Original Article

Prevalence of Lingual Concavities in the Posterior Mandible Using Cone Beam Computed Tomography in a Tertiary Care Hospital in Pakistan

Maham Farooq[1], Khurram Ataullah[2], Farheen Qureshi[3], Zubair Ahmad Khan[4], Ayesha Binte Aslam[5], Lubna Yousaf[6]

[1-4]Department of Periodontology, Fatima Memorial Dental Hospital, Shadman, Lahore, Pakistan; [5]Department of Oral & Maxillofacial Surgery, AIMC / Jinnah Hospital, Lahore, Pakistan; [6]Department of Community Dentistry, Avicenna Dental College, Bedian Road, Lahore, Pakistan

Corresponding Author: ***Dr. Maham Farooq***, *Senior Registrar, Department of Periodontology, Fatima Memorial Dental Hospital, Shadman, Lahore, Pakistan* **Email:** *mahamfarooqwarraich@gmail.com*

Abstract

Background: Lingual cortical plate perforations during implant placement are more likely to occur in the posterior mandible where there are lingual concavities. However, Cone beam computed tomography (CBCT) allows for detailed analysis of this anatomy and local data do not exist.

Objective: To assess the prevalence of lingual concavity in posterior mandible, its depth and angle in CBCT images of adult population aged 18-45 years in a Tertiary Care Hospital Lahore and to compare its frequency, depth and angle according to sex and age group.

Methods: This cross sectional study was conducted in Fatima Memorial Dental Hospital, Lahore, Pakistan from December 2023 to May 2024. The subjects were 95 patients (18–45 years of age) who had lost some or all of their posterior mandibular teeth, and were recruited via non-probability consecutive sampling. A lingual concavity depth and lingual concavity angle was measured by one observer on cross-sectional CBCT images, which were referenced to 2 mm above the inferior alveolar canal. Pearson's chi-square and Welch's t-test ($p < 0.05$) were used for group comparisons.

Results: The mean age was 30.67 ± 7.83 years (51.58% female). Lingual concavity was present in 43 participants (45.26%; 95% CI 35.6–55.3); overall mean depth was 3.79 ± 1.87 mm and mean angle 62.89 ± 8.74°. Concavity was more frequent in males than in females (60.87% vs 30.61%; $p = 0.003$) and deeper (4.21 ± 1.84 vs 3.40 ± 1.82 mm; $p = 0.033$), but angle did not differ ($p = 0.96$). Frequency (43.75% vs 46.81%; $p = 0.76$), depth ($p = 0.54$) and angle ($p = 0.56$) were similar in the 18–30-year and 31–45-year groups.

Conclusion: Lingual concavity was seen in nearly 50% of this one centre sample, more frequently and more severely in males, and was not significantly different across the age groups.

Keywords: Cone beam computed tomography, lingual concavity, posterior mandible, dental implants, prevalence

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Introduction

Dental implants are widely used to replace missing teeth and have high long-term success rates.[1] Most serious complications of implant surgery occur intraoperatively and are often related to inadequate planning or incorrect implant orientation.[2–4] In the posterior mandible, the submandibular fossa is a depression on the lingual surface below the mylohyoid line that produces a lingual concavity (also described as a lingual undercut) of variable depth.[2,5] A deep concavity increases the risk that the osteotomy or implant will perforate the lingual cortical plate,[2,6] which can lead to sublingual or submandibular haematoma, bleeding or infection.[2,3] Although uncommon, life-threatening floor-of-mouth haemorrhage requiring emergency airway management has been reported after implant placement in the mandible.[7] Concavities with an angle below 60° have been classed as deep.[8] Periapical and panoramic radiographs provide no buccolingual information, and clinical palpation gives limited information about the lingual contour, so deep concavities may go undetected.[9] Cone Beam Computed Tomography (CBCT) provides cross-sectional images from which concavity depth and angle can be measured directly before surgery.[5,9] The reported prevalence of lingual concavity varies widely, from about one-third to more than two-thirds of sites or patients: for example, 32.8% in a Malaysian population,[10] 42.5% of edentulous posterior mandibular sites in one CBCT series,[11] 52.7% in Saudi Arabia,[12] and 64% to 68% in Spanish, Chinese

and other cohorts.[2,13,14] These differences reflect ethnicity, the definition of concavity, dentition status and the tooth region examined; in one series, concavities were present at 34.7% of first-molar sites but 98% of second-molar sites.[9]

Local data are limited. In Pakistan, the only CBCT study of lingual concavity that we identified, from Rawalpindi, found an undercut ridge in 46.7% of images.[15] Because ridge morphology may differ between populations,[2,9] region-specific data stratified by sex and age are needed to inform implant planning for local patients. The objective of this study was to determine the prevalence of lingual concavity in the posterior mandible on CBCT in adults aged 18–45 years at a tertiary care hospital in Lahore, and to compare its frequency, depth and angle by sex and age group.

Methods

This cross-sectional study was conducted in the Department of Periodontology, Fatima Memorial Dental Hospital, Lahore, Pakistan from December 2023 to May 2024. This study was approved by the Institutional Review Board, FMH College of Medicine & Dentistry, Lahore, Pakistan (FMH-03/05/2023 -IRB-1212). All subjects provided written informed consent and granted their permission before enrolment.

The sample size was calculated using the formula for estimating a single proportion, $n = Z^2P(1-P)/d^2$, with a 95% confidence level (Z=1.96), a 10% margin of error (d=0.10) and an expected prevalence (P) of lingual concavity on CBCT of 42.5%.[11] This gave a minimum of 94 participants; 95 patients were enrolled by non-probability consecutive sampling. Patients were eligible if they were aged 18–45 years, in good general and mental health, and had unilateral or bilateral loss of one or more mandibular teeth (first or second molars, premolars or canines), sufficient vertical bone height for an implant of ≤10 mm length and 4 mm diameter, and an available CBCT of the mandible. Patients were excluded if they were edentulous, pregnant or lactating, taking medications such as bisphosphonates, or had a retained tooth or root within the edentulous site to be assessed. The posterior mandible was defined as the part of the mandible posterior to the mental foramen. All scans were acquired with the Planmeca Romexis 3D Mid system (60–120 kV; scan time 9–33 s; voxel size 200 µm) using a standardised technique, and only scans from this system were included. Lingual concavity was defined as a depression of the lingual surface of the posterior mandible caused by compression of the mandibular cortex by the submandibular and sublingual salivary glands. Measurements were made on cross-sectional images using a method adapted from Chan et al.[5] A frame of two horizontal lines 2 mm apart was superimposed on the cross-section, with the top of the inferior alveolar canal (IAC) placed on the lower line. Point A was the intersection of the upper line with the lingual boundary of the alveolar ridge, and point D was the outermost point of the lingual alveolar boundary. The concavity angle was the angle between line D–A and the upper horizontal line. Concavity depth was the horizontal distance A–B and ridge width the distance A–C (Figure 1).

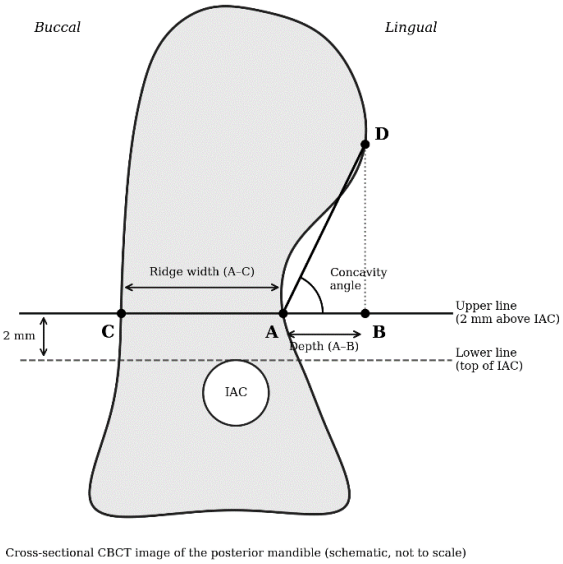


Figure 1: *Schematic of the measurement of lingual concavity on a cross-sectional CBCT image (not to scale). The upper line lies 2 mm above the lower line, which is placed on the top of the inferior alveolar canal (IAC). A: intersection of the upper line with the lingual boundary of the ridge; D: outermost point of the lingual alveolar boundary; B: point on the upper line vertically below D; C: buccal boundary of the ridge on the upper line. Concavity angle = angle between line D–A and the upper line; depth = A–B; ridge width = A–C.*

All measurements were made by a single observer to avoid inter-observer variability and were recorded on a purpose-designed proforma. Intra-observer reliability was not assessed (see Strengths and limitations). Data were analysed in R version 4.1.2. The

participant was the unit of analysis (n = 95), so each patient contributed one observation to each analysis and no adjustment for clustering was needed. Categorical variables (sex, age group, presence of lingual concavity) are presented as frequencies and percentages, with 95% confidence intervals for proportions calculated by the Wilson method. Quantitative variables (age, concavity depth, concavity angle) are presented as mean ± standard deviation (SD). Data were stratified by sex and by age group (18–30 and 31–45 years). Frequencies were compared using Pearson's chi-square test and mean depth and angle using Welch's two-sample t-test, with mean differences reported with 95% confidence intervals. All tests were two-sided, and $p < 0.05$ was considered statistically significant.

Results

Ninety-five patients were included (mean age 30.67 ± 7.83 years, range 18–45): 49 (51.58%) were female and 46 (48.42%) male, and 48 (50.53%) were aged 18–30 years and 47 (49.47%) were aged 31–45 years (Table 1). Lingual concavity was present in 43 of 95 participants (45.26%; 95% CI 35.6–55.3). For the whole sample, the mean concavity depth was 3.79 ± 1.87 mm and the mean concavity angle was 62.89 ± 8.74° (Table 1).

Table 1: *Participant Characteristics and Overall Lingual Concavity Findings (n = 95)*

Variable	Value
Age, years, mean ± SD (range)	30.67 ± 7.83 (18–45)
Sex, n (%)	
Female	49 (51.58)
Male	46 (48.42)
Age group, n (%)	
18–30 years	48 (50.53)
31–45 years	47 (49.47)
Lingual concavity present, n (%) [95% CI]	43 (45.26) [35.6–55.3]
Concavity depth, mm, mean ± SD	3.79 ± 1.87
Concavity angle, degrees, mean ± SD	62.89 ± 8.74

CI, confidence interval (Wilson method); SD, standard deviation. Depth and angle are summarised for all 95 participants.

Lingual concavity was significantly more frequent in males than in females (p = 0.003; Table 2). Mean depth was greater in males, by 0.81 mm (95% CI 0.06 to 1.56); p = 0.033, whereas mean angle did not differ between the sexes (p = 0.96).

Table 2: *Lingual Concavity by Sex*

Variable	Female (n = 49)	Male (n = 46)	Test statistic / mean difference (95% CI)[c]	p-value
Lingual concavity, n (%)				
Present	15 (30.61)	28 (60.87)	$\chi^2 = 8.77$	0.003[a]
Absent	34 (69.39)	18 (39.13)		
Depth, mm, mean ± SD	3.40 ± 1.82	4.21 ± 1.84	0.81 (0.06 to 1.56)	0.033[b]
Angle, degrees, mean ± SD	62.85 ± 8.96	62.93 ± 8.60	0.08 (−3.50 to 3.66)	0.96[b]

[a] Pearson's chi-square test (1 degree of freedom). [b] Welch two-sample t-test. [c] Mean difference = male minus female. CI, confidence interval. Depth and angle are summarised for all participants in each group.

There were no significant differences between the 18–30-year and 31–45-year groups in the frequency of lingual concavity (p = 0.76), mean depth (p = 0.54) or mean angle (p = 0.56) (Table 3).

Table 3: *Lingual Concavity by Age Group*

Variable	18–30 years (n = 48)	31–45 years (n = 47)	Test statistic / mean difference (95% CI)[c]	p-value
Lingual concavity, n (%)				
Present	21 (43.75)	22 (46.81)	$\chi^2 = 0.09$	0.76[a]
Absent	27 (56.25)	25 (53.19)		
Depth, mm, mean ± SD	3.91 ± 1.78	3.67 ± 1.96	−0.24 (−1.00 to 0.52)	0.54[b]
Angle, degrees, mean ± SD	62.37 ± 8.78	63.42 ±8.76	1.05 (−2.52 to 4.62)	0.56[b]

[a] Pearson's chi-square test (1 degree of freedom). [b] Welch two-sample t-test. [c] Mean difference = 31–45 years minus 18–30 years. CI, confidence interval. Depth and angle are summarised for all participants in each group.

Discussion

In this CBCT study of 95 adults aged 18–45 years, lingual concavity was present in 45.26% of participants (95% CI 35.6–55.3). It was more frequent and deeper in males, whereas angle did not differ between the sexes and no measure differed between

age groups. Our prevalence is close to that reported in Pakistan (46.7%),[15] Turkey (47.8%)[16] and in the edentulous sites studied by Braut et al. (42.5%).[11] It is higher than the 32.8% reported in Malaysia[10] and lower than the 52.7–68% reported in other series.[2,5,12-14] Direct comparison is limited because studies differ in ethnicity, dentition status, definition of concavity and the region examined. Prevalence rises from the first to the second molar (34.7% vs 98% in one series;[9] 32.7% vs 62.7% in another[17]), so studies restricted to the first molar report lower figures than those that include the second molar. Our participants were also younger than those in several reference series.[2,5,18]

The mean depth of 3.79 mm was greater than the values reported from Saudi Arabia (2.38 mm),[12] Turkey (2.36 mm)[16] and earlier CBCT series (about 2.4 mm),[5,19] but similar to the 3.1–4.5 mm reported by Herranz-Aparicio et al.[2] and the 3.8–4.4 mm reported by Pishva et al.[9] The mean angle of 62.89° is comparable with values of 57.7° (Chan et al.),[5] 59.7–61.5° (Pishva et al.)[9] and 61.1° (Dala and İpek),[16] and lower than the 66.6–71.6° and 67–69° reported by Herranz-Aparicio et al. and Alzaben et al.[2,12] Depth and angle were averaged over all participants here, whereas most other studies report them only for ridges with a concavity, and landmarks differ between studies, so these comparisons should be interpreted cautiously. A mean angle just above 60° also implies that some patients may have angles below the 60° threshold used to define deep concavities;[8] the distribution of angles was not analysed.

The higher frequency and greater depth of lingual concavity in males agree with larger or deeper concavities in males reported from China,[13] Malaysia[10,18] and East Asia,[20] and with the numerically greater depth in males (4.5 vs 3.1 mm) in Herranz-Aparicio et al., although that difference was not significant.[2] In contrast, no sex difference in depth was found in studies from Rawalpindi,[15] Saudi Arabia,[12] Turkey[16] and Iran.[21] The reasons for these discrepancies are unclear. Sex-related differences in mandibular size and bone development have been proposed,[20] and differences in sample size, measurement method and tooth site probably also contribute. Because only 15 women and 28 men in our sample had a concavity, the sex comparison should be regarded as exploratory. We found no difference between the two age groups, consistent with reports of no association between age and concavity depth in Turkish, Iranian and Malaysian samples.[16,18,21] Herranz-Aparicio et al., however, found a negative correlation between age and concavity depth.[2] Our sample was restricted to 18–45 years and dichotomised at 30 years, which may have limited the ability to detect age-related differences, and older patients were not represented.

Almost half of the patients had a lingual concavity, and the mean angle was close to the 60° threshold used to define deep concavities.[8] These findings support assessing the lingual contour on cross-sectional CBCT images when planning implants in the posterior mandible, so that the osteotomy and implant trajectory can be planned to avoid the lingual cortex.[2,6] This study did not evaluate perforation, complications or implant outcomes and therefore cannot show that CBCT-based planning reduces them. The strengths of this study are the use of a single CBCT system with a standardised acquisition protocol, a predefined operational definition based on a published method, measurement by one observer, and analysis stratified by sex and age group. Its limitations are as follows. First, it was a single-centre study using non-probability consecutive sampling of 95 patients; this limits generalisability, and the sample was sized to estimate overall prevalence rather than to detect subgroup differences. Second, only patients aged 18–45 years with missing posterior mandibular teeth who were candidates for implants were included. Third, measurements were made by one observer and neither intra-observer nor inter-observer reliability was assessed. Fourth, results were not reported by tooth region, although concavity varies between regions.[9,17] Fifth, depth and angle were summarised across all participants rather than only those with a concavity, and the proportion of concavities with an angle below 60° was not analysed. Sixth, sex and age were analysed separately without multivariable adjustment. Finally, clinical outcomes were not assessed. Future multicentre studies should report results by tooth region, assess measurement reliability, classify concavity severity, and include clinical outcomes.

Conclusion

In this single-centre sample of 95 adults aged 18–45 years, lingual concavity was present in the posterior mandible of 45.26% of patients on CBCT, with a mean depth of 3.79 ± 1.87 mm and a mean angle of 62.89 ±

8.74°. Concavity was more frequent and deeper in males, and there was no difference in angle between sexes or in any measure between age groups. These findings support assessing the lingual contour on cross-sectional CBCT images before implant planning in this region; larger multicentre studies that include clinical outcomes are needed.

Ethical Approval: The Institutional Review Board, FMH College of Medicine & Dentistry, Lahore, Pakistan approved this study vide IRB number: FMH-03/05/2023-IRB-1212.

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Authors' Contribution:

MF: Conception and design; acquisition, drafting of article, analysis and interpretation of data, final approval of the version to be published

KA: Critical revisions for important intellectual content, final approval of the version to be published

FQ: Conception and design, analysis and interpretation of data, critical revisions for important intellectual content

ZAK: Acquisition of data, critical revisions for important intellectual content

ABA: Analysis and interpretation of data

LY: Analysis and interpretation of data

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