RESEARCH PAPER

Cone Beam Computed Tomographic Evidence of the Association of Periodontal Status with Maxillary Sinus Mucosal Thickening

Running title: *Evidence of association of periodontal status with maxillary sinus mucosal thickening.*

Ravindra Tripathi (Bds)[1], Yasir S. Khan (Mds)[2], Amitabh Srivastava (Mds)[3], Anuj Mishra (Mds)[4], Sajid Husain (Mds)[5], Tanu Sahney (Mds)[6*]

[1] Post Graduate Student, Department of Periodontology, Sardar Patel Post Graduate Institute of Dental and Medical Sciences, Lucknow (U.P). Email: tripathiravindra95@gmail.com

[2] Professor, Department of Periodontology, Sardar Patel Post Graduate Institute of Dental and Medical Sciences, Lucknow (U.P). Email: Yasirk11@gmail.com

[3] Professor & Head of the Department, Department of Periodontology, Sardar Patel Post Graduate Institute of Dental and Medical Sciences, Lucknow (U.P). Email: docamitabh74@gmail.com

[4] Professor, Department of Oral Medicine and Radiology, Sardar Patel Post Graduate Institute of Dental and Medical Sciences, Lucknow (U.P). Email: Diagnosticcentre89@gmail.com

[5] Reader, Department of Periodontology, Sardar Patel Post Graduate Institute of Dental and Medical Sciences, Lucknow (U.P). Email: shrizvi.rizvi@gmail.com

[6*] Reader, Department of Periodontology, Sardar Patel Post Graduate Institute of Dental and Medical Sciences, Lucknow (U.P). (Corresponding Author) Email: tanu.sahney910@gmail.com

This work belongs to: Department of Periodontology, Sardar Patel Post Graduate Institute of Dental and Medical Sciences, Lucknow, Uttar Pradesh.

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ABSTRACT

Introduction: Periodontitis is a chronic inflammatory disease characterized by progressive destruction of the supporting tissues of the teeth. Owing to the close anatomical proximity between the maxillary posterior teeth and the maxillary sinus, periodontal inflammation may extend to the Schneiderian membrane, resulting in maxillary sinus mucosal thickening (MSMT). Cone Beam Computed Tomography (CBCT) offers a reliable three-dimensional imaging modality for simultaneous evaluation of periodontal bone status and sinus mucosa.

Objectives: To observe the effect of periodontally affected maxillary posterior teeth on maxillary sinus mucosal thickening (MSMT) using CBCT and to evaluate the association of minimum residual alveolar bone height (minRABH) and alveolar bone loss (ABL) with MSMT and to compare MSMT across age groups and gender.

Methods: This observational cross-sectional study included 90 systemically healthy adult participants exhibiting varying degrees of periodontal bone loss. CBCT imaging was used to obtain three-dimensional assessments of periodontal and sinus parameters. Measurements included MSMT, minRABH, and ABL. Statistical analysis was performed to determine correlations between periodontal variables and mucosal thickening, with significance set at $P < 0.05$.

Results: A statistically significant positive correlation was observed between periodontal disease severity and MSMT. Maxillary Sinus Mucosal thickening of 4–10 mm and beyond showed moderate to severe association with periodontitis. A significant inverse relationship was found between minRABH and MSMT.

Conclusion: Periodontal disease severity and reduced residual alveolar bone height are critical determinants of Maxillary sinus mucosal changes, with important implications for periodontal therapy, implant planning, and sinus augmentation procedures.

Keywords: minRABH, MSMT, ABL, CBCT.

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Introduction

Periodontitis is a chronic, multifactorial inflammatory disease initiated by microbial plaque biofilm and mediated by the host immune response, resulting in progressive destruction of the periodontal supporting tissues, including gingiva, periodontal ligament, cementum, and alveolar bone[1] and is characterized by clinical attachment loss, pocket formation, and alveolar bone resorption, ultimately leading to tooth loss if left untreated. Due to its chronic and destructive nature, periodontitis has been increasingly recognized not only as a localized oral disease but also as a condition capable of influencing adjacent anatomical structures and contributing to extraoral pathology.[2]

The maxillary sinus occupies a strategically important position in the craniofacial complex and shares an intimate anatomical relationship with the roots of maxillary premolars and molars. In many individuals, the sinus floor is separated from the root apices by only a thin layer of cortical bone or, in some cases, by mucosa alone.[3] Chronic periodontal infection is associated with the release of inflammatory mediators such as interleukin-1β, tumour necrosis factor-α, and prostaglandins, as well as the presence of pathogenic subgingival microbiota, all of which may contribute to sinus mucosal reactions, including mucosal thickening.[4]

Traditionally, evaluation of the maxillary sinus and periodontal structures relied on two-dimensional imaging modalities such as periapical radiographs and panoramic radiography. The introduction of cone beam computed tomography (CBCT) has revolutionized maxillofacial imaging by providing high-resolution, three-dimensional visualization of hard and soft tissue interfaces, with radiation doses lower than conventional medical computed tomography when appropriately justified and optimized.[5]

Several CBCT-based studies have demonstrated an association between periodontal disease severity and increased maxillary sinus mucosal thickening.[6–8] These findings suggest that periodontal inflammation may play a contributory role in sinus mucosal changes, reinforcing the concept of odontogenic and periodontogenic influences on maxillary sinus health.

The study aimed to observe the effect of periodontally affected maxillary posterior teeth on maxillary sinus mucosal thickening (MSMT) using CBCT.

Materials And Method

A Cross-Sectional observational study was carried out on patients between the age group of 18-60 years with multiple maxillary posterior teeth below the maxillary sinus (except third molar) present, Resorption of alveolar bone more than 2 mm beyond CEJ who visited the Outpatient Department of Periodontology in Sardar Patel Post Graduate Institute of Dental and Medical Sciences, Lucknow, Uttar Pradesh after clearance from Institutional ethical committee (IEC).

The patients were informed about the study and those who were willing to participate were clinically examined. Patients fulfilling the inclusion criteria were provided consent forms and were sent to Department of Oral Medicine and Radiology for the CBCT scan. Patients were selected irrespective of caste, creed, sex, religion or socio-economic status.

Edentulous maxilla, Dental implants present in posterior maxilla, Any radiographic opacity except for the mucosal thickening, History of trauma or injury in the posterior maxilla, CBCT scans including artifacts that interfere with the appropriate display of relevant anatomical landmark, Poor quality scan, Any recent surgery, Periapical lesion, Root fracture, Endodontically treated tooth, Past periodontal therapy, Past history of maxillary sinusitis, Any developmental anomalies involving maxilla, Any malignancies in the orofacial region, Pregnant females.

Specifications of CBCT image analysis includes Voxel Size:- .25 Voxels, Current- 20.27 mA, Time- 14.7 Secs, kVp- 120, Patient were subjected for CBCT where mid sagittal plane and occlusal plane was aligned with the help of laser beam pointer, FOV- 16x6 cm.

The clinical examination was performed on patients and periodontal indices were reviewed (Clinical Attachment Loss ≥ 1mm) according to 2017 World Workshop on the Classification of Periodontal and Peri-Implant Diseases and Conditions[1] to confirm periodontitis clinically. The procedure was explained to the patient and a CBCT scan was performed where the status of periodontal defect and the mucosal thickness was measured and recorded. The CBCT images were evaluated using an Invivo software.

Radiographic (CBCT) parameters included assessment of Maxillary sinus mucosal thickening (MSMT)[9] in which the entire length of the thickened mucosa was determined by tracing the floor of the maxillary sinus in the region of mucosal thickness. When the thickness of the sinus mucosa was greater than 2 mm, mucosal thickening was taken into consideration. The thickness was measured in millimetres from the sinus floor to the point of greatest sinus mucosa thickness.

Assessment of minimum Residual Alveolar Bone Height (minRABH)[9] was also done and was calculated by measuring the distance from the base of the periodontal defect to the floor of the maxillary sinus,

These values were classified into 3 levels:- LEVEL I - <4mm, LEVEL II- 4-10 mm, LEVEL III- >10mm.
Assessment of alveolar bone loss (ABL)[9] was also done, the amount of alveolar bone loss was measured from the mesial, distal, buccal and lingual side of the maxillary molars (in millimetres), Normal alveolar bone height was within 2 mm of the boundary of CEJ. The % of maximal alveolar bone loss relative to normal bone height was calculated. Mild- bone resorption less than 25%, Moderate- bone resorption 25-50%, Severe- bone resorption >50%

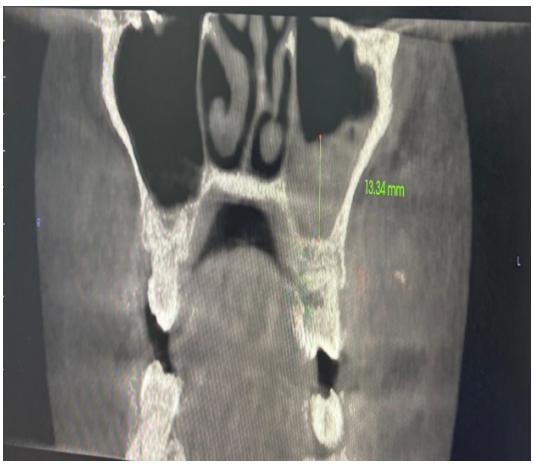


Fig 1. Maxillary Sinus Mucosal Thickening (in mm)

Fig 2. Minimum Residual Alveolar Bone Height (in mm)

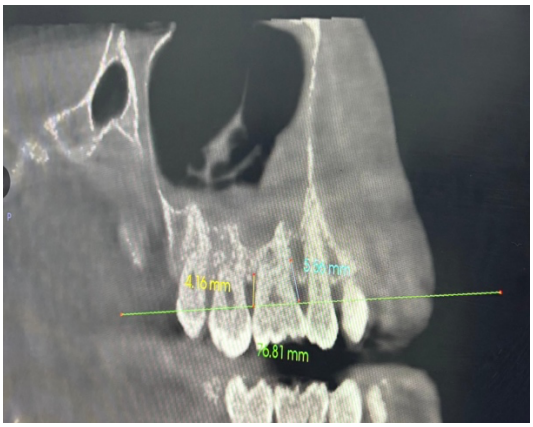


Fig 3. Alveolar Bone Loss

Result

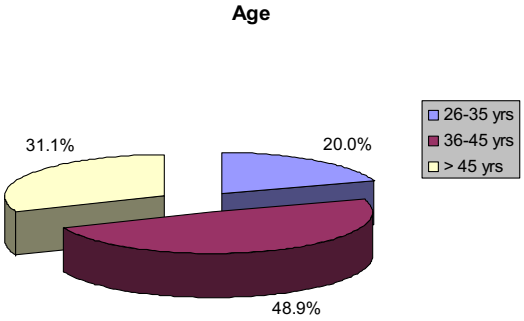
The outcome measures of the study were mucosal thickness, minimum residual alveolar bone height (min RABH) and alveolar bone loss (ABL). The both mucosal thickness and min RABH were measured in millimetre (mm) whereas ABL in percentage (%). The min RABH was further quantified in min RABH index (Level 1: min RABH < 4 mm, Level 2: min RABH 4-10 mm and Level 3: min RABH > 10 mm) whereas ABL in ABL severity (Mild: ABL < 25%, moderate: ABL 25-50% and severe: ABL > 50%).

The primary objective of the study was to assess the association of mucosal thickness with min RABH index (Level 1, Level 2 and Level 3) and severity of ABL (Mild, Moderate and Severe). The secondary objective of the study was to assess the association of mucosal thickness with age and gender.

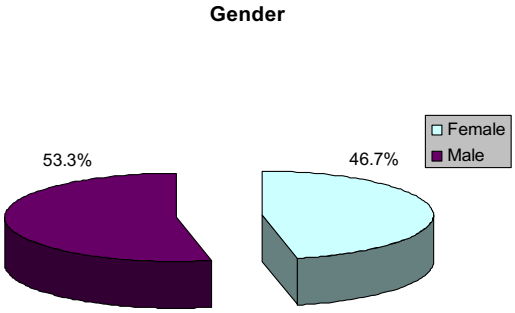
The age of subjects ranged from 26-56 yrs with mean (± SD) 41.49 ± 6.54 yrs and median 42 yrs. Of total18 (20.0%) subjects were 26-35 yrs aged, 44 (48.9%) were 36-45 yrs and 28 (31.1%) were >45 yrs. Further, among subjects, 42 (46.7%) were females and 48 (53.3%) were males.

The mucosal thickness, min RABH and ABL of subjects ranged from 2.06-15.67 mm, 2.34-16.92 mm and 14.50-88.50%, respectively with mean 6.71 ± 3.64 mm, 7.21 ± 3.35 mm and 44.06 ± 23.33%, respectively with median 6 mm, 7 mm and 36%, respectively.

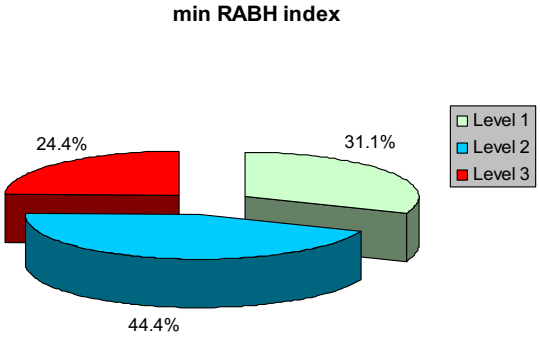
Further, according to min RABH index, 28 (31.1%) subjects had Level 1 bone height, 40 (44.4%) had Level 2 and 22 (24.4%) had Level 3 . Similarly, according to severity of ABL, 24 (26.7%) subjects with mild bone loss (or bone resorption), 37 (41.1%) moderate and 29 (32.2%) severe .



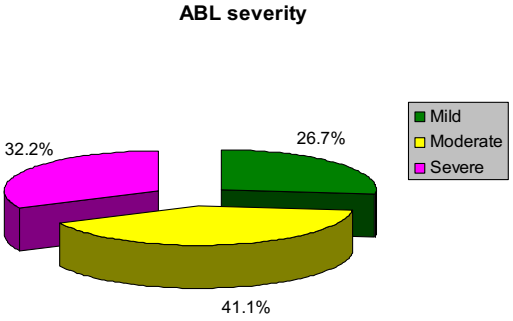
Distribution of age of subjects.



Distribution of gender of subjects.



Graph. 3. Distribution of min RABH index of subjects.

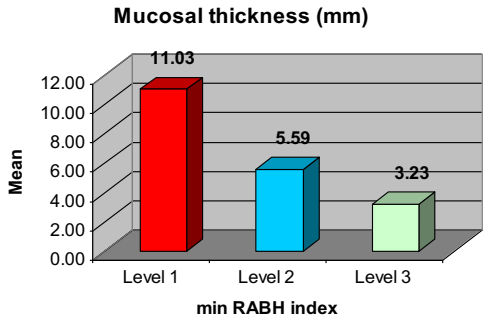


Graph. Distribution of ABL of subjects.

The association of mucosal thickness of subjects according to their min RABH index (Level 1, Level 2 and Level 3) is summarised in Table below . The mean (± SD) value of min RABH in Level 1, 2 and 3 were 3.39 ± 0.42, 7.43 ± 1.42 and 11.69 ± 1.78 mm, respectively. The mean mucosal thickness of subjects at Level 1, 2 and 3 were 11.03 ± 2.01, 5.59 ± 2.39 and 3.23 ± 0.55 mm, respectively. The mean mucosal thickness decreases linearly with increase in min RABH index levels (Level 3 < Level 2 < Level 1).

min RABH index	**N**	**min RABH (mm) (mean ± SD)**	**Mucosal thickness (mm) (Mean ± SD)**
Level 1	28	3.39 ± 0.42	11.03 ± 2.01
Level 2	40	7.43 ± 1.42	5.59 ± 2.39
Level 3	42	11.69 ± 1.78 mm	3.23 ± 0.55

The mucosal thickness of subjects according to their min RABH index were summarised in Mean ± SD.



Mean mucosal thickness between three min RABH index groups.

The association of mucosal thickness of subjects according to the severity of ABL (Mild, Moderate and Severe) is summarised in Table below.

Association of mucosal thickness (mm) with ABL (n=90)

ABL	**N**	**ABL (%)** (mean ± SD)	**Mucosal thickness (mm) (Mean ± SD)**
Mild	24	20.58 ± 4.30	3.30 ± 0.63
Moderate	37	35.09 ± 7.24	5.50 ± 2.20
Severe	29	74.95 ± 8.99	11.07 ± 1.98

The mucosal thickness of subjects according to their ABL were summarised in Mean ± SD.

The mean (± SD) value of ABL in Mild, Moderate and Severe were 20.58 ± 4.30, 35.09 ± 7.24 and 74.95 ± 8.99%, respectively.

The mean mucosal thickness of subjects at Mild, Moderate and Severe were 3.30 ± 0.63, 5.50 ± 2.20 and 11.07 ± 1.98 mm, respectively. In contrast of min RABH index, the mean mucosal thickness increases gradually with increase in ABL (Mild < Moderate < Severe).

The mean mucosal thickness of Severe was found the maximum and it was 70.2 and 50.3% higher as compared to both Mild and Moderate, respectively. Moreover, it was also found 40.0% higher in Moderate as compared to Mild.

In conclusion, mucosal thickness of subjects found to be associated with their Severity of ABL.

The association of mucosal thickness of subjects according to their age (26-35 yrs, 36-45 yrs and > 45 yrs) is summarised in Table below. The mean mucosal thickness of subjects in 26-35, 36-45 and > 45 yrs were 6.60 ± 3.02, 6.81 ± 3.71 and 6.62 ± 3.99 mm, respectively. The mean mucosal thickness not show any trend with age, minimum in 26-35 yrs followed by > 45 yrs and 36-45 yrs, the maximum (26-35 yrs <> 45 yrs < 36-45 yrs).

Association of mucosal thickness (mm) according to age of subjects (n=90)

Age	N	Mucosal thickness (mm) (Mean ± SD)
26-35 yrs	18	6.60 ± 3.02
36-45 yrs	44	6.81 ± 3.71
> 45 yrs	28	6.62 ± 3.99

The mucosal thickness of subjects according to their age were summarised in Mean ± SD.

the mean mucosal thickness in 36-45 yrs was found the maximum and it was 3.1 and 2.8% higher as compared to both 26-35 yrs and > 45 yrs, respectively. Moreover, it was also found 0.3% higher in > 45 yrs as compared to 26-35 yrs.

In conclusion, mucosal thickness of subjects not found to be associated with their age.

The association of mucosal thickness of subjects according to their genders (female and male) is summarised in Table below. The mean mucosal thickness of female and male were 6.45 ± 3.67 and 6.94 ± 3.63 mm, respectively. The mean mucosal thickness was slightly higher in male than female (Female < Male).

Association of mucosal thickness (mm) with gender (n=90)

Gender	N	Mucosal thickness (mm) (Mean ± SD)
Female	42	6.45 ± 3.67
Male	48	6.94 ± 3.63

The mucosal thickness of subjects according to their genders were summarised in Mean ± SD.

In conclusion, mucosal thickness of subjects did not found to be associated with their gender.

Discussion

The present observational study utilized CBCT to evaluate the association between periodontal status-measured through minimum residual alveolar bone height (min RABH) and alveolar bone loss (ABL) and maxillary sinus mucosal thickening (MSMT) among 90 systemically healthy adults. The findings of this study revealed a strong and statistically significant association between periodontal tissue destruction and maxillary sinus mucosal thickening. This relationship was evident when mucosal thickness was compared with both min RABH index and ABL, the two primary periodontal parameters assessed. In contrast, demographic factors such as age and gender were not associated with variations in mucosal thickness.

These outcomes collectively emphasize the importance of recognizing periodontal disease as a potential contributor to sinus mucosal alterations observed on CBCT.

One of the major findings of this study was the significant inverse relationship between mucosal thickness and min RABH index. Subjects with the lowest bone height (Level 1, <4 mm) demonstrated the highest average mucosal thickness (11.03 ± 2.01 mm), while those with bone height greater than 10 mm (Level 3) showed the least mucosal thickening (3.23 ± 0.55 mm). The decrease in mucosal thickness was linear and statistically significant across all three levels ($P < 0.001$).

This finding can be anatomically and patho-physiologically explained by the intimate relationship between the inflamed periodontium and the sinus floor. As periodontal destruction progresses apically, the distance between the infectious/inflammatory environment and the Schneiderian membrane diminishes. The findings of the present study are in agreement with those of Zhang T et al.[9] who reported that increased maxillary sinus mucosal thickness is associated with a reduction in residual alveolar bone height. Phothikhun et al.,[11] (2012) and Sheikhi et

al.,(2014)[6] who have also reported maxillary sinus mucosal thickening to be commonly associated with periodontal bone loss.

The results in the present study revealed that individuals with level1 and level 2 minimum residual alveolar bone height exhibited significantly higher levels of mucosal thickening compared to those with level 3 minimum residual alveolar bone height. This aligns with the understanding that chronic inflammation within the periodontal tissues can extend beyond the alveolar bone and influence adjacent structures.

ABL severity, categorized as mild, moderate, and severe based on percentage bone loss, also showed a strong association with varying degrees of sinus mucosal thickening. In this case, the relationship was positive: mucosal thickness increased progressively from mild (3.30 ± 0.63 mm) to moderate (5.50 ± 2.20 mm) to severe ABL (11.07 ± 1.98 mm) . All comparisons between these groups were statistically significant ($P < 0.001$).

The present findings are consistent with Lathiya et al.[10] and Zhang T et al[9] who observed that increased ABL was significantly associated with greater maxillary sinus mucosal thickness on CBCT evaluation. Bisla et al.[12] a graded increase in maxillary sinus mucosal thickness with increasing severity of periodontal disease. Al Rowi et al. [13] further confirmed that periodontal disease severity was a significant predictor of sinus mucosal thickening, independent of demographic variables, strengthening the validity of the present findings.

Severity in ABL reflects extensive periodontal tissue breakdown, often associated with deep periodontal pockets, pathogenic subgingival microbiota, and long-standing chronic infection.[6]

In this study, mucosal thickness did not vary significantly among different age groups (26–35, 36–45, and >45 years). Despite slight numerical differences, none of the comparisons reached statistical significance ($P > 0.05$).

In contrast to our study Bozhikova et al.[14] revealed the incidence of mucosal thickening increased significantly in the age over 26 years with highest percentage of frequency over 60 years (66,7%) and the association between the mucosal thickness and age is statistically significant. While reporting a significant age-related increase in mucosal thickening, it also acknowledged that periodontal status was not separately controlled, which may explain discrepancies with the study.

Similar to age, gender did not show a significant impact on mucosal thickness. Although male subjects exhibited slightly higher mean mucosal thickness (6.94 mm) compared to females (6.45 mm), the difference was not statistically significant ($P = 0.530$). These findings suggest that the inflammatory response of the Schneiderian membrane to periodontal disease is comparable in both males and females. However, Janner et al [15] and Phothikhun et al [11] observed a higher prevalence and greater degree of sinus mucosal thickening in male patients, which they attributed to confounding factors such as smoking habits, occupational exposure, and higher prevalence of periodontal disease severity among males rather than intrinsic sex-related biological differences.

Conclusion

The findings of this research provide a comprehensive, three-dimensional validation of the "periodontal-sinus axis," establishing that the health of the maxillary sinus is inextricably linked to the integrity of the supporting periodontal structures. The present study suggests that the **inflammatory burden** of the periodontium exerts a far more potent influence on the Schneiderian membrane than the chronological age or biological sex of the patient.

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