

## Evaluation of prevalence and pattern of maxillary sinus mucosal thickening in cone beam computed tomography of dental implant candidates in Shiraz, Iran

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### Original Article

#### Abstract

**BACKGROUND AND AIM:** This study aimed to assess maxillary sinus floor membrane thickness and ostium patency (OP) in patients undergoing cone beam computed tomography (CBCT) evaluation for implant placement in the posterior maxilla. Mucosal thickening (MT) could be cause of post-operative complications in implant procedures; awareness of this incidence could help proper detection and further success of implantation.

**METHODS:** The CBCT scans of 620 implant candidates were examined and MT of  $\geq 2$  mm was considered pathological. The mucosal appearance, the OP as “patent” or “obstructed”, and unilateral or bilateral MT was assessed. Age, gender, smoking condition, and season were considered. Chi-square test was used to show the association between different variants in our study. A value of  $P < 0.05$  was considered significant.

**RESULTS:** An MT  $\geq 2$  mm was detected in 39.8% of patients; cases were mostly bilateral (56.3%) and detected during the winter (38.1%). There was a higher incidence among male patients (59.9%). Most participants who smoked had an MT  $\geq 2$  mm (70.8%). The irregular shape was the most prevalent appearance (43.5%). Ostium obstruction was observed in (55.7%) of sinuses with MT and was mostly seen as unilateral sinus involvement. The complete appearance had the highest risk of ostium obstruction (100%) and the round shape had the lowest (17.3%).

**CONCLUSION:** The present study revealed that maxillary sinus MT was highly prevalent during the winter and among smokers and men. Complete and unilateral type of MT is associated with an increased risk of ostium obstruction. Therefore, the precise study of a CBCT scan could influence dental implant planning or necessitate special consideration.

**KEYWORDS:** Cone-Beam Computed Tomography; Dental Implant; Maxillary Sinus; Mucous Membrane; Smoking

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The maxillary sinus is the largest and most important of the paranasal sinuses. It has a closed relationship with the upper posterior teeth and is considered to be a critical anatomical structure during surgical procedures in the maxillary posterior region.<sup>1</sup> A mucous membrane which is composed of respiratory epithelium lines the maxillary sinus with a normal thickness of approximately 1 mm.<sup>2</sup> The maxillary sinus ostium is located on the

highest part of the sinus medial wall. Mucous, which is produced by goblet cells in mucociliary escalator, is pushed toward the ostium and then to the nasal cavity. Some factors and diseases may interrupt this basic process by reducing activities of mucociliary cells or obstruction. Any disease within the lining of the sinus, the adjacent paranasal sinuses, nasal space, dental and oral tissues, or in the adjacent bone with expansion into the sinus could involve the maxillary sinuses

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as well.<sup>3</sup> The inflammatory disease is the most reported disease in maxillary sinuses.<sup>4</sup>

Approximately 10%–12% of cases of inflammatory maxillary sinus disease are of dental origin and most of them relate to pulpal necrosis, periapical disease, and oro-antral communications following dentoalveolar surgery.<sup>3,5</sup> Malignancy disease of paranasal sinuses is relatively rare (1.0%), with mostly arising in the maxillary sinus (80%).<sup>3</sup> According to Beaumont et al., who studied the prevalence of maxillary sinus diseases, the chronic sinusitis following sinus cysts was the most common diagnosis in their study.<sup>6</sup>

The normal membrane cannot be seen on routine radiographs. However, when the mucosa is inflamed from either infectious or allergic process, it may be imaged on radiographs as radiopaque areas and identified as different types of maxillary sinus inflammatory disease such as sinusitis or pseudocyst. The inflammation of the maxillary sinus mucosa could be a response to a wide variety of factors such as infectious or allergic processes.<sup>7,8</sup> Smoking could also cause mucosal inflammation.<sup>9</sup> Although mild mucosal thickening (MT) is often asymptomatic and is considered to be a normal radiographic finding, some studies have reported that the maxillary sinus with thickness of mucosa greater than  $> 2$  mm is probably a pathologic condition and could be used as the threshold for identification of MT.<sup>10,11</sup> Sinus infections or inflammatory conditions may increase the risk of dental procedures and cause post-operative complications.<sup>12</sup> MT may compromise the prognosis of maxillofacial surgeries such as implant insertion and ridge augmentation.<sup>13</sup>

Endosseous dental implants and augmentation of the maxillary sinus are well-documented in procedures that include elevation of the sinus floor and placing a bone graft in that area to increase the thickness of upper jaw bone.<sup>14</sup> Any abnormal alterations, such as pre-existing sinus diseases or allergic conditions that may lead to chronic reactive mucosal changes, could cause postoperative

complications in sinus augmentation and should cause concern.<sup>15</sup> Proper preoperative evaluation of implant candidates could help to minimize these problems.<sup>6</sup>

MT could be detectable with the use of panoramic images; however, it provides a two-dimensional (2D) representation of a three-D (3D) object and suffers from superimposition.<sup>16</sup> Cho et al. evaluated the value of panoramic radiography for assessment of maxillary sinus inflammation and suggested that panoramic radiography may not be adequate for clinical decision-making.<sup>17</sup> According to studies, computed tomography (CT) is the gold standard imaging method and the coronal cross-section is the preferred imaging plane to measure the amount of MT in the paranasal sinuses.<sup>18</sup>

Cone beam CT (CBCT) with its unique ability to provide 3D information with a relatively low radiation dose, has become an established diagnostic tool for dental implant surgery and visualization of the paranasal sinuses.<sup>19,20</sup> It is also an accurate method for dimensional measurements.<sup>21</sup>

The objectives of present study were to 1) evaluate the effects of age, gender, smoking, and seasonal variations on the thickness of maxillary sinus mucosal membrane, 2) study the correlation of the MT appearance and type of involvement with ostium obstruction, and 3) provide information to dental surgeons about the incidence and characteristics of maxillary sinus MT, and suggest to use preoperative CBCT images of patients to predict sinus outflow obstruction, especially for dental implant placement in the molar and premolar region of maxilla.

## Methods

This cross-sectional study included 620 CBCT images (1240 maxillary sinuses) of implant candidates (310 men, 310 women) with one or more missing maxillary posterior teeth. MT was studied in the coronal plane in which the maxillary ostium could be observed. The patients were referred by their dentists to a private oral and maxillofacial radiology clinic

in Shiraz, Iran, between March 2014 and March 2015 for CBCT examination prior to maxillary dental implant insertion. The Ethics Committee of Shiraz University of Medical Sciences reviewed and approved the study (Code NO# IR.SUMS.REC.1394.S311). All pre-implant CBCT images of all participants were taken with a Planmeca Promax 3D (Planmeca Oy, Helsinki, Finland) with a field of view (FOV) of 10 cm × 10 cm. The standard resolution mode in this machine was 0.3 mm with the following specifications: tube potential: 90 kV, tube current: 10-12 mA, scan time: 2.7-16 seconds, and reconstruction time: 13-26 seconds. The image analysis was performed with Planmeca Romexis dental imaging software in illumination of dim light.

Placema Romexis 3.2.0 3D software was used in a multiplanar reconstruction window in which the axial, coronal, and sagittal planes could be visualized. We studied the images in which the whole maxillary sinuses (medial and lateral walls plus the floor of sinuses) could be seen. Patients with maxillary sinus aplasia or hypoplasia, previous dental implant placement or bone grafting in the maxillary area, and a history of trauma or other manipulations of the maxillary sinus were excluded from the study. The criterion for hypoplasia was about 15 ml (range 9.5-20 ml) which was less than the average capacity of the maxillary sinus.<sup>22</sup> Height was classified according to metric thickening of < 2 mm as a normal condition of mucous membrane and greater than 2 mm as MT.<sup>10</sup> The measurement was taken separately at the thickest part of the mucous membrane in two sinuses. Thickening of the mucous membrane was evaluated at the floor and the medial and lateral walls of the maxillary sinus. An experienced oral and maxillofacial radiologist evaluated the coronal cross-sections of the right and left maxillary sinuses for measurement of the MT, its shape, and ostium patency (OP) which was categorized as "patent" or "obstructed".

In addition to demographic information including sex, age, and smoking status, the season in which the CBCT study was

performed and the type of maxillary sinus MT (unilateral or bilateral) were also recorded. The patients' age ranged from 24 to 63 years, with a mean age of  $46.75 \pm 9.29$ .

In this study, we included the participants as smokers who were current active tobacco smokers (direct use of tobacco). We considered a person as a tobacco smoker who smoked any tobacco products (cigar, cigarette, pipe, and smokeless types) at least once a day in the past one month. We excluded the people as smokers who were passive smokers (second-hand tobacco exposure) and former smokers. We defined "former smokers" as those who smoked in past but did not currently smoke. Since smoking status was determined by self-reporting, we had limitation for classifying smokers in details according to quantity and duration of smoking. Intra-observer reliability was assessed by re-evaluating 50 randomly selected cases with a minimum interval of 14 days using interclass Kappa test (correlation coefficient = 0.91).

The shape of the MT was classified into four categories of A-D as follows<sup>23</sup> (Figure 1):

A: round: massive round thickening resembling a mucosal pseudo-retention cyst.

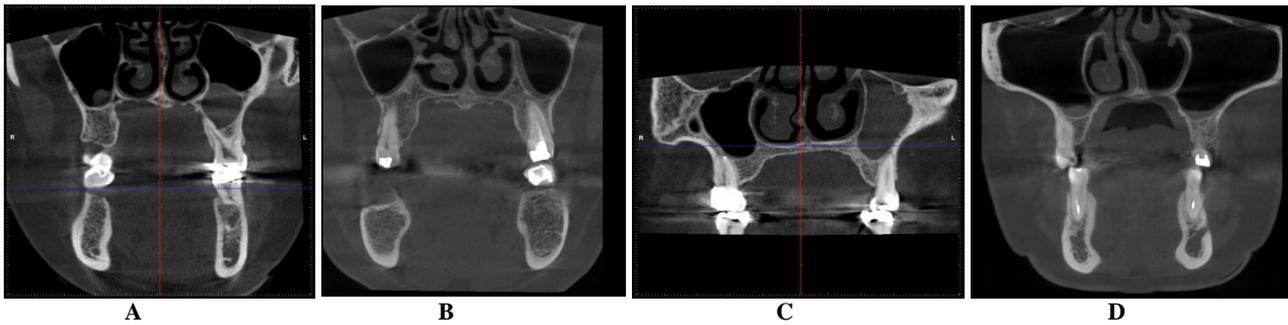
B: circumferential: uniform shallow MT following the sinus outline.

C: complete: opacification of whole sinus completely.

D: irregular: without any specific outline, and including one or more sinus walls.

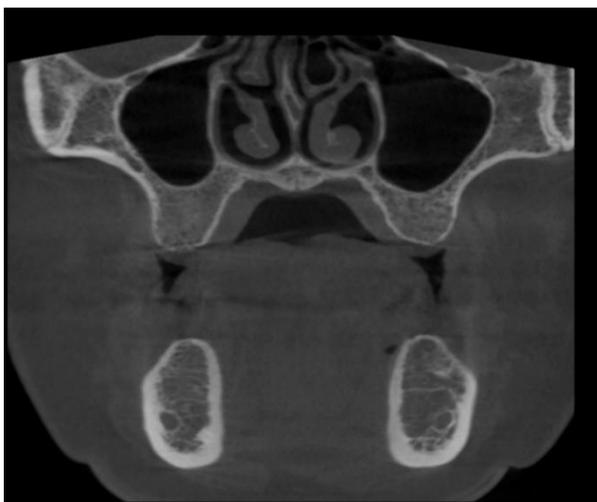
A normal maxillary sinus with MT < 2 mm with patent ostium was showed in figure 2.

Data were analyzed using SPSS software (version 17, SPSS Inc., Chicago, IL, USA). The results of the descriptive analysis were presented as frequency and percentage. A chi-square test was used to show the associations between the frequency of MT and gender, smoking, and the season in which CBCT was taken. The association between smoking and MT was determined using Pearson's  $\chi^2$  test. It was also used to evaluate the possible association between ostium obstruction and MT appearance, as well as the type of sinus involvement (unilateral or bilateral).



**Figure 1.** Sample of cone beam computed tomography (CBCT) images of 4 patients in this study showing classification of maxillary sinus mucosal thickening (MT) by appearance  
 A) Rounded shape: (MT > 2 mm) in right sinus which could resemble retention cyst; B) Circumferential shape: (MT > 2 mm) in left and right sinus with obstruction of right sinus ostium; C) Complete shape: (MT > 2mm) in left sinus with obstruction of ostium; D) Irregular shape: bilateral (MT > 2 mm) involvement of right and left sinus with obstruction of left sinus ostium

A Student's t-test was used to compare the mean age of cases with and without MT. A value of  $P < 0.050$  was considered significant.



**Figure 2.** Normal maxillary sinus with mucosal thickening (MT) < 2 mm with patent ostium  
 Taken by Planmeca Promax 3D, Helsinki, Finland,  
 Standard resolution mode: 0.3 mm, Tube potential: 90 (KV), Tube current: 10-12 (mA), Reconstruction time: 13-26 (s), Scan time: 2.7-16 (s), Field of view: 10 cm × 10 cm

## Results

In this study, we evaluated the CBCT

images of 620 patients (1240 maxillary sinuses; 310 women, 310 men) who met the study criteria. There was no significant difference between the mean age of the cases with and without MT. A total of 373 patients (60.2%) had a normal mucous membrane ( $\leq 2$  mm). An MT > 2 mm was found in at least one of the maxillary sinuses (left or right) in 247 cases (39.8%) and in 386 sinuses (31.1%).

Distribution of MT  $\geq 2$  mm according to gender, smoking, sinus involvement, and OP are shown in table 1. The study included 139 cases of bilateral and 108 cases of unilateral maxillary sinus MT. There was no significant difference in the distribution of MT between the right and left sinuses.

Table 2 shows the distribution of MT by sinus involvement and the association between MT involvement and ostium obstruction. Most of the obstructed sinuses were unilateral rather than bilateral. There was a significant relationship between ostium obstruction and sinus involvement. The most common appearance of MT was irregular, followed by complete, round, and circumferential, respectively.

**Table 1.** Distribution of mucosal thickening (MT)  $\geq 2$  mm according to gender, smoking, sinus involvement, and ostium patency (OP)

	MT $\geq 2$ mm	Gender		Smoker	Bilateral	Unilateral		OP	
		Men	Women			Right sinus	Left sinus	Patent	Obstructed
n	247	148	99	34	139	51	57	98	149
%	39.8	59.9	40.1	70.8	56.3	20.6	23.1	39.7	60.3
P	0.001	0.001		0.001		0.001		0.001	

MT: Mucosal thickening; OP: Ostium patency

**Table 2.** Association of mucosal thickening (MT) sinus involvement and ostium obstruction

Patients	Sinus involvement [n (%)]	Obstructed ostium [n (%)]
Unilateral	108 (43.7)	83 (55.7)
Bilateral	139 (56.3)	66 (44.3)
P = 0.021 X <sup>2</sup> = 5.3420		

All sinuses with a complete shape of MT showed ostium obstruction, and most sinuses with a circumferential shape had ostium obstruction. Table 3 reports the distribution of MT by appearance and the association between appearance and ostium obstruction which was significant.

**Table 3.** Distribution of mucosal thickening (MT) by appearance and association between MT appearance and ostium obstruction

Appearance of MT in sinuses	Mucosal appearance [n (%)]	Obstructed ostium [n (%)]
Round	75 (19.4)	13 (17.3)
Irregular	168 (43.5)	76 (42.2)
Circumferential	59 (15.3)	42 (71.2)
Complete	84 (21.8)	84 (100)
P = 0.001 X <sup>2</sup> = 55.9640		

MT: Mucosal thickening

There was a significant difference among the distributions of MT in different seasons ( $P < 0.050$ ). MT had the highest frequency in winter, followed by autumn, spring, and summer (Table 4).

**Table 4.** Prevalence of maxillary sinus mucosal thickening (MT) identified by cone beam computed tomography (CBCT) imaging in different seasons

Season	Patient with MT [n (%)]
Spring	44 (17.8)
Summer	41 (16.6)
Autumn	68 (27.5)
Winter	94 (38.1)
P = 0.003 X <sup>2</sup> = 41.0380	

MT: Mucosal thickening

## Discussion

Kahnberg et al. reported successful outcomes of sinus floor augmentation even with the

present of MT in the maxillary sinus before the surgery.<sup>24</sup> Maska et al. also concluded that the physiologic MT could not cause failure in implant placement or grafting.<sup>11</sup> However, according to Timmenga et al., only a pre-disposition for sinusitis could result in post-operative chronic sinusitis.<sup>25</sup>

Vallo et al. reported that most patients with maxillary sinusitis had MT > 2 mm, and 12% of 5021 individuals in their study had MT.<sup>16</sup> In the present study, maxillary sinus MT was observed in 39.8% of cases, which was very close to the findings of Carmeli et al.<sup>23</sup> and Ritter et al.<sup>26</sup>

We also found that the frequency of MT was higher in men (59.9%) than women (40.1%), which concurred with other studies.<sup>26,27</sup> Janner et al. studied CBCT of patients who needed implant treatment to evaluate the characteristics of the Schneiderian membrane of maxillary sinus. They concluded that gender was the most important parameter influencing mucosal thickness in asymptomatic patients.<sup>19</sup> Since the dental pathologies which could cause irritation of the sinus mucosa are more prevalent among men, we can explain the reason of higher prevalence of MT among this gender.<sup>16</sup>

Several studies have investigated the effects of smoking on the health of the upper airways and paranasal sinuses.<sup>28</sup> Lieu and Feinstein analyzed the association of smoking with the prevalence of any sinusitis, including both acute and recurrent or chronic sinusitis. They reported a higher prevalence of any sinusitis in current cigarette smokers compared to former smokers or patients who had never smoked.<sup>29</sup> The prevalence of MT in the present study was also significantly higher among participants who smoked than among nonsmokers, which concurs with the findings of Lieu and Feinstein.<sup>29</sup>

Our analysis revealed that most of the maxillary sinus MT occurred bilaterally (56.30%). Unilateral involvement had approximately the same frequency in both the right (20.65%) and left sides (23.08%). In

contrast to our results, a study by Ritter et al. reported a higher rate of unilateral thickening.<sup>26</sup> Differences in the study population, variations in sample size, and the definition of MT could be possible causes for the variations in results.

Irregular MT was the most frequent form observed in this study (43.5%), followed by complete (21.8%), round (19.4%), and circumferential (15.3%) MT. Carmeli et al. used the same categories for classification of MT in the maxillary sinus. They reported that the round shape was the most frequent type of MT, followed by irregular, circumferential, and complete.<sup>23</sup>

In our study, we concluded that among 386 maxillary sinuses with MT, 215 had ostium obstruction (55.7%). These ostium obstruction cases were mostly unilateral.

Similar to the study of Carmeli et al.,<sup>23</sup> we also found a significant relationship between the different appearance of MT and the prevalence of sinus obstruction. Carmeli et al. found a higher risk of sinus obstruction (100%) in the circumferential and complete forms of MT. In contrast, the round appearance had the lowest risk for obstruction (6.1%).<sup>23</sup> In our study, we concluded the same final results, as all MT with a complete shape has shown ostium obstruction (100%), followed by circumferential (71.2%), irregular (42.2%), and round (17.3%). The association between the shape of MT and ostium obstruction was significant; there was a higher risk of obstruction if the shape was round or circumferential.

Janner et al.<sup>19</sup> classified the appearance of MT according to criteria adapted from Soikkonen and Ainamo<sup>30</sup>; where the most frequent MT appearance diagnosed according to their definition was flat (circumferential).<sup>19</sup>

The present study revealed a significant relationship between the prevalence of MT and the season. Most cases were observed during the coldest season (winter) (38.1%), followed by autumn (27.5%), spring (17.8%), and summer (16.6%). Some studies suggested that the prevalence of sinus cysts may vary

according to the mean temperature, the relative air humidity, and seasons of the year, with winter likely to play a role due to the low temperature, and summer due to the use of air conditioners.<sup>31,32</sup>

Carter et al. found significant differences in the prevalence of MT in the shape of pseudo cysts in winter compared with summer (44.3% vs. 8.6%, respectively). They stated that this marked increase in MT during cold months supported the concept that seasonal variation may be related to an increased incidence of inflammatory conditions of the maxillary sinus, or irritation from dry, forced air heating during this period.<sup>33</sup> In contrast, patients in Riyadh, Saudi Arabia, a place with mild winter seasons, did not show this seasonal variation.<sup>34</sup>

## Conclusion

Based on the present study, MT of the maxillary sinus with unilateral ostium obstruction is a relatively common finding in CBCT examinations of implant candidates, especially during cold seasons. The MT is more likely to occur among men, in an irregular shape, with bilateral involvement of the maxillary sinus. Membrane thickening  $\geq 2$  mm, especially of a complete and unilateral type, is associated with an increased risk of ostium obstruction. Smoking was strongly associated with the maxillary sinus MT. Considering the possible effect of MT on the post-operative complications of implant surgery, ridge augmentation, and sinus lifting in cold seasons, it is wise to be more careful in performing such procedures during these seasons. Assessing CBCT images, especially in an area with seasonal variations, could help predict pre-implant diseases and prevent post-operative complications.

Further studies are necessary to determine how osteointegration could be affected by the presence of MT, and to study the prevalence of MT before and after ridge augmentation. In addition, the severity of MT on post-operative complications could be evaluated clinically.

### Conflict of Interests

Authors have no conflict of interest.

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