed to assess the reliability between and within examiners.

RESULTS

The age distribution by teeth and gender was almost the same. The distance between buccal and lingual alveolar crest was 20.3±1.3 mm for permanent left mandibular second premolar and for permanent right mandibular second premolar was 20.3±1.1 mm among females and that for males the two teeth had average distance of 20.8 and 20.7 mm. The width of the alveolar process for permanent mandibular second premolars in females was 51.1 and 51.6 while for males this width was 52.8 and 52.6 mm respectively. The width of basal bone was a little higher for males but not different within gender for two teeth. The average angle between the long axis of the permanent mandibular second premolar and alveolar bone (<a)° among females for mandibular second premolars were 3.1 and 3.0 while for males this average was 2.9 and

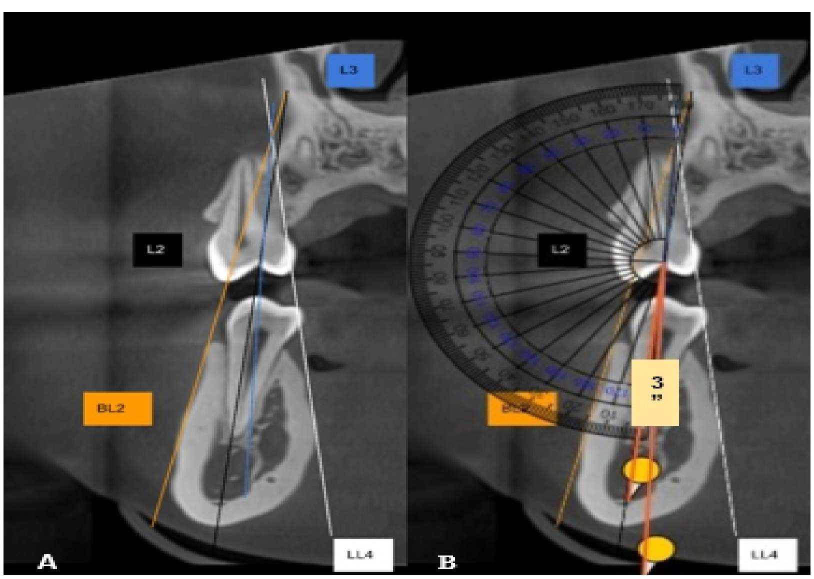

Figure 4: The straight type; L2 and L3 exhibited a state of overlap or near overlap. The upper internal angle (b) is small in this case.

Table I: Presentation of anatomical morphology for teeth 35 and 45 by gender

Variables	Female				Male			
	Tooth 35		Tooth 45		Tooth 35		Tooth 45	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Age (years)	33.5	6.9	34.3	7.2	35.8	7.4	35.2	7.1
Distance between buccal & lingual alveolar crest EF (mm)	20.3	1.3	20.3	1.1	20.8	1.1	20.7	1.2
Width of alveolar process (AB) (mm)	51.1	4.1	51.6	3.0	52.8	3.7	52.6	3.7
Width of basal bone (CD) (mm)	52.1	4.0	52.2	3.1	53.5	3.7	53.4	3.6
Angle between long axis of second premolar and alveolar bone (<a)°	3.1	1.6	3.0	1.7	2.9	1.6	3.2	1.6
Angle between long axis between alveolar bone and basal bone (<b)°	5.8	3.1	5.1	1.7	5.0	1.5	5.6	2.0

SD:Standrad deviation; mm: millimeter

Table II: Comparison of anatomical morphology measures between two genders

Variables	Gender		p-value
	Female	Male	
	Mean (SD) Median (Q_1-Q_3)	Mean (SD) Median (Q_1-Q_3)	
Age (years)	32.5 (28.0-38.0)	33.0 (29.0-42.0)	0.151
Distance between buccal & lingual alveolar crest EF (mm)	20.3 (1.1)	20.8 (1.2)	0.013
Width of alveolar process (AB) (mm)	52.2 (49.3-53.7)	53.1 (51.8-55.0)	0.003
Width of basal bone (CD) (mm)	53.0 (50.2-54.5)	54.0 (52.8-55.8)	0.006
Angle between long axis of second premolar and alveolar bone (<a)°	3.0 (2.0-4.0)	3.0 (2.0-4.0)	0.973
Angle between long axis between alveolar bone and basal bone (<b)°	5.0 (4.0-6.0)	5.5 (4.0 – 6.0)	0.718

SD:Standrad deviation; mm: millimeter

Table III: Types of mandibular premolars as per classification

Variables	Female		Male		Total	
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
Straight type	25	30.5	24	29.3	49	29.9
Oblique type	57	69.5	58	70.7	115	70.1
Total	82	100.0	82	100.0	164	100.0

Chi-square = 0.03; p-value = 0.865

3.2 respectively. For females the angle between the long axis between alveolar bone and basal bone was 5.8±3.1 for tooth 35 and 5.1±1.7 for tooth 45 respectively. For males the average angle was 5.6±2.0 for tooth 45 and 5.0±1.5 for tooth 35 (Table I).

The median age for females was 32.5 (28.0-38.0) years and 33.0 (29.0-42.0) years for the males, and the difference was insignificant with p-value 0.151. The distance between buccal and lingual alveolar crest for females was 20.3±1.1 mm while for male was 20.8±1.2 mm which was significantly higher with p-value 0.013. The width of the alveolar process was also significantly higher for males by 0.9 mm with a p-value 0.003, and similarly the width of basal bone was also higher by 1.0 mm for males with p-value 0.006. The median angle between the long axis of the second premolar and alveolar bone (<a)° was 3.0 for both males and females, and this difference was insignificant with p-value 0.973. The median angle between alveolar and basal bone was 5.5(4.0-6.0) for males while 5.0(4.0-6.0) for females and this difference was insignificant with p-value 0.718 (Table II).

When examined the oblique type was most common (70.1%) overall and the remaining were straight type. There was no difference between the two genders (p-value = 0.865) (Table III).

DISCUSSION

The present study evaluated CBCT records to assess the alveolar and basal bone characteristics of the mandibular second premolar region. Our findings revealed significant gender differences in alveolar process width and basal bone dimensions, although age distribution and angular measurements remained consistent across genders. Over 70% of cases exhibited an oblique alveolar morphology, highlighting the anatomical variability of this region. These results emphasize that successful implant placement depends on a detailed understanding of the implant site's morphology. Specifically, increased socket angulation heightens the risk of buccal and lingual perforations, making the prevention of perforation and bone overload critical for implant effectiveness.[11] Ensuring that the implant's long axis of occlusal forces closely matches the original long axis of missing teeth's occlusal force is very important, as the alveolar bone exhibits greater resistance to compressive force compared to shear stress.[12] Venkatesh E, compared CBCT to conventional imaging and found that it helps detect anatomical variations and pathologies more clearly as it can show anatomical structures from different angles.[9] In another article by Gupta S, et al., it was deduced that CBCT provides rapid data acquisition with little radiation exposure. It generates images replicating those used in daily clinical practice.[11] Therefore, due to the more significant advantages of CBCT over other techniques, it is the technique of choice for implant imaging.

In this study, CBCT image data from 164 cases were selected to assess and categorize the bone morphology of the mandibular second premolars. This method showed the original state of the buccal and lingual bone around the tooth.

Since the mandible resorbs downwards and outwards to become wider, it can affect implant placement's success. And as mentioned earlier, there are more chances of buccal perforation in cases where buccal resorption of alveolar bone is fast, and the alveolar process is buccally angled. Several techniques have been suggested to uphold the dimensions of the alveolar ridge, aiming to preserve its structure. Implant placement immediately after tooth extraction is a technique employed to mitigate bone resorption.[12,13] Nevertheless, limited scientific research provides substantial evidence to support the exclusive use of immediate implant placement in preventing bone alterations. Consequently, it is advisable to contemplate augmentation concurrent with implant placement. The results agreed with previous immediate implant placement studies.[8,14]

This study examined the connection among the mandibular second premolar axis and the alveolar bone axis. It was determined that the angle between these two structures was not affected by demographic factors such as gender or age. It was observed that the angle was primarily positively large, indicating a buccally angled alveolar process in conjunction with the basal bone. This type of angulation induced the resorption of buccal bone at a faster rate. Therefore, the implant would be positioned buccally to the alveolar bone axis. By examining the tooth axis and jaw form of a similar tooth on the opposite side, it may be possible to determine the direction of the implant.[15]

To achieve optimal implant positioning in cases with oblique morphology, it may be beneficial to select a shorter tapered implant that deviates slightly from the long axis of occlusal forces. This approach can help minimize the risk of buccal perforations. However, it's important to note that the limited sample size and the lack of data on the risk of lingual perforations in this study prevent us from drawing definitive conclusions applicable to all cases. Further research with larger sample sizes is necessary to validate these findings and fully assess potential risks.

CONCLUSION

The morphology of the mandibular second premolar is crucial for determining implant placement feasibility. Analysis of CBCT images in this study identified two distinct morphologies: straight and oblique. The straight type, where the basal bone and alveolar process are closely aligned, is generally more favorable for implantation. In contrast, the oblique type, characterized by buccal angulation of the alveolar process relative to the basal bone, is more common. However, it poses greater challenges for implant placement due to increased buccal bone resorption following tooth extraction. Consequently, CBCT is essential as a diagnostic tool to ensure optimal implant positioning and reduce the risk of complications.

REFERENCES

1. Abraham CM. A brief historical perspective on dental implants, their surface coatings and treatments. Open Dentist J 2014;8:50-5. https://doi.org/10.2174/1874210601408010050
2. Chan HL, Benavides E, Yeh CY, Fu JH, Rudek IE, Wang HL. Risk assessment of lingual plate perforation in posterior mandibular region: a virtual implant placement study using cone-beam computed tomography. J Periodontol 2011;82(1):129-35. https://doi.org/10.1902/jop.2010.100313
3. Herranz-Aparicio J, Marques J, Almendros-Marqués N, Gay-Escoda C. Retrospective study of the bone morphology in the posterior mandibular region. Evaluation of the prevalence and the degree of lingual concavity and their possible complications. Med Oral Pathol Oral Cir Bucal 2016;21(6):e731. https://doi.org/10.4317/medoral.21256
4. Juodzbalys G, Wang HL. Identification of the mandibular vital structures: practical clinical applications of anatomy and radiological examination methods. J Oral Maxillofac Res 2010;1(2):e1. https://doi.org/10.5037/jomr.2010.1201
5. Samuels J, Zhang A, Monsour P. The cross-sectional morphology of the mandible in the premolar region: a retrospective cone-beam computed tomography study. Int J Dent Med Spec 2020;7(1):2-6. https://doi.org/10.30954/IJDMS.1.2020.2
6. Hsu JT, Huang HL, Fuh LJ, Li RW, Wu J, Tsai MT, et al. Location of the mandibular canal and thickness of the occlusal cortical bone at dental implant sites in the lower second premolar and first molar. Comput Math Methods Med 2013;2013(1):608570. https://doi.org/10.1155/2013/608570
7. Haiderali Z. The role of CBCT in implant dentistry: uses, benefits and limitations. Br Dent J 2020;228(7):560-1. https://doi.org/10.1038/s41415-020-1522-x
8. Bungthong W, Amornsettachai P, Luangchana P, Chuenjitkuntaworn B, Suphangul S. Bone dimensional change following immediate implant placement in posterior teeth with CBCT: a 6-month prospective

clinical study. Molecules 2022;27(3):608.https://doi.org/10.3390/molecules27030608

9. Venkatesh E, Elluru SV. Cone beam computed tomography: basics and applications in dentistry. J Istanbul Univ Fac Dent 2017;51(3 Suppl 1):102-21. https://doi.org/10.17096/jiufd.00289

10. Gallucci GO, Khoynezhad S, Yansane AI, Taylor J, Buser D, Friedland B. Influence of the Posterior Mandible Ridge Morphology on Virtual Implant Planning. Int J Oral Maxillofac Implants 2017;32(4):801-6. https://doi.org/10.11607/jomi.5546

11. Gupta S, Patil N, Solanki J, Singh R, Laller S. Oral implant imaging: a review. The Malaysian J Med Sci 2015;22(3):7.

12. Aliabadi E, Tavanafar S, Khaghaninejad MS. Marginal bone resorption of posterior mandible dental implants with different insertion methods. BMC Oral Health 2020;20:1-7. https://doi.org/10.1186/s12903-020-1019-7

13. Saha A. Residual Ridge Resorption: The Unstoppable Phenomenon. 2019. [Accessed on: August 23, 2023]. Aailable from URL: https://dentalreach.today/residual-ridge-resorption-the-unstoppable-phenomenon/

14. Matarasso S, Salvi GE, Iorio Siciliano V, Cafiero C, Blasi A, Lang NP. Dimensional ridge alterations following immediate implant placement in molar extraction sites: a six-month prospective cohort study with surgical re-entry. Clin Oral Implant Res 2009;20(10):1092-8. https://doi.org/10.1111/j.1600-0501.2009.01803.x

15. Kong ZL, Wang GG, Liu XY, Ye ZY, Xu DQ, Ding X. Influence of bone anatomical morphology of mandibular molars on dental implant based on CBCT. BMC Oral Health 2021;21:1-1 https://doi.org/10.1186/s12903-021-01888-3

AUTHORS' CONTRIBUTION

Following authors have made substantial contributions to the manuscript as under:

NZ & MEF: Conception and study design, analysis and interpretation of data, drafting the manuscript, critical review, approval of the final version to be published

SA & MQ: Acquisition, analysis and interpretation of data, drafting the manuscript, approval of the final version to be published

Authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

CONFLICT OF INTEREST

Authors declared no conflict of interest, whether financial or otherwise, that could influence the integrity, objectivity, or validity of their research work.

GRANT SUPPORT AND FINANCIAL DISCLOSURE

Authors declared no specific grant for this research from any funding agency in the public, commercial or non-profit sectors

DATA SHARING STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request

KMUJ web address: www.kmuj.kmu.edu.pk
Email address: kmuj@kmu.edu.pk