Risk assessment of maxillary sinusitis using computed tomography

CT を用いた上顎洞炎のリスク評価

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本論文は、

1) Thin Alveolar Bone Height Can Cause Maxillary Sinus Mucosal Thickening: Computed Tomographic Study
International Journal of Oral-Medical Sciences (Impress)

2) Forms of Maxillary Sinus with Septa can Cause by Mucosal Thickening of Maxillary Sinus: Computed Tomographic Study
International Journal of Oral-Medical Sciences (Impress)

をまとめたものである。

Abstract

Purposes:

The purposes of this study were to evaluate the risks of maxillary sinusitis using computed tomography (CT) by determining 1) the association between alveolar bone height around the maxillary molar and mucosal thickening of the maxillary sinus, and 2) the relationship between the form of maxillary sinus and maxillary sinus septa and the presence of mucosal thickening of the maxillary sinus.

Materials and Methods:

The university ethics committee approved this retrospective study (EC 15-12-009-1).

1) Materials consisted of 679 maxillary sinuses [age 20-92 years] on CT images performed for dental implant surgery planning or suspected maxillary sinusitis in the 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 bone height 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.

2) Materials consisted of reviewed 645 maxillary sinuses [age 20-92 years] that were imaged for dental implant surgery planning and suspicion of maxillary sinusitis in the

department from August 2016 to October 2017. 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 or convex (without septa), and Group 4: circular or convex (with septa). CT images were evaluated for mucosal thickening (>2 mm) of the maxillary sinus floor.

Results:

1) 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, Groups 1 and 4, Groups 2 and 3, Groups 2 and 4, and Groups 3 and 4 ($P<0.01$). However, the differences between Groups 1 and 2 were not statistically significant. The prevalence of mucosal thickening was the highest in Group 4.

2) 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. The highest incidence of mucosal thickening was observed in Group 4. These data showed that circular or convexity form 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 ($P < 0.01$).

Conclusions:

Decrease of alveolar bone height can increase mucosal thickening of the maxillary sinus. The circular or convex form of the floor of the maxillary sinus with septa can increase mucosal thickening of the maxillary sinus. These results suggested that alveolar bone height, form of maxillary sinus and with or without septa could be useful information in risks of maxillary sinusitis.

Key Words:

alveolar bone, form, maxillary sinus, septa

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 maxillary molar 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, tooth extraction, and implant treatment (6). Additionally, chronic sinusitis has been reported as a risk factor for maxillary sinus cancer (7). 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 (2, 5).

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 (8, 9). However, there have been very few reports evaluating the role of alveolar bone

height in maxillary sinusitis.

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). Maxillary 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.

The purposes of this study were to evaluate the risks of maxillary sinusitis using computed tomography (CT) by determining 1) the association between alveolar bone height around the maxillary molar and mucosal thickening of the maxillary sinus, and 2) the relationship between the form of maxillary sinus and maxillary sinus septa and the presence of mucosal thickening of the maxillary sinus.

Materials and Methods

This retrospective study was approved by the Institutional Review Board of the Nihon University School of Dentistry at Matsudo (EC 15-12-009-1).

1. Prevalence of maxillary sinus mucosal thickening and the anatomic relationship between the maxillary sinus floor and alveolar height

Subjects

Four hundred fifty-one outpatients (285 females and 166 males) 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, and >80 years of age.

Image Assessment

CT imaging was performed with a multi detector row CT scanner (MDCT) system

(Aquilion 64; Toshiba Medical Systems, Tochigi, Japan). All patients were scanned using the routine clinical protocol for maxillofacial examination at the hospital as follows: 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 reformat, 3 mm; and three-dimensional (3D) images. 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 alveolar crest of palatal root of the maxillary first molar and maxillary sinus floor was established. The alveolar bone height average is reported about 7 mm (14). Therefore, the present study evaluated it based on 7 mm. Patients were classified into the following four groups based on the distance between the alveolar bone height 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). Thickening of the maxillary sinus floor mucosa was evaluated on the coronal image. 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) (2) (Fig.2).

2. Prevalence of mucosal thickening in the maxillary sinus and forms of maxillary sinus and maxillary sinus septa

Subjects

Four hundred seventeen patients (261 females, 156 males; mean age 50.4 years, range 20 - 92 years) were examined in this study. These patients underwent CT of the maxilla at the 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- multi detector row CT system (Aquilion 64; Toshiba Medical Systems, Tochigi, Japan). All patients were scanned using the routine clinical protocol for maxillofacial 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 performed using 3D reconstruction of facial CT images. 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 by the flat form based on the basic form of the maxillary sinus (10, 11). One comprises flat form of the maxillary sinus floor. The other comprises circular or convex form 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. Septa measuring more than 2.5mm in height were included in the analysis (13). Therefore, 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 or convex (without septa); and Group 4, circular or convex (with septa) (Fig. 3). Mucosal thickening in the maxillary sinus floor was evaluated on coronal 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) (2) (Fig. 2).

Statistical Analysis

Two oral radiologists independently evaluated CT images to determine the forms of maxillary sinuses, septa, alveolar bone height and the presence or absence of mucosal thickening. Statistical analyses of the presence or absence of mucosal thickening, with respect to its association with each of the above groups, was performed using the χ^2 test

or Fisher's exact test (version 14.0; SPSS Japan, Tokyo, Japan). P-values less than .01 were considered to indicate statistical significance.

Results

1. Prevalence of maxillary sinus mucosal thickening and the anatomic relationship between the maxillary sinus floor and alveolar height

The CT images of 679 maxillary sinuses (242 [35.6%] in maxillary sinuses of male patients and 437 [64.4%] in maxillary sinuses of 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, and 71.4% (10/14) in patients older than 80 years (Fig 4). The prevalence of mucosal thickening of the maxillary sinus increased with age. The highest prevalence of mucosal thickening of maxillary sinus was seen in patients older than 80 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, Groups 1 and 4, Groups 2 and 3, Groups

2 and 4, and Groups 3 and 4 (P<0.01). However, the differences between Groups 1 and 2 were not statistically significant. The prevalence of mucosal thickening was the highest in Group 4 (Table 1).

2. Prevalence of mucosal thickening in the maxillary sinus and forms of maxillary sinus and maxillary sinus septa

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 males, 152/412 (36.9%) of females 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 2). These data showed that circular or convex form of the floor of maxillary sinus were significantly associated with mucosal thickening (P < 0.01) (Table 3). The presence of maxillary sinus septa was significantly associated with mucosal thickening (P < 0.01) (Table 4).

Discussion

1. Prevalence of maxillary sinus mucosal thickening and the anatomic relationship between the maxillary sinus floor and alveolar height

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. Multiplanar 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 (4). In present 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 present study, the highest prevalence of mucosal thickening was seen in patients older than 80 years of age compared to other age groups. The prevalence of mucosal thickening increased with age. Sheikhi et al. reported that the alveolar bone loss increased with age (15). With age, almost every individual presents with dental ailments, including periodontal disease, periapical periodontitis and other pathologic conditions,

and this has also been shown to increase the likelihood of maxillary sinusitis (2).

Inflammation of periodontitis 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 (2, 15). According to the 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. 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.

2. Prevalence of mucosal thickening in the maxillary sinus and forms of maxillary sinus and maxillary sinus septa

In this study, the circular or convexity form of the floor of maxillary sinus and the presence of maxillary sinus septa can increase mucosal thickening of maxillary sinus.

CT imaging provides high-resolution images and allows simultaneous and accurate assessment of the maxillary sinuses, teeth, and adjacent tissues in all planes; this allows assessment of the relationships among these structures (3). 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 present 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 was high in males which is consistent with previous reports (5).

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 (2, 15). In present study, circular or convex form of the maxillary sinus and septa was 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. Circular or convex form 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. The septa increase the risk of acute or chronic sinusitis by the maxillary sinus floor elevation surgery (11). The presence of maxillary sinus septa with the presence of the circular or convex form of the floor provide a complicated structure inside the maxillary sinus. Therefore, inflammation in the maxillary sinus may be hard to expel from the maxillary sinus, which increases the likelihood that it will become chronic. In addition, maxillary sinus floor of the circular or convex form protrudes to the oral side. Therefore, maxillary sinus floor may be affected to the inflammation of oral region.

Present study has some limitations. 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, the relationship between the size, number, location and shape of the septa and the maxillary sinuses were not evaluated, because of only the presence or absence of the septa was evaluated. Therefore, further research is needed regarding this aspect.

Conclusion

Decrease of alveolar bone height can increase mucosal thickening of the maxillary sinus. The circular or convex form of the floor of the maxillary sinus with septa can increase mucosal thickening of the maxillary sinus. These results suggested that alveolar bone height, form of maxillary sinus and with or without septa could be useful information in risk of maxillary sinusitis.

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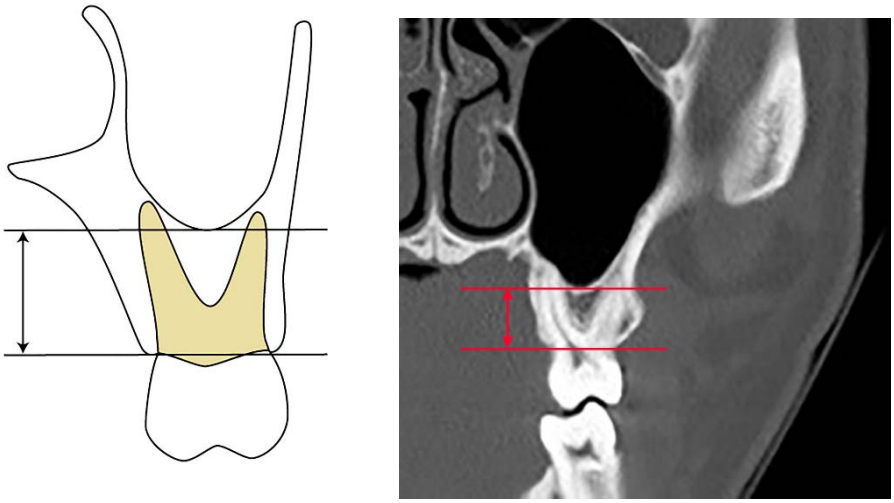
detect the relationship between the periodontal bone loss and mucosal thickening of the maxillary sinus. Dent Res J, 11: 495-501, 2014.

Fig. 1

The measurement of the alveolar bone height to the maxillary sinus floor

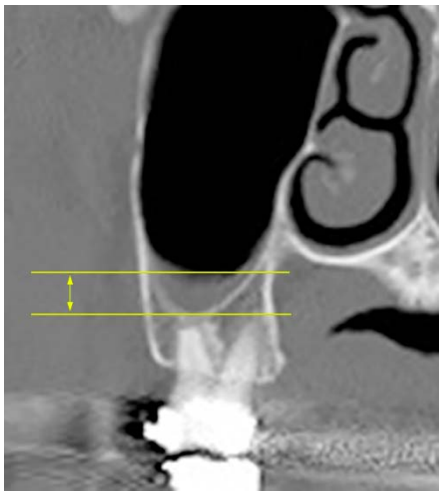


An anatomical relationship between the alveolar crest of palatal root of the maxillary first molar and maxillary sinus floor was established. The present study classified the amount of the alveolar bone height as follows.

Group I: ≧10, Group II: 10-7mm, Group III: 7-4mm, Group IV: <4mm.

Fig. 2

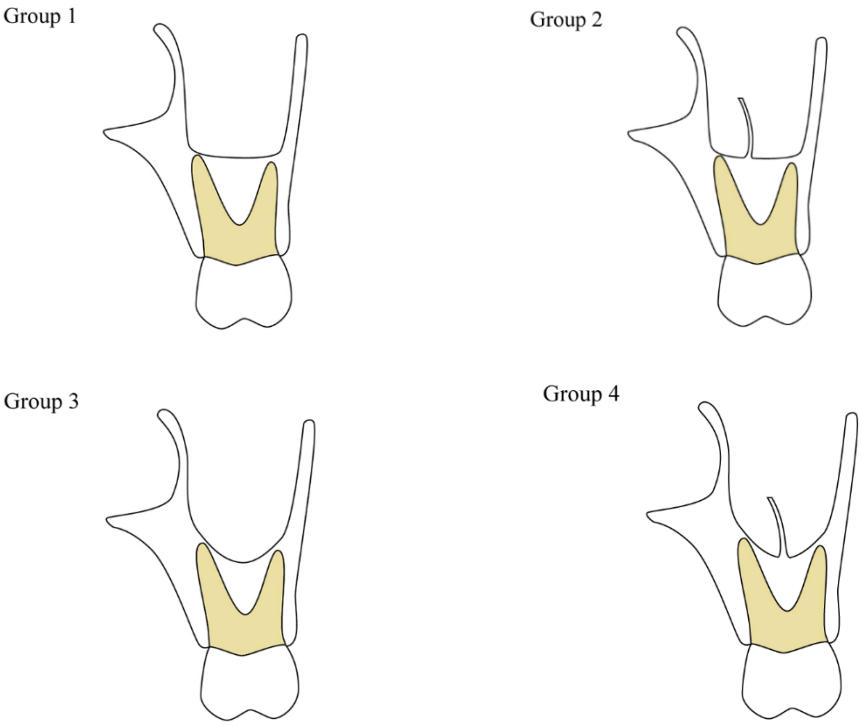
Assessment of maxillary sinusitis using CT



With mucosal thickening (>2 mm) was evaluated as maxillary sinusitis.

Fig. 3

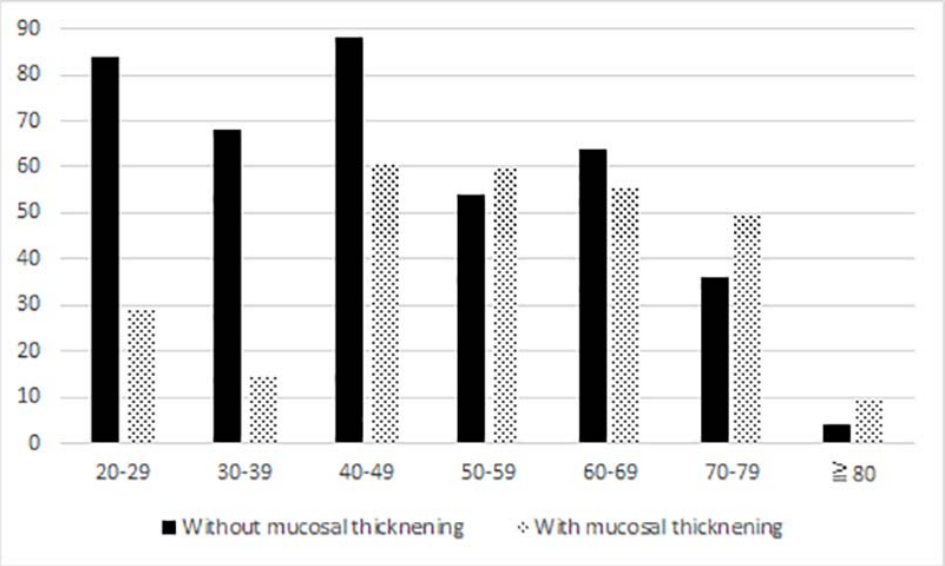
Type of maxillary sinus form and with or without septa



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 or convex (without septa), and Group 4: circular or convex (with septa)

Fig. 4
Relationship between prevalence of mucosal thickening of maxillary sinus and age



The prevalence of mucosal thickening of the maxillary sinus increased with age.

Table 1

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

	Group 1 N=165 (24.3%)	Group 2 N=235 (34.6%)	Group 3 N=195 (28.7%)	Group 4 N=84 (12.4%)
With mucosal thickening of maxillary sinus N=281 (41.4%)	30 (18.2%)	49 (20.9%)	125 (64.1%)	77 (91.7%)
Without mucosal thickening of maxillary sinus N=398 (58.6%)	135 (81.8%)	186 (79.1%)	70 (35.9%)	7 (8.3%)

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.

Correlation is significant at the 0.01 level

Table 2

Relationship between prevalence of mucosal thickening of maxillary sinus and maxillary sinus form with or without septa

		Septa	
		without	with
form	flat	24/145 (16.6%)	13/28 (46.4%)
	circular or convex	208/408 (51.0%)	50/64 (78.1%)

Value are mucosal thickening of maxillary sinus.

Table 3

Relationship between prevalence of mucosal thickening of maxillary sinus and maxillary sinus form

		Group1+Group2 (flat form)	Group3+Group4 (circle or convex)
mucosal thickening	without	136/173 (78.6%)	214/472 (45.3%)
	with	37/173 (21.4%)	258/472 (54.7%)
total		173	472

These data showed that circular or convex form of the floor of maxillary sinus was significantly related to the mucosal thickening ($P < 0.01$).

Table 4

Relationship between prevalence of mucosal thickening of maxillary sinus and septa

		Group1+Group3 (without septa)	Group2+Group4 (with septa)
mucosal thickening	without	321/553 (58.0%)	29/92 (31.5%)
	with	232/553 (42.0%)	63/92 (68.5%)
total		553	92

The presence of maxillary sinus septa was significantly related to the mucosal thickening ($P < 0.01$).