ORIGINAL PAPER

ASSOCIATION BETWEEN ACCESSORY MAXILLARY OSTIUM, HALLER CELL, AND SINUS PATHOLOGIES IN CONE-BEAM COMPUTED TOMOGRAPHY

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ABSTRACT

Introduction: Ostiomeatal complex variations may be affected by maxillary and ethmoid sinus pathologies.

Objectives: To evaluate the presence of accessory maxillary ostium (AMO), Haller cell (HC), maxillary sinus pathologies, and ethmoid sinusitis, using cone-beam computed tomography (CBCT).

Material and methods: CBCT images of 628 patients (339 males and 289 females) between 19 and 91 years (mean age, 47.5 ± 15.3 years) were retrospectively evaluated. Presence of AMO, HC, maxillary sinus pathologies, and ethmoid sinusitis was investigated. Maxillary sinus pathologies were classified. Associations of parameters with each other, and with maxillary sinus pathologies and ethmoid sinusitis were observed. Chi-square test was applied to analyze the relationships between variables and distribution of parameters.

Results: AMO was detected in 27%, HC in 15.3%, ethmoid sinusitis in 61.5%, and maxillary sinus pathology in 47.9% of the images. The most common maxillary sinus pathology was localized mucosal thickening, with 28.8% on the right and 25.2% on the left. Statistically significant differences were determined between AMO and maxillary sinus pathologies with ethmoid sinusitis ($p < 0.001$), and HC with maxillary sinus pathologies ($p < 0.05$). Maxillary sinus pathology and presence of ethmoid sinusitis were more common in males ($p < 0.001$).

Conclusions: There was a significant association among maxillary sinus pathology, AMO, HC, and ethmoid sinusitis. Significant relationship was observed between ethmoid sinusitis and all parameters, except for HC. The presence of these variations may increase the possibility of maxillary and ethmoid sinus pathologies. CBCT is a very successful imaging method in examining the anatomy of the paranasal sinus region.

Key words: accessory maxillary ostium, Haller cell, maxillary sinus pathologies, ethmoid sinusitis, cone-beam computed tomography.

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INTRODUCTION

Opening in the medial wall that drains the maxillary sinus to the nasal cavity is called primary maxillary ostium (PMO). Obstruction in the ostium can cause maxillary sinusitis that can expand to other para-nasal sinuses [1]. Accessory maxillary ostium (AMO) originates from the membranous region in the medial maxillary wall located between uncinate process and inferior concha [2].

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AMO is one of the anatomical variations that can cause the development of chronic maxillary sinusitis [3].

Cells formed by the anterior ethmoid sinus extending to the floor of orbit and superior to the maxillary sinus are called Haller cell (HC) [4]. HC is contiguous to maxillary sinus ostium and is localized at upper border of orbital floor, the lower border of maxillary sinus roof, and the medial border of infundibulum [5]. If HC become infected, the maxillary sinus ostium can become blocked, resulting in chronic sinusitis [6].

Since the maxillary sinus is consistently exposed to irritants, it is among the most frequently inflamed areas of the body, and is an important part of the respiratory system [7]. The causes of the development of maxillary sinus pathologies are multifactorial, and include anatomical, immune, genetic, allergic, inflammatory, and infectious components [8, 9].

With an infection of these anatomical variations, the risk of maxillary and ethmoid sinusitis increases. This situation may cause serious problems, especially in maxilla-facial surgery, orthognathic surgery, dental implant application, and sinus lift applied to the maxillary sinus [2, 5].

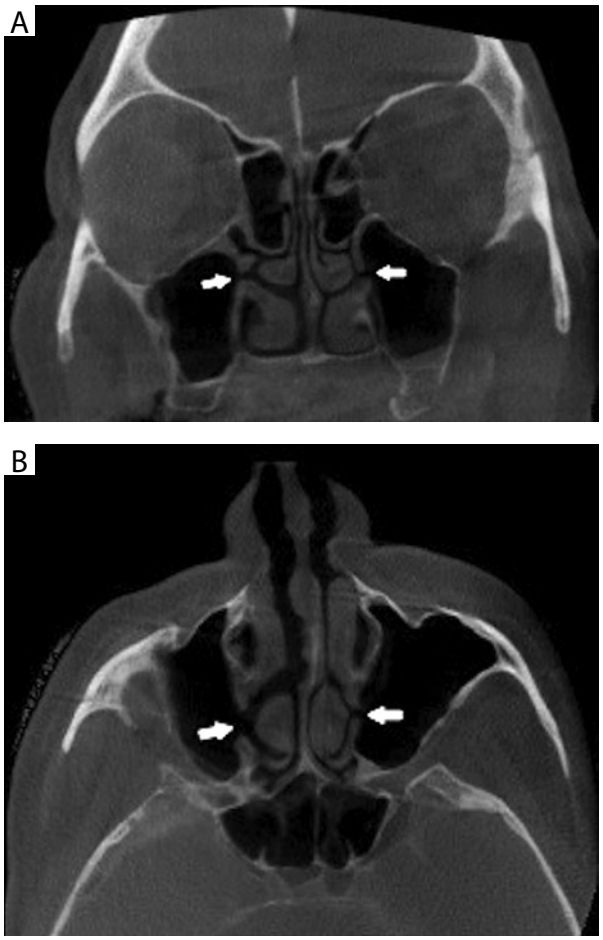

FIGURE 1. Coronal (**A**) and axial (**B**) cone-beam computed tomography (CBCT) images showing right and left accessory maxillary ostium (white arrows). Coronal CBCT image demonstrates mucosal thickening localized in the left maxillary sinus

Evaluation of maxillary sinus, surrounding anatomical structures, and anatomical variations is of great importance for oral and maxilla-facial surgeons and radiologists. Two-dimensional radiographs, such as Waters and Caldwell as well as magnetic resonance imaging, computed tomography (CT), and cone-beam computed tomography (CBCT) have been used in the diagnosis of maxillary sinus pathologies and ethmoid sinusitis [10]. CBCT facilitates the assessment of the maxilla-facial region due to its' high geometric accuracy data, isotropic voxel values, and short scan times. It ensures higher sensitivity, lower radiation dose, and lower cost comparing with CT [11, 12]. In previous studies, the prevalence of AMO and HC, the relationship between AMO and HC with maxillary sinus pathologies, and ethmoid sinus and anatomical variations in nasal cavity were investigated [1, 13-15]. However, there are quite a limited number of studies evaluating CBCT, and none of these studies have examined maxillary sinus pathologies by classifying them in detail.

OBJECTIVES

The aim of this study was to classify the maxillary sinus pathologies by assessing the presence of AMO, HC, maxillary sinus pathologies, and ethmoid sinusitis as well as to examine the relationships of all parameters with each other using CBCT.

MATERIAL AND METHODS

Before the study, ethical approval was obtained from clinical researches ethics committee of Gaziantep University (Protocol No:, 2020/358). In this retrospective study, the images taken with Planmeca Promax 3D (Helsinki, Finland) CBCT device between 2017-2020 in the tomography archive of Gaziantep University Faculty of Dentistry, Dentomaxillofacial Radiology Department were investigated. Multiplanar images were obtained from 16 × 9, 16 × 16 field of view (FOV), with 0.4 mm^3 voxel size and 1 mm slice thickness. Inclusion criteria were availability of CBCT scans without distortion, magnification, artefact, and foreign body in the study area. Exclusion criteria were syndrome and facial growth disorder, presence of metabolic disease involving a bone, presence of a cyst, tumor and fracture line in examination area, presence of a cyst affecting maxillary sinuses, tumor, trauma, and odontogenic infection. CBCT scans of 628 patients (339 males and 289 females) aged 19-91 (mean age, 47.5 ± 15.3 years) were evaluated retrospectively.

IMAGE ANALYSIS

Romexis software (Helsinki, Oy, Finland) was used to analyze the images. On CBCT images, the presence of AMO (Figure 1), HC (Figure 2), maxillary sinus pathologies, and ethmoid sinusitis (Figure 3) as well as the relationship between the variables were evaluated. Maxillary sinus pathologies were categorized as localized mucosal thickening, generalized mucosal thickening, polypoidal mucosal thickening, partial opacification, and total opacification. Sinusitis is inflammation of the para-nasal sinus membranes. Accumulation of secretions accompanying ethmoid sinusitis narrows the air space, causing it to appear radiopaque, and the thin outer walls of the ethmoid air cells are indistinguishable [16]. Inflammatory changes in the mucosal inner surface of para-nasal sinuses are called mucosal thickening. If the membrane thickness is between 2-3 mm, mucosal thickening is taken into account, and if it is more, other pathologies are considered. It is usually asymptomatic and is the most common pathology in the maxillary sinus. When mucosal thickening is seen in one or more walls of the maxillary sinus, it is called localized mucosal thickening (Figures 1A, 3A), when it is located in all its' walls, generalized mucosal thickening (Figure 3B), and the formation of a dome in the maxillary sinus wall is called polypoidal mucosal thickening (Figure 3A) [17]. Sinus opacification is used to describe unilateral or bilateral partial (Figure 3C) or total opacification (Figure 3D) of the maxillary sinus. In inflammatory diseases, fungal infections, mucoceles, mucosal retention cysts, and benign neoplasms in the maxillary sinus are replaced by air with a complete radiopaque appearance [18]. All evaluations were performed by two dento-maxillofacial radiologists; one is research assistant (EMAO), the other with eight year of experience (EDY). When a disagreement existed among the observers, consensus was reached by a discussion. For intra-examiner calibration and reliability of the evaluations, the images were reviewed by the same observers two weeks after the first evaluation.

STATISTICAL ANALYSIS

Kappa statistics was applied to calculate the inter-observer and intra-observer agreement. Chi-square test was used to examine the relationships among categorical variables. SPSS software, version 22.0 (IBM Corp., Armonk, NY, USA) was utilized to analyze the data. Statistical significance was accepted as $p < 0.05$.

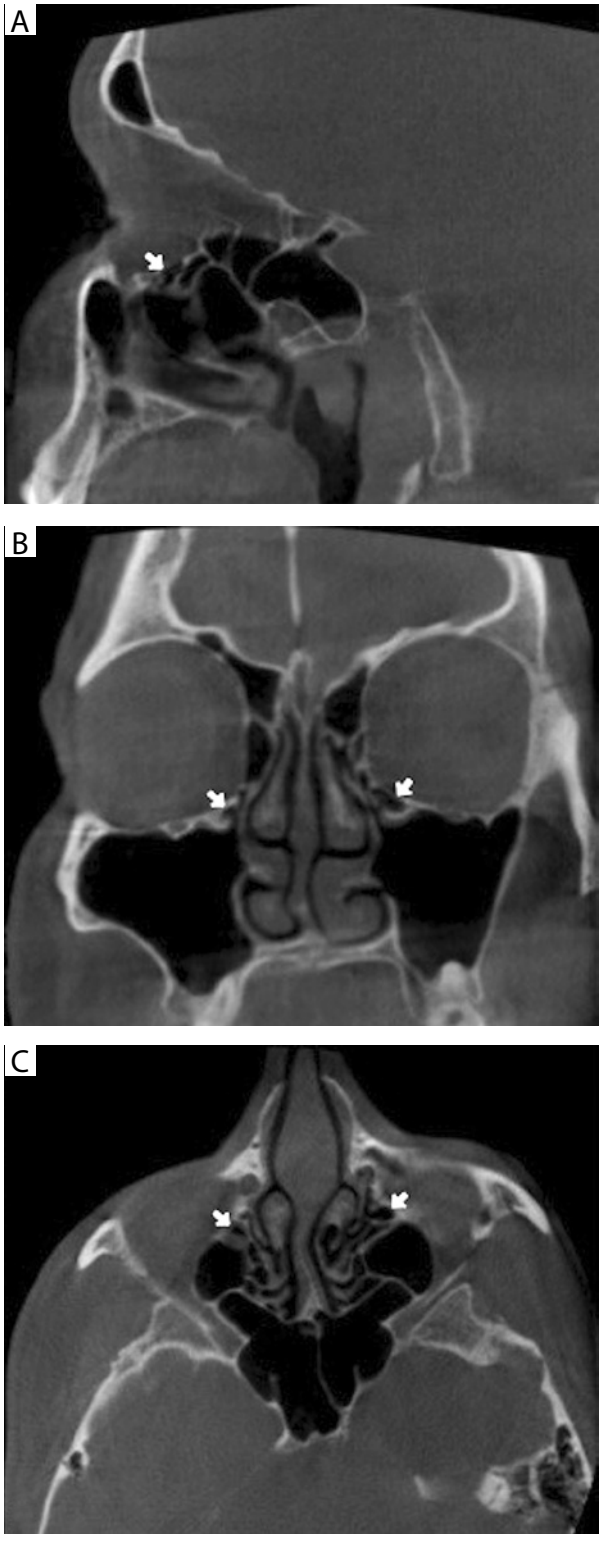

FIGURE 2. Coronal (**A**), sagittal (**B**), and axial (**C**) cone-beam computed tomography images showing Haller cell (white arrows)

RESULTS

The coefficient of intra- and inter-observer reliability for all the assessments was found to be excellent (0.93 and 0.88, respectively). The total of 638 CBCT images of 339 (54%) males and 289 (46%) females (with a mean age of 47.89 ± 15.25 and 47.03 ± 15.29, respectively) were investigated.

In the analyzed images, AMO at a rate of 27.1% on the right, 26.9% on the left, HC at a rate of 18.8% on

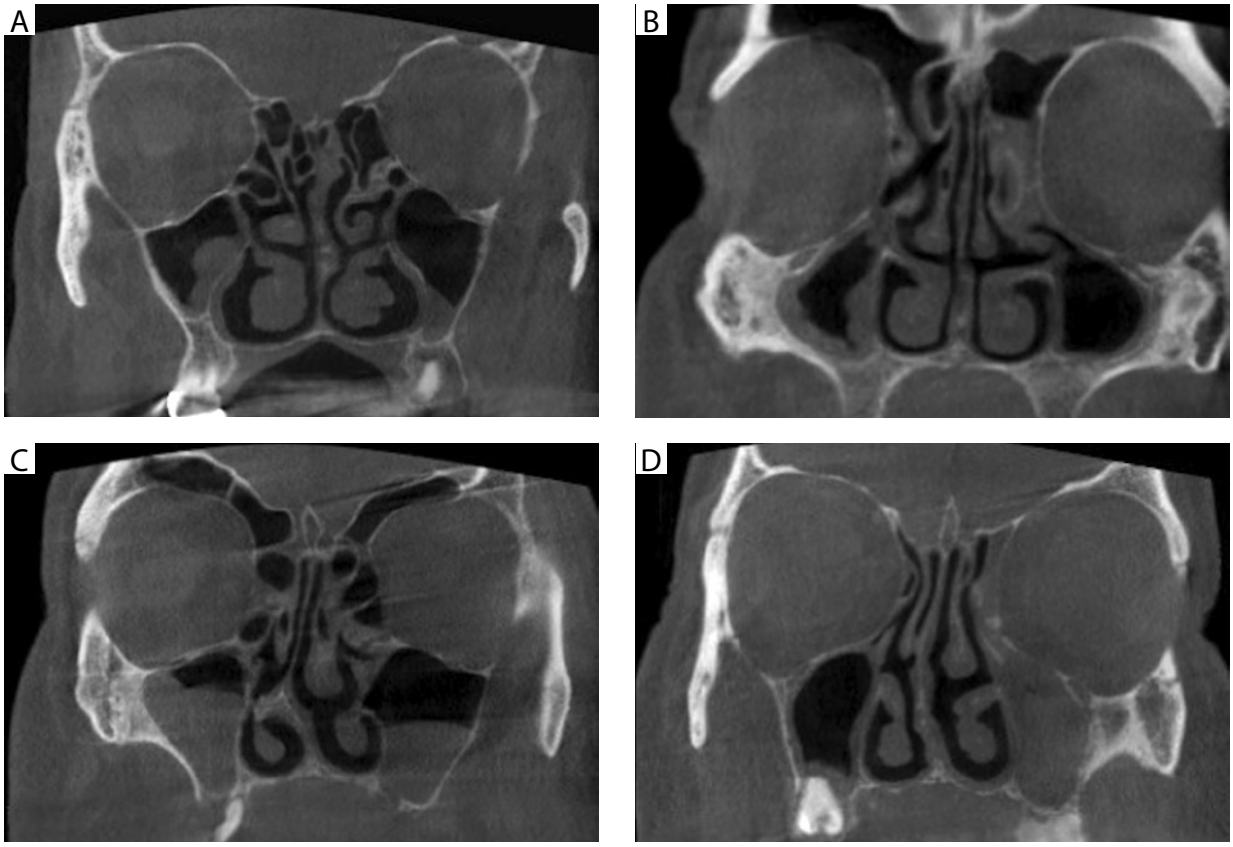

FIGURE 3. Maxillary sinus pathologies on coronal cone-beam computed tomography images. **A**) Ethmoid sinusitis and polypoidal mucosal thickening in the right maxillary sinus, localized mucosal thickening in the left maxillary sinus. **B**) Ethmoid sinusitis and generalized mucosal thickening in the right maxillary sinus. **C**) Ethmoid sinusitis and partial opacification in the right and left maxillary sinuses. **D**) Ethmoid sinusitis and total opacification in the left maxillary sinus

TABLE 1. Frequency of anatomical variations and sinus pathologies

Variables	Right		Left	
	Present, *n* (%)	Absent, *n* (%)	Present, *n* (%)	Absent, *n* (%)
Accessory maxillary ostium	170 (27.1)	458 (72.9)	169 (26.9)	459 (73.1)
Haller cell	118 (18.8)	510 (81.2)	74 (11.8)	554 (88.2)
Maxillary sinus pathology	318 (50.6)	310 (49.4)	283 (45.1)	345 (54.9)
Ethmoid sinusitis	386 (61.5)	242 (38.5)	386 (61.5)	242 (38.5)

the right, 11.8% on the left, maxillary sinus pathology at a rate of 50.6% on the right, 45.1% on the left, and ethmoid sinusitis at a rate of 61.5% were followed. The frequency of anatomical variations and sinus pathologies are shown in Table 1.

When the relationship between parameters and gender was examined, a significant relationship was detected between ethmoid sinusitis, AMO, maxillary sinus pathologies, and gender. Ethmoid sinusitis and maxillary sinus pathologies on both sides were significantly higher in males than in females ($p < 0.001$). Moreover, left AMO was significantly higher in males ($p < 0.05$), while the absence of right AMO was significantly higher in females ($p < 0.001$). Distribution of anatomical variations and sinus pathologies by gender is demonstrated in Table 2. The distribution of the maxillary sinus pathologies classification on the right and left sides is shown in Table 3.

In the evaluation, the relationship between AMO, HC, ethmoid sinusitis, and maxillary sinus pathology, there was no significant difference determined between ethmoid sinusitis and HC ($p > 0.05$), while significant relationship was noted between ethmoid sinusitis with AMO and maxillary sinus pathology ($p < 0.001$). In the presence of ethmoid sinusitis, maxillary sinus pathology was detected on both sides. In addition, an inverse relationship with AMO was observed on both sides in the presence of ethmoid sinusitis. There was a significant difference

TABLE 2. Distribution of anatomical variations and sinus pathologies by gender

	Female		Male		*p*-value
	Present, *n* (%)	Absent, *n* (%)	Present, *n* (%)	Absent, *n* (%)	
Right					
Accessory maxillary ostium	58 (9.2)	231 (36.8)	112 (17.8)	227 (36.1)	0.001*
Haller cell	63 (10.0)	226 (36.0)	55 (8.8)	284 (45.2)	0.075
Maxillary sinus pathology	110 (17.5)	179 (28.5)	208 (33.1)	131 (20.9)	0.001*
Left					
Accessory maxillary ostium	63 (10.0)	226 (36.0)	106 (16.9)	233 (37.1)	0.008*
Haller cell	35 (5.6)	254 (40.4)	39 (6.2)	300 (47.8)	0.814
Maxillary sinus pathology	94 (15.0)	195 (31.1)	189 (30.1)	150 (23.9)	0.001*
Ethmoid sinusitis	154 (24.5)	135 (21.5)	232 (36.9)	107 (17.0)	0.001*

*χ^2 test; $p < 0.05$

determined between the absence of right AMO and the absence of right HC ($p < 0.05$). However, significant difference was determined among the absence of AMO on both sides and the absence of maxillary sinus pathology ($p < 0.001$). In addition, significant difference was observed between the presence of right maxillary sinus pathology with the absence of right HC ($p < 0.05$). The relationships between AMO, HC, ethmoid sinusitis, and maxillary sinus pathologies are demonstrated in Table 4. Localized mucosal thickening was found to be the most common maxillary sinus pathology on both sides. The relationship of maxillary sinus pathologies with anatomical variations and ethmoid sinusitis are shown in Table 5. When parameters were compared among right and left sides, a significant difference was found between right and left AMO ($p < 0.001$), right and left HC ($p < 0.001$), and right and left maxillary sinus pathologies ($p < 0.001$). In all these relationships, in the absence of one parameter, the other relevant parameter was significantly absent.

TABLE 3. Distribution of maxillary sinus pathologies

Classification of maxillary sinus pathologies	Right, *n* (%)	Left, *n* (%)
Generalized mucosal thickening	11 (1.8)	7 (1.1)
Localized mucosal thickening	181 (28.8)	158 (25.2)
Polypoidal mucosal thickening	32 (5.1)	29 (4.6)
Partial opacification	60 (9.6)	58 (9.2)
Total opacification	33 (5.3)	32 (5.1)
Absent	311 (49.5)	344 (54.8)
Total	628 (100.0)	628 (100.0)

DISCUSSION

In this study, the presence of AMO, HC, maxillary sinus pathologies, and ethmoid sinusitis on CBCT images were examined, and the relationship of these variables with each other were investigated. There are limited number of CBCT studies on this subject in the literature [1, 4, 13-15], and to the best of the authors' knowledge, this study is the first CBCT study to classify maxillary sinus pathologies in detail, and to examine the relationship between AMO, HC, and ethmoid sinusitis. In the present study, a significant relationship was detected between ethmoid sinusitis, maxillary sinus pathologies, and AMO. Ethmoid sinusitis and maxillary sinus pathologies were

TABLE 4. Correlations between anatomical variations and sinus pathologies

	Ethmoid sinusitis	Right			Left		
		Accessory maxillary ostium	Haller cell	Maxillary sinus pathology	Accessory maxillary ostium	Haller cell	Maxillary sinus pathology
	p	*p*	*p*	*p*	*p*	*p*	*p*
Ethmoid sinusitis	*****	0.001*	0.459	0.001*	0.001*	0.522	0.001*
Accessory maxillary ostium	*****	*****	0.012*	0.001*	*****	0.762	0.001*
Haller cell	*****	0.762	*****	0.028*	0.762	*****	0.738
Maxillary sinus pathology	*****	0.001*	0.028*	*****	0.001*	0.738	*****

*χ^2 test; $p < 0.05$

TABLE 5. Relationship of maxillary sinus pathologies sub-types with anatomical variations and ethmoid sinusitis

	Right Maxillary Sinus Pathologies						
	Generalized mucosal thickening	Localized mucosal thickening	Polypoidal mucosal thickening	Partial opacification	Total opacification	Absent	*p*-value
Right							
Accessory maxillary ostium							
Present, *n* (%)	4 (0.6)	55 (8.8)	5 (0.8)	30 (4.8)	25 (4.0)	51 (8.1)	0.001*
Absent, *n* (%)	7 (1.1)	126 (20.1)	27 (4.3)	30 (4.8)	8 (1.3)	260 (41.4)	
Haller cell							
Present, *n* (%)	1 (0.2)	33 (5.3)	4 (0.6)	7 (1.1)	4 (0.6)	69 (11.0)	0.232
Absent, *n* (%)	10 (1.6)	148 (23.6)	28 (4.5)	53 (8.4)	29 (4.6)	242 (38.5)	
Ethmoid sinusitis							
Present, *n* (%)	10 (1.6)	113 (18.0)	27 (4.3)	50 (8.0)	29 (4.6)	157 (25.0)	0.001*
Absent, *n* (%)	1 (0.2)	68 (10.8)	5 (0.8)	10 (1.6)	4 (0.6)	154 (24.5)	
	Left Maxillary Sinus Pathologies						
	Generalized mucosal thickening	Localized mucosal thickening	Polypoidal mucosal thickening	Partial opacification	Total opacification	Absent	*p*-value
Left							
Accessory maxillary ostium							
Present, *n* (%)	2 (0.3)	42 (6.7)	10 (1.6)	28 (4.5)	25 (4.0)	62 (9.9)	0.001*
Absent, *n* (%)	5 (0.8)	116 (18.5)	19 (3.0)	30 (4.8)	7 (1.1)	282 (44.9)	
Haller cell							
Present, *n* (%)	1 (0.2)	19 (3.0)	5 (0.8)	6 (1.0)	1 (0.2)	42 (6.7)	0.644
Absent, *n* (%)	6 (1.0)	139 (22.1)	24 (3.8)	52 (8.3)	31 (4.9)	302 (48.1)	
Ethmoid sinusitis							
Present, *n* (%)	5 (0.8)	117 (18.6)	16 (2.5)	50 (8.0)	26 (4.1)	172 (27.4)	0.001*
Absent, *n* (%)	2 (0.3)	41 (6.5)	13 (2.1)	8 (1.3)	6 (1.0)	172 (27.4)	

*χ^2 test; $p < 0.05$

more common in males. The most common of maxillary sinus pathologies was localized in mucosal thickening, and the most common variation in this region was AMO. In addition, a relationship was observed between HC, AMO, and maxillary sinus pathologies on the right side.

CBCT provides valuable information in examining sinonasal bone anatomy, with its' success in three-dimensional imaging. The use of CBCT is recommended because of its' advantages, such as lower radiation dose, higher image quality, and less metal artifact created by dental restorations in three-dimensional imaging of maxillary sinuses, naso-ethmoidal region, anatomical structures, and maxillary sinus pathologies [19, 20].

In the literature, the prevalence of AMO has been reported between 0% and 43% [21, 22]. In a study of Yenigün *et al.* [1], AMO was found at a rate of 19.1%. They stated that significant relationship was detected between the presence of AMO with mucus retention cyst, mucosal thickening, and maxillary sinusitis. However, there was no significant relationship between AMO and HC. In a study conducted by Özcan *et al.* [13], AMO was found to be 24.7%, and a significant relationship was determined between existence of AMO and maxillary sinus pathology. In a study by Bani-Ata *et al.* [23], AMO was found at 29.5% in the right and left, and 18.5% bilaterally, and significant relationship was specified between AMO and maxillary sinusitis. In a study conducted by Ali *et al.* [14], AMO was observed at 23.7%, and a significant relationship between AMO and the presence of maxillary sinusitis was observed. In line with the literature, in the present study, AMO was determined at 27.0%, and a significant relationship was found between maxillary sinus pathology and AMO.

In the literature, it has been stated that the prevalence of HC is highly variable and ranges from 3.7% to 68.0% [4, 24]. Ali *et al.* [14] detected HC as 36.3%, and no significant relationship was found between HC and maxillary sinusitis. In a study, Özcan *et al.* [13] found HC as

7.3%, and there was no significant relationship between HC and maxillary sinus pathologies. Additionally, no significant relationship was determined between AMO and HC. In a research conducted by Mathew *et al.* [4], HC was noted as high as 60.0%, but no significant relationship was found between HC and maxillary sinusitis. Göçmen *et al.* [25] reported HC as 19.3%, with no significant relationship between HC and gender. In a study by Khojastepour *et al.* [24], HC was determined at 68.0%, and there was no significant association between HC and gender. Yenigün *et al.* [1] observed HC at 18.4%, and did not find significant association between AMO and Shokri *et al.* [15] observed HC at 28.8% in their study. It was shown that there was no significant relationship between AMO and HC with each other and gender. In the current study, the rate of HC was found to be 15.3%, and unlike the literature, significant association was reported among HC and AMO with maxillary sinus pathologies on the right side.

Bozdemir *et al.* [26] detected ethmoid sinusitis as 48.5%, mucosal thickening as 24.3%, maxillary sinusitis as 6.5%, and polypoid lesions as 22.3%. Khojastepour *et al.* [24] found various degrees of mucosal thickening at 60.7% in their study, and the prevalence of mucosal thickening was higher in males. An inverse correlation was stated between HC and mucosal thickening. Yenigün *et al.* [1] determined mucosal thickening in 25% of the cases and maxillary sinusitis in 14.5%, and found a significant relationship between AMO with mucosal thickening and maxillary sinusitis. Özcan *et al.* [13] reported maxillary sinus pathology at a rate of 34.1%, and Ali *et al.* [14] detected maxillary sinusitis at 66.2%. In a study conducted by Bani-Ata *et al.* [23], ethmoid sinusitis was determined as 45.0% and maxillary sinusitis as 61.4%. There was a significant relationship found between right AMO and right maxillary sinusitis and ethmoid sinusitis. Furthermore, significant association was discovered among ethmoid sinusitis and maxillary sinusitis, and the prevalence of maxillary and ethmoid sinusitis was higher in males.

In the present study, in line with the literature, maxillary sinus pathologies were observed with a rate of 47.8%, but ethmoid sinusitis (61.5%) was detected with a higher rate compared with the literature. Consistent with the results in the literature, significant association was noted among AMO with maxillary sinus pathology and ethmoid sinusitis. Significant association was reported among gender with maxillary sinus pathologies and ethmoid sinusitis.

In this study, it was concluded that AMO, HC, maxillary sinus pathologies, and ethmoid sinusitis were mostly significantly associated with each other. The reason for these relationships may be that in the presence of ethmoid airway obstruction, the primary and accessory maxillary ostium ventilation and the drainage in the vicinity are affected, causing sinus pathologies. Furthermore, age, ethnicity, presence of systemic disease, anatomical variations, and genetic factors may cause these differences. Different results in the literature may be due to the above-mentioned reasons.

The limitation of this study was that the medical history and systemic diseases without bone findings of the patients were not known since the study was retrospective in nature. In future studies, the sample size may be increased and cases divided into age groups.

CONCLUSIONS

In the current study, significant association among AMO with maxillary sinus pathologies and all other parameters was observed. There was a significant difference between ethmoid sinusitis and all parameters, except for HC. The existence of these variations may increase the possibility of maxillary and ethmoid sinus pathologies. Therefore, the presence of anatomical variations that can be easily visualized with CBCT in sinus lifting and endoscopic sinus surgery, should be carefully examined.

CONFLICT OF INTEREST

The authors declare no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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