The Association Between Maxillary Sinus Mucosal Thickening and Periapical Radiolucency Using Cone-Beam Computed Tomography Scanning: A Retrospective Study

Original Article

Hooman Khorshidi[1], Shoaleh Shahidi[2], Jannan Ghapanchi[3], Saeed Raoofi[1], Maryam Paknahad[4], Navid Khajeh Daloiee[5], Aisa Zamani[6]

[1]Assistant Professor, Department of Periodontology, School of Dentistry, Shiraz University of Medical Sciences, Shiraz, Iran.
[2]Professor, Department of Oral and Maxillofacial Radiology, School of Dentistry, Shiraz University of Medical Sciences, Shiraz, Iran.
[3]Associate Professor, Department of Oral Medicine, School of Dentistry, Shiraz University of Medical Sciences, Shiraz, Iran.
[4]Assistant Professor, Department of Oral and Maxillofacial Radiology, School of Dentistry, Shiraz University of Medical Sciences, Shiraz, Iran.
[5]Dentist.
[6]Dental Student, School of Dentistry, Shiraz University of Medical Sciences, Shiraz, Iran.

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Corresponding Author:
Jannan Ghapanchi
Address: Department of Oral Medicine, School of Dentistry, Shiraz University of Medical Sciences, Shiraz, Iran.
Telephone:+989173161094
Email: ghabanj@sums.ac.ir
Fax:+987136270325

Abstract

Introduction:
Cone-beam computed tomography (CBCT) scanning is a technological innovation developed in recent years with potential use in oral surgery and many other dental procedures. The aim of this study is to determine the maxillary sinus mucosal thickening in the maxillary premolar-molar area using the CBCT technique.

Materials and Methods:
In this retrospective study, a total of 105 cases (49 females and 56 males) that had 186 exposed maxillary sinuses were included. The age range of the cases was 24–58 years old. Periapical infections of maxillary molars and mucosal thickness changes were detected and recorded by two specialists; a radiologist and a periodontist.

Results:
Mucosal thickening in either one or both maxillary sinuses was found in the periapical area of 14 second premolars (13.3%), 48 first molars (45.7%), 39 second molars (37.1%), and 4 third molars (3.8%), with mucosal thickenings >1.8 mm. The mean maxillary sinus mucosal thickening in cases with PA radiolucency was 1.7 mm, and in patients without PA radiolucency, the mean was 2.1 mm (p = 0.01). Mucosal thickening due to pulpal infections of untreated teeth was seen in 39 (37.1%) cases, and mucosal thickening due to inadequate previous root canal therapy was seen in 66 (62.9%) patients.

Conclusion:
CBCT is a helpful method for detecting periapical lesions which affect the maxillary sinus and is recommended in maxillary surgical procedures.

Key words:
•Cone-Beam Computed Tomography •Maxillary Sinus • Mucosal Thickening

Introduction

Dental pain that originates from the maxillary sinuses may pose a diagnostic problem for the dental clinician. Due to the close proximity of the roots of the maxillary posterior dentition to the floor of the sinus, along with a common innervation, there is potential for pathosis of the sinus to cause dental symptoms.[1] Likewise, the integrity of the sinus floor can be affected by pulpal inflammation or infection. The development of a periapical lesion in teeth whose root apices are close to or extending into the maxillary sinuses can evoke inflammatory changes in the mucosal lining and, subsequently, the development of sinusitis.[2] In 1943, Bauer was first to describe the extension of periapical inflammation into the maxillary sinus.[3] Periapical inflammation was shown to be capable of affecting the sinus mucosa with and without perforation of the cortical bone of the sinus floor. Infection and inflammatory mediators can thereby spread directly or via bone marrow, blood vessels, and lymphatics to the maxillary sinus.[3] Sinusitis is the major cause of mucosal thickening in symptomatic individuals. The relationship between dental infections and maxillary sinusitis is well established. The hyperplasia of sinus mucosa may contribute to the clinical symptoms leading to a diagnosis of atypical odontalgia or temporomandibular pain [4], and in the case of chronic sinusitis, the patients may complain of postnasal drip, dental pain, and a sore throat.[5]

Cone-beam computed tomography (CBCT) presents detailed three-dimensional images of the structures scanned. The use of CBCT scans in endodontic practice can bring about improved treatment planning for surgical procedures by displaying the size and location of the lesion in relation to other anatomic structures. Computed tomography scanning has become the standard in medicine for visualizing the maxillary sinuses due to its ability to visualize both bone and soft tissue in multiple views with thin sectioning.[6] Since an unresolved sinusitis may be exacerbated by an untreated dental condition, having both axial and coronal views allows the clinician to assess the relationship of a periapical lesion to a sinus floor defect.[7]

In the case of odontogenic sinusitis, using CBCT technology could allow for improved treatment planning by combining both nonsurgical and surgical dental and medical treatments.[8] Sinusitis of an odontogenic origin has traditionally been considered to account for approximately 10% of sinusitis cases.[7] In the maxilla, odontogenic infections will most frequently extend through the thin buccal alveolar wall and into the vestibule.

The floor of the sinus is composed of dense cortical bone; therefore, sinus infections from a dental source were thought to be uncommon. However, they can occur in the case of a pneumatized sinus in which the Schneiderian membrane can be easily penetrated by pathogens. Moreover, the labial levator and orbicularis oculi muscles attach to the lateral wall of the maxilla, forming the anterior wall of the sinus. These muscle attachments can direct infection into the sinus via soft-tissue spaces.[5]

By using computed tomography scanning, Obayashi et al.[9] found over 70% of the patients diagnosed with maxillary dental infection showed changes in the maxillary sinus. It may be the result of periapical infection or inflammation, periodontal disease, perforation of the sinus during extraction, or root tips or other foreign objects being forced into the sinus during surgical treatment.[4] The aim of this study is to determine the maxillary sinus mucosal thickening in the premolar-molar area using the CBCT technique in patients referred to Shiraz University of Medical Sciences from March 2010 to May 2015.

Materials and Methods

This retrospective radiologic study was carried out with the approval of Shiraz University of Medical Sciences, Iran. CBCT scans of consecutive patients undergoing various procedures at the Implant Department were collected from March 2010 to May 2015. Standard parameters (120 kVp, 15 mA, and 9.6 s) were used for all CBCTs. The CBCT images were taken by a NewTom VGi (QR Srl, Venora, Italy) with a field of view of 15 cm × 15 cm. High quality CBCTs of patients older than 15 years (in order to allow the sinuses to fully develop) were evaluated.

Patients with at least one maxillary sinus exposure were included in the study. Patients with a history of acute or chronic sinusitis, trauma, surgery or maxillary sinus pathological defects, loss of one or more posterior maxillary teeth (premolar or molar teeth), and patients having one or more maxillary implants were excluded.

Periapical infections of maxillary molars and mucosal thickness changes were detected and recorded. The research also focused on the measurement of the distance between the periapical lesion and the floor of the maxillary sinus by using a digital ruler.

A large number of CBCTs (900 images) were evaluated. A total of 105 patients (49 females and 56 males) who had 186 exposed maxillary sinuses met our inclusion criteria. The age range of the subjects was 24–58 years old. All CBCT images were evaluated by two specialists (a radiologist and a periodontist).

To investigate a possible correlation between findings that we obtained by CBCT, the positions of the root tips and periapical lesions in relation to the sinus floor were categorized. This permitted classification of the apices into three types of anatomic relationships: 1) with a gap or space between the root tip and the sinus floor, 2) the root tip touched the sinus floor, and 3) the root tip entered the sinus floor. The following categories were applied for the periapical lesions: 1) with a space between the lesion and the sinus floor, 2) the lesion was in contact with the sinus floor, and 3) the lesion entered the sinus floor. The Sidexis X-G software (Sirona Dental X-ray Imaging System next Generation, Sirona Dental Systems GmbH, Bensheim, Hessen, Germany) was used for the image analysis.

After inter-examiner calibration, axial, coronal, and sagittal sections of each image were evaluated. If there was disagreement on the interpretation of the images, a consensus was reached after discussion between the two observers.

The mucosal thickness, periapical lesions of adjacent teeth and roots, tooth position, and patient's sex and age were noted and recorded. Mucosal thickness was measured at the point of maximum thickness from the sinus floor.

The diameter of the periapical lesion was measured at the maximum range. The data analysis was conducted with the SPSS software version 17 (SPSS Inc., Chicago, IL). The Mann-Whitney U test was employed to compare the groups.

P value less than 0.05 was considered statistically significant.

Results

Mucosal thickening in either one or both maxillary sinuses was found in the periapical area of 14 second premolars (13.3%), 48 first molars (45.7%), 39 second molars (37.1%), and 4 third molars (3.8%), with mucosal thickenings >1.8 mm. The first molar root involvement frequently affected the sinus; followed by the second molar, second premolar, and finally, wisdom teeth.

All changes around each tooth were measured separately. The mean maxillary sinus mucosal thickening in cases with PA radiolucency was 1.7 mm, and in patients without PA radiolucency, the mean was 2.1 mm. Mucosal thickening due to pulpal infections of untreated teeth was seen in 39 (37.1%) cases, and mucosal thickening due to inadequate previous root canal therapy was seen in 66 (62.9%) patients. Radiolucency in the apical area was detected in 90 subjects, and in 15 cases, the radiolucent area was not seen. The majority of patients, encompassing all degrees of maxillary sinus mucosal thickening, had an anatomic relationship between the root tip and sinus floor ($p = 0.944$). The cortical bone in the floor of the sinus was disrupted in the majority of cases of thickening mucosa in which a dental etiology was identified ($p = 0.072$). However, in some cases with periapical radiolucency, we could not detect any thickening in sinus mucosa (Figure 1 and 2).

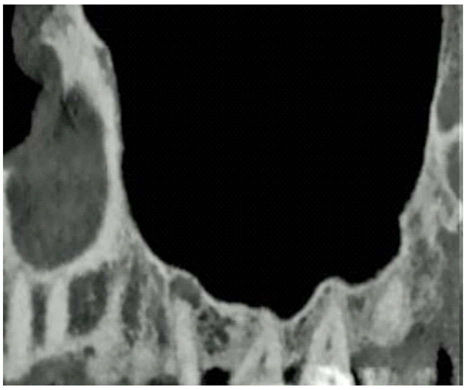

Figure 1. Periapical radiolucency of maxillary premolar without any thickening in the sinus mucosa (pseudo panoramic view).

The mean diameter of the remaining bone between the floor of the sinus and the apex of the roots in patients with periapical radiolucency was 2.5 mm, and in subjects without periapical radiolucency, the mean diameter was 1.3 mm.

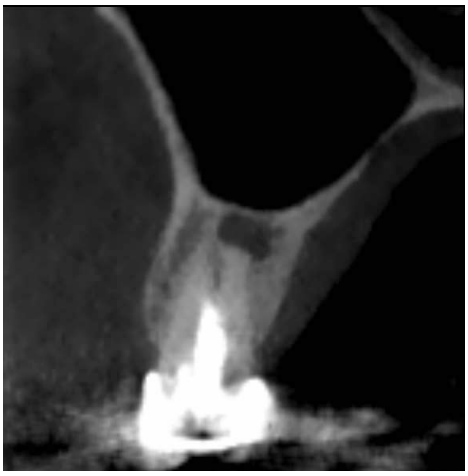

Figure 1. Periapical radiolucency of maxillary molar without any thickening in the sinus mucosa (Trans-axial view).

The median diameter of the bone disruption in patients with periapical radiolucency was 1.5 mm, and in subjects without periapical radiolucency, the median diameter was 1 mm. The median diameters of the mucosal thickenings were 1.5 and 1.6 mm in cases with and without periapical radiolucency, respectively. The results are explained in Table 1.

Table 1. The prevalence of mucosal thickening in the present study.

Position	Mucosal Thickening	
	Number	Percent
Second premolar	14	13.3
First molar	48	45.7
Second molar	39	37.1
Third molar	4	3.8

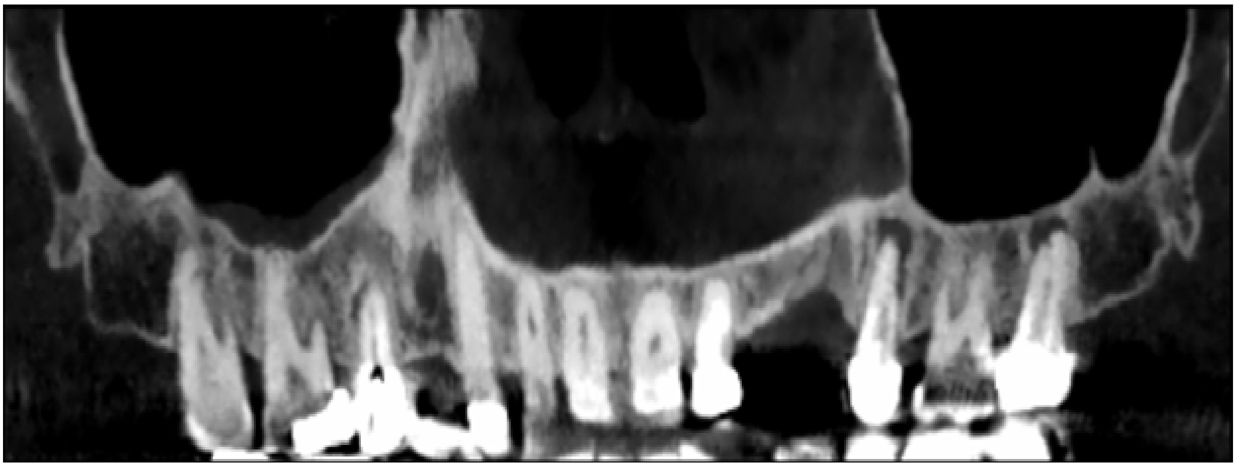

Figure 1. Thickening of the right maxillary sinus mucosa adjacent to the first molar with pulpal involvement extending to mesial and distal. In the left side, the sinus mucosa seems to be normal, despite apical radiolucency and pulpal involvement of the adjacent teeth.

Discussion

Mucosal thickening and mucosal cysts of the maxillary sinus are often detected in asymptomatic individuals by various radiographic techniques. In current research, mucosal thickening was seen in proximity of 105 molars and premolars. The reported prevalence of mucosal thickening of the maxillary sinus ranged from 8% to 29% [10,11,12], whereas that of mucosal cysts ranged from 2% to 36%.[13] Phothikhun et al. and Janner et al.[14,15] both used CBCT to evaluate the sinomucosal thickness. Phothikhun measured the mucosal thickening in both sides of the tooth and then selected the upper measurement for statistical analysis, whereas in the present study, both the mesial and distal sides of each tooth were analyzed, which could be more accurate.[14] Nevertheless, in a recent study, Insua et al. compared the membrane thickness measured by CBCT to the gold standard histological assessment and reported that the CBCT assessment was more accurate than the histological examination.[16]

Janner and coworkers [15] reported sinus abnormalities in 55% of the maxillary sinuses of patients referred for dental implant surgery. Sinus augmentation surgery is a widely used procedure to increase the bone height for implant placement in the posterior maxilla. The study by Janner et al. focused only on the mucosal thickening in patients with dental pulp involvement, so it is different from our study. The presence of sinus abnormalities may pose problems when sinus augmentation surgery is planned. Eberhardt et al.[17] reported a mean distance of 1.97 mm between the floor of the maxillary sinus and the roots of the adjoining maxillary premolar and molar teeth. The displacement of bacteria from infected periapical tissue often results in acute or chronic sinusitis. In the present research, the palatal root of the first molar was most commonly associated with the sinus mucosal thickening. The first molar erupts by the age of six and, therefore, is more susceptible to caries, restorations, and occlusal wear over time than the second molar. This could account for more frequent periapical pathosis and subsequent extension of this pathosis to the sinus. The maxillary sinuses vary in size depending not only on the individual's characteristics but also on his/her age. On occasion, the roots of the maxillary teeth project into the sinus cavity, with the apices surrounded by sinus mucoperiosteum.[5] The dimensions of the maxillary sinus indicated bilateral symmetry, and there were no significant gender differences when compared.[18]

In the case of an involved sinus, a clinician may observe clouding (opacifying), mucosal thickening, and/or accumulation of fluid.[4] Rak et al. [19] reviewed 128 magnetic resonance images of the paranasal sinuses and found that 4 mm of mucosal thickening was significantly related to clinical symptoms. The authors determined that 1 to 2 mm of mucosal thickening was a normal variant. In our research, clinical symptoms, such as pain or headache, were not recorded, and we only evaluated the sinus wall changes and mucosal thickening. Obayashi et al.[9] found that mucosal thickening of 4 mm or more was significantly associated with clinical symptoms. They reported that 71.3 % of cases of dental infection were associated with changes in the maxillary sinus. In their study, periapical pathosis was diagnosed first, followed by radiographic examination of the sinuses. The study first noted sinus pathology and then evaluated the dentition. The average amount of mucosal thickening noted in this investigation was 3.8 mm. Lu, et al.[20] studied 372 patients' CBCT images. The cases had 508 exposed maxillary sinuses. Among clinical features, age and sex of the patients and pathologic findings of the maxillary sinus and adjacent teeth were recorded, graded, and analyzed. The study revealed the presence of maxillary sinus mucosal thickening in 180 (48.4%) patients and 235 (46.2%) sinuses. They also reported a dramatic increase in the prevalence of maxillary sinus mucosal thickening when the severity of apical periodontitis rose (from 41.5% in those without periodontal disease to 100%). The main finding of this study was that mucosal thickening was more prevalent close to the teeth without apical radiolucency. This research showed that pulpal involvement without periapical radiolucency may affect mucosal sinuses more than periapical lesions. This finding may be related to bacterial variants and their toxins that may affect the sinus mucous membrane.

The present research is a retrospective study of existing scans only and does not include patients' symptoms. The most frequent referral for CBCT scans has been implant placement. For a tooth already treated, there are several factors affecting the clinician's decision to retreat it or not and whether the retreatment should be surgical or non-surgical.[21] The surgical retreatment approach may be more appropriate if clinicians are aware of whether or not the sinus has been perforated by the periapical lesion. Depending on the size of the perforation, surgical endodontics may not be recommended or a hospital setting may be selected for the surgical procedure. The accurate identification of changes in the maxillary sinus with a dental cause can also improve the quality of life for patients with remaining symptoms after dental treatment.

Conventional radiographic techniques used to diagnose maxillary sinus mucosal thickening and apical periodontitis include X-ray radiography, magnetic resonance, computed tomography scanning, and conventional periapical radiography. CBCT scanning is a technological innovation developed in recent years with potential use in oral surgery, orthodontic evaluation, implant treatment planning, apical periodontitis evaluation, and periodontal disease planning.[22]

Conclusion

A retrospective inspection of CBCT images revealed that the prevalence of maxillary sinus mucosal thickening was high in CBCT images, and the first molar root involvement frequently affected the sinus; followed by the second molar, second premolar, and, finally, wisdom teeth. CBCT imaging is applicable for the evaluation of the maxillary sinuses and adjacent teeth.

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Ethical approval

This article does not contain any studies with human participants or animals performed by any of the authors.

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