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RESEARCH ARTICLE

RELATIONSHIP BETWEEN THICKNESS OF THE SCHNEIDERIAN MEMBRANE AND DENTAL FINDINGS: A RETROSPECTIVE CBCT STUDY

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ABSTRACT

Background: The aim of the present study is to determine the relationship between dental findings and mucosal abnormalities of the maxillary sinus among dental patients, using cone-beam computed tomography (CBCT). ***Materials and methods:*** Two hundred forty-nine CBCT scans of dental patients were studied. The correlation between changes in the maxillary sinus including the change in the thickness of maxillary sinus membrane (Schneiderian membrane), presence of underwood's septa, presence of mucosal cyst, presence of air or fluid in sinus indicating sinusitis and dental findings including periodontal bone loss, periapical lesion, root canal treated teeth was assessed. Comparison of mean of outcome variables between the groups was done using t- test (for 2 groups) & one-way ANOVA for > 2 groups. Comparison of frequencies between various categories of each variable was done using chi square test. ***Results:*** Mucosal thickening was present in 37.3% of patients and in 74.3% of sinuses studied. Mucosal cysts were present in 7.2% of patients and in 7.2% of sinuses studied. Males presented both abnormalities more frequently than females. Severe periodontal bone loss was non-significantly associated with mucosal thickening (P>0.05). The periapical lesions and root canal fillings were not associated with mucosal thickening. There was a slight positive correlation observed between number of Underwood's septae with mucosal thickness (but statistically non-significant, p>0.05). There was no association between dental findings and mucosal cysts. ***Conclusion:*** This study showed that mucosal cysts and mucosal thickening was common among general population. There was no statistically significant correlation between presence of periodontitis and increase in mucosal thickness.

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INTRODUCTION

Various radiographic techniques often detect mucosal cysts and mucosal thickening of the maxillary sinus in asymptomatic individuals. The reported prevalence of mucosal cysts ranged from 2% to 36% (Soikkonen *et al.,* 1995; Vallo *et al.,* 2010; Bhattacharyya, 2000; Carter *et al.,* 1998; Casamassimo *et al.,* 1980; Harar *et al.,* 2007; Kanagalingam *et al.,* 2009; MacDonald-Jankowski, 1994; Mardinger *et al.,* 2007; Mathew *et al.,* 2009). whereas that of mucosal thickening of the maxillary sinus ranged from 8% to 29% (Soikkonen *et al.,* 1995; Vallo *et al.,* 2010; Havas *et al.,* 1988; Iwabuchi *et al.,* 1997). The widely used procedure to increase the bone height for implant placement is sinus augmentation surgery. The presence of maxillary sinus abnormalities may pose a problem during planning of sinus augmentation procedure (Janner *et al.,* 2011). One study (Ziccardi *et al.,* 1999) reported sinus abnormalities in 55% of the maxillary sinuses of patients referred for dental implant surgery. Infections and mucosal irritations are the potential causes of thickening of the maxillary sinus and the relationship between maxillary sinusitis and dental infections is well established (Brook, 2009). Odontogenic sinusitis accounts for approximately 10% to 12% of maxillary sinusitis cases (Engstro¨m *et al.,* 1988). The cause of mucosal thickening among asymptomatic individuals, however, is unclear. Previous studies have suggested that periodontitis and periapical lesions were related to mucosal thickening (Vallo *et al.,* 2010; Falk *et al.,* 1986; Nenze´n *et al.,* 1967). But, these studies had various limitations, such as small sample size or use of conventional radiographic techniques, that did not allow accurate assessment of sinus pathology. The maxillary sinus cysts are classified into 1) Mucocele; 2) Retention cyst 3) Pseudocyst. A sinus mucocele is an expansible and destructive lesion formed due to blockage of an ostium that completely fills the sinus and rare in occurrence. A retention cyst is formed due to the partial blockage possibly by a plug of inspissated mucous, of a

seromucinous gland of the sinus leading to dilatation of the duct into a cystic structure which could consequently be lined by an epithelium. It is usually present near the ostium but can be found throughout the sinus. This dome-shaped radiopacity of antral wall, may be indistinguishable from a pseudocyst or polyp. Pseudocyst shows a dome-shaped radiopacity, formed by accumulation of fluid beneath periosteum, lifting it off the bone and floor of the sinus to form characteristic dome-shaped structure. It is inflammatory in origin with no epithelial lining and lined by compact layer of fibrous connective tissue which appears to be periosteum. It is often solitary and can be bilateral with predilection for the floor of the sinus. Polyps are usually sessile than pendulous, often multiple with more fibrous connective tissue (Gardner, 1984; Shear and Speight, 2007). The etiology of antral cysts remains unclear with allergy, barotrauma, rhinitis and dental infections as some suggested causative factors (Gardner, 1984; Shear and Speight, 2007). Computer tomography (CT) scan is used for evaluation of the paranasal sinuses, craniofacial bones, as well as the extent of pneumatization of the paranasal sinuses due to its ability to provide multiple sections through these structures at different planes (Mafee *et al.,* 2006). Cone-beam computed tomography has been introduced in the dentistry which has various potential advantages over CT scan such as X-ray beam limitation, image accuracy, rapid scan time, dose reduction, reduced image artefact and reduced cost (Scarfe *et al.,* 2006). In addition, the resolution of CBCT can be as small as 0.125 – 2mm as compared to 0.5 – 1mm for CT. CBCT is a reliable method for evaluation of periapical pathology, periodontal alveolar bone loss and gross pathology and bony anatomy of the maxillary sinus (Lofthag-Hansen *et al.,* 2007; Misch *et al.,* 2006; Guijarro-Martinez *et al.,* 2011).

The references regarding the use of CBCT for evaluation of the maxillary sinus abnormalities and associated dental diseases in asymptomatic individuals are limited. Yoo *et al.* (2011) conducted a study on healing pattern of the mucous membrane after tooth extraction in the maxillary sinus. They found that the thickening of mucous membrane was significantly higher for periodontal disease than pulp disease and tooth fracture. They also found that males had significantly higher mucosal thickening than females. Janner *et al.* (2011) in their study for measurement of thickness of Schneiderian membrane in dental implant patients found that gender was the only parameter affecting the thickness of the Schneiderian membrane. Age, rhinologic disease, tobacco use, last tooth removal in the examined maxillary segment, endodontic and periodontal status of the dentition in the region of interest and weather were not associated with mucosal thickness. However, they classified all the mucosal pathologies such as mucosal thickening, mucocele, mucosal cysts and any other mucosal pathology in one group which may be inappropriate owing to varying causes for different types of mucosal pathologies. The purpose of the current study is to find the correlation between changes in the maxillary sinus including the change in the thickness of maxillary sinus membrane (Schneiderian membrane), presence of underwood's septa, presence of mucosal cyst, presence of air or fluid in sinus indicating sinusitis and dental findings including periodontal bone loss, periapical lesion and root canal treated teeth.

METHODS

Study Samples: The CBCT images from January 2017 to January 2018 were retrieved from Digital Imaging and Communications in Medicine (DICOM) archive folder of Government Dental College and Hospital, Aurangabad and retrospectively examined. Individuals received CBCT for various purpose, mostly pathologies and dental implants. The inclusion criteria for CBCT images were 1) images taken with a 17×13.5-cm field of view, a 250×250×250-µm voxel size, 70 kVp, 10 mA, and an X-ray pulse time of 30 ms. 2) the occlusal plane of the image was parallel to the floor; 3) there was ≥ 1 upper posterior tooth below each sinus. The main exclusion criteria were the absence of upper posterior teeth below the sinus.

CBCT Image Analysis: Ray-sum panoramic (20 mm thickness) and cross-sectional views (2.3 mm thickness) of the maxilla were reconstructed for evaluation and measurements. All images were reconstructed and evaluated by one examiner (SP) who was trained by an experienced oral radiologist (VC). For calibration and evaluation of intra-examiner reliability, 25 CBCT images were measured twice on two different days. The mean difference was 0.09 ± 0.03 mm/image.

Assessment of periapical lesions, periodontal bone loss and root canal filling: Examination of all maxillary posterior teeth was done. Unerupted teeth were excluded. A periapical lesion was defined as a periapical radiolucency in connection with the apical part of a root exceeding at least twice the width of the periodontal ligament space. In CBCT images the lesion had to be visible in more than 1 of the image planes (Lofthag-Hansen *et al.,* 2007). A periapical lesion was considered present when 1≥ tooth below the maxillary sinus had a periapical lesion.

The periodontal bone loss was classified in the present study as follows:

1)Normal to mild, <25% bone loss
2)Moderate, 25 – 50% bone loss
3)Severe, >50% bone loss[28]

The normal periodontal bone level was considered 2mm below the cemento-enamel junction of a tooth (Hausmann *et al.,* 2009). The periodontal bone loss was measured at mesial and distal side of each tooth and calculated as percentage of normal periodontal bone height. (Image 1) The normal periodontal bone height was determined by measuring from the normal bone level to the tip of the root. Periodontal bone loss was considered normal to mild when all the teeth below the sinus had <25% bone loss. Periodontal bone loss was classified as moderate when ≥1 side of a tooth below the sinus had 25-50% bone loss. Periodontal bone loss was classified as severe when ≥1 side of a tooth below the sinus had >50% bone loss. Root canal filling was recorded when a radiopaque material was seen within the root canal on a panoramic view. A root canal filling was considered present when ≥1 tooth below the sinus had a root canal filling. When there was a case where a tooth with endodontic treatment, periapical lesion and bone loss were present simultaneously such tooth was included in all the three categories.

Measurement of mucosal thickening: The cross-sectional view was used to measure the presence or absence of mucosal thickening at the floor of the maxillary sinus. For each sinus, the mucosal thickening was considered present when the thickness of the sinus mucosa was ≥1 mm. When thickening of mucosa was present, the thickness of the mucosa was measured from the floor of the sinus to the highest border of the mucosa (Image 2).

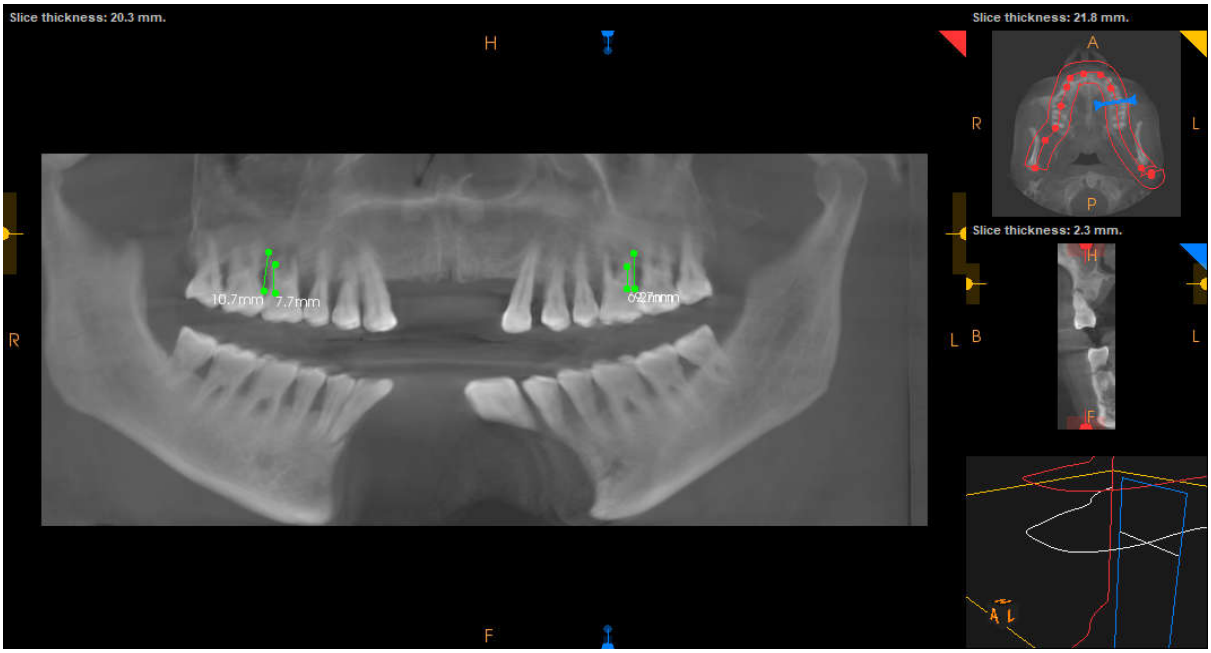

Image 1. Showing periodontal bone loss measured at mesial and distal side of each tooth and calculated as percentage of normal periodontal bone height

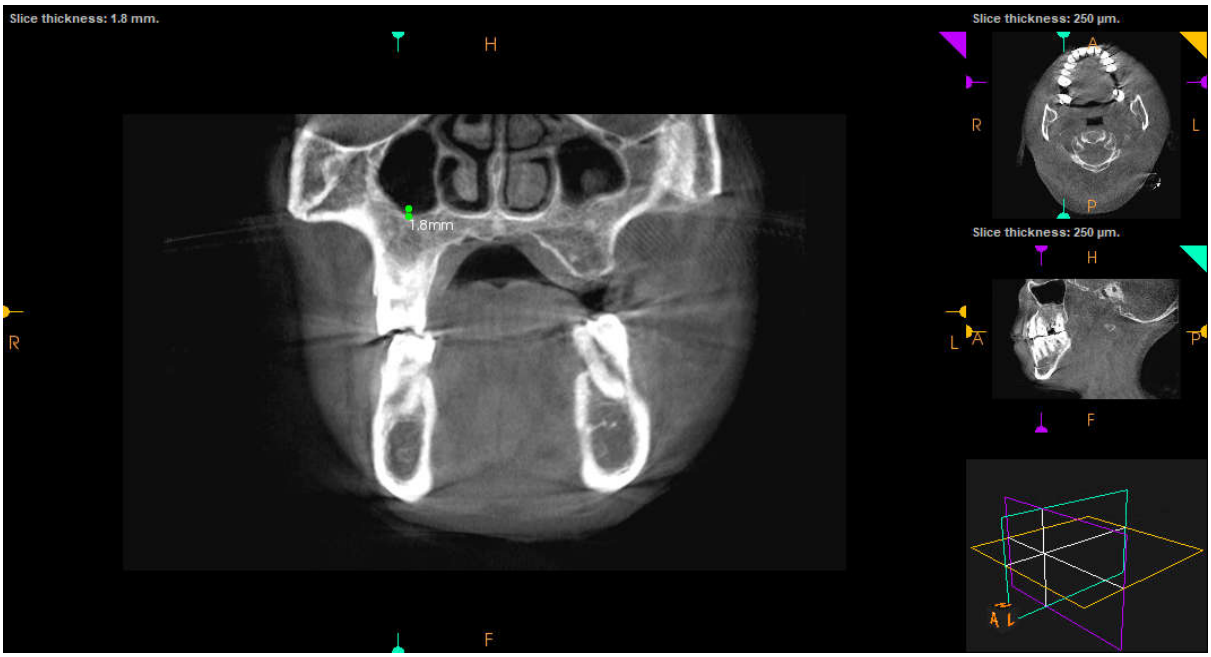

Image 2 The thickness of the mucosa was measured from the floor of the sinus to the highest border of the mucosa

Assessment of mucosal cyst: The presence of mucosal cyst was analysed in panoramic and cross-sectional views. The radiographic characteristics for diagnosis of a cyst were: 1) a homogeneous dome-shaped opacity within the maxillary sinus with sharp demarcation of lateral borders; 2) absence of bony erosion; 3) absence of communication with a tooth root; and 4) a smooth, spherical outline at the free border of the cyst. The size of the cyst was measured from the floor of the sinus to the highest border of the cyst with inclusion of only the cyst present on the floor of the sinus. (Image 3) The mucosal cyst was considered present when ≥1 cyst was present on the floor of the sinus.

Assessment of Underwood's septa: Maxillary sinus septa are barriers of cortical bone that arise from the floor or the walls of the sinus and may divide the sinus into several recesses. The CT images were examined for the presence of antral septa using the axial planes of each section. (Image 4)

Statistical Analyses: Data obtained was compiled on a MS Office Excel Sheet (v 2010) and was subjected to statistical analysis using Statistical package for social sciences (SPSS v 21.0, IBM). Descriptive statistics like mean age & other numerical variables, percentage & frequencies of gender-wise distribution & other nominal variables has been depicted. Comparison of Mean of outcome variables between the groups has been done using t test (for 2 groups) & one-way ANOVA for > 2 groups. Comparison of frequencies between various categories of each variable has been done using chi square test. For all the statistical tests, $p<0.05$ was considered to be statistically significant, keeping α error at 5% and β error at 20%, thus giving a power to the study as 80%.

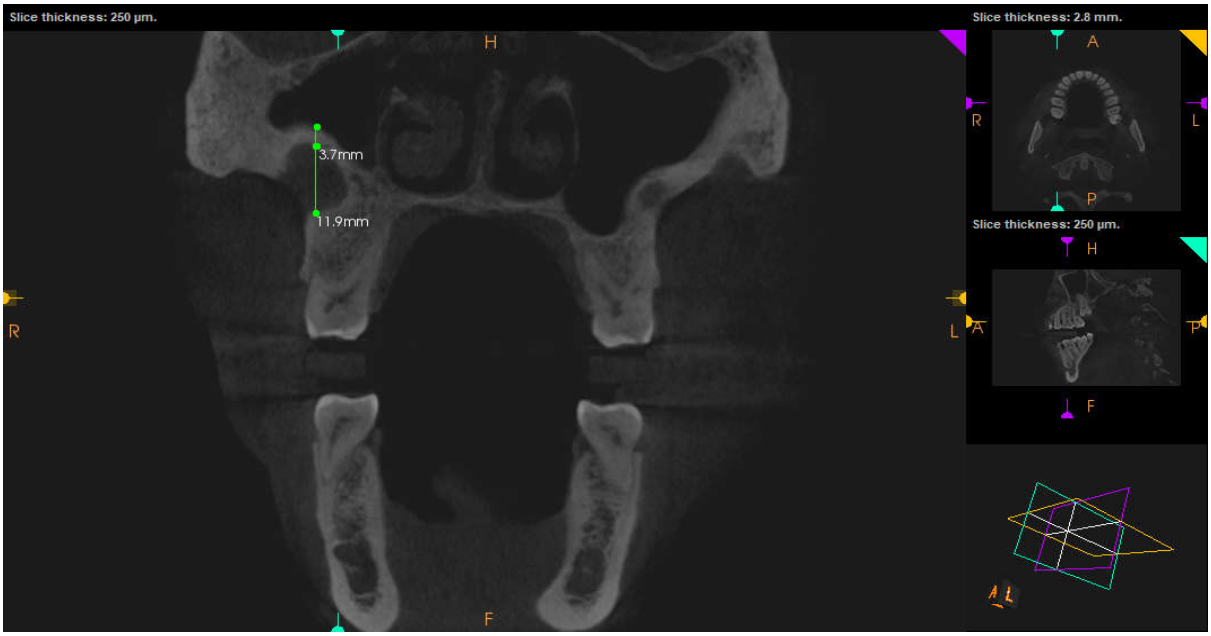

Image 3. Showing mucosal cyst of height 11.9 mm and mucosal thickness of 3.7mm

Image 4. The CT images were examined for the presence of antral septa using the axial planes of each section

RESULTS

The CBCT images of 249 maxillary sinuses and 934 teeth of 125 individuals (74 males and 51 females, aged 20 to 65 years; mean age: 42.63 ± 12.2 years) were examined. Mucosal thickening was observed in 112 patients (45%) and 185 sinuses (74.3%). Mucosal cysts were detected in 18 patients (14.4%) and 18 sinuses (7.2%). The average mucosal thickness in sinuses with mucosal thickening was 2.0 ± 1.6 mm (range: 0.4 to 11.1 mm). The majority of sinuses with mucosal thickening had a mucosal thickness <5 mm. Mucosal cysts, however, had an average height of 11.8 ± 4.6 mm (range: 6.3 to 21.6 mm), with the majority of mucosal cysts having a height of >5 mm (Table 1). Figure 1 and 2 shows the prevalence of mucosal thickening and mucosal cysts by age and sex respectively. There was a higher prevalence of mucosal thickening and mucosal cysts in males than in females.

The prevalence of mucosal thickening was higher among the middle age group (30-49 years old), whereas the mucosal cyst was more prevalent among the older age group (>49 years old). The distribution of the cases according to the dental findings presented and their frequency found in the sample is shown in Table 2. The percentage of sinuses with teeth having normal-to-mild, moderate, and severe periodontal bone loss was 43.3%, 25.3%, and 31.3%, respectively. The percentage of sinuses with teeth having periapical lesions and root canal fillings was 11.2% and 11.6%, respectively. The relationship between these dental findings and maxillary sinus abnormalities are presented in figures 3 - 4. We found that mucosal thickening was not significantly associated with periodontal bone loss, periapical lesions and root canal fillings($p>0.05$). Mucosal cysts were not associated with any of these dental findings. There was a slight positive association ($p = 0.07$) seen between number of Underwood's septa with thickness of the Schneiderian membrane (but statistically non-

significant, p>0.05). Presence of fluid in the maxillary sinus was found in 33 sinuses (13.2%) and 20 patients (8.03%) and it was not associated with periodontal bone loss (p > 0.05).

Table 1. Prevalence of mucosal thickenings and presence of cyst according to the bone loss codes

Codes (mm)	Mucosal thickenings		Cyst	
	Frequency	Percent	Frequency	Percent
0-1	64	25.7	-	-
1.1-5	173	69.5	-	-
5.1-10	10	4.0	7	2.8
10-15	2	0.8	7	2.8
>15	-	-	4	1.6

Table 2. The distribution of the cases according to the dental findings presented and their frequency found in the sample

Dental findings	Periodontal bone loss	
	Frequency	Percent
Normal to Mild	108	43.3
Moderate	63	25.3
Severe	78	31.3
Periapical lesions	28	11.2
Root canal fillings	29	11.6

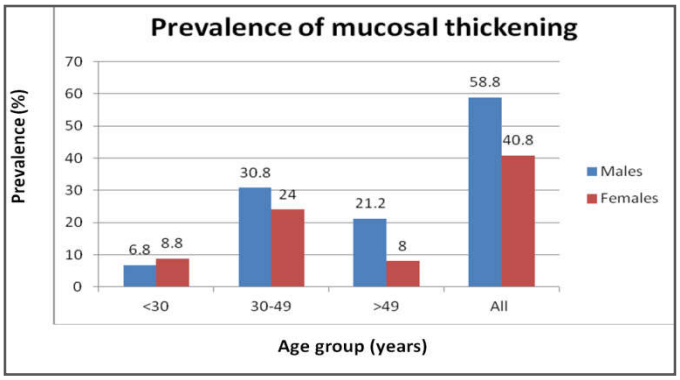

Figure 1.

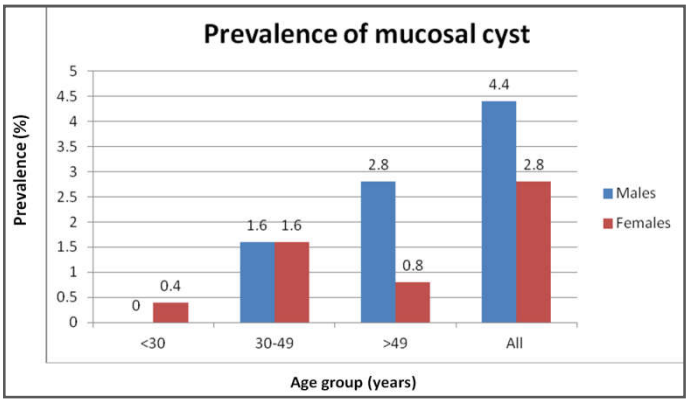

Figure 2.

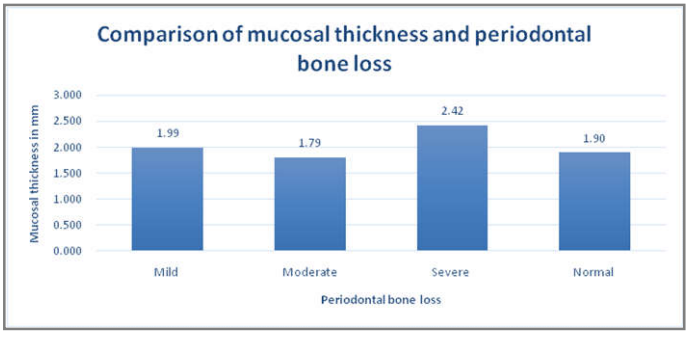

Figure 3.

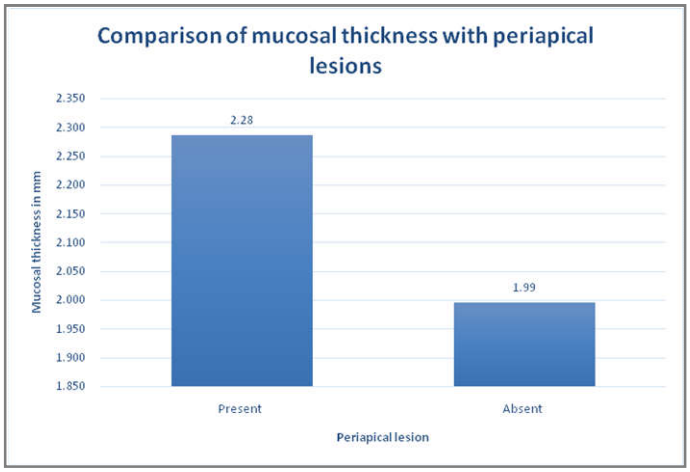

Figure 4.

DISCUSSION

In the current study evaluating the CBCT images of patients, we found a high prevalence of mucosal abnormalities. Mucosal thickening was present in 37% of patients and 74.3% of sinuses. The prevalence of mucosal thickening has been reported between 8-29% (Soikkonen *et al.,* 1995; Vallo *et al.,* 2010; Havas *et al.,* 1988; Iwabuchi *et al.,* 1997). As the normal thickness of the maxillary sinus mucosa is reported to be 0.8 – 1mm, we chose mucosal thickness of >1mm as the evidence of mucosal thickening (Misch *et al.,* 2008). Vallo *et al*. (2010) recorded mucosal thickness if there was a 3-6mm thick non-corticated radiopaque band following the bony wall of the sinus. Soikkonan and Ainamo (Soikkonen *et al.,* 1995) recorded mucosal thickenings, which represented the more diffuse radiopacities along the margins of the sinus without well-defined rounded outlines. Both studies (Soikkonen *et al.,* 1995; Vallo *et al.,* 2010) used panoramic radiographs for measurement of the mucosal thickness, thus they do not allow accurate measurements. The high prevalence of mucosal thickening was observed when a more sensitive imaging technique, such as CT scan and magnetic resonance imaging was used (Soikkonen *et al.,* 1995; Vallo *et al.,* 2010; Havas *et al.,* 1988; Iwabuchi *et al.,* 1997). The present study showed the risk of mucosal thickening with periodontal bone loss where severe periodontal bone loss was associated with increased mucosal thickening. Vallo *et al.* (2010) found that periapical lesions, horizontal alveolar bone loss, vertical infrabony pockets, and furcation lesions were all significantly associated with mucosal thickening. The sites with severe periodontal bone loss show increased levels of pathogenic bacteria and bacterial products along with increased inflammatory mediators such as cytokines and tumour necrosis factor alpha (Feng, 2006). These products may reach the sinus mucosa via direct diffusion through porous maxillary bone or blood and lymph vessels causing mucosal thickening. Thus, periodontitis may be a cause for mucosal thickening. We investigated the relationship of age and sex with mucosal thickness. We found higher prevalence of mucosal thickening in males than in females. This finding supports the previous study (Vallo *et al.,* 2010). A higher prevalence of mucosal thickening was found in the middle age group (30-49 years) in our study contrary to the previous study which found a higher prevalence in the older age group (>49 years) (Iwabuchi *et al.,* 1997). We found mucosal cysts in 14.4% of patients and in 7.2% of sinuses. We found higher prevalence of mucosal cysts in males than

females similar to the previous studies (Vallo *et al.,* 2010; Casamassimo and Lilly , 1980; Feng, 2006; Phothikhun *et al.,* 2012). The mucosal cysts were more prevalent in the older age group (>49 years) contrary to the previous studies which showed higher prevalence in young age group (Vallo *et al.,* 2010; Casamassimo and Lilly , 1980; Feng, 2006; Phothikhun *et al.,* 2012). Mucosal cysts were not associated with periodontal bone loss contrary to the study by Casamassimo (Casamassimo and Lilly, 1980) which revealed trends toward larger cysts in terms of both vertical size and area with increasing severity of periodontal disease. Soikkonen and Ainamo[1] found same prevalence of mucosal cysts (5%) in both dentulous and edentulous subjects suspecting odontogenic causes may not be a major contributing factor in their formation. In our study, the average height of the mucosal cysts was 11.8 mm which is less than the previous studies (Bhattacharyya , 2000; Harar *et al.,* 2007). As the mucosal cysts are benign in nature, showing favourable course and in majority of cases, the absence of any symptoms, treatment of mucosal cysts is mostly unnecessary and should be performed in clearly symptomatic cases (Giotakis and Weber, 2013).

In the present study, mucosal thickness did not show statistically significant change with presence of periapical lesion which is similar to the previous study (Janner *et al.,* 2011) but mucosal thickness increased with presence of periapical lesion. In contrary, Vallo *et al.* (2010) showed statistically significant increase in mucosal thickness with presence of periapical lesion. In the present study, mucosal thickness did not show statistically significant change with root canal filling but mucosal thickness decreased with root canal fillings contrary to the previous study (Vallo *et al.*, 2010). The floor of the sinus in an adult is around 1 to 1.25 cm below the level of the floor of the nasal cavity. The significance of this floor is related to its relationship to the roots of the maxillary teeth and the alveolar process. The bony floor may be dehisced completely above the apices of the roots, bringing the periapical tissues into direct contact with the membranous lining of the sinus. Such a close relationship between the sinus and the teeth may facilitate the spread of pathologic conditions of dental origin into the sinus (Mathew *et al.,* 2009).

The presence of mucosal thickening and mucosal cyst are though not contraindications for maxillary sinus augmentation procedures, may pose a problem during or after the procedure (Mardinger *et al.,* 2007). Mucosal thickening has been associated with obstruction of ostium of maxillary sinus which may lead to postoperative sinusitis after sinus augmentation surgery. It is possible that in case of patent sinus outflow, the bone graft particles are efficiently delivered from the sinus cavity to the nasal cavity and the digestive tract. However, in an obstructed sinus, the particles, which advance through the oral flora, are trapped and optimal conditions for local infection develop (Carmeli *et al.,* 2011). However, studies have also shown that a sinus augmentation procedure can be performed safely in the presence of mucosal cysts and mucosal thickening (Mardinger *et al.,* 2007; Carmeli *et al.,* 2011; To¨zu¨m *et al.,* 2009; Kara *et al.,* 2010). Therefore, proper preoperative assessment of the patient with CBCT for presence of mucosal thickening or mucosal cysts as well as consultation with otolaryngologists for the presence of sinusitis is required before the sinus augmentation procedure. Similar to our study, previous studies indicate that severe periodontitis may initiate mucous membrane thickening in the maxillary sinus, though our study showed statistically non-significant results (Engstro *et al.,* 1988; Falk *et al.,* 1986). The successful periodontal treatment results in normalisation of the sinus mucosa (Engstro *et al.,* 1988; Falk *et al.,* 1986). The current study has several implications in implant dentistry. The current study showed a high prevalence of mucosal thickness and mucosal cysts in general population indicating need of radiological assessment of maxillary sinus before augmentation procedure. The successful treatment of periodontitis is necessary before sinus augmentation as this study indicates increase in thickness of Schneiderian membrane with periodontitis. The current study also had some limitations. The use of cross-sectional views with a thickness of 2.3mm for the evaluation of the periapical lesions and for the measurement of the maxillary sinus mucosa is may interfere with the visualization of periapical lesions and the correct measurement of mucosal thickening, thus influencing the results of the study. There was neither information regarding the status of sinus of individual patient nor any questionnaire indicating the same. Thus, the current study might have included both patients with or without sinusitis. The individual patient's clinical periodontal and periapical status was not available. Thus, this study may have included both treated and untreated cases of periodontitis. Hence, the strength of association in this study might be underestimated.

Conclusion

This study showed that mucosal cysts and mucosal thickening was common among general population. There was no statistically significant correlation between presence of periodontitis and increase in mucosal thickness.

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