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Research Article

The Prevalence of MSMT and its Association with Periapical Lesion and Periodontal Bone Loss using Cone-Beam Computed Tomography

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Abstract

Objective: This study aimed to examine the prevalence of Maxillary Sinus Mucosal Thickening (MSMT) and its association with the dental status of the adjacent teeth, including periapical lesions and PBL, using Cone Beam Computed Tomography (CBCT).

Materials and Methods: This retrospective study analyzed 322 maxillary sinuses. MSMT was considered pathological if it exceeded 2 mm and was classified as localized or generalized based on the extent of the affected area. The periapical and periodontal status of 1092 posterior teeth were investigated. CBCTPAI was used to investigate the periapical lesion size; the distance from the upper edge of the lesion to the sinus floor was also studied. PBL was evaluated by pattern (horizontal or vertical) and severity.

Results: The prevalence of MSMT in all samples was 34.8% (95% CI: 29.5-40.0%). Of these, 73.2% were localized and 26.8% were generalized. There was a significant correlation between periapical lesions and MSMT ($P<0.001$), as well as between PAL size and MSMT ($P<0.001$). The distance between the upper edge of the PAL and the sinus floor was inversely related to MSMT ($P<0.001$). No significant difference was found between the type of MSMT (generalized or localized) and periapical lesions or PBL ($P>0.05$). Likewise, there was no significant association between MSMT and the presence, pattern, or severity of PBL ($P>0.05$).

Conclusions: This study used CBCT imaging for its high accuracy and sensitivity compared to two-dimensional radiographs. The results showed that MSMT was not related to age or gender. The presence and size of periapical lesions increased the likelihood of MSMT, while the distance of the lesions from the sinus floor decreased it. The type of MSMT did not depend on the dental condition. The presence, pattern, and severity of PBL did not affect MSMT.

Keywords: Maxillary sinus, Cone-beam computed tomography, Periapical Periodontitis, Alveolar bone loss.

Introduction

The maxillary sinus is the largest paranasal sinus, located bilaterally around the nasal cavity and below the orbit [1]. The maxillary sinus floor typically extends from the first premolar to the maxillary tuberosity [2,3].

One of the most common pathological findings of the maxillary sinus is MSMT (MSMT) [4]. Mucosal thickness greater than 1-3 mm is considered pathological [5], and its prevalence has been reported as 35.1%- 66% in various studies [6-11]. In radiographic images, MSMT can be seen as localized or generalized.

MSMT can be caused by odontogenic infections [12,13], which have increased in prevalence in recent decades [14].

The maxillary sinus can be affected by odontogenic infections due to its anatomical relationship with upper jaw teeth [15]. Odontogenic sinus diseases can range from inflammation and localized MSMT to generalized MSMT and maxillary sinusitis [16-18]. Periapical and periodontal infections are among the odontogenic causes of MSMT [16].

To diagnose sinus diseases radiographically, CT[1], CBCT, and MRI[2] can be used [18]. CBCT has lower radiation dose and cost than conventional CT and provides three-dimensional images of craniofacial structures for dental purposes [19,20]. CBCT can detect changes in the maxillary sinus [21] as well as their possible causes, such as the condition of the adjacent teeth [22].

Materials and Methods

CBCT images collection

This study was approved by the IRB of Kashan University of Medical Sciences (IR.KAUMS.MEDNT.REC.1401.077) on July 26, 2022. This retrospective descriptive-analytical study examined CBCT images of patients referred to an oral, maxillofacial radiology center[1] in Kashan City between 2019 and 2021. Most of the CBCTs were taken for radiological evaluation before implant procedures. The inclusion criteria were CBCTs of visitors to a radiology center in Kashan City from August 2019 to October 2021 who were over 18 years old and had at least one posterior maxillary tooth. The exclusion criteria were CBCT images with radiographic signs of tumor or other maxillary sinus disorders (such as polyps, pseudo-cysts, and enteroliths) [11], presence of implants (due to the possibility of sinus changes during surgical procedures), history of ortho-surgery or orthodontic appliances, poor quality or insufficient FOV CBCT images and CBCT images with signs of allergic or acute sinusitis.

CBCT images evaluation

All CBCT images were taken using the Planmeca 3D (Helsinki, Finland) High-resolution device (mA: 6, kVp: 89, FOV: 8x10 cm2) by an experienced radiologist according to the manufacturer's recommendations. Then, the images were processed by Romex is 3D Dental software.

Maxillary sinus evaluation

By examining the CBCT images from sagittal and coronal views, MSMT was considered pathological if it exceeded 2 mm [23,24] and affected up to two adjacent teeth (localized) or if it exceeded 2 mm and involved the entire sinus floor (generalized) [25]. Also, the maximum thickness of the radiopaque areas to the sinus floor was measured as the maxillary sinus mucosal thickness (Figure 1) [25].

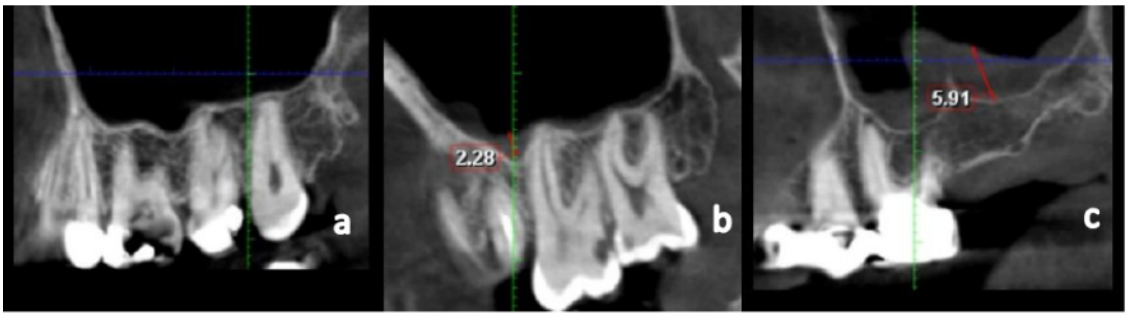

Figure 1. Sagittal views of the maxillary sinus. a. Normal mucosa, b. Localized mucosal thickening generalized mucosal thickening.

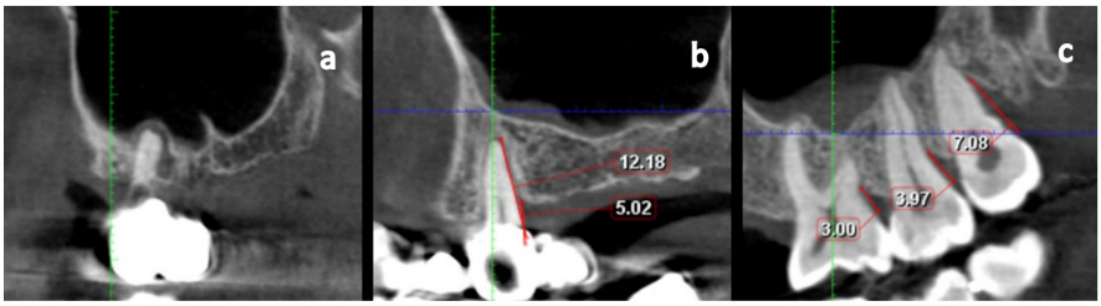

Figure 2. Sagittal views of the maxillary sinus and posterior upper teeth, a. Peri-apical lesion, b. Horizontal bone loss, c. Vertical bone loss.

Dental condition evaluation

Peri-apical lesions[4]

Radiolucency associated with at least one root of a tooth and a diameter of at least 0.5 mm or more than twice the diameter of a healthy periodontal ligament [26] was considered a peri-apical lesion.
An index called CBCTPAI was used to evaluate a tooth's periapical tissue condition better. This index divides the PAL according to its diameter as follows [27]:

1. The periapical bone structure is intact.
2. The diameter of the PAL is 0.5 to 1 mm.
3. The diameter of the PAL is 1 to 2 mm.
4. The diameter of the PAL is 2 to 4 mm.
5. The diameter of the PAL is 4 to 8 mm.
6. The diameter of the PAL is more than 8 mm (Figure 2).

Also, the distance from the upper edge of the PAL to the floor of the sinus was measured as follows:

1. The distance between the upper edge of the PAL and the maxillary sinus floor is 0 mm or less.
2. The distance from the upper edge of the PAL to the floor of the maxillary sinus is 0 to 2 mm.
3. The distance from the upper edge of the PAL to the floor of the maxillary sinus is more than 2 mm.

Periodontal bone loss[5]

The pattern of PBL was evaluated as follows:

1. Horizontal: This is the most common pattern of bone loss in periodontal diseases, in which the edge of the resorbed bone forms a nearly perpendicular angle with the tooth surface [28].
2. Vertical: In this pattern, the edge of the bone forms an acute angle with the tooth surface [28].

Vertical bone loss is classified according to the number of bony walls surrounding the defect. Angular defects may have one, two, or three walls.
The severity of horizontal PBL was assessed based on Phothikhun's criteria [30] as follows:
(Bone height with a maximum distance of 2 mm below the cementoenamel junction is considered normal; if this distance increases, alveolar bone loss has occurred.)

1. Less than 25% bone loss: mild
2. 25-50% bone loss: Moderate
3. More than 50% bone loss: Severe

Finally, the relationship between the MSMT types and the adjacent teeth' condition was investigated.

Statistical analysis

The results of this study were analyzed using descriptive statistics (percentage frequency). The chi-square and Fisher's tests were used to evaluate the relationship between MSMT types and dental conditions. The significance level was considered at $P>0.05$, and statistical analysis was performed using SPSS statistical software.

Results

In this study, among 322 samples, most of them were from female patients (78.3%). The average age of the samples was 42.2 ± 12.8 years, and the prevalence rate of MSMT in all the samples was 34.8% (29.5-40.0%: 95% CI) (Table 1). We also found that the prevalence rate of different types of MSMT, i.e., localized and generalized thickening, among the samples with MSMT was 73.2% and 26.8%, respectively (Table 2). There was no significant relationship between the prevalence of MSMT and age (Table 3, Figure 3).

Variable	n	%	95% CI
Increased Mucosal thickness	112	34.8	29.4-75.2
Normal mucosal thickness	210	65.2	59.7-82.2
Total	322	100	-

Table 1. Prevalence of MSMT.

Variable	n	%	95% CI
localized Mucosal thickening	82	73.2	64.8-12.7
generalized Mucosal thickening	30	26.8	19.3-30.9
Total	112	100	-

Table 2. Prevalence of types of MSMT (generalized & localized).

Sex	n	Mucosal thickening		p-value
		Absence N (%)	Presence N (%)	
Male	70	47 (67.1%)	23 (32.8%)	P>0.05
Female	252	163 (64.7%)	89 (35.3%)	
Total	322	210 (65.2%)	112 (34.8%)	

Table 3. Prevalence rate of maxillary sinus mucus thickness increases according to gender.

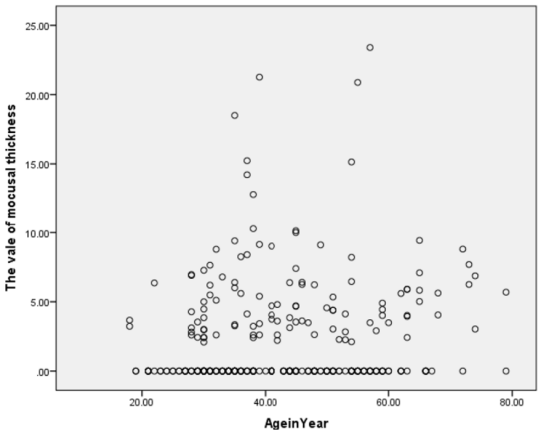

Figure 3. Distribution of MSMT.

Among the 322 samples, 125 (38.8%) had at least one tooth with a periapical lesion. We studied the relationship between the PAL and MSMT and found a significant relationship between them (P<0.001) (Table 4). Then, we examined the relationship between the PAL and the type of MSMT (generalized or localized) and found no significant relationship (P>0.05) (Table 5). We also examined the diameter of the PAL using the CBCTPAI [29], and there was a statistically significant relationship between them (P<0.001) (Table 6). Moreover, we measured the distance between the upper edge of the PAL and the floor of the maxillary sinus, and there was a statistically significant relationship between them (P<0.001) (Table 7).

Periapical lesion	n	Mucosal thickening		p-value
		Absence N (%)	Presence N (%)	
Absence	197	146 (74.1%)	51 (25.9%)	P<0.000
Presence	125	64 (51.2%)	61 (48.8%)	
Total	322	210 (65.2%)	112 (34.8%)	

Table 4. Relationship between peri-apical lesion and MSMT.

Periapical lesion	Type of Mucosal thickening		p-value
	localized N (%)	generalized N (%)	
Absence	36 (70.6%)	15 (29.4%)	0.566
Presence	46 (75.4%)	15 (24.6%)	
Total	82 (73.2 %)	30 (26.8%)	

Table 5. Relationship between peri-apical lesion and types of MSMT.

Diameter of peri-apical lesion according to CBCTPAI[a] index	n	Mucosal thickening		p-value
		Absence N (%)	Presence N (%)	
0	197	146 (74.1%)	51 (25.9%)	P<0.000
1	12	7 (58.3%)	5 (41.7%)	
2	42	28 (66.7%)	14 (33.3%)	
3	45	21 (46.7%)	24 (53.3%)	
4	25	8 (32%)	17 (68%)	
5	1	0 (0%)	1 (100%)	
Total	322	210 (65.2%)	112 (34.8%)	

Table 6. The relationship between the peri-apical lesion diameters according to CBCTPAI. Index and the MSMT.

a:
0. There is no peri-apical lesion.
1. The diameter of the peri-apical lesion is 0.5 to 1 mm.
2. The diameter of the peri-apical lesion is 1 to 2 mm.
3. The diameter of the peri-apical lesion is 2 to 4 mm.
4. The diameter of the peri-apical lesion is 4 to 8 mm.
5. The diameter of the peri-apical lesion is more than 8 mm.

Distance between the upper edge of the peri-apical lesion and maxillary sinus floor (millimeters)	n	Mucosal thickening		p-value
		Absence N (%)	Presence N (%)	
≥0	21	8 (38.1%)	13 (61.9%)	P<0.000
0< <2	57	25 (43.9%)	32 (56.1%)	
≤2	47	31 (66%)	16 (34%)	
Total	125	210 (65.2%)	112 (34.8%)	

Table 7. The relationship between the distance of the upper edge of the peri-apical lesion in millimeters and the MSMT.

Among the 322 samples, 138 (42.8%) had at least one tooth with PBL. The prevalence of samples with PBL according to the pattern of bone loss, i.e., horizontal or vertical, was 79.7% and 20.3%, respectively. In this study, we not only examined the samples for the presence of MSMT and PBL but also for the type of MSMT (localized or generalized), the pattern of PBL (horizontal or vertical bone loss), and the severity of horizontal PBL (mild, moderate or severe). We found no statistically significant relationship between them (P>0.05) (Table 8-11).

PBL	n	Mucosal thickening		p-value
		Absence N (%)	Presence N (%)	
Absence	184	127 (69%)	57 (31%)	0.098
Presence	138	83 (60.1%)	55 (39.9%)	
Total	322	210 (65.2%)	112 (34.8%)	

Table 8. Relationship between PBL and the MSMT.

PBL	Type of Mucosal thickening		p-value
	localized N (%)	generalized N (%)	
Absence	45 (78.9%)	12 (21.1%)	0.163
Presence	37 (67.3%)	18 (32.7%)	
Total	82 (73.2 %)	30 (26.8%)	

Table 9. Relationship between PBL and type of the MSMT.

PBL	n	Mucosal thickening		p-value
		Absence N (%)	Presence N (%)	
horizontal	110	70 (63.6%)	40 (36.4%)	0.097
vertical	28	13 (46.4%)	15 (53.6%)	
Total	138	83 (60.1%)	55 (39.9%)	

Table 10. Relationship between type of PBL and the MSMT.

Horizontal PBL	n	Mucosal thickening		p-value
		Absence N (%)	Presence N (%)	
mild	98	61 (62.2%)	37 (37.8%)	0.566
moderate/severe	12	9 (75%)	3 (25%)	
Total	110	70 (63.6%)	40 (36.4%)	

Table 11. Relationship between severity of horizontal PBL and MSMT.

Discussion

CBCT imaging allows for three-dimensional analysis of jaw and facial structures with high-resolution images. This technique is more sensitive and accurate than two-dimensional radiographs. It can simultaneously and precisely evaluate maxillary sinuses [13,14], teeth, and adjacent tissues in coronal, sagittal, and axial dimensions. Therefore, this study used CBCT imaging because of its wide application and high accuracy and sensitivity compared to two-dimensional radiographs. However, CBCT imaging may overestimate the thickness of the Schneiderian membrane compared to histological measurements [29]. In this study, we chose a 2 mm thickness of maxillary sinus mucosa as the pathological limit, even though previous studies suggested a 1-3 mm range.

This study examined 195 patients, 322 maxillary sinuses, and 1092 posterior permanent teeth (from the first premolar to the third molar).

The association between the peri-apical lesion and MSMT

We found a significant relationship between having a PAL and having MSMT ($P<0.001$). Hong et al.'s study [30] and Nascimento et al.'s study [25] also found a significant relationship between these two factors. However, Phothikhun et al.'s study [31] found no significant relationship between them. This could be because Phothikhun et al.'s study had a lower prevalence of PAL (7.8 percent) and a lower diagnostic criterion of MSMT (1 mm) than this study (2 mm).

We also investigated the relationship between the PAL and the type of MSMT (generalized or localized), and we did not find a significant relationship between them (P>0.05). Nascimento et al.'s study [25] concluded that the PAL could cause a "localized" MSMT. Other studies did not differentiate between the types of MSMT.

We used the CBCTPAI index [27] to examine the diameter of the PAL in this study, and we observed that the prevalence of MSMT increased almost continuously with the increase in lesion diameter. We also found that the prevalence of MSMT increased significantly with the decrease in this distance in millimeters. Therefore, we expect that the prevalence of MSMT is related to the increase in lesion diameter and the reduction in the length from its upper edge to the sinus floor. The results of our study were consistent with the investigations of Nance et al. [8] and Nascimento et al. [25].

The association between PBL and MSMT

In this study, no significant relationship was found between PBL and MSMT. However, Sheikhi et al. [32] and Shahidi et al. [33] reported that PBL is significantly related to increased maxillary sinus mucosa thickness. Nascimento et al. [25] reported that mild and moderate/severe bone loss increased the prevalence of "generalized" mucosal thickening. Phothikhun et al. [31] observed a significant link between the severe type of PBL and the increase in MSMT.

The presence of bone loss due to the decrease in the height of the bone barrier to the maxillary sinus floor can facilitate the penetration of odontogenic infection into the maxillary sinus space [8, 34-36].

Conclusion

However, bone loss cannot increase mucosa thickness without active infection (bacteria and virulence factors). Therefore, since PBL does not always involve active odontogenic infection, it is reasonable not to find a significant relationship between PBL (including its pattern and severity) and MSMT.

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