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Determination Of Posterior Mandibular Alveolar Bone Morphology In Terms Of Lingual Concavity Angulation In Subgroup Of Indian Population: A Morphometric Analysis

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ABSTRACT:

Introduction: Cross-sectional analysis using cone beam computed tomography (CBCT) is appropriate for assessing lingual undercuts and preventing lingual cortex perforation and subsequent complications.

Aim: The purpose of this study was to evaluate the mandibular lingual concavity angulation and determine the mandibular alveolar bone morphology on CBCT scans at the edentulous mandibular first molar site in order to prevent lingual cortex perforation during implant insertion.

Materials & methods:106 images were assessed in this study.The protocol for morphological assessment and measurements of lingual concavity was adapted from study conducted by Fatemah Salemi et.al. and Yoon et al. The region of interest was the edentulous mandibular first molar region.

Results: A total of 106 scans were analyzed, and the average age of 38.52 yrs ± 11.93 (range 18 to 68 years) with 52.8% (56) male population & 47.2% of females (50).The results showed the degree of lingual concavity was 68.83±9.70, with the mean of 68.29 ± 9.73 amongst males and 65.20 ± 9.48 in the females. In terms of mandibular

alveolar bone morphology the most prevalent was type U accounting for 96.2% (50.9% in males and 45.3% in females). 82% of mandibular U type of morphology showed low risk, 17% had a high risk and 1% had extremely high risk for lingual cortical perforation.

Conclusion The type U mandibular morphology was predominantly seen in this subset of Indian population and 18% indicated high risk for lingual cortex perforation. Hence morphometric analysis of implant site using three dimensional imaging may be recommended to analyze the risk and future outcomes of mandibular posterior implant placement.

Key words: anatomy,mandible,lingual concavity,implant,complication

Introduction:

Over the decades replacement of missing teeth are slowly and steadily actuated by newer modalities like implants which has brought a new era of reconstructive therapy.[1,2,3]The posterior mandibular ridge is the most frequent site for placement of dental implant post molar loss.[4]The complex anatomy of this area makes it extremely challenging for surgeons to place dental implants.[5] The most ambiguous anatomical variation is the lingual undercut or lingual concavity which jeopardises the site for implant placement therefore the angulation and implant positioning has to be assessed radiographically.[5] Since CBCT scans facilitate more accurate lingual concavity visualization in the first molar region, as well as improved implant fixture selection in terms of size, position, and buccolingual angulation;they are the most preferred radiological assessment method in implant planning and intervention.[6]

Various authors have used different reference points to measure lingual concavity [1,5].Watanabe et al. classified posterior mandibular cross-sectional morphology as types A, B, and C. Types which was described by the outlines of the buccal and lingual cortical plates.Fatemah Salemi et al. and Nickenig et al. classified posterior cross-sectional morphology as type U, type C, and type P. The assessment was based on width of ridge base & its alveolar ridge. Thomas Y.H.Yoon classified mandibular bone morphology based on lingual angulation.

To the best of our knowledge no study has been conducted to assess the mandibular bone morphology by determining the lingual concavity angulation. Hence we conducted the study among the subset Indian population based on the classification put forward by Yoon et.al.

According to Thomas Y.H. Yoon, images with a lingual undercut of less than 60˚ were classified as concave. When the angle was between 60˚ and 70˚, the image was classified as parallel. Convex images were defined as those with angles greater than 70˚.

Therefore, this study focuses on prevalence & degree of lingual concavity &categorizing the edentulous posterior mandibular bone morphology on the basis of lingual concavity angulation in a subset of Indian population.

The purpose of the study was i) To measure the degree of lingual concavity& depth in this subgroup of population.ii) To categorize the edentulous posterior mandibular alveolar bone morphology by measuring the degree of lingual concavity.iii) To correlate the depth of the lingual undercut with the degree of lingual concavity. iv) To correlate the posterior mandibular alveolar bone morphology with age & gender. v) To determine the risk assessment of lingual plate perforation based on concavity angle.

Materials & methods:

The study was given approval by the Institutional Review Board on March 17, 2023, the reference number is IREB/2023/OMR/01.

CBCT Image Data

All of the images used in the study were obtained from the patients archives at the department of Oral and Maxillofacial Radiology between January 2020 and January 2021.The CBCT scans were obtained from Kodak 9000 CSextra oralimaging System with the pixel detector ranging from 70 µ – 200µ& 70 Kvp ,10ma,14.2 seconds. The images were analysed using Carestream 3D Imaging Software by Kodak.

The site under investigation was the edentulous mandibular first molar area, either unilateral or bilateral. A total of 106(edentulous sites)were scrutinized, bilateral edentulous areas were of particular interest. The excluded scans comprised those of low resolution, having artifacts and intraosseous pathologies as well as scans of alveolar bone grafts and dental implants.

Assessment of lingual angulation &cross-sectional mandibular morphology

All morphological assessment and measurements were appraised by a single investigator on CBCT software.

The region of interest (ROI) included the mandibular occlusal plane and the inferior border.

Location of lingual concavity measurement[2]

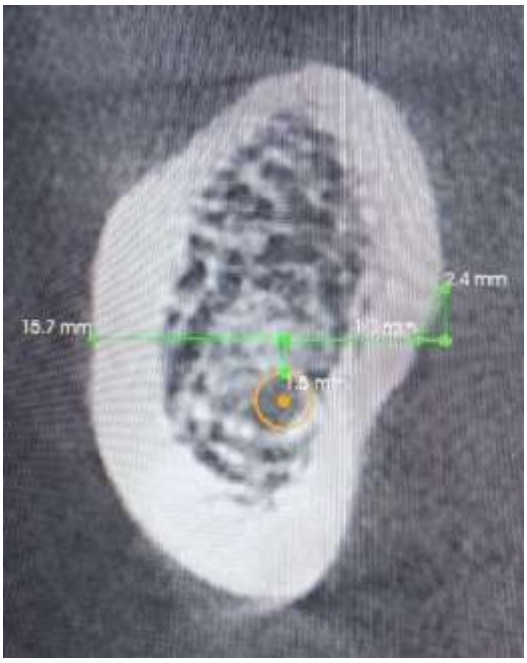
According to basic definitions provided in various studies a protocol for measurement was derived. In the presence of second molar,the location of measurement was taken from the midpoint of the mesio-distal length between the second premolar and second molar region on the sagittal section(Figure 1)

In the absence of the second molar the location for meaurement was taken 5mm distal to the second premolar area on the sagittal section.(Figure 1)

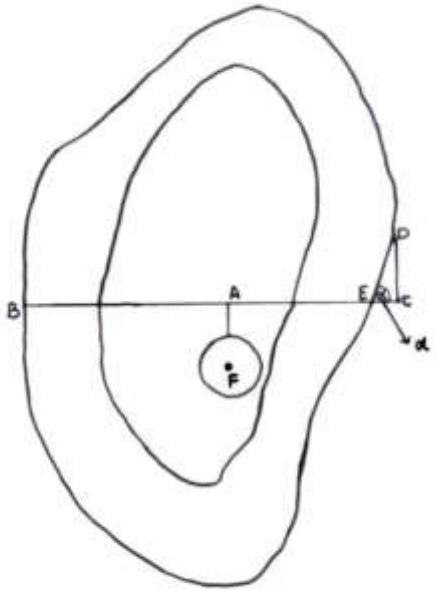
Tab/Figure 1: Cross-sectional slice of CBCT in the posterior mandible.
Left in presence of second molar; Right in absence of second molar.

Measurement of lingual concavity angulation[1]

The method for measurement of angle of lingual concavity was adapted from the study conducted by Yoon et al.The coronal image of the located site was considered for evaluation. Measurement was taken about 1.5 mm above the superior cortical border of the inferior alveolar nerve canal and a horizontal line (HL) was drawn.We denoted the most prominent point on the lingual aspect of the bone as reference point(D).A vertical line was drawn from reference point (D) to the horizontal line extended beyond the cortex lingually creating a triangle with three sides. (Figures 2,3) The lingual concavity angle was measured using the HL at the border of the mandible that formed the hypotenuse of the triangle.



Tab/Figure 2: Schematic view of measurements taken on CBCT scans



Table/Figure 3: 2˚Schematic view of measuements taken on CBCT scans

F-Inferior alveolar nerve canal
BC-A horizontal line drawn 1.5mm above the superior above the superior part of the IANC.
D-The most prominent point on the lingual aspect.
E-The deepest point in the lingual surface.
CE-Concavity depth.
DEC(α)-Concavity depth angle measured in degree.

Types of the cross-sectional mandibular morphology determined by lingual concavity angulation.
In measuring the posterior mandibular region when the angulation was less than 85° it was classified as concave (U type) when there was no obvious lingual undercut or the morphology was between 85° to 95° the image was classified as parallel (P type).If the angle was larger than 95° the image was classified as convex(C type).[1]

Lingual depth assessment
The horizontal distance between points C and E was measured to assess the linear concavity depth (CE). (Figures 2,3)

RESULTS
The 106 scans that were evaluated included 56 male population (52.8%) and 50 female population (47.2%) having an age range 18 to 68 years, with a mean age of 38.52 and standard deviation 11.93.The mean age ± Standard deviation is 38.52 yrs ± 11.93. Higher incidence of undercut ridge morphology (41%) was recognized in age ranging between 30-45 years .
56scans (53%) were on the left side & 46 scans(43.39%) on the right & 4 scans were bilateral.
Average degree of lingual concavity in the mandibular first molar region was 68.83±9.70, with the mean of 68.29 ± 9.73 amongst males and 65.20 ± 9.48 in the females. Statistical analysis did not reveal a significant difference detected with in Age (P value =0.818) and Gender(0.647).
The lingual concavity angulation(typical form) range from (38-81).The average degree of lingual concavity was 68.83±9.70,with a mean of 68.29 ± 9.73 amongst males and 65.20 ± 9.48 in the females.

Type of ridge morphology
In terms of ridge morphology, type U had a frequency of 96.2% , (50.9% in males and 45.3% in females), while type P had a frequency of 3.8% (males (1.9%) & females (1.9%)) and C type of alveolar bone morphology was not found in our study findings.

Lingual Concavity Depth range and distribution
The lingual concavity depth range from (0.5-4.30).Average linear depth of lingual concavity with a mean of (1.93) amongst males and (1.76) females.
Among the U type mandibular morphology,54.7% had a lingual concavity linear depth less than 2mm,in 28.3% was between 2-3mm & in 14.2%,it was more than 3mm.Only 3% P type bone morphology had linear lingual depth less than 2mm.
There was no significant association between ridge morphology and age groups as well as gender. ($P > 0.05$)

A negative correlation was also noted between lingual concavity angulation and its depth. Increase in linear depth of the lingual concavity showed a significant decrease in the lingual cortical angulation ($P<0.05$).

82% of mandibular U type of morphology showed low risk (>60˚), 17% had a high risk and 1% had extremely high risk for lingual perforation.

Statistical analysis was done ,and the results were analyzed .Pearson correlation analysis were used to compare mean values of angulation with gender & angulation with depth. Spearman correlations were used to compare age with type of morphology. (Tab/Figure -4).

Table/figure 4: CORRELATION OF TYPE OF RIDGE MORPHOLOGY AND AGE GROUP

AGE GROUP (YEARS)	RIDGE MORPHOLOGY TYPE		TOTAL	P-VALUE
	U	C		
YOUNGER THAN 30 (25.5%)	26 (24.5%)	1 (0.9%)	27 (25.5%)	0.818
30-45 (41.5%)	43 (40.6%)	1 (0.9%)	44 (41.5%)	
45-60 (30.2%)	30 (28.3%)	2 (1.9%)	32 (30.2%)	
OVER 60 (2.8%)	3 (2.8%)	0 (0%)	03 (2.8%)	
TOTAL	102 (96.2%)	4 (3.8%)	106 (100%)	

P < 0.05 = Significant
P > 0.05 = Not Significant
Tabulated Value = 7.82
*** CHI SQUARE TEST DOES NOT SHOWS STATISTICAL DIFFERENCE BETWEEN GROUPS, P VALUE AND SIGNIFICANE**

***ANOVA DOES NOT SHOWS STATISTICAL DIFFERENCE BETWEEN AGE GROUPS, P VALUE AND SIGNIFICANE IN ANY OF THE VARIABLES**

Table/figure 5: CORRELATION OF TYPE OF RIDGE MORPHOLOGY AND GENDER

GENDER	RIDGE MORPHOLOGY TYPE		TOTAL	P-VALUE
	U	C		
MALE (52.8%)	54 (50.9%)	2 (1.9%)	56 (52.8%)	0.647
FEMALE (47.2%)	48 (45.3%)	2 (1.9%)	50 (47.2%)	
TOTAL	102 (96.2%)	4 (3.8%)	106 (100%)	

P < 0.05 = Significant
P > 0.05 = Not Significant
Tabulated Value = 3.84
*** CHI SQUARE TEST DOES NOT SHOWS STATISTICAL DIFFERENCE BETWEEN GROUPS, P VALUE AND SIGNIFICANE**

Table /figure 6: MEAN VALUES OF MEASURED VARIABLES IN MALES AND FEMALES

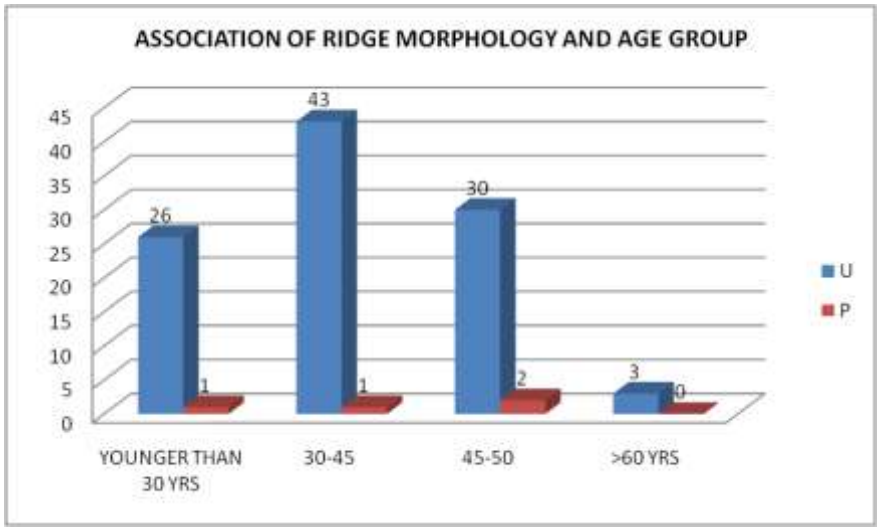
VARIABLE	RANGE	GENDER	NUMBER	MEAN	STANDARD DEVIATION	P-VALUE
RIDGE HEIGHT	0.90-10.40	MALE	56	4.50	2.30	0.020*
		FEMALE	50	3.50	1.80	
RIDGE DEPTH	0.50-4.30	MALE	56	1.93	1.10	0.001*
		FEMALE	50	1.76	0.95	
ANGULATION	38-92	MALE	56	68.29	9.73	0.102
		FEMALE	50	65.20	9.48	
ANGULATION RIGHT	47-81	MALE	27	69.00	9.09	0.132

	51-79	FEMALE	21	66.88	6.53	
ANGULATION LEFT	44-79	MALE	29	66.45	9.02	0.218
	38-72	FEMALE	29	61.92	9.44	
RIDGE DEPTH < 2 MM	0.50-1.90	MALE	29	1.02	0.44	0.21
		FEMALE	32	1.16	0.08	
RIDGE DEPTH > 2 MM	2.01 - 4.30	MALE	27	2.89	0.65	0.801
		FEMALE	18	2.84	0.58	

P < 0.05 = Significant
P > 0.05 = Not Significant
Tabulated Value = 1.98

***T-TEST TEST SHOWS A STATISTICAL SIGNIFINT DIFFERENCE BETWEEN MALES AND FEMALES IN RIDGE HEIGHT FROM THE RIDGE CREST TO 2 MM ABOVE THE INFERIOR ALVEOLAR CANAL THAT THIS DISTANCE WAS SIGNIFICANTLY GREATER IN MALES THAN FEMALES (P-VALUE=0.020) AND P < 0.05**
*Correlation of Association between RIDGE MORPHOLOGY AND AGE GROUPS FOUND NO SIGNIFICANT ASSOCIATION (P > 0.05)

Table /figure 7:Association of ridge morphology and age group



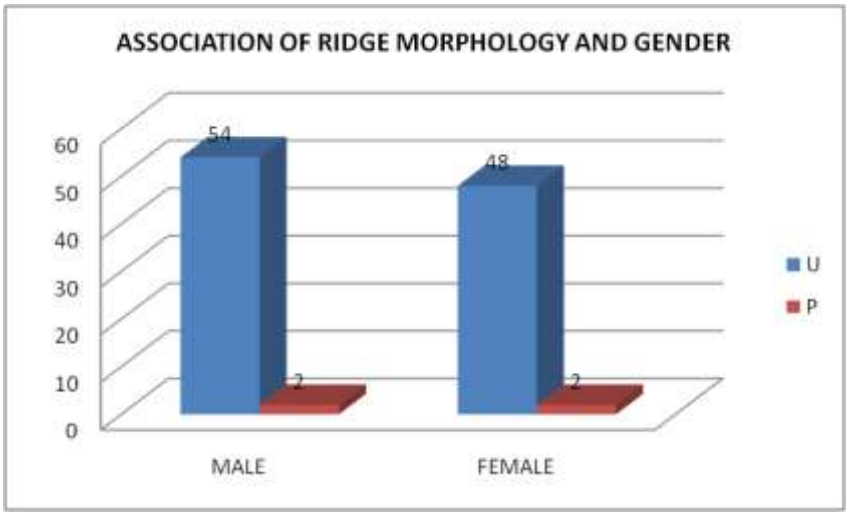
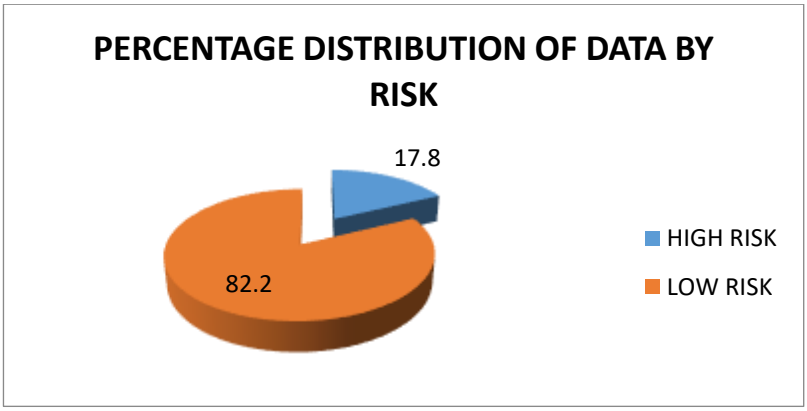


Table / figure 8: Association of ridge morphology and gender



Table/Figure 9:Percentage distribution of data by risk

DISCUSSION

The present study evaluated the lingual concavity angle to categorise the alveolar bone morphology in the mandibular first molar region using CBCT. The CBCT qualifies as a perfect tool in morphological evaluation of mandibular posterior location, in particular the identification of lingual concavity.[6]

For safe implant surgery, understanding the anatomy of lingual concavities is essential. Life-threatening lingual plate perforation can occur when implant placement damages vital structures.[7,8,9]

The lingual concavity angle measurement and cross-sectional mandibular morphology classification were assessed using Yoon et al methodology.[1]The mean concavity angle observed in our study was 68.83±9.70, with 68.29 ± 9.73 in males and 65.20 ± 9. in females, which was found to be statistically significant ($p<0.001$). Yoon et al reported an average concavity angulation of 75.87° (F) and 75.45° (M) on the right and 75.39° (F) and 75.19° (M) on the left. (figure 6,8)

Few studies evaluated the average concavity angulation but the measurement parameters was different from the current study.[1]

Majority of the subjects had a U type mandibular morphology (96.2%) which was significantly higher than (60%) reported by Yoon et al [1].

Most of the literature reviewed, identified variations in mandibular morphology among studies which can be attributed to variation of cut off angle for defining undercut, parameters employed for classifications, differing ethnicity of the study population, site of assessment as well as dentate status.[10,11]

To the best of our knowledge this may be the first study conducted on Indian population that has used concavity angulation to subcategorise cross-sectional mandibular morphology.

Mean linear depth of lingual concavity varied among studies.Results of our study was in accordance with Fatemah et.al .Different reference points and variations in the duration of edentulism may explain the unconformity in the results. Lingual concavity deeper than 2 mm can increase the risk of lingual plate perforation and complications during implant placement.This study showed 14.2% of U type morphology having a depth more than 3mm but higher percentage(44.7%) was noted in study conducted by Fatemah et.al.[2,9]

No significant difference was seen across gender in the type of mandibular morphology,which was consistent with the findings of Fatemah Salemi et al,Yoon T.Y et al,and Chan et al.[1,2,7]Our study did not show significant association between age and lingual concavity which was in disagreement Yoon T.Y,et.al .It can attributed to more younger patients (less than 50 yrs of age)that was prevalent in the scans[1,12,13,14,15,16,17]

A negative correlation was observed between lingual undercut depth and concavity angle which was in congruence with the results of Fatemah s et.al.[2]

Several previous studies have addressed the issue posed by lingual concavity and risk assessment.[7,11,13] A study conducted on German population defined concavity angles of >60°, has low risk (do not pose a serious complication).Concavity angles <60° has high risk (risk of lingual perforation), Concavity angles <40°, extremely deep lingual concavities(demands serious caution) .In their study the low-risk cases accounted for 73% of all posterior sockets on the other hand 26% of cases had deep lingual concavities of <60° and 1.4% had extremely deep lingual concavities of <40°, which demands serious caution.[10]In accordance to this study our data also revealed similar results with 82% of mandibular U type of morphology showed low risk,17% had a high risk and 1% had extremely high risk for lingual cortical perforation.(figure 9,10)

Generalising validity of this study could be probably affected by the small sample size .To overcome the limitation imposed by the retrospective study design used in the current study, further studies employing a prospective study design with a large sample size and taking into account confounding variables such as site of implant placement, duration of edentulism,age grouping, and extraction method are recommended.A standardised protocol of measuring concavity angle&standardising cut off angles for determining mandibular morphology may be prerequisite for further studies.

CONCLUSION

Lingual concavities are common in the edentulous mandibular posterior area.[1,2,12,14] In our study U type ,mandibular morphology were predominant in this subset of population. The authors conclude that 3D preoperative assessment may be considered as prerequisite as 18% U type of alveolar bone morphology posed a high risk for lingual plate perforation.External validity would have been affected by small sample size hence future studies should aim at large sample.standardised measuring protocol , cut off values and definition for mandibular morphology.Research should also focus on identifying characteristics that may predict the degree of lingual concavity and the probability of posterior lingual plate perforation.

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