Original Article

Association between Maxillary Teeth and Maxillary Sinus Pathologies: A Retrospective CBCT Evaluation

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KEY WORDS
Cone-beam computed tomography;
Maxillary sinus;
Tooth diseases;

ABSTRACT

Background: Maxillary sinus (MS) pathologies are often influenced by odontogenic conditions due to the close anatomical relationship between the sinus and maxillary teeth. Cone-beam computed tomography (CBCT) enables comprehensive assessment of this association by providing high-resolution visualization of both MS structures and adjacent dental pathology.

Purpose: The aim of this study was to retrospectively evaluate the etiological association between odontogenic factors and MS pathologies using CBCT.

Materials and Method: This was a descriptive-analytical cross-sectional study. MS of patients who underwent CBCT between 2024 and 2025 were examined. MS were evaluated for mucosal thickening, polyps, retention cysts, and partial and total opacities, while related dental pathologies were assessed for periapical lesions, post-extraction perforations, and sinus-related foreign bodies. Data were analyzed using SPSS version 27.0, with descriptive statistics and Chi-square tests applied for group comparisons, and a p Value < 0.05 was considered statistically significant.

Results: A total of 400 patients (43.3% male, 56.8% female) were evaluated. While no pathology was detected in 42.5% of the patients' MS, 31.0% showed unilateral pathology and 26.5% exhibited bilateral pathology (p= 0.046). A significant correlation was observed between MS pathologies and dental pathologies in terms of location (p< 0.001). MS pathology was significantly more prevalent in patients with dental pathologies than in those without (66.5% vs. 34.6%, p < 0.001). Among periapical lesions, the most frequent finding was the absence of sinus pathology (38.5%), followed by mucosal thickening (26.1%). Post-extraction perforations were associated with mucosal thickening (27.3%) and partial or total opacification (22.7%), while all cases with foreign bodies demonstrated MS pathology.

Conclusion: Odontogenic factors are important etiological factors in MS pathologies and evaluation with CBCT plays a significant role in early diagnosis and treatment. Multidisciplinary collaboration between dental practitioners and otorhinolaryngologists is essential for optimal management of MS pathologies.

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Introduction

The maxillary sinus (MS) is located in close anatomical proximity to the roots of premolar, molar, and in some cases the canine teeth, making it vulnerable to dental-origin pathologies [1]. Odontogenic sinus pathologies account for approximately 10–14% of maxillary sinusi-

tis cases [2], while a review have reported rates as high as 40% [3] ; nevertheless, odontogenic sinusitis remains frequently overlooked in clinical practice. Radiographic features such as mucosal thickening, polypoid lesions, and partial or total opacification are common findings in the MS, with odontogenic factors often implicated in their development [4]. These pathologies have been associated with dental conditions including caries, periapical lesions, periodontal disease, and oroantral communications arising after tooth extractions [5].

Establishing the association between odontogenic factors and MS pathologies is essential for accurate diagnosis and effective treatment planning. Several imaging modalities are available, such as Water's radiographs, panoramic radiography, computed tomography (CT), magnetic resonance imaging, and cone-beam computed tomography (CBCT) [6]. Although CT is considered the gold standard for MS assessment, its limitations include higher radiation exposure and cost. CBCT, in contrast, offers advantages such as lower radiation dose, shorter scanning time, and reduced cost, making it the preferred modality for MS evaluation [7].

Several CBCT-based studies have reported that odontogenic factors may be associated with a wide spectrum of MS findings, with considerable variability in prevalence depending on study design and diagnostic criteria [4, 8-10]. Recent reviews and consensus statements have emphasized that odontogenic contributions to MS pathology are frequently underestimated, underscoring the importance of detailed radiological assessment of the relationship between dental pathologies and the MS [3-4]. Therefore, further CBCT-based investigations focusing on the regional and laterality-related association between dental pathologies and MS findings remain warranted.

The aim of this study was to examine the association between MS pathologies and odontogenic factors, thereby contributing to increased awareness among dental practitioners and otorhinolaryngologists regarding their multidisciplinary management.

Materials and Method

This study was designed as a descriptive-analytical cross-sectional study, as CBCT images were retrospectively evaluated at a single time point to describe MS findings and to analyze their association with dental pathologies.

CBCT images obtained for various clinical indications such as impacted teeth, implant planning, temporomandibular joint (TMJ) disorders, orthodontic assessment, complex endodontic cases, and supernumerary teeth from patients who presented to the Department of Oral and Maxillofacial Radiology at the Faculty of Dentistry, Marmara University, between 2024 and 2025, were evaluated. This study was ethically approved by the Marmara University Faculty of Medicine (Protocol No: 09.2025.25-0175).

A total of 400 patients aged 16 years and older were included. The study included patients with diagnostically adequate CBCT scans in which the MS were completely visible within the field of view, and had provided informed consent for the use of their clinical and radiographic data in research. Exclusion criteria comprised patients younger than 16 years (due to incomplete sinus development), those without available CBCT scans or with insufficient image quality, and patients with syndromic conditions like cleft lip and palate. In addition, individuals with a history of trauma such as MS fractures or sinus surgery, genetic or systemic bone disorders like Paget's disease, fibrous dysplasia, or benign and malignant tumors of the jaws were excluded from the study.

All scans were obtained by an operator using a ProMax 3D Mid imaging device (Planmeca Oy, Helsinki, Finland), with exposure settings adjusted according to patient size. Images were evaluated using multiplanar reconstructions (coronal, axial, and sagittal) with standardized acquisition parameters, including 90 kVp, 12 mA, an exposure time ranging from 12 to 27 seconds, and an isotropic voxel size of 0.4 mm^3. Image analysis was performed using Romexis software version 2.92 (Planmeca Oy, Helsinki, Finland) on a 23-inch monitor with a resolution of 1920×1080 pixels. All CBCT scans were evaluated independently by two oral and maxillofacial radiology residents with 3 and 4 years of clinical experience, respectively, under standardized viewing conditions. Intraobserver and interobserver agreement were assessed using intraclass correlation coefficients. For intraobserver reliability, 20% of the CBCT scans were randomly selected and re-evaluated by the same observer after a two-week interval. Interobserver agreement was assessed between the two observers, who ind-

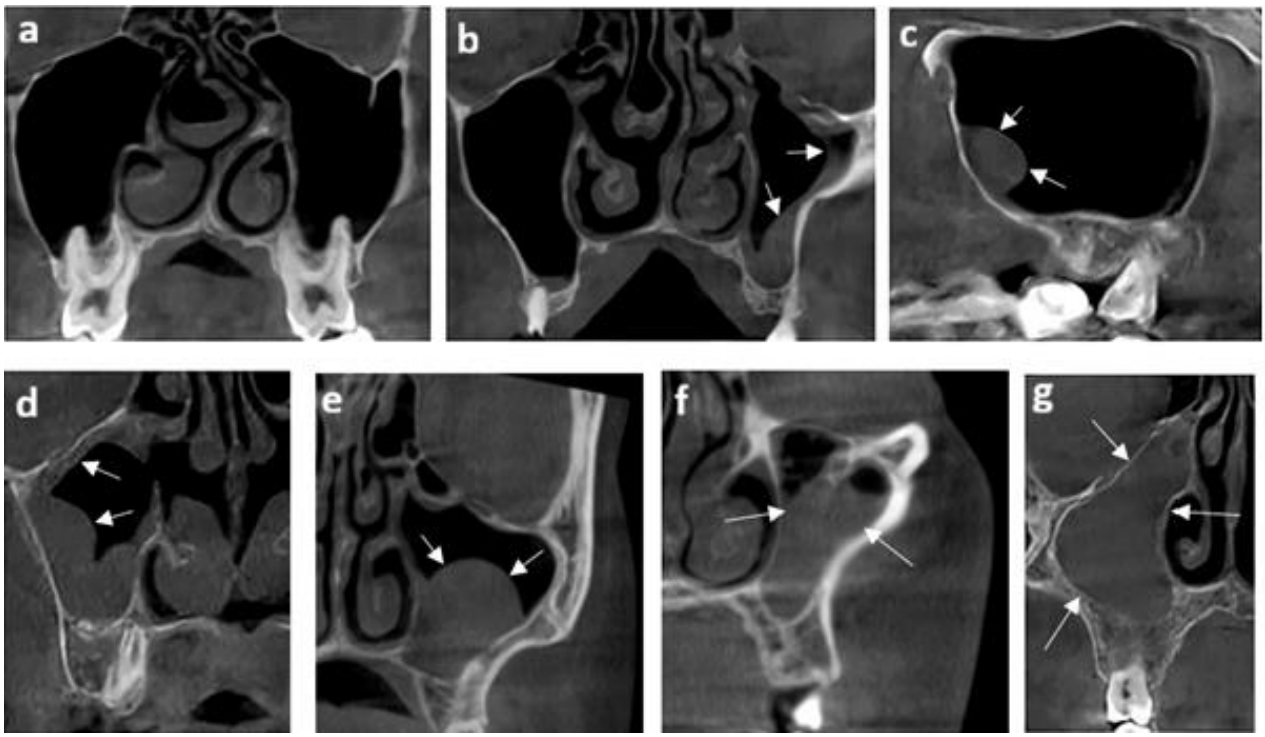

Figure 1: Cone-beam computed tomography (CBCT) images of maxillary sinus pathologies, **a:** no pathological findings (coronal view), **b:** mucosal thickening (coronal view), **c:** polypoid structure (sagittal view), **d:** mucosal thickening and polypoid structures (coronal view), **e:** retention cyst (coronal view), **f:** partial opacity (coronal view), **g:** total opacity (coronal view)

ependently evaluated the selected scans under identical conditions.

The MS were assessed bilaterally for mucosal thickening, polyps, mucosal thickening with polypoid structures, retention cysts, partial opacity, and total opacity. Mucosal thickening was defined as a radiopaque band greater than 2 mm, as previously described in CBCT-based studies [11]. Polyps were recorded as round or oval soft-tissue masses, and retention cysts were defined as dome-shaped lesions. However, it should be noted that these entities may not always be reliably distinguished using imaging alone. Partial opacity involved more than three sinus walls, and total opacity indicated complete sinus filling [11] (Figure 1).

The "no dental pathology" group included cases with no CBCT evidence of odontogenic pathology in teeth adjacent to the MS. Cases showing radiographic signs of periodontal disease, defined as alveolar bone loss exceeding 2 mm apical to the cementoenamel junction [12], were not included in this group. Periapical pathology was defined as the presence of a periapical radiolucency exceeding the normal periodontal ligament space, in accordance with established radiographic criteria [13]. Cases with post-extraction sinus floor defects or sinus-related foreign bodies were also excluded.

Dental pathologies were considered related to the MS when they were located adjacent to or in direct contact with the sinus floor on CBCT images, or when disruption of the cortical boundary of the sinus floor was observed, in accordance with previously reported CBCT-based radiographic criteria used to evaluate odontogenic–sinus relationships [4, 14]. Regarding these criteria, periapical lesions were identified as radiolucent areas around the root apex, post-extraction perforations were defined as discontinuities in the sinus floor following tooth extraction, and sinus-related foreign bodies were recorded when implant material, endodontic filling material, or retained roots were detected within the sinus cavity [4] (Figure 2).

Data were analyzed using Statistical Package for the Social Sciences version 27.0 (SPSS, IBM Corp., Armonk, NY, USA). Descriptive statistics were used to summarize the data. Chi-square tests were used to assess associations between categorical variables when the expected cell counts were adequate, whereas the Fisher–Freeman–Halton exact test was applied in cases with small, expected frequencies. When applicable, effect sizes were estimated using Cramer's V and odds ratios with 95% confidence intervals. A p Value <0.05 was considered statistically significant. The unit of analysis

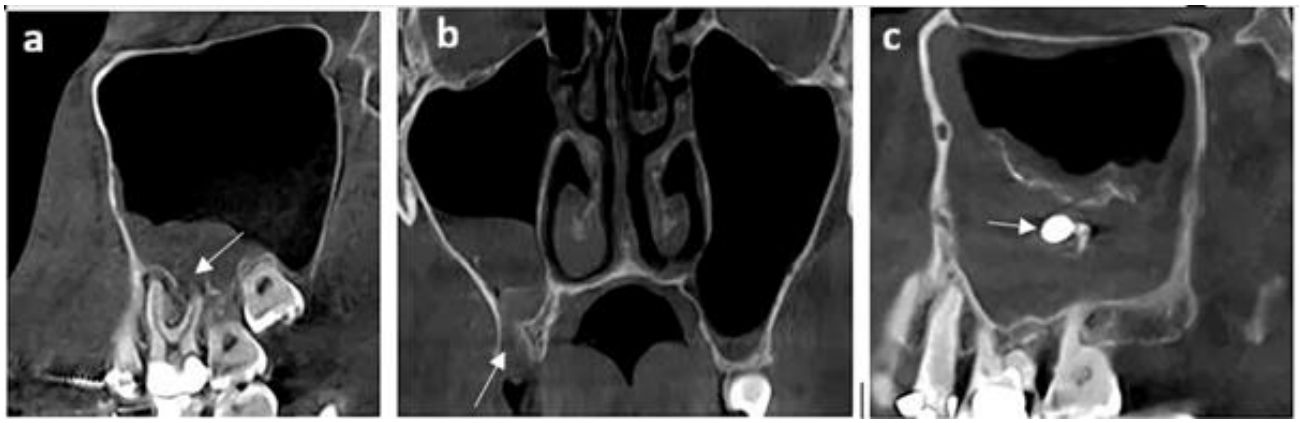

Figure 2: Cone-beam computed tomography (CBCT) images of dental pathologies: a. periapical lesion (sagittal view) b. post-extraction perforation (coronal view) c. foreign body (sagittal view)

differed according to the variables evaluated. Demographic characteristics were analyzed on a patient basis (n= 400), whereas MS findings were evaluated on a sinus basis (right and left sinuses; n= 800).

Results

A total of 400 patients were included in the study, comprising 227 females (56.8%) and 173 males (43.3%). The largest age group was 16–29 years (53.8%). Regarding sinus findings, 42.5% of patients exhibited no pathology, while 31.0% showed unilateral pathology and showed 26.5% bilateral pathology (Table 1).

A statistically significant association was observed between gender and the presence of MS pathology (p= 0.046), although the effect size was weak (Cramer's V= 0.12). While the absence of pathology was the most common finding in both sexes, bilateral involvement was more frequent in males. No significant difference was found between age groups and MS pathology (p= 0.230). The distribution of pathology did not vary significantly with age.

The distribution of MS pathologies according to dental pathologies is presented in Table 2. In the absence of dental pathology, no pathology was the most common finding (65.4%). In patients with periapical lesions, the most frequent sinus finding was also the absence of pathology (38.5%), followed by mucosal thickening (26.1%). In patients with post-extraction perforations, mucosal thickening (27.3%) was the predominant finding, followed by polypoid lesions, partial, and total opacification (each 22.7%). In cases with foreign bodies, the most common pathology was combined mucosal thickening and polypoid formations (40.0%).

The prevalence of sinus pathology was significantly higher in patients with dental pathologies (66.5%) com-

Table 1: Descriptive characteristics of the study population

Variables	n	%
Gender		
Female	227	56.8
Male	173	43.3
Age groups		
16–29	215	53.8
30–39	59	14.8
40–49	51	12.8
50–59	46	11.5
≥60	29	7.2
Maxillary sinus pathology		
No pathology	170	42.5
Unilateral	124	31.0
Bilateral	106	26.5
Total	400	100.0

Table 2: Distribution of maxillary sinus pathologies according to dental pathologies

	No dental pathology (n, %)	Periapical lesion (n, %)	Post-extraction of perforation (n, %)	Foreign body in sinus (n, %)	Total (n, %)
No maxillary sinus pathology	400 (65.4)	62 (38.5)	1 (4.5)	0 (0.0)	463 (57.9)
Mucosal thickening	55 (9.0)	42 (26.1)	6 (27.3)	1 (20.0)	104 (13.0)
Polypoid structure	35 (5.7)	1 (0.6)	0 (0.0)	0 (0.0)	36 (4.5)
Mucosal thickening and polypoid structure	80 (13.1)	35 (21.7)	5 (22.7)	2 (40.0)	122 (15.3)
Retention cyst	14 (2.3)	6 (3.7)	0 (0.0)	0 (0.0)	20 (2.5)
Partial opacification	17 (2.8)	8 (5.0)	5 (22.7)	1 (20.0)	31 (3.9)
Total opacification	11 (1.8)	7 (4.3)	5 (22.7)	1 (20.0)	24 (3.0)
Total	612 (100.0)	161 (100.0)	22 (100.0)	5 (100.0)	800 (100.0)

Table 3: Association between dental pathologies and maxillary sinus pathologies

		Dental Pathologies			
		Absent	**Present**	**Total**	***p*** values*
Maxillary Sinus Pathologies	Absent	400 (65.4)	63 (33.5)	463 (57.9)	<0.001
	Present	212 (34.6)	125 (66.5)	337 (42.1)	
	Total	612 (100.0)	188 (100.0)	800 (100.0)	

*Chi-square test

pared to those without (34.6%) ($p< 0.001$). The odds of having sinus pathology were approximately 3.8 times higher in patients with dental pathology (odds ratio= 3.75), and the strength of association was moderate (Cramer's V= 0.28) (Table 3).

A significant regional association was observed between sinus and dental pathologies ($p< 0.001$). The strength of this association was moderate (Cramer's V= 0.23). Unilateral dental pathologies were frequently related to ipsilateral MS pathologies while bilateral dental pathologies were predominantly associated with bilateral sinus involvement (51.4%). In contrast, in the absence of dental pathology, more than half of the patients (52.8%) showed no sinus pathology (Table 4).

Intraobserver agreement was high, with an intraclass correlation coefficient of 0.88, indicating consistent evaluations by the same observer over time. Interobserver agreement also demonstrated high reliability (0.85), reflecting a strong level of consistency between the two observers.

Discussion

The MS and dental structures are anatomically adjacent, and this close relationship suggests that dental pathologies may be associated with MS pathologies. The proximity of the apices of maxillary premolars and molars to the sinus increases the likelihood that odontogenic infections are related to changes in the sinus mucosa [15]. In recent years, CBCT has provided more detailed three-dimensional imaging compared with conventional radiographic methods, offering considerable advantages in evaluating the association between the MS and adjacent dental structures [8]. Early identification of odontogenic factors using CBCT is therefore essential for preventing and managing sinus pathologies.

In the literature, the prevalence of MS pathology has been reported to range from 37% to 73% [9-10]. In the present study, sinus pathologies were observed in 42.1% of patients, which aligns with these reported ranges. A significant association between gender and sinus involvement was identified ($p= 0.046$). Bilateral sinus pathologies were more frequent in males (32.4%), while females more commonly exhibited no sinus pathology (46.7%). Some previous studies have also reported a higher prevalence of sinus pathology in males [16-17], although other reports found no significant gender differences [9, 18]. In addition to anatomical considerations, demographic factors have also been evaluated in relation to MS pathology. The role of age in sinus pathology remains controversial. Some studies suggest age-related differences [19-20], while others consistent with our results, report no significant association between age and the prevalence of MS pathologies [21-22]. Variability may be attributed to differences in study populations, imaging modalities, or environmental factors.

Beyond demographic factors, the relationship between dental pathologies and MS findings has been a major focus of interest in the literature [9, 14]. Dental infections have long been reported to be associated with MS pathologies, likely due to localized inflammatory processes affecting the sinus mucosa [4, 14]. The present study supported this association, showing that sinus

Table 4: Regional association between dental and maxillary sinus pathologies

		Dental Pathologies					
		None (n, %)	**Unilateral (Right) (n, %)**	**Unilateral (Left) (n, %)**	**Bilateral (n, %)**	**Total (n, %)**	***p*** value*
Maxillary Sinus Pathologies	None	132 (52.8)	17(27.4)	10 (19.6)	11 (29.7)	170(42.5)	<0.001
	Unilateral (Right)	39(15.6)	19 (30.6)	3(5.9)	3(8.1)	64(16.0)	
	Unilateral (Left)	32(12.8)	5(8.1)	19 (37.3)	4(10.8)	60(15.0)	
	Bilateral	47(18.8)	21(33.9)	19(37.3)	19 (51.4)	106(26.5)	
	Total	250 (100.0)	62 (100.0)	51(100.0)	37(100.0)	400 (100.0)	

* Fisher–Freeman–Halton exact test

pathology was significantly more prevalent in patients with dental pathologies (66.5%) compared to those without (34.6%) ($p< 0.001$), showing a significant alliance between these conditions. Previous studies have similarly demonstrated an increased frequency of sinus pathology in patients with odontogenic factors [9, 14].

Our findings also revealed a notable regional association between the location of dental and sinus pathologies. Unilateral dental pathologies were commonly associated with ipsilateral sinus pathology, whereas bilateral dental pathologies were linked to bilateral MS pathologies. This is consistent with previous reports that odontogenic sinusitis often presents unilaterally, in contrast to non-odontogenic sinus pathologies, which more frequently occur bilaterally [4, 23]. From a clinical perspective, these findings emphasize the importance of considering odontogenic sources when unilateral MS pathologies are detected on CBCT, while also recognizing that non-odontogenic factors should be considered in the absence of corresponding dental pathology. Nevertheless, in nearly one-third of cases, unilateral MS pathologies were observed without corresponding dental pathologies, suggesting that additional local factors (such as ostium narrowing due to anatomical variations, post-surgical scarring) or systemic issues (like allergic disease, immunodeficiency) may contribute to their development [24].

Within this context, specific dental conditions demonstrated distinct patterns of association with MS findings. Periapical lesions have been frequently reported in association with MS pathologies [25]. Previous studies have reported MS pathologies in 16–95% of cases with periapical pathology [4, 26]. In our study, 61.4% of teeth with periapical lesions were associated with sinus pathology, most frequently mucosal thickening. From a clinical perspective, this finding suggests that periapical lesions should be carefully evaluated on CBCT scans, as their proximity to the MS may be associated with concurrent sinus changes that could otherwise remain unrecognized.

Post-extraction perforations and sinus foreign bodies were also significant contributors to sinus pathologies [27-28]. Previous studies have reported that post-extraction perforations lead to MS pathologies in 30–48% of cases [29-30]. In the present study, mucosal thickening was the most common finding in such cases, followed by mucosal thickening with polypoid structures and partial or total opacification. Clinically, the observed association between post-extraction perforations and both partial and total sinus opacification highlights the importance of assessing the MS following extraction procedures, particularly when radiographic sinus findings persist.

Foreign bodies within the sinus have been reported in association with MS pathologies in 2–28% of cases [30-31]. In our study, all cases with sinus foreign bodies exhibited sinus pathology, most frequently combined mucosal thickening and polypoid formations (40%). These findings highlight the importance of careful surgical and restorative procedures in the posterior maxilla to prevent iatrogenic sinus complications.

Considering the complexity of MS pathologies, particularly in cases where odontogenic and non-odontogenic origins overlap, interdisciplinary collaboration between dental practitioners and otorhinolaryngologists is crucial. Such an approach ensures more accurate diagnosis, optimizes treatment planning, and underscores the clinical relevance of our findings.

Several limitations of the present study should be acknowledged. First, due to the retrospective cross-sectional design, clinical examination findings could not be correlated with radiological results, and causal relationships between dental pathologies and MS findings cannot be established. In addition, clinical information was limited to available medical records and patient anamnesis. Although cases with evident acute upper respiratory tract infection symptoms were reviewed based on anamnesis, transient inflammatory conditions at the time of CBCT acquisition could not be completely excluded. This factor should be considered when interpreting MS findings, particularly mucosal changes.

Furthermore, previous studies have reported variability in the age at which MS development is considered complete, ranging from early adolescence to late teenage years, depending on the population studied, imaging modality, and whether volumetric growth or functional maturation was assessed. This variability in the literature should be considered when interpreting age-related findings. The study population was also predominantly composed of younger individuals, with more than half of the participants aged between 16 and 29 years. This age distribution may have influenced the frequency and

distribution of odontogenic and sinus pathologies and may limit the generalizability of the results to older populations. This can be partly explained by the study design, as evaluation of odontogenic–sinus relationships required the presence of maxillary premolar and molar teeth adjacent to the sinus, a condition less frequently observed in older individuals.

Despite these limitations, the present study highlights the value of CBCT in identifying dental pathologies associated with MS findings. Future prospective studies integrating radiological and clinical assessments are warranted to further clarify these associations.

Conclusion

This study demonstrated significant associations between odontogenic factors and MS pathologies. Odontogenic lesions were strongly associated with sinus involvement, often occurring on the same anatomical side, thereby emphasizing their role as key etiological factors.

CBCT proved to be an effective diagnostic tool for the early detection of MS pathologies, allowing for detailed evaluation of both sinus and dental structures. Its use facilitates the identification and management of underlying odontogenic causes and support clinical decision-making in the assessment of MS pathologies.

Conflicts of Interest

The authors declare that they have no conflict of interest.

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