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Correlation between Depth of Floor of Mouth and Calculus Deposition in the Mandibular Anterior Region: A Cross-Sectional Study

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Background: *Dental calculus is a mineralized plaque deposit commonly found on the lingual surfaces of mandibular anterior teeth. Although its role in periodontal disease progression is well established, the influence of anatomical factors on calculus accumulation remains unclear.*
Aim: *To investigate the relationship between the anatomical depth of the floor of the mouth and calculus deposition in the mandibular anterior region.*
Methodology: *A total of 100 participants were evaluated. Calculus deposition was assessed using CSSI. Following oral prophylaxis and fabrication of a customized occlusal stent, floor of mouth depth was measured using a UNC-15 periodontal probe.*
Results: *The mean calculus index score was 1.12 ± 1.037, while the mean floor of mouth depth was 7.53 ± 1.623 mm. A statistically significant positive correlation was observed between floor of mouth depth and calculus deposition (Spearman's rho = 0.734, p < 0.001).*
Conclusion: *Greater floor of mouth depth was associated with increased calculus deposition in the mandibular anterior region.*
Keywords
Dental Calculus; Floor of Mouth Depth; Lingual Vestibule; Mandibular Anterior Teeth; Calculus Surface Severity Index; Periodontal Disease; Anatomical Risk Factors; Depth of Floor of Mouth; Calculus.

I. INTRODUCTION

Dental calculus is a mineralized form of dental plaque formed by the precipitation of calcium and phosphate ions derived primarily from saliva and gingival crevicular fluid. It is considered one of the most important local contributing factors in the initiation and progression of periodontal disease because of its plaque-retentive nature and its role in maintaining chronic inflammation of periodontal tissue.[1]. In addition, calculus acts as a chronic local irritant that promotes plaque retention and perpetuates the cycle of gingival inflammation.

Although calculus itself is not directly pathogenic, its rough surface provides an ideal substrate for bacterial colonization, thereby facilitating persistent plaque accumulation and periodontal destruction.[2]

Various factors influence the formation and deposition of calculus, including salivary composition, salivary flow rate, oral hygiene practices, tooth morphology, and variations in oral soft tissue anatomy.[3] The distribution of dental calculus within the oral cavity is not uniform. Supragingival calculus is most commonly observed on the buccal surfaces of maxillary molars adjacent to the openings of the parotid duct and on the lingual surfaces of mandibular anterior teeth near the submandibular and sublingual salivary gland ducts. Among these sites, the lingual surfaces of mandibular anterior teeth exhibit the greatest tendency for calculus accumulation. This preferential deposition has been attributed to the close proximity of salivary duct openings, increased salivary film velocity, rapid clearance of fermentable carbohydrates, and maintenance of a relatively alkaline pH favouring mineral precipitation.[4,5,6] Dawes C et al. (2006) reported that plaque in the mandibular anterior lingual region remains above the critical pH for prolonged periods because of rapid salivary clearance, increased salivary film velocity, and shallow Stephan curves, thereby favouring mineral precipitation and calculus formation.[4]

Among the various anatomical factors that may influence site-specific calculus deposition, vestibular anatomy and the depth of the floor of the mouth have received comparatively limited scientific attention. Vestibular depth has been defined by Ward VJ (1976)[7] as "the distance between the crest of the lip and the greatest concavity of the mucobuccal fold or the distance between the coronal border of the attached gingiva and the mucobuccal fold." Although vestibular anatomy has been extensively evaluated in relation to periodontal health, prosthodontic rehabilitation, and gingival recession, its influence on calculus deposition remains inadequately explored.

The floor of the mouth is anatomically related to the sublingual and submandibular salivary glands and determines the spatial relationship between salivary secretions and the lingual surfaces of the mandibular anterior teeth. Variations in the functional depth of the floor of the mouth may influence salivary pooling, salivary film velocity, tongue movement, and plaque retention, thereby potentially affecting the degree of calculus deposition in this region.[4,8]A shallow lingual vestibule may limit effective plaque control by restricting toothbrush accessibility and impairing patient-performed oral hygiene procedures.[7,9]Additionally, reduced vestibular depth may alter the natural self-cleansing mechanisms of the oral cavity, thereby promoting plaque accumulation and subsequent calculus formation

Understanding the relationship between floor of mouth anatomy and calculus accumulation may provide valuable insight into individual susceptibility to periodontal disease and may help clinicians identify patients at greater risk for recurrent calculus formation. Such information could contribute to improved preventive strategies, personalized oral hygiene instructions, and more effective periodontal maintenance protocols.

Therefore, the present study was undertaken to investigate the relationship between the anatomical depth of the floor of the mouth and calculus deposition in the mandibular anterior region. The study aimed to evaluate whether variations in the anatomical depth of the floor of the mouth influence calculus accumulation on the lingual surfaces of mandibular anterior teeth. In addition, calculus deposition was assessed using the Calculus Surface Severity Index (CSSI),[10,11,12] and the average anatomical depth of the floor of the mouth within the study population was evaluated. By assessing these parameters, an attempt was made to understand the possible role of lingual vestibular anatomy as a contributing factor in site-specific calculus deposition and periodontal health.

II. MATERIALS AND METHOD

Study Design and population

The present study was designed as a cross-sectional observational study to evaluate the correlation between the anatomical depth of the floor of the mouth and calculus deposition in the mandibular anterior region. The study was conducted in the Outpatient Department of Periodontology, over a duration of 4 months during the year 2024. Patients reporting to the outpatient department were screened for eligibility and randomly recruited according to predefined inclusion and exclusion criteria using a purposive convenience sampling technique. After obtaining the ethical board clearance, Informed consent was obtained from all participants prior to their inclusion in the study. The study was conducted in accordance with the ethical principles of the Declaration of Helsinki of 1975, as revised in 2013.

Sample size was determined using the estimated values from literature Padmini et al. 2018 [13] using the formula.

Total sample size = $N = [(Z_\alpha+Z_\beta)/C]^2 + 3$

where Z_α is the z variate of alpha error i.e. a constant with value 1.96,

Z_β is the z variate of beta error i.e. a constant with value 0.84

$C = 0.5 * \ln[(1+r)/(1-r)]$.

Approximate estimates: 80% power

Type I error to be 5%

Type II error to be 20%

Minimum correlation between the 2 variables as 0.28. Approximately 98 samples need to be taken in the present study. So total of 100 samples were recruited.

The inclusion criteria in the study were subjects aged between 25 and 60 years who were willing to participate and provide written informed consent. Subjects were required to have a minimum of 20 teeth excluding third molars, should not have undergone professional oral prophylaxis within the previous six months, and were required to be systemically healthy.

Patients unable to provide informed consent, those undergoing orthodontic treatment, subjects with lower anterior crowding, missing mandibular anterior teeth, lower anterior fixed prosthesis, pathological tooth wear, tobacco or smoking habits, and high lingual frenum attachment were excluded from the study.

Subjects were withdrawn from the study if they developed any exclusion criterion during the course of the study, voluntarily withdrew participation, experienced any adverse event, or failed to comply with study appointments and procedures.

Clinical Procedure

Recording of Calculus Score

After obtaining informed consent, the amount of calculus deposition on the lingual surfaces of mandibular anterior teeth was assessed clinically using the Calculus Surface Severity Index (CSSI) which was given by Ennever J et al. (1961)[10,11,12]

The index scoring criteria were as follows:

- **Score 0** – No calculus present.
- **Score 1** – Calculus observable but less than 0.5 mm in width and/or thickness.
- **Score 2** – Calculus not exceeding 1 mm in width and/or thickness.
- **Score 3** – Calculus exceeding 1 mm in width and/or thickness. (Fig 1)

The assessment was performed on the lingual surfaces of mandibular incisors. Tooth number 41 was selected as the reference tooth; in its absence, tooth number 31 was evaluated. (Fig 2)

After recording the calculus score, complete oral prophylaxis was performed to remove supra- and subgingival deposits. Subsequently, an impression of the mandibular arch was made for fabrication of an occlusal stent, which was used to standardize the angulation and positioning of the periodontal probe during measurement procedures, thereby improving reproducibility and minimizing measurement errors.

The anatomical depth of the floor of the mouth was measured using a UNC-15 periodontal probe. The cementoenamel junction (CEJ) of the mandibular central incisor served as the upper reference point, while the lower reference point was the functional depth of the floor of the mouth recorded when the tongue was elevated to its superior-most functional position. Measurements were recorded in millimetres with the aid of the customized occlusal stent to ensure standardized probe orientation.[13] Since the measuring capacity of the UNC-15 probe is limited to 15 mm, measurements were obtained in sections using standardized anatomical reference points, and the cumulative value was recorded as the final depth of the floor of the mouth.[8] (Fig 3 &4)

The primary parameters assessed in the study were the depth of the floor of the mouth and the calculus score in the mandibular anterior region.

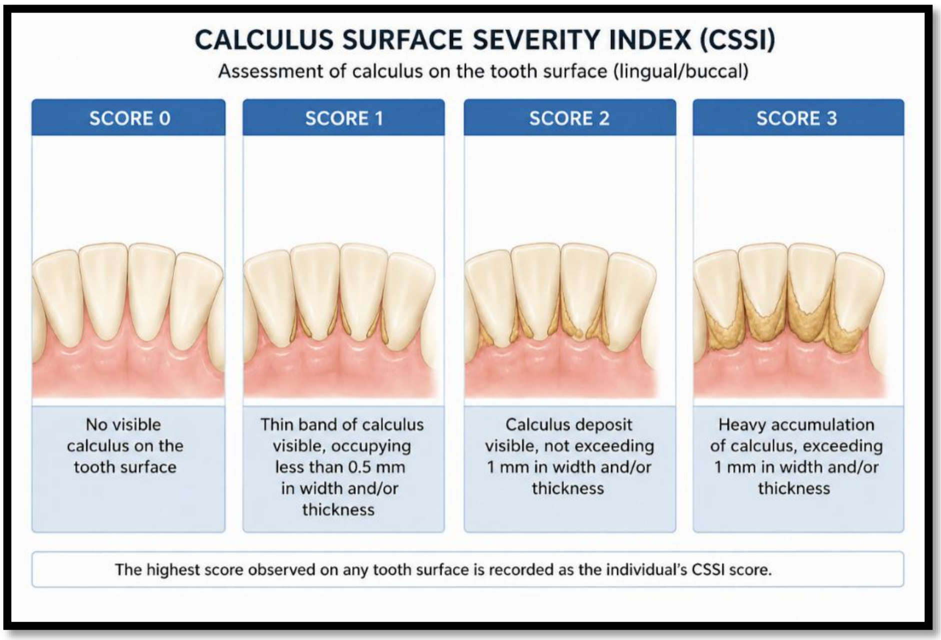

Fig 1: Calculus surface severity index (CSSI)

Fig 2: Calculus deposits on lingual surface

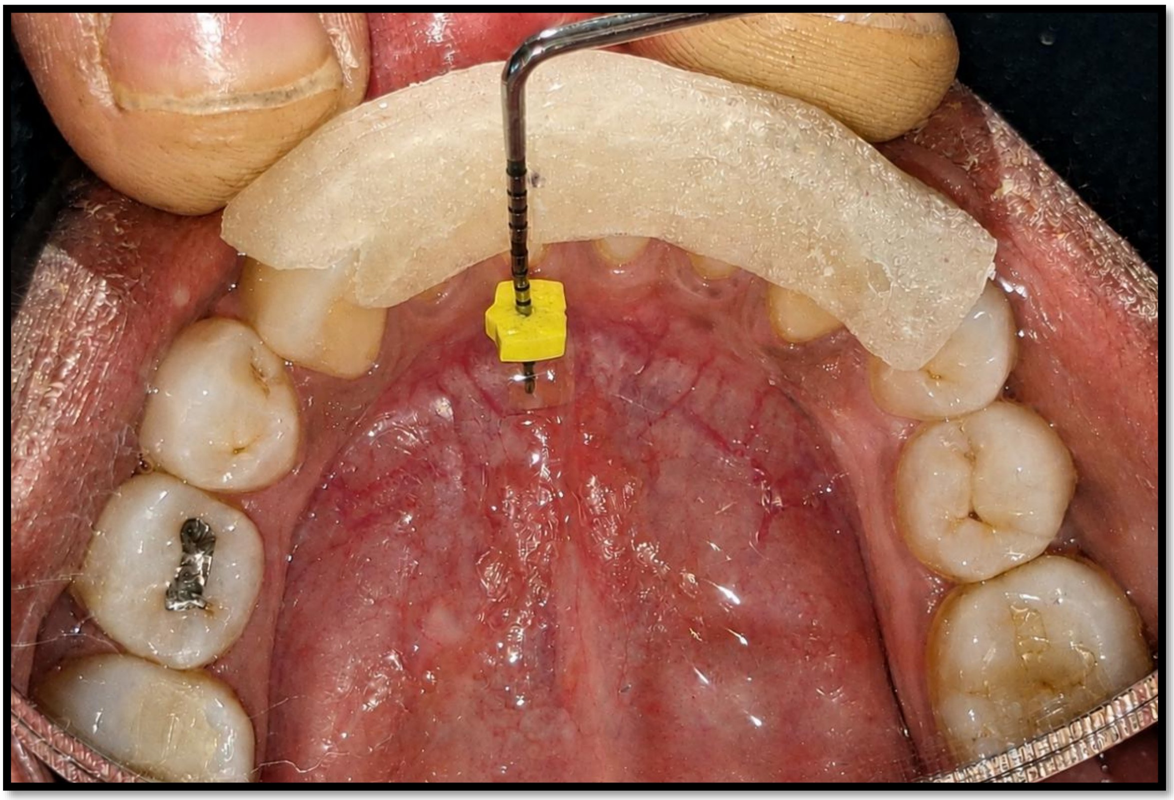

Fig 3: Measuring depth of floor of mouth using UNC-15 Probe and occlusal stent.

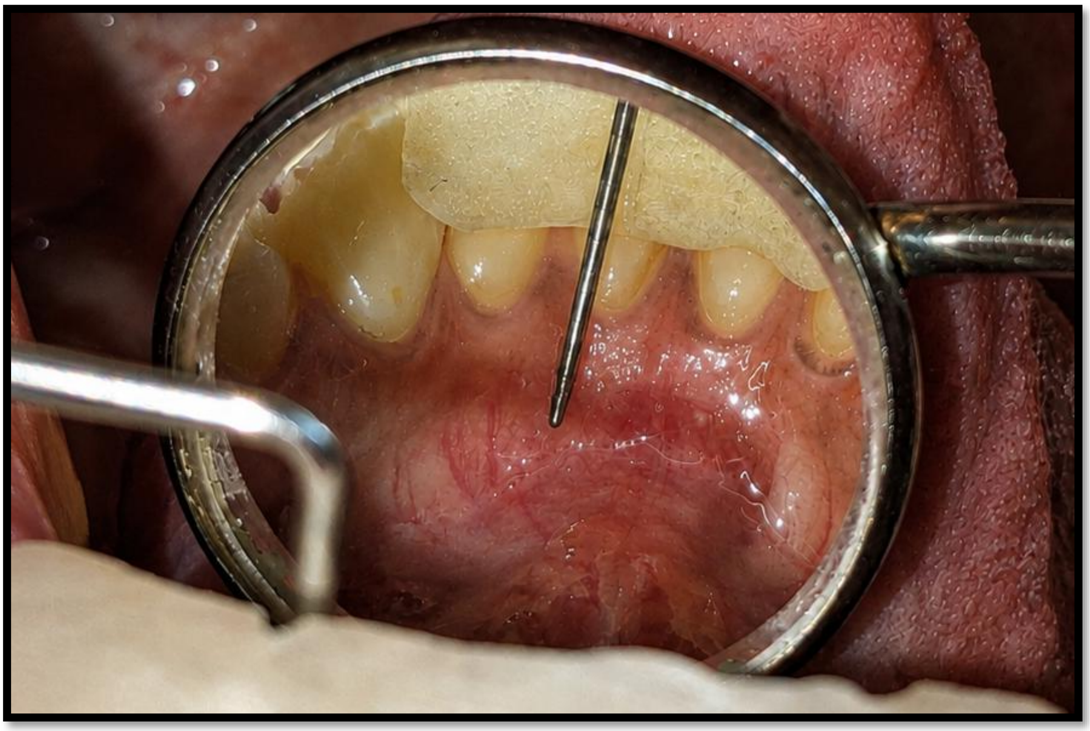

Fig 4: Measuring depth of floor of mouth using UNC-15 Probe and occlusal stent.

Measures Taken to Minimize Bias

Several measures were undertaken to minimize potential sources of bias in the present study. Standardized inclusion and exclusion criteria were applied to ensure homogeneity of the study population. All clinical measurements were performed by a single calibrated examiner to reduce inter-examiner variability. The Calculus Surface Severity Index (CSSI), a validated index, was used for assessment of calculus deposition. A customized occlusal stent was fabricated for each participant to standardize the position and angulation of the UNC-15 periodontal probe during measurement of floor of mouth depth, thereby minimizing measurement bias.

Oral prophylaxis was performed only after recording the calculus scores to avoid information bias. Uniform measurement protocols were followed for all participants. Statistical analyses were conducted using appropriate non-parametric tests after assessment of data normality. However, the use of convenience sampling and the cross-sectional design may have introduced selection bias and limited the establishment of causal relationships.

Statistical procedure

All data were entered into a computer by giving coding system, proofed for entry errors

- Data obtained was compiled on a MS Office Excel Sheet (v 2019, Microsoft Redmond Campus, Redmond, Washington, United States).
- Data was subjected to statistical analysis using Statistical package for social sciences (SPSS v 26.0, IBM).
- Descriptive statistics like frequencies and percentage for categorical data, Mean & SD for numerical data has been depicted.

Normality of numerical data was checked using Shapiro-Wilk test & was found that the data did not follow a normal curve; or for graded data, hence **non-parametric tests** have been used for comparisons.

- ✓ Bivariate correlation between 2 numerical variables was checked using Kendall's Tau correlation coefficient

For all the statistical tests, $p<0.05$ was considered to be statistically significant, keeping α error at 5% and β error at 20%, thus giving a power to the study as 80%.

III. RESULTS

A total of 100 participants were included in the present cross-sectional study to evaluate the correlation between the depth of the floor of the mouth and calculus deposition in the mandibular anterior region. Among the study participants, 33% demonstrated a calculus index score of 0, indicating absence of detectable calculus, while 37% of subjects showed a calculus index score of 1. Furthermore, 15% of participants each exhibited calculus index scores of 2 and 3 respectively. The mean calculus index score was found to be 1.12 ± 1.037.(Table 1)

The depth of the floor of the mouth ranged from 4 mm to 11 mm, with a mean value of 7.53 ± 1.623 mm, indicating that the average anatomical depth of the floor of the mouth among the study population was approximately 7.5 mm. (Table 2)

Normality of the collected data was assessed using the Shapiro–Wilk test. The calculus index demonstrated a Shapiro–Wilk value of 0.834 with p = 0.000, while depth of the floor of the mouth demonstrated a value of 0.942 with p = 0.000. Since the p value for both variables was less than 0.05, the data did not follow normal distribution; therefore, non-parametric correlation analysis was considered appropriate. (Table 3)

Correlation between calculus deposition and depth of the floor of the mouth was evaluated using Kendall's Tau-b and Spearman's rank correlation coefficient tests. Spearman's correlation analysis revealed a statistically highly significant positive and very strong correlation between calculus index and depth of floor of the mouth, with a correlation coefficient (r) of 0.734 and p value = 0.000 ($p < 0.01$). Similarly, Kendall's Tau-b correlation coefficient was found to be 0.646 with p = 0.000, further confirming the association between the two variables.

The positive correlation observed in the present study indicates that as the depth of the floor of the mouth increased, calculus deposition in the mandibular anterior region also increased. Subjects with greater floor of mouth depth tended to exhibit higher calculus scores.

The scatter plot analysis further demonstrated an upward linear trend between calculus index and depth of the floor of the mouth. In the graph, the x-axis represents the calculus index scores ranging from 0 to 3, while the y-axis represents the measured depth of the floor of the mouth in millimetres. The plotted data points demonstrate an upward trend, indicating that greater calculus scores are associated with increased depth of the floor of the mouth. The linear regression line shown in the graph further supports this observation and demonstrates a positive association between the two variables. (Fig. 5)

Based on the statistical findings of the present study, the null hypothesis stating that "there is no correlation between depth of floor of mouth and calculus deposition in the mandibular anterior region" was rejected, and the alternate hypothesis was accepted.

Overall, the findings of the present study suggest a significant association between anatomical depth of the floor of the mouth and calculus deposition on the lingual surfaces of mandibular anterior teeth.

Table 1: calculus index

	Frequency	Percent
0	33	33.0
1	37	37.0
2	15	15.0
3	15	15.0
Total	100	100.0

Table 2: Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
calculus index	100	0	3	1.12	1.037
Depth	100	4	11	7.53	1.623

Table 3: Tests of Normality

	Shapiro-Wilk		
	Statistic	df	p value
calculus index	.834	100	.000
Depth	.942	100	.000

p<0.05 indicates normality not followed

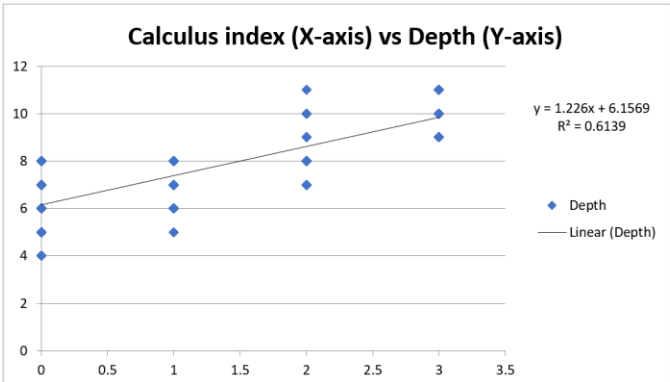

Fig 5: Scatter plot analysis

IV. DISCUSSION

Dental calculus is recognized as one of the major local contributing factors in the initiation and progression of periodontal disease because of its plaque-retentive nature and its role in maintaining chronic gingival inflammation. These findings are also consistent with the classical periodontal concepts described by Carranza et al., who emphasized the role of calculus as a major plaque-retentive factor in periodontal disease progression.[1]

The present cross-sectional study was conducted to evaluate the correlation between the anatomical depth of the floor of the mouth and calculus deposition in the mandibular anterior region. The results of the present study demonstrated a statistically highly significant and strong positive correlation between the depth of the floor of the mouth and calculus deposition. Spearman's correlation coefficient was found to be 0.734 with $p = 0.000$, indicating that individuals with increased floor of mouth depth showed greater accumulation of calculus on the lingual surfaces of mandibular anterior teeth.

The average depth of the floor of the mouth observed in the present study was 7.53 ± 1.623 mm. These findings are in accordance with previous anatomical studies evaluating vestibular and floor of mouth dimensions. **Ward VJ et al. (1976)**,[7] who evaluated the depth of the vestibular fornix in the mandibular anterior region. In their study, measurements were performed on the labial/buccal vestibular side extending from the gingiva to the mucobuccal fold and from the crest of the lip to the mucobuccal fold. They reported that vestibular depth ranged from 2.5 mm to 11.5 mm when measured from the gingiva to the mucobuccal fold and concluded that vestibular depth was approximately uniform from canine to canine in periodontally healthy individuals. Although the present study evaluated the lingual floor of mouth depth, the range of measurements observed was comparable, suggesting that anatomical soft tissue dimensions show individual variation throughout the mandibular anterior region. There were considerable variations in vestibular depth within the mandibular anterior region, suggesting that anatomical differences among individuals may influence periodontal conditions and oral hygiene maintenance.

The present findings may be explained by the close anatomical relationship between the floor of the mouth and the submandibular and sublingual salivary glands. Increased depth of the floor of the mouth may alter salivary pooling and salivary film dynamics adjacent to the lingual surfaces of mandibular anterior teeth, thereby creating conditions favourable for mineral precipitation and calculus formation. Furthermore, deeper anatomical areas may reduce the efficiency of natural self-cleansing mechanisms by tongue movement and saliva circulation, allowing prolonged plaque stagnation and subsequent mineralization thereby formation of calculus.

These observations are supported by the study conducted by **Dawes C et al. (2006)**,[4] who explained why supragingival calculus forms preferentially on the lingual surfaces of mandibular anterior teeth. They reported that plaque in this region remains above the critical pH for prolonged periods because of high salivary film velocity, rapid clearance of fermentable carbohydrates, and shallow Stephan curves. These factors favour mineral precipitation and facilitate calculus formation. Similarly, **Schroeder et al. (1969),[6]** reported that mineral precipitation within dental plaque is strongly influenced by salivary supersaturation with calcium and phosphate ions, particularly in regions adjacent to salivary duct openings. They further observed that calculus deposition occurs preferentially in areas receiving direct salivary influence, especially on the lingual surfaces of mandibular anterior teeth and the buccal surfaces of maxillary molars. The findings of the present study are consistent with these observations and further suggest that the anatomical depth of the floor of the mouth may influence salivary and plaque dynamics, thereby contributing to increased calculus deposition.

Similarly, **Corbett TL et al. (1998),[5]** in their study on site-specificity of supragingival and subgingival calculus deposition, observed that mandibular central incisors exhibited greater supragingival calculus accumulation compared to lateral incisors, canines, and premolars on the lingual surfaces. Their study emphasized the importance of local anatomical and environmental factors in calculus deposition. The findings of the present study are in agreement with these observations and further strengthen the concept that anatomical characteristics influence site-specific calculus formation.

The methodology used in the present study for measuring functional depth of the floor of the mouth was based on the principles described by **Casey DM et al. (1980).[8]** They described a method for accurately marking the functional depth of the floor of the mouth in its superior-most position and transferring the measurements to diagnostic casts. Their technique was specifically designed for the **lingual floor of mouth region** to aid in mandibular removable partial denture framework design. In the present study, use of an occlusal stent and UNC-15 periodontal probe helped standardize the angulation and reproducibility of measurements, thereby improving reliability

Previous studies evaluating vestibular depth have mainly focused on its relationship with periodontal health, gingival recession, and prosthodontic considerations. **Nandkeoliar T et al. (2023)**,[15] in an observational cross-sectional study, concluded that vestibular depth was decreased in subjects with gingival recession compared to periodontally healthy individuals. Their study evaluated the **buccal/labial vestibular depth** and emphasized that understanding normal vestibular dimensions may help identify conditions associated with shallow vestibules and future periodontal complications. Although the present study evaluated calculus deposition rather than gingival recession, the findings similarly indicate that anatomical soft tissue dimensions may influence periodontal health-related conditions.

Likewise, **Sbricoli L et al. (2023)** evaluated the role of vestibular fornix depth on periodontal health and reported significant anatomical differences between maxillary and mandibular arches, with deeper vestibular fornices in the maxilla. Their study primarily assessed the **buccal vestibular fornix depth** and its relationship with width of keratinized gingiva. However, they concluded that vestibular depth did not significantly influence oral hygiene efficacy in healthy young individuals. The difference between their findings and those of the present study may be attributed to differences in study parameters, age group, evaluated anatomical region, and outcome measures. While **Sbricoli et al.** assessed periodontal health parameters in healthy individuals, the present study specifically focused on calculus accumulation in relation to lingual floor of mouth anatomy. **[9]**

Parihar N et al. (2022), in their study evaluating sulcus and vestibular depth in completely edentulous patients, measured vestibular depth at multiple anatomical locations including the lingual frenum and lingual notch regions. Their study mainly focused on prosthodontic rehabilitation and patient satisfaction with dentures. The lingual frenum depth and lingual notch depth were found to be 5.66 ± 1.57 mm and 5.83 ± 1.57 mm respectively. Although performed in edentulous patients, their findings demonstrated the variability of lingual vestibular anatomy and highlighted the importance of accurately evaluating lingual anatomical dimensions. The present study extends these observations to dentate individuals and further evaluates the influence of lingual floor of mouth depth on calculus deposition.[16]

The regression analysis and scatter plot in the present study further demonstrated a positive linear relationship between calculus index and floor of mouth depth. The coefficient of determination ($R^2 = 0.6139$) indicated that approximately 61% of the variability in floor of mouth depth could be explained by calculus deposition, thereby suggesting a strong association between the two variables.

One possible explanation for increased calculus deposition in subjects with deeper floor of mouth anatomy may be impaired plaque control in this region. Deeper lingual vestibules may reduce accessibility during toothbrushing and interfere with natural self-cleansing mechanisms of the tongue and saliva, thereby promoting plaque retention and mineralization.

Lindhe et al. emphasized that anatomical variations of oral soft tissues may influence plaque control efficiency and oral hygiene maintenance. Areas with limited accessibility or altered vestibular morphology may predispose to increased plaque retention and subsequent calculus formation. The findings of the present study are consistent with these observations and further suggest that increased depth of the floor of the mouth may contribute to site-specific calculus accumulation in the mandibular anterior region.[14]

The present study is among the few studies evaluating the association between floor of mouth depth and calculus deposition in mandibular anterior teeth. The findings highlight the possible clinical significance of oral anatomical variations in determining individual susceptibility to recurrent calculus accumulation and periodontal disease progression.

Despite the significant findings, certain limitations of the present study should be acknowledged. The cross-sectional design does not permit establishment of a causal relationship between floor of mouth depth and calculus deposition. The study sample was selected using convenience sampling, which may limit generalization of the findings. Additionally, factors such as salivary composition, oral hygiene practices, dietary habits, and microbial profile were not evaluated and may also influence calculus formation.

Further longitudinal studies with larger sample sizes and assessment of additional salivary and anatomical parameters are recommended to better understand the role of floor of mouth anatomy in calculus formation and periodontal disease susceptibility. They may also help establish normal reference ranges for lingual vestibular depth and identify anatomical risk factors associated with recurrent calculus accumulation.

V. CONCLUSION

Within the limitations of the present cross-sectional study, it can be concluded that a statistically highly significant and strong positive correlation exists between the anatomical depth of the floor of the mouth and calculus deposition in the mandibular anterior region. The mean depth of the floor of the mouth observed among the study population was 7.53 ± 1.623 mm. An increase in the depth of the floor of the mouth was associated with greater calculus accumulation on the lingual surfaces of mandibular anterior teeth, as evidenced by a strong positive correlation coefficient (Spearman's rho = 0.734, $p < 0.01$).

The findings of the present study suggest that anatomical variations in the floor of the mouth may influence plaque retention and subsequent calculus formation, possibly due to altered salivary dynamics, salivary pooling, and reduced self-cleansing mechanisms in the lingual mandibular anterior region.

Thus, depth of the floor of the mouth may be considered an important anatomical factor influencing site-specific calculus deposition. Evaluation of lingual vestibular anatomy may therefore aid clinicians in identifying individuals at increased risk for recurrent calculus accumulation and periodontal disease progression, thereby contributing to improved preventive and periodontal maintenance strategies.

Conflicts of Interest: Nil

Financial Support: Not available

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