



Original Article

Assessment of relationship between maxillary sinus membrane thickening and the adjacent teeth health by cone-beam computed tomography



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KEYWORDS

Cone-beam computed tomography;
Sinus membrane thickening;
Periodontal disease;
Periapical lesions

Background/purpose: Maxillary posterior teeth have close anatomical proximity to the maxillary sinus floor. The aim of this retrospective study was to evaluate the associations between maxillary sinus membrane thickening and the adjacent teeth health by cone-beam computed tomography (CBCT).

Materials and methods: CBCT images were collected from 235 Taiwanese patients. The sinus mucosal thickening >2 mm is considered a pathologic sinus membrane. Demographic data such as sex, age, the thickness of sinus membrane, and the adjacent teeth health were recorded, graded, and analyzed.

Results: A total prevalence of maxillary sinus membrane thickening of 36.6% (86/235) was found in this study. The sinus membrane thickening was significantly associated with periodontal bone loss ($p < 0.001$) and periapical lesions ($p < 0.001$), respectively. A multivariate logistic regression model demonstrated that males had a significantly higher risk of sinus membrane thickening than females (OR: 2.08, 95% CI = 1.21–3.56). The patients in the age group ≥ 60 years showed a 4.35-fold increased risk of sinus membrane thickening compared with the patients in the age group ≤ 35 years (95% CI: 1.94–9.77). Severe periodontal bone loss was significantly associated with mucosal thickening with an OR of 4.78 as compared with normal to mild group (95% CI: 1.69–13.58). The patients having teeth with apical lesions had a 5.04 time OR for sinus membrane thickening than those having teeth without apical lesions (95% C.I.: 2.37–10.69).

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Conclusion: The prevalence of maxillary sinus membrane thickening was more frequently occurred in male and older people. Periodontal bone loss and periapical lesions were significantly associated with maxillary sinus membrane thickening.

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Introduction

The maxillary sinus is a pyramid-shaped cavity with its base facing the nasal wall and apex pointing to the zygoma. The inferior wall of sinus is lined with Schneiderian membrane. Odontogenic sinusitis is the most common result of iatrogenic injury of Schneiderian membrane which could result in thickening due to inflammatory reaction.^{1,2} Tooth extraction, posterior maxillary dental implant placement, sinus lift, and orthognathic surgery were the causal relations of odontogenic sinusitis.³ Other potential etiologies such as periodontal and periapical disease were also included.

The conditions of posterior maxillary teeth are usually examined by periapical radiographs and panoramic tomography during routine dental visits. However, plain films are 2-dimensional to represent the 3-dimensional structures which make it difficult to evaluate the actual situation between sinus floor and adjacent teeth.⁴ Recently, cone-beam computed tomography (CBCT) is widely utilized in oral-maxillofacial region especially for implant dentistry.^{5,6} CBCT has many advantages such as the lower radiation dose, easier image acquisition, and higher-definition tooth images as compared with routine panoramic tomography and computed tomography.⁷

It is important to evaluate the health conditions of posterior maxillary region before implant placement and routine dental check-up. However, little is known the relationship between the maxillary posterior teeth and sinus floor in Taiwanese population. In this study, CBCT scanning was used to evaluate the relationship between sinus membrane thickening and the adjacent teeth health. The correlations were analyzed by age, gender, periodontal bone level, and periapical lesion.

Materials and methods

CBCT images collections

This retrospective study was approved by the Chung Shan Medical University Hospital institutional review board (CS2-18151). CBCT images were collected from the Department of Dentistry, Chung Shan Medical University Hospital from 2014 to 2018. The reasons for CBCT scanning were mostly asking for dental implant treatment. The inclusion criteria were the patient who had at least one maxillary posterior tooth. CBCT images fulfilling the following criteria were excluded: (1) patient under 18 years old; (2) patient with history of maxillary sinus operation; and (3) patient loss all maxillary posterior teeth.

CBCT images evaluations

The CBCT scanner used in this study was the iCAT CBCT machine (iCAT, Hatfield, PA, USA). CBCT images were read by a dentist (YT Huang) who had no previous exposure to the patient and who did not treat the patients. Images were examined using the software supplied by the manufacturer of the CBCT scanner (iCAT Classic; Imaging Sciences International, Hatfield, PA, USA). For calibration and evaluation of intra-examiner repeatability, 20 CBCT images were measured twice on two different days ($\kappa = 0.89$).

Measurement of maxillary sinus membrane thickness

A comprehensive review has shown that 2 mm is the cut-off thickness to distinguish between normal mucosa and pathological status by CBCT scan image.⁸ Therefore, mucosal thickening greater than 2 mm was considered a pathologic sinus membrane identified from the cross-sectional view in this study (Fig. 1).

Definition of conditions of adjacent teeth

Periodontal bone loss was categorized into three levels: (1) normal to mild, alveolar bone loss $< 1/3$, (2) moderate, $1/3$ to $2/3$ alveolar bone loss, (3) severe, $> 2/3$ alveolar bone loss. The periapical status was graded as the presence of lesion and absence of lesion. The healthy conditions of teeth were assessed from the panoramic and cross-sectional views.

Statistical analysis

The chi-squared test was used for the categorical variables. A multivariate logistic regression model was performed for subgroup analysis. All results are presented as odds ratio (OR) and 95% confidence intervals (CIs). All analyses were performed by SAS software (Version 9.4; SAS Institute, Inc., Cary, NC, USA). The significant level was set $p < 0.05$.

Results

468 patients with CBCT scans were reviewed. According to the criteria described in the method section, 235 patients (107 males and 128 females) were captured and analyzed in this study. As shown in Table 1, sinus membrane thickening in either one or both of their sinuses were found in 86 patients (mean age: 51.74 ± 14.56 years). The average age of 149 normal sinus membrane subjects was 43.18 ± 16.13

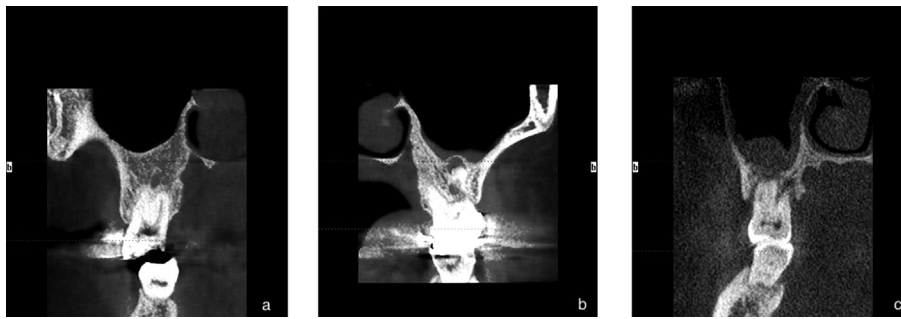


Figure 1 Cross-sectional views of the maxillary sinus. (a) normal membrane (b) membrane thickening (c) dome-shape membrane thickening.

Table 1 Demographic characteristics of individuals in this study.

	Membrane thickening (N = 86)		Normal thickness (N = 149)	
	n	%	n	%
Sex				
Female	37	28.91	91	71.09
Male	49	45.79	58	54.21
Age				
≤35 years	14	21.88	50	78.13
36–49 years	17	29.82	40	70.18
50–59 years	27	42.86	36	57.14
≥60 years	28	54.90	23	45.10
Mean ± SD	51.74 ± 14.56		43.18 ± 16.13	

years old. The prevalence of sinus membrane thickening in this study was 36.6%.

The presence of unhealthy teeth adjacent to the sinus was noted in [Table 2](#). The mucosal thickening was significantly associated with periodontal bone loss ($P < 0.001$) and periapical lesions ($P < 0.001$), respectively.

The results of multivariate regression on OR of sinus mucosal thickening were shown in [Table 3](#). The male group had sinus mucosal thickening than female group (OR = 2.08, 95% C.I.: 1.21–3.56). The patients in the age group ≥60 years showed a 4.35-fold increased risk of sinus

Table 2 Association between tooth conditions and sinus membrane thickening.

	Membrane thickening		P value
	Presence (N = 86)	Absence (N = 149)	
Periodontal bone loss			<0.0001*
Normal to mild	15 (17.4%)	69 (46.3%)	
Moderate	47 (54.7%)	68 (45.6%)	
Severe	24 (27.9%)	12 (8.1%)	
Periapical lesions			<0.0001*
Presence	75 (87.2%)	78 (52.3%)	
Absence	11 (12.8%)	71 (47.7%)	

*represents statistical significance ($p < 0.05$).

Table 3 OR and 95% CIs for the risk of sinus membrane thickening.

	Membrane thickening		
	OR	95% CI	P value
Sex			
Female	1		
Male	2.08	1.21–3.56	0.0079*
Age			
≤35 years	1		
36–49 years	1.52	0.67–3.45	0.3189
50–59 years	2.68	1.23–5.81	0.0127*
≥60 years	4.35	1.94–9.77	0.0004*
Periodontal bone loss			
Normal to mild	1		
Moderate	1.98	0.90–4.38	0.0910
Severe	4.78	1.69–13.58	0.0033*
Periapical lesions			
Absence	1		
Presence	5.04	2.37–10.69	<0.0001*

*represents statistical significance ($p < 0.05$).

membrane thickening compared with the patients in the age group ≤35 years (95% CI: 1.94–9.77). We showed that severe periodontal bone loss was significantly associated with mucosal thickening with an OR of 4.78 as compared with normal to mild group (95% CI: 1.69–13.58). Teeth with apical lesion had a 5.04 time OR for sinus mucosal thickening than without apical lesion (95% C.I.: 2.37–10.69).

Discussion

To the best of our knowledge, we first report that the prevalence of maxillary sinus membrane thickening in Taiwanese population is 36.6% by CBCT. Similar findings were shown in previous studies using three-dimensional CT ranged from 37% to 42.5%.^{9–12} However, the lower prevalence about 12% were reported in two-dimensional radiographic examinations.^{13,14} The diagnosis by two-dimensional radiographic techniques may underestimate the abnormalities of maxillary sinus. The biases will occur during the transformation from three-dimensional subjects into two-dimensional images.

The most important issue of the present article is the decision of sinus membrane thickening in which being determined as > 2 mm from a comprehensive review.⁸ From the literature review, most original articles accepted 2 mm to be the criteria of pathological sinus mucosal thickening.^{11,15–17} However, according to the most recent narrative reviewed article, it would be better to consider sinus membrane thickening as a range of 2–3 mm as pathological mucosal thickening.¹⁸ These differences raise the point that the definition of sinus membrane thickness still needs further assessments such as systematic review and meta-analysis to obtain the consensus.

Many studies have analyzed the factors affecting sinus membrane thickening such as age, sex, periodontal and endodontic statuses of the neighboring teeth, respectively. In this study, a higher prevalence rate of sinus membrane thickening was found in elder age groups (>50 years old). The results were in agreement with previous reports by either 2D or 3D radiographic examinations.^{15,19,20} Similar results were also demonstrated a higher prevalence among male subjects in this survey and previous publications.^{21,22} Taken together, these studies suggest that sinus membrane thickening was in an age and sex-specific manner.

In this study, we showed that sinus membrane thickening was significantly associated with periodontal bone loss and periapical lesions, respectively. In line with our results, many studies have also demonstrated that membrane thickening was related to periodontal and periapical health statuses.^{12,16,17,23–27} In interpreting such similar findings, differences in populations, sample sizes, and diagnostic thresholds for membrane thickening measurement should be taken into consideration. However, in this study, the risk of sinus membrane thickening was analyzed by sex, age, and the adjacent teeth health by the rigorous statistical analysis with a multivariate logistic regression model. This would be easier to catch up the OR for sinus membrane thickening.

The associations can be explained in part by the fact that the presence of periodontal or periapical lesions close to the maxillary sinus may allow the spread of odontogenic infection evoking sinus membrane thickening. The anaerobic periodontal pathogens *Prevotella* species, *Fusobacterium* species, and *Peptostreptococcus* species have been cultured from odontogenic sinus infections.^{28,29} Intra-radicular bacterial species such as streptococcus, *Staphylococcus aureus*, *Enterococcus faecalis* were also cultured from odontogenic sinusitis.^{28,30}

Some potential limitations should be noted in the current study. First, due to this is a retrospective CBCT revisit, sinus examination or history regarding the individual's sinus condition could not be obtained. Even there is evidence of sinus membrane thickening, the patients would be still without clinical symptoms. Second, the clinical examinations such as probing depth, gingival swelling, and the timing of periodontal or endodontic treatment intervened were not available in this image databank. Lastly, the prospective cohort study design is required to confer a higher level of evidence to suggest a causal relationship rather than the cross sectional design.

In conclusion, within the limitations of this study, the prevalence of maxillary sinus membrane thickening was high, with 36.6% of the patients presenting with CBCT

radiographic symptoms. The prevalence of maxillary sinus mucosal thickening increased with the age of the patient and predominant in male. The sinus membrane thickening was significantly associated with the adjacent teeth health. Preoperative assessment of the maxillary sinus is strongly suggested before performing implant placement and sinus augmentation by CBCT examination.

Declaration of Competing Interest

The authors declare that there is no conflict of interest.

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