Original Article

Evaluation of Odontogenic Maxillary Sinusitis with Cone Beam Computed Tomography: A Retrospective Study with Review of Literature

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Abstract

Aim and Objectives: The purpose of this study was to describe the radiographic characteristics of odontogenic maxillary sinusitis as seen on cone beam computed tomography (CBCT) scans and determine whether any tooth or any tooth root, was more frequently associated with this disease.

Materials and Methods: The present study included 500 CBCT images that included the entire maxillary sinus of both the sides in all the three planes. The modified classification of Abrahams and Glassberg was used to assess maxillary sinusitis of odontogenic origin. Furthermore, the proximity of the tooth root to the sinus floor, periapical pathology, and the septae within the maxillary sinus were also assessed.

Results: In the present study, 1000 hemimaxillas were analyzed. Majority of the cases (74.9%) the apex of either tooth was touching the floor of the sinus. While 16.9% were in close relationship to the sinus while 8.2% of the cases, the apices were present within the sinus. Furthermore, in the present study, 38 of the total cases had an odontogenic cause of maxillary sinusitis, whereas 273 of them had a nonodontogenic cause, 96 have an undetermined cause, and the rest 593 cases had healthy sinus.

Conclusion: The incidence of odontogenic sinusitis is likely under-reported in the available literature. The introduction of low-dose CBCT is particularly useful to establish a definitive diagnosis to augment in the treatment of chronic maxillary sinusitis of odontogenic origin.

Keywords: *Cone beam computed tomography, maxillary sinusitis and periodontitis, odontogenic sinusitis*

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Introduction

Odontogenic pain originating from the maxillary sinus can pose a diagnostic challenge for the clinician. As the roots of the maxillary posterior teeth are close to the floor of the sinus, along with common innervation, there is a probable reason for pathosis of the sinus to cause dental symptoms.[1] It is believed that the breach of the Schneiderian membrane owing to microbial incursion in periapical infections,[2] periodontal disease or iatrogenic factors[3] increases the risk of maxillary sinusitis. The progress of a periapical lesion in maxillary posterior teeth can give rise to inflammatory changes in the mucosal lining of the maxillary sinus and subsequently, the development of sinusitis.[4] The extension of periapical inflammation into the maxillary sinus was first described in 1943 by Bauer.[5] This was a cadaveric study with microscopic evaluation of sections of human teeth, alveolus, and sinus. Periapical inflammation was found to be proficient for affecting the sinus mucosa with or without perforation of the cortical bone of the

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sinus floor.[5] Radiographic imaging has always played an imperative role in establishing the odontogenic etiology of (mostly chronic) maxillary sinusitis and complement results of the clinical examination.[6] The purpose of this retrospective study was to describe the radiographic characteristics of odontogenic maxillary sinusitis as seen on cone beam computed tomography (CBCT) scans and to determine whether any tooth or any tooth root, was more frequently associated with this disease.

Materials and Methods

The present study included 500 CBCT images that included the entire maxillary sinus of both the sides in all the three planes. The source of data for the study was patients that reported to the department of oral medicine and radiology from January 2017 to 2018. The CBCT had been advised for the evaluation of teeth in the posterior region of maxilla for various diagnostic purposes. A prior ethical approval was obtained from the Institutional Ethical Committee (Letter No: KIIT/KIDS/IEC0345) before the start of the study. The CBCT scans were done using Hyperion X9 digital imaging system (Myray, Italy). The images were obtained at 70–75 kV, 8–10 mA, and 11–12.3 s exposure time. The field of view size was 11 mm × 8 mm with a 300-μm image resolution. For evaluation of the CBCT scans, a 21-inch LCD monitor's (HP L1910, Hewlett-Packard Development Co., Palo Alto, CA, USA) with 1280 × 1024 pixel was used. The NNT Imaging Software (v4.6) Windows edition (Myray, Italy) was used. Images were selected considering a high-level technical standard (i.e., appropriate sharpness, density, and contrast), clearly showing the maxillary posterior teeth apices and the sinuses floor. An assessment of the topographic relationship of each root to the maxillary sinus floor was conducted in CBCT images.

For the purpose of this study, diagnostic criteria for sinusitis diagnosis were developed based on published literature.[7] Based on these criteria, the maxillary sinusitis/pathology was divided into four categories [Figures 1-6].

The relationship of the tooth apex to the floor of the maxillary sinus and periapical lesion to the floor of the maxillary sinus is depicted in Figure 1.

Results

In the present study, 1000 hemimaxillas were analyzed. A total of 500 participants including 314 males and 186 females participated in the study. All the participants in the present study were adults and were between the ages of 25–65 years. In the present study, descriptive statistics was used to summarize the features of odontogenic and nonodontogenic sinusitis. Statistical Package for the Social Sciences (SPSS; IBM, California, USA) version 20.0 was used to perform the statistical analysis. Student's *t*-test was used to assess the relation ($P < 0.05$ was considered to be statistically

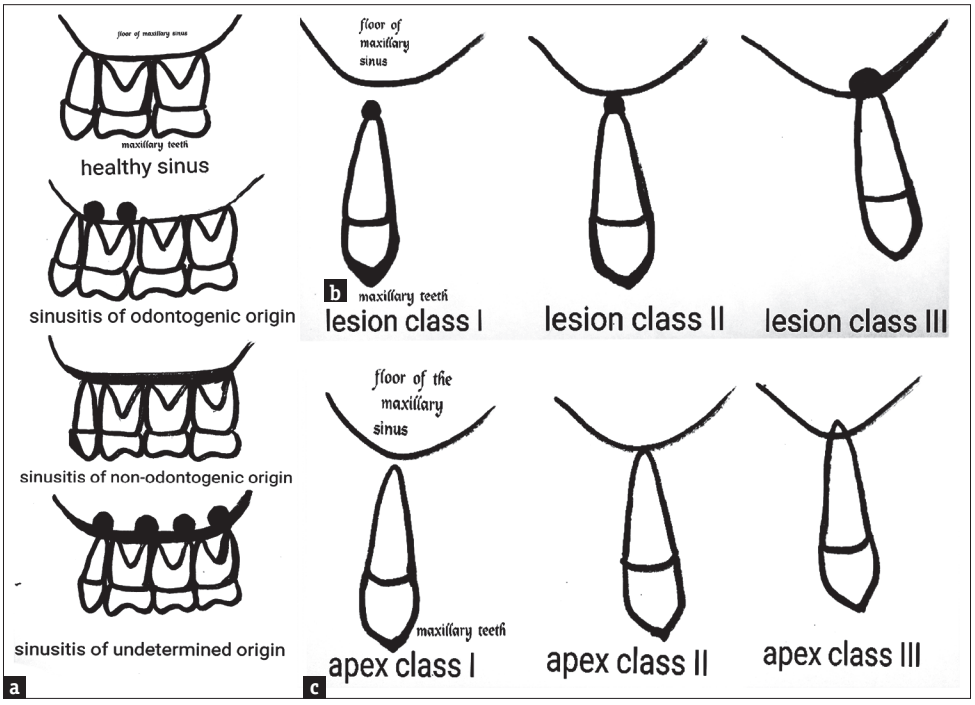

Figure 1: Line Diagram of the maxillary teeth with the floor of the maxillary sinus. (a) Modified classification of Abrahams and Glassberg for maxillary sinusitis. (b) Relation of the periapical pathology of teeth with that of the sinus floor. (c) Relation of the tooth apex with the floor of the sinus

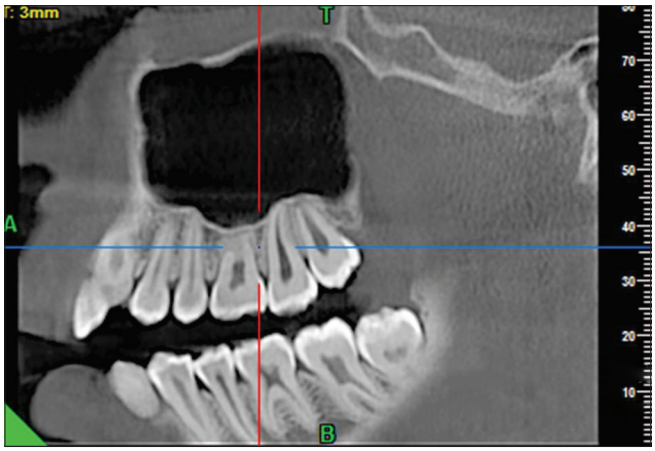

Figure 2: A multiplanar reformatted sagittal cone beam computed tomography image of healthy maxillary sinus with its compliment of teeth

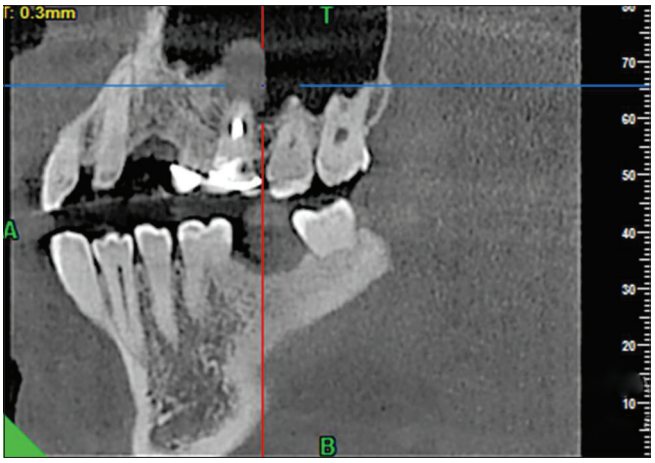

Figure 3: A multiplanar reformatted sagittal cone beam computed tomography image of odontogenic maxillary sinusitis with its compliment of teeth

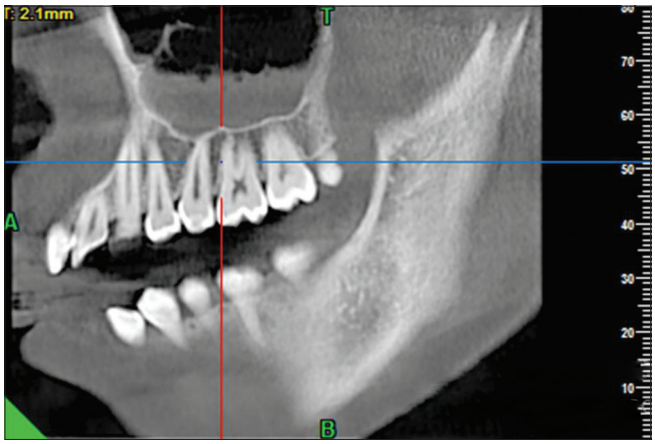

Figure 4: A multiplanar reformatted sagittal cone beam computed tomography image of nonodontogenic maxillary sinusitis with its compliment of teeth

Figure 5: A multiplanar reformatted sagittal cone beam computed tomography image of undetermined maxillary sinusitis with its compliment of teeth

significant) between the odontogenic pathology and maxillary sinus infection.

In general, the apices of premolars and molars are in close proximity to the floor of the maxillary sinus. Majority of the cases (74.9%), the apex of either tooth was touching the floor of the sinus. A total of 16.9% of the cases had a close relationship to the sinus while 8.2% of the cases the apices were present within the sinus [Table 1]. In the present study, out of the 1000 maxillary sinus, 606 were healthy, 387 had sinusitis, six had mucous retention cyst, and only one participant had calcification within the maxillary sinus [Table 2]. On the other hand, out of the 1000 hemimaxillas, 671 cases had healthy teeth while 139 (out of 1000) had a history of extraction done of which 69 cases had healthy sinus whereas 70 of them had sinus pathology. Fifty-eight (out of 1000) had a history of root canal treatment done in which the ratio of healthy and diseased sinus was equal. Sixty (out of 1000) had periodontitis out of which only nine cases had healthy sinus, while the others had diseased sinus. Seventeen (out of 1000) had periapical pathology out of which only three had a healthy sinus while the rest 14 had diseased sinus. Forty-seven (out of 1000) had carious teeth with no periapical pathology out of which 21 had a healthy sinus whereas 26 had diseased sinus. Similarly, eight (out of 1000) had restorations done in the teeth out of which seven had healthy sinus whereas only one had a diseased sinus [Table 3].

Interestingly, majority of the cases having either periodontitis or periapical pathology had sinus pathology.

Majority of the cases 749 (out of 1000) the apices of the teeth were touching the sinus floor of which 294 had a sinus pathology whereas 455 were normal. Similarly, 82 (out of 1000) of the cases had the apices of the teeth within the sinus cavity of which 44 had sinus pathologies while 38 were healthy [Table 4].

Out of the 1000 hemimaxillas, 361 had periapical pathology. In 270 (out of 361) cases, the periapical

lesion was in close proximity to the sinus of which 125 had no sinus pathology while 145 had diseased sinus. In 54 (out of 361) cases, the periapical lesion was touching the floor of the maxillary sinus of which 18 had no sinus pathology while 36 had diseased sinus. Similarly, in 37 (out of 361) cases, the periapical lesion was present within the maxillary sinus of which only 10 had a healthy sinus while 27 had diseased sinus [Table 5].

Discussion

An extensive search for various articles was done through Google Scholar, PubMed, Cochrane Library, and EMBASE. It included all articles published between the year 2000 and 2018. The keywords used were "odontogenic sinusitis," "chronic maxillary sinusitis," "sinusitis of dental origin," "sinusitis of undetermined origin," "chronic apical periodontitis," "periapical pathology and sinusitis," and "iatrogenic sinusitis." All the articles including case reports, case series, review, retrospective, and prospective studies were sorted out to gather all descriptions regarding odontogenic cause of maxillary sinusitis, and the type of imaging modality used[8-31] [Table 6].

In the present study, the incidence of odontogenic-related sinusitis was more commonly seen in males than in females. This was in accordance with the study done by Vallo *et al*.[32] All the participants in the present study were above 12 years of age, as the

Table 1: Relation of tooth apex with the floor of the maxillary sinus

Gender	Apex classification			Total	*P*
	A	B	C		
Male (%)	102 (10.2)	474 (47.4)	52 (5.2)	628 (62.8)	0.771
Female (%)	67 (6.7)	275 (27.5)	30 (3.0)	372 (37.2)	
Total (%)	169 (16.9)	749 (74.9)	82 (8.2)	1000 (100.0)	

P<0.05 is considered to be significant

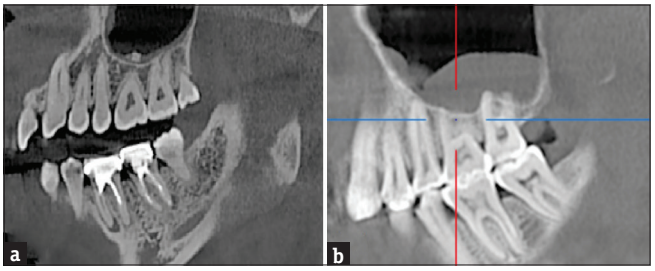

Figure 6: (a) A multiplanar reformatted sagittal cone beam computed tomography image of an antrolith within the maxillary sinus. (b) A multiplanar reformatted sagittal cone beam computed tomography image of a mucous retention cyst within the maxillary sinus

Table 2: Relationship between sinus pathology and odontogenic pathology

Sinus pathology	Odontogenic pathology							Total	*P*
	No lesion	Extraction	RCT	Periodontitis	Granuloma/abcess	Carious	Restoration		
Healthy (%)	468 (46.8)	69 (6.9)	29 (2.9)	9 (0.9)	3 (0.3)	21 (2.1)	7 (0.7)	606 (60.6)	0.000
Sinusitis (%)	196 (19.6)	70 (7)	29 (2.9)	51 (5.1)	14 (1.4)	26 (2.6)	1 (0.1)	387 (38.7)	
Mucous retention cyst (%)	6 (0.6)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	6 (0.6)	
Calcification (%)	1 (0.1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (0.1)	
Total (%)	671 (67.1)	139 (13.9)	58 (5.8)	60 (6)	17 (1.7)	47 (4.7)	8 (0.8)	1000 (100)	

P<0.05 is considered to be significant. RCT=Randomized clinical trials

Table 3: Relationship between odontogenic pathology and maxillary sinusitis

Sinusitis classification	Odontogenic pathology							Total	*P*
	No lesion	Extraction	RCT	Periodontitis	Granuloma/abcess	Carious	Restoration		
Healthy (%)	459 (45.9)	69 (6.9)	27 (2.7)	9 (0.9)	3 (0.3)	19 (1.9)	7 (0.7)	593 (59.3)	0.000
Odontogenic (%)	6 (0.6)	2 (0.2)	4 (0.4)	16 (1.6)	6 (0.6)	4 (0.4)	0 (0)	38 (3.8)	
Nonodontogenic (%)	186 (18.6)	63 (6.3)	19 (1.9)	2 (0.2)	0 (0)	2 (0.2)	1 (0.1)	273 (27.3)	
Undetermined (%)	20 (2)	5 (0.5)	8 (0.8)	33 (3.3)	8 (0.8)	22 (2.2)	0 (0)	96 (9.6)	
Total (%)	671 (67.1)	139 (13.9)	58 (5.8)	60 (6)	17 (1.7)	47 (4.7)	8 (0.8)	1000 (100)	

P<0.05 is considered to be significant. RCT=Randomized clinical trials

Table 4: Relationship between the maxillary sinus pathology and the tooth apex relation to the floor of the sinus

Apex classification	Sinus pathology				Total	*P*
	Healthy	Sinusitis	Mucous retention cyst	Calcification		
A	113 (11.3)	56 (5.6)	0 (0)	0 (0)	169 (16.9)	0.001
B	455 (45.5)	290 (29)	3 (0.3)	1 (0.1)	749 (74.9)	
C	38 (3.8)	41 (4.1)	3 (0.3)	0 (0)	82 (8.2)	
Total (%)	606 (60.6)	387 (38.7)	6 (0.6)	1 (0.1)	1000 (100)	

P<0.05 is considered to be significant

Table 5: Relationship between the maxillary sinus pathology and the relation of the periapical pathology to the floor of the maxillary sinus

Lesion classification	Sinus pathology				Total	*P*
	Healthy	Sinusitis	Mucous retention cyst	Calcification		
No lesion	453 (45.3)	179 (17.9)	6 (0.6)	1 (0.1)	639 (63.9)	0.000
I	125 (12.5)	145 (14.5)	0 (0)	0 (0)	270 (27)	
II	18 (1.8)	36 (3.6)	0 (0)	0 (0)	54 (5.4)	
III	10 (1)	27 (2.7)	0 (0)	0 (0)	37 (3.7)	
Total (%)	606 (60.6)	387 (38.7)	6 (0.6)	1 (0.1)	1000 (100)	

P<0.05 is considered to be statistically significant

maxillary sinus is not completely developed before the age of 12 years.[33] Two-dimensional (2D) imaging has a very limited diagnostic value in identifying maxillary sinusitis because the radiologic signs are nonspecific. Carious lesions and periapical radiolucencies can be appreciated in Intraoral Periapical Radiograph (IOPAR) because periapical radiograph has a higher spatial resolution.[34] However, such lesions must attain considerable size to be seen periapical radiograph.[35,36] Whereas panoramic radiographs have a lower sensitivity than IOPAR in identifying periapical lesions.[37] 3D-computed tomography is considered to be the most acceptable method for visualization of nasal and paranasal sinuses. As it has a higher contrast resolution and eliminates, the superposition of anatomical structures.[38] Thus, 2D imaging is of little or no use for accurate morphometric assessment.[39] 3D-imaging overcomes the 2D limitations by providing multiplanar views with no magnifications, superimpositions, and distortions.[40] Panoramic studies have demonstrated the root-maxillary sinus relationship in 39%–57% of the cases.[41,42] With due advancement in 3D imaging the prevalence of root apices protruding into the maxillary sinus ranges from 5% to 10%.[24,39,40]

In the present study, when the tip of tooth root was in contact with the floor of maxillary sinus, the incidence of mucosal thickening was lower than when the tip of root exceeded and protruded within the floor of the maxillary sinus. This finding was in accordance with the study done by Lu *et al*.[11] There is histological evidence of a thin cortical bone surrounding the maxillary sinus with perforation present in 14%–28% of the cases.[41] Due to this perforation or absence of thin layers of cortical bone, the periodontal tissues are in direct contact with the maxillary sinus mucosa. The knowledge of which is essential for planning dental treatment. Many researchers have found out that an odontogenic irritation may be potentially influenced by the proximity between roots of the teeth with periapical lesions and floor of sinus.[32,43,44] CBCT increases the accuracy of detecting periapical lesions when compared to conventional imaging modalities.[36,45]

However, the interpretation of CBCT must be carried out cautiously as incipient and chronic periapical lesions detected by a CBCT examination might present low potential for identifying sinus inflammatory signs and symptoms. CBCT is far superior to multislice CT in terms of image resolutions, as thinner sections can be achieved. Apart from that CBCT equipment have reduced radiation exposures and a low equipment cost when compared to multi-slice CT.[10]

Some studies have shown that the root of the 2nd maxillary molar is closest to sinus.[36,46] It was found out that Mesio-Buccal root of maxillary 2nd molar is on average 0.67 mm closer to the sinus than the palatal root of maxillary 1st molar.[39] This finding was consistent with the present study as well. On the contrary, it is the palatal root of the maxillary 1st molar that is most commonly associated with maxillary sinusitis as it is the first permanent maxillary molar to erupt into the oral cavity.[8,47]

Distinguishing a healthy and a diseased sinus radiographically is not so problematic keeping into consideration its shape, loci, and lobulations. Because the sinus it is air-filled, the sinus appears radiolucent and has clearly defined margins.[4] In case of diseased sinus; a clinician may easily identify clouding (opacifications), mucosal thickening and or accumulation of fluid.[48] Previous studies have suggested the thickness of the mucosal lining of the sinus to be in the range from 2 to 6 mm.[32,47,49-52] However, the study done by Maillet *et al*., the average amount of mucosal thickening was 7.4 mm.[9] The current investigation was a retrospective study of existing scans only and did not include patient symptoms, or the reasons for the referral for CBCT scans. Maillet *et al*. in their study found 75% prevalence of maxillary sinusitis associated with dental conditions.[9] According to previous studies, there is a definitive odontogenic cause for diseased maxillary sinus of which apical periodontitis accounts for 83% of all cases. Furthermore, the prevalence of other sinus disorders such as mucosal thickening, mucous retention cyst, and odontogenic maxillary sinusitis ranges from 8% to 29%, 2%–36%, and 10%–86%, respectively.[53-56]

Table 6: Literature search of odontogenic sinusitis

Reference number	Author	Year	Article	Number of cases	Type of study	Imaging	Conclusion
[8]	Arias-Irimia *et al*.	2010	Meta-analysis of the etiology of odontogenic maxillary sinusitis	770 cases	Retrospective	Literature	The principal etiological factor is extraction
[9]	Maillet *et al*.	2011	CBCT evaluation of maxillary sinusitis	82 cbcts	Retrospective	CBCT	Changes in the maxillary sinuses appear associated with periapical pathology in >50% of the cases. Maxillary first or second molar teeth are most often involved, and individual or multiple roots may be implicated in the sinusitis. The use of CBCT scans can provide the identification of changes in the maxillary sinus and potential causes of the sinusitis
[10]	Brüllmann *et al*.	2012	Correlation of CBCT findings in the maxillary sinus with dental diagnoses: A retrospective cross-sectional study	204 patients	Cross-sectional	CBCT	CBCT examinations revealed a correlation between basal mucosal thickening in the maxillary sinus and decayed posterior maxillary teeth or periodontitis
[11]	Lu *et al*.	2012	Associations between maxillary sinus mucosal thickening and apical periodontitis using CBCT scanning: A retrospective study	372 patients	Retrospective	CBCT	A retrospective inspection of CBCT images revealed that the prevalence and severity of maxillary sinus mucosal thickening were positively associated with the degree of apical periodontitis
[12]	Rege *et al*.	2012	The occurrence of maxillary sinus abnormalities detected by cone beam CT in asymptomatic patients	1113 cbcts	Retrospective	CBCT	No association was observed between the proximity of periapical lesions and the presence and type of inflammatory abnormalities (P=0.124)
[13]	Shanbhag *et al*.	2013	Association between periapical lesions and maxillary sinus mucosal thickening: a retrospective cone-beam computed tomographic study	243 patients	Retrospective	CBCT	Maxillary sinuses are significantly influenced by various odontogenic conditions, including periodontal bone loss, periapical lesions, and missing teeth, which may result in thickening of the maxillary sinus mucosa
[14]	Dobele *et al*.	2013	Radiographic assessment of findings in the maxillary sinus using CBCT	34 patients	Retrospective	CBCT	Anatomic variations and lesions of the maxillary sinus were common findings in CBCT examinations of the maxilla required for dental preprosthetic planning. Routine CBCT scans, including maxillary sinus ostium, are recommended for risk assessment before surgery
[15]	Pokorny and Tataryn	2013	Clinical and radiologic findings in a case series of maxillary sinusitis of dental origin	67 patients	Retrospective	CT	Radiographic CT findings of MSDO showed periapical abscess in 18 cases (55%), periodontal abscess in 3 cases (9%), and no obvious dental pathology in 12 cases (36%)
[16]	Shiki *et al*.	2014	The significance of CBCT for the visualization of anatomical variations and lesions in the maxillary sinus for patients hoping to have dental implant-supported maxillary restorations in a private dental office in Japan	61 pairs	Retrospective	CBCT and Panoramic radiograph	The detection rate of mucosal thickening was significantly higher in the Implant group than in the nonimplant group. The detection rates for the features analyzed were significantly lower on panoramic radiographs

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Table 6: Contd...

Reference number	Author	Year	Article	Number of cases	Type of study	Imaging	Conclusion
[17]	Saibene *et al*.	2014	Redefining boundaries in odontogenic sinusitis: a retrospective evaluation of extramaxillary involvement in 315 patients	315 patients	Retrospective	CT	It is unclear whether disease in the maxillary sinus contralateral to the primary maxillary sinus demonstrating odontogenic-induced disease is incidental, associated, or represents a subclinical odontogenic infection
[18]	Block and Dastoury	2014	Prevalence of sinus membrane thickening and association with unhealthy teeth: A retrospective review of 831 consecutive patients with 1662 cone-beam scans	831 patients	Retrospective	CBCT	Of the 469 sinuses with membrane thickening, 210 were adjacent to unhealthy teeth, 233 were adjacent to healthy teeth, and 26 were in edentulous maxilla. Of the 210 unhealthy teeth, 30 had postextraction CBCT scans available for evaluation
[19]	von Arx *et al*.	2014	The proximity of premolar roots to maxillary sinus: A radiographic survey using CBCT	192 patients	Retrospective	CBCT	Based on the calculated mean distances of the present study, only few premolars (and if so second premolars) would present a risk of violating the border of the maxillary sinus during conventional or surgical endodontic treatment or in case of tooth extraction
[20]	Matsumoto *et al*.	2015	Association between odontogenic infections and unilateral sinus opacification	190 patients	Retrospective	CT, OP, EPT	The most common cause of unilateral paranasal sinusitis was odontogenic infection, as seen in 138 cases (72.6%), followed by chronic inflammation in 43 cases (22.6%). Among patients diagnosed with odontogenic infection, one patient was also diagnosed with coexistent polyps and mycosis. Based on CT, OP, EPT, and oral examination, final distribution was 138 patients (72.6%) in Group A, 32 (16.8%) in Group B, and 20 (10.5%) in Group C
[21]	Malina-Altzinger *et al*.	2015	Evaluation of the maxillary sinus in panoramic radiography-a comparative study	54 cases	Retrospective	OPG CBCT	There is a moderate risk for false diagnosis of findings of the maxillary sinus if only panoramic radiography is used. Based on the ten predefined conditions, solely maxillary bone cysts penetrating into the sinus were frequently detected differently comparing 2D-3D diagnostics. Additionally, on panoramic radiographs, the inter-observer comparison demonstrated that basal septa were significantly often rated differently and the intra-observer comparison showed a significant lack in reliability in detecting maxillary bone cysts penetrating into the sinus

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Table 6: Contd...

Reference number	Author	Year	Article	Number of cases	Type of study	Imaging	Conclusion
[22]	Shahbazian *et al*.	2015	Comparative assessment of periapical radiography and CBCT imaging for radiodiagnostics in the posterior maxilla	145 patients	Retrospective	CBCT IOPA	The results of this study demonstrated that periapical radiographs are not adequate in observing the anatomical relationship between maxillary molars and the sinus floor. CBCT showed an intimate relationship of 1st and 2nd molar with the maxillary sinus in 50 and 45% of the cases, respectively. Periapical radiography could only spot approximately 40% of apical periodontitis on posterior maxillary teeth and 3% of all apical infections extending to the sinus, seen on CBCT
[23]	Tian *et al*.	2016	An analysis of the proximity of maxillary posterior teeth to the maxillary sinus using CBCT	848 patients	Retrospective	CBCT	Cone-beam computed tomographic imaging is an effective method to study the position of the posterior roots to the maxillary sinus floor. Variation in proximity measurements was found by age, with those under the age of 40 showing a greater likelihood of the position of maxillary roots above/ inside the sinus floor
[24]	Roque-Torres *et al*.	2016	Association between maxillary sinus pathologies and healthy teeth	109 patients	Retrospective	CBCT	Dental roots in the maxillary sinus are almost twice as likely to be associated with diseased sinuses than normal sinuses. Healthy teeth whose roots are inside the maxillary sinus may induce an inflammatory response in the sinus membrane. It is suspected that dental procedures may exacerbate the condition
[25]	Schreindorfer *et al*.	2017	Maxillary sinusitis as a diagnostical adverse finding of the dental CBCT study	170 cases	Retrospective	CBCT	During the present study, the upper first molars palatal and the second molars mesiobuccal roots were mainly associated with maxillary odontogenic sinusitis
[26]	Zirk *et al*.	2017	Odontogenic sinusitis maxillaris: A retrospective study of 121 cases with surgical intervention	121 patients	Retrospective	CBCT	69 out of 121 cases of OMS occurred after dental surgery (extractions, augmentation or implant surgery)
[27]	Ata-Ali *et al*.	2017	What is the frequency of anatomical variations and pathological findings in maxillary sinuses among patients subjected to maxillofacial CBCT? A systematic review	23 studies 11971 patients	Retrospective	CBCT	Although the main indication of CBCT of the maxillary sinus in dentistry is sinus floor elevation/treatment planning and evaluation before dental implant placement, this imaging modality is increasingly also used for endodontic and periodontal purposes
[28]	Dau *et al*.	2017	Evaluation of symptomatic maxillary sinus pathologies using panoramic radiography and CBCT - influence of professional training	28 patients	Retrospective	CBCT PAN	PAN alone is not sufficient for the evaluation of pathologies of the maxillary sinus. But, depending on the examiners' clinical experience, it remains a useful diagnostic tool. Along with the observers' training, significant benefits of an additional sFOV-CBCT for evaluation of symptomatic maxillary sinus pathologies were detected

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Table 6: Contd...

Reference number	Author	Year	Article	Number of cases	Type of study	Imaging	Conclusion
[29]	Vestin Fredriksson *et al*.	2017	When Maxillary Sinusitis Does Not Heal: Findings on CBCT scans of the Sinuses with a particular focus on the occurrence of odontogenic causes of maxillary sinusitis	303 sinuses	Retrospective	CBCT	The present study confirms the close relationship between odontogenic infections and unilateral maxillary sinusitis
[30]	Aksoy and Orhan	2018	Association between odontogenic conditions and maxillary sinus mucosal thickening: a retrospective CBCT study	294 patients	Retrospective	CBCT	Multiple conditions, including periapical infection, root canal treatment, and close relationship maxillary teeth and sinus, may have a precursor effect on the occurrence of mucosal thickening in the maxillary sinus. Periodontal status and its role as a risk factor in triggering maxillary sinus infections should be also considered not only by dental professionals but also the medical professionals to plan for the treatment of maxillary sinus lesions
[31]	Little *et al*.	2018	Odontogenic sinusitis: A review of the current literature	PubMed literature	Retrospective	Literature	Odontogenic sinusitis is an inflammatory condition of the paranasal sinuses that is the result of dental pathology, most often resulting from prior dentoalveolar procedures, infections of maxillary dentition, or maxillary dental trauma

CBCT=Cone beam computed tomography, OP/OPG/PAN=Panoramic radiography, CT/CT Scan=Conventional computed tomography, EPT=Electric pulp testing, IOPA=Intraoral periapical radiograph, MSDO=Maxillary sinus disorders

In a study done by Cha *et al*. they found various abnormalities of maxillary sinus such as acute sinusitis with a prevalence of 7.5%, retention cyst with a prevalence of 3.5% and polypoid mucosal thickening in 2.3% of the cases, respectively.[57] In addition, in previous studies, the prevalence of flat mucosal thickening of the maxillary sinus ranged from 23.7% to 38.1%, polypoid mucosal thickening ranged from 6.5% to 19.4%, acute maxillary sinusitis 3.6%, partial opacification of maxillary sinus 12%, and total opacification of maxillary sinus 7%, respectively.[58,59] Several authors have reported that around 10%–12% of the total maxillary sinus pathology has an odontogenic cause.[4,50,60] In the present study, 51.8% of the participants had odontogenic sinusitis, whereas 65.4% of the total participants had a diseased maxillary sinus along with periapical lesions. This was in accordance with the previously computed tomography studies that demonstrated around 71%–86% of sinus infections have an odontogenic cause.[47]

Several studies have reported a great variability in the prevalence of incidental findings in the maxillary sinus of asymptomatic subjects when multiplanar images are used. Multislice CT scan studies have found abnormalities in the maxillary sinus in 30% of the cases.[61,62] Whereas, CBCT studies have found abnormalities in maxillary sinus in 24.6% to 56.3% of the cases.[57-59] In the present study, the prevalence of abnormalities in the maxillary sinus was 39.4% which was in accordance with the previous studies. However, a study done by Rege *et al*. the prevalence was as high as 68.3%.[12] The discrepancy could be due to the sampling criteria selected for the study, the study design, variations in image interpretation, diagnostic criteria for maxillary sinusitis, and the influence of the climate in different geographical areas.[63,64]

Conclusion

The incidence of odontogenic sinusitis is likely under-reported in the available literature. Radiographic analysis plays a pivotal role in the diagnosis of odontogenic sinusitis. It has been established in the published literature that 2D-imaging modalities may obscure the origin of odontogenic maxillary sinusitis. The introduction of low-dose CBCT is particularly useful to establish a definitive diagnosis to augment in the treatment of chronic maxillary sinusitis of odontogenic origin.

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Conflicts of interest

There are no conflicts of interest.

References

1. Radman WP. The maxillary sinus; Revisited by an endodontist. J Endod 1983;9:382-3.
2. Watzek G, Bernhart T, Ulm C. Complications of sinus perforations and their management in endodontics. Dent Clin North Am 1997;41:563-83.
3. Low KM, Dula K, Bürgin W, von Arx T. Comparison of periapical radiography and limited cone-beam tomography in posterior maxillary teeth referred for apical surgery. J Endod 2008;34:557-62.
4. Maloney PL, Doku HC. Maxillary sinusitis of odontogenic origin. J Can Dent Assoc (Tor) 1968;34:591-603.
5. Bauer W. Maxillary sinusitis of dental origin. Am J Orthod Oral Surg 1943;29:133-513.
6. Bogaerts P, Hanssens JF, Siquet JP. Healing of maxillary sinusitis of odontogenic origin following conservative endodontic retreatment: Case reports. Acta Otorhinolaryngol Belg 2003;57:91-7.
7. Abrahams JJ, Glassberg RM. Dental disease: A frequently unrecognized cause of maxillary sinus abnormalities? AJR Am J Roentgenol 1996;166:1219-23.
8. Arias-Irimia O, Barona-Dorado C, Santos-Marino JA, Martínez-Rodriguez N, Martínez-González JM. Meta-analysis of the etiology of odontogenic maxillary sinusitis. Med Oral Patol Oral Cir Bucal 2010;15:e70-3.
9. Maillet M, Bowles WR, McClanahan SL, John MT, Ahmad M. Cone-beam computed tomography evaluation of maxillary sinusitis. J Endod 2011;37:753-7.
10. Brüllmann DD, Schmidtmann I, Hornstein S, Schulze RK. Correlation of cone beam computed tomography (CBCT) findings in the maxillary sinus with dental diagnoses: A retrospective cross-sectional study. Clin Oral Investig 2012;16:1023-9.
11. Lu Y, Liu Z, Zhang L, Zhou X, Zheng Q, Duan X, *et al.* Associations between maxillary sinus mucosal thickening and apical periodontitis using cone-beam computed tomography scanning: A retrospective study. J Endod 2012;38:1069-74.
12. Rege IC, Sousa TO, Leles CR, Mendonça EF. Occurrence of maxillary sinus abnormalities detected by cone beam CT in asymptomatic patients. BMC Oral Health 2012;12:30.
13. Shanbhag S, Karnik P, Shirke P, Shanbhag V. Association between periapical lesions and maxillary sinus mucosal thickening: A retrospective cone-beam computed tomographic study. J Endod 2013;39:853-7.
14. Dobele I, Kise L, Apse P, Kragis G, Bigestans A. Radiographic assessment of findings in the maxillary sinus using cone-beam computed tomography. Stomatologija 2013;15:119-22.
15. Pokorny A, Tataryn R. Clinical and radiologic findings in a case series of maxillary sinusitis of dental origin. Int Forum Allergy Rhinol 2013;3:973-9.
16. Shiki K, Tanaka T, Kito S, Wakasugi-Sato N, Matsumoto-Takeda S, Oda M, *et al.* The significance of cone beam computed tomography for the visualization of anatomical variations and lesions in the maxillary sinus for patients hoping to have dental implant-supported maxillary restorations in a private dental office in Japan. Head Face Med 2014;10:20.
17. Saibene AM, Pipolo GC, Lozza P, Maccari A, Portaleone SM, Scotti A, *et al.* Redefining boundaries in odontogenic sinusitis: A retrospective evaluation of extramaxillary involvement in 315 patients. Int Forum Allergy Rhinol 2014;4:1020-3.
18. Block MS, Dastoury K. Prevalence of sinus membrane thickening and association with unhealthy teeth: A retrospective review of 831 consecutive patients with 1,662 cone-beam scans. J Oral Maxillofac Surg 2014;72:2454-60.
19. von Arx T, Fodich I, Bornstein MM. Proximity of premolar roots to maxillary sinus: A radiographic survey using cone-beam computed tomography. J Endod 2014;40:1541-8.
20. Matsumoto Y, Ikeda T, Yokoi H, Kohno N. Association between odontogenic infections and unilateral sinus opacification. Auris Nasus Larynx 2015;42:288-93.
21. Malina-Altzinger J, Damerau G, Grätz KW, Stadlinger PD. Evaluation of the maxillary sinus in panoramic radiography – A comparative study. Int J Implant Dent 2015;1:17.
22. Shahbazian M, Vandewoude C, Wyatt J, Jacobs R. Comparative assessment of periapical radiography and CBCT imaging for radiodiagnostics in the posterior maxilla. Odontology 2015;103:97-104.
23. Tian XM, Qian L, Xin XZ, Wei B, Gong Y. An analysis of the proximity of maxillary posterior teeth to the maxillary sinus using cone-beam computed tomography. J Endod 2016;42:371-7.
24. Roque-Torres GD, Ramirez-Sotelo LR, Vaz SL, Bóscolo SM, Bóscolo FN. Association between maxillary sinus pathologies and healthy teeth. Braz J Otorhinolaryngol 2016;82:33-8.
25. Schreindorfer K, Kiss Á, Marada G. Maxillary sinusitis as a diagnostical adverse finding of the dental cone-beam computed tomography study. Orv Hetil 2017;158:1747-53.
26. Zirk M, Dreiseidler T, Pohl M, Rothamel D, Buller J, Peters F, *et al.* Odontogenic sinusitis maxillaris: A retrospective study of 121 cases with surgical intervention. J Craniomaxillofac Surg 2017;45:520-5.
27. Ata-Ali J, Diago-Vilalta JV, Melo M, Bagán L, Soldini MC, Di-Nardo C, *et al.* What is the frequency of anatomical variations and pathological findings in maxillary sinuses among patients subjected to maxillofacial cone beam computed tomography? A systematic review. Med Oral Patol Oral Cir Bucal 2017;22:e400-9.
28. Dau M, Marciak P, Al-Nawas B, Staedt H, Alshiri A, Frerich B, *et al.* Evaluation of symptomatic maxillary sinus pathologies using panoramic radiography and cone beam computed tomography-influence of professional training. Int J Implant Dent 2017;3:13.
29. Vestin Fredriksson M, Öhman A, Flygare L, Tano K. When maxillary sinusitis does not heal: Findings on CBCT scans of the sinuses with a particular focus on the occurrence of odontogenic causes of maxillary sinusitis. Laryngoscope Investig Otolaryngol 2017;2:442-6.
30. Aksoy U, Orhan K. Association between odontogenic conditions and maxillary sinus mucosal thickening: A retrospective CBCT study. Clin Oral Investig 2019;23:123-31.
31. Little RE, Long CM, Loehrl TA, Poetker DM. Odontogenic sinusitis: A review of the current literature. Laryngoscope Investig Otolaryngol 2018;3:110-4.
32. Vallo J, Suominen-Taipale L, Huumonen S, Soikkonen K, Norblad A. Prevalence of mucosal abnormalities of the maxillary sinus and their relationship to dental disease in panoramic radiography: Results from the health 2000 health examination survey. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2010;109:e80-7.
33. Diament MJ, Senac MO Jr., Gilsanz V, Baker S, Gillespie T, Larsson S, *et al.* Prevalence of incidental paranasal sinuses opacification in pediatric patients: A CT study. J Comput Assist Tomogr 1987;11:426-31.
34. Boeddinghaus R, Whyte A. Current concepts in maxillofacial imaging. Eur J Radiol 2008;66:396-418.
35. Bender IB, Seltzer S. Roentgenographic and direct observation of experimental lesions in bone: II 1961. J Endod 2003;29:707-12.
36. Van Assche N, Jacobs R, Coucke W, van Steenberghe D, Quirynen M. Radiographic detection of artificial intra-bony defects in the edentulous area. Clin Oral Implants Res 2009;20:273-9.
37. Estrela C, Bueno MR, Leles CR, Azevedo B, Azevedo JR. Accuracy of cone beam computed tomography and panoramic and periapical radiography for detection of apical periodontitis. J Endod 2008;34:273-9.
38. White S, Pharaoh M. Advanced imaging modalities. Oral Radiology: Principles and Interpretation. 6th ed., Ch. 13. St. Louis: Mosby; 2009. p. 207-24.

39. Eberhardt JA, Torabinejad M, Christiansen EL. A computed tomographic study of the distances between the maxillary sinusfloor and the apices of the maxillary posterior teeth. Oral SurgOral Med Oral Pathol 1992;73:345-6.
40. Kilic C, Kamburoglu K, Yuksel SP, Ozen T. An assessment of the relationship between the maxillary sinus floor and the maxillary posterior teeth root tips using dental cone-beam computerized tomography. Eur J Dent 2010;4:462-7.
41. Sharan A, Madjar D, Hashomer T. Correlation between maxillary sinus floor topography and related root position of posterior teeth using panoramic and cross-sectional computed tomography imaging. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2006;102:375-81.
42. Wehrbein H, Diedrich P. The initial morphological state in the basally pneumatized maxillary sinus – A radiological-histological study in man. Fortschr Kieferorthop 1992;53:254-62.
43. Mehra P, Jeong D. Maxillary sinusitis of odontogenic origin. Curr Allergy Asthma Rep 2009;9:238-43.
44. Hauman CH, Chandler NP, Tong DC. Endodontic implications of the maxillary sinus: A review. Int Endod J 2002;35:127-41.
45. Lofthag-Hansen S, Huumonen S, Gröndahl K, Gröndahl HG. Limited cone-beam CT and intraoral radiography for the diagnosis of periapical pathology. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2007;103:114-9.
46. Nogi T, Kanazawa E. Morphometry of the maxillary sinus and the relationship between the sinus base and the tooth roots. J Oral Sci 2001;27:227-34.
47. Obayashi N, Ariji Y, Goto M, Izumi M, Naitoh M, Kurita K, *et al.* Spread of odontogenic infection originating in the maxillary teeth: Computerized tomographic assessment. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2004;98:223-31.
48. Thunthy KH. Diseases of the maxillary sinus. Gen Dent 1998;46:160-5.
49. Carmeli G, Artzi Z, Kozlovsky A, Segev Y, Landsberg R. Antral computerized tomography pre-operative evaluation: Relationship between mucosal thickening and maxillary sinus function. Clin Oral Implants Res 2011;22:78-82.
50. Mehra P, Murad H. Maxillary sinus disease of odontogenic origin. Otolaryngol Clin North Am 2004;37:347-64.
51. Lim WK, Ram B, Fasulakis S, Kane KJ. Incidental magnetic resonance image sinus abnormalities in asymptomatic Australian children. J Laryngol Otol 2003;117:969-72.
52. Gordts F, Clement PA, Destryker A, Desprechins B, Kaufman L. Prevalence of sinusitis signs on MRI in a non-ENT paediatric population. Rhinology 1997;35:154-7.
53. Melén I, Lindahl L, Andréasson L, Rundcrantz H. Chronic maxillary sinusitis. Definition, diagnosis and relation to dental infections and nasal polyposis. Acta Otolaryngol 1986;101:320-7.
54. Engström H, Chamberlain D, Kiger R, Egelberg J. Radiographic evaluation of the effect of initial periodontal therapy on thickness of the maxillary sinus mucosa. J Periodontol 1988;59:604-8.
55. Bhattacharyya N. Do maxillary sinus retention cysts reflect obstructive sinus phenomena? Arch Otolaryngol Head Neck Surg 2000;126:1369-71.
56. Mathew AL, Pai KM, Sholapurkar AA. Maxillary sinus findings in the elderly: A panoramic radiographic study. J Contemp Dent Pract 2009;10:E041-8.
57. Cha JY, Mah J, Sinclair P. Incidental findings in the maxillofacial area with 3-dimensional cone-beam imaging. Am J Orthod Dentofacial Orthop 2007;132:7-14.
58. Pazera P, Bornstein MM, Pazera A, Sendi P, Katsaros C. Incidental maxillary sinus findings in orthodontic patients: A radiographic analysis using cone-beam computed tomography (CBCT). Orthod Craniofac Res 2011;14:17-24.
59. Ritter L, Lutz J, Neugebauer J, Scheer M, Dreiseidler T, Zinser MJ, *et al.* Prevalence of pathologic findings in the maxillary sinus in cone-beam computerized tomography. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2011;111:634-40.
60. Brook I. Sinusitis of odontogenic origin. Otolaryngol Head Neck Surg 2006;135:349-55.
61. Diament MJ, Senac MO, Gilsanz V, Baker S, Gillespie T, Larsson S. Prevalence of incidental paranasal sinuses opacification in pediatric patients: a CT study. J Comput Assist Tomogr 1987;11:426-31.
62. Havas TE, Motbey JA, Gullane PJ. Prevalence of incidental abnormalities on computed tomographic scans of the paranasal sinuses. Arch Otolaryngol Head Neck Surg 1988;114:856-9.
63. Bolger WE, Butzin CA, Parsons DS. Paranasal sinus bony anatomic variations and mucosal abnormalities: CT analysis for endoscopic sinus surgery. Laryngoscope 1991;101:56-64.
64. Rodrigues CD, Freire GF, Silva LB, Fonseca da Silveira MM, Estrela C. Prevalence and risk factors of mucous retention cysts in a Brazilian population. Dentomaxillofac Radiol 2009;38:480-3.