Thin Alveolar Bone Height Can Cause Maxillary Sinus Mucosal Thickening: Computed Tomographic Study

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Abstract
Odontogenic maxillary sinusitis primarily results from multiplication of bacteria secondary to dental infection. Since the maxillary premolar and molar roots have the closest proximity to the antral floor, periodontitis of these teeth is the most common cause of odontogenic maxillary sinusitis. The purpose of this study was to evaluate the association between alveolar bone height around the maxillary molar and mucosal thickening of the maxillary sinus using computed tomography (CT) images. We reviewed 679 maxillary sinuses [age 20–92] on CT images performed for dental implant surgery planning or suspected maxillary sinusitis in our department from August 2016 to October 2017. An anatomical relationship between the teeth and maxillary sinus was classified into the following four groups based on the space between the alveolar crest and sinus floor: Group 1, ≥10 mm; Group 2, 7–10 mm; Group 3, 4–7 mm; and Group 4, < 4 mm. CT images were evaluated for mucosal thickening (> 2 mm) of the maxillary sinus floor. There was significant difference of the prevalence of mucosal thickening of maxillary sinus between Groups 1 and 3 and between Groups 1 and 4 (P<0.01). The highest incidence of mucosal thickening was seen in Group 4. Our results suggest that alveolar bone height decreasing can increase of mucosal thickening of maxillary sinus.

Keywords:
alveolar bone,
CT (Computed Tomography),
maxillary sinus

Introduction
The epithelium on the inner surface of the maxillary sinus is a Schneiderian membrane which is a respiratory mucosa of about 1 mm in thickness. In the past literatures reported that the mucosal thickening of maxillary sinus with maxillary sinusitis was 2 mm or more, so mucosal thickening of maxillary sinus exceeding 2 mm is considered to be an important index of maxillary sinusitis (1, 2). Pathogenic microorganisms cause chronic maxillary sinusitis via the oral cavity or nasal ostium (3). Odontogenic etiologies for maxillary sinusitis include periapical periodontitis, marginal periodontitis, dental trauma, tooth extraction, and implant placement (4). The most common route for odontogenic maxillary sinusitis is via the maxillary molars, especially the first molar (4, 5). Non-odontogenic etiologies include upper respiratory tract infections and allergic reactions in many cases (5, 6). Also, chronic sinusitis can be a risk factor for maxillary sinus cancer (7). Shanbhag et al. reported that odontogenic maxillary sinusitis accounts for 30–40 % of all maxillary sinusitis (8). The alveolar bone around the maxillary molars is thought to play an important role in the occurrence of odontogenic maxillary sinusitis along with odontogenic lesions (9). However, there have been very few reports evaluating the role of alveolar bone height in maxillary sinusitis. The purpose of this study was to evaluate the association between alveolar bone height around the maxillary molars and mucosal thickening of the maxillary sinuses using Computed tomography (CT) images.

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Materials and Methods

Patients

This retrospective study was approved by the Institutional Review Board (IRB) of the Nihon University School of Dentistry at Matsudo (EC 15-12-009-1). Four hundred fifty-one outpatients (285 female and 166 male) who underwent CT imaging for dental implant surgery planning and maxillary sinus diseases in the Department of Radiology at the Nihon University Dental Hospital, between August 2016 and October 2017, were included in this study. The CT images of 223 sinuses were excluded due to the absence of maxillary molars, presence of maxillary tumors, apical periodontitis, and incomplete imaging. As a result, CT images of 679 maxillary sinuses were analyzed retrospectively. The age of the patients ranged from 20–92 years (mean age, 49.5 years). To evaluate the influence of age on the prevalence and severity of maxillary sinus mucosal thickening, the patients were grouped based on age as follows: 20–29, 30–39, 40–49, 50–59, 60–69, 70–79, 80–89, and >90 years of age.

CT imaging techniques

CT imaging was performed with a multidetector row CT scanner (MDCT) system (Aquilion 64; Toshiba Medical Systems, Tochigi, Japan). All patients were scanned using the routine clinical protocol for craniomaxillofacial examination at our hospital as follows: tube voltage, 120 kV; tube current, 100 mA; field of view, 240 × 240 mm; helical pitch, 1: slice thickness, 0.5 mm; bone and soft tissue algorithm reconstruction; coronal and sagittal reformat, 3 mm; and three-dimensional (3D) images.

Prevalence of mucosal thickening of maxillary sinus and the anatomic relationship between the sinus floor and alveolar crest

Odontogenic sinusitis was identified as a localized thickening of the maxillary sinus mucosa. An anatomical relationship between the teeth and maxillary sinus was evaluated using CT images. An anatomical relationship between the palatal root of the maxillary first molar and maxillary sinus floor was established; patients were classified into the following four groups based on the distance between the alveolar crest and the sinus floor: Group 1, ≥10 mm; Group 2, 7–10 mm; Group 3, 4–7 mm; and Group 4, <4 mm (Fig. 1).

Assessment of mucosal thickening on the maxillary sinus floor on CT images

Thickening of the maxillary sinus floor mucosa was evaluated on the axial, coronal, and sagittal images. Mucosal thickening was measured at the point of maximum
thickness from the maxillary sinus floor. Patients were categorized into two groups based on the presence or absence of mucosal thickening (>2 mm) (Fig. 2).

**Statistical analysis and inter observer reliability**

Two oral radiologists independently evaluated CT images to determine the alveolar bone and the presence or absence of mucosal thickening. The axial, coronal, and sagittal sections of each image were evaluated. The relationship between alveolar bone thickness around the palatal root of the maxillary first molar and mucosal thickening was evaluated using $\chi^2$ test with Fisher's exact test. The $P$ value adjustment method was Holm adjustment. A value of $P<0.01$ was considered to indicate statistical significance.

**Results**

The CT images of 679 maxillary sinuses (242 [35.6%] in male patients and 437 [64.4%] in female patients) were examined. Of the 679 investigated patient images, 281 (41.4%) maxillary sinuses demonstrated mucosal thickening and 398 (58.6%) did not present with mucosal thickening.

The prevalence of mucosal thickening of the maxillary sinus was 25.7% (29/113) in patients aged 20–29 years, 18.1% (15/83) in patients aged 30–39 years, 40.9% (61/149) in patients aged 40–49 years, 52.6% (60/114) in patients aged 50–59, 46.7% (56/120) in patients aged 60–69 years, 58.1% (50/86) in patients aged 70–79 years, 80.0% (8/10) in patients aged 80–89 years, and 50.0% (2/4) in patients older than 90 years (Table 1). The prevalence of mucosal thickening of the maxillary sinus increased with age, except in patients older than 90 years (the group with only four patients). The highest prevalence of mucosal thickening of maxillary sinus was seen in patients between 80 and 89 years of age.

The prevalence of mucosal thickening of maxillary sinus was 18.2% (30/165) in Group 1, 20.9% (49/235) in Group 2, 64.1% (125/195) in Group 3, and 91.7% (77/84) in Group 4. The prevalence of mucosal thickening of the maxillary sinus was significantly different between Groups 1 and 3, between Groups 1 and 4, between Groups 2 and 3, between Groups 2 and 4 and between Groups 3 and 4 ($P<0.01$). However, the differences between Groups 1 and 2 were not statistically significant. Group 4 was noted to be most likely to present with mucosal thickening (Table 2).

**Discussion**

The present study attempted to clarify the possible relationship between mucosal thickening of maxillary sinus and alveolar bone height of the maxillary molars using CT images. CT is useful for evaluation of alveolar bone height and mucosal thickening of the maxillary sinus. Multplanar images with high spatial resolution can assist in identifying odontogenic cause of maxillary sinusitis.

Previous CBCT studies using maxillary sinuses found prevalence rates ranging from 29.2%–56.3% for thickening of the mucosa (10). In our study, of the 679 investigated maxillary sinuses, 281 (41.4%) demonstrated mucosal thickening. This variation could be attributed to the differences in race or age as well as the different diagnostic techniques used.

In our results, the highest prevalence of mucosal thickening was seen in patients between 80–89 years of age compared to other age groups. We found that the prevalence of mucosal thickening increased with age. From previous studies, Sheikhi et al. reported that the alveolar bone loss increased with age (11). With age, most individuals present with dental ailments, including periodontal disease, apical periodontitis, and other pathologic conditions; hence, this may likely increase the possibility of maxillary sinusitis (12).
Periodontitis inflammation is known to affect the sinus mucosa. Infection and inflammatory mediators are able to spread directly or indirectly from the alveolar bone to the maxillary sinus mucosa. The indirect spread can occur through the numerous vascular anastomoses, porous alveolar bone marrow, and lymphatics (13, 14). According to our results, the decrease in alveolar bone height was found to be closely related to the increase in mucosal thickening.

Mucosal thickening of the maxillary sinus was found to increase with a reduction in alveolar bone height below 7 mm. We believe that the pathogenic bacteria, toxins, and inflammatory cytokines commonly seen in periodontitis may directly infiltrate the porous maxillary bone because of the proximity of the alveolar bone to the maxillary sinus.

Our study has limitation. Chronic maxillary sinusitis may be caused by pathogenic microorganisms via the nasal
ostium. However, in this study, nasal ostium have not been evaluated. Thus, we need further research this point.

**Conclusions**

Our results suggest that decreased alveolar bone height can increase mucosal thickening of the maxillary sinus.

**Conflict of Interest**

The authors declare no conflicts of interest associated with this manuscript.

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