The Laryngoscope

Frequency of a Dental Source for Acute Maxillary Sinusitis

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Objective: To identify radiographic features of odontogenic acute maxillary sinusitis and to determine the frequency of a causative dental infection in patients with radiographic evidence of maxillary sinus fluid.

Study Design: Retrospective review of 101 sinus computed tomography scans with unilateral or bilateral maxillary sinus fluid.

Methods: Each maxillary sinus was graded for extent of fluid, degree of mucosal thickening, and presence of dental pathology. Univariate chi-square analysis was used to identify potential radiologic and demographic features predictive of sinus fluid. Multivariate logistic regression was then used to determine which features were independently predictive.

Results: 124 of the 202 maxillary sinuses (61%) had sinus fluid. Univariate analysis excluded age, gender, and prior surgery as predictive features. The multivariate analysis included the radiographic features of oroantral fistula, periapical abscess, periodontal disease, projecting tooth root, and dental caries. Of these, only oroantral fistula and the combination of periodontal disease with either a projecting tooth root or periapical abscess were identified as significant sources of maxillary sinusitis. In sinuses that were <1/3 opacified by fluid, 17% had a dental source of infection. In sinuses with 1/3 to 2/3 fluid opacification, 53% had an identifiable dental source, and in sinuses that were >2/3 opacified by fluid, 79% had an identifiable dental source. Mucosal thickening demonstrated a similar relationship with dental sources, so that sinuses having both >2/3 fluid opacification and moderate mucosal thickening were 86% likely to have an identifiable dental source.

Conclusions: Odontogenic infections are often the source of acute maxillary sinusitis, especially if the radiographic findings of sinusitis are severe.

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INTRODUCTION

An estimated 10% to 12% of cases of maxillary sinusitis have historically been attributed to odontogenic infections.[1] Conditions that violate the Schneiderian membrane, such as periapical abscesses, periodontal disease, dental trauma, tooth extractions or placement of dental implants, are thought to increase the risk of maxillary sinusitis.[2] Previous studies evaluating computed tomographic (CT) images of patients with periodontal disease found a twofold increase in maxillary sinus disease compared to age- and gender-matched controls. Radiographic features suggesting a causal relationship between periodontal disease and ipsilateral maxillary sinusitis were found in 38% of cases.[3] Sinusitis of dental etiology is of particular interest because the pathophysiology, microbiology, and treatment differ from sinusitis caused by other conditions.[4]

Patients with persistent symptoms are frequently referred to otolaryngologists despite maximal medical therapy and negative workups from dental providers. Dental providers frequently image patients using bitewing and panoramic radiography, but these imaging modalities underestimate the amount of bone loss, only demonstrating it months after the soft tissue changes have occurred.[5] These imaging modalities have an estimated sensitivity of 60% for dental caries and 85% for periodontal disease, so false negatives will occur at a significant rate.[6] Axial and coronal sinus CT imaging is frequently performed by the otolaryngologist in the workup of sinusitis. When dental and periodontal pathology is revealed on the same side as a diseased maxillary sinus, causality may be inferred. The purpose of this study is to identify radiographic features of odontogenic acute maxillary sinusitis and to determine the frequency of these features in patients with radiographic evidence of maxillary sinus fluid.

MATERIALS AND METHODS

This retrospective radiologic study was conducted with the approval of the institutional review board. Archived CT scan

reports from April 2002 through April 2008 at the University of Pittsburgh Medical Center Hospitals were queried to identify radiology reports that included the phrase "acute maxillary sinusitis" in the impression. Patients were included in the study if they were 18 years of age or older and had fluid-density material layering in at least one maxillary sinus. Patients were excluded if the scan did not include the maxillary teeth, if the patient was immunocompromised, if the patient had a history of nasal polyposis, cystic fibrosis, allergic fungal sinusitis or if the scan was performed for evaluation of an acute traumatic injury. The study was restricted to conventional CT scans (positron emission tomography (PET) and CT scans were excluded due to variable CT slice thickness and field of view).

186 patients met our inclusion criteria. 85 scans were excluded because of the following: incomplete imaging of the maxillary teeth (41 patients); trauma (15); nasal polyposis (2); allergic fungal sinusitis (1) or immunocompromised status (11 for transplantation, 9 for active chemotherapy, 4 for active leukemia, 1 for myeloma, and 1 for HIV). The remaining 101 scans (202 maxillary sinuses) were retrospectively reviewed in axial and coronal planes using bone and soft tissue algorithms.

All radiographic images were rereviewed by a board-certified radiologist with certificate of added qualification in neuroradiology and with 8 years of experience in head and neck imaging (BFB). The following parameters were assessed for each sinus: 1) the presence of prior maxillary sinus surgery, 2) the presence of teeth adjacent to the floor of the maxillary sinus, and 3) dental or periodontal disease in any teeth adjacent to the floor of the maxillary sinus. The radiographic severity of fluid in the maxillary sinus was graded based on the linear percentage of the aerated sinus that was opacified by fluid when viewed in the axial plane of imaging. Portions of the sinus opacified by mucosal thickening were excluded from this calculation (Fig. 1).The amount of fluid was categorized as: none, mild (</3 opacified), moderate (1/3 to 2/3 opacified), and near-complete (>2/3 opacified). Mucosal thickening was subjectively graded as none, mild or severe. Dental disease in the teeth of interest was classified as absent, treated (i.e., filled with dental amalgam) or untreated.

Lastly, the presence of a radiographically-identifiable, specific dental source of infection was sought. Three radiographic findings were considered: 1) projecting tooth root, defined as a tooth root that extends superiorly above the floor of the maxillary sinus; 2) periapical abscess, defined as a rounded lucency surrounding the roots of a tooth; 3) oroantral fistula, defined as a lucency that extends from a tooth root or socket directly into the sinus without bony covering. (Fig. 2). It should be noted that an oroantral fistula was considered to be present even if the tooth was still present, because in the absence of bone, there is a direct communication between the periodontal ligament and the sinus mucosa (Fig. 3). In the evaluation of dental and periodontal disease, only those teeth adjacent to the maxillary sinus were considered.

Demographic and radiographic parameters were tested using univariate chi-square analysis to determine which parameters could predict the degree of fluid within an affected sinus. A P value of less than .05 was considered significant. The tested parameters were: gender, age, prior sinus surgery, presence or absence of teeth adjacent to the maxillary sinus (molars and premolars), treated or untreated dental disease, periodontal disease, projecting tooth root, periapical abscess, and oroantral fistula. Parameters that were found to be significant in univariate analysis were included in a multinominal logistic regression with stepwise forward inclusion, again using a P value threshold of .05. Those parameters that were significant in the logistic regression were considered identifiable odontogenic sources of infection, and the rates of these identifiable sources were tabulated in patients with radiographic findings indicative of acute maxillary sinusitis.

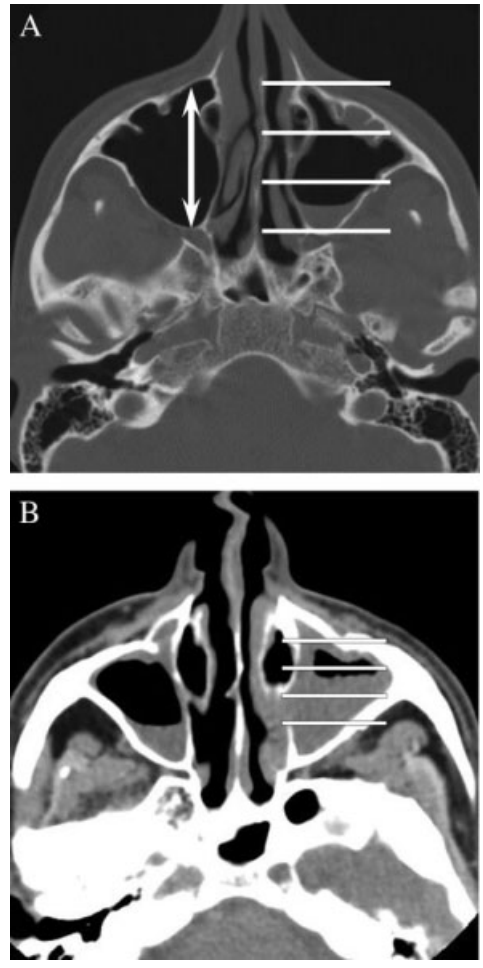

Fig. 1. Categorization of amount of sinus fluid. (A) On axial CT images, the antero-posterior dimension of the sinus (double arrow) was divided into thirds (horizontal lines). The amount of fluid in the sinus was categorized as: no fluid, <1/3 fluid-filled, 1/3 to 2/3 fluid-filled, or >2/3 fluid-filled. In this example, the amount of fluid in the left maxillary sinus would be <1/3. (B) If mucosal disease was present, the antero-posterior measurement excluded the mucosal thickening. Only the potentially aerated portions of the sinus were divided into thirds (horizontal lines). Note that the posterior mucosal thickness must be estimated. In this example, the left maxillary sinus is 1/3–2/3 filled.

RESULTS

The 101 patients (58 females, 43 males) who met our study criteria were ages 19–94 (mean: 54.9); all 202 maxillary sinuses were evaluated. Eleven patients had prior maxillary sinus surgery (6 unilateral; 5 bilateral) equivalent to 8% of maxillary sinuses (16/202). Sixty-one percent (124/202) of sinuses had maxillary sinus fluid; 42% (42/101) of patients had left unilateral sinus fluid; 36% (36/101) of patients had right unilateral sinus fluid; and 23% (23/101) of patients had bilateral sinus fluid. Eighteen percent (36/202) of maxillary sinuses had no adjacent premolars or molars, whereas 82% (166/202) of sinuses had at least one adjacent tooth. Twenty-six

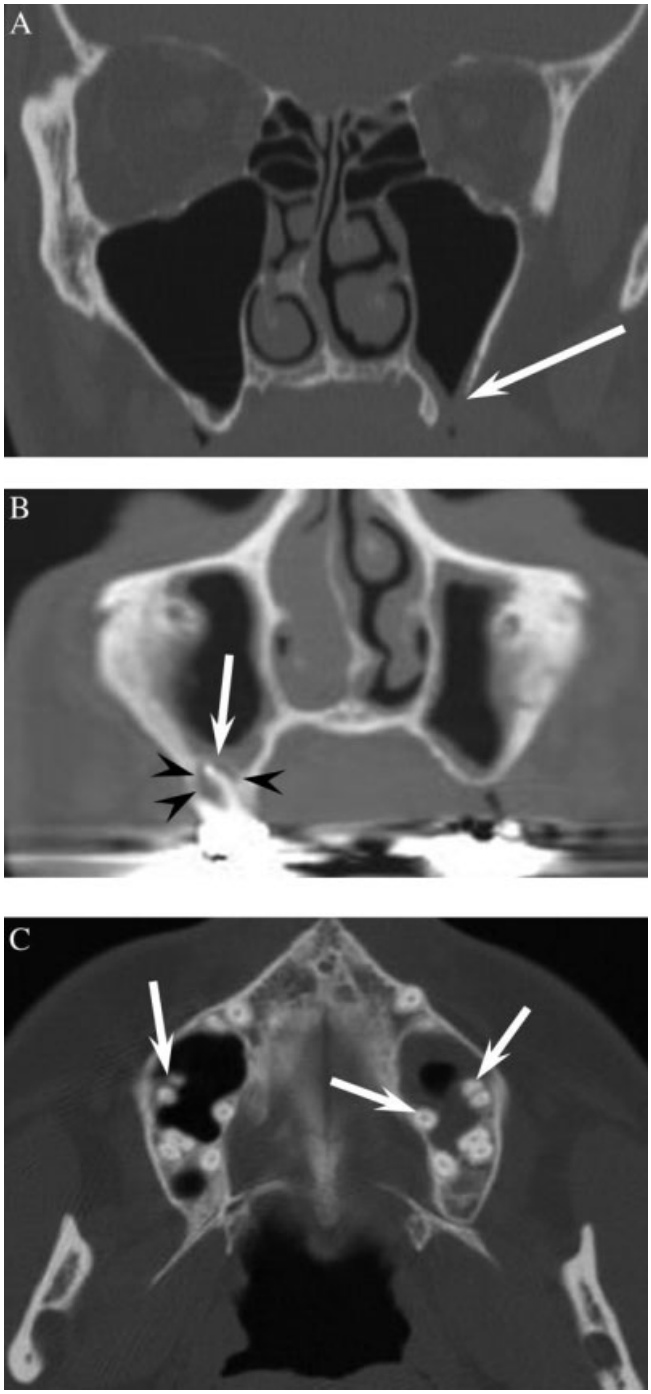

Fig. 2. Radiographically evident dental sources of maxillary sinus fluid. (A) Coronal reformatted CT shows a gap (arrow) in the bone of the floor of the left maxillary sinus, indicating oroantral fistula. (B) On coronal reformatted CT, a rim of lucency (black arrowheads) around a tooth root, with an intact covering of bone (white arrow), indicates apical abscess. (C) Axial CT shows tooth roots (arrows) above the floor of the maxillary sinus, but without bony covering, representing projecting tooth roots.

percent (41/166) of sinuses with teeth had active dental disease, and 37% (61/166) had periodontal disease.

Significant univariate associations were found with oroantral fistula, apical abscess, periodontal disease, and projecting tooth root. Regression analysis revealed the

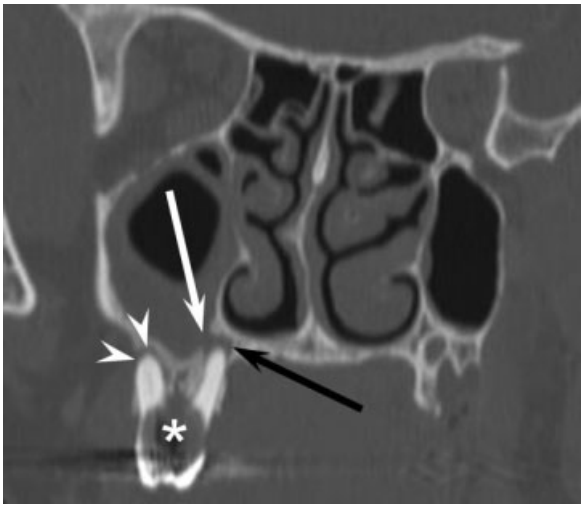

Fig. 3. Dental sources of maxillary sinus fluid. Coronal reformatted CT shows a halo of lucency (white arrowheads) around a molar tooth, indicating periodontal disease. An apical abscess (black arrow) is seen in association with another root of the tooth. There is breakthrough (white arrow) of the abscess into the sinus, which was considered to be a form of oroantral fistula in this study. Extensive untreated dental disease (*) is also noted in this tooth.

oroantral fistula to be an independent predictor of fluid in the sinus. Periodontal disease, projecting tooth root, and apical abscess were not independent predictors, but there were two interaction effects: the presence of periodontal disease along with either a projecting tooth root or an abscess was predictive. The other demographic and radiologic parameters were not predictive of severity of fluid in the maxillary sinus.

The likelihood of finding a dental source of infection increased dramatically as the amount of maxillary sinus fluid increased (Fig. 4). The likelihood of an odontogenic source for a patient with no or <1/3 opacification was 18% and 14%, respectively, but increased to 53% and 79% for 1/3 to 2/3 and >2/3 opacification (Table I).

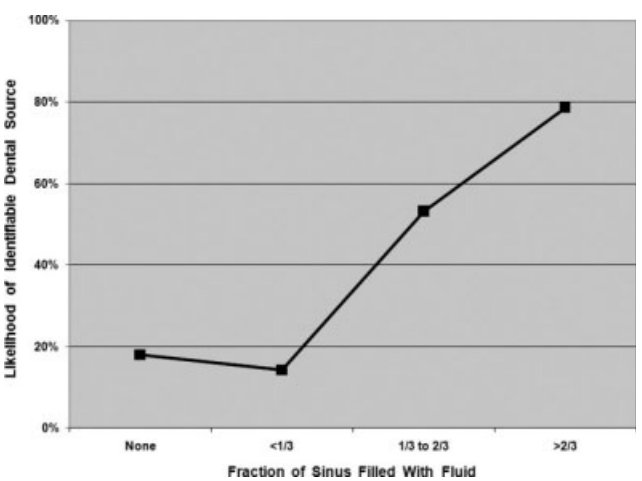

Fig. 4. Association between maxillary sinus fluid and dental source of infection. The likelihood of identifying a dental source of infection radiographically increased with the amount of fluid in the sinus. Patients with <1/3 of the sinus filled with fluid were unlikely to demonstrate a dental source.

TABLE I.
Likelihood of a Dental Source of Infection, Given Different Amounts of Sinus Fluid.

	Periodontal Disease in a Projecting Root	Periapical Abscess With Periodontal Disease	Oroantral Fistula	Any Source
No fluid	1% (1/78)	12% (9/78)	6% (5/78)	18% (14/78)
Mild fluid (<1/3)	3% (2/63)	3% (2/63)	11% (7/63)	14% (9/63)
Moderate fluid (1/3 to 2/3)	9% (4/47)	26% (12/47)	32% (15/47)	53% (25/47)
Severe fluid (>2/3)	0% (0/14)	79% (11/14)	64% (9/14)	79% (11/14)

Column headers are the three potential sources of infection. "Any Source" is a combination of the three potential sources (some patients had more than one potential source).

Mucosal thickening was independently associated with an increased likelihood of dental source of infection. When evaluated without regard to the amount of fluid, the likelihood of finding radiographic evidence of a dental source rose from 9% with no thickening to 63% for severe thickening (Table II). When only patients with substantial amounts of fluid in the sinus (>1/3 opacification) were included, mucosal disease was still a strong independent predictor (Fig. 5). The association between dental disease and the three identifiable sources was calculated at 16% (9/56) for those with no dental disease, 24% (25/105) for those with treated dental disease, and 61% (25/41) for those with active dental caries. However, dental disease was covariate with periodontal disease, and thus dental disease was not independently predictive.

DISCUSSION

This study demonstrates that maxillary sinus fluid can be attributed to odontogenic infections at a much higher rate than previously suspected (up to 86% of patients with severe CT findings). There are three radiographic appearances that are particularly suggestive of a dental etiology when seen in teeth that are adjacent to the maxillary sinus: 1) oroantral fistula, 2) periodontal disease with a periapical abscess, and 3) a projecting premolar or molar tooth root that has periodontal disease. Increasing amounts of fluid and mucosal inflammation in the maxillary sinus on CT scan dramatically increases the likelihood of finding an odontogenic source for the sinus disease.

Although this effect did not reach statistical significance when other factors were considered, an identifiable dental source was more likely to be found in patients with active dental disease (61%) than with treated dental disease (24%) or with no dental disease at all (16%). We believe this represents a logical progression of dental disease, where untreated dental caries allow bacteria to infiltrate the pulp chamber, root canal, and root apex to cause edema and bone loss known as a periapical abscess.[3] Given an average proximity of two millimeters from the maxillary sinus floor to the roots of the maxillary premolars and molars, sinus mucosa may become inflamed.[7] Numerous vascular anastamoses perforate this space and may serve as channels for the spread of bacteria with the potential to cause acute sinusitis.[8]

Our study is limited in that it was restricted to radiographic images. The radiologic finding that most closely correlates with acute bacterial sinusitis is a fluid level within the sinus, but this is a substitute for the reference standard of culturing the sinus contents. Our retrospective study design prevented fluid sampling in every patient, but our overall results would be unlikely to change with this additional data. Although fluid in the maxillary sinuses is usually considered a specific sign for acute bacterial sinusitis, this axiom may not be applicable in the setting of odontogenic infections. Anecdotally, several patients in our study had long-standing treatment-resistant sinusitis without a clinically acute exacerbation at the time of the CT scan.

Our study is also limited by a biased control group, because we only included patients with maxillary sinus fluid. The contralateral sinuses without fluid served as controls. However, this bias should only have undermined our findings, and with the degree of differences noted in the study, it unlikely that gathering scans of matched controls would have changed our final conclusions. Another bias occurs because the patients include those referred to our tertiary referral center, so they may represent more treatment-resistant disease than would be seen in a primary care setting. Lastly, despite a greater degree of uncertainty regarding the significance of projecting tooth roots, they were included in the analysis because we feel that the uncertainty derives from the relatively few patients with this finding in our study. A projecting root with periodontal disease occurred only 7 times in our study, and our overall conclusion would not have been changed by their exclusion.

Of all maxillary sinuses with fluid, 29% (36/124) had >1/3 opacification with fluid and an identifiable odontogenic source suggestive of a causal relationship.

TABLE II.
Likelihood of a Dental Source of Infection, Given Different Degrees of Mucosal Thickening.

Mucosal Thickening	All Sinuses	Sinuses With >1/3 Fluid
None	9% (5/56)	29% (2/7)
Mild ≤1/3 opacification)	26% (27/103)	44% (14/32)
Severe (>1/3 opacification)	63% (27/43)	86% (19/22)

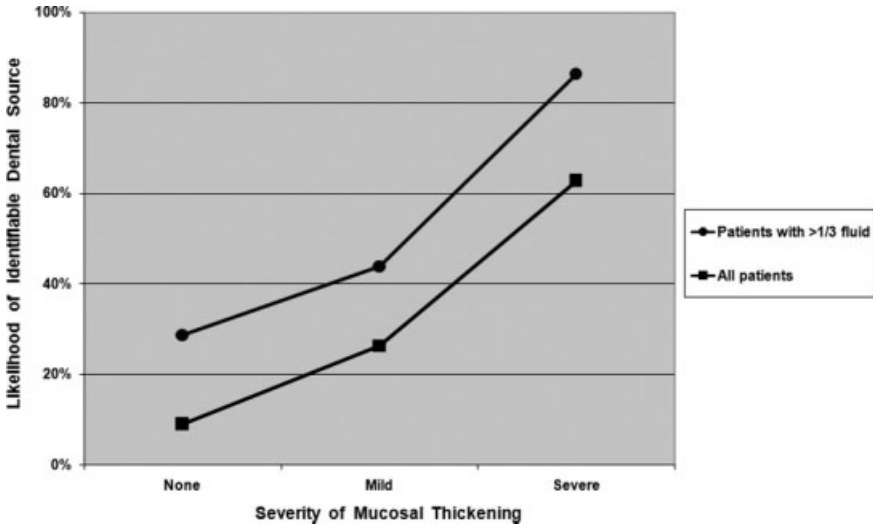

Fig. 5. Association between maxillary sinus mucosal thickening and dental source of infection. The likelihood of identifying a dental source of infection radiographically increased with the degree of mucosal thickening. The effect was present even in those patients with substantial amount of fluid, suggesting that mucosal thickening is independently predictive.

This is of great importance to the clinician, because treatment will differ if an odontogenic source is found. Empiric antibiotic management will differ from that of routine sinusitis, as anaerobic bacteria are more likely to be found in sinusitis of odontogenic origin.[4] A dental provider must be involved to decide whether a root canal will suffice or if tooth extraction is necessary. Although surgical endoscopic management of the sinus has been advocated at the time of treatment of the odontogenic source,[9] we prefer to treat the sinus conservatively, and have dental providers treat the dental pathology prior to surgical consideration. With odontogenic maxillary sinusitis so common, the otolaryngologist must have a low threshold to image with CT with particular attention to the maxillary tooth roots in any patient with persistent maxillary sinus symptoms. Radiologists, likewise, need to comment on any dental pathology in patients with maxillary sinus fluid.

CONCLUSION

Odontogenic infections are often the source of maxillary sinusitis, with rates up to 86% of patients when the radiographic findings of sinusitis are severe. Clinicians should consider dental sources of infection in acute maxillary sinusitis because the treatment of sinusitis of dental origin differs from that of nonodontogenic sinusitis. Radiologists should routinely comment on dental sources of infection in patients with maxillary sinus fluid.

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