BJHBS

Association between endodontic conditions and the relationship of upper posterior teeth and the thickening of the maxillary sinus mucosa. A study using cone beam computerized tomography

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Abstract

Introduction: Sinus mucosal thickness and maxillary sinusitis can be caused by several predisposing factors. Some studies indicate that sinusitis can be of odontogenic origin and that this condition is responsible for 10 to 12% of maxillary sinusitis. Objective: To assess the odontogenic conditions of the maxillary posterior teeth and their proximity to the maxillary sinus (SM) and correlate these factors with the mucosal thickness of the SM, using cone beam computed tomography images. Methodology and resources: CBCT images of 393 patients aged between 18 and 75 years were analyzed, noting aspects such as the presence of root canal fillings, periapical lesions, and the contact of the roots of the maxillary posterior teeth with the floor of the SM. Results and discussion: All results are presented as odds ratios (OR) and 95% confidence intervals (CIs). Statistically significant differences ($p<0.001$) were found among the variables studied, and the probability of thickness of the MS mucosa is greater in men (1.73%), 7.27% when periapical lesions are present and 2.03% in the presence of endodontic treatment. Conclusion: We conclude that periapical lesions, root canal filling and proximity of the dental roots to the floor of the maxillary sinus interfere with the appearance of sinus mucosal thickness.

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BJHBS, Rio de Janeiro, 2024;23(2):38-48
DOI: 10.12957/bjhbs.2024.85386
Received on 04/02/2024. Approved on 20/09/2024.

Keywords: Maxillary sinus, Cone beam computed tomography, Anatomy, Radiography, Imaging.

Introduction

The paranasal sinuses are cavities inside some skull and facial bones caused by pneumatic *diverticula*. These sinuses have several functions, including reducing the weight of the skull, protecting infraorbital and intracranial structures, absorbing impacts and contributing to facial growth. The maxillary sinus (MS) is the largest of the paranasal sinuses and is the pneumatic space contained within the maxilla, a pair of bones that constitute the middle third of the face.[1]

Thickness of the sinus mucosa, greater than 2mm, and maxillary sinusitis are globally prevalent pathologies.[2,3] Inflammation of the Schneiderian membrane can be caused by several predisposing factors, including upper respiratory tract infections, immunodeficiency, asthma and inhalation of foreign bodies.[4] However, some studies indicate that sinusitis can be of odontogenic origin and that this condition corresponds to 10 to 12% of maxillary sinusitis, being more common in adults than in children.[2,3]

The anatomical proximity of the floor of the MSs to the apices of the teeth leads one to assume that dental and sinus pathologies may be closely related (AKSOY, 2016). According to some studies, periapical changes, dental implants, periodontal diseases and endodontic treatments point to such a relationship.[5,6]

Since treatments differ in accordance with the cause of maxillary sinusitis, an accurate diagnosis needs to be made. If the underlying odontogenic conditions are not diagnosed correctly, the treatment will not be successful. However, even today, some scholars disagree with this position and believe that sinus mucosal thickening is totally unrelated to dental pathologies and, therefore, further studies must be conducted.[7]

In search of evidence to prove this association between periapical lesions, intimate contact relationships of dental roots, and endodontic treatments with mucosal thickening and MS opacification, this study using Cone Beam Computed Tomography (CBCT) was conducted to better assess dental and sinus conditions and to evaluate the existence of this relationship in a Brazilian population.

The study's null hypothesis is that periapical lesions, endodontic treatment, and proximity to the root of teeth with MS do not influence its thickening.

Methodology

This is an observational, longitudinal, and retrospective study, which was approved by the Permanent Committee on Ethics in Research Involving Human Beings of the State University of Maringá (CAAE - 03629118.4.00000104). Since it is an observational study, the informed consent form was waived for patients. A total of 750 CBCT scans were evaluated, and referred to the Image Laboratory for Clinical Research (LIPC) of the Health Technology Center (CTS), of the Research Support Center Complex (COMCAP), located in the Department of Dentistry of the Universidade Estadual of Maringá (DOD-UEM), from 2014 to 2019. The study included CBCT scans performed for different purposes, which contained the regions of interest and images of: patients younger than 18 years old; patients with a history of trauma or surgery in the region to be investigated; syndromic patients; patients with some bone pathology (especially osteoporosis); patients whose images showed scattering and insufficient visualization of bone edges; edentulous patients; and patients in whom a mucous retention cyst was present.

All images were obtained by use of i-CAT Next Generation® equipment (Imaging Sciences International, Hatfield, PA, USA), with a volume of 300µ of isometric voxel, FOV (Field of View) of 17 × 23cm, tube tension of 120kVp and tube current 3-8mA. All examinations were performed by the same radiologist as prescribed by the clinician responsible for each patient. The images were analyzed with the tomographer's own program (Xoran version 3.1.62; Xoran Technologies, Ann Arbor, MI, USA) by two previously calibrated examiners, who evaluated the images at two different times, with a minimum time interval of one week between assessments. To avoid eyestrain, only 10 images/day were observed.

Twenty tomographic images were evaluated for calibration purposes. All images used for calibration came from the LIPC database and were subsequently discarded. The calibration lasted 2 weeks, and intra-examiner agreement was evaluated, using Cohen's Kappa test for categorical and discrete variables and Lin's Concordance Correlation Coefficient (CCC) for continuous variables to ensure the reproducibility of the study. A significance level of 5% was adopted.

For image analysis, the work by Aksoy et al. 2019 was used as a reference, where mucosal thickness in the MS at CBCT was measured (at the point of maximum thickness of the MS floor), recorded and classified as: Grade 1 - 0 to ⩽2mm (normal mucosal thickening), Grade 2 - <2 to ⩽10mm (moderate mucosal thickening), and Grade 3 - <10mm (severe mucosal thickening)8.

The presence of the first and second premolars, as well as the first, second and third molars in the upper right and left regions, was registered in the data table. The presence of root canal fillings and periapical lesions of these teeth was also recorded when these had a thickness greater than or equal to 0.5mm. The anatomical relationship between MSs and teeth was determined for each tooth individually and classified as: Type 1: A gap exists between the roots and the MS floor; Type 2: At least one tooth root is in contact with the MS floor; and Type 3: At least one tooth root has entered the floor of the MS. These measurements and classifications were made in the sagittal and coronal reconstructions and entered into a spreadsheet for statistical analysis.

A database containing qualitative and quantitative variables was organized to allow tabulation and statistical analysis. All statistical procedures were performed with the R software version 3.6.0. (R., Auckland, NZL). Descriptive analysis was performed to extract initial information from the data. The chi-square test was used for categorical variables. A multinomial logistic regression model was performed for subgroup analysis. All results are presented as odds ratios (OR) and 95% confidence intervals (CIs) obtained by multinomial regression, while controlling for the risk of thickening in relation to age, sex, periapical lesions, endodontic treatment, and the relationship with the roots and the MS. The Intraclass Correlation Coefficient (ICC) was used to evaluate inter-observer and intra-observer agreement. The chi-square test was applied to compare the distribution of MS mucosal thickness according to the number of cases and their form (unilateral or bilateral), the type of relationship between the tooth roots and MS thickness, and the association between periapical lesions, endodontic treatment, and thickening of the MS mucosa.

The established significance level was p-value ⩽0.05.

Figure 1. Parasagittal reconstruction exemplifying measurements of mucosal thickness in the sinus mucosa. A: Grade 1 - 0 to ⩽2mm (normal mucosal thickening), B: Grade 2 - <2 to ⩽10mm (moderate mucosal thickening) and C: Grade 3 - <10mm (severe mucosal thickening)

Figure 2. Parasagittal reconstruction exemplifying the close relationships between the roots of posterior teeth and the floor of the sinus mucosa. A: Type 1: A space between the roots and the sinus floor, B: Type 2: At least one tooth root is in contact with the sinus floor, and C: Type 3: At least one tooth root has entered the sinus floor from the breast

Results

The sample consisted of 393 individuals, 246 of whom were female (62.59%) and 147 male (37.40%). The mean age was 33.64 years (±12.21), with a maximum of 80 years and a minimum of 18 years. Use of the Intraclass Correlation Coefficient (ICC) led to the conclusion that the null hypothesis — that inter-examiner agreement is purely random — was rejected for all variables under study (p-value <0.001). In other words, inter-examiner and intra-examiner agreements were verified, with coefficients ranging from 0.89 to 0.98 (Landis & Koch, 1977), thus indicating excellent reliability and reproducibility.

Table 1. Demographic characteristics of study subjects.

Analyzed groups	Thickness of the MS mucosal (n=284)		Normal mucosa of the MS (n=502)	
	N	%	n	%
Gender				
Male	7.2 (±0.8)	8.2 (±0.8)	7.4 (±0.3)	56.67%
Female	8.5 (±1.0)	9.5 (±1.0)	8.4 (±0.3)	36.67%
Age				
18 to 33	10.5 (±1.0)	11.5 (±1.0)	10.5 (±0.3)	40.00%
34 to 49	11.0 (±1.0)	12.0 (±1.0)	11.5 (±0.3)	40.00%
>49	12.3 (±1.1)	13.3 (±1.1)	12.5 (±0.3)	36.67%

Legend: MS= Maxillary Sinus.

The right MS mucosa presented 250 type 1 (normal), 94 type 2 (moderate), and 49 type 3 (severe) cases. The left MS mucosa was responsible for 252 type 1 (normal), 97 type 2 (moderate), and 44 type 3 (severe) cases. A breakdown of the total of 786 MSs and adjacent teeth shows 736 first premolars, 725 second premolars, 725 first molars, 749 second molars, and 224 third molars, totaling n=3159 teeth and a total of 771 missing teeth. Of the total, 502 MSs were classified with type 1 mucosa (0mm to 2mm-normal), 191 MSs with type 2 mucosa (2.1mm to 10mm-moderate), and 93 MSs with type 3 mucosa (greater than 10mm-severe), resulting in 284 MSs (36.13%) with moderate to severe thickening. Thickening of the MS mucosa greater than 2mm in one or both SMs was observed in 193 (49.11%) patients. This thickening was present only on the right side in 55 patients, of which 44 type 2 and 11 type 3; while 52 showed thickening only on the left side, with 39 type 2 and 13 type 3; and 86 were bilateral.

As shown in Table 2, when analyzing all MSs (n=786), most scans presented grade 1 thickening (normal) and a type 2 relationship with the roots (at least one tooth root in contact with the MS floor). However, grade 2 thickening and type 2 root relationship were significantly elevated (n=135).

Table 2. Association between the types of anatomical relationship of the roots of the teeth and thickening of the maxillary sinus mucosa.

Degree of thickness	Number total	Type 1 relationship all teeth n (%)	Type 2 relationship at least 1 tooth n (%)	Type 3 relationship with at least 1 tooth n (%)	Total n (%)
1	502	100 (12.72)	361 (45.93)	41 (5.22)	502 (63.87)
2	191	14 (1.79)	135 (17.17)	42 (5.34)	191 (24.30)
3	93	4 (0.51)	61 (7.76)	28 (3.56)	93 (11.83)
Total	786	118 (15.02)	557 (70.86)	111 (14.12)	786 (100)

Legend: Degree of thickness = Degree of thickness of the MS mucosa. Total number = Total number of MS. Type 1 relationship all teeth = Number of MSs that presented type 1 anatomical relationship (%) in all teeth. Type 2 relationship with at least 1 tooth = Number of MSs that have type 2 anatomical relationship with at least 1 tooth (%). Type 3 relationship in at least 1 tooth = Number of MSs that presented type 3 anatomical relationship in at least 1 tooth (%).

Table 3 shows that, when analyzing all MSs (n=786), grade 1 MS thickening predominates in all tooth groups.

Table 3. Association between the degree of mucosal thickening in the MS and different groups of teeth

MS thickness degree	Group of teeth					
	1 PM n (%)	2PM n (%)	1M n (%)	2M n (%)	3M n (%)	Total n (%)
1	476 (15.07%)	468 (14.81%)	469 (14.84%)	482 (15.26%)	141 (4.46%)	2036 (64.44%)
2	175 (5.54%)	169 (5.35%)	171 (5.41%)	176 (5.57%)	55 (1.74%)	746 (23.61%)
3	85 (2.69%)	88 (2.79%)	85 (2.70%)	91 (2.88%)	28 (0.89%)	377 (11.95%)
Total	786	118 (15.02)	557 (70.86)	111 (14.12)	786 (100)	

Legend: 1PM: 1 premolar. 2PM-2 premolar. 1M- 1 molar. 2M- 2molar. 3M- 3 molar

Table 4 shows that the 1M and 2M are the teeth that present the greatest association with MS mucosa thickening (n=786) grades 2 and 3 in type 2 and 3 root relationships with the MS.

Table 4. Association between groups of teeth with MS mucosal thickness and type of relationship between roots and MS.

Groups of teeth	Thickness of the MS mucosa	Relationship of the roots with the MS			
		Type 1 n	Type 2 n	Type 3 n	Total n
1PM	1	466	10	0	476
	2	169	6	0	175
	3	78	7	0	85

Table 4. Association between groups of teeth with MS mucosal thickness and type of relationship between roots and MS (cont.).

Groups of teeth	Thickness of the MS mucosa	Relationship of the roots with the MS			
		Type 1 n	Type 2 n	Type 3 n	Total n
2PM	1	380	83	5	468
	2	126	42	1	169
	3	63	23	2	88
1M	1	163	280	26	469
	2	31	116	24	171
	3	15	54	16	85
2M	1	121	336	25	482
	2	32	124	20	176
	3	9	63	19	91
3M	1	51	84	6	141
	2	12	38	5	55
	3	3	19	6	28
Total		1719	1285	155	3159

Legend: 1PM: 1 premolar. 2PM-2 premolar. 1M- 1 molar. 2M- 2molar. 3M- 3 molar.

Individual analysis of the MSs shows that most of the grade 2 and 3 thickenings occurred unilaterally (n=154 and n=73, respectively), and that these differences are statistically significant (Table 5).

Table 2. Association between the types of anatomical relationship of the roots of the teeth and thickening of the maxillary sinus mucosa.

Thickness of the MS mucosa (n=786)	Maxillary Sinus n (%)	Form of involvement n (%)		p value
		Unilateral n (%)	Bilateral n (%)	
1	502 (63.88)	107 (13.61)	395 (50.25)	<0.001*
2	191 (24.30)	154 (19.59)	37 (4.71)	
3	93 (11.83)	73 (9.32)	20 (2.54)	
Total	786 (100)	334 (42.52)	452 (57.5)	

Legend: *p<0.05 statistically significant difference. Chi square test.

Table 6 shows that approximately half of the MSs present some degree of mucosal thickening (n=1122), and that n=585 of them have some relationship with the root of at least one tooth.

Table 6. Type of relationship between tooth roots and MS thickening.

Thickness of the MS mucosa	Relationship of the roots with the MS			Total n (%)	P-value
	Type 1 n (%)	Type 2 n (%)	Type 3 n (%)		
1	1181 (37.40)	793 (25.11)	62 (1.96)	2036 (64.47)	<0.001*
2 + 3	537 (17.1)	492 (15.58)	93 (2.94)	1122 (35.62)	
Total	1718 (54.5)	1285 (40.6)	155 (4.9)	3158 (100)	
P-value	0.0002*[3]	0.038*[3]	<0.001*[3]		

Legend: *p<0.05 statistically significant difference. Chi square test.

Table 7 shows that the majority of the 786 MSs did not present any mucosal thickening. However, in cases where the MS presented thickening, both grade 2 and grade 3, an association existed between the thickening and the presence of a periapical lesion or endodontic treatment, and this association was statistically significant (p<0.001).

Table 7. Association values between periapical lesions, root canal treatment and mucosal thickening in the MS.

Degree of thickness of the MS mucosa	Total	Total number of periapical lesions	Mean number of periapical lesions of the MS	P value	Total number of endodontic treatments	Mean number of root treatments per MS	P value
1	502	22	0.04 a	<0.001	81	0.16 a	<0.001*
2	191	43	0.22 b	<0.001	54	0.28 b	0.001*
3	93	28	0.30 c	<0.001	26	0.28 c	<0.001*
Total	786	93	0.12		161	0.20	

Legend: Chi-square test *Statistically significant (p<0.05) Different superscript letters indicate that a significant difference between the datasets pertaining to the presence of lesions and the degree of mucosal thickening, in each vertical column, at the 0.05% level. Values with the same superscript letters were not statistically different, p<0.05 (a vs b, a vs c, and b vs c).

Given the evidence from the statistical tests suggesting a possible association between some variables that could cause thickening of the MS mucosa, a new statistical test was performed. Table 8 presents the risk of MS thickening concerning the presence of a periapical lesion, endodontic treatment, male sex, and type 2 and 3 root relationships of the teeth, with the risks being 7.27, 2.03, 1.73, 1.36, and 3.29, respectively.

Table 8. OR and 95% CIs for risk of MS thickening in terms of sex, age, periapical lesion, endodontic treatment and relationship between tooth roots and MS.

Variables	MS mucosal thickness						
	Present	%	Absent	%	OR	95%CI	p value
Gender							
Male (n=294)	130	16.54	164	20.86	1.73	1.29-2.34	0.0004*
Female (n=492)	154	19.59	338	43.00	1		
Age							
18 to 33 (n=431)	144	18.32	287	36.56	1		
34 to 49 (n=255)	95	12.08	160	20.35	1.18	0.86-2.20	0.34
>49 (n=100)	45	5.72	55	7.00	1.55	1.04-2.53	0.06
Periapical lesion							
Present (n=93)	71	9.03	22	2.8	7.27	4.39-12.04	<0.0001*
Absent (n=693)	213	27.0	480	61.07	1		
Endodontic treatment							
Present (n=161)	80	10.18	81	10.30	2.03	1.43-2.89	<0.0001*
Absent (n=625)	204	25.95	421	53.6	1		
Proximity relationship of roots with MS							
Type 1 (n=1718)	537	17	1181	37.39	1		
Type 2 (n=1285)	492	15.58	793	25.11	1.36	1.17-1.58	<0.0001*
Type 3 (n=155)	93	2.94	62	1.96	3.29	2.35-4.62	<0.0001*

Legend: Chi square test. CI = confidence interval at 95%.

Discussion

Sinusitis is a pathology that affects the population of the entire world and can manifest itself chronically or acutely (Aksoy and Orhan, 2019). The main causes are septum deviation or enlarged nasal turbinates, issues related to bacterial, viral, and fungal infections, as well as allergies and polyps, cystic fibrosis, nasal and sinus tumors, and odontogenic conditions.[9]

Some studies report a prevalence rate of mucosal sinus thickening that varies between 37% and 62%.[6,10–12] In our study, a prevalence of 36.13% was found, which is close to the values found in the literature.

Our results reveal that the teeth most closely related to the MSs were the maxillary second molars, first molars, second premolars, third molars and first premolars respectively. This result is very similar to the findings of several authors,[13–16] except for the inversion of the order of the second premolar with the third molar.[13–16] This inversion may have been caused by the number of missing third molars in our sample.

In the present study, 585 roots were found in close contact with the floor of the MS or within the MS, suggesting that this is an odontogenic factor for possible mucosal thickening. The analysis shows that when there is a relationship between the floor of the MS and the root of the type 3 tooth, the probability of developing mucosal thickening increases (OR= 3.29), while the probability is lower (OR=1.36) in type 2.

In clinical practice, the proximity between adjacent teeth and the MS should be considered, since alterations can result in various complications such as sinusitis, oroantral fistula, displacement of the file, and root or filling materials into the MS.[15]

In our work, we observed that individuals over 49 years of age have an increased chance of having mucus thickening in the MS (OR=1.55). Some studies[3,6,10] indicate that the occurrence of mucosal thickening increases with patient age. According to Aksoy and Orhan 2018, older individuals may be more susceptible to dental disease, which in turn increases the prevalence of maxillary sinusitis.[16]

From the results obtained, we observed a statistically significant difference (p=0.0004) between the presence of mucous thickening and sex. Males are more likely (OR=1.73) to develop this alteration than females. Perhaps this greater involvement can be explained by the fact that some studies show us that men have more endodontic treatments and periapical lesions. In addition, women between 40-59 years of age use regular dental services approximately 40% more than men in the same age group.[17]

With regard to the prevalence of periapical lesions, our results in general show that 11.83% (n=93) of the teeth had periapical lesions and 20.48% (n=161) had undergone endodontic treatment. These values are close to those found by Aksoy and Orhan 2018. Our study found that 71 teeth (76.34%) with periapical lesions and 80 teeth (49.68%) with endodontic treatment were involved with thickening of the MS mucosa.

Most previous studies[2,3,6,18–21] have reported a positive association between periapical lesions and mucosal thickening, although some results show the opposite.[10–12]

The results of this study indicate a positive relationship between the prevalence of sinus mucosal thickening and the presence of periapical lesions (p<0.001). Furthermore, we found that individuals with periapical lesions are more likely (OR=7.27) to show thickening of the MS mucosa. In individuals with endodontic treatment, this chance decreases considerably (OR= 2.03) but even so, it was twice as high as that of an untreated individual.

This can be explained, given that, after the occurrence of pulpal necrosis, bacterial virulence factors promote bacterial invasion and tissue degradation in the periodontal bone.[22] The infection and its by-products originating from the infected tooth can spread to the MSs and irritate the sinus mucosa.[23,24]

A relevant point to be remembered is that mild mucus thickening in the MS is a normal and frequent finding in asymptomatic patients, but sinus mucus thickening greater than 2mm may

be related to sinusitis.[25] On the other hand, mucosal thickening of the MS equal to or greater than 4mm may represent rhinosinusitis, and this individual may suffer from headache or facial pain, daytime cough, nighttime cough, obstruction, and nasal discharge.[26] In cases where treatments have already been performed for these conditions and a recurrence of the case happens, a dental investigation should be carried out.

This research study presents limitations due to the number of participants and would have been greatly enriched by an expansion that would enable us to evaluate patients and verify the clinical signs and symptoms caused by the mucous thickening, identify where patients presented symptoms, what these were, how to treat them and how to help the patient in relation to the treatment.

Conclusion

We can conclude that the presence of periapical lesions, root canal filling, and proximity of the dental roots to the floor of the sinus mucosa may be related to the appearance of sinus mucosa mucosal thickening. Patients with type 3 mucosal thickening can develop maxillary sinusitis of odontogenic origin.

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