

CORRELATION OF MAXILLARY SINUS MUCOSAL THICKNESS WITH ALVEOLAR BONE LOSS USING COMPUTED TOMOGRAPHY

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Introduction: Because of close association of roots of maxillary premolars and molars with maxillary sinuses, effect of periodontal bone loss on sinuses needs to be evaluated.

Objective: The current study aimed to analyze relationship between of maxillary sinus mucosal thickening and alveolar bone loss using computed tomography.

Methods: All erupted second premolars, first and second molars in the maxillary arch bilaterally, were assessed for periodontal bone loss (PBL), so 12 points in each patient (mesial and distal sides of each tooth) and at same locations, mucosal thickening (MT) was assessed on maxillary sinus floor. Furthermore, probable effect of each tooth pulpoperiapical condition (PPAC) on sinus mucosal thickening was assessed.

Results: The present study consisted of 110 individuals of which CT images of 220 maxillary sinuses and 639 teeth (total 1278 teeth surfaces) were studied. MT was observed in 71.83% of sinus locations showing thickening of 1-3mm in 64.38%, 3.1-6mm, in 14.71%, 6.1-10mm in 11.33%, and >10mm in 9.59% of cases. PBL was observed in 69.01% of teeth surface locations showing mild alveolar bone loss in 69.84%, moderate in 25.06%, and severe in 5.10% of cases. When statistically analyzed, sinus MT was significantly associated with PBL and PPAC but stronger effect of PBL was present.

Conclusions: In our study, observed prevalence of sinus MT was 71.83% and prevalence of periodontitis was 69.01%. Sinus MT was associated significantly with PBL.

Key Words: Maxillary sinus, alveolar bone loss, pulpoperiapical condition, sinus mucosal thickening, computed tomography.

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Conflicts of interest:

The authors declare no conflicts of interest.

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CORRÉLATION ENTRE L'ÉPAISSEUR DE LA MUCOSE DU SINUS MAXILLAIRE ET LA PERTE OSSEUSE ALVÉOLAIRE PAR TOMOGRAPHIE INFORMATIQUE

Introduction: En raison de l'association étroite des racines des prémolaires et molaires maxillaires avec les sinus maxillaires, l'effet de la perte osseuse parodontale sur les sinus doit être évalué.

Objectif: La présente étude visait à analyser la relation entre l'épaississement de la muqueuse du sinus maxillaire et la perte osseuse alvéolaire à l'aide de la tomодensitométrie.

Méthodes: Toutes les deuxièmes prémolaires, les première et deuxième molaires bilatérales en bouche de l'arcade maxillaire, ont été évaluées pour la perte osseuse parodontale (PBL) donc en 12 points chez chaque patient (côtés mésiaux et distaux de chaque dent) et aux mêmes endroits, l'épaississement de la muqueuse (MT) a été évaluée sur le plancher du sinus maxillaire. De plus, l'effet probable de chaque état pulpo-périapical (PPAC) sur l'épaississement de la muqueuse sinusale a été évalué.

Résultats: La présente étude portait sur 110 individus dont des images tomодensitométriques de 220 sinus maxillaires et 639 dents (total 1 278 surfaces dentaires) ont été étudiées. La MT a été observée dans 71,83 % des emplacements des sinus, montrant un épaississement de 1 à 3 mm dans 64,38 %, de 3,1 à 6 mm dans 14,71 %, de 6,1 à 10 mm dans 11,33 % et > 10 mm dans 9,59 % des cas. Des PBL ont été observées dans 69,01 % des emplacements de la surface des dents, montrant une perte osseuse alvéolaire légère dans 69,84 %, modérée dans 25,06 % et sévère dans 5,10 % des cas. Lors d'une analyse statistique, la MT sinusale était associée de manière significative aux PBL et aux PPAC, mais un effet plus fort des PBL était présent.

Conclusions: Dans notre étude, la prévalence observée de la MT sinusale était de 71,83 % et celle de la parodontite de 69,01 %. La MT sinusale était associée de manière significative aux PBL.

Mots clés : Sinus maxillaire, perte osseuse alvéolaire, affection pulpo-apicale, épaississement de la muqueuse sinusale, tomодensitométrie.

Introduction

The roots of the maxillary posterior teeth i.e., molars and premolars and sometimes canine are in close proximity with the sinus floor and occasionally may appear to project within the sinus [1]. But in fact, radiographically projected roots into the sinus are proven histologically to be covered with thin layer of cortical bone which shows perforations in 14-28% of cases [2]. Air filled bony cavities of maxillary sinuses communicate through ostium with the nasal cavity [3]. One mm thick respiratory mucous membrane lining of the sinus not visible radiographically may increase 10-15 times in thickness due to allergic or infectious diseases and appears radiographically as a layer of non-corticated radiopacity along the sinus walls [4].

Dental etiology accounts for maxillary sinusitis in approximately 10-12 % of cases [5]. Most frequently considered reasons for odontogenic sinusitis are dental abscesses and periodontal diseases that penetrate the membranous lining of the sinus. Few of the earlier researches have shown interrelation between sinus mucosal thickening (MT) and periapical lesions and periodontal diseases [6-9]. But shortcomings of these studies such as conventional radiographic approach and smaller sample size didn't let correct evaluation of sinus pathology. The gold standard recognized for sinus interpretation is the computed tomography (CT) [10].

In patients without symptoms prevalence noted of sinus MT varied from 8% to 29% [3, 6, 11]. Regardless of high frequency of dental infections odontogenic source of sinusitis is low because sinus floor is made of dense cortical bone. However, particularly in the pneumatized sinus odontogenic sinusitis can occur where roots are in close proximity with the sinus floor [12]. Dissemination of microbes and microbial byproducts to floor of sinus

can be greatly facilitated by porosity of the maxillary bone [13]. More commonly anaerobic bacteria are recovered from odontogenic rather than non-odontogenic sinusitis and antibiotics generally prescribed for non-odontogenic sinusitis are not effective against these anaerobes [14]. Therefore, it is important to diagnose the correct infection source for appropriate planning of treatment.

The primary feature of periodontitis is alveolar bone loss. Goswami [15], Sekhon et al [16] and Sanadhya et al [17] in their studies found prevalence rate of periodontitis as 85.62%, 61% and 51.1% respectively. Close proximity of maxillary teeth and surrounding alveolar bone with maxillary sinus and aforementioned high periodontitis rate, necessitates study evaluating adverse effects of periodontitis on maxillary sinuses.

The aim of the present study was to evaluate the correlation of the maxillary sinus mucosal thickness with the alveolar bone loss using computed tomography.

Material and Methods

After Institutional Ethics Committee approval (Approval number - DMIMS(DU)/IEC/5052), the present study was carried out. CT examinations were done after obtaining written informed consent from the participants. Utilizing Philips multislice spiral CT scanner (Koninklijke Philips N.V., Amsterdam, Netherlands) with exposure parameters of 230 mA and 130 kVp, CT scans were carried out in the axial plane and multiplanar images were obtained. Evaluation and measurements were done on the sagittal and coronal sections of the maxilla.

The inclusion criteria for patients were existence of at least one maxillary posterior tooth amongst the second premolars or first and second molars on the left or right side and high-quality CT images. The exclusion criteria were the CT scans of

patients with developmental anomalies, trauma and acute non-odontogenic sinusitis. Accordingly, CT images of 110 patients were selected in the age group of 14-80 years. The primary objective of the study was to determine correlation of the maxillary sinus mucosal thickness with the alveolar bone loss. The secondary objectives were to determine prevalence of periodontal bone loss, sinus mucosal thickening and to compare sole effect of PBL and PPAC on sinus MT. To achieve the objectives of the present study, assessment of periodontal bone loss (PBL), assessment of PPAC and assessment of sinus MT was done.

Assessment of PBL

All erupted first and second molar and second premolar teeth in the maxillary arch bilaterally were evaluated for assessment of PBL (Figure 1). Location two millimeters below cemento-enamel junction (CEJ) was decided normal for alveolar crest [18]. The distance between this normal location and the present alveolar crest was measured as PBL at mesial and distal surface of each tooth. Additionally, periodontitis status was classified as: 1. Normal (bone loss - 0%); 2. Mild (bone loss < 25%); 3. Moderate (between 25-50% bone loss); 4. Severe (bone loss > 50%) [19].

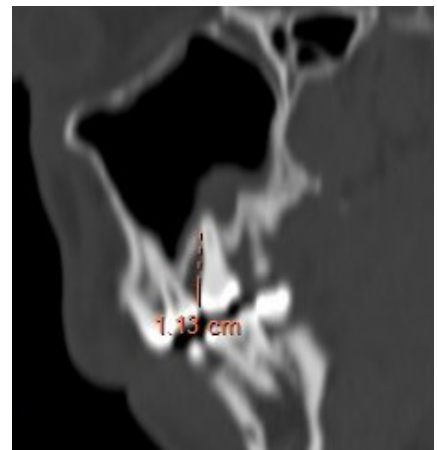


Figure 1. CT section showing periodontal bone loss

Assessment of pulpoperiapical condition

The existing teeth were divided in three categories to evaluate possible impact of pulpoperiapical condition on MT of sinus: 1. Normal (code number 0); 2. Teeth having extensive caries that extend for more than half of dentin thickness (code number 1); 3. Teeth having lesion at periapex (code number 2). Code number in brackets indicate the probable effect of PPAC with increasing order on sinus mucosal thickening.

Assessment of MT

Sinus MT was measured from the sinus floor to the highest point of mucosa above the sinus floor using measurement tool in the software. These measurements were done on the mesial and distal surfaces of maxillary second premolar, first and second molars bilaterally (Figure 2). Sinus mucosa >1 mm was recognized as thickened. The extent of MT was divided in five categories: 1) 1mm or less 2) 1.1 - 3mm 3) 3.1 - 6mm 4) 6.1 - 10mm 5) 10mm or more [4, 20].



Figure 2. CT section showing sinus mucosal thickening

Statistical analysis

Descriptive and inferential statistical analysis was done using F-test, Z-test, Pearson's correlation, Regression analysis and Multiple Regression Analysis. SPSS 22.0 version, EPI-INFO 5.0 version,

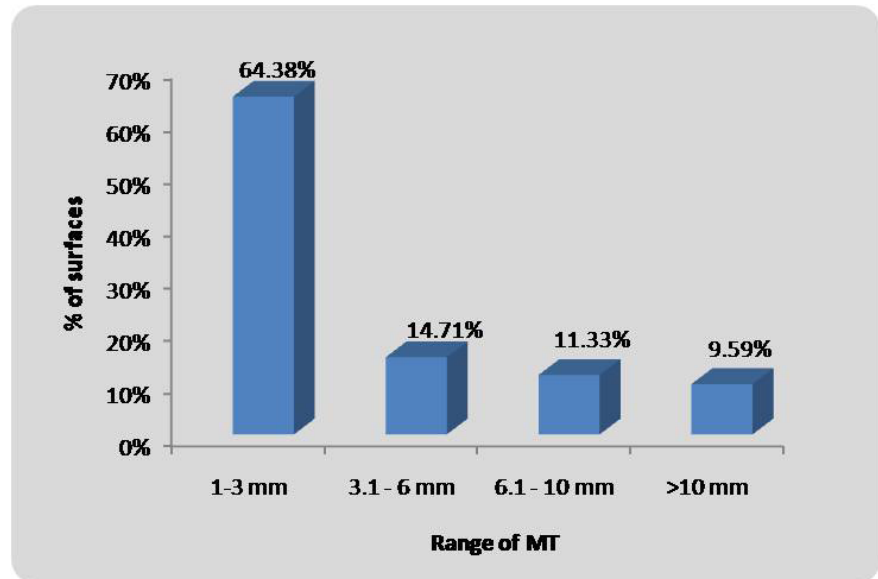


Figure 3. Graph showing distribution of patients according to range of MT

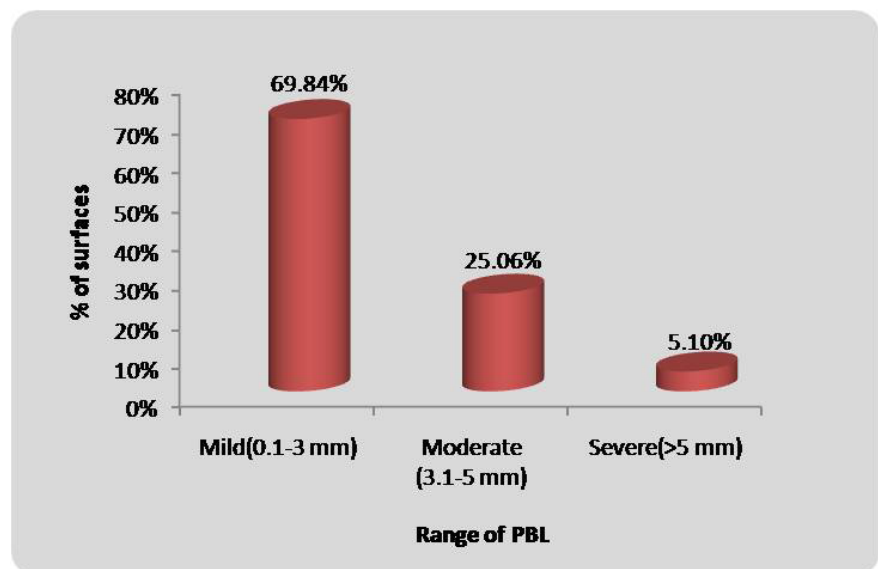


Figure 4. Graph showing distribution of patients according to range of PBL

GraphPad Prism 6.0 version software were used for the analysis. Level of significance was considered when statistical difference with value of $p < 0.05$ was present. In the present study, the confidence interval of the difference was 95%.

Results

The present study consisted of 66 (60%) male and 44 (40%) female patients among 110 individuals of which CT images of 220 maxillary sinuses and 639 teeth (total 1278 teeth surfaces) were studied. The

mean age of patients was 40.33 ± 17.12 years with age range of 14 to 86 years. MT was observed in 71.83% of sinus locations. Mucosal thickening of 1-3mm was present in 64.38%, 3.1-6mm in 14.71%, 6.1-10mm in 11.33%, and >10mm in 9.59% (Figure 3). PBL was observed in 69.01% of teeth surface locations. Mild alveolar bone loss was present in 69.84%, moderate in 25.06%, and severe in 5.10% (Figure 4).

The mean sinus MT found in the present study was 4.43mm and mean PBL was 2.59mm. Age was si-

gnificantly correlated with both the sinus MT and the PBL ($r = 0.240$, $p = 0.0001$ and $r = 0.272$, $p = 0.0001$ respectively) (Table 1). Higher prevalence was present in men than women for both sinus MT and PBL and the difference was significant statistically ($P < 0.05$) (Table 2). Greater mean sinus MT was found at locations with PBL than without PBL and the difference was statistically significant ($P < 0.05$) (Table 3).

Association between MT and PBL was determined with by relative correlation. A significant association was found between sinus MT and PBL ($r = 0.272$, $P < 0.01$) (Table 4). Furthermore, association between MT and PPAC was determined with by relative correlation. Sinus MT was significantly associated with PPAC ($r = 0.119$, $P < 0.01$) (Table 5). Sinus MT was evaluated for sole effect of PBL and PPAC with multiple linear regression analysis. Linear regression analysis demonstrated that sinus MT was associated with PBL as well as PPAC, but stronger effect of PBL over PPAC was present (Table 6). The relationship noted as: $MT = 1.821 + 0.789 \times (PPAC) + 0.988 \times (PBL)$, $P < 0.01$.

Discussion

With the aim to find out correlation of maxillary sinus mucosal thickness with alveolar (periodontal) bone loss the present study was carried out using computed tomographic images. As stated in the literature, sinus is lined internally by 1mm thickness of respiratory mucosa and therefore we selected mucosal thickness >1 mm as evidence of mucosal thickening. We observed prevalence of 71.83% for sinus MT which is noteworthy [4]. Various other studied defined sinus MT using different criteria. Considering 3-6 mm radiopaque layer along sinus walls as evidence, sinus MT was observed in 12% of patients by Vallo et al [6]. Diffuse radiopacity along sinus walls was considered and 70% prevalence of sinus MT was found

Table 1: Correlation of age in years with PBL and MT

	Mean	Std. Deviation	N	Correlation 'r'	p-value
PBL	2.59	1.39	1278	0.272	0.0001*
MT	4.43	5.18	1278	0.240	0.0001*
Age(yrs)	40.33	17.05	1278	-	-

* Significant ($p < 0.05$).

Table 2: Prevalence of MT and PBL in male and female

Gender	Male	Female	χ^2 value	p value
MT %	65.36	34.64	18.00	0.0001*
PBL %	65.31	34.69	18.00	0.0001*

* Significant ($p < 0.05$).

Table 3: Mean MT with and without PBL

Classification according to PBL	MT of sinus(mm)		z-value
	Mean	SD	
Locations with PBL	4.53	5.26	2.92 $p = 0.004^*$
Locations without PBL	1.96	0.69	

* Significant ($p < 0.05$).

Table 4: Association between PBL and MT

	Mean	Std. Deviation	N	Correlation 'r'	p-value
PBL	2.59	1.39	882	0.272	0.0001*
MT	4.43	5.18	918		

* Significant ($p < 0.05$).

Table 5: Association between Pulpoperiapical conditions and MT

	Mean	Std. Deviation	N	Correlation 'r'	p-value
PPAC	0.12	0.45	918	0.119	0.0001*
MT	4.43	5.18	918		

Table 6: Multiple regression analysis to assess sole effect of PBL and PPAC on MT

	Unstandardized Coefficients		Standardized Coefficients	t	p-value
	B	Std. Error	Beta		
MT	1.821	0.361		-	-
PPAC	0.789	0.318	0.081	2.479	0.013*
PBL	0.988	0.124	0.261	7.987	0.0001*

* Significant ($p < 0.05$).

by Soikkonen et al [3]. Janner et al considered sinus MT if it was greater than 2 mm and found 37% prevalence of sinus MT [21]. Mucosal thickness >1 mm was considered by Phothikhun et al similar to our study and observed MT in 42% of patients [20]. Using similar standard 39.4 % prevalence of sinus MT was observed in a study conducted by Sheikhi et al [22].

Varied prevalence of periodontitis has been reported in the Indian population from 42% to 85% [15-17]. We also found higher prevalence of periodontitis in the present study i.e., 69.01%. This might have resulted in higher prevalence of MT i.e., 71.83% as chronic irritation to sinus mucosa may be caused by periodontitis of the posterior teeth in maxillary arch where roots are in close proximity to sinus floor. In the present study we found greater prevalence in males than females for sinus MT and PBL ($P < 0.05$). Furthermore, we found that age was significantly correlated with both the sinus MT and PBL. These results are in concordant with previous studies [6, 11, 20].

In this study, we demonstrated that sinus MT was significantly associated with PBL ($P < 0.01$). The results of other studies supported the findings in our study [6,20]. Increased quantity of pathogens and their products and cytokines resulted from periodontitis may reach the sinus mucosa by directly disseminating through the porosity of the maxillary bone or indirectly via the lymphatics and blood vessels [13]. So, possibly periodontitis

results in maxillary sinus MT. We demonstrated that sinus MT was significantly associated with pulpoperiapical conditions ($P < 0.01$). The observations of other studies are in accordance with our results [6,9]. On the contrary, sinus MT and periapical lesions were not significantly associated in observations by some other studies [20,21]. Different classification of carious teeth might have resulted in their different results. Results in the present study might be more relevant because we constituted comprehensive grading of teeth which includes teeth with severe caries and teeth with periapical lesions denoting pulpoperiapical conditions. In this study MT of the maxillary sinus was analyzed for the sole effect of PBL and pulpoperiapical conditions by multiple linear regression analysis. We demonstrated that sinus MT was significantly co-related with both the PBL and PPAC however stronger effect of PBL over PPAC was present. The observations obtained in other studies supported these findings of our study [22, 23].

Thickened sinus mucosa can be asymptomatic [20, 22, 24, 25]. Thickened sinus mucosa as observed in the present study has various clinical implications. CT examination should be accomplished earlier to sinus augmentation procedure as ostium may get obstructed or inflammation of sinus can happen by thick mucosa during sinus elevation. Carmeli et al., observed 11.1% risk of sinus obstruction with sinus mucosal thickness of <5mm, 36.2% with 5 to 10mm and 74.3% with

>10mm [26]. Prior to sinus augmentation procedure it is recommended that sinus mucosal anomalies should be removed [27]. Also, sinus MT was significantly associated with PBL in present study. This denotes that whenever periodontitis is causally related to sinus MT, proper periodontal therapy to restrain associated pathogens and their products may alleviate sinus MT. Though there is extensive dispute over the normal mucosal thickness of maxillary sinus, mucosal thickening greater than 2-3 mm is accepted by most authors as pathologic. There is increasing evidence that odontogenic cause for maxillary sinusitis is more common than previously believed and is increasing in incidence [28].

Conclusions

In our study, observed prevalence of sinus MT was 71.83% and prevalence of periodontal bone loss was 69.01%. Both PBL and PPAC should be considered in the sinus MT. In present study sinus MT was associated more significantly with PBL than PPAC. We found high prevalence of sinus MT. Sinuses should be evaluated for mucosal anomalies before sinus augmentation procedures. We also found high prevalence of periodontitis. Dental etiology should be ruled out in cases of chronic maxillary sinusitis. Future studies are required to evaluate clinical consequences of thickened sinus mucosa secondary to dental etiology and their therapeutic and prognostic implications.

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