Cone-beam Computed Tomography Evaluation of Maxillary Sinusitis

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Abstract

Introduction: Dental pain originating from the maxillary sinuses can pose a diagnostic problem. Periapical lesion development eliciting inflammatory changes in the mucosal lining can cause the development of a sinusitis. The purpose of this study was to describe the radiographic characteristics of odontogenic maxillary sinusitis as seen on cone-beam computed tomography (CBCT) scans and to determine whether any tooth or any tooth root was more frequently associated with this disease. **Methods:** Eighty-two CBCT scans previously identified as showing maxillary sinus pathosis were examined for sinusitis of odontogenic origin in both maxillary sinuses. **Results:** One hundred thirty-five maxillary sinusitis instances with possible odontogenic origin were detected. Of these, 37 sinusitis occurrences were from nonodontogenic causes, whereas 98 instances were tooth associated with some change in the integrity of the maxillary sinus floor. The average amount of mucosal thickening among the sinusitis cases was 7.4 mm. Maxillary first and second molars were 11 times more likely to be involved than premolars, whereas either molar was equally likely to be involved. The root most frequently associated with odontogenic sinusitis is the palatal root of the first molar followed by the mesiobuccal root of the second molar. **Conclusions:** Changes in the maxillary sinuses appear associated with periapical pathology in greater than 50% of the cases. Maxillary first or second molar teeth are most often involved, and individual or multiple roots may be implicated in the sinusitis. The use of CBCT scans can provide the identification of changes in the maxillary sinus and potential causes of the sinusitis. *(J Endod 2011;37:753–757)*

Key Words

Cone-beam computed tomography, odontogenic sinusitis, root apex

Dental pain originating from the maxillary sinuses can pose a diagnostic problem for the dental clinician. Because of 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, pulpal inflammation or infection can affect the integrity of the sinus floor. The development of a periapical lesion in teeth whose root apices are close to or extending into the maxillary sinuses could elicit inflammatory changes in the mucosal lining and, subsequently, the development of sinusitis (2).

The extension of periapical inflammation into the maxillary sinus was first described in 1943 by Bauer (3).This was a cadaver study with microscopic evaluation of sections of human teeth, alveolus, and sinus. 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 are able to spread directly or via bone marrow, blood vessels, and lymphatics to the maxillary sinus (3). When the ostium is blocked, the patient may experience pain with symptoms in the face, eye, nose, and oral cavity, including swelling. They may also experience a vague headache (4) and with chronic sinusitis may complain of postnasal drip, dental pain, and a sore throat (5).

Cone-beam computed tomography (CBCT) provides detailed three-dimensional images of the structures scanned. The use of CBCT scans in endodontic practice could allow for improved treatment planning of surgical procedures by showing 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 because of the ability to visualize both bone and soft tissue in multiple views with thin sectioning (6). Because 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 and any resultant changes in the soft tissue of the sinus (7). In the case of odontogenic sinusitis, using CBCT technology could allow for improved treatment planning in combining both nonsurgical and surgical dental and medical treatments (8).

Sinusitis of odontogenic origin has traditionally been considered to account for approximately 10% of sinusitis cases (7). In the maxilla, odontogenic infections will most frequently spread through the thin buccal alveolar wall and into the buccal vestibule. The floor of the sinus is composed of dense cortical bone; therefore, sinus infections from a dental source were thought to be uncommon, but they can occur, particularly in the case of a pneumatized sinus in which the Schneidarian membrane can be easily penetrated by pathogens. Also, the labial levator and orbicularis oculi muscles attach to the lateral wall of the maxilla, which forms the anterior wall of the

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sinus. These muscle attachments can direct infection into the sinus via soft-tissue spaces (5).

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. When sinusitis is of odontogenic origin, 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 purpose of this retrospective study was to describe the radiographic characteristics of odontogenic maxillary sinusitis as seen on CBCT scans and to determine whether any tooth, or any tooth root, was more frequently associated with this disease.

Materials and Methods

Study Scans

Approval for this study was obtained from the University's Institutional Review Board. The investigators initially examined 871 CBCT radiology reports from 2006 to 2008 that a board-certified oral and maxillofacial radiologist had previously identified as showing sinusitis in one or both of the maxillary sinuses. The radiologist had 18 years of experience in interpreting cross-sectional imaging and at the time of the study had interpreted about 3,000 CBCT scans. Based on these radiology reports, 82 CBCT scans were included in the study. Inclusion criterion was the presence of the words "maxillary sinusitis" in the radiographic impression section of the report. Exclusion criteria were totally edentulous maxilla and the presence of motion or beam hardening artifacts in the maxillary periapical areas. The age of the patients ranged from 18 to 87 years, with a mean age of 57.3 years. The patient pool included 49 men and 33 women. CBCT scans were taken using a dentomaxillofacial volumetric imaging system, CBCT, on a Next Generation i-CAT (Imaging Sciences, Hatfield, PA). Voxel size in the study population ranged from 0.25 mm to 0.40 mm. The acquisition time was 27 seconds or less. The total volume of the acquired data was available to the observers.

Observers

Two observers (an endodontic resident and a board certified oral and maxillofacial radiologist) were calibrated by reviewing and discussing 20 CBCT scans that had normal sinus findings or previously diagnosed sinusitis. For the study, the scans were reviewed by both the observers independently on a Dell 24-inch nonglossy monitor (1,920 × 1,200 resolution) with a Dell Precision Workstation using iCATVison software (Imaging Sciences). Each scan was reviewed in axial, coronal, and sagittal sections and in the "implant" view for assessing individual tooth/root. If there was a disagreement on the diagnosis, a consensus was reached after a discussion between the two observers.

Diagnostic Criteria for Sinusitis

For the purposes of this study, diagnostic criteria for sinusitis diagnosis were developed based on published literature (10). These criteria divided maxillary sinusitis into four categories, with line diagrams shown in Figure 1 and sample CBCT pictures shown in Figure 2:

1. Normal sinus: a sinus is considered normal if it has no mucosal thickening detected on the images or uniform mucosal thickening less than 2 mm (11). The adjacent teeth may be healthy, carious, pulp exposed, restored, extracted, and with or without radiographically evident periapical lesion (Fig. 1*A* and *B*).
2. Sinusitis of odontogenic origin: a soft-tissue density mass within the sinuses is a sinusitis of odontogenic origin if it fulfills the following criteria: carious tooth, tooth with defective restoration, or extraction site with or without radiographically evident periapical lesion and mucosal thickening limited to the area of the tooth or extraction site in question (Fig. 1*C*).
3. Sinusitis of nonodontogenic origin: a soft-tissue density mass within the sinuses is a sinusitis of nonodontogenic origin if it fulfills the following criteria: teeth are noncarious, have coronal and/or endodontic restorations of good quality without radiographically evident periapical lesion or if extracted, intact or healing socket and mucosal thickening is not limited to any tooth (Fig. 1*D* and *E*).
4. Sinusitis of undetermined origin: a soft-tissue density mass within the sinuses is a sinusitis of undetermined origin if it fulfills the following criteria: carious tooth, tooth with defective restoration, presence of a periapical lesion, or a disrupted socket and mucosal thickening is not limited to any tooth (Fig. 1*F*).

In the case of a diagnosis of odontogenic sinusitis, the etiologic tooth was recorded as well as the root associated with the periapical lesion. If the tooth had previous endodontic therapy, this was recorded as well as the presence of extruded material. In addition, the integrity of the medial and lateral walls and floor of the sinus was noted. The investigators recorded disruption in the bone and/or any sclerosing of these walls.

Mucosal thickening was measured at the point of maximum thickness from the sinus floor. In the event of discrepancy between individual reviewers' measurements, consensus was reached by re-evaluating the scan together. In those images in which the sinuses contained fluid, the distinction of the mucosal thickness was not possible and images were termed as sinusitis of undetermined origin (diagnostic criterion 4).Dome-shaped radiopacities in the maxillary sinus were recorded but classified as polyps or retention pseudocysts. These were considered to be pathological entities of nonodontogenic origin.

Measurement of the Mucosal Thickening

The thickness of the mucosa was determined at the maximum thickness from the sinus wall using the measurement tool provided in the iCATVision software. The threshold of measurement reliability was 0.25 or 0.40 mm depending on the voxel size of the scan.

Results

From the database of 871 CBCT scan radiology reports, 82 reports (9.4%) contained a conclusion of "maxillary sinusitis." From these 82 scans, we detected 135 instances of findings involving sinusitis with a potential odontogenic origin (Fig. 3). In 98 instances (100 teeth were shown to be associated with sinusitis, but 2 teeth were involved in 2 instances, providing sinusitis of odontogenic origin with 100 teeth), it was noted that teeth were associated with some change in the integrity of the maxillary sinus floor. Of the odontogenic cases, 3 occurrences were first premolars, 8 were second premolars, 55 were first molars, and 34 were second molars. Of these 98 odontogenic cases, 28 were considered to be indeterminate because the sinusitis was not limited to a diseased or defectively restored tooth (diagnostic criterion 4). Although odontogenic etiology in these 28 cases was present with disruption of the sinus floor in the area of the teeth involved, the extent of the sinusitis was large and considered indeterminate even though tooth-associated changes were present. When considering the total number of maxillary posterior teeth (534 teeth) included in examination, 3 of 132 maxillary first premolars, 8 of 141 maxillary second premolars, 55 of 137 maxillary first molars, and 34 of 124 maxillary second molars showed odontogenic etiology for the sinusitis. Thirty-seven other occurrences were because of nonodontogenic causes,

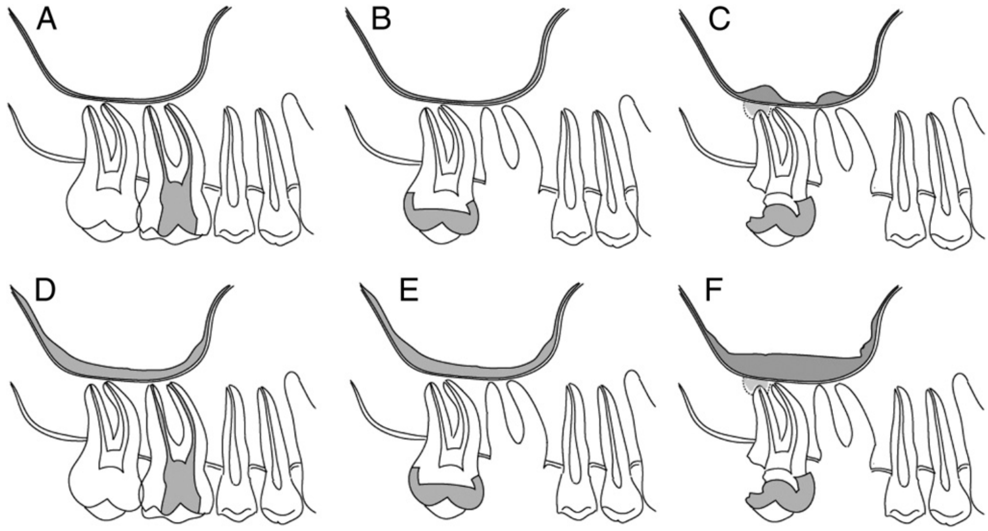

Figure 1. (*A* and *B*) Normal sinus mucosal thickening of less than 2 mm. Adjacent teeth may be healthy, carious, pulp exposed, restored, extracted, and with or without radiographically evident periapical lesion. (*C*) Sinusitis of an odontogenic origin. Mucosal thickening limited to carious tooth, tooth with defective restoration with or without radiographically evident periapical lesion, or extraction site. (*D* and *E*) Sinusitis of a nonodontogenic origin. Mucosal thickening is not limited to any tooth, periapical lesions, or extraction socket. (*F*) Sinusitis of an undetermined origin. A possible odontogenic source is present, but mucosal thickening is not limited to any carious tooth, tooth with defective restoration, a periapical lesion, or a disrupted socket.

with common findings of fluid in the sinuses and sclerosis of the sinus floor and the lateral wall of the sinus. No sclerosis of the medial wall was noted. In six of these cases, the medial wall of the maxillary sinus was disrupted, but all of these cases involved sinus pathology of nonodontogenic or indeterminate origin and included sinonasal polyposis, solitary polyps, cancer, mucoceles, retention cysts, antroliths, fungal sinusitis, or sinusitis lacking dental etiology.

There were 35 cases of sinusitis in patients who had existing premolars and molars. Sinusitis was more likely to be associated with the molars with an odds ratio of 11 (molars were 11 times more likely to be associated with sinusitis than premolars). There were 48 cases of sinusitis in patients who had existing first and second molars. In these instances, sinusitis was equally likely to be associated with either molar (odds ratio of 1). Two cases had two separate teeth involved with the sinusitis, which included one case with a premolar and molar and one case with a first and second molar.

In many instances, multiple roots were implicated in the sinusitis. The first premolar group involved solely the buccal root in one instance and solely the palatal root in one instance. In the third case, both roots were involved with disruption of the sinus floor. Of the eight second premolars associated with maxillary sinusitis, six were single-rooted teeth. In the remaining two, one case involved the buccal root and the other involved both the buccal and palatal roots. In the first molar group, 38 of the 55 teeth involved the palatal root, 18 involved the mesiobuccal root, and 17 involved the distobuccal root. In the second molar group, 27 of the 34 cases involved the mesiobuccal root, 10 involved the palatal root, and 8 involved the distobuccal root. No third molars were evaluated during the investigation.

The average amount of mucosal thickening noted among the sinusitis cases was 7.4 mm. The cortical bone in the floor of the sinus was disrupted in all cases in which a dental etiology was identified. We saw an association of this thickening with a periapical lesion from carious or heavily restored teeth. The tooth most commonly associated with these findings was the maxillary first molar, and the palatal root of the first molar was most commonly associated with the perforation of the sinus floor. The distribution of teeth associated with maxillary sinusitis is shown in Figure 4. Of the sinusitis cases with an odontogenic etiology, 55% were from maxillary first molars, and 34% were from maxillary second molars. Among all 100 teeth associated with maxillary sinusitis, 21 had previous root canal therapy, and 2 of the 21 cases had extruded root canal filling material.

Discussion

For this study, we developed radiographic diagnostic criteria for sinusitis of odontogenic origin. The diagnostic criteria are a modification of the classification by Abrahams and Glassberg (10). This existing classification, which was developed by medical radiologists, did not evaluate carious lesions or endodontic status of the involved tooth. We found that our modified classification system allowed comprehensive analysis of sinusitis of an odontogenic origin. In this study, odontogenic sinusitis was identified as a localized thickening of the mucous membrane of the maxillary sinus. The tooth most commonly associated with these findings was the maxillary first molar. This finding is consistent with previous reports (9, 12). However, these reports did not address the involvement of a particular root with sinusitis. In our study, the palatal root of the first molar was most commonly associated with the perforation of the sinus floor. What is perhaps surprising about these findings is the fact that the palatal root of the first molar is not the closest root to the sinus. The mesiobuccal root of the maxillary second molar is on average 0.67 mm closer to the sinus than the palatal root of the first molar (13). The first molar erupts earlier (by 4–5 years), however, and is therefore 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 into the sinus. When the second molar was involved, pathosis associated with the mesiobuccal root was the most common etiology. The cortical bone in the floor of the sinus was disrupted in all cases in which dental etiology was identified.

The maxillary sinuses are variable in size depending not only on the individual but also on the individual's age. These sinuses complete their growth between the ages of 12 and 14 years concurrently with the eruption of the maxillary teeth and growth of the maxillary alveolar process. In some people, expansion of the maxillary sinuses will

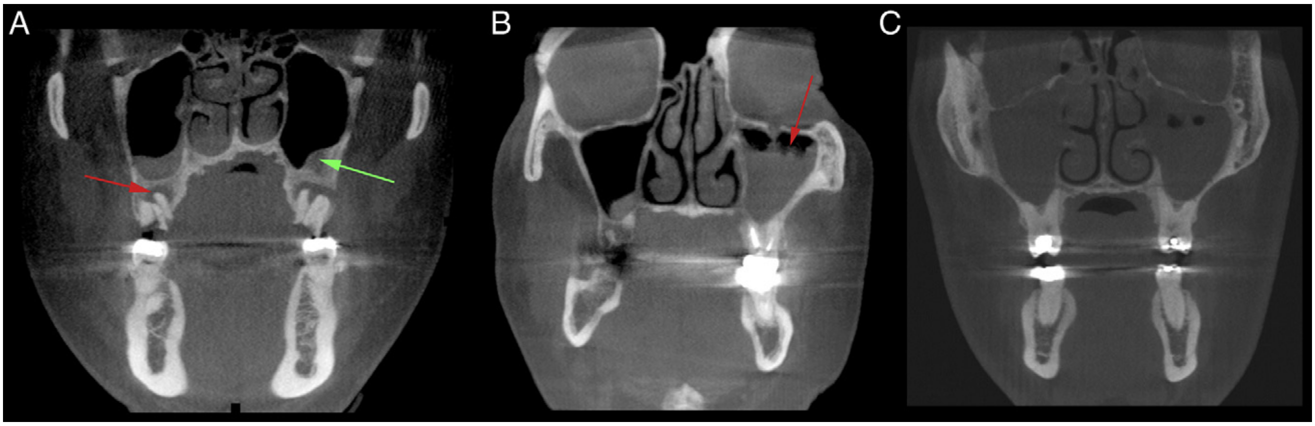

Figure 2. (*A*) A CBCT scan (coronal section) through the skull at the level of the first molar. Carious maxillary first molars with periapical lesions (*red arrow*) are associated with localized thickening of mucosa (*green arrow*) in both maxillary sinuses. (*B*) A CBCT scan (coronal section) through the skull at the level of the first molar. Nonodontogenic sinusitis. The left maxillary sinus is filled with fluid and contains air bubbles (*red arrow*). The first maxillary molar has an intact restoration, has root canal therapy of good quality, lacks a periapical lesion, and the corticated floor of the sinus remains intact. (*C*) A CBCT scan (coronal section) through the skull at the level of the first molar. Sinusitis of an indeterminate origin. Both molars are heavily restored. The root perforates the maxillary sinuses. The sinuses are filled, making localization of the source of inflammation impossible.

continue throughout life, resulting in an inferior displacement of the floor of the sinus toward the root apices of the maxillary posterior teeth. On occasion, the roots of the maxillary teeth project into the sinus cavity, with the apices surrounded by sinus mucoperiosteum (5).

Radiographically, the normal maxillary sinus has a shape that is inconsistent, with many loci and lobulations (14). Because it is air filled, the sinus is radiolucent, but it has clearly defined margins (2). In the case of a diseased sinus, a clinician may observe clouding (opacifying), mucosal thickening, and/or accumulation of fluid (4). Rak et al (11) 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 (11). Other authors have found that mucosal thickening of 4 mm or more was significantly associated with clinical symptoms (9). The average amount of mucosal thickening noted during this investigation was 7.4 mm. The current investigation was a retrospective study of existing scans only, and did not include patient symptoms, or the reasons for the referral for CBCT scans.

Based on a study by Maloney and Doku in 1968 (2), several reports had indicated that only 10% to 12% of sinusitis cases have an odontogenic source (5, 7). However, more recent works based on computed tomography images have shown that sinusitis of odontogenic origin is not a rare condition; rather, as high as 86% of sinusitis cases have a potential odontogenic source (9, 15, 16). This is exemplified by a recent report of five patients who had undergone an average of 2.8 sinus surgeries in which the sinusitis persisted with symptoms for 3 to 15 years until the true cause of the problem, their dental infection, was treated (17). What is even more important is that three of these five patients had been seen by their respective dentists (they underwent examination and dental radiographs) and told that there was no dental pathology, which shows that unrecognized periapical infection can be a cause of sinusitis. Obayashi et al (9) found that 71.3 % of cases of dental infection were associated with changes in the maxillary sinus. In that study, periapical pathosis was diagnosed first, followed by radiographic examination of the sinuses. The present study first noted sinus pathology and then evaluated the dentition. When we consider all the sinusitis cases (135) and examine the odontogenic cases (70 as two teeth were associated in two cases each), there exists

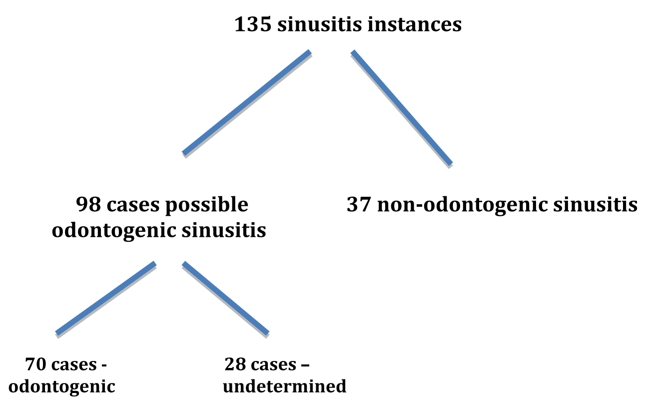

Figure 3. From 82 scans, 135 instances of findings involving sinusitis with potential odontogenic origin were detected. The breakdown of cases from these 135 sinusitis instances are shown.

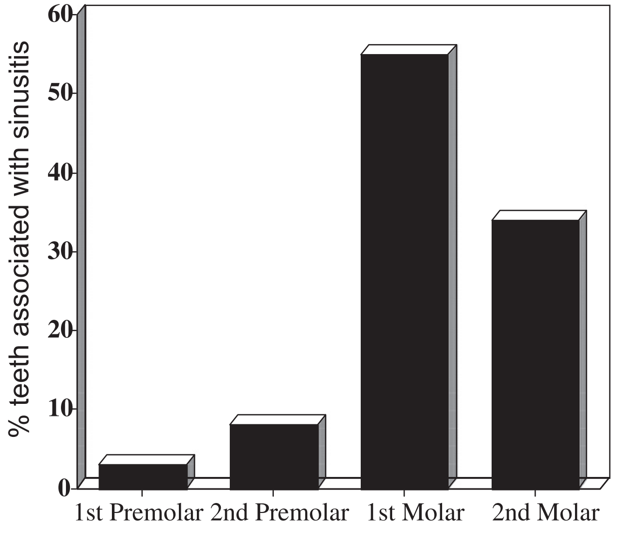

Figure 4. The incidence of 100 maxillary posterior teeth possibly involved with maxillary sinusitis. Periapical disease from the first and second maxillary molars is by far the largest contributor.

a 51.8% incidence of odontogenic sinusitis (70/135). Without considering the indeterminate cases of sinusitis, there existed 65.4% (70/[70 odontogenic + 37 nonodontogenic cases]) of the maxillary sinusitis cases associated with maxillary posterior teeth having periapical pathology, which closely matches the occurrence rate found by Obayashi et al (9).

It is important to note that although this study did not address the issue of sinusitis associated with peri-implantitis, this condition has been noted in the literature (18), and the identifying factors for odontogenic sinusitis could also be applied to a dental implant. Having more accurate data available at the time of diagnosis can lead to better treatment planning. The use of CBCT in the endodontic practice could provide the clinician with important information regarding the size and location of a periapical lesion, which could affect a clinician's treatment decision (8). If a tooth has been previously treated, there are several factors that will influence the decision whether to retreat or not and whether the retreatment should be surgical or nonsurgical (19). A clinician who has elected for a surgical retreatment approach may be better prepared for the surgery if they are aware of whether or not the sinus had 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 could also improve the quality of life for those patients with remaining symptoms after dental treatment. During this investigation, 28 cases had an extensive sinusitis as well as odontogenic pathosis. For these patients, combined therapy between the dentist and an otolaryngologist may be required.

Cone-beam technology has many applications including temporomandibular joint evaluation, orthodontic evaluation, implant treatment planning, oral surgery, and the assessment of craniofacial trauma and reconstruction (20). The main drawbacks to including CBCT in endodontic practice are the high financial cost and the higher radiation dose as compared with conventional radiography. However, in many cases, the information gained could be of paramount importance.

Conclusions

The following conclusions can be made: (1) radiographic diagnostic criteria for sinusitis of odontogenic origin were developed for this study; (2) odontogenic sinusitis can be identified as a localized thickening of the mucous membrane of the maxillary sinus associated with a carious or heavily restored tooth with a periapical lesion or extraction site; (3) in patients with maxillary sinusitis, over half of the cases appear to be associated with odontogenic pathology; (4) molars are 11 times more likely than premolars to be associated with odontogenic sinusitis when both teeth are present; (5) first and second molars are equally likely to be associated with odontogenic sinusitis when both molars are present; (6) in this study, the first molar was most frequently associated with changes in the maxillary sinus; and (7) the root most frequently associated with odontogenic sinusitis is the palatal root of the first molar followed by the mesiobuccal root of the second molar.

Acknowledgments

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

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