The Relationship between Root Concavities in Premolars and Mandibular Molars and Chronic Periodontitis: A Tomographic Study

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ABSTRACT

Introduction: Root concavities accumulate plaque by hindering effective cleansing predisposing to periodontitis. CBCT scans provide high-resolution images that display root concavities and alveolar bone defects. The aim of this study was to correlate the impact of root concavities in premolars and mandibular molars with chronic periodontitis.

Material and methods: Three dimensional reconstruction in CBCT was used to observe root concavities and alveolar bone defects in mesial and distal sites of 235 premolars and mandibular molars from 20 patients.

Results: The incidence of root concavity was 100% and 70% in mesial and distal sites of maxillary first premolars. In mandibular molars the incidence was 95-100%. The agewise distribution of concavities was not statistically significant. Males showed more concavities and more bone loss as compared to females. Probing depth and clinical attachment loss of teeth with root concavities were significantly higher than those without($p < 0.05$). Ramp bone defects were dominant for teeth without concavities, while craters were seen for teeth with concavities ($p < 0.05$).

Conclusion: Root concavities of the premolars and mandibular molars were associated with periodontal disease and interproximal alveolar bone defects.

Keywords: Cone Beam Computed Tomography, Root Concavities, Chronic Periodontitis

INTRODUCTION

Periodontitis is characterized by resorption of the marginal bone of the alveolar process with accompanying loss of attachment of gingival and periodontal fibres. However, certain anatomic factors may predispose the periodontium to disease which includes cervical enamel projections, bifurcation ridges and root concavities. Additionally, the shape of the roots may contribute to the development of periodontal defects by providing an environment favorable to the retention of the plaque.[1]

Root concavities exposed through loss of attachment can vary from shallow flutings to deep depressions. They appear more marked on maxillary first premolars, the mesiobuccal root of the maxillary first molar, both roots of mandibular first molars, and the mandibular incisors. They also create areas that can be difficult for both the dentist and the patient to clean.[2] Hence, root concavities promote the accumulation of plaque and accelerates the onset of periodontitis.[3] Therefore, an improved understanding of the root morphology of dental tissues should greatly assist both the diagnosis and treatment of periodontitis.[4]

Root concavity or root groove can exist in various forms. Root concavities are diagnosed only when surgically elevating a flap or during nonsurgical procedures performed under anaesthesia.

The chief limitation of current conventional intraoral and panoramic imaging for common dentoalveolar diseases is the problem of conspicuity,[5-6] which is largely the result of the representation of a 3D structure depicted by a two-dimensional (2D) image.

Cone-beam computerized tomography (CBCT) is a medical image acquisition technique based on a cone-shaped X-ray beam centered on a two-dimensional (2D) detector. The source-detector system performs one rotation around the object producing a series of 2D images. The images can be reconstructed in a three-dimensional (3D) data set using a modification of the original cone-beam algorithm developed by Feldkamp et al in 1984.[7]

Use of CBCT also provides high spatial resolution and accuracy. This noninvasive and quantitative technique studies both the teeth and periodontal tissues.[3] The shape of the root surface as well as alveolar bone is also made clearly visible by CBCT. Thus, CBCT provides essential data in the evaluation of both the status of periodontal tissues and extent of bone destruction.[5]

Hence the study was done with the aim to correlate the impact of root concavities found in premolars and mandibular were molars on chronic periodontal disease and objectives to evaluate the percentage distribution of the different types of root concavities in premolars and mandibular molars and in terms of age and gender, to evaluate the significance of premolar and mandibular molar root concavities on plaque accumulation and alveolar bone defects and to correlate the impact of root concavities found in premolars and mandibular molars on chronic periodontal disease.

MATERIAL AND METHODS

A total of 20 patients who were diagnosed with chronic periodontitis were included in this study. Based on the published literature by Zhao H, Wang H, Pan C and Jin X to estimate the difference of 60.7% with 80% power and 5%

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level of significance, the required sample size was 229 teeth. Patients were recruited randomly (14 males and 6 female) at the time of admission to the Department of Periodontics, M.S.Ramaiah Dental College and Hospital between November 2015 and August 2016.

All patients were native Indians from Bangalore with a mean age of 46.6 ±11.1 years (range 27–72 years). 235 teeth were selected for inclusion in the study. Written and informed consent was obtained from the recruited patients. The ethics committee of the M.S. Ramaiah Dental College and Hospital approved the study protocol.

Inclusion criteria

- Patients between the age group 25-80 years both males and females diagnosed with chronic periodontitis.
- Patients having periodontal pockets with probing depth of ≥5 mm or clinical attachment loss of ≥ 4mm

Exclusion criteria

- Patients who had received periodontal treatment within the past 6months.
- Patients who had taken antibiotics and/or non-steroidal medication in the previous 6 months.
- Patients who had a history of systemic diseases.
- Patients who were pregnant or lactating.

Study design

- OPD patients who met all criteria were selected and detailed case history was recorded.
- Probing pocket depth was measured of the selected teeth using UNC-15(Hu-Friedy's) probe.
- Plaque index was scored from 0 to 3 (Silness and Loe 1964), where "0" indicated no plaque.
  - ➢ A score of "1" – Plaque film adhering to the gingival margin and the tooth.
  - ➢ A score of "2" - Plaque on the tooth and gingival margin visible to the naked eye.
  - ➢ A score of "3" – abundance of plaque on the tooth and gingival margin.

Scanning by cone beam computed tomography technique

All subjects were scanned using the CS9300 Carestream CBCT machine. They were all operated under the same parameters. Cylindrical volumes of 5x5 inches, settings in the range 84 kV and 8 mA and an exposure time of 20 seconds and voxel size of 90 x 90 x 90 µm was used depending on the region of interest. The slice thickness was set at 449µm. The CBCT scan data was then transferred to CS software to permit subsequent data analysis.

Morphological and anatomical characteristics of the selected teeth roots was observed in the sagittal, coronal and axial surfaces using the CS software program, wherein three-dimensional images of the teeth were reconstructed. These were evaluated by an operator who had no knowledge about the clinical parameters.

The concavity identified was classified according to Ong's classification:

1. Type I represented a root surface without concavity;
2. Type II represented root concavities that originated in the enamel;
3. Type III represented concavities that had initiated at the CEJ;
4. Type IV represented concavities that had initiated below the CEJ but above the one-third part of the root;
5. Type V represented a root concavity that had originated at the middle and apical parts of the root.

Observation of alveolar bone defects

The 3D reconstruction helped to identify the bucco-lingual alveolar bone defects on mesial and distal sites of premolars and mandibular molars.

Accordingly, the following patterns were defined:

- "Crater pattern", defined as a bone defect which was confined to facial and lingual walls with loss of interproximal bone.
- "Ramp pattern", defined as an irregular bone defect wherein the interproximal bone margins of the deformity were found at different levels.
- "Plane pattern", defined as a flat bone defect wherein the interproximal bone margins of the deformity were at the same level.

STATISTICAL ANALYSIS

The study data was analyzed using SPSS software V.22, IBM. Corp. Chi square test was used to compare the proportional difference in the distribution of categorical variables like types of root concavities and alveolar bone defects for age and gender. Kruskal-Wallis test was used to compare the mean PPD and CAL scores between upper and lower posterior teeth for mesial and distal concavities types. Spearman's Correlation test was used to correlate the concavity type's maxillary / mandibular right and left premolars. The level of significance was set at $P<0.05$.

RESULTS

Morphological analysis of interproximal surfaces of the selected teeth

Tooth	Mesial concavity	Distal concavity
Maxillary first premolars	100%	70%
Mandibular premolars	100%	100%
Right mandibular molars	100%	83%
Left mandibular molars	95%	95%

Age distribution

There were no statistically significant differences between the age distribution and the presence of concavities or even their type. However 92% of the samples showed crater type of alveolar bone defect whereas incidence of ramp shaped alveolar bone defect was higher between 30-60 years.

Gender distribution

Males showed more number of concavities than females. 51.5% males showed a Type II concavity whereas only 34.3% females showed type II concavity (p=0.01). Females showed more number of type III and IV concavities. The differences were all statistically significant.

Type of alveolar bone defect and concavities

There was statistically significant difference in the type of alveolar bone defect seen in males and females. 65.5% of males showed crater type of bone defect while only 50% of females showed crater in association with root concavities (p=0.02). Ramp shaped defect was seen more in females. Plane defects were seen more in females (p=0.02). All the parameters were found to be statistically significant with respect to gender and the type of concavity on the mesial side.

Type II, III, IV concavities was seen more in males than females on the distal root surfaces of premolars and mandibular molars (p=0.004).

Greater plaque accumulation was observed at sites having concavities compared to sites which did not have concavities.

Probing depth and concavities

Higher periodontal pocket depth was consistently observed in teeth with concavities than in those without. On comparison of mean probing depth between different mesial and distal concavity types (types II-V) there was statistically significant differences between probing depths of type II(p=0.03) and IV(p=0.04). This concludes that deeper probing depths were found with increase in grade of concavity.

Clinical attachment loss was seen to be higher in teeth having mesial and distal root concavities than in those without and these were statistically significant in the case of mandibular molars.

A moderate positive correlation was found between 34 and 44 mesially and distally which was statistically significant (p=0.02). There was a moderate positive correlation between 24 and 44 on the mesial side which was found to be statistically significant.

DISCUSSION

Contemporary periodontal treatment generally aims at the removal of plaque and calculus through scaling and root planing. Scaling and root planing has limitations, particularly if the disease has led to the formation of pockets deeper than 5 mm around the affected teeth.

Root concavities act as predisposing factors in the disease process by providing a haven for bacterial plaque and by complicating oral hygiene procedures. The concavities, which are limited mainly to the proximal surfaces, are generally inaccessible for cleaning with routine oral hygiene procedures.

Till now concavities have been observed only after the tooth gets extracted due to poor prognosis. Treatment failures have been linked to the incomplete removal of root accretions and incomplete preparation of the pathologically altered root surface.

Hence the aim of this study was to correlate the impact of root concavities found in premolars and mandibular molars on chronic periodontal disease.

CBCT helps to diagnose and detect the topography of alveolar bone defects without opening up the surgical area and gives the clinician accurate information during the treatment planning phase. Thus it has an edge over conventional methods like OPG and bone sounding.

Hence the study was done by selecting the teeth which fulfilled the inclusion and exclusion criteria and scanning them with CBCT. Previously these morphologic abnormalities were observed only after extraction of these teeth and staining them with appropriate dyes to recognize grooves and concavities. However with the advent of CBCT it is possible to observe these anomalies in vivo.

Hence 470 sites in 20 patients were observed for concavities in this study.

According to a study by Zhao H[3] in 2014, the incidence of mesial and distal root concavities of the maxillary first premolars was 100% and 39.3% respectively, and in the mandibular first premolars the incidence was 42.5% and 31.3% respectively. Joseph[8] et al in 1996 reported a 100% incidence of mesial and distal concavities only in extracted maxillary first premolar teeth. This study was in agreement to the above two studies. However in this study the incidence of mesial and distal root concavities of maxillary first premolars was 100% and 70% respectively and in mandibular first premolars it was 95% and 80% respectively. But in this study maxillary and mandibular second premolars and mandibular first and second molars were also included. So the incidence of mesial and distal concavities in the maxillary second premolars were 87% and 85.5% respectively. With regard to mandibular first molars, the incidence of mesial and distal concavities were 100% on both right and left sides. And in mandibular second molars the incidence of mesial and distal concavities were 89% and 62.5%.

This study was not in agreement to a study conducted by Fox and Bosworth[1] in which they reported 100% concavities for all mandibular teeth. In their study, the prevalence by surface ranged from 0% to 100% for the distal and 67% to 100% for the mesial surface. The maxillary first and second premolars had concavities on all the proximal surfaces surveyed. On the contrary in this study, the incidence of maxillary second premolar concavities ranged from 85-87%.

The differences in the incidence rates of concavities can be explained from the mere fact that this study focuses on concavities present 4.7- 5mm from the CEJ. Hence it can be deduced that the teeth which did not show concavities might be having them, just that the bone loss which exposes the concavities may not be present. This kind of difference stems from the fact that this is an invivo study whereas all previous studies have been performed on extracted teeth.

In a study by Ong[9] et al in 1990, the prevalence of concavities in the maxillary second premolars was 93% for mesial surfaces and 100% for distal surfaces. The mandibular second molars had 77% concavities for mesial surfaces and 40% for distal surfaces. However, the mandibular first premolars, first and second molars all had mesial concavities which was in accordance with this study.

However all the above studies were invitro studies being done on extracted teeth. This study is conducted invivo and the variations in study may be attributed to racial aspects or even geographical differences. This study was exclusively done on Indians at Bangalore, Karnataka.

Gher and Vernino[4] reported that root concavities tend to become shallower with age. This may be due to apparent deposition of cementum in the concave areas than over the convex surfaces. In the older patient, this continued deposition of cementum may result in a significantly altered root morphology. Selective cementum deposition and the resultant shallowing of the concavity have both negative and positive effects. The additional cementum may provide a reservoir for retention of bacterial by-products. Therefore several studies have attempted to analyse the effect of age on root concavities.

In the current study there were no statistically significant differences between the age distribution and the presence of concavities or even their type. Hence it was in agreement to a study by Zhao[3] et al in 2014 in which they reported no evidence to suggest that the type of first premolar root concavity was associated with the age of the patient. However the Zhao[10] in 2015 in another study revealed that 40–59 year old patients with chronic periodontitis had severe bone loss.

With regard to gender distribution, the same study reported a lower degree of alveolar bone loss in males than females ($p< 0.05$). This was contrary to the current study which reported a higher degree of alveolar bone loss in males than females especially on the mesial root surface of the selected teeth ($p<0.05$). Males also showed greater percentage of crater shaped defects compared to females. Females showed higher percentage of ramp alveolar defects which could be attributed to higher number of teeth without concavities.

In the current study there was a positive association between probing pocket depth and type of concavity on the tooth root surface. This could be attributed to the fact that progressive loss of bone is responsible for exposing concavities. If the gingival margin is located near the CEJ, the root concavities remain hidden beneath the tissue in a periodontal pocket. Hence concavities located closer to the gingival margin are more accountable in causing chronic periodontal disease. These findings are consistent with studies done by Knut Leknes[5], Gher and Vernino[4], Fox and Bosworth[1] and Bhusari[11] where these authors advocated that proximal grooves and concavities were responsible for greater loss of attachment.

Chronic periodontitis has been reported to produce alveolar bone defects of different types. On the mesial surface, crater shaped defects (65.6%) were seen on predominantly on the teeth exhibiting concavities ($p<0.001$). Ramp shaped defects (65%) were seen on teeth without concavities ($p<0.001$).

On the distal surface, crater shaped defects (53.6%) were seen on predominantly on the teeth exhibiting concavities ($p<0.001$*). These findings were consistent with the study by Zhao H[3] et al 2014. However Zhao H[3] had only considered first premolar teeth for his study. In this study the higher incidence of crater and ramp shaped defects can be attributed to the more number of teeth namely second premolars and mandibular molars being included.

Based on the findings in this study it can be concluded that the accumulation of bacterial plaque and calculus on these teeth with concavities make them an inevitable combination for progressive loss of attachment.

According to studies by Zamora and Mol[12,13] CBCT is better at detecting periodontal bone defects than other imaging modalities.

This study has also attempted to correlate the impact of concavities between mesial and distal concavities between maxillary left and right premolars, between mandibular left and right premolars and between maxillary and mandibular premolars.

The limitations of the study include smaller sample size considering the wide variety of teeth used in the study.

The findings of this study show that teeth exhibiting concavities are significantly predisposed towards pocket formation and clinical attachment loss. However long term clinical studies with much greater sample size are required to establish definitive results.

CONCLUSION

Observations from this study indicated that any association observed between the root concavities of premolars and mandibular molars and chronic periodontal disease could be rather more significant than had been previously appreciated. The presentation of different types of root concavities located in these teeth were associated with both clinical indices of chronic periodontitis and the presence of alveolar bone defects. A comprehensive assessment of both the location and morphology of root concavities should be considered during mechanical plaque control thereby facilitating effective resolution of periodontal disease. However clinical studies with larger sample sizes are recommended to provide more definitive results.

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