Prevalence and Association of Haller Cells with Maxillary Sinus Mucosal Thickening in a Group of Thai Patients: A CBCT Study

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Abstract

Objective**:** To evaluate the prevalence of Haller cells and maxillary sinus mucosal thickening in a group of Thai patients using cone beam computed tomography (CBCT) and to assess the association between these findings, with an emphasis on side-specific relationships relevant to dental implant treatment planning.

Methodology**:** A retrospective cross-sectional study was performed using CBCT scans from 150 patients. The presence of Haller cells and maxillary sinus mucosal thickening (>2 mm) was evaluated bilaterally. Associations were analyzed using the chi-square test. Binary logistic regression analysis was conducted to calculate odds ratios (ORs) and 95% confidence intervals (CIs), with an additional side-specific (ipsilateral) analysis.

Results: Haller cells were identified in 25 patients (16.7%) on the right side and 21 patients (14%) on the left side. Bilateral Haller cells were observed in 10 patients (6.7%). A significant association was found between Haller cells and maxillary sinus mucosal thickening on both the right and left sides ($p < 0.001$). Logistic regression analysis demonstrated that the presence of Haller cells significantly increased the odds of mucosal thickening on the right side (OR = 10.06; 95% CI: 4.41 to 22.92) and the left side (OR = 19.80; 95% CI: 7.51 to 52.22). Male sex was also significantly associated with mucosal thickening on both sides.

Conclusion**:** Haller cells were significantly associated with maxillary sinus mucosal thickening in Thai patients evaluated using CBCT imaging. These findings emphasize the importance of careful assessment of anatomical variations of the maxillary sinus during preoperative CBCT evaluation for dental implant treatment planning.

Keywords**:** *Haller cells, Maxillary sinus, Mucosal thickening, Cone-beam computed tomography, Dental implant*

1. Introduction

The maxillary sinus is a critical anatomical structure in dental implant treatment planning, particularly in the posterior maxilla, where reduced residual bone height and proximity to the sinus floor often necessitate sinus-related surgical procedures. Cone-beam computed tomography (CBCT) has therefore become the preferred imaging modality for preoperative evaluation, as it enables accurate three-dimensional assessment of maxillary sinus anatomy and pathology relevant to implant dentistry (Maillet et al., 2011; Ata-Ali et al., 2017). CBCT-based studies have consistently shown that maxillary sinus mucosal thickening is the most frequently observed sinus abnormality in dental populations. A wide range of prevalence has been reported, even among asymptomatic patients undergoing implant assessment (Ata-Ali et al., 2017; Block & Dastoury, 2014). Mucosal thickening of the Schneiderian membrane is generally regarded as a manifestation of inflammatory changes and has been associated with altered sinus physiology and potential clinical implications for implant-related procedures (Block & Dastoury, 2014; Costa et al., 2018). From a clinical perspective, the presence of maxillary sinus mucosal thickening may increase surgical complexity and the risk of complications during maxillary sinus floor elevation and implant placement. Consequently, careful preoperative assessment of sinus membrane conditions using CBCT is considered an essential component of implant treatment planning (Rapani et al., 2016; Krennmair et al., 2020).

In addition to odontogenic factors, anatomical variations of the sinonasal region have been proposed as contributors to maxillary sinus mucosal changes. Variations involving the osteomeatal complex may compromise sinus drainage and predispose the maxillary sinus mucosa to inflammatory thickening (Bolger et al., 1991). Among these variations, Haller cells, which are infraorbital ethmoid air cells located along the medial orbital floor and the roof of the maxillary sinus, have been implicated in the narrowing of the maxillary infundibulum and the disruption of normal sinus drainage. CBCT-based studies have reported a possible

association between Haller cells and maxillary sinus pathology; however, results remain inconsistent, and side-specific relationships have not been fully elucidated (Akbulut & Dilaver, 2019; Özcan et al., 2021; Çapar et al., 2025).

Furthermore, data regarding the prevalence and clinical significance of Haller cells in Southeast Asian populations are limited. Therefore, the present study aimed to evaluate the prevalence of Haller cells and maxillary sinus mucosal thickening in a group of Thai patients using CBCT imaging, and to investigate the association between these findings with a particular emphasis on side-specific relationships relevant to dental implant treatment planning.

2. Objectives

1) To determine the prevalence of Haller cells in CBCT scans of a group of Thai patients.

2) To assess the side-specific association between the presence of Haller cells and maxillary sinus mucosal thickening on the corresponding side.

3) To investigate the association between Haller cells and maxillary sinus mucosal thickening in relation to patient sex.

3. Materials and Methods

3.1 Sample selection

This retrospective cross-sectional study was approved by the Mahidol University Institutional Review Board (COA No. MU-DT/PY-IRB 2024/DT046). CBCT scans were retrieved from the radiographic database during the period from January 2023 to December 2025. Eligible scans were consecutively selected from patients who underwent CBCT examination for implant treatment planning purposes during the study period. The sample size was calculated for the comparison of two proportions using the chi-square test, with a significance level of 0.05 and a statistical power of 80%. Based on prevalence estimates from previous CBCT-based studies (Ata-Ali et al., 2017; Costa et al., 2017), the required sample size was 59 subjects per group, resulting in a minimum total sample size of 118 subjects. To improve statistical reliability and to allow for possible exclusions, a total of 150 CBCT scans were included in the present study. Patients over 20 years of age were included. Only CBCT scans with acceptable image quality for the evaluation of the maxillary sinus and Haller cells were included. Acceptable image quality was defined as clear visualization of the maxillary sinus walls, sinus mucosa, Haller cells, orbital floor, and infraorbital ethmoid region without distortion that could interfere with interpretation. Scans with motion artifacts, incomplete visualization of the region of interest, previous sinus surgery, cysts, tumors, or other severe maxillary sinus pathology were excluded.

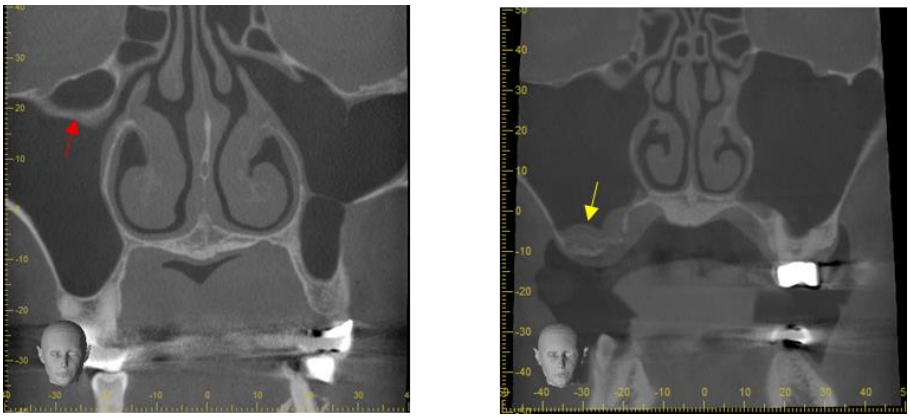
3.2 Tools of measurement

For CBCT image acquisition, scans were captured using a 3D Accuitomo 170 (J Morita, Kyoto, Japan) and saved as DICOM files. The exposure factors were 90 kVp, 6 mA, and 17.5 s. The field of view for the CBCT images was 8x8 cm, 10x10 cm, or 14x10 cm, resulting in a voxel size of 0.16 mm^3, 0.20 mm^3, and 0.25 mm^3, respectively. Images were assessed using the proprietary software equipped with the machines. An 18.0-inch, light-emitting diode, high-definition screen (resolution 1366 x 768 pixels) was used for image assessment. The examiners were allowed to use the zoom tool and to adjust the brightness and contrast of the images.

3.3 Measurement of Haller cells and Maxillary sinus mucosal thickening

Haller cells are recognized as ethmoidal air cells located along the medial orbital floor above the primary maxillary ostium and extending into the maxillary sinus. They were investigated in the coronal section and recorded as present or absent. Laterality was assessed by evaluating Haller cells and maxillary sinus mucosal thickening separately for the right and left sides. An ipsilateral association was defined when both findings were present on the same side.

Maxillary sinus mucosal thickness was measured perpendicular to the sinus wall on coronal sections at the point of maximum visible thickness. Each measurement was recorded once for analysis. Mucosal thickening was defined as a membrane thickness greater than 2 mm, in accordance with previous CBCT-based studies and systematic reviews that have demonstrated the clinical relevance of this threshold in implant dentistry and sinus augmentation procedures (Block & Dastoury, 2014; Amid et al., 2021). The CBCT images were evaluated by one examiner. Prior to image assessment, the examiner was calibrated using representative CBCT scans to standardize the interpretation criteria for Haller cells and mucosal thickening with an oral and maxillofacial radiologist.



(a) (b)

Figure 1 (a) Presence of Haller cells (Red arrow) (b) Presence of mucosal thickening (Yellow arrow)

Descriptive statistics were used to summarize the characteristics of the study population and to determine the prevalence of Haller cells and maxillary sinus mucosal thickening. The association between the presence of Haller cells and maxillary sinus mucosal thickening was evaluated using the chi-square test. Binary logistic regression analysis was additionally performed to assess the association between Haller cells and maxillary sinus mucosal thickening while evaluating the effect of sex as an independent variable. A p-value of less than 0.05 was considered statistically significant.

4. Results and Discussion

4.1 Result

In Table 1, a total of 150 patients (age range 20 to 83, mean age of 59.51 ± 12.81 years) with CBCT scans were included in the analysis. Haller cells were absent in 94 patients (62.6%), while unilateral Haller cells were detected on the right side in 25 patients (16.7%) and on the left side in 21 patients (14%). Bilateral Haller cells were identified in 10 patients (6.7%).

Table 1 Prevalence of Haller cells

Site of Haller cells	No. of Patients	Percentage
Left	21	14%
Right	25	16.7%
Bilateral	10	6.7%
Absent	94	62.6%

Table 2 shows the association between Haller cells and mucosal thickening. On the right side, maxillary sinus mucosal thickening was present in 35 of 47 cases (74.5%) with Haller cells, compared with 24 of 103 cases (23.3%) without Haller cells. This association was statistically significant ($p < 0.001$). On the left side, mucosal thickening was observed in 31 of 39 cases (79.5%) with Haller cells, whereas only 21

of 111 cases (18.9%) without Haller cells exhibited mucosal thickening. This difference was also statistically significant ($p < 0.001$).

Table 2 Association between Haller Cells and mucosal thickening (side-specific analysis)

Side	Haller cells	Mucosal thickening (+)	Mucosal thickening (–)	p-value
Right	Present	35 (74.5%)	12 (25.5%)	<0.001*
Right	Absent	24 (23.3%)	79 (76.7%)	
Left	Present	31 (79.5%)	8 (20.5%)	<0.001*
Left	Absent	21 (18.9%)	90 (81.1%)	

*Significant difference at p<0.001

Binary logistic regression analysis confirmed a strong association between the presence of Haller cells and maxillary sinus mucosal thickening. On the right side, Haller cells were associated with a significantly increased likelihood of mucosal thickening (OR = 10.06; 95% CI: 4.41 to 22.92; $p < 0.001$). Male sex was also a significant predictor (OR = 2.60; 95% CI: 1.14 to 5.91; $p = 0.023$). On the left side, the presence of Haller cells demonstrated an even stronger association with mucosal thickening (OR = 19.80; 95% CI: 7.51 to 52.22; $p < 0.001$). Male sex remained significantly associated with mucosal thickening (OR = 3.45; 95% CI: 1.41 to 8.46; $p = 0.007$).

Table 3 Binary logistic regression analysis for maxillary sinus mucosal thickening

Side	**Variable**	**OR**	**95% CI**	**p-value**
Right	Haller cells (present vs absent)	10.06	4.41–22.92	<0.001*
Right	Gender (male vs female)	2.60	1.14–5.91	0.023*
Left	Haller cells (present vs absent)	19.80	7.51–52.22	<0.001*
Left	Gender (male)	3.45	1.41–8.46	0.007**

Significant difference at p<0.001
Significant difference at p<0.05

4.2 Discussion

This study demonstrated a significant association between the presence of Haller cells and ipsilateral maxillary sinus mucosal thickening in a group of Thai patients evaluated using CBCT imaging. The side-specific findings support the concept that localized anatomical variations may contribute to impaired sinus drainage and subsequent mucosal changes. In the present study, Haller cells were identified in 37.4% of patients when unilateral and bilateral prevalence were combined. This prevalence falls within the wide range reported in previous CBCT-based studies, which have demonstrated considerable variability depending on population characteristics, imaging protocols, and diagnostic criteria. Ata-Ali et al. (2017) reported a prevalence of Haller cells ranging from approximately 10% to over 45% across different populations, highlighting substantial heterogeneity in the literature. Our study findings contribute additional data on the prevalence of Haller cells in a Southeast Asian population, where available evidence remains limited.

A notable finding of the present study was the significant side-specific association between Haller cells and mucosal thickening on both the right and left sides. Because Haller cells are located in the infraorbital ethmoid region adjacent to the maxillary infundibulum, their presence may contribute to the narrowing of the drainage pathway and reduced ventilation of the maxillary sinus. Such localized obstruction may predispose the Schneiderian membrane to inflammatory thickening, which could explain the ipsilateral pattern observed in the present study. Additionally, our dataset indicates that male patients had higher odds of radiographic mucosal change compared with females in this Thai cohort. Findings of higher prevalence or stronger associations in males have also been reported by Çapar et al. (2025). They observed greater mucosal pathology in male subjects and discussed possible explanations, including greater occupational and environmental exposures, higher rates of smoking, and differences in oral health behaviors that could predispose men to sinus mucosal changes.

Özcan et al. (2021) reported that the presence of Haller cells alone was not always associated with sinus pathology, suggesting that their clinical significance may depend on the coexistence and cumulative effect of additional anatomical variations. More recently, Çapar et al. (2025) demonstrated that the narrowing of the maxillary sinus ostium was significantly associated with multiple anatomical factors, including Haller cells, reinforcing the concept that reduced sinus patency is the result of complex anatomical interactions. From this perspective, the association identified in the present study may reflect the contribution of Haller cells as part of a broader constellation of anatomical variations affecting sinus drainage, rather than as an isolated etiologic factor. Therefore, careful CBCT assessment of Haller cells and the osteomeatal complex should be considered an important component of preoperative evaluation for dental implant treatment planning.

This study has several limitations. First, some potentially relevant clinical variables, such as smoking status, allergy history, sinonasal symptoms, and other medical factors, were not available in the radiographic database and therefore could not be analyzed. Second, this was a single-center study conducted in a group of the Thai population, which may limit the generalizability of the findings to other populations or clinical settings. In addition, other sinonasal anatomical variations were not comprehensively evaluated in the present study, and their combined influence on sinus mucosal changes should be investigated in future research.

5. Conclusion

The presence of Haller cells was significantly associated with ipsilateral maxillary sinus mucosal thickening in a group of Thai patients evaluated using CBCT imaging. These findings suggest that localized sinonasal anatomical variations may contribute to maxillary sinus mucosal changes. Careful assessment of Haller cells and adjacent sinus anatomy on preoperative CBCT scans may provide valuable information for risk assessment and treatment planning in dental implant procedures involving the posterior maxilla.

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