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Mesial root concavity and bone loss in maxillary first premolars: A retrospective study

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Abstract:
The influence of mesial root concavity morphology on periodontal bone loss in maxillary first premolars remains insufficiently understood. Therefore, it is of interest to evaluate the association between mesial root concavity morphology and radiographic bone loss (RBL) in periodontally healthy individuals and patients with periodontitis using cone-beam computed tomography (CBCT). A total of 100 CBCT scans were divided into two groups: Group A comprised patients with Stage I and II periodontitis according to the 2017 AAP classification, while Group B comprised periodontally healthy individuals; concavity angle, depth, corono-apical location, root length and RBL were assessed. Mesial root concavity depth showed a modest but statistically significant positive association with RBL ($r = 0.330$, $p = 0.001$), whereas concavity angle showed a modest negative association ($r = -0.304$, $p = 0.002$). Mesial root concavity morphology was significantly associated with periodontal bone loss in maxillary first premolars, suggesting that deeper and narrower concavities may be associated with greater bone loss; however, further prospective studies are required to establish their clinical significance.

Keywords: Periodontitis, root concavity, maxillary first premolar, stage II periodontitis and cone beam computed tomography (CBCT)

Background:
Periodontitis is a chronic, multifactorial inflammatory disease that leads to the destruction of the supporting structures of the teeth, including periodontal ligament and alveolar bone. While the microbial biofilm plays a key etiological role, local anatomical factors such as root morphology can significantly influence the pattern and severity of periodontal destruction **[1].** Among the teeth, the maxillary first premolars are particularly challenging in periodontal therapy due to their complex root anatomy, which often includes bifurcations, variable canal configurations and prominent mesial root concavities **[2, 3].** These concavities act as plaque-retentive zones, making complete debridement difficult during routine periodontal procedures. As a result, they can contribute to persistent inflammation, clinical attachment loss and alveolar bone resorption **[4] (Figure 1).** Recent studies have emphasized that these concavities, especially when present near the cemento-enamel junction (CEJ), are closely associated with increased bone loss and worsening of periodontal indices **[5].** Zhao *et al.* showed that the presence of root concavities in maxillary first premolars was significantly associated with crater-type bone defects and greater clinical attachment loss compared to teeth without concavities **[6].** The use of cone-beam computed tomography (CBCT) has enabled detailed three-dimensional visualization of root morphology and surrounding alveolar structures, offering superior diagnostic capability over conventional two-dimensional radiographs. CBCT studies have confirmed a high prevalence of mesial root concavities and emphasized their potential contribution to localized periodontal breakdown **[7].** Therefore, it is of interest to evaluate the morphological characteristics of root concavities in periodontitis-affected maxillary first premolars and their association with alveolar bone loss in an Indian population using retrospective CBCT analysis.

Materials and Methods:
This retrospective cross-sectional study included 100 CBCT scans chosen at random divided into two groups: Group A: 50 scans from patients with Stage II periodontitis, identified by 15–33% RBL reaching from the coronal to middle third of the root, as per AAP 2017 classification **[6].** Group B: 50 scan from periodontally healthy individuals without clinical or radiographic signs of periodontal disease. All radiographs were retrieved from the institutional archives and the study was conducted in the Department of Periodontics and Implant Dentistry, CSI College of Dental Sciences and Research, Madurai, Tamil Nadu, India. The CBCT device used was Planmeca ProMax3D, with voxel size of 75 to 100 µm and field of view (FOV) 8x8 cm. Inclusion criteria for Group A were derived from the clinical staging guidelines and included radiographic bone loss between 15–33%, absence of systemic conditions and clear visibility of the root surface and CEJ in the scan.

Parameters assessed:
[1] Sex and age of patients
[2] Angle of root concavity (in degrees) (**Figure 2a)**
[3] Depth of mesial root concavity (in mm from surface to deepest point) **(Figure 2b)**
[4] Position of concavity (coronal, middle, or apical third of the root)
[5] Total root length (CEJ to apex) **(Figure 2c)**
[6] Radiographic bone loss (RBL) measured from the CEJ to the crest of the alveolar bone (**Figure 2d**)

Measurement reliability:
All measurements were performed by a single calibrated examiner to minimize variability. Calibration was carried out on 10% of the sample prior to the study and intra-examiner reliability was assessed using repeated measurements taken two weeks apart, yielding an intraclass correlation coefficient (ICC)

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of ≥0.85. Inter-examiner reliability was not assessed, as only one examiner conducted the measurements.

Ethical aspects:
Ethical approval for this study was obtained from the Institutional Ethical Committee (Ref No.: CSICDSR/IEC/0343/2024). As this was a retrospective chart review, ethics approval was sought prior to data analysis.

Statistical analysis:
Pearson's correlation coefficient was used to assess the relationship between root concavity parameters and periodontal bone loss. This test measured the linear association between continuous variables, with a significance level set at $p < 0.05$. No formal sample size calculation was performed; the study sample was based on the available records that met the inclusion criteria. Although exploratory in nature, the analysis provided a quantitative basis to explore how anatomical variations may influence periodontal destruction.

Results:
A bivariate correlation analysis was conducted to evaluate the relationship between the degree of bone loss and root concavity parameters, specifically the angle of concavity and the linear measurement of concavity. The analysis revealed a significant negative correlation between the angle of concavity and the extent of bone loss (Pearson's correlation coefficient = -0.304, p = 0.002) **(Table 1).** This indicates that a decrease in the angle of concavity is associated with an increase in bone loss, suggesting that narrower root concavities may contribute to or exacerbate periodontal destruction in the maxillary first premolars (**Figure 3**). Conversely, a significant positive correlation was observed between the measurement of concavity and bone loss (Pearson's correlation coefficient = 0.330, p = 0.001) **(Table 1**). This suggests that greater concavity depth is associated with increased bone loss in periodontitis-affected teeth, although the strength of correlation in both cases was weak (**Figure 4**). The study demonstrates a weak but significant relationship between root concavity and bone loss, warranting further research to clarify its clinical relevance. These findings highlight the influence of root morphological variations, particularly concavity angle and depth, on the pattern and severity of periodontal destruction in maxillary first premolars.

Table 1: Correlation of Bone loss with Angle of concavity and measurement of concavity

	Angle of concavity	Measurement
Pearson Correlation	-0.304**	0.330**
P value	0.002	0.001
Strength of correlation	100	100

Discussion:
The present study aimed to evaluate the correlation between root concavity abnormalities and periodontal bone loss in maxillary first premolars affected by periodontitis. The results showed a statistically significant negative correlation between the angle of concavity and bone loss and a positive correlation between the depth of concavity and bone loss, indicating that as the concavity becomes deeper and narrower, the extent of alveolar bone destruction increases.



Figure 1: Representative extracted maxillary first premolars illustrating mesial root concavity.



Figure 2a: Representative CBCT image illustrating the assessment of mesial root concavity angle.

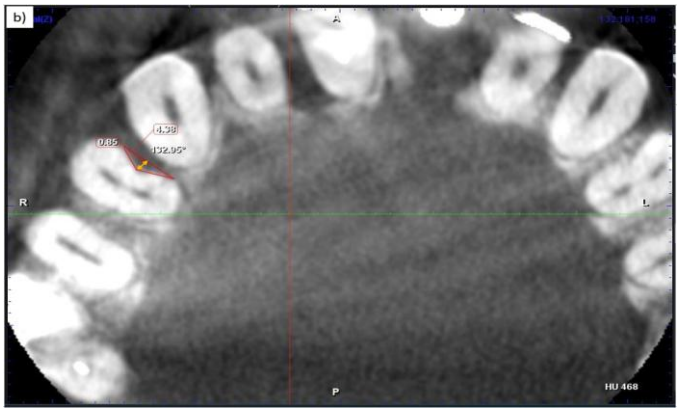


Figure 2b: Representative CBCT image illustrating the assessment of concavity depth.

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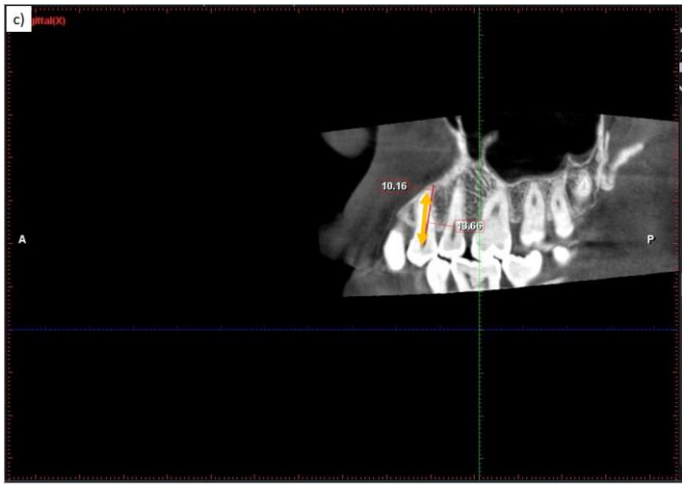


Figure 2c: Representative CBCT image illustrating the assessment of root length



Figure 2d: Representative CBCT image illustrating the assessment of periodontal bone loss.

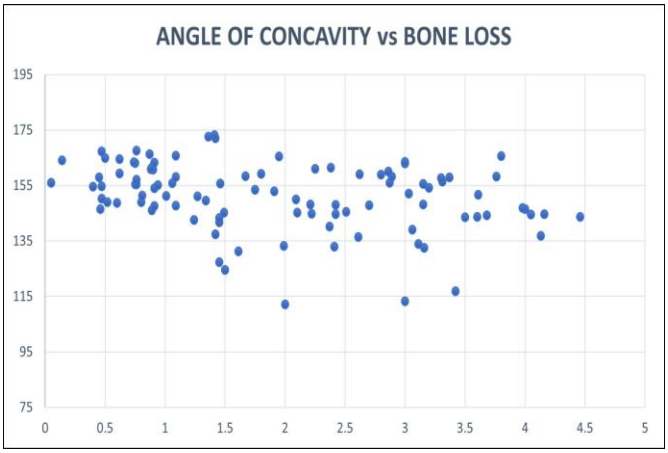


Figure 3: Graph showing correlation of between angles of concavity vs. bone loss

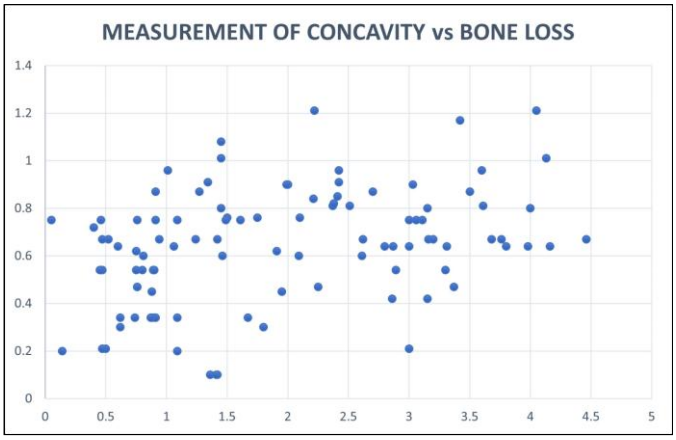


Figure 4: Graph showing correlation of between measurements of concavity vs. bone loss

These findings are supported by Beycioglu *et al.*, who found that concavities located at the cervical third of the root and greater concavity depth were significantly associated with increased bone loss, particularly in cases where furcation was positioned coronally **[1].** Similarly, Chen *et al.* reported that mesial concavities at the cemento-enamel junction (CEJ) of maxillary first premolars exacerbated bone resorption and clinical attachment loss in patients with periodontitis **[4].** Recent evidence further emphasizes the importance of root morphology in periodontal prognosis. Li *et al.* (2024) showed that premolar mobility in stage III/IV grade C periodontitis was significantly influenced by root length, alveolar bone resorption and crown-to-root ratio, with shorter roots exhibiting increased susceptibility to mobility even at lower levels of bone loss **[8].** These findings align with the present study, which highlights the role of mesial root concavities as an anatomical determinant of bone loss severity in maxillary first premolars. Collectively, such results suggest that anatomical features including root concavities, root length and crown-to-root ratio, should be considered together when assessing the risk of periodontal breakdown and tooth prognosis. Zhao *et al.* also observed a strong association between root concavities and deeper periodontal pockets and crater-shaped bone defects, particularly in mesial sites of maxillary first premolars **[6].** These morphological irregularities make complete subgingival debridement challenging and facilitate persistent bacterial colonization, further exacerbating tissue breakdown. Fan *et al.*, in their CBCT-based morphometric analysis, reported that the mean angle of mesial concavity was approximately 147.9° and the depth was around 1.64 mm, with deeper concavities observed in teeth with more than one root **[5].** This anatomical complexity, also noted in Booker and Loughlin's earlier morphologic analysis of adolescent maxillary first premolars, reinforces the notion that root concavity is a significant local risk factor **[9]** Furthermore, Stosić *et al.* emphasized the anatomical variability of premolar roots and canals and highlighted the need for clinicians to be aware of these differences during diagnosis and treatment **[2].** In terms of prevalence, a high percentage of premolars (up to 73.8% of two-rooted premolars) exhibited cervical concavities **[4],** mirroring the high prevalence found in our sample. Sachdeva *et al.* showed that the form of alveolar bone defects is influenced by the original morphology

of the alveolar bone, with interradicular and crater defects frequently observed in posterior teeth **[10].** This supports the role of concavities in the progression of periodontal destruction. Compared with second premolars, first premolars exhibit a greater risk of buccal bone perforation due to their alveolar bone concavity angle, particularly in women **[13].** Additionally, CBCT imaging provides three-dimensional visualization of the root and surrounding structures, which is superior to conventional radiography for identifying concavities and bone defects **[7, 9].** As noted by Alshomrani, CBCT enhances diagnostic accuracy and allows for more precise treatment planning in periodontal therapy **[7].** These findings reinforce the rationale for using CBCT in the present study to assess root concavities, thereby improving diagnostic accuracy and treatment planning in both periodontally affected and healthy cases. One of the notable strengths of the present study is that it is among the very few radiographic investigations from India focusing specifically on the correlation between root concavity morphology and periodontal bone loss in maxillary first premolars. The use of retrospective radiographic analysis provides a non-invasive yet clinically relevant approach to studying root anatomy in periodontitis-affected teeth. Moreover, applying objective measurements such as concavity angle and depth adds quantitative value to the findings and strengthens the association observed with bone loss. However, certain limitations must be acknowledged. Being a retrospective study, it is subject to inherent biases such as variability in radiographic quality and lack of clinical parameters like probing depth and attachment loss. Additionally, the sample size was relatively limited and the study was localized to a specific demographic population. Hence, to validate these findings and enhance their generalizability, long-term, multicentric studies with larger and more diverse sample sizes are warranted in the future. Assessment of concavity may be considered when evaluating risk for bone loss, but further longitudinal or interventional studies are required to establish causality **[11, 12].**

Conclusion:

Mesial root concavity morphology was significantly associated with periodontal bone loss in maxillary first premolars. Deeper and narrower concavities were associated with greater bone loss, suggesting a potential role of root morphology in localized periodontal destruction. Further prospective studies are warranted to confirm these findings and clarify their clinical significance.

Advancement to knowledge:

The influence of mesial root concavity morphology on the extent of periodontal bone loss remains inadequately established. This study provides evidence of a significant association between mesial root concavity morphology and periodontal bone loss in maxillary first premolars, highlighting the potential influence of root anatomy on localized periodontal destruction.

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