ORIGINAL ARTICLE

Original Araştırma

Yazışma adresi
Correspondence address

Rümeysa ŞENDİŞÇİ GÖK
Department of Oral and Maxillofacial Radiology, Faculty of Dentistry, Akdeniz University, Antalya, Turkey
rumeysasendisci@hotmail.com

Geliş tarihi : 26 May 2023
Received
Kabul tarihi : 14 June 2023
Accepted
E-Yayın tarihi : 31 August 2023
Online published

Bu makalede yapılacak atıf
Cite this article as

Şendişçi Gök R, Stevanovic Sancar B, Ekinci A, Günen Yılmaz S.
Evaluation of the relationship between maxillary sinus pathologies and odontogenic factors by cone beam computed tomography
Akd Dent J 2023;2(2): 61-68

Rümeysa ŞENDİŞÇİ GÖK
Department of Oral and Maxillofacial Radiology, Faculty of Dentistry, Akdeniz University, Antalya, Turkey
ORCID ID: 0000-0001-8252-8914

Bilay STEVANOVIC SANCAR
Department of Oral and Maxillofacial Radiology, Faculty of Dentistry, Akdeniz University, Antalya, Turkey
ORCID ID: 0000-0003-4307-3237

Ali EKİNCİ
Department of Oral and Maxillofacial Radiology, Faculty of Dentistry, Akdeniz University, Antalya, Turkey
ORCID ID: 0000-0001-7078-6588

Sevcihan GÜNEN YILMAZ
Department of Oral and Maxillofacial Radiology, Faculty of Dentistry, Akdeniz University, Antalya, Turkey
ORCID ID: 0000-0002-4566-2927

Evaluation of the Relationship Between Maxillary Sinus Pathologies and Odontogenic Factors by Cone Beam Computed Tomography

Maksiller Sinüs Patolojileri ile Odontojenik Faktörler Arasındaki İlişkinin Konik Işınlı Bilgisayarlı Tomografi ile Değerlendirilmesi

ABSTRACT

Objectives:

The aim of this study is to determine the odontogenic factors that can cause maxillary sinus (MS) pathologies and to evaluate the usability of cone beam computed tomography (CBCT) for this purpose.

Material and Methods:

In our study, CBCT images of 200 patients who applied to the Department of Oral and Maxillofacial Radiology of Akdeniz University Faculty of Dentistry for various reasons were retrospectively scanned to determine the relationship between the presence of MS pathology and odontogenic factors. MS pathologies; mucosal thickening, mucus retention cyst, sinusitis, polyp and anthrolite. Cases with a sinus mucosa thickness of 2 mm or more were considered pathological. Odontogenic factors; chronic apical lesion, marginal bone loss, oro-antral fistula, restorative applications, root canal treatment, implant, impacted tooth and residual root. SPSS was used in the analysis of the data and $P < 0.05$ was considered statistically significant.

Results:

The prevalence of MS pathology was 96% in 192 of 200 patients. The most common MS pathology in both MSs was mucosal thickening. The most rare MS pathology was antrolite. While right MS pathology differed according to gender ($p = 0.02$), there was no relationship between left MS pathology and gender ($p = 0.1$). Odontogenic factors were present in 182 patients (91%). There were 175 patients (87.5%) with both odontogenic factors and MS pathologies. There was a statistically significant correlation between mucosal thickening and chronic periapical periodontitis ($p = 0.004$). A statistically significant correlation was found between sinusitis and oroantral relationship ($p = 0.0001$). A statistically significant correlation was found between anthrolite and residual root ($p = 0.04$).

Conclusion:

Periodontal diseases, chronic apical periodontitis, restorative procedures, residual roots close to theMS region are associated with MS pathologies. With its low radiation dose and high spatial resolution, CBCT can help determine the odontogenic etiology in maxillary sinusitis pathologies.

Key Words:

Cone-beam computed tomography, Maxillary sinus, Pathology, Odontogenic factors

ÖZ

Amaç:

Bu çalışmanın amacı maksiller sinüs (MS) patolojilerine neden olabilecek odontojenik faktörleri belirlemek ve bu amaçla konik ışınlı bilgisayarlı tomografinin (KIBT) kullanılabilirliğini değerlendirmektir.

Gereç ve Yöntemler:

Çalışmamızda Akdeniz Üniversitesi Diş Hekimliği Fakültesi Ağız Diş ve Çene Radyolojisi Anabilim Dalı'na çeşitli nedenlerle başvuran 200 hastanın KIBT görüntüleri MS patolojisi varlığı ile odontojenik faktörler arasındaki ilişkiyi belirlemek amacıyla retrospektif olarak taranmıştır. MS patolojileri; mukozal kalınlaşma, mukus retansiyon kisti, sinüzit, polip ve antrolittir. Sinüs mukoza kalınlığı 2 mm veya daha fazla olan vakalar patolojik olarak kabul edildi. Odontojenik faktörler; kronik apikal lezyon, marjinal kemik kaybı, oro-antral fistül, restoratif uygulamalar, kanal tedavisi, implant, gömülü diş ve rezidüel kök olarak belirlendi. Verilerin analizinde SPSS kullanıldı ve $P < 0.05$ istatistiksel olarak anlamlı kabul edildi.

Bulgular:

MS patolojisi prevalansı 200 hastanın 192'sinde %96 idi. Her 2 MS'te de en sık görülen MS patolojisi mukozal kalınlaşmaydı. En nadir MS patolojisi antrolit idi. Sağ MS patolojisi cinsiyete göre farklılık gösterirken ($p = 0.02$), sol MS patolojisi ile cinsiyet arasında ilişki yoktu ($p = 0.1$). Odontojenik faktörler 182 hastada (%91) mevcuttu. Hem odontojenik faktörler hem de MS patolojileri olan 175 hasta (%87.5) vardı. Mukozal kalınlaşma ile kronik periapikal periodontitis arasında istatistiksel olarak anlamlı bir korelasyon vardı ($p = 0.004$). Sinüzit ile oroantral ilişki arasında istatistiksel olarak anlamlı bir korelasyon bulundu ($p = 0.0001$). Antrolit ile rezidüel kök arasında istatistiksel olarak anlamlı bir korelasyon bulundu ($p = 0.04$).

Sonuç:

Periodontal hastalıklar, kronik apikal periodontitis, restoratif işlemler, MS bölgesine yakın rezidüel kökler MS patolojileri ile ilişkilidir. Düşük radyasyon dozu ve yüksek uzaysal çözünürlüğü ile KIBT, maksiller sinüzit patolojilerinde odontojenik etiyolojinin belirlenmesine yardımcı olabilir.

Anahtar Sözcükler:

Konik ışınlı bilgisayarlı tomografi, Maksiller sinüs, Patoloji, Odontojenik faktörler

INTRODUCTION

The maxillary sinüs (Highmore's space, antrum) (MS) is the largest of the four paranasal sinuses and is in close anatomical relationship with the maxillary teeth (1). Disorders due to inflammatory lesions in the MSs are among the most common ailments in a dentist's daily practice. MS diseases caused by odontogenic factors constitute a very diverse group. Pulp disease, inflammatory lesions in periapical tissues, periodontium disease, complications of endodontic treatment and surgical treatment may cause MS pathologies (2-4).

The proximity of the teeth and MSs is believed to facilitate the spread of odontogenic infections through the bone of the alveolar process or directly as a result of a discontinuity at the sinus floor (5). Posterior maxillary premolars, molars, and to a lesser extent canines are anatomically close to the floor of the MS, and the roots of the maxillary posterior teeth are mostly located within the sinus (2). It is important to understand this close relationship in order to make the differential diagnosis of MS pathologies and to apply the correct treatment, odontogen-induced effects as the source of the discomfort.

Radiographic evaluation is the main diagnostic method used to reveal the relationship between periapical lesion and maxillary sinusitis, in addition to the anamnesis and clinical findings used to detect the pathological changes caused by odontogenous pathogens at the base of the MS (6). Multi-plane images obtained with cone-beam computed tomography (CBCT) provide radiologists with the opportunity to examine the entire volume of the image obtained and the anatomical variations and abnormalities that may be present in the image volume (7). MS pathologies, sinus septums, exocytosis, periapical lesions expanding to the MS can be diagnosed with CBCT. Also CBCT is a reliable radiography method in the evaluation of the size and borders of the sinus lesion, the condition of the sinus wall and the ostium (8).

The aim of this study is to evaluate the relationship between odontogenic factors and MS pathologies on the images of the CBCT device in patients with radiographic findings of MS pathology.

MATERIALS and METHODS

This study was conducted in accordance with the Principles of the Declaration of Helsinki and ethical compliance was obtained by the Akdeniz University Faculty of Medicine Clinical Research Ethics Committee before starting the study (Decision no: KAEK: 400).

Data collection

In the study, 400 MS CBCT images of 200 patients obtained for various reasons at Akdeniz University Faculty of Dentistry between January 2022 and January 2023 were evaluated retrospectively. The specified exclusion criteria were applied for the study: Images that do not allow optimal

evaluation of the sinuses; metal and movement artefacts; trauma cases; bone diseases (Fibrous dysplasia, Paget's Disease, Osteoporosis); hypoplastic sinuses; Patients under 16 years of age were excluded because of benign or malignant neoplasms of bone and incomplete formation of the MS. The anamnesis information of the patients was obtained with the Metasoft Dentasist program (version 3.0.448 (Eskişehir, Turkey).

Acquisition and interpretation of images

CBCT images were acquired by the same X-ray technician with the Veraview X800 CBCT device (J. Morita Mfg. Corp., Kyoto, Tokyo, Japan) according to the manufacturer's instructions (image field: 15x 15x 14.1; 4.8 mA; 99 kvP and 35.8 sec). Scans were analyzed using i-Dixel (Version 2.3.6.1 J Morita Mfg. Corp.) software. All CBCT images were evaluated independently by 2 researchers who are experts in dental radiology on the same LED monitor, approximately 40-50 cm from the monitor, in a dimly lit room and with appropriate tonal adjustments. Up to ten CBCT images per day were evaluated by the investigators to prevent investigator fatigue.

Age and gender information of 200 patients included in the evaluation were entered. In the radiographic evaluation of the MSs, 1 mm thick axial, coronal and sagittal sections; MSs with air-filled, hypodense/radiolucent appearance, completely clean borders, or sinuses with Schneider membrane thickness ≤2 mm were recorded as healthy (9). Radiographic changes were recorded in 5 groups as mucosal thickening, mucus retention cyst, sinusitis, polyp and anthrolite. Right and left were recorded separately for each MS.

CBCT sections matching the posterior maxillary region in sagittal and coronal planes were scanned, follow-up findings of teeth (premolar and molar) were investigated, and the numbers of etiological teeth were recorded. The variables determined as odontogenic factors were collected under 8 groups: chronic apical lesion, marginal bone loss, oro-antral fistula, restorative applications, root canal treatment, implant, impacted tooth and residual root.

Statistical analysis

Statistical analysis of the data was performed with the IBM SPSS Statistics (Version 22.0. Armonk, NY: IBM Corp, USA) program. The assumption of normality of the data was evaluated by Shapiro Wilk. Data were expressed as mean±standard deviation, number, and percentage. Pearson chi-square test was used in the analysis of possible differences between groups and $P < 0.05$ was considered significant.

RESULTS

In our study, 103 (51.5%) of the patients were female, 97 (48.5%) were male, and the mean age was 43.53 ± 19.18 years. The prevalence of MS pathology was 96% in 192 of 200 patients. There was a correlation between right and left MS pathologies ($p = 0.001$). Table 1 shows the distribution and lateralization of maxillary sinus pathologies according to the type of pathology.

Table 1. Type and lateralization of MS pathology.

Type of maxillary sinüs pathology	Right side	Left side
Mucosal thickening	124 (62%)	126 (63%)
Mucosal thickening with polypoid structure	4 (2%)	4 (2%)
Mucosal thickening with anthrolit	5 (2,5%)	8 (4%)
Mucous retention cyst	3 (1,5%)	4 (2%)
Sinusitis	27 (13,5%)	21 (10,5%)
Sinusitis with anthrolit	2 (1%)	0
Polypoid structure	14 (7%)	11 (5,5%)
Anthrolit	1 (0,5%)	3 (1,5%)
None	20 (10%)	23 (11,5%)
Total		200

The most common MS pathology in both MSs was mucosal thickening. The most rare MS pathology was antrolite. In both MSs, 4 patients had both mucosal thickening and polypoid structure. While both mucosal thickening and anthrolite were observed in 5 patients in the right MS, it was observed at a higher rate (8 patients) in the left MS. Both mucosal thickening and antrolite were observed in the right MS at a rate of 1% (2 patients).

The most common pathology of the right maxillary sinus in both men and women was mucosal thickening and sinusitis, while antrolith was the most rare pathology (Table 2a).

Table 2a. Distribution of MS pathology on the right side by gender according to Pearson correlation significance tests.

Type	Male	Female
Mucosal thickening	55	69
Mucosal thickening with polypoid structure	2	2
Mucosal thickening with anthrolit	2	3
Mucous retention cyst	1	2
Sinusitis	18	9
Sinusitis with anthrolit	2	0
Polypoid structure	9	5
Anthrolit	0	1
None	8	12

While mucosal thickening in the right MS was more common in women, sinusitis and polypoid structure were more common in men.

The most common pathology of the left MS in both men and women was mucosal thickening and sinusitis (Figure 1).

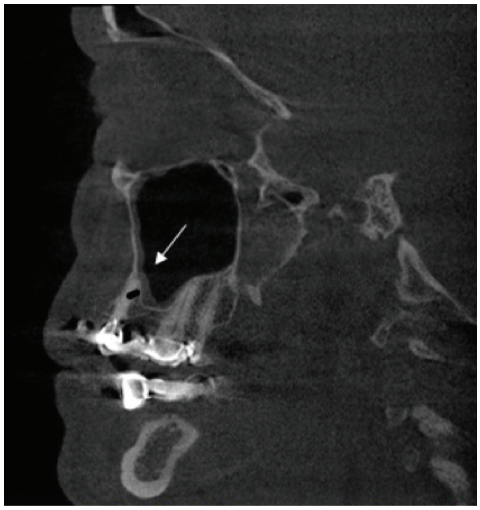

Figure 1. CBCT sagittal image view of mucosal thickening in the MS (white arrow)

While the most rare pathology in men was anthrolite, the least amount of mucus retention cyst was seen in women (Figure 2).

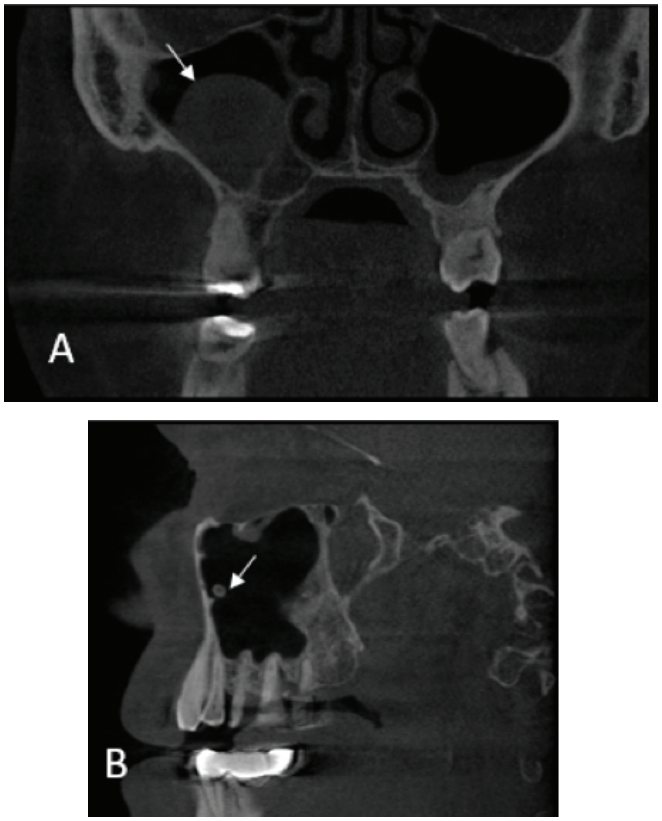

Figure 2. Various MS pathologies on CBCT images. A. Mucus retention cyst (white Arrow) B. Anthrolite (white Arrow)

Looking at Tables 2a and 2b, while right MS pathology differed according to gender ($p = 0.02$), there was no significant relationship between left MS pathology and gender ($p = 0.1$).

Table 2b. Distribution of MS pathology on the left side by gender according to Pearson correlation significance tests.

Type	Male	Female
Mucosal thickening	58	68
Mucosal thickening with polypoid structure	2	2
Mucosal thickening with anthrolit	2	6
Mucous retention cyst	3	1
Sinusitis	14	7
Sinusitis with anthrolit	0	0
Polypoid structure	8	3
Anthrolit	0	3
None	10	13

Odontogenic factors were present in 182 patients (91%). Odontogenic factors were observed in 92 male and 90 female patients. Table 3 shows the distribution of odontogenic factors by lateralization.

Table 3. Distribution of odontogenic factors and their lateralization.

Odontogenic factors	Right	Left
Chronic periapical periodontitis	20 (10%)	45 (22,5%)
Marginal bone lost	74(37%)	52 (26%)
Oroantral relationship	3 (1,5%)	1 (0,5%)
Restorative procedure	89 (44,5%)	89 (44,5%)
Endodontic procedure	33 (17%)	34 (17,5%)
Implant	14 (7%)	11 (5,5%)
Residual root	5 (2,5%)	7 (3,5%)
Impacted teeth	40 (20%)	40 (20%)

Restorative treatments and marginal bone loss were the most common odontogenic factors on both sides. While chronic apical periodontitis was observed at a higher rate (22.5%) on the left side, marginal bone loss was more on the right side. Oroantral relationship and residual root were the rarest odontogenic factors on both sides.

Odontogenic factors were found in 182 (91%) patients, while MS pathology was observed in 192 patients (96%). 175 patients (87.5%) with both odontogenic factors and MS pathologies were detected. 400 hemimaxillae were analyzed in this study. There was a statistically significant correlation between mucosal thickening and chronic periapical periodontitis ($p = 0.004$). A statistically significant correlation was found between sinusitis and oroantral relationship ($p = 0.0001$). A statistically significant correlation was found between anthrolite and residual root ($p = 0.040$) (Tables 4a, 4c, and 4e).

Table 4a Relationship betwen mucous thickening and odontogenic factors.

Mucous thickening	None	present	p
Chronic periapical periodontitis	11	54	0,004
Marginal bone loss	36	90	0,201
Oroantral relationship	3	1	0,061
Restorative procedure	61	116	0,401
Endodontic procedure	17	50	0,101
Implant	8	17	0,901
Residuel root	5	7	0,401
Impacted teeth	30	50	0,201
	171	385 (69.2%)	

Table 4b Relationship betwen mucous retantion cyst and odontogenic factors.

Mucous retantion cyst	None	present	p
Chronic periapical periodontitis	65	0	0,201
Marginal bone loss	122	4	0,101
Oroantral relationship	4	0	0,701
Restorative procedure	176	1	0,101
Endodontic procedure	66	1	0,801
Implant	25	0	0,401
Residuel root	12	0	0,601
Impacted teeth	79	1	0,7
		7 (1,25%)	

Table 4c Relationship betwen sinusitis and odontogenic factors.

Sinusitis	None	present	p
Chronic periapical periodontitis	57	8	0,901
Marginal bone lost	106	20	0,101
Oroantral relationship	1	3	0,0001
Restorative procedure	156	21	0,701
Endodontic procedure	59	8	0,801
Implant	21	4	0,501
Residuel root	12	0	0,101
Impacted teeth	71	9	0,701
		13,1%	

Mucosal thickening in the MS was most common in restorative procedures (29%) and in patients with marginal bone loss (22.5%), while the lowest rate was observed in patients with oronantral relationship (0.25%).

The highest rate of mucus retention cyst was found in patients with marginal bone loss, but no significant relationship was found between mucus retention cyst and any odontogenic factor ($P > 0.05$).

Looking at Tables 4c and 4d, sinusitis and polypoid structure were mostly found in patients who underwent restorative intervention and marginal bone lost. While there was a statistically significant correlation between sinusitis and oroantral relationship ($p = 0.0001$), no relationship was observed between polypoid structure and odontogenic factors.

Table 4d Relationship betwen polypoid structure and odontogenic factors.

Polypoid structure	None	present	p
Chronic periapical periodontitis	61	4	0,501
Marginal bone lost	116	10	0,801
Oroantral relationship	4	0	0,501
Restorative procedure	159	18	0,201
Endodontic procedure	63	4	0,401
Implant	23	2	0,901
Residuel root	10	2	0,201
Impacted teeth	74	6	0,701
		8,2%	

Table 4e shows the relationship between anthelmintic and odontogenic factors. Anthrolite was present at the highest rate in patients undergoing restorative procedures. There was a statistically significant correlation between anthrolite and residual root ($p = 0.04$).

Table 4e Relationship betwen anthrolit and odontogenic factors.

Anthrolit	None	present	p
Chronic periapical periodontitis	64	1	0,101
Marginal bone lost	123	3	0,101
Oroantral relationship	4	0	0,601
Restorative procedure	171	6	0,201
Endodontic procedure	65	2	0,401
Implant	25	0	0,201
Residuel root	10	2	0,04
Impacted teeth	79	1	0,101
		2,7%	

DISCUSSION

This study set out to investigate the effects of various odontogenic factors on MS pathologies. In the literature, the relationship between odontogenic factors and sinus pathologies has been described in detail, and it has been emphasized that pathogens of odontogenic origin may cause deterioration in Schneider membrane integrity (10,11). We evaluated the possible effects of dental factors such as the presence of periapical lesions, periodontal bone loss, restorative procedures, root canal treatment, missing and impacted teeth, oroantral relationship, presence of implants and residual roots on the MSs and their relationship with pathologies. Both odontogenic factors and (13-15) pathology are present in 87.5% of the patients. This finding was consistent with a computed tomography study showing that approximately 71-86% of sinus infections have an odontogenic

cause (12). According to previous studies (13-15) MS pathologies had a definite odontogenic cause, with apical periodontitis accounting for 83% of all cases. Moreover, the prevalence of other sinus disorders such as mucosal thickening, mucus retention cyst, and odontogenic maxillary sinusitis ranges from 8% to 29%, 2-36%, and 10-86%, respectively.
The most common (13-15) pathology in our study was mucosal thickening with a prevalence of 62/63% (right/left side). A number of studies (16-18) have reported prevalence rates of sinus mucosal thickening ranging from 37% to 62%.

This inconsistency between studies can be attributed to the use of different diagnostic criteria (> 1, > 2, > 3 mm) in the literature in the evaluation of pathological radiographic mucosal thickening. Other explanations are likely due to the difference in indications for the CBCT scans included in the study and ethnic differences between the populations studied (19).

In the study of Bozdemir et al. (20) 6.5% sinusitis, 22/20.6% (right/left) mucus retention cyst and polypoid structure, 0.3/1.3% (right/left) anthrolite were observed. Our results are compatible with this study only in terms of anthrolite ratio. In this study, the prevalence of sinusitis was higher (13.5/10.5%) and the polypoid structure was found to be less (7/5.5%). In the same study, there was a significant difference between the sexes (p = 0.02), and men (53.5%) had more sinus pathology than women (46.5%). Bajoria et al. (21) and Turfe et al. (22) found higher rates of maxillary sinus pathology in men, while Saibene et al. (23) and Arias-Irimia et al. (24) observed that women had more pathology. In our study, we found that right MS pathology differed according to gender (p = 0.02), and there was no relationship between left MS pathology and gender (p = 0.1).
In our study, the percentage of patients with sinus findings (96%) in CBCT examinations was determined by Ritter et al. (25) and Panzera et al. f(26) ound higher.

The main reasons for the differences in our study may be due to the patient population or the different sensitivity of CBCT devices for soft tissues. Various CBCT devices have flat panel detectors of various sizes, and the geometry of large area detectors is more likely to be hit by scattered photons. Therefore, the extent of the distorting effect of scattered radiation differs between CBCT device. It is well known that dispersion reduces soft tissue contrast (27). Therefore, the inclusion and exclusion criteria should be reviewed and patients with very large metallic restorations may need to be excluded (28).

Maillet et al. (29) in their study, they found a 75% prevalence of maxillary sinusitis associated with dental conditions. We found this rate much lower (13.1%). In the study of Bajoria et al. (21) sinusitis was found at a rate of 5.1% in patients with periodontitis, while this rate was found to be 3.5% in our study. In another study (21) 1.4% of patients with chronic periapical periodontitis were seen, which is consistent with our results.
The majority of previous studies (30-32) reported a positive relationship between periapical lesions and mucosal thickening, despite some adverse results (17,33). Our study shows that there is a positive correlation between the prevalence of mucosal thickening in the MS and the presence of periapical lesions (p = 0.004). There are limited studies investigating periodontal bone loss and mucosal thickening, and they have shown that there is no relationship between mucosal thickening and periodontal bone loss (34,35).

In our literature review, we came across a study investigating the relationship between restorative procedures and maxillary sinusitis. Connor et al. (36) evaluated the relationship between dental restorations and MS diseases in their computed tomography (CT) study on 330 MSs in 165 patients with inflammatory sinus disease. As a result, they found that dental restorations were not associated with MS pathologies, but were associated with mucosal thickening. In our study, although we found the incidence of restorative procedures to be high in patients, we did not find any association with MS pathologies. Finding different results with ours, Connor et al. (36) While they evaluated only dental restorations as an odontogenic factor in their CT study on patients with sinusitis, the evaluation of many odontogenic factors in our study may be the reason for the difference between the 2 studies.

CONCLUSION

The findings of our study have proven that the evaluation of maxillary posterior region pathologies in the diagnosis of MS pathology is important in terms of the course of the disease and treatment planning. Since there may be a relationship between odontogenous MS pathology, 3D imaging methods are needed in order to diagnose the cases correctly and not be overlooked. CBCTs with high spatial resolution can be used as an imaging method in illuminating cases of MS pathology of odontogenic origin.

Ethics Committee Approval:
This study was conducted in accordance with the principles of the Declaration of Helsinki and ethical approval was obtained from Akdeniz University Faculty of Medicine Clinical Research Ethics Committee (Decision no: KAEK: 400).

Author Contribution Statement:
Concept - Ş.G.R., S.S.B.; Design - Ş.G.R., G.Y.S.; Supervision - Collection and/or Processing - Ş.G.R., E.A.; Analysis and/or Interpretation - S.S.B., Ş.G.R., E.A.; Literature Review - Ş.G.R., S.S.B.; Manuscript Writing - S.S.B., Ş.G.R., Critical Review - Ş.G.R., G.Y.S.

Informed Consent:
Written informed consent was obtained from the participants in this study.

Conflict of Interest:
There is no conflict of interest between the authors.

Financial Disclosure:
No financial support was received.

1. Porter GT, Quinn FB. Paranasal Sinuses: Anatomy and Function. The University of Texas Medical Branch (UTMB), Department of Otolaryngology, Galveston TX January Grand Rounds presentation. 2002;1:1-3.

2. Mehra P, Jeong D. Maxillary sinusitis of odontogenic origin. Curr Allergy Asthma Rep. 2009;9:238-43.

3. Troeltzsch M, Pache C, Troeltzsch M, Kaeppler G, Ehrenfeld M, Otto S, Probst F. Etiology and clinical characteristics of symptomatic unilateral maxillary sinusitis: a review of 174 cases. J Craniomaxillofac Surg. 2015;43:1522-9.

4. Feng L, Li H, Li CJ, Ding Y. Pathological changes in the maxillary sinus mucosae of patients with recurrent odontogenic maxillary sinusitis. Pak J Med Sci. 2014;30:972-5.

5. Simuntis R, Kubilius R, Vaitkus S. Odontogenic maxillary sinusitis: a review. Stomatologija. 2014;16:39-43.

6. Shahbazian M, Jacobs R. Diagnostic value of 2D and 3D imaging in odontogenic maxillary sinusitis: a review of literature. J Oral Rehabil. 2012;39:294-300.

7. Carter L, Farman AG, Geist J, Scarfe WC, Angelopoulos C, Nair MK, Hildebolt CF, Tyndall D, Shrout M; American Academy of Oral and Maxillofacial Radiology executive opinion statement on performing and interpreting diagnostic cone beam computed tomography. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2008;106:561-2. .

8. Naitoh M, Suenaga Y, Kondo S, Gotoh K, Ariji E. Assessment of maxillary sinus septa using cone-beam computed tomography: etiological consideration. Clin Implant Dent Relat Res. 2009;11:e52-8.

9. Oliveira LD, Carvalho CA, Carvalho AS, Alves Jde S, Valera MC, Jorge AO. Efficacy of endodontic treatment for endotoxin reduction in primarily infected root canals and evaluation of cytotoxic effects. J Endod. 2012;38:1053-7.

10. Mehra P, Murad H. Maxillary sinus disease of odontogenic origin. Otolaryngol Clin North Am. 2004;37:347-64.

11. Rôças IN, Neves MA, Provenzano JC, Siqueira JF Jr. Susceptibility of as-yet-uncultivated and difficult-to-culture bacteria to chemomechanical procedures. J Endod. 2014;40:33-7.

12. Obayashi N, Ariji Y, Goto M, Izumi M, Naitoh M, Kurita K, Shimozato K, Ariji E. 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.

13. 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.

14. Bhattacharyya N. Do maxillary sinus retention cysts reflect obstructive sinus phenomena? Arch Otolaryngol Head Neck Surg. 2000;126:1369-71.

15. Mathew AL, Pai KM, Sholapurkar AA. Maxillary sinus findings in the elderly: a panoramic radiographic study. J Contemp Dent Pract. 2009;10:E041-8.

16. Lu Y, Liu Z, Zhang L, Zhou X, Zheng Q, Duan X, Zheng G, Wang H, Huang D. Associations between maxillary sinus mucosal thickening and apical periodontitis using cone-beam computed tomography scanning: a retrospective study. J Endod. 2012;38:1069-74.

17. Janner SF, Caversaccio MD, Dubach P, Sendi P, Buser D, Bornstein MM. Characteristics and dimensions of the Schneiderian membrane: a radiographic analysis using cone beam computed tomography in patients referred for dental implant surgery in the posterior maxilla. Clin Oral Implants Res. 2011;22:1446-53.

18. Phothikhun S, Suphanantachat S, Chuenchompoonut V, Nisapakultorn K. Cone-beam computed tomographic evidence of the association between periodontal bone loss and mucosal thickening of the maxillary sinus. J Periodontol. 2012;83:557-64.

19. Aksoy U, Orhan K. Association between odontogenic conditions and maxillary sinus mucosal thickening: a retrospective CBCT study. Clin Oral Investig. 2019;23:123-131.

20. Bozdemir E, Gormez O, Yıldırım D, Aydogmus Erik A. Paranasal sinus pathoses on cone beam computed tomography. J Istanb Univ Fac Dent. 2016;50:27-34.

21. Bajoria AA, Sarkar S, Sinha P. Evaluation of odontogenic maxillary sinusitis with cone beam computed tomography: a retrospective study with review of literature. J Int Soc Prev Community Dent. 2019;9:194-204.

22. Turfe Z, Ahmad A, Peterson EI, Craig JR. Odontogenic sinusitis is a common cause of unilateral sinus disease with maxillary sinus opacification. Int Forum Allergy Rhinol. 2019;9:1515-20. .

23. Saibene AM, Pipolo GC, Lozza P, Maccari A, Portaleone SM, Scotti A, Borloni R, Messina F, Di Pasquale D, Felisati G. Redefining boundaries in odontogenic sinusitis: a retrospective evaluation of extramaxillary involvement in 315 patients. Int Forum Allergy Rhinol. 2014;4:1020-3.

24. 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.

25. Ritter L, Lutz J, Neugebauer J, Scheer M, Dreiseidler T, Zinser MJ, Rothamel D, Mischkowski RA. 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.

26. 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.

27. Tofts PS, Gore JC. Some sources of artefact in computed tomography. Phys Med Biol. 1980;25:117-27.

28. 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. .

29. Maillet M, Bowles WR, McClanahan SL, John MT, Ahmad M. Cone-beam computed tomography evaluation of maxillary sinusitis. J Endod. 2011;37:753-7.

30. 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.

31. Goller-Bulut D, Sekerci AE, Köse E, Sisman Y. 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. Med Oral Patol Oral Cir Bucal. 2015;20:e572-9.

32. Nunes CA, Guedes OA, Alencar AH, Peters OA, Estrela CR, Estrela C. Evaluation of periapical lesions and their association with maxillary sinus abnormalities on cone-beam computed tomographic ımages. J Endod. 2016;42:42-6.

33. 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.

34. Dagassan-Berndt DC, Zitzmann NU, Lambrecht JT, Weiger R, Walter C. Is the Schneiderian membrane thickness affected by periodontal disease? A cone beam computed tomography-based extended case series. J Int Acad Periodontol. 2013;15:75-82.

35. Acharya A, Hao J, Mattheos N, Chau A, Shirke P, Lang NP. Residual ridge dimensions at edentulous maxillary first molar sites and periodontal bone loss among two ethnic cohorts seeking tooth replacement. Clin Oral Implants Res. 2014;25:1386-94.

36. Connor SE, Chavda SV, Pahor AL. Computed tomography evidence of dental restoration as aetiological factor for maxillary sinusitis. J Laryngol Otol. 2000;114:510-3.