ACTA SCIENTIFIC DENTAL SCIENCES (ISSN: 2581-4893)

Volume 4 Issue 7 July 2020

Research Article

Prevalence of Odontogenic-Related Maxillary Sinus Pathologies in an United States Dental School Population

Yueh Ju Hsiao[1]*, Shang Lun (Allen) Liu[2], Jie Yang[3], Randolph R Resnik[4] and Jon B Suzuki[5]

[1]Assistant Professor in the Department of Periodontology and Oral Implantology, Temple University Kornberg School of Dentistry, Philadelphia, Pennsylvania, USA

[2]Periodontist, Private Practice, Federal Way, Washington, USA

[3]Professor and Director of Oral and Maxillofacial Radiology, Temple University Kornberg School of Dentistry, Philadelphia, Pennsylvania, USA

[4]Adjunct Clinical Professor, Department of Periodontology and Oral Implantology, Temple University Kornberg School of Dentistry, Philadelphia, Pennsylvania, USA

[5]Professor, Department of Periodontology and Oral Implantology, Temple University Kornberg School of Dentistry, Philadelphia, Pennsylvania, USA

***Corresponding Author:** Yueh Ju Hsiao, Assistant Professor in the Department of Periodontology and Oral Implantology, Temple University Kornberg School of Dentistry, Philadelphia, Pennsylvania, USA.

Received: June 02, 2020

Published: June 16, 2020

Abstract

Objectives: Odontogenic-related maxillary sinus pathologies are identified in cone beam computerized tomography taken for maxillary sinus augmentation and dental implant therapies. The purpose of this study is to determine the prevalence of odontogenic-related maxillary sinus pathologies among a dental school population.

Materials and Methods: Eight hundred and twenty-one patients were retrospectively evaluated for odontogenic-related maxillary sinus pathologies using cone beam computed tomography (CBCT). Age, gender, ethnicity, and dentition status were evaluated to determine potential relationships of the presence of odontogenic-related sinus pathologies.

Results: Among 534 CBCT scans, 331 scans presented without sinus pathology bilaterally and 203 scans presented with sinus pathologies in one or both sinuses. 79 scans presented with odontogenic-related maxillary sinus pathologies. The most frequent observations were mucosal thickening. The tooth most frequently associated with pathologic findings were first molars followed by second molars. The findings were higher in males than females ($p = 0.006$). Age and ethnicity was not a significant factor ($p = 0.10$, $p = 0.05$). Dentition status showed root canals (34.65%) were the most commonly associated with pathology.

Conclusion: The prevalence of odontogenic-related maxillary sinus pathology was found in 36% of sinuses. Identification and management of odontogenic pathologies are essential to minimize complications. CBCT is highly recommended as a diagnostic tool prior to lateral wall maxillary sinus augmentation surgery and implant placement. Management of odontogenic-related maxillary sinus pathologies need to be tailored to individual patients and involves varying combinations of medical and dental management.

Keywords: Cone Beam Computed Tomography; Maxillary Sinus Pathologies; Maxillary Sinusitis; Odontogenic Sinusitis

Introduction

The use of cone beam computerized tomography (CBCT) has increased for diagnosis and treatment planning of complex dento-maxillofacial rehabilitation. The expanded diagnostic information provided by CBCT provides clinicians with a powerful tool to expand current knowledge of patient anatomy and potential anomalies/pathologies prior to sinus augmentation for dental implant therapies.

The sinus membrane is lined by the Schneiderian membrane which is composed of pseudo-stratified columnar ciliated epithelium. Normal Schneiderian membrane thickness ranges from 0.13 to 0.5 mm histologically. The membrane can undergo thickening due to various etiologies. Minimal mucosal thickening less than 3 mm is thought to be a normal variant and possibly a function of the physiologic nasal cycle. Minimal thickening is not clinically sig-

nificance in asymptomatic patients. Otolaryngology consultation is advisable when membrane thickenings of more than 3 to 4 mm are identified [1,2].

There are six general categories of maxillary sinus pathology that have been described in the literature: 1) Inflammatory lesions, 2) Cystic conditions, 3) Neoplasms, 4) Developmental, 5) Calcification, and 6) Traumatic [3]. Inflammatory lesions are the most common category of maxillary sinus pathology. They can be divided into acute, chronic rhinosinusitis or allergic sinusitis. Etiologies may be derived from odontogenic and/or non-odontogenic sources. Ly and Hellgren 2018 [4] evaluated 1338 patients with sinusitis in Ear-nose and throat (ENT) clinic. and found 48% with odontogenic maxillary sinusitis. The proximity of Schneiderian membrane may irritated by odontogenic origins of periapical damages, periapical infection, root canal treatment, periodontitis, dental trauma, or iatrogenic causes. An odontogenic infection is a polymicrobial aerobic-anaerobic infection, with anaerobes outnumbering the aerobes [5,6]. Management often consists of both sinus and related tooth therapies.

Non-odontogenic causes may be from viral, bacterial, fungal, and allergy sources. Rhinosinusitis was classified based on duration of symptoms such as acute (less than 4 weeks), subacute (4 - 12 weeks), or chronic (greater than 12 weeks) [7]. The acute form is typical of viral or bacterial infections of the upper respiratory tract. Chronic sinusitis consist of mainly anaerobic bacteria. Fungal infections are rarely found but cases of eosinophilic fungal rhinosinusitis has been reported. Allergic sinusitis is a form of allergy-induced inflammatory changes of the sinus membrane. Polyp formation may be noted and is usually multiple, smooth, rounded and radiopaque on the walls of the maxillary sinus. Polyps are commonly located near the ostium and are easily noted. Fungal sinusitis is more rare, often caused by aspergillosis, mucormycosis, or histoplasmosis. They may appear as mucosal thickenings to complete opacification depending on severity.

Cystic lesions are the next most common category after inflammatory conditions. Maxillary sinus cysts are clinically benign lesions and generally divided into two categories, secretory and non-secretory cysts. They are depicted radiographically as smooth homogenous, dome-shaped, round to ovoid and well defined radiopacities. Retention cysts differ in the presence of epithelial lining and are very small. Mucoceles often involve the entire sinus and are opacified. They may cause destruction of the mucosal lining. Maxillary cysts are well defined, radiolucent, and usually spherical.

Malignant tumors of the sinus are generally squamous cell carcinomas or adenocarcinomas. The radiographic appearance includes radiopaque masses, complete opacification, or bony wall destruction. On occasion, calcified masses are found within the walls of the maxillary sinus and are called anthroliths. The nidus of calcification may be extrinsic such as a foreign body in the sinus or intrinsic such as stagnant mucous or a fungal ball [8]. Radiographic features are well-delineated, smooth or irregular outlines of round ovoid radiopaque structure embedded within the mucoperiosteum with the sinus wall intact.

Using CBCT, Maillet 2011 [9] found that odontogenic sinusitis can be identified as localized thickening of the mucous membrane of the maxillary sinus associated with dental lesion. The study aims to expand current knowledge and evaluate the prevalence of odontogenic-related pathologies in the maxillary sinus in an United States dental school population. The study also evaluates whether age, gender, ethnicity, tooth condition and tooth position are associated with odontogenic-related maxillary sinus pathology.

Materials and Methods

The study was based on a retrospective evaluation of 821 CBCT scans taken over five years (2009 to 2013). The research was approved by the Temple University Institutional Review Board for Clinical Research (protocol No. 23455). The CBCT scans were all performed using the same imaging device (i-CAT Imaging Science International, Inc. Hatfield, PA, USA) with flat panel image detector. Images were taken at 120 kvp, 5 mA, and a voxel size of 0.3 mm, with an exposure time of 8.9 seconds. Fourteen (14) bits gray scales and 8.9 second scan times. The number of slices in one CBCT volume is 327.

These scans were screened based on the inclusion and exclusion criteria. Inclusion criteria required patients with partial and/or complete dentition age 18-90 years old with a CBCT scan attained during the five year periods including the maxillary sinus. Scans were excluded based on the following factors: completely edentulous patients, patients with only a mandibular CBCT scan, poor quality scans, patients with maxillary deficiency, and patients younger than 18 years old.

Based on the inclusion and exclusion criteria, 534 scans were selected for evaluation. The mean age of the included subjects was 53.61 years old. The participants included 286 females and 248 males. The race distribution included 352 Caucasian, 105 African American, 51 Asians and 26 Hispanics. The subjects were also categorized based on age into 8 groups of 25 subjects 18 - 19 years, 49

subjects 20 - 29 years, 30 subjects 30 - 39 years, 60 subjects 40 - 49 years,134 subjects 50 - 59 years, 158 subjects 60- 69 years, 64 subjects 70 - 79 years and 14 subjects 80 - 90 years. Group 1 to 5 were combined to group age < 60 and group 6 to 8 were combined to group age > 60.

CBCT images were viewed using i-CAT vision software to provide a panoramic reconstruction view module and an MPR screen module, i.e. axial, sagittal and coronal slides. All images were assessed under standardized conditions at the same examination workplace (Windows XP with Microsoft Office Software). Three trained examiners viewed each scan bilaterally for the presence of an intraosseous anastomosis on the lateral wall of the maxillary sinus in sagittal slices on the panoramic view.

The maxillary sinuses findings were categorized to various groups according to level and pattern of sinus opacification, Schneiderian membrane, and inflammation. The categories were healthy, mucosal thickening > 3 mm, polypoidal mucosal thickening, partial air/fluid level, and complete opacification (Figure 1). Patients who were categorized as healthy and ranged from 0 to 3 mm of mucosal thickening [1,2]. When the mucosal thickening was polypoidal in nature, the findings can be into small, large, single, multiple when pseudocysts or nasal polyps are present. The partial air and or fluid level category are findings with mucosal thickening, which displayed more than 50% of sinus opacification and the presence of air/fluid level. The complete opacification was noted when the sinus cavity was occupied with opacification high enough to block the ostium.

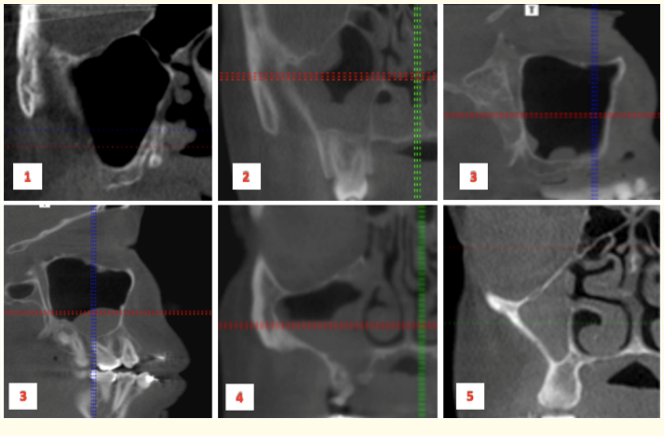

Figure 1: Classification of maxillary sinus findings (1: Heathy, 2: Mucosal thickening > 3 mm, 3: Polypoidal mucosal thickening which can be small/large, single or multiple, 4: Partial air/fluid level opacification and 5: Complete opacification).

Single or multiple teeth may be associated with sinus pathology. Tooth/teeth are associated with sinus pathologies with presence of caries, restorations, crowns without root canal therapy, root canal therapy with or without crowns, impaction, and non-restorable fracture root tip (Figure 2). In regards to tooth position, teeth found to be related to pathology were categorized into, 3rd molar, 2nd molar, 1st molar, 2nd premolar and 1st premolar.

Figure 2: Odontogenic-related maxillary sinus pathologies.

Data was recorded using Microsoft Excel spreadsheet and chi square test was used to determine if prevalence of odontogenic sinusitis statistically significant with age, gender and ethnicity.

Results

Of 534 CBCT scans, which were reviewed, 331 patients were healthy and the remaining 203 patients (38.01%) exhibited some evidence of maxillary sinus pathology in one or both sinuses. 287 of 1068 sinuses (26.87%) exhibited maxillary sinus pathology. Of 203 patients with sinus pathology, 43 patients had pathology present in both sinuses and 160 patients had either right or left sinus pathology (Table 1 and figure 3).

Out of the 287 sinuses with evidence of pathology, there were 167 sinuses with mucosal thickenings > 3 mm, 93 sinuses with polypoidal mucosal thickenings, 20 sinuses with opacification air or

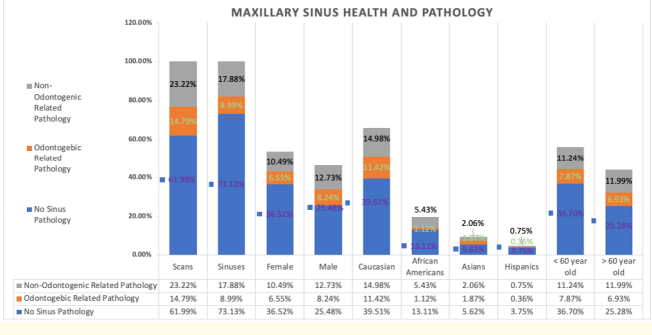

Figure 3: Maxillary sinus findings based on CBCT scans, sinuses, gender, ethnicity and age.

	No Sinus Pathology	Presence of Sinus Pathology	Odontogenic-related	Non-odontogenic-related	Total
CBCT scans/Subjects	331 (61.99%)	203 (38.01%)	79 (14.79%)	124 (23.22%)	534
Sinuses	781 (73.13%)	287 (26.87%)	96 (8.99%)	191 (17.88%)	1068
Female	195 (36.52%)	91 (17.04%)	35 (6.55%)	56 (10.49%)	286 (53.56%)
Male	136 (25.48%)	112 (20.96%)	44 (8.24%)	68 (12.73%)	248 (46.44%)
Caucasian	211 (39.51%)	141 (26.40%)	61 (11.42%)	80 (14.98%)	352 (65.92%)
African Americans	70 (13.11%)	35 (6.55%)	6 (1.12%)	29 (5.43%)	105 (19.66%)
Asians	30 (5.62%)	21 (3.93%)	10 (1.87%)	11 (2.06%)	51 (9.55%)
Hispanics	20 (3.75%)	6 (1.12%)	2 (0.36%)	4 (0.75%)	26 (4.87%)
18 - 19 year old	15	10	2	8	25
20 - 29 year old	36	13	4	9	49
30 - 39 year old	18	12	5	7	30
40 - 49 year old	39	21	13	8	60
50 to 59 year old	88	46	18	28	134
60 to 69 year old	86	72	28	44	158
70 to 79 year old	42	22	7	15	64
80 to 90 year old	7	7	2	5	14
< 60 year old	196 (36.70%)	102 (19.10%)	42 (7.87%)	60 (11.24%)	298 (55.81%)
> 60 year old	135 (25.28%)	101 (18.92%)	37(6.93%)	64 (11.99%)	236 (44.19%)

Table 1: Maxillary sinus findings based on subjects, sinuses, gender, ethnicity, and age.

fluid level > 50% and 7 sinuses with complete opacification. This translated to 58.19%, 32.40%, 6.97%, and 2.44% respectively for 4 categories.

Among 203 scans with sinus pathologies, 79 subjects (38.92%) presented with odontogenic-related sinus pathology. Among 287 sinuses with sinus pathology, 96 sinuses (33.45%) presented with odontogenic-related sinus pathologies and 191 sinuses (66.55%) presented with non-odontogenic-related sinus pathologies.

When categorizing in terms of gender, 195 females (36.52%) and 136 males (25.48%) presented with no sinus pathologies, and 91 (17.04%) females and 112 males (20.96%) presented with sinus pathologies. Among pathological findings, 32 females and 44 males presented with odontogenic-related sinus pathologies, and 56 females and 68 males presented with non-odontogenic-related sinus pathologies (Table 1 and figure 3) With chi square analysis, there is statistically significant between females and males ($p = 0.006$).

When categorizing the results in terms of ethnicity, 211 Caucasians (39.51%), 70 African Americans (13.11%), 30 Asians (5.62%) and 20 Hispanics (3.75%) presented with presented with no sinus pathologies and 141 Caucasians (26.40%), 35 African Americans (6.55%), 21 Asians (3.93%) and 6 Hispanics (1.12%) presented with presented with sinus pathologies. Among pathological findings, 61 Caucasians, 6 African Americans, 10 Asians and 2 Hispanics presented with odontogenic-related sinus pathologies (Table 1 and figure 3). With chi square analysis, there is no statistically significant between ethnicity ($p = 0.05$).

When categorizing the results in terms of age, 196 subjects (36.70%) for the groups < 60 year old and 135 subjects (25.28%) for the groups > 60 year old presented with no sinus pathologies, and 102 subjects (19.10%) < 60 year and 101 subjects (18.92%) > 60 year old presented with sinus pathologies. 42 subjects (7.87%) < 60 year and 37 subjects (6.93%) > 60 year old presented with odontogenic-related sinus pathologies (Table 1 and figure 3). With chi square analysis, there is no statistically significant difference between age ($p = 0.10$).

In terms of maxillary sinus findings, 781 sinuses presented with no or slight mucosal thickening, 167 sinuses presented with mucosal thickenings > 3 mm, 93 sinuses of polypoidal mucosal thickening, 20 sinuses with partial opacification and 7 sinuses with complete opacification. Among sinuses with pathological findings,

possible odontogenic contributions are 80 sinuses with mucosal thickening > 3 mm, 36 sinuses with polypoidal mucosal thickening, 6 sinuses with partial opacification, and none with complete opacification (Table 2).

	Findings	Odontogenic-related	Non-odontogenic-related
Normal	781		
Mucosal thickening > 3 mm	167	80	87
Polypoidal mucosal thickening	93	36	57
Partial opacification	20	6	14
Complete opacification	7	0	7

Table 2: Classification of maxillary sinus findings and its association of presence or absence of dental disorders.

In terms of tooth association with odontogenic-related maxillary pathology, highest prevalence is 56.69% first molars following by 33.07% second molars. In terms of tooth disorders, presence of root canal therapy with or without crown (RCT), follow by presence of restorations and crowns without root canal therapy (Table 3 and figure 4, 5).

Discussion

Maxillary sinus pathology may be rhinogenic, odontogenic, traumatic, allergic, neoplastic and bone-related origin [5]. This study found 38.92% subjects presented with odontogenic-related sinus pathology, which several studies have reported varying prevalence ranges of odontogenic maxillary sinusitis ranging from 10% to 86% [10-13].

Tooth Associated with Sinus Pathology	Total	Caries	Restorations	Root Canal Therapy with or without Crown (RCT)	Crown without Root Canal Therapy	Residual Root	Impacted
First premolar	4	1	2	1	0	0	0
Second premolar	8	3	2	3	0	0	0
First Molar	72	7	19	27	18	1	0
Second Molar	42	4	12	13	11	1	1
Third Molar	1	0	0	0	0	0	1
Total	127	15 (11.81%)	35 (27.56%)	44 (34.65%)	29 (22.83%)	2 (1.57%)	2 (1.57%)

Table 3: Tooth condition and location associated with maxillary sinus pathology.

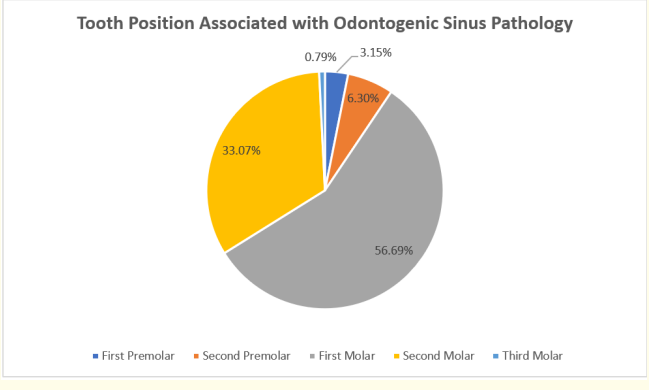

Figure 4: Tooth associated with odontogenic-related maxillary sinus pathologies.

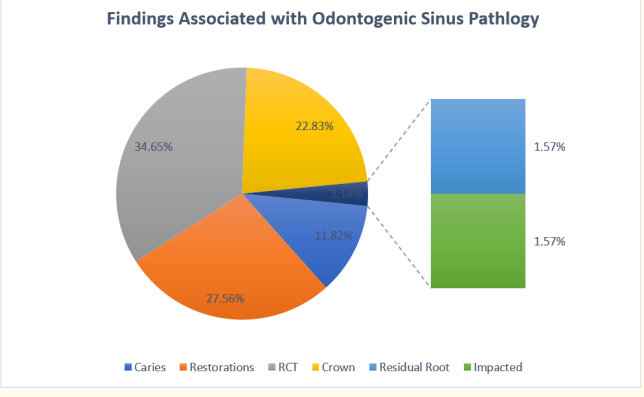

Figure 5: Dental disorders associated with odontogenic-related maxillary sinus pathologies.

Conner [14] evaluated 165 patients for presence of restorative dentistry in the adjacent teeth, maxillary sinus floor mucosal thickening, any maxillary sinus disease (including complete opacification, air fluid levels, diffuse mucosal thickening and focal mucosal thickening. 192 sinuses adjacent to restorative dentistry. The study found the presence of restorative dentistry predisposes to focal mucosal thickening in the floor of maxillary sinus.

Arias-Irimia [5] evaluated 770 cases of maxillary sinusitis with literature review of 15 articles and found it is more common in females (57.7%) and is most often diagnosed in the fifth decade of life. The teeth most predominantly affected are the molars (47,68%), with the first molar tooth being the most frequently involved. The principal etiological factor is extraction.

Bronstein [15] evaluated 50 limited CBCT scans with periapical pathology and 50 scans without apical pathology. The study showed that the Schneiderian membrane in the vicinity of roots with apical lesions tends to be significantly thicker when compared with the roots of teeth without apical pathologies.

Phothikhun [16] evaluated 250 CBCT scans with dental findings of periodontal bone loss, periapical lesions, and root canal fillings. 42% subjects and 29.2% sinuses presented with mucosal thickening. 16.4% subjects and 10% sinuses presented with mucosal thickening. Severe periodontal bone loss was significantly associated with mucosal thickening (odds ratio: 3.02, $P < 0.001$). The study also found periapical lesions and root canal fillings were not associated with mucosal thickening. There was no association between dental findings and mucosal cysts.

Lu., *et al*. [17] evaluated 372 CBCT images. Mucosal thickening was found in 48.4% patients and 46.2% sinuses. Periapical lesions were found in 29.2% patients with maxillary sinus mucosal thickening. Sinus mucosal thickening increased dramatically as the severity of apical periodontitis from bacterial invasion of the pulp of the tooth increased. Among the teeth with periapical lesions, 46 were first molars followed by 28 second premolars, 14 second molar and 1 third molar. The study also found patients more than 60 years of age were found most likely present with sinus mucosal thickening ($p < 0.01$).

Brullmann., *et al*. [18] evaluated 204 CBCT scans. The study showed there is significant association between periodontitis and radiological signs of sinusitis. Basal mucosal thickening in the maxillary sinus was more likely in patients with decayed and non-vital maxillary posterior teeth compared to healthy teeth (OR = 5.2).

Dagassan-Berndt [19] evaluated 17 dentate patient CBCT and found in molar regions with periodontal destruction, maxillary sinus membrane thickening occurred particularly in combination with the root tips or periapical lesions. Clinical signs of periodontal destruction (increased probing pocket depth or furcation involvement) were not associated with Schneiderian membrane thickness.

Shanbhag [20] evaluated 243 CBCT scans. 60.5% patients and 44.6% sinuses presented with mucosal thickening > 3 mm. 30.4% sinuses were associated with teeth showing periapical lesions and 45.6% showing periodontal diseases. Teeth with periapical lesions were most frequently first and second molars.

Schneider [21] evaluated 138 CBCT scans. 45.65% presented with of flat shallow mucosal thickening. Study found patient age, season, and endodontic status of the neighboring teeth had no significant effect on thickness of the mucosa.

Block [22] evaluated 831 scans. Mucosal thickening was found in 46.7% patients and 30.1% of sinuses. Of 469 sinuses with membrane thickening, 44.78% were adjacent to unhealthy teeth and 49.68% were adjacent to healthy teeth and 5.54% were in edentulous maxilla. The prevalence of sinus membrane thickening was almost equal in association with unhealthy and healthy teeth. The removal of unhealthy teeth decreased, but did not completely resolve sinus membrane thickening.

Lechien [23] systematic review indicated causes of chronic maxillary rhinosinusitis of dental origin among 674 patients and verified that an iatrogenic etiology accounted for 65.7% of the cases, apical periodontal pathologies accounted for 25.1% of cases, and marginal periodontitis accounted for 8.3% of cases.

Goller-Bulut [24] evaluated 205 CBCT scans to determine the relationship between mucosal thickening of the maxillary sinus and tooth condition. The study found 33.8% presented with mucosal thickening. Periapical lesions were found in 159 teeth and mucosal thickening was seen in 62.5%. Among teeth with periapical lesions, 48 were first molars, 36 were second molars, 41 first premolars and 34 were second premolars. The possibility of maxillary sinus mucosal thickening increased dramatically as the degree of periapical lesions increased. There was a positive correlation between maxillary sinus MT and age of the patient and PBL.

Ren [25] evaluated 221 subjects with periodontal diseases and analyze factors impacting maxillary sinus mucosal thickening using CBCT. 48.9% patients presented with mucosal thickenings. The probability of mucosal thickening increased as alveolar one loss

increased. The study concluded periodontal pathologies found in furcation lesions and vertical infrabony pockets were also more likely to coincide with mucosal thickening.

Shahbazian [26] evaluated 145 subjects. CBCT showed an intimate relationship of 1st and 2nd molar with the maxillary sinus in 50 and 45% of the cases, respectively. 42% of sinuses showed mucosal thickening in CBCT images. Tooth-related etiology occurred in 67% of the cases. The most likely cause of odontogenic mucosal thickening was periapical lesions (88%) followed by periodontal diseases (12%). Results also showed first molar has the highest prevalence of presence of apical periodontitis.

Zamfir [27] evaluated the odontosinusal influences of 31 cases of patients suffering from chronic rhinogenic sinusitis with ages between 16 and 60 years. 5 patients showed signs radiographically pulp chamber modifications. The study concluded there is possible 2 way relation of apical inflammation influenced the sinusal evolution and sinusal inflammation modified the tooth condition.

Wang [28] evaluated 55 patients with odontogenic sinusitis. 64% of these patients were diagnosed by CT scan showing dental pathology.

Nascimento., *et al.* [29] evaluated 400 CBCT scans with presence of sinus disease in 1 or both maxillary sinuses. Sinus pathology was found in 85.9% of the maxillary sinuses. The most prevalent condition was generalized mucosal thickening (65.2%) followed by localized mucosal thickening (24.8%), maxillary sinusitis (6.4%) and retention cysts (3.6%). Only generalized and localized mucosal thickening were found to be related to odontogenic conditions. Generalized mucosal thickening was more related to male. Localized mucosal thickening was associated with periapical lesions.

Nunes., *et al.* [30] compared CBCT scans of 178 subjects with periapical lesions to 178 subjects without periapical lesions. The study found the most frequent sinus abnormality was mucosal thickening and there was relation between periapical lesions and sinus abnormalities.

Kasikcioglu [31] evaluated 461 CBCT scans and found prevalence of right and left odontogenic maxillary sinusitis was 59.5% and 64%. Periapical pathologies were commonly found in first and second molars and significantly increased the risk of maxillary sinus pathology. The pathology was also more common in males and no relationship with age.

Zirk [32] evaluated 121 patients and the dental origin was evaluated by reviewing surgery reports, medical history and patient's CBCT findings. Odontogenic maxillary sinusitis was diagnosed in 46.3% cases for the right maxillary sinus and in 46.3% cases for the left maxillary sinus; 7.4% patients had OMS in both maxillary sinuses. Studies found various origins of odontogenic maxillary sinusitis, such as 33.9% caries, root canal infection, periodontitis, 57% oral surgery related, 2.5% oral surgery related and medication related osteonecrosis of the jaws, and 6.6% endodontic treatment.

de Lima 2017 [33] evaluated 83 CBCT to determine the correlation between presence of chronic sinusitis and periapical lesions and periodontal bone loss. Among the odontogenic changes studied, the most common was endodontic infection (49.1%). 50.6% of maxillary sinuses with chronic maxillary sinusitis presented with endodontic infection and 28.9% of chronic maxillary sinusitis presented with periodontal disease.

Branas., *et al.* [34] evaluated 179 maxillary sinuses. Among 70 cases presented with sinus membrane thickening, 66% were odontogenic origin and 34% were non-odontogenic origin. The main odontogenic cause was caries (46%), followed by failing endodontic therapy (26%). First molar on the right (33%) being the most frequently involved followed by the first molar on the left side (30%).

Souza-Nunes., *et al.* [35] evaluated 631 endodontically treated teeth and found 70.52% presented with maxillary sinus abnormality including mucosal thickening (38.19%), sinus polyp (5.23%), antral pseudocyst (9.35%), nonspecific opacification (7.13%), periostitis (8.72%) and antral calcification (1.90%). 55.94% periapical lesions were observed in cases with mucosal thickening.

Terlemez., *et al.* [36] recent study indicated at least 1 apical lesion adjacent to the right maxillary sinus increased the risk of maxillary sinus pathology by 2.37 times ($P < 0.05$).

Sakir., *et al.* [37] evaluated 50 CBCT scans and found of the apical periodontitis cases, 32% were right first molars, 30% were right second molars, 20% were left first molars, and 18% were left second molars. The frequency of mucosal thickening in the maxillary sinus adjacent to molars with periapical lesions was 36%. The most common pathologic findings of maxillary sinus was 36% mucosal thickening, 20% polypoid lesions, 20% retention cysts, 10% partial opacification, 10% total opacification, and 2% antroliths.

The present study found in terms of tooth position, the highest prevalence is the first molar following by the second molar, which is consistent with several studies that evaluated the relationship between maxillary posterior teeth and the maxillary sinus floor using cone beam computer tomography [5,38,39].

The present study found in term of gender, there is possible significance between females and males (p = 0.006). Arias-Irimia [5] found odontogenic sinusitis more common in females. However, Nascimento., *et al.* [29] found generalized mucosal thickening was more related to male.

The present study did not find a significant difference between age groups and the presence of odontogenic-related sinus pathologies (p = 0.10). Tian [40] indicated that age had a significant impacts, with those under the age of 40 showing a greater likelihood of the position of maxillary roots above/inside the sinus floor. Arias-Irimia [5] showed maxillary sinusitis most often diagnosed in the fifth decade of life (mean 47.2 years old). Lu., *et al.* [17] found patients more than 60 years of age were found most likely present with sinus mucosal thickening (p < 0.01).

In term of tooth condition, the present study showed more common association with odontogenic-related sinusitis were presence of root canal follow by crowns and restorations. Most studies also reported endodontic association with periapical lesions and mucosal thickening [15,17,19,23,24,26,27,29-31,33,35-37]. Some studies found a higher association with periodontal disease and mucosal thickening [16,18,20,25].

Roque-Torres [41] indicated dental roots in the maxillary sinus are 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. Due to the close anatomical relationship between maxillary posterior teeth and the maxillary sinus, Schneiderian membranes maybe altered due to dental-related disorders and restorative dentistry [14,34].

Conclusion

The prevalence of odontogenic-related maxillary sinus pathology was found in 36% of sinuses. The most associated findings are mucosal thickenings. The tooth most associated with pathologic findings was the first molar followed by the second molar. The findings are higher in males than females (p = 0.006). Age and ethnicity is not a significant factors. Dentition status showed presence of endodontic treatments (34.65%) being the most commonly associated with maxillary sinus pathology.

The high incidence of sinus pathology of odontogenic origin shows the need for interdisciplinary work involving dentists and otorhinolaryngologists. Periapical lesions (apical periodontitis), endodontic findings, periodontitis, caries, restorations, crowns and the presence of root remnants are reported causes of Schneiderian membrane thickening. The use of CBCT for diagnosis and treatment planning allows detecting maxillary sinus membrane thickening and determining its association with an odontogenic etiology. Management of odontogenic-related maxillary sinus pathology needs to be tailored to each individual patient and may involve varying combinations of medical and dental management.

Further research and additional data is needed to evaluate the association with age, ethnicity, gender with odontogenic-related sinus pathology. Based on these findings, CBCT should be carefully evaluated for possible odontogenic causes prior to maxillary sinus augmentation for dental implant placements.

Conflict of Interest Statement

The authors whose names are listed certify that they have NO affiliations with or involvement in any organization or entity with any financial or non-financial interest in the subject matter or materials discussed in this manuscript.

Approval

The study received Temple University Office for Human Subjects Protections Institutional Review Board approval (no. 23455)

Acknowledgements

Thanks to Dr Natalie B Amoa and Dr Thomas A. Langan Jr. for participating in data collection.

Bibliography

1. Testori T., *et al.* "Maxillary sinus surgery and alternatives in treatment". Hanover Park, IL. Quintessence Publishing Co. Ltd. (2009):7-23.

2. Rak KM., *et al.* "Paranasal sinuses on MR images of the brain: significance of mucosal thickening". *American Journal of Roentgenology* 156.2 (1991):381-384.

3. Misch CE., *et al.* "Maxillary sinus anatomy, pathology, and graft surgery". In: Misch, CE. Contemporary Implant Dentistry. 3rd edition. St. Louis: Mosby: (2008): 905-974.

4. Ly D and Hellgren J. "Is dental evaluation considered in unilateral maxillary sinusitis? A retrospective case series". *Acta Odontologica Scandinavica* 76.8 (2018): 600-604.

5. Arias-Irimia O., *et al.* "Meta-analysis of the etiology of odontogenic maxillary sinusitis". *Medicina Oral Patologia Oral Y Cirugia Bucal* 15.1 (2010): e70-e73.

6. Mehra PM and Murad H. "Maxillary sinus disease of odontogenic origin". *Otolaryngologic Clinics of North America* 37.2 (2004): 347-364.

7. Chan Y and Kuhn FA. "An updated on the classifications, diagnosis, and treatment of rhinosinusitis". *Current Opinion in Otolaryngology Head Neck Surgery* 17.3 (2009): 204-208.

8. Lim WK., *et al.* "Incidental magnetic resonance image sinus abnormalities in asymptomatic Australian children". *The Journal of Laryngology and Otology* 117.12 (2003): 969-972.

9. Maillet M., *et al.* "Cone-beam computed tomography evaluation of maxillary sinusitis". *Journal of Endodontics* 37.6 (2011): 753-757.

10. Brock I. "Sinusitis of odontogenic origin". *Otolaryngology Head Neck Surgery* 135.3 (2006): 349-355.

11. Ritter L., *et al.* "Prevalence of pathologic findings in the maxillary sinus in cone-beam computerized tomography". *Oral Surgery Oral Medicine Oral Pathology Oral Radiology and Endodontology* 111.5 (2011): 634-640.

12. Obayashi N., *et al.* "Spread of odontogenic infection originating in the maxillary teeth: computerized tomographic assessment". *Oral Surgery Oral Medicine Oral Pathology Oral Radiology and Endodontology* 98.2 (2004): 223-231.

13. Bomeli SR., *et al.* "Frequency of a dental source for acute maxillary sinusitis". *Laryngoscope* 119.3 (2009): 580-584.

14. Conner SE., *et al.* "Computed tomography evidence of dental restoration as an etiological factor for maxillary sinusitis". *The Journal of Laryngology and Otology* 114.7 (2000): 510-513.

15. Bronstein MM., *et al.* "Characteristics and dimensions of the Schneiderian membrane and apical bone in maxillary molars referred for apical surgery: a comparative radiographic analysis using limited cone beam computed tomography". *Journal of Endodontics* 38.1 (2012): 51-57.

16. Phothikhun S., *et al.* "Cone beam computed tomographic evidence of the association between periodontal bone loss and mucosal thickening of the maxillary sinus". *Journal of Periodontology* 83.5 (2012): 7557-564.

17. Lu Y., *et al.* "Associations between Maxillary Sinus Mucosal Thickening and Apical Periodontitis Using Cone-Beam Computed Tomography Scanning: A Retrospective Study". *Journal of Endodontics* 38.8 (2012): 1069-1074.

18. Brullmann DD., *et al.* "Correlation of cone beam computed tomography (CBCT) findings in the maxillary sinus with dental diagnosis: a retrospective cross-sectional study". *Clinical Oral Investigations* 16.4 (2012): 1023-1029.

19. Dagassan-Berndt DC., *et al.* "Is the Schneiderian membrane thickness affected by periodontal disease? A cone beam computed tomography-based extended case series". *International Academy of Periodontology* 15.3 (2013):75-82.

20. Shanbhag S., *et al.* "Association between periapical lesions and maxillary sinus mucosal thickening: a retrospective cone-beam computed tomographic study". *Journal of Endodontics* 39.7 (2013): 853-857.

21. Schneider AC., *et al.* "Characteristics and dimensions of the sinus membrane in patients referred for single implant treatment in the posterior maxilla: a cone beam computed tomographic analysis". *International Journal of Oral and Maxillofacial Implants* 28.2 (2013): 587-596.

22. Block MS and Dastoury K. "Prevalence of sinus membrane thickening and association with unhealthy teeth: a retrospective review of 831 consecutive patients with 1662 cone beam scans". *Journal of Oral and Maxillofacial Surgery* 72.12 (2014): 2454-2460.

23. Lechien JR., *et al.* "Chronic maxillary rhinosinusitis of dental origin: a systematic review of 674 patient cases". *International Journal of Otolaryngology* (2014): 465173.

24. Goller-Bulut D., *et al.* "Cone beam computed tomographic analysis of maxillary premolars and molars to detect the relationship between periapical and marginal bone loss and mucosal thickness of maxillary sinus". *Medicina Oral Patologia Oral y Cirugia Bucal* 20.5 (2015): 2572-579.

25. Ren S., *et al.* "Significance of maxillary sinus mucosal thickening in patients with periodontal disease". *International Dental Journal* 65.6 (2015): 303-310.

26. Shahbazian M., *et al.* "Comparative assessment of periapical radiography and CBCT imaging for radiodiagnostics in the posterior maxilla". *Odontology* 103.1. (2015): 97-104.

27. Zamfir MR. "Odonto-sinusal influences". *Journal of Medicine and Life* 8.1(2015): 21-23.

28. Wang KL., *et al.* "Odontogenic sinusitis: a case series studying diagnosis and management". *International Forrum of Allergy and Rhinology* 5.7 (2015): 587-691.

29. Nascimento EH., *et al.* "Association between odontogenic conditions and maxillary sinus disease: A study using cone-beam computed tomography". *Journal of Endodontics* 42.10 (2016):1509-1515.

30. Nunes CA., *et al.* "Evaluation of periapical lesions and their association with maxillary sinus abnormalities on cone-beam computed tomographic images". *Journal of Endodontics* 42.1 (2016):42-46.

31. Kasikcioglu A and Gulsahi A. "Relationship between maxillary sinus pathologies and maxillary posterior tooth periapical pathologies". *Oral Radiology* 32 (2016): 180-186.

32. Zirk M., *et al.* "Odontogenic sinusitis maxillaries: a retrospective study of 121 cases with surgical intervention". *Journal of Craniomaxillofacial Surgery* 45.4 (2017): 520-525.

33. De Lima CO., *et al.* "Correlation between endodontic infection and periodontal disease and their association with chronic sinusitis: a clinical tomographic study". *Journal of Endodontics* 43.12 (2017): 1978-1983.

34. Branas GV., *et al.* "Relation between periapical lesions and sinus membrane thickening assessed by Cone Beam Computed Tomography". *Acta Odontologica Latinoamericana* 31.3 (2018): 154-169.

35. Souza-Nunes LA., *et al.* "Periapical and endodontic status scale for endodontically treated teeth and their association with maxillary sinus abnormalities: A cone-beam computed tomographic study". *Journal of Endodontics* 45.12 (2019): 1479-1488.

36. Terlemez A., *et al.* "Comparison of cone-beam computed tomography and panoramic radiography in the evaluation of maxillary sinus pathology related to maxillary posterior teeth: Do apical lesions increase the risk of maxillary sinus pathology?" *Imaging Science in Dentistry* 49.2 (2019): 115-122.

37. Sakir M and Ercalik Yalcinkaya S. "Associations between Periapical Health of Maxillary Molars and Mucosal Thickening of Maxillary Sinuses in Cone-beam Computed Tomographic Images: A Retrospective Study". *Journal of Endodontics* 46.3 (2020): 397-403.

38. Kang SH., *et al.* "Proximity of posterior teeth to the maxillary sinus and buccal bone thickness: A biometric assessment using cone-beam computed tomography". *Journal of Endodontics* 41.11 (2015):1839-1846.

39. Gu Y., *et al.* "Evaluation of the relationship between maxillary posterior teeth and the maxillary sinus floor using cone-beam computer tomography". *BMC Oral Health* 18.1 (2018): 164.

40. Tian XM., *et al.* "An Analysis of the proximity of maxillary posterior teeth to the maxillary sinus using cone-beam computed tomography". *Journal of Endodontics* 42.3 (2016): 371-377.

41. Roque-Torres GD., *et al.* "Association between maxillary sinus pathologies and healthy teeth". *Brazilian Journal Otorhinolaryngology* 82.1 (2016): 33-38.