



Cone-beam computed tomography Evaluation of the Relationship Between Maxillary Sinus Membrane Thickness and The Health of the maxillary posterior Teeth. Cross-sectional study.

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Abstract

Background: this study is designed to assess the relationships between the thickening of the maxillary sinus membrane and the condition of the nearby maxillary teeth by CBCT. **Materials and methods:** CBCT images were assembled from 150 Egyptian patients. The maxillary sinus membrane thickness exceeding 2 mm is considered a pathologic membrane. Demographic data such as age and sex were recorded, as well as sinus membrane thickness, and the health condition of the adjacent teeth was noted down, classified, and investigated. **Results:** In the current study, the mean mucosal thickening of the maxillary sinus was 24.8 ± 6.4 mm. Intra-class correlation coefficient (ICC) has shown nearly perfect agreement between observers for assessment of the mucosal thickening of the maxillary sinus (ICC= 0.9997) with a mean difference of -0.0099 ± 0.15 (P=0.4195). Inter-observer agreement for the presence of dental caries, periodontal disease, periapical pathosis, and endodontic treatment was perfect ($\kappa=1.0000$). **Conclusion:** The results of this study showed that the prevalence of MT is directly correlated with age, the existence, and severity of a periapical lesion, and is higher in males.

Keywords: Cone beam CT, maxillary sinus, Schneiderian membrane.

Background:

Schneiderian membrane thickness may impact the ultimate clinical results of dental and sinus augmentation. Mucosal thickening has been identified as a risk factor for problems following treatment.¹

For all routine dental investigations, periapical radiographs and panoramic tomography are typically used to assess the health of the posterior maxillary teeth. The 2-dimensional representation of 3-dimensional structures in plain films, however, makes it challenging to assess the actual condition between the sinus floor and surrounding teeth. Therefore, Cone-beam CT

(CBCT) has recently gained acceptance in the oral and maxillofacial region, particularly for implant dentistry.^{2,3}

On CBCT scans, thicker mucosa is seen as a distinct radiopaque band running parallel to the sinus bone walls. In both symptomatic and asymptomatic individuals, it is common in daily dentistry practice, to see thickening of the maxillary sinus mucosa. Therefore, before performing any surgical procedure on the posterior maxillary region, a pre-operative evaluation of the maxillary sinus, including an analysis of its bony walls and thickening of its mucosal lining, is considered now as a mandatory routine procedure.^{4,5}

Prior to posterior maxilla surgery, the sinus should be evaluated to detect sinus pathology and anatomic variations in the bony components. The evaluation should determine the quantity and quality of the bone, the neighbouring dentition's periodontal health, the patient's history of tooth discomfort, and the presence of sinus issues. The maxillary sinus can be seen and membrane thickening can be found using a pretreatment cone-beam computed tomographic (CBCT) scan.⁶

Prior to implant implantation and routine dental checkups, it is crucial to assess the posterior maxillary region's health.⁷

The association between the health of the maxillary posterior teeth and the sinus floor in the Egyptian population, however, is little understood. Therefore, in this study, the association between sinus membrane thickening and the health of the teeth in the maxillary molar area was assessed by CBCT scanning. Age, gender, periodontal bone level, endodontic treatment status, and periapical lesion were used to analyse the associations.

MATERIALS AND METHODS

For this study, a retrospective analysis of 150 CBCT scans from Egyptian patients seeking dental care was conducted. The scans were retrieved retrospectively from the faculty of dentistry's oral and maxillofacial radiology department's database between February 2023 and June 2023 in Egypt's October University of Modern Science and Arts. The patients ranged in age from 20 to 75. The CBCT Newtom GIANOHR was used to obtain each scan with exposure parameters 90 kVp, 12.5 mA, 14 s.

Sample size

The primary outcome, the correlation between periodontal disease and thickness of the sinus mucosa, was used to calculate the sample size. According to the findings of Shahidi et al (2016), the odds ratio for this connection was 14.39, and 52.2% of patients had mucosal thickening >1 mm in addition to periodontal disease. The minimum estimated sample size, with alpha (α) level of (5%), was 41 participants. Software G*Power version 3.1.9.2 (Franz Faul, Universitat Kiel, Germany)

was used to calculate the sample size. In order to increase the study power and reduce the level of uncertainty, the calculated sample size was increased to 150 cases (98 males (65.3%) and 52 females (34.7%), with a mean age of (47.8 ± 12.4) years.⁸

Blinding

The scans were coded, and the patients' age and sex were concealed from the authors with the help of a fellow. All of the scans were evaluated by the two researchers.

To calibrate and determine intra-examiner reliability, one researcher measured and evaluated 20 randomly chosen scans twice on two different days. After the same fellow had interpreted the coded signs, the results of each CBCT scan, including the tooth condition and mucosal membrane thickness, together with demographic information, such as age, gender, and the reason for the scan, were registered and analyzed.

The study comprised 150 maxillary CBCT scans of Egyptians whose names, ages, and sexes were known, in addition to the reasons for the scans. The scans that had good quality and showed the maxillary sinus floor, the posterior teeth on either side of the maxilla, and at least one first and second molar or second premolar on each side of the mouth were included in this study. (**Inclusion criteria**).

Any CBCT scan showing developmental disorder, traumatic lesion, bony changes of neoplastic features or cystic lesions in the posterior maxilla and/or maxillary sinus, signs of non-odontogenic sinusitis, or scans with metallic artifacts concealing the discernibility of the related maxillary posterior teeth or the floor and/or the lower part of the maxillary sinus were excluded. (**Exclusion criteria**).

The following factors pertaining to the targeted teeth were evaluated: Whether the tooth was present or missing; whether a periapical lesion, a root canal filling, the severity of periodontal bone loss, and the existence of dental caries.

The periodontal health was assessed using the procedures: listed below: The cemento-enamel junction (CEJ) was thought to be 2 mm apart from the usual alveolar crest. At the mesial and distal sides of each tooth, the distance was measured between the site 2 mm apical to the CEJ and the crest of the alveolar bone. Additionally, we classified periodontal bone loss into three groups: Mild (25%), Moderate (25–50%), and Severe (>50%).

Evaluation and measurement of the thickness of maxillary sinus membrane: The thickness of the mucosa was measured in millimeters from the sinus floor to the highest border of the membrane (figure 1&figure 2). Categorization was based on the classification proposed by Sheikhi et al 2014;

this classification divided the MT into 5 classes; 1. MT less than 1 mm; 2. 1-3 mm; 3. 3-6 mm; 4. 6-10 mm and 5. More than 10 mm.⁵

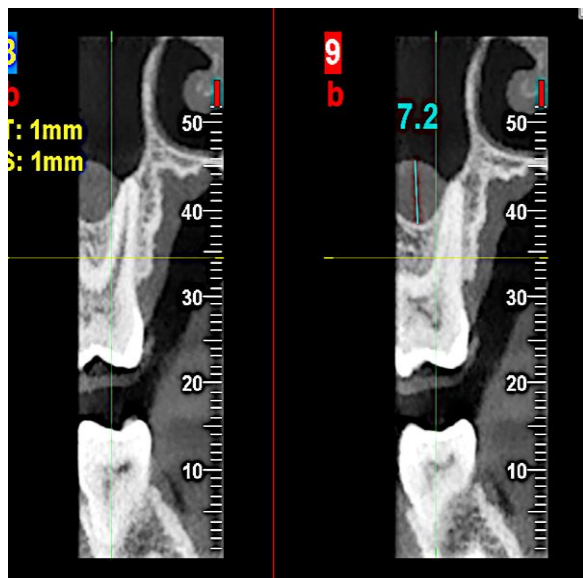


Figure 1 sagittal images showing measurement of the MT

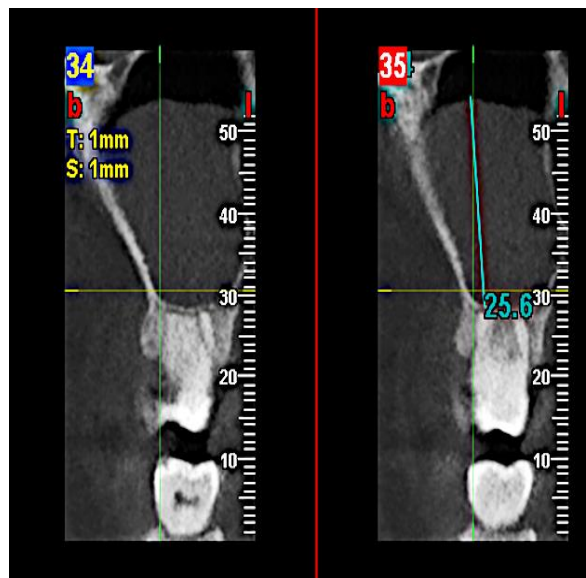


Figure 2 sagittal images showing measurement of the MT

Using the personal computer's installed NNT Viewer, images were analyzed. The condition of the second premolar, first, and second molar bilaterally, as well as the thickness of the sinus mucosa-associated with each of the aforementioned teeth, were evaluated using sagittal images with 1mm thickness.

Statistical analysis

Data was analyzed using Medcalc software, version 19 for Windows (MedCalc Software Ltd, Ostend, Belgium). Continuous data were explored for normality using Kolmogorov Smirnov and Shapiro Wilk tests. Continuous data showed normal distribution and were described using mean and standard deviation. Categorical data were described as frequency and percentage. Correlation between categorical data was performed using Spearman's rank correlation, while correlation between continuous data was performed using Pearson's correlation. The intra-class correlation coefficient was used to assess inter-observer agreement for continuous variables, while Kappa coefficient was used for inter-observer agreement for ordinal and nominal variables. A P-value less than or equal to 0.05 was considered statistically significant.

Results

In the current study 150 CBCT were retrieved retrospectively for assessment of correlation between age, gender, presence of caries, periodontal disease, endodontic treatment, presence of periodontal lesion and mucosal thickening of the maxillary sinus. The mean mucosal thickening of the maxillary sinus was 24.8 ± 6.4 mm. Intra-class correlation coefficient (ICC) have shown nearly perfect agreement between observers for assessment of the mucosal thickening of the maxillary sinus (ICC= 0.9997) with a mean difference of -0.0099 ± 0.15 (P=0.4195). Inter-observer agreement for presence of dental caries, periodontal disease, periapical pathosis and endodontic treatment was perfect ($\kappa=1.0000$).

The mean age of participants in the current study was 47.8 ± 12.4 years, there was medium positive correlation between age and mucosal thickening of the maxillary sinus ($r=0.496$, $P<0.0001$). Mean mucosal thickening of the maxillary sinus was 8.9 ± 6.7 mm for 21-30 years, 5.2 ± 3.8 mm for 31-40 years, was 8.2 ± 6.5 mm for 41-50 years, was 14.1 ± 4.7 mm for 51-60 years, was 14.7 ± 4.5 mm for 61-70 years and was 14.6 ± 2.6 mm for above 70 years. As age increases, mucosal thickening of the maxillary sinus increases except for the age group (31-40 years) which showed decrease in mucosal thickening.

There was 98 males (65.3%) and 52 females (34.7%) in the current study, there was weak negative correlation between gender and mucosal thickening of the maxillary sinus ($r=-0.233$, $P=0.0041$). Mean mucosal thickening of the maxillary sinus was 11.2 ± 6.7 mm for males and 7.8 ± 5.2 mm for females. This means that mucosal thickening of the maxillary sinus is higher in males than females. 40 patients in the current study showed periapical pathosis; 27 maxillary 2nd premolar (67.5%), 12 maxillary 1st molar (30%) and 1 maxillary 2nd molar (2.5%), there was very weak positive correlation between presence of periapical lesion and mucosal thickening of the maxillary sinus ($r=0.079$, $P=0.6267$). Mean mucosal thickening of the maxillary sinus was 11.2 ± 6.5 mm in maxillary 2nd premolar, 11.9 ± 7.9 mm for maxillary 1st molar was 22.3 mm for maxillary 2nd molar. This means that as we move posterior in the dental arch, the mucosal thickening of the maxillary sinus increases with periapical lesions.

50 patients in the current study showed dental caries; 12 maxillary 2nd premolar (22.2%), 12 maxillary 1st molar (22.2%) and 30 maxillary 2nd molar (55.6%), there was weak negative correlation between presence of dental caries and mucosal thickening of the maxillary sinus ($r=-0.321$, $P=0.0179$). Mean mucosal thickening of the maxillary sinus was 13.3 ± 4.6 mm in maxillary 2nd premolar, 15.4 ± 7.3 mm for maxillary 1st molar was 10.7 ± 5.5 mm for maxillary 2nd molar.

45 patients in the current study showed endodontic treatment; 13 maxillary 2nd premolar (28.9%), 17 maxillary 1st molar (37.8%) and 15 maxillary 2nd molar (33.3%), there was very weak negative correlation between presence of endodontic treatment and mucosal thickening of the maxillary sinus ($r=-0.064$, $P=0.6780$). Mean mucosal thickening of the maxillary sinus was 14.5 ± 7.7 mm in maxillary 2nd premolar, 11.7 ± 4.1 mm for maxillary 1st molar was 13.1 ± 6.5 mm for maxillary 2nd molar.

All patients in the current study showed periodontal disease; 33 maxillary 2nd premolar (22%), 39 maxillary 1st molar (26%) and 78 maxillary 2nd molar (52%), there was very strong positive

correlation between presence of periodontal disease and mucosal thickening of the maxillary sinus ($r=0.899$, $P<0.0001$). This means that as the severity of periodontal diseases increases, the thickening of the mucosa of the maxillary sinus increases and vice versa. Mean mucosal thickening of the maxillary sinus was 2.7 ± 0.5 mm in mild periodontal disease, 5.8 ± 1.8 mm for moderate periodontal disease and 15.3 ± 4.3 mm for severe periodontal disease.

Age	Frequency	Percentage	Mucosal thickening
21-30	14	9%	8.9 ± 6.7
31-40	28	19%	5.2 ± 3.8
41-50	51	34%	8.2 ± 6.5
51-60	31	21%	14.1 ± 4.7
61-70	20	13%	14.7 ± 4.5
>70	6	4%	14.6 ± 2.6
Total	150	100%	
Gender	Frequency	Percentage	Mucosal thickening
Male	27	67.5%	11.2 ± 6.7
Female	12	30.0%	7.8 ± 5.2
Total	40	100.0%	
Periapical lesion	Frequency	Percentage	Mucosal thickening
Maxillary 2 nd premolar	27	67.5%	11.2 ± 6.5
Maxillary 1 st molar	12	30.0%	11.9 ± 7.9
Maxillary 2 nd molar	1	2.5%	22.3
Total	40	100.0%	
Dental caries	Frequency	Percentage	Mucosal thickening

Maxillary 2 nd premolar	27	67.5%	13.3±4.6
Maxillary 1 st molar	12	30.0%	15.4±7.3
Maxillary 2 nd molar	1	2.5%	10.7±5.5
Total	40	100.0%	
Endodontic treatment	Frequency	Percentage	Mucosal thickening
Maxillary 2 nd premolar	27	67.5%	14.5±7.7
Maxillary 1 st molar	12	30.0%	11.7±4.1
Maxillary 2 nd molar	1	2.5%	13.1±6.5
Total	40	100.0%	
Periodontal disease	Frequency	Percentage	Mucosal thickening
Mild	27	67.5%	2.7±0.5
Moderate	12	30.0%	5.8±1.8
Severe	1	2.5%	15.3±4.3
Total	40	100.0%	

Variable	Correlation coefficient	P value
Periapical pathosis	0.079	0.6267
Dental caries	-0.321	0.0179
Endodontic treatment	-0.064	0.6780
Periodontal disease	0.899	<0.0001
Gender	-0.233	0.0041
Age	0.496	<0.0001

Discussion

In the literature, many break values for mucosal thickness were employed. While utilizing Waters' view and panoramic radiography, respectively, Savolainen et al and Vallo et al regarded mucosal thickening if greater than 6mm and mucosal thickening beginning from 3-6mm, respectively.^{9,10} Later studies performed on CBCT images used different values; Ren et al followed by Lathiyia et al considered mucosal thickening greater than or equal to 2mm to be pathologic while Goller et al, Janner et al, Yoo et al, Lu et al, Shanbhag et al, Bulut et al and Aksoy et al used more than 2mm as the starting point for their measurements.¹¹⁻¹⁹ In their investigation, Shahidi et al. took into account MT bigger than 1mm.⁸

Imaging usually cannot reveal the paranasal sinus mucosa, which is typically less than 1mm thick. However, imaging can show that the mucosa can increase in thickness by 10 to 20 times as a result of inflammation. Based on this conclusion, our investigation takes mucosal thickness of at least 1 mm into account.¹⁹⁻²³ The four categories of severity are as follows: According to Sheiki et al. 2014, the ranges should be (1-3 mm), (3-6 mm), (6-10 mm), and more than 10 mm.⁵

This study was designed to evaluate the relationship between thickening of the maxillary sinus mucosal lining and various dental problems. The inclusion and exclusion criteria listed in the methodology section were used to select the CBCT images. The age of the patients who participated in the study began at 20 years old since that is thought to be the approximate age at which the maxillary sinus finishes growing.²⁴⁻²⁶ Additionally, second premolar, first, and second molar teeth were chosen for assessment because of how closely they resembled the sinus floor.

The analysis of our investigation revealed that there was positive correlation between age and mucosal thickening of the maxillary sinus ($r=0.496$, $P<0.0001$)., similar results have been reported previously by Aksoy & Orhan, Goller-Bulut et al, Lathiyia et al, Shahidi et al Phothikhun et al, Lu et al and Shanbhag et al who found a significant association between age and sinus MT.^{8,11,12,14,17,18,21}

The prevalence of MT rises with age, which may be attributed to the accumulative effects of irritations and dental diseases as people age as well as the effect of pneumatization, which rises with age and causes infection to spread to the maxillary sinus through the porous maxillary bone, resulting in thickening of the mucosa.^{8,11,12,14,17,18,21}

Rege et al. and Nascimento et al. found no evidence of an influence of age on the occurrence of sinus anomalies which is in contrast to this study.^{6,27} The research of Tian et al., who discovered that the distances between maxillary premolars and molars and the nearby boundary of the sinus floor grew longer with age, may help to explain this. As a result, MT in senior persons may not be associated to dental issues.²⁸ The differences between the studies could be the result of different MT classifications, different age groups in the sample, and differences in the distance between an

individual's tooth root apex and sinus floor, which could result in different outcomes depending on where the dental issue is located.

According to the current study's findings, there was very weak correlation between presence of periapical lesion and dental caries with the mucosal thickening of the maxillary sinus ($r=0.079$, $P=0.6267$). These results were in agreement with those of Rege et al, Phothikhun et al and Janner et al who found that periapical lesions were not associated with mucosal thickening of the maxillary sinus.^{6,15,21} While, these results were in contrary with those of Aksoy et al, Sheiki et al, Goller-Bulut et al, Ezzat et al, Lu et al, Shanbang et al, Sakir & Ercalik and Bornstein et al found that mucosal thickening was more frequently observed in relation to teeth with periapical lesions and dental caries.^{5,11,12,18,20,29,30} This difference could be explained by variations in race or age, carious lesions, periapical lesion diameters, and periapical lesions' proximity to the sinus floor.

Regarding the effect of gender on mucosal membrane thickening, our study concluded that, there was weak negative correlation between gender and mucosal thickening of the maxillary sinus ($r=-0.233$, $P=0.0041$). Mean mucosal thickening of the maxillary sinus was 11.2 ± 6.7 mm for males and 7.8 ± 5.2 mm for females. This means that mucosal thickening of the maxillary sinus is higher in males than females. This supports the findings of other research that indicated that men were more likely than women to have MT.^{5,8,15-18,21,31-35,37} Their findings were related to the fact that males exhibit more pathologic dental findings than females, which irritates the sinus mucosa. According to Pazera et al., there was no difference in mucosal thickening between the sexes.³⁶ Different demographics, sample selection procedures, ethnic disparities among the analysed groups, and variations in the indications of the CBCT scans that were included in the study could all contribute to the discrepancy between our results and those of the other studies.

This study also revealed that there was very strong positive correlation between presence of periodontal disease and mucosal thickening of the maxillary sinus ($r=0.899$, $P<0.0001$). Mean mucosal thickening of the maxillary sinus was 2.7 ± 0.5 mm in mild periodontal disease, 5.8 ± 1.8 mm for moderate periodontal disease and 15.3 ± 4.3 mm for severe periodontal disease. This means, that as the severity of periodontal diseases increases, the thickening of the mucosa of the maxillary sinus increases and vice versa. This was in agreement with the results of Shahidi et al and Sheiki et al whose found a significant association between PBL and sinus MT.^{5,8} While these results were in contrary with Janner et al and Sakir & Ercalik who found a non-statistically significant association between periodontal bone loss and MT.^{15,29} The literature's conclusions for such a relationship are debatable, which may be due to differences in how MT and periodontal disease are defined and how severe they are.

According to the results of this study, there was very weak correlation between presence of endodontic treatment and mucosal thickening of the maxillary sinus ($r=-0.064$, $P=0.6780$). Mean mucosal thickening of the maxillary sinus was 14.5 ± 7.7 mm in maxillary 2nd premolar, 11.7 ± 4.1 mm for maxillary 1st molar was 13.1 ± 6.5 mm for maxillary 2nd molar. This was in agreement with

Phothikhun et al and Janner et al.^{15,21} In contrary to Shahidi et al who found significant association between mucosal membrane thickening and root canal treated teeth.⁸

After thorough analysis of the whole results of this study, we recommend future investigations that report on the patient's teeth status before extraction and the condition of the sinus mucosa after extraction because we lacked information regarding the patient's case history in our retrospective analysis, including any history of non-odontogenic sinusitis or history of missing teeth. Furthermore, there was no sinus examination or survey available for the patient's sinus condition. We also lacked clinical data on the periodontal and periapical states of the teeth.

Conclusion

The results of this study showed that the mucosal lining of the maxillary sinuses is affected by a number of dental diseases, and that the prevalence of mucosal thickening is directly correlated with age, the existence and severity of a periapical lesion, and is higher in males.

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