

Original Article

Using cone beam computed tomography to detect the relationship between the periodontal bone loss and mucosal thickening of the maxillary sinus

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ABSTRACT

Background: Maxillary sinuses are covered by a 1 mm thick mucous membrane that when this membrane becomes inflamed, the thickness may increase 10-15 times. The common causes of odontogenic sinusitis are dental abscesses and periodontal disease. Computed tomography (CT) is considered the gold standard for sinus diagnosis. Recently, cone beam computed tomography (CBCT) has been introduced for dental and maxillofacial imaging, which has several advantages over traditional CT, including lower radiation dose and chairside process. This study aims to find the association between mucosal thickening (MT) of the sinus and periodontal bone loss (PBL) and pulpoperiapical condition.

Materials and Methods: A total of 180 CBCT images were reviewed. PBL was assessed in six points under each sinus at the mesial and distal sides of the upper second premolar and first and second molars by measuring the distance from the alveolar crest to the point 2 mm under the cemento-enamel junction (CEJ). The MT was assessed at six points in the floor of the sinus precisely over the mentioned points. To assess the possible role of pulpoperiapical condition on the sinus MT, the existing teeth were classified into five groups due to the probable effect of each condition on the pulp and peri-apex. The statistical association between MT of sinus and PBL and pulpoperiapical condition was assessed using SPSS software (SPSS Inc., version 16.0, Chicago, IL, USA) and bivariate correlation and binary linear regression statistical tests ($P < 0.05$).

Results: MT was observed in 39.4% of patients (mean = 4.68 ± 5.25 mm). PBL was seen in 33% of the patients (mean = 1.87 ± 1.63 mm). Linear regression test showed that there is an association between both PBL and pulpoperiapical condition and MT, but the effect of PBL was about 4 times stronger.

Conclusion: This study showed that MT of the maxillary sinus was common among patients with PBL and MT of the maxillary sinus was significantly associated with PBL.

Key Words: Maxillary sinus, mucosal thickening, periodontal bone loss

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INTRODUCTION

The maxillary sinuses are air cavities that communicate with the nasal cavity by ostium.^[1] The

sinuses are covered by a thin respiratory mucous membrane, which adheres to the periosteum and is normally about 1 mm thick. The normal sinus mucosa is not visualized on a radiograph. However, when the mucosa becomes inflamed from either an infectious or allergic process, it may increase by 10-15 times in thickness and may be seen radiographically. Mucosal thickening (MT) greater than 3 mm is most likely pathological. The radiographic image of thickened mucosa is as a non-corticated radiopaque band, paralleling the bony wall of the sinus.^[2]

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It is estimated that 10-12% of maxillary sinusitis cases has a dental etiology.^[3] The most common causes of odontogenic sinusitis are dental abscesses and periodontal disease that perforates the Schneiderian membrane. Some of the previous studies have shown a relationship between periodontitis and periapical lesions and MT.^[3-7] The floor of the sinus is composed of dense cortical bone. Therefore, sinus infections from a dental source were thought to be uncommon, but they can occur particularly in the case of a pneumatized sinus in which the schneiderian membrane can be easily penetrated by pathogens.^[8] The porous maxillary bone can directly contribute to the diffusion of pathogens and their products to the sinus floor.^[9] The most common pathogens in the cases of non-odontogenic sinusitis are aerobic, whereas in the cases of odontogenic sinusitis, pathogens are commonly anaerobic that don't respond to antibiotic therapies which is prescribed for common non-odontogenic origins,^[10] so recognizing the accurate source of infection is essential for proper treatment planning. In the cases of MT of sinus due to periodontal disease, treatment of periodontal problems to reduce the pathogens and their products result in reduction of MT.^[5-7] Many previous studies have applied conventional radiographic techniques that have not allowed accurate detection and measurement of MT.^[1,4,9,11]

Computed tomography (CT) is considered the gold standard for sinus diagnosis.^[12] Recently, cone beam computed tomography (CBCT) has been introduced for dental and maxillofacial imaging, which has several advantages over traditional CT, including lower radiation dose and chairside process.^[13] Therefore, the aim of the present study was to find the association between MT of the maxillary sinus and periodontal bone loss (PBL) and considering the possible contribution of tooth pulpoperiapical condition by using CBCT.

MATERIALS AND METHODS

The CBCT images that were taken using the Gallileos unit (Sirona dental systems GmbH, Bensheim, Hessen, Germany), at the Department Of Radiology, Dental School, Isfahan University of Medical Sciences, from October 2011 to November 2012 were retrospectively examined. CBCT prescriptions were due to different purposes including developmental disorders, paranasal

sinus diseases and trauma and most often, implant treatment planning. The inclusion criteria were:

1. Good quality of the images;
2. Existence of at least one of the first and second molar or second premolar in each left or right sides;
3. No sign of acute non-odontogenic sinusitis, including air-fluid level and thickening of all the sinus walls;
4. No prescription of CBCT due to the developmental problems or trauma.

260 CBCT images were examined and finally 180 images (51% males and 49% females), aged 13-81 years (mean age: 44.1 ± 15.7 years) were included for the analysis. The majority of images was excluded due to the absence of second premolar and first and second molar teeth below the sinus.

The Sidexis X-G software (Sirona Dental X-ray Imaging System next Generation, Sirona Dental Systems GmbH, Bensheim, Hessen, Germany), was used for the image analysis.

Panoramic, tangential and cross-sectional views of the maxilla were considered for evaluation and measurements. All images were evaluated by one trained post-graduate student of oral and maxillofacial radiology. To evaluate the intraexaminer reliability, 20 CBCT images were measured 10 days later again. The intraclass correlation coefficient was 0.93 for PBL measurements and 0.95 for MT of sinus measurements.

Assessment of PBL

All erupted maxillary second premolar and first and second molar teeth were examined. PBL was assessed from the panoramic and tangential views. The normal situation of the alveolar crest was assumed to be 2 mm under the cemento-enamel junction (CEJ).^[13] To calculate the amount of PBL, the distance between the point 2 mm under the CEJ and the crest of the alveolar bone was measured at the mesial and distal sides of each tooth (totally 12 points in each patient). Furthermore, we classified the amount of the PBL as follows:

1. Normal;
2. Mild, <25% bone loss;
3. Moderate, 25-50% bone loss and
4. Severe, >50% bone loss.^[14]

Assessment of pulpoperiapical condition

To assess the possible role of pulpoperiapical condition of teeth on the sinus MT, we classified the existing teeth into six groups:

1. Normal;
2. Teeth with prosthetic crown;
3. Teeth with root canal therapy;
4. Teeth with both root canal therapy and crown;
5. Teeth with severe carries that proceed more than half of dentin and
6. Teeth with periapical lesion. The code number of each group (0-5), indicates the probable effect of each tooth pulp and peri-apex condition (from the least effect to the most effect).

Assessment of MT

The presence or absence of MT in the floor of the maxillary sinus was evaluated from the cross-sectional, tangential and panoramic views. In each sinus, the MT is measured in six points precisely located over the mesial and distal sides of second premolar and first and second molar teeth of the sinus floor to the highest bidder of the mucosa. For each point, MT was considered to be when there was a thickness of >1 mm. The amount of MT was also classified into five groups:

1. MT less than 1 mm;
2. 1-3 mm;
3. 3-6 mm;
4. 6-10 mm and
5. More than 10 mm.^[2,3]

Statistical analysis

All data were analyzed using SPSS statistical software (version 16) (Statistical Package for Social Sciences, SPSS Inc., Chicago, IL, USA) was used to analyze the data. Bivariate correlation was used to determine any correlation between age and sex with PBL and MT. Binary linear regression analysis was used to determine the relationship between the PBL and pulpoperiapical condition on the maxillary sinus MT independently. Statistical differences with a $P < 0.05$ and confidence intervals of 95% were considered to be significant.

RESULTS

The CBCT images of 358 maxillary sinuses and 2142 teeth of 180 individuals (51% males and 49% females), aged 13-81 years; (mean age: 44.1 ± 15.7) were examined. MT was observed in 39.4% of patients, which 46.6% were 1-3 mm, 26.4% were 3-6 mm, 15.1% were 6-10 mm and 3% were more than 10 mm. The mean mucosal thickness was 4.68 ± 5.25 [Table 1].

PBL was seen in 33% of the patients, of whom 70.5% were mild, 28.5% were moderate and 3% were severe. The mean PBL was $1.87 \text{ mm} \pm 1.63 \text{ mm}$ [Table 2].

There is a significant correlation between age and both PBL and MT of maxillary sinus ($r = 0.38$, $P < 0.001$ and $r = 0.245$, $P < 0.005$ respectively).

The independent *t*-test showed a higher prevalence of PBL in men than women ($P < 0.05$), whereas the difference between the mean bone loss was not significant ($P > 0.05$). Furthermore, the prevalence of sinus MT and the mean MT were significantly higher in men than women ($P < 0.05$).

The independent *t*-test showed a significant difference between the mean sinus MT in individuals with PBL and without it ($P < 0.01$) [Table 3].

Bivariate correlation revealed a significant association between the PBL and MT ($r = 0.620$, $P < 0.01$) [Figure 1].

To assess the probable effect of pulpoperiapical condition on the MT, the teeth were classified into six groups, the code number which is referred to each group indicates the probable effect of each tooth pulp and peri-apex condition (minimum code number = 0, maximum = 5, mean = 0.79, standard deviation = 1.47). The distribution of the teeth due

Table 1: Measures of PBL and MT of the maxillary sinus (mm)

	Minimum	Maximum	Mean	Standard deviation
PBL (mm)	0.2	10	1.87	1.63
MT (mm)	1.3	33.8	4.68	5.25

PBL: Periodontal bone loss; MT: Mucosal thickening

Table 2: The prevalence and mean PBL and MT of sinus in males and females

Sex	Prevalence of PBL %	Prevalence of mucosal thickening %	The mean PBL (mm)	The mean MT (mm)
Male	50	55.9	0.50 (standard deviation: 0.7)	3.04 (standard deviation: 6.1)
Female	23	30	0.29 (standard deviation: 0.86)	0.96 (standard deviation: 2.4)

PBL: Periodontal bone loss; MT: Mucosal thickening

Table 3: The mean MT in the patients with and without PBL (mm)

Classification of the patients according to the PBL	MT of sinus (mm)	
	Mean	Standard deviation
Patients with PBL	4.69	5.91
Patients without PBL	0.54	1.76

PBL: Periodontal bone loss; MT: Mucosal thickening

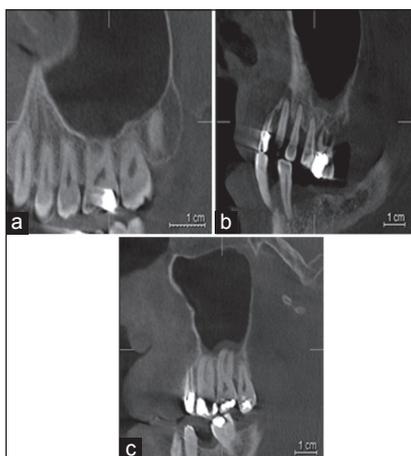


Figure 1: Cone beam computed tomography, tangential views of three patients (a) without any thickening of sinus mucosa (b) mucosal thickening (MT) of sinus floor in addition to severe periodontal bone loss (c) MT of sinus floor in addition to bone loss in the distal of second molar tooth

Table 4: The mean MT in the different pulp and periapical conditions (mm)

Different pulp and periapical conditions	Mean MT (mm)	Standard deviation
Normal (code number=0)	1.43	3.66
Crown (code number=1)	4.42	6.60
RCT (code number=2)	4.4	6.01
RCT and crown (code number=3)	2.59	5.37
Extensive carries (code number=4)	4.95	5.12
Pulpoperiapical lesion (code number=5)	4.01	2.97

MT: Mucosal thickening; RCT: Root canal therapy

to their pulpoperiapical conditions are shown in Figure 2.

The mean MT of the sinus in the different pulpoperiapical conditions are shown in Table 4.

Bivariate correlation revealed a significant association between the pulpoperiapical condition and MT ($r = 0.27$ $P < 0.01$).

Linear regression test was used to detect the pure effect of pulpoperiapical condition and PBL on the MT of the maxillary sinus. Linear regression test showed that there is an association between both PBL and pulpoperiapical condition and MT, but the effect of PBL was stronger. The relationship was as follows:

$$MT = 0.684 + 0.329 \times (\text{pulpoperiapical condition}) + 1.379 \times (\text{PBL}), P < 0.01.$$

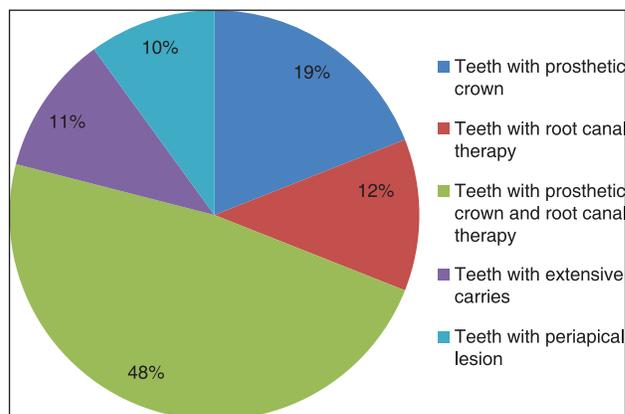


Figure 2: Distribution of the teeth due to the pulpoperiapical condition

DISCUSSION

The aim of the present study was to clarify the possible association between PBL and MT of maxillary sinus.

In the present study, the use of CBCT sections without super imposition seen in conventional radiographs and high resolution capability allows more accurate investigation of MT of maxillary sinus as well as PBL.^[15-17] In most of the previous studies^[1,4] conventional radiographic techniques have been used in which differentiation between MT of infectious disease, maxillary sinus cysts and neoplasms^[18] can be difficult. Since the normal thickness of the maxillary sinus mucosa (Schneiderian membrane) is about 1 mm,^[2,19] the mucosal thickness of >1 mm was selected as evidence of MT. In the present study, MT was found in 39.4% of patients. The prevalence of the MT can change in accordance with the definition of normal mucosal thickenss. Soikkonen and Ainamo and Vallo *et al.* used panoramic radiographs in which accurate measurements of sinus mucosal thickness may not have been obtained.^[1,4] In the study of Vallo *et al.*, MT was found in 12% of cases when a 3-6 mm-thick radiopaque band along the wall of the sinus was seen.^[4] Soikkonen and Ainamo did not define a baseline for MT of sinus; their assumption was the existence of diffuse radio-opacity along the sinus walls and they found the prevalence of 70% for sinus MT.^[1] Savolainen *et al.* defined abnormal thickness as a measure of more than 6 mm.^[20] Phothikhun *et al.* and Janner *et al.* both used CBCT to evaluate the sinomucosal thickness.^[3,21] Janner *et al.* defined the presence of MT when it was more than 2 mm and found MT in 37% of patients.^[21] Similar to our study, Phothikhun *et al.* defined the mucousal thickening when it was >1 mm and found MT in 42% of patients.^[3]

Periodontitis is regarded as the second most common disease world-wide after dental decay. In the United States has a prevalence of 30-50% of the population, but only about 10% have the severe forms.^[22] In the present study, the prevalence of PBL was 33% and most of the patients (70%) had mild PBL. Due to the present study findings, a higher prevalence of MT and PBL was seen among males ($P < 0.05$), which was consistent with the results of Vallo *et al.* study.^[4] Furthermore, there was a significant correlation between both the PBL and MT of the maxillary sinus and age, which was consistent with the previous studies.^[3,4,11]

Due to the findings of the present study, PBL and pulpoperiapical condition are significantly associated with MT ($P < 0.01$), but the linear regression analysis showed that the coefficient of effect of PBL was much more than pulpoperiapical condition (coefficient of 1.379 for PBL and 0.329 for pulpoperiapical condition).

Similar to the results of the present study, Vallo *et al.* found that MT was associated with vertical and horizontal bone loss.^[4] Janner *et al.* also found that there is an association between the MT of the maxillary sinus and PBL.^[21] Phothikhun *et al.* found that MT of maxillary sinus was associated with PBL, especially in severe PBL.^[3] The similarity of the results of these studies with the present study can be due to the similar methods of research.

The local increased level of the pathogenic bacteria, their products and also inflammatory cytokines can diffuse directly to the sinus mucosa from maxillary bone and they can reach indirectly through blood and lymphatic vessels. Both direct and indirect ways causing thickening of sinus can be retrieved by proper periodontal therapy.^[23]

Similar to the present study, Vallo *et al.* and Nenzén and Welander^[4,7] found that there was an association between periapical lesions and root canal fillings and MT of sinus and their findings were in contrast with results of Phothikhun *et al.* and Janner *et al.*^[3,21] This difference can be due to the different classification of teeth. In the present study, classification of the teeth according to pulpoperiapical condition is more comprehensive and the results could be more accurate. Yoo *et al.* found that in the areas of tooth extraction due to the pulpal problems, thickening of sinus mucosa was much higher than the areas in which tooth were extracted due to the PBL.^[24] In the present study, use of linear regression allowed the accurate

measurement of pure effect of both the PBL and pulpoperiapical condition on MT. Due to the findings of the present study, both the PBL and pulpoperiapical conditions were associated with thickening, but the association between PBL and MT was about 4 times stronger. Phothikhun *et al.*^[3] measured the PBL and MT in the both sides of the teeth and then selected the upper measurement for statistical analysis, whereas in the present study both the mesial and distal sides of each tooth were analyzed, which could be more accurate.

According to the results of the present study, the mean MT was 4.68 mm and the majority of patients were referred for CBCT for implant treatment and not for sinus problems. Therefore, MT can be asymptomatic even in measurements up to 4-5 mm and the patient may not be aware of this pathology. This fact causes some authors to define high measures of thickening as a normal.^[1,3,4,20,21,25]

Rak *et al.* showed that MT up to 3 mm can be clinically asymptomatic and doesn't need complementary considerations.^[26] In the Phothikhun *et al.* study the mean MT was 5 mm and most of the patients were asymptomatic.^[3] Although most of the MTs in the sinus can be asymptomatic, but detection of this pathology is important in some conditions including sinus augmentation. This procedure is recommended in the cases in which there is a lack of enough height in the maxillary bone to insert the implant.^[27] Carmeli *et al.* showed that there is an increased risk of sinus obstruction that may result in impaired drainage of sinus and cause acute sinusitis in patients especially if thickening is more than 5 mm.^[28] As was seen in the present study, the prevalence of MT was increased in correlation with increase in age and the majority of patients who were referred for CBCT, are partially or completely edentulous patients that needed implant treatment. It is estimated that 10-12% of maxillary sinusitis cases have an odontogenic origins.^[12] The most common pathogens in the cases of non-odontogenic sinusitis are aerobic and in the cases of odontogenic sinusitis pathogens are commonly anaerobic, which don't respond to antibiotic therapies prescribed for common non-odontogenic pathogens.^[10] Hence, recognizing the accurate source of infection is essential for proper treatment planning. In the cases of MT of sinus due to periodontal disease, treatment of periodontal problems to reduce the pathogens and pathogenic products result in reduction of MT.^[5-7]

Since in the present study the archival CBCT images were used, there was the lack of clinical examination and accurate history about the periodontal and sinus problems. Furthermore, cases with the signs of acute sinusitis including air-fluid level and complete thickening in all the sinus walls were excluded, so there is a need for additional researches to clarify the accurate association between the PBL and MT of maxillary sinus with regards to the clinical symptoms.

CONCLUSION

Within the limitations of this study, it was shown that there was an association between both PBL and pulpoperiapical condition and MT, but the effect of PBL was stronger.

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