Evaluation of Periapical Lesions and Their Association with Maxillary Sinus Abnormalities on Cone-beam Computed Tomographic Images

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Abstract

Introduction: Periapical inflammation is often responsible for distinct maxillary sinus (MS) changes. This retrospective, cross-sectional study evaluated the association between the clinical characteristics of periapical lesions (presence, size, and distance) in maxillary posterior teeth and the presence of sinus abnormalities by evaluating cone-beam computed tomographic (CBCT) images obtained from an archived collection. Apart from sex, no other patient information was available.

Methods: The study sample was composed of CBCT images of 143 MSs of patients with at least 1 maxillary posterior tooth with a periapical lesion and 178 MSs of patients without periapical radiolucent lesions. Sinus abnormalities were classified as mucosal thickening, sinus polyp, antral pseudocyst, nonspecific opacification, periostitis, and antral calcification; periapical radiolucent areas were classified using the CBCT periapical index, and the distance between the periapical lesion edge and the MS floor was measured. Data were analyzed using chi-square tests at a level of significance set at \( \alpha = 0.05 \). Results: Most sinus abnormalities were associated with at least 1 maxillary posterior tooth with a periapical lesion (\( P > .05 \)). The most frequent sinus abnormality in the presence of a periapical lesion was mucosal thickening. All teeth with a CBCT periapical index score of 5 were associated with sinus abnormalities. The highest frequency of abnormalities was found when the radiolucent area was subjacent to the sinus floor.

Conclusions: Maxillary posterior teeth with periapical radiolucent lesions had the highest frequency of sinus abnormalities. The size of a periapical lesion was not associated with the frequency of sinus abnormalities. A close spatial relationship between periapical lesions and sinususes resulted most frequently in sinus abnormalities. (\( J \) Endod 2016;42:42–46)

Key Words

Anatomy, cone-beam computed tomography, maxillary sinus, periapical lesion, sinusitis

Diffuse pain in the posterior maxilla may be difficult to diagnose because of the relationship between the roots of the maxillary posterior teeth and the maxillary sinus (MS) floor. Because the MS and the maxillary teeth share a common nerve supply, an accurate differential diagnosis should be made when the patient complains of pain (1, 2).

The MS floor extends from the first premolar to the maxillary tuberosity but may reach the zygomatic bone, the alveolar ridge after extractions, and the anterior canine. Located at a lower level than the floor of the nasal cavity, the MS is closely associated with maxillary tooth roots (3, 4). Normal sinus mucosa is not visualized on radiographs, but, when affected by infection or allergy, it may become thicker and, therefore, visible on images (3). Periapical infections in the maxilla may spread along several paths depending on tooth position. Bacteria, their toxins, and products of pulp necrosis may spread to adjacent anatomic structures, such as the MS, and lead to inflammation (5–8).

Radiographs are important tools in the diagnosis of periapical changes and MS abnormalities. Panoramic radiographs, films exposed according to the Water technique, and periapical images have all been used to assess both the integrity of the MS and its anatomic relationship with roots of maxillary posterior teeth (9–11). However, radiographs are 2-dimensional (2D) representations of 3-dimensional (3D) structures, which make it especially difficult to evaluate the relationship of roots and periapical lesions (PLs) with the MS floor (5, 6, 9, 11–13).

For the MS, computed tomographic (CT) imaging is the reference imaging test because it shows bone and soft tissue and because images may be obtained in thin CT slices and multiple planes (9). Cone-beam CT (CBCT) imaging has proven to be a valuable complementary test to evaluate root canal treatment failures and probable MS involvement (1, 9, 14, 15). The well-known entity of odontogenic sinusitis is found in 10%–12% of the cases of maxillary sinusitis (9).

CBCT imaging may help make a diagnosis and define the treatment of odontogenic sinusitis (9, 13–15). Therefore, to make the diagnosis of maxillary sinus abnormalities, an accurate imaging test should be used to investigate the association of PLs and MS changes. This retrospective, cross-sectional study evaluated the association between the clinical characteristics of PLs (presence, size, and distance) in maxillary posterior teeth and the presence of sinus abnormalities by evaluating CBCT images obtained from an archived collection.

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Materials and Methods

Image Selection

The sample was composed of CBCT images of 200 patients (125 women, 75 men; mean age = 41.2 years) seen from January 2009 to July 2013 in a private dental radiology service for diagnosis. Apart from sex, no other patient information was available. A total of 321 MSs were evaluated: 143 MSs on CBCT imaging showing all posterior teeth and at least 1 posterior tooth with a PL and 178 MSs on CBCT imaging showing no posterior teeth with PLs.

Inclusion criteria were maxillary CBCT scans showing all first and second premolars and first and second molars, all fully erupted and with fully formed roots. CBCT scans that showed the imaging device or an orthodontic retainer, bone abnormalities, and suspected tumors in the posterior area of the maxillary or in the MS were excluded. This study was approved by the research ethics committee (Proc. #19715613.5.0000.5083) of the institution.

Imaging Methods

The CBCT images were obtained using an I-CAT Cone Beam 3D System unit (Imaging Sciences International, Hatfield, PA). The following settings were used: field of view of 16 × 6 cm, volume reconstruction using 0.25-mm isometric voxels, a voltage of 120 kVp, a tube current of 3.8 mA, and an exposure time of 40 seconds. The images were analyzed using the CBCT unit software (Xoran 3.1.62; Xoran Technologies, Ann Arbor, MI) and a computer running Microsoft Windows 7 Professional 32-Bit with XP Mode.

Figure 1. Changes in MS observed in sagittal CBCT imaging: (A) absence of alteration; (B) mucosa thickening; (C) sinus polyp; (D) antral pseudocyst; (E) nonspecific opacification; (F) mucosa thickening and periostitis; (G) antrolith; and (H) mucosa thickening and antrolith.
Clinical Research

Abnormalities in the MS observed on CBCT scans were recorded and classified into the following groups:

0: Normal (radiolucent, intact cortical, mucosal thickness <3 mm)
1: Mucosal thickening (area without cortical bone and with soft tissue density, thickness >3 mm, parallel to sinus bone wall)
2: Sinus polyp (area with soft tissue density forming an extension [fold] adjacent to thickened MS mucosa)
3: Antral pseudocyst (area with soft tissue density and no cortical bone, dome-shaped, intact sinus floor)
4: Nonspecific opacification (soft tissue density, partial or total homogenous MS opacification)
5: Periostitis (thick and homogeneous opaque area, laminated, adjacent to cortical bone of MS floor, above radiolucent area associated with tooth apex)
6: Antrolith (antral calcification) (well-defined radiopaque area, typical characteristics of calcification, and intact MS cortical bone or cortical bone within the MS) (3) (Fig. 1A–H)

Teeth without PLs had periapical bone structures, a normal CBCT aspect of trabecular and cancellous bone, and no radiolucent area; teeth with PLs had a radiolucent area in the periapical region. PLs were measured using the CBCT periapical index (CBCTPAI) as described before (16). CBCT images were analyzed in 3 dimensions, and 4 measurements were made: sagittal (mesiodistal), coronal (lingual to buccal), transverse (diagonally), and axial (mesial to distal and lingual to buccal). The reference value was the largest diameter of the lesion together with cortical bone expansion or destruction. PLs were classified according to the diameter of the radiolucent area as follows:

1. Periapical bone structures intact
2. >0.5–1 mm
3. >1–2 mm
4. >2–4 mm
5. >4–8 mm
6. >8 mm

Variables that could be added to the scores were also included as follows: E (cortical expansion) and D (cortical destruction). Teeth that had more than 1 root with a PL were assigned the score of the root with the highest CBCTPAI.

The distances between the upper lesion edge and the MS floor were measured, and results were classified as follows:

1. 0 mm, lesion was juxtaposed to the MS floor
2. >0 to <2 mm
3. ≥2 mm

MSs were also classified according to lesion: at least 1 tooth with a PL or no teeth with a lesion.

All evaluations were performed by 2 examiners who are experts in dental radiology and imaging and experienced in using CBCT imaging with more than 10 years of experience. Of the sample of CBCT scans that followed the criteria for inclusion and exclusion, 10% not included in this study were used for previous examiner calibration. When there was no consensus, a third examiner with the same qualifications rated the images.

Table 1. Frequency (%) of Maxillary Sinus Abnormalities Associated to the Presence, Size of Periapical Lesions (cone-beam computed tomographic periapical index), and Distance between the Upper Edge of the Periapical Lesion and the Maxillary Sinus Floor

<table>
<thead>
<tr>
<th>Clinical factors</th>
<th>Absent, n (%)</th>
<th>Present, n (%)</th>
<th>P value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>PL</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Absent</td>
<td>93 (52.25)</td>
<td>85 (47.75)</td>
<td>&lt;.05</td>
</tr>
<tr>
<td>Present</td>
<td>51 (35.66)</td>
<td>92 (64.34)</td>
<td></td>
</tr>
<tr>
<td>Size CBCTPAI (scores)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1a</td>
<td>18 (9)</td>
<td>15 (8)</td>
<td>&lt;.05</td>
</tr>
<tr>
<td>2b</td>
<td>20 (10.5)</td>
<td>27 (14)</td>
<td></td>
</tr>
<tr>
<td>3b,c</td>
<td>14 (7.3)</td>
<td>37 (19.2)</td>
<td></td>
</tr>
<tr>
<td>4b,c</td>
<td>11 (6)</td>
<td>39 (20)</td>
<td></td>
</tr>
<tr>
<td>5b,c</td>
<td>0 (0.0)</td>
<td>12 (6)</td>
<td></td>
</tr>
<tr>
<td>Distance from the top edge of the PL to the MS floor</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≤0 mm²</td>
<td>25 (13)</td>
<td>87 (45)</td>
<td>&lt;.05</td>
</tr>
<tr>
<td>&gt;0 to &lt;2 mmån,b</td>
<td>12 (6)</td>
<td>17 (9)</td>
<td></td>
</tr>
<tr>
<td>≥2 mm²</td>
<td>20 (10)</td>
<td>32 (17)</td>
<td></td>
</tr>
</tbody>
</table>

CBCTPAI, cone-beam computed tomographic periapical index; MS, maxillary sinus; PL, periapical lesion.

Categories with same letter are not statistically different from each other (P > .05).

*Chi-square test.
of the MS associated with periapical infections (1, 2, 5–10). Studies (2, 9, 25) have shown that potent virulence factors are produced because of pulp necrosis, such as collagenase and lysosomal enzymes, which promote the destruction of periapical tissues and may reach the MS.

In this study, 64.3% of MSs had abnormalities in the presence of periapical radiolucent lesions. These results were lower than those reported by Shanbhag et al (6) and Lu et al (13), which found that about 80% of MS changes were associated with PLs. The differences between results may be caused by different diagnostic criteria. In our study, mucosal thickening was recorded when the mucosa was more than 3-mm thick, whereas previous authors (6, 13) have used values beginning at 2 mm.

There is no consensus in the literature about how thick the mucosa should be to indicate mucosal thickening, and cutoff values range from 2–6 mm in different studies (26, 27). Vallo et al (28) reported that MSs associated with PLs were 3.5 times more likely to have abnormalities, whereas Shanbhag et al (6) and Brüllmann et al (29) found even greater odds, 9.75 and 10.2, respectively.

PLs are seen on CBCT images as a radiolucent area associated with the apex of teeth that have a thickness of at least twice that of the periodontal ligament (30) or only as a radiolucent area around the tooth with an apex suggestive of bone destruction and probably imperceptible or irregular lamina dura (26). However, Lemagner et al (31) evaluated the prevalence of apical bone defects on CBCT images and determined the associated factors. The authors have considered using the term apical bone defect and not apical periodontitis because the study was based on radiographic detection of the lesions without information on the associated clinical conditions.

An index to identify apical periodontitis using CBCT imaging (ie, CBCTPAI) based on scores defined according to the diameter of the radiolucent area has been proposed (16). In the current study, when the PL diameter was >8 mm, all MSs had abnormalities (100%). These results confirm those reported by Lu et al (13), who used the periapical index (32) to evaluate CBCT images and found that the likelihood of changes in MS was directly associated with lesion size and that the probability of severe apical periodontitis was higher although this result was not significantly different. However, Pope et al (33) recommended caution in applying the periapical index (32) to examine CBCT images because the 3D image seems to show a greater variation of periodontal ligament space than 2D images, which may affect the assessment of the periapical area.

One of the advantages of the CBCTPAI (16) is the use of 3 anatomic planes of reference, which ensure the 3-dimensionality of the image and, therefore, a more precise analysis of periapical lesion size and changes that may be found in adjacent anatomic structures. Another benefit is that the PL can be measured, which rules out subjectivity and reduces examiner interference.

The proximity of PLs and the MS may be a potential factor of sinus mucosal irritation (2, 28). In this study, MS associated with teeth whose most apical lesion edge was subjacent to the floor (distance = 0) had the highest number of abnormalities, suggesting an effect of PL distance on the MS, but Rege et al (26) and Lu et al (13) found no association between PL proximity and sinus abnormalities. These conflicting results may be explained by the different criteria used in selecting the sample and for image interpretation (13) because the classification of distance (34) was based on periapical radiographs.

The topographic anatomic relationship between the maxillary posterior teeth and the MS has been evaluated in recent studies (8, 35). Although the mean thickness of the cortical bone of the MS floor in the region closest to the roots apices is low, ranging from 0–1.6 mm (35), the sinus floor may act as a barrier that rarely allows direct penetration of dental infections into its interior, which may explain a low incidence of sinusitis associated with odontogenic infections even when the frequency of pulp necrosis and apical periodontitis is high (25).

Sinusitis of an odontogenic origin accounts for 10%–12% of all cases of maxillary sinusitis (9). Sinusitis is detected and classified based on signs, symptoms, and disease course, but imaging findings are important to make a diagnosis (9, 14, 15). MS mucosal thickening and accumulation of secretion that accompanies sinusitis reduce the air content of the sinus, gradually creating a radiopaque area inside (3, 4). Criteria for the diagnosis of sinusitis, based on CBCT images, were discussed in a study by Maillet et al (1), and sinusitis was diagnosed when there was a mass with soft tissue and mucosal thickening >2 mm. In this study, mucosal thickening was the most frequent change in the MS of patients with at least 1 tooth with a PL. Although this result confirms findings in other studies that used CT (8) and CBCT imaging (6, 13, 29), mucosal thickening found only on the sinus floor might suggest something other than sinusitis although it may progress to involve the entire MS (3).

Anatomic knowledge about the relationship between the root apex and the sinus floor as well as its cortical thickness is an important factor in evaluating the spread of odontogenic infection, which occurs through cancellous bone, reaches the cortex of the floor bone, and crosses it more or less quickly depending on the characteristics of the offending agent, host resistance, and physical peculiarities of this path (distance, bone porosity, thickness, blood in cortical bone, and lymphatic vessels).

The present cross-sectional study was performed as a retrospective analysis of CBCT examinations consecutively selected from a private radiology clinic’s secondary database. It should be noted that the clinical interpretation of these results is limited by the lack of prior radiographic assessment and the absence of information on patient health history such as pre-existing chronic sinusitis and systemic conditions that cause bone changes. In addition, no information was available on diagnostic factors used by clinicians including the condition of the dentition, the history of dental treatment, and the etiology of the PLs.

In conclusion, within the limitations of this study, maxillary posterior teeth with periapical radiolucent lesions had the highest frequency of sinus abnormalities. The size of a PL was not associated with the frequency of sinus abnormalities. A close spatial relationship between the PL and the sinus resulted most frequently in sinus abnormalities.

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The authors deny any conflicts of interest related to this study.
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