Original Research

Morphological Variations of the Maxillary Sinus Floor Adjacent to Periapical Chronic Injuries

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Abstract

Background: Today, there are several diagnostic methods to determine the exact size and nature of periapical lesions. Furthermore, there are studies that described thickening of the mucous membrane of the maxillary sinus (MS) in patients with periapical lesions and demonstrated a causal relation. **Aims:** This study aims to evaluate the morphological variations of the MS floor (MSF) adjacent to chronic periapical lesions in molars and premolars using cone-beam computed tomography (CBCT). **Methods:** Twenty-five CBCTs with periapical lesions adjacent to maxillary molars and premolars were evaluated. A total of 50 maxillary sinuses were analyzed (12 males and 13 women) taking into account density changes within the sinus cavity. The thickening of the sinus mucosa and the periapical lesions was measured in a caudal-cephalic direction. The axial and sagittal axis was taken as reference on the sagittal and coronal sections. **Statistical Analysis:** Chi-square, Fisher exact, and the Mann–Whitney tests were used in this study. **Results:** A significant association between the size of the periapical lesions (>4 mm) and the presence of MSF affectation was found on sagittal and coronal views ($P < 0.001$). No significant differences between the presence or absence of periapical lesions and the thickening of the sinus mucosa were found ($P = 0.241$). The presence of opacification on the MS had no direct associations with the periapical lesions. **Conclusions:** Maxillary sinus floor affectation was associated with chronic periapical lesions >4 mm. The opacification or thickening of the sinus mucosa was not related with the periapical lesions.

Keywords: *Cone-beam computed tomography, maxillary sinus, periapical diseases*

Introduction

Inflammatory periapical lesions represent pathological entities of the pulp with a typical apex formation. Periapical lesions have been a clinical challenge while specialists consider different treatments. Today, there are several diagnostic methods to determine the exact size and nature of periapical lesions.[1,2] Furthermore, there are studies that evaluate etiological factors, such as periodontal disease, tooth decay, large restorations, surgical procedures, apical periodontitis and endodontic therapies, as well as thickening of the mucosa on the maxillary sinus (MS).[3,4] Abrahams and Glassberg,[5] described a double increase on the maxillary sinus disease in patients with periodontal disease and demonstrated a causal relation. Sheikhi *et al*.[6] demonstrated that the thickening of the mucous membrane of the maxillary sinus was more common in patients with periodontal bone loss. Furthermore, Vallo *et al*.[7] claimed that dental infections are the main etiology behind thickening of the mucosa lining the antrum, but not for antral mucous cysts. In addition, inflammatory pathologies of the periapical region are influenced by pathogenic characteristics and by a number of microorganisms which invade this area in conjunction with the dynamics of the guest response.[8] However, there are no investigations comparing periapical lesions on the affected side versus healthy unaffected side in the same patient.

Anatomically, the maxillary sinus is located between the nasal and oral cavities, being vulnerable to pathogenic organism invasion.[9-11] It is necessary to recognize its limits, which appear on radiographic images as a faint radiopaque line that would correspond to the cortical bone. Normally, it is seen as a continuous image. Lesions can be detected if small interruptions can be seen in the uniformity or density.[12] It has been reported that pathological lesions of the maxillary sinus occur most commonly between the second and third decades.[9] A

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review of the literature reported that many cases of acute recurrent sinusitis were due to secondary chronic dental bacterial colonization of the antral mucosa. Melén *et al*.[13] found an incidence of 40.6% for chronic maxillary sinusitis of dental origin. This could only be confirmed in 43 of the 99 cases by oral examination. Bomeli *et al*.[14] came to the conclusion that the odontogenic infections were often the source of onset of acute sinusitis. To stop the progression of the disease and to avoid excessive antibiotic treatment, early preventive and therapeutic interventions are necessary.[9,15,16] The proximity between the root apex of the upper teeth and the maxillary sinus floor can generate a superimposed image of radiographic structures on 2D examinations. Incipient lesions can hide damage to the integrity of the maxillary sinus cortical floor that is associated with an oroantral communication.[17-19] It is necessary to obtain a good differential diagnosis based on the duration of clinical symptoms. Cone-beam computed tomography (CBCT) has a clinical relevance on anatomical observation for a more accurate diagnosis of the integrity of the maxillary sinus, the alveolar bone, and teeth.[20]

This research has radiological significance because it seeks to establish the imaging criteria to help general dentists and specialists distinguish whether or not there are alterations in the anatomical structures of maxillary sinus which would help in the prevention of pathologies that may arise from external injuries of dental origin. At the same time, this research could serve to make a proper diagnosis to treat pathologies of the maxillary sinus, and also to contribute and enrich the clinic knowledge in this field. Finally, the objective of this research was to evaluate with CBCT, morphological variations of the maxillary sinus floor adjacent to chronic periapical lesions (CPL) in molars and premolars.

Methods

This retrospective study was approved by the Ethics Committee of Científica del Sur University (Approval No. 000259). The study population was composed of 330 CBCTs scans of participants aged ≥20-year-old with chronic periapical lesions close to the maxillary sinus floor of premolars and molars selected from an existing database. Twenty-five CBCTs (13 women and 12 men) were selected and met the selection criteria from a private dental imaging center (CDI Lima, Perú) between January 2010 and December 2015. To avoid bias in evaluating periapical status of premolars and molars by only one examiner, radiographs of the 25 cases were subjected to stringent evaluation by two experienced radiologists. Two examiners evaluated the radiographs independently until they agreed on 25 cases that met the criteria listed later. In case of disagreement, no attempts were made to come to a consensus and the case was excluded. Only cases where the evaluators completely agreed were included.

Fifty maxillary sinuses were analyzed based on density changes within the sinus cavity. To assess the association with the pathologic features found on the floor of the maxillary sinus, the proximity and size of the periapical lesions were considered taking into account a hypodense image around the apex. The criteria for classifying the presence of a pathology included the identification of at least one type of the following abnormalities, such as the opacification of the maxillary sinus, the discontinuity of the maxillary sinus floor, and the thickening of the sinus mucosa.

Previously, root canal treated teeth and teeth with restorations were also included in the study. Exclusion criteria included those teeth that needed immediate therapy due to an endodontic emergency. Endodontically involved teeth that had a history of trauma or radiographic evidence of fracture were excluded from the study. Patients had been referred by their private dentists or from different dental school departments. Patients refusing to use their CBCT for research were excluded. CBCTs scans with images where the anatomical structure of the maxillary sinus could not be observed or with traumatic or pathological lesions were also excluded.

Radiographic examination and analysis

The CBCT images were obtained with the Picasso Trio imaging device (Vatech, Hwaseong, South Korea) with the following exposure protocol: 90 kV and 8 mA, 20 s of exposure time, and a voxel size of 0.4 mm. All the images were taken in accordance with the recommended protocol according to the manufacturer recommendations.

The largest diameter in millimeters of the periapical radiolucency was measured on CBCT images (all three dimensions: axial, sagittal, and coronal) by one blinded examiner using the Real Scan 2.0 software and enhancement tools in a random order. The contrast and brightness of the images were adjusted using the tool-processing images in the software to ensure optimal viewing. Images were viewed in a dimly lit room on an 18-inch monitor (Toshiba, Tokyo, Japan) set at a screen resolution of 1366 × 768 and 32-bit color depth at 5 day intervals, and evaluations of each image set were repeated 1 month after the initial viewings. All measurements were taken twice, and the calculated mean was used for further analysis. For the CPL, the lesions were further divided into three groups according to their size: I: 1–2 mm, II: 3 mm, and III: ≥4 mm. More than 3 mm of mucosa thickening was considered a pathological sign [Figure 1]. Both maxillary sinuses (left and right) were separately registered, and then compared with the unaffected contralateral side, determining the degree of the lesion or maxillary sinus floor damage.

The presence of periapical lesions on the upper posterior teeth was evaluated independently by the examiner

considering the lamina dura continuity loss and the presence of hypodense images around the apex of the evaluated tooth [Figure 2]. The CPL was measured on the coronal and sagittal views, to determine if they were related to the affected maxillary sinus floor [Figure 3].

Kappa values were calculated to assess intraobserver agreement according to the following criteria: 0.10, no agreement; 0.10–0.40, poor agreement; 0.41–0.60, significant agreement; 0.61–0.80, strong agreement; and 0.81–1.00, excellent agreement. Quantitative variables were analyzed with the intraclass correlation coefficient (ICC). A result of 0.9–1 was obtained for all variables.

Statistics

All statistical analyses were performed using SPSS ver. 23 for Windows (IBM SPSS, Armonk, NY, USA). Descriptive statistics was conducted for the maxillary sinus floor variable (present or absent) in each study group. Presence or absence of periapical lesions was evaluated. The association between these two qualitative variables was determined with the Chi-square test. The size of the periapical lesion and the dimension of the thickening of the sinus mucosa on the sites with periapical lesion (present on the affected study group) was compared with the contralateral side (without affectation of periapical injury). The association between the periapical lesions and the presence of opacification of the maxillary sinus was observed considering the maxillary sinus density pathology (hyperdense-hypodense) according to Fisher's exact test. The evaluation of the normality was carried out with Shapiro–Wilk Test, as well as the U of Mann–Whitney Test. $P < 0.05$ was considered to indicate statistical significance.

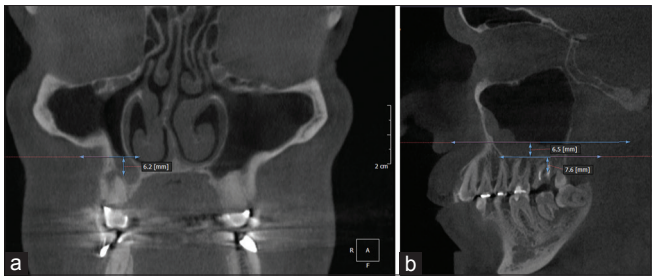


Figure 1: (a) Maxillary sinus thickening measurement based on a coronal view. (b) Sagittal view of the MS thickening measurement

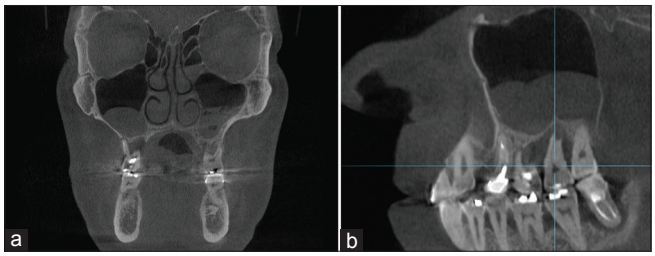


Figure 2: (a) Coronal view of a periapical hypodense chronic lesion on the upper right molar near the maxillary sinus floor. (b) Sagittal view showing a huge hypodense periapical lesion that includes more than one tooth

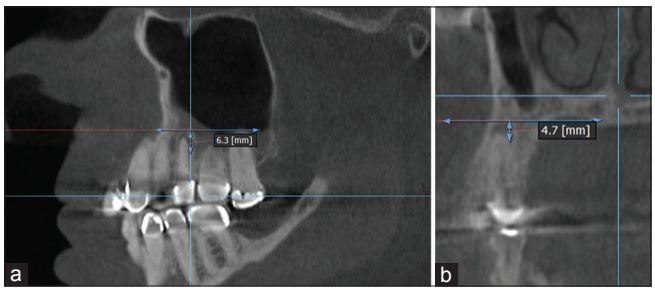


Figure 3: (a) Sagittal view with the measurement of a chronic periapical lesion in a cephalocaudal direction. (b) Coronal view showing the chronic periapical lesion measurement, tangential axes were considered as reference lines

Results

Fifty CBCT images of maxillary sinuses from 25 individuals (48% men and 52% women), age range 22–79 years (41 ± 13.1) were examined. The evaluation of periapical lesions according to the affected teeth was 12% on premolars, 60% on molars, and 28% on both teeth.

No statistically significant differences were found between the periapical lesions and the presence of opacification of the maxillary sinus. Besides, 40% of the patients that presented periapical injury had opacification of the maxillary sinus and 60% did not show this entity [Table 1].

Furthermore, no association was reported between periapical injuries and the integrity of the cortical bone of the inferior wall of the maxillary sinus. Only 12% presented bone erosion of the inferior wall of the maxillary sinus [Table 2].

The size of the periapical lesion was also assessed. 14 participants (56%) presented >4 mm of length affecting the

Table 1: Association between the periapical lesion and the presence of opacification on the maxillary sinus

Periapical lesión	MS opacification		Total (%)	*P*
	Present (%)	Absent (%)		
Present	10 (40.0)	15 (60.0)	25 (100)	0.364
Absent	6 (24.0)	19 (76.0)	25 (100)	
Total	16 (32.0)	34 (68.0)	50 (100)	

Fisher's exact test. MS=Maxillary sinus

Table 2: Association between the periapical lesion and the integrity of the cortical bone of the lower wall of the maxillary sinus

Periapical lesion	Integrity of the cortical bone of the lower wall of MS		Total (%)	*P*
	Presence of erosion (%)	Absence of erosion (%)		
Present	3 (12.0)	22 (88.0)	25 (100)	0.235
Absent	0 (0.0)	25 (100)	25 (100)	
Total	3 (6.0)	47 (94.0)	50 (100)	

Fisher's exact test. MS=Maxillary sinus

maxillary sinus floor. Statistical significant differences were found with the Fisher exact test ($P < 0.001$) [Tables 3 and 4]. With regard to the sinus mucosa, thickening an average of 4 mm ± 7 mm and of 3.84 mm ± 6.78 mm was measured, respectively, on the sagittal and coronal views. In cases with no periapical injury, an average of 2 mm ± 5 mm and 2.14 mm ± 4.58 mm were obtained [Table 5].

Discussion

The radiological characteristics of hypodense images around the apex were described in this article to evaluate the association with pathological features on the maxillary sinus. Selection bias was controlled in the methodological design of this investigation; the final sample included 25 patients and 50 maxillary sinuses. In addition, a pilot study was conducted to calibrate the observer on periapical lesions diagnosis related to the maxillary sinus based on the main radiological characteristics of the studied pathologies.

In our study, a significant association was found between the periapical lesions and the maxillary sinus affectation. This was also reported on the study published by Maillet *et al*.,[20] with a prevalence on the first and second maxillary molars. In their study, the palatine root of the first molar was more commonly associated with the maxillary sinus floor perforation. This can be because the first molar erupts first at the age of 6-year-old, so they are more susceptible to develop caries, premature restorations, and occlusal attrition, compared to second molars. When second molars were involved, they found that the periapical pathology was associated with the mesiobuccal root compromising the maxillary sinus with an average distance of 0.67 mm (closest root to the maxillary sinus). These associations can be considered for future research.

Table 3: Relationship between the periapical lesion size and the maxillary sinus floor

Periapical lesion size sagittal view (mm)	MS floor		Total (%)	*P*
	Not affected (%)	Affected (%)		
I (1-2)	2 (100)	0 (0.0)	2 (100)	<0.001
II (3)	9 (100)	0 (0.0)	9 (100)	
III (+4)	0 (0.0)	14 (100)	14 (100)	
Total	11 (44.0)	14 (56.0)	25 (100)	

Chi-square Pearson test

Table 4: Coronal relationship of the periapical lesion size with the maxillary sinus floor

Periapical lesion size coronal view (mm)	MS floor		Total (%)	*P*
	Not affected (%)	Affected (%)		
I (1-2)	2 (100)	0 (0.0)	2 (100)	<0.001
II (3)	9 (100)	0 (0.0)	9 (100)	
III (+4)	0 (0.0)	14 (100)	14 (100)	
Total	11 (44.0)	14 (56.0)	25 (100)	

Chi-square Pearson test

Regarding the relationship between periapical lesions and the integrity of the cortical bone of the maxillary sinus floor, no significant associations were found between these variables. Our findings are not consistent with those reported by Maillet *et al*.,[20] who concluded that the cortical bone of the floor of the maxillary sinus was interrupted in all cases with dental etiology, being that the maxillary sinus is dependent variable affected by these lesions and by age. Lee and Lee[17] found that 12 (44.40%) of the 23 cases studied presented with bone erosion of the maxillary sinus floor and were directly related to the infected roots protruding through the maxillary sinus cortical floor. They concluded that this was due to anatomically thin cortical bone in the maxillary sinus floor. In our study, 12% of the patients with periapical lesions presented bone erosion of the lower wall of the maxillary sinus, related to the proximity of the periapical lesions toward the maxillary sinus floor, which was not evaluated in the present study.

In relation to periapical lesions sizes and the maxillary sinus floor. The strong association found in our study between the maxillary sinus floor and severe lesion (large sizes) was also consistent with the findings of Abrahams and Berger.[21] However, their associations derived from very large lesions (13.5 mm to 18.9 mm) and a small sample. On the other side, Ariji *et al*.[22] did not associate the size of the periapical lesion with the maxillary sinus floor. They concluded that the odontogenic maxillary buccopalatal infection originated on the first and second molars and was influenced by the horizontal position of the root in relation to the maxillary sinus floor cortex. The results of Nunes *et al*.[23] contrasts with our results since they conclude that the size of a periapical lesion was not associated necessarily with the maxillary sinus pathology frequency. However, they found a direct relationship

Table 5: Association of the sinus mucosa thickening with the presence of periapical lesions on sagittal and coronal views

Periapical lesions	Sinus mucosa thickening measurement	*n*	Mean±SD	Minimum	Maximum	*P*
Present	Sagittal view	25	4±7	0	26.6	0.241
Absent	Sagittal view	25	2±5	0	16.4	
Present	Coronal view	25	3.84±6.78	0	26.7	0.256
Absent	Coronal view	25	2.14±4.58	0	16.9	

U de Mann–Whitney test. SD=Standard deviation

between the roots associated with periapical lesions close to the maxillary sinus floor.

Otherwise, our results did not show any statistically significant difference with regard to the thickening of the sinus mucosa measured in a cephalocaudal direction on sagittal and coronal views and the presence or absence of periapical lesions. These findings agreed with those of Lu *et al*.,[24] who found sinus mucosa thickening on 48.4% of patients. In spite of the nature of the spatial relationship between the maxillary sinus floor and the apex of the infected roots related to the floor of the sinus, there was no effect on the thickening of the sinus mucosa. However, Brüllmann *et al*.[25] found an association between periodontitis and radiological signs of sinusitis with a wall thickening of the mucosa in patients with decayed and nonvital teeth compared with patients with healthy teeth. Furthermore, Rege *et al*.[26] reported a thickening of the sinus mucosa associated with some type of irritation such as the odontogenic pathology and allergic etiologic factors.

Conclusions

Maxillary sinus floor involvement was associated with chronic periapical lesions >4 mm. The opacification or thickening of the sinus mucosa was not related with the periapical lesions.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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