Forms of Maxillary Sinus with Septa can Cause by Mucosal Thickening of Maxillary Sinus: Computed Tomographic Study

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Abstract

Background: Odontogenic maxillary sinusitis primarily results from multiplication of bacteria secondary to dental infection. Because the maxillary premolar and molar roots have the closest proximity to the antral floor, odontogenic infections of these teeth are often the cause of odontogenic maxillary sinusitis. This study aimed to evaluate the associations between the forms of maxillary sinus and maxillary sinus septa and the presence of mucosal thickening of the maxillary sinus using computed tomography (CT).

Methods: In this retrospective study, we reviewed 645 maxillary sinuses (from patients 20-92 years of age) that were imaged for dental implant surgery planning and suspicion of maxillary sinusitis in our department from August 2016 to October 2017. In our study, maxillary sinuses were classified into four groups based on forms of maxillary sinus and maxillary sinus septa: Group 1: flat (without septa), Group 2: flat (with septa), Group 3: circular and convex (without septa), and Group 4: circular and convex (with septa). CT images were evaluated for mucosal thickening (>2 mm) of the maxillary sinus floor.

Results: Circular and convex forms toward the lower side of the floor of maxillary sinus were significantly associated with mucosal thickening (P<0.01). The presence of maxillary sinus septa was significantly associated with mucosal thickening (P<0.01). The highest incidence of mucosal thickening was observed in Group 4.

Conclusions: The circular and convex form of the floor of maxillary sinus and the presence of maxillary sinus septa can increase mucosal thickening of the maxillary sinus.

Introduction
Pathogenic microorganisms cause chronic maxillary sinusitis via the oral cavity or nasal ostium (1). Etiologies of non-odontogenic factors include upper respiratory tract infections and allergic reactions in many cases (2, 3). Maxillary sinusitis may be affected by odontogenic infections because of its anatomical relationship with the upper teeth (4). Shanbhag et al. reported that odontogenic maxillary sinusitis comprises 30–40% of all cases of maxillary sinusitis (5). An increased risk of odontogenic maxillary sinusitis has been reported in patients with the following conditions: periapical periodontitis, marginal periodontitis, dental trauma, tooth extraction, and implant treatment (6). Additionally, chronic sinusitis has been reported as a risk factor for maxillary sinus cancer (7). The epithelium on the inner surface of the maxillary sinus is a Schneiderian membrane, which comprises a respiratory mucosa of approximately 1 mm in thickness. Prior reports have described mucosal thickening of the maxillary sinus as ≥2 mm in maxillary sinusitis; therefore, mucosal thickening of the maxillary sinus > 2 mm is considered to be an important index of maxillary sinusitis (4, 8, 9). The maxillary sinus exhibits a pyramidal shape. The base of this pyramid is the lateral wall of the nasal cavity, pointing towards the zygomatic process of the maxilla (10, 11). However, maxillary sinus shape varies, and there are partitions in the maxillary sinus (12). Notably, maxillary

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sinus septa are partitions of cortical bone formed within the maxillary sinus (13).

There have been many reports regarding forms of the maxillary sinus and maxillary sinus septa. However, there have been very few reports that evaluated these forms as potential causes of mucosal thickening of the maxillary sinus. This study aimed to evaluate the associations between forms of the maxillary sinus and the presence of mucosal thickening of the maxillary sinus, using computed tomography (CT).

Materials and Methods

Study Design and Participants

The university ethics committee approved this retrospective study (EC 15–12–009–1). Altogether, 417 patients (156 men, 261 women; mean age 50.4 years, range 20–92 years) were examined in this study. These patients underwent CT of the maxilla at our hospital between August 2016 and October 2017. One hundred eighty-nine maxillary sinuses were excluded due to the presence of maxillary tumors, periapical periodontitis, and/or incomplete imaging. Therefore, CT images of 645 maxillary sinuses were analyzed in this study.

Image Assessment

CT imaging was performed with a 64-row Multi-Detector CT system (Aquilion 64; Toshiba Medical Systems, Tochigi, Japan). All patients were scanned using the routine clinical protocol for craniofacial examination at our hospital: tube voltage, 120 kV; tube current, 100 mA; field of view, 240 × 240 mm; helical pitch, 41; slice thickness, 0.5 mm, bone and soft tissue algorithm reconstruction, coronal and sagittal reformats, 3 mm, and three-dimensional (3D) images.

A morphological study of the floor of the maxillary sinus using 3D reconstruction of facial CT images, was performed. Forms of the maxillary sinus were evaluated based on coronal images of the maxillary first molar. Forms of the maxillary sinus can be divided into two main groups. One comprises circular forms with convexity toward the lower side of the maxillary sinus floor. The other comprises flat forms of the maxillary sinus floor. Maxillary sinuses can be further divided into two subtypes: those with or without maxillary sinus septa on the floor of the sinus. In our study, maxillary sinuses were classified into four groups based on the forms of the maxillary sinus and presence or absence of maxillary sinus septa: Group 1, flat (without septa); Group 2, flat (with septa); Group 3, circular and convex (without septa); and Group 4, circular and convex (with septa) (Fig. 1).

Mucosal thickening in the maxillary sinus floor was evaluated on coronal and sagittal images. Mucosal thickening was measured at the point of maximum thickness from the maxillary sinus floor. Mucosal thickening of the maxillary sinus floor was categorized as either presence or absence of mucosal thickening (>2 mm) (Fig. 2).

Statistical Analysis

Two oral radiologists independently evaluated CT images to determine the forms of maxillary sinuses and the presence or absence of mucosal thickening. Statistical analyses of the presence or absence of mucosal thickening, with respect to its relation of form (Group 1+ Group 2 vs Group 3+ Group 4), septa (Group 1+ Group 3 vs Group 2+ Group 4), was performed using the χ² test or Fisher’s exact test (version 14.0; SPSS Japan, Tokyo, Japan). A value of P < 0.01 was considered to indicate statistical significance.

Results

Of the 645 investigated maxillary sinuses, 295 (45.7%) demonstrated mucosal thickening. In contrast, 350 (54.3%) maxillary sinuses did not show mucosal thickening. Of the 645 investigated maxillary sinuses, 143/233 (61.4%) of men, 152/412 (36.9%) of women demonstrated mucosal thickening. This study assessed the ratio of maxillary sinus mucosal thickening of the four groups, which were constructed based on the forms of the maxillary sinus and maxillary sinus septa. The prevalence of maxillary sinus mucosal thickening were 16.6% (24/145) in Group 1, 46.4% (13/28) in Group 2, 51.0% (208/408) in Group 3, and 78.1% (50/64) in Group 4 (Table 1). These data showed that circular forms with convexity toward the lower side of the floor of maxillary sinus were significantly associated with mucosal thickening (P < 0.01) (Table 2). The presence of maxillary sinus septa was significantly associated with mucosal thickening (P < 0.01) (Table 2).

Discussion

In this study, the circular and convex form of the floor of the maxillary sinus, combined with the presence of maxillary sinus septa, showed an association with increased maxillary sinus mucosal thickening.

CT imaging provides high-resolution images and allows
Fig. 1. Maxillary sinuses were classified into four groups based on forms of maxillary sinus and maxillary sinus septa.
Group 1: flat forms (without maxillary sinus septa), Group 2: flat forms (with maxillary sinus septa), Group 3: circular and convexity forms (without maxillary sinus septa), and Group 4: circular and convexity forms (with maxillary sinus septa)

simultaneous and accurate assessment of the maxillary sinuses (14), teeth, and adjacent tissues in all planes; this allows assessment of the relationships among these structures (15). Therefore, CT imaging can assist in identifying odontogenic causes of maxillary sinusitis. The present study used CT imaging to evaluate possible relationships between forms of the maxillary sinus, with or without maxillary sinus septa, and mucosal thickening of the maxillary sinus.

Previous CBCT studies using maxillary sinuses found prevalence rates ranging from 29.2%–56.3% for thickening of the mucosa (4). In our study, of the 645 investigated maxillary sinuses, 295 (45.7%) 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 study, variation in the prevalence of
mucosal thickening was observed by sex. The rate of mucosal thickening were high in males which is consistent with previous reports (5). Although most instances of mucosal thickening are asymptomatic, they may obstruct the meatal ostium and lead to maxillary sinusitis (16). Notably, cancer may occur as a result of the presence of chronic inflammation in the maxillary sinus. Therefore, mucosal thickening may be an important early indicator of maxillary sinusitis.

Odontogenic infections can affect the sinus mucosa. Infection and inflammatory mediators can spread directly or indirectly from the alveolar bone to the maxillary sinus mucosa. Indirect spreading can cause infiltration through numerous vascular anastomoses, porous alveolar bone marrow, and lymphatics, thereby infecting the sinus mucosa (17). In our study, certain forms of the maxillary sinus and maxillary sinus septa were closely related to the presence of mucosal thickening. The prevalence of maxillary sinus mucosal thickening were 16.6% in Group 1, 46.4% in Group 2, 51.0% in Group 3, and 78.1% in Group 4. Importantly, circular forms with convexity toward the lower side of the floor of maxillary sinus were significantly associated with mucosal thickening. The presence of maxillary sinus septa was also significantly associated with mucosal thickening.

| Table 1  | Relationship between prevalence of mucosal thickening of maxillary sinus, maxillary sinus form and maxillary sinus septa |
|----------|---------------------------------------------------------------------------------------------------------|
| **Septa** | **without** | **with** |
| **form**  | **flat** | **24/145** | **13/28** |
|           | **circular and convex** | **208/408** | **50/64** |

Value are mucosal thickening of maxillary sinuses.

| Table 2  | The relation of septa and the relation of form |
|----------|-----------------------------------------------|
| **Group1+Group2** | **Group3+Group4** |
| **mucosal thickening** | **without** | **136** | **214** |
| **with** | **37** | **258** |
| **mucosal thickening** | **Group1+Group3** | **Group2+Group4** |
| **without** | **321** | **29** |
| **with** | **232** | **63** |

These data showed that circular forms and convexity toward the lower side of the floor of maxillary sinus was significantly related to the mucosal thickening (P<0.01). The presence of maxillary sinus septa was significantly related to the mucosal thickening (P<0.01).

**Correlation is significant at the 0.01 level**

The septa increase the risk of acute or chronic sinusitis by the maxillary sinus floor elevation surgery (12). We consider that the presence of maxillary sinus septa, combined with the presence of the circular form of the maxillary sinus with convexity toward the lower side of the floor, provide a complicated structure inside the maxillary sinus. Therefore, we suspect that inflammation in the maxillary sinus may not be expelled from the maxillary sinus, which increases the likelihood that it will become chronic. In addition, maxillary sinus floor of the circular and convex form protrudes to the oral cavity side. Therefore, we considered that maxillary sinus floor is susceptible to the inflammation of oral.
Our study has any notable limitation. First, chronic maxillary sinusitis may be caused by pathogenic microorganisms via the nasal ostium. However, in this study, the nasal ostium was not evaluated. Second, we were not able to evaluate the size, number, location and shape of the septa, because of only the presence or absence of the septa was evaluated. Thus, further research is needed regarding this aspect.

Conclusions
Our results suggest that the circular and convex form of the floor of the maxillary sinus, combined with the presence of maxillary sinus septa, 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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