

Correlations between anatomical variations of the nasal cavity and ethmoidal sinuses on cone-beam computed tomography scans

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ABSTRACT

Purpose: Anatomical variations of the external nasal wall are highly important, since they play a role in obstruction or drainage of the ostiomeatal complex and ventilation and can consequently elevate the risk of pathological sinus conditions. This study aimed to assess anatomical variations of the nasal cavity and ethmoidal sinuses and their correlations on cone-beam computed tomography (CBCT) scans.

Materials and Methods: This cross-sectional study evaluated CBCT scans of 250 patients, including 107 males and 143 females, to determine the prevalence of anatomical variations of the nasal cavity and ethmoidal sinuses. All images were taken using a New Tom 3G scanner. Data were analyzed using the chi-square test, Kruskal-Wallis test, and the Mann-Whitney test.

Results: The most common anatomical variations were found to be nasal septal deviation (90.4%), agger nasi air cell (53.6%), superior orbital cell (47.6%), pneumatized nasal septum (40%), and Onodi air cell (37.2%). Correlations were found between nasal septal deviation and the presence of a pneumatized nasal septum, nasal spur, and Haller cell. No significant associations were noted between the age or sex of patients and the presence of anatomical variations ($P > 0.05$).

Conclusion: Radiologists and surgeons must pay close attention to the anatomical variations of the sinonasal region in the preoperative assessment to prevent perioperative complications. (*Imaging Sci Dent* 2019; 49: 103-13)

KEY WORDS: Ethmoid Sinus; Cone-Beam Computed Tomography; Anatomical Variation

Introduction

The paranasal sinuses are 4 pairs of air spaces located around the nasal cavity. The nasal cavity and the paranasal sinuses decrease the weight of the skull, warm and moisturize the inhaled air, regulate speech resonance and intranasal pressure, and improve the sense of smell.^{1,2} Pathological changes are often of greater interest to radiologists than anatomical variations.³ Nonetheless, anatomical variations of the lateral nasal wall are highly important since they play a

role in obstruction or drainage of the ostiomeatal complex and ventilation, and can consequently elevate the risk of sinus conditions.⁴ Moreover, anatomical variations can affect the outcomes and safety of surgical procedures performed in this region.⁵

The formation of paranasal sinuses following depression of the nasal mucosa around the facial bones explains the high frequency of anatomical variations in this region.⁶ Anatomical variations of the paranasal sinuses are highly important since they may predict inflammatory changes in the paranasal sinuses. Such variations of the sinus can complicate clinical procedures, particularly functional endoscopic surgery, in which accurate assessment of the region plays a pivotal role in the success and safety of surgical procedures.⁷ Most dental clinicians are

Received October 1, 2018; Revised January 18, 2019; Accepted February 5, 2019

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acquainted with radiographic images of the maxillary sinuses on 2-dimensional (periapical and panoramic) radiographs.² Computed tomography (CT) is the modality of choice for assessing the paranasal sinuses, and the coronal section is the best section for evaluation of the ostiomeatal complex.⁷

Cone-beam computed tomography (CBCT) is the most significant technological advance in maxillofacial imaging since the introduction of panoramic radiography. CBCT, which was initially developed commercially for angiography in the early 1980s,⁸ is a novel imaging modality that generates high-quality images with high accuracy.⁹ In comparison to CT scans, the lower radiation dose of CBCT, its lower cost, and the compact scanner design have made CBCT a suitable modality for diagnosis and treatment planning, particularly in the head and neck region. According to recent studies, CBCT has adequate quality for imaging of paranasal sinuses, even with low doses of X-ray irradiation.^{6,10}

Considering the advances in imaging technology in recent decades, increased attention has been paid to the radiographic details of the anatomy of the paranasal sinuses and ostiomeatal complex.¹¹ CBCT may be preferable to CT for these purposes because it yields high-quality images of bony structures, including maxillary structures, and is particularly valuable for assessing the position, shape, and variations of the paranasal sinuses.⁷

To the best of our knowledge, a comprehensive range of anatomical variations and their correlations have been evaluated in a limited number of studies. Thus, the aim of this

study was to calculate the frequency of anatomical variations of the nasal cavity and ethmoidal sinuses on CBCT scans, to determine the statistical significance of differences in the frequency of these anatomical variations according to sex and age, and to evaluate the correlations between different variations.

Materials and Methods

This cross-sectional study evaluated CBCT scans of the nasal cavity and ethmoidal sinuses retrieved from the archives of the Radiology Department of the School of Dentistry, Hamadan University of Medical Sciences, Iran from 2013 to 2016 and received ethical approval from Hamadan University of Medical Sciences under the code IR.UM-SHA.REC.1396.616. This study included images from 250 patients (107 males and 143 females) in the age range of 10-55 years. The patients' age was limited to the range of 10-55 years to ensure sufficient accuracy of the statistical results because the majority of the patients were in this age range. Patients with a history of surgical procedures in this region, trauma to the head or face, and clefts or benign or malignant tumors of the sinonasal mucosa causing changes in the anatomy of the nasal cavity or ethmoidal sinuses were excluded. Patients were divided into 3 age groups (10-25 years, 26-40 years, and 41-55 years) to obtain a uniform sample distribution.

All images were captured with a New Tom 3G CBCT scanner (Quantitative Radiology, Verona, Italy) and evaluated in the axial, coronal, and sagittal planes by an oral

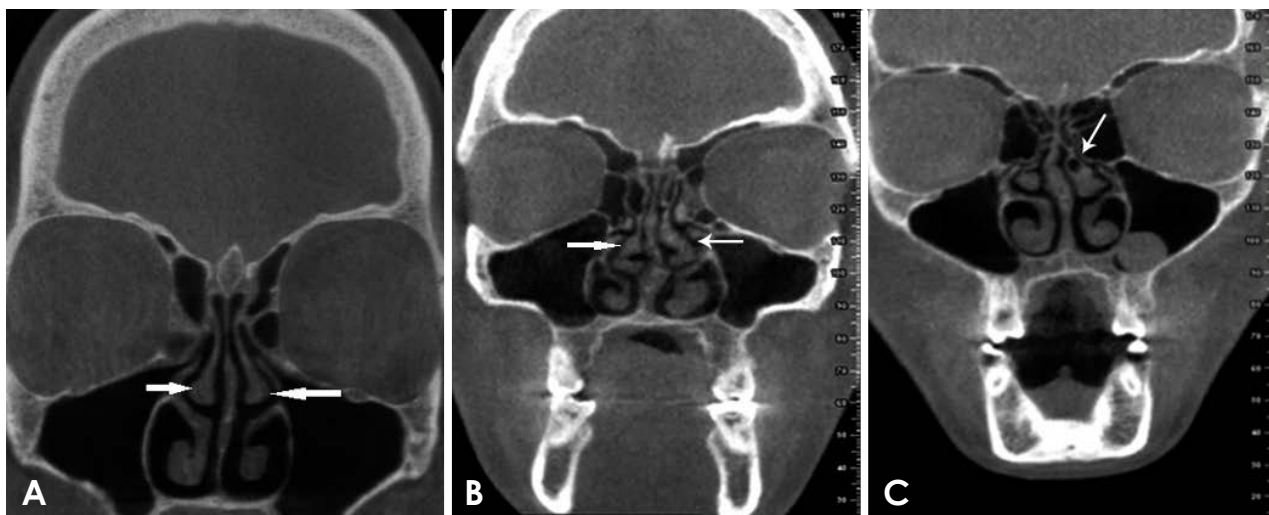


Fig. 1. Coronal cone-beam computed tomographic images. The arrows indicate a normal middle turbinate (A), bilateral paradoxical middle turbinate (B), and concha bullosa (C).

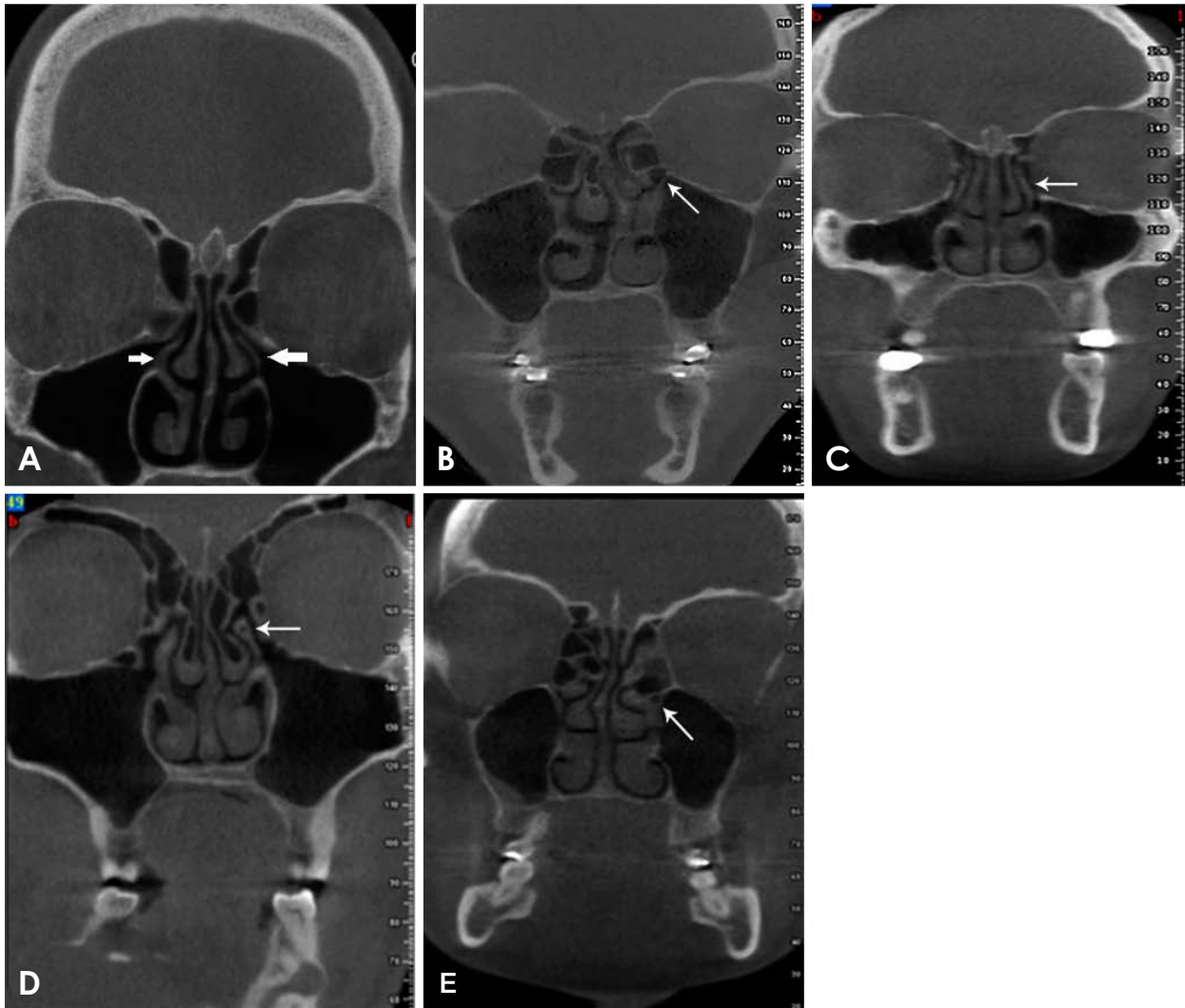


Fig. 2. Coronal cone-beam computed tomographic images. The arrows indicate a normal uncinata process (A), an atelectatic uncinata process (B), lamina terminalis (C), a pneumatized uncinata process (D), and a curved uncinata process (E).

and maxillofacial radiologist with 10 years of educational experience and a senior resident of oral and maxillofacial radiology using NNT Viewer software (New Tom, Verona, Italy). The images were viewed on a 20-inch LG monitor (LG, Seoul, Korea) in partly dark conditions. The observers could change the optical density and contrast of images using rendering software. The results were documented using a checklist. If there was any conflict between the 2 observers, the final decision was made by consulting a third observer, who was an experienced oral and maxillofacial radiologist. All images were analyzed again by the observers after 2 weeks, and the results were documented. The parameters that were evaluated are described below.

The first parameter was the shape of the middle turbinate, which was categorized as normal, paradoxical, or concha

bullosa (Fig. 1). A paradoxical middle turbinate is a rare developmental variation of the middle turbinate in which the border of the middle turbinate is bent and its convex surface faces the lateral aspect. There is no evidence supporting a correlation between the presence of paradoxical middle turbinate and sinusitis, although clear obstruction of the nasal airway can occur due to a paradoxical middle turbinate.^{12,13} Concha bullosa, which can occur in any part of the ethmoid bone complex that becomes pneumatized, is the most common anatomical variation that occurs in the middle turbinate. When it occurs, posterior ethmoidal air cells are pulled in to pneumatize the middle turbinate. The area of pneumatization of the turbinate can be small, medium, or large. Very large cases can cause nasal septal deviation and nasal obstruction.^{1,12}



Fig. 3. A coronal cone-beam computed tomographic image. The arrow indicates the nasal septal deviation.

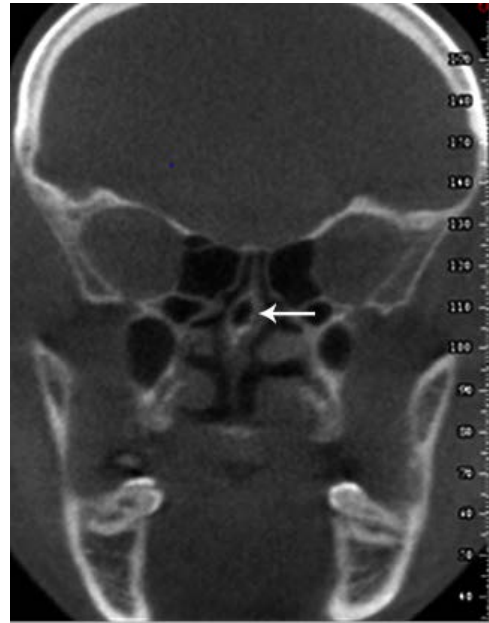


Fig. 4. Pneumatization of the nasal septum is seen on a coronal cone-beam computed tomographic image (arrow).

The second parameter was the shape of the uncinat process. The uncinat process of the ethmoid bone is a thin hook-like osseous structure of the wall of the lateral nasal cavity, which can be normal, atelectatic, inclusive of the lamina terminalis, pneumatized, or curved (Fig. 2). In an atelectatic uncinat process, the free margin of the uncinat process may sometimes be attached to the orbital floor or the inferior surface of the lamina papyracea. It is often associated with a hypoplastic maxillary sinus, which is usually opaque due to obstruction of the infundibulum.¹² The lamina terminalis is defined as a superior extension of the uncinat process towards the roof of the anterior ethmoid.¹² Pneumatization of the uncinat process is rare, but may occur as the result of intrusion of air cells into the uncinat process, which can cause narrowing of the infundibulum and impair ventilation.¹ A curved uncinat process is defined as any curvature in the uncinat process that can cause stenosis of the ostium of the maxillary sinus.¹²

The third parameter was nasal septal deviation (Fig. 3), which refers to any curvature in the nasal septum and is seen in more than half of patients. Nasal septal deviation leads to compensatory hypertrophy of the inferior turbinate and the occurrence of concha bullosa in the middle turbinate at the convex side of the nasal septum. This further aggravates nasal obstruction.¹

The fourth parameter was pneumatization of the nasal septum (Fig. 4). Air cells are often seen in the posterosupe-

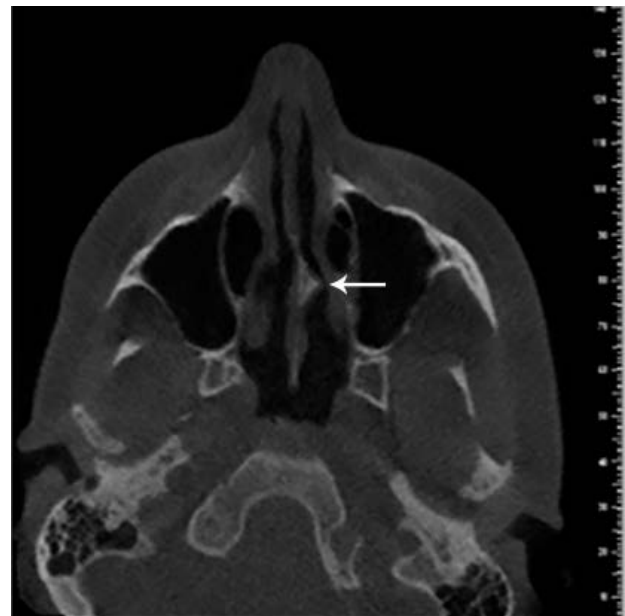


Fig. 5. Nasal septal spine is found on an axial cone-beam computed tomographic image (arrow).

rior part of the nasal septum. When present, they are related to the sphenoid sinus. Thus, inflammatory disease in the paranasal sinuses may affect these cells.¹²

The fifth parameter was the presence of a nasal septal spine (Fig. 5). A spine may be present on the nasal septum. It often forms at the interface of the perpendicular plate of



Fig. 6. An Onodi cell is seen on a coronal cone-beam computed tomographic image (arrow).



Fig. 8. Asymmetry of the ethmoid roof on a coronal cone-beam computed tomographic image (arrow).



Fig. 7. An anterior agger nasi cell is seen on a coronal cone-beam computed tomographic image (arrow).



Fig. 9. Accessory maxillary sinus ostium on a coronal cone-beam computed tomographic image (arrow).

the ethmoid bone and the upper surface of the vomer. In some cases, a nasal spine forms on the convex or concave part of a deviated nasal septum and can be tangent to the turbinate or the lateral nasal wall.¹²

The sixth parameter was the presence of an Onodi cell (Fig. 6). Posterior ethmoidal cells can also invade the sphenoid bone, usually from the superior and lateral parts, and

may become associated with the optic nerve and internal carotid artery. This phenomenon is therefore a risk factor during surgical procedures.^{7,12}

The seventh parameter was the presence of an anterior agger nasi cell (Fig. 7), which reflects a clinically important pattern of the outward spread of air cells. Anterior ethmoidal cells can pneumatize the frontal process of the maxilla.



Fig. 10. Haller cell on a coronal cone-beam computed tomographic image (arrow).

These cells are known as agger nasi cells and are related to the lacrimal bone.¹²

The seventh parameter was asymmetry of the ethmoid roof (Fig. 8). Any asymmetry in the height of the ethmoid roof should be taken into account, because in endoscopic surgery of the sinus, such anatomical variations increase the risk of further penetration into the brain from the lower side of the roof.¹²

The eighth parameter was the presence of accessory maxillary sinus ostium (Fig. 9). The membranous areas in the middle meatus can disintegrate following obstruction of the maxillary sinus ostium, sinusitis, or other anatomical or pathological factors, resulting in the formation of accessory maxillary sinus ostium.¹²

The ninth parameter was the presence of a Haller cell (Fig. 10), which is a posterior ethmoidal cell invading the floor of the orbit and internal orbital wall; Haller cells can sometimes obstruct the ostiomeatal complex and impair sinus drainage, thereby leading to persistent infections.^{7,12}

The tenth parameter was the presence of a superior orbital cell (Fig. 11). Anterior ethmoidal cells can pneumatize the orbital floor as supraorbital ethmoidal cells. Not detecting such cells can cause surgical procedures of the frontal sinus to fail.¹²

The chi-square test, Kruskal-Wallis test, and Mann-Whitney test were used for multiple comparisons. *P* values lower than 0.05 were considered to indicate statistical signifi-



Fig. 11. Superior orbital cell on a coronal cone-beam computed tomographic image (arrow).

cance. All statistical analyses were performed using SPSS version 24 (IBM Corp., Armonk, NY, USA).

Results

The intra-class correlation was calculated to assess intraobserver and interobserver reliability, and values of 94% and 92% were found for interobserver agreement and intraobserver agreement, respectively.

The highest prevalence of anatomical variations was noted in 10- to 25-year-olds. The Mann-Whitney test revealed no significant relationship between the prevalence of anatomical variations and patients' sex ($P=0.254$), and the Kruskal-Wallis test showed no significant relation between the prevalence of anatomical variations and patients' age ($P=0.273$). Table 1 summarizes these data.

The most common anatomical variations in order of frequency were as follows: nasal septal deviation (90.4%), agger nasi cells (53.6%), superior orbital cells (47.6%), a pneumatized nasal septum (40%), and Onodi cells (37.2%). Table 2 summarizes these findings.

There were significant correlations between the presence of nasal septal deviation and pneumatized nasal septum ($P=0.03$), Haller cell ($P=0.01$), as well as between a pneumatized nasal septum and asymmetry of the ethmoid roof ($P=0.01$). Correlations were also observed between the presence of a Haller cell and an agger nasi cell ($P=0.04$)

Table 1. Anatomical variations by age (Kruskal-Wallis test, $P=0.05$) and sex (Mann-Whitney test, $P=0.05$)

Anatomical variations	Age			P value	Sex		P value
	<25 years	26-40 years	>40 years		Male	Female	
Nasal septum deviation	142 (70.8%)	71 (16.7%)	13 (5.8%)	0.18	100 (44.2%)	126 (55.8%)	0.15
Pneumatization of the nasal septum	97 (64.7%)	47 (32.3%)	6 (4.0%)	0.16	62 (41.3%)	88 (58.7%)	0.56
Nasal septal spine	54 (62.1%)	24 (27.6%)	9 (10.3%)	0.47	28 (32.2%)	59 (67.8%)	0.95
Haller cell	50 (69.4%)	18 (25.0%)	4 (5.6%)	0.13	31 (43.1%)	41 (56.9%)	0.95
Onodi cell	53 (57.0%)	31 (33.3%)	9 (9.7%)	0.94	40 (4.03%)	53 (57.0%)	0.92
Anterior agger nasi cell	84 (62.7%)	41 (30.6%)	9 (6.7%)	0.70	57 (42.5%)	77 (57.5%)	0.81
Asymmetry of the ethmoid roof	32 (49.2%)	32 (49.2%)	1 (1.5%)	0.16	27 (41.5%)	38 (58.5%)	0.11
Accessory maxillary sinus ostium	38 (58.5%)	18 (27.7%)	9 (13.8%)	0.11	32 (49.2%)	33 (50.8%)	0.22
Superior orbital cell	73 (61.3%)	41 (34.5%)	5 (4.2%)	0.18	51 (42.9%)	68 (57.1%)	0.98
Middle turbinate morphology	86 (66.7%)	37 (28.7%)	6 (4.7%)	0.40	48 (37.2%)	81 (62.8%)	0.13
Uncinate process morphology	73 (58.4%)	41 (32.8%)	11 (8.8%)	0.13	52 (41.6%)	73 (58.4%)	0.70

Table 2. The frequency of anatomical variations

Anatomical variations	Number	Frequency (%)
Paradoxical middle turbinate	42	16.8%
Concha bullosa	87	34.8%
Atelectatic uncinate process	60	24.0%
Lamina terminalis	13	5.2%
Pneumatized uncinate process	32	12.8%
Curved uncinate process	20	8.0%
Nasal septal deviation	226	90.4%
Pneumatization of the nasal septum	100	40.0%
Nasal septal spine	87	34.8%
Onodi cell	93	37.2%
Anterior agger nasi cell	134	53.6%
Asymmetry of the ethmoid roof	65	26.0%
Accessory maxillary sinus ostium	65	26.0%
Haller cell	72	28.8%
Superior orbital cell	119	47.6%

and nasal septal spine ($P=0.03$), as well as between the presence of a superior orbital cell and accessory maxillary sinus ostium ($P=0.04$). Table 3 summarizes these data.

Discussion

Anatomical variations of the sinonasal region should be carefully identified prior to surgical procedures. These anatomical variations are important for 2 reasons. First, anatomical variations have a direct correlation with the drainage and ventilation of the paranasal sinuses. Second, anatomical variations can significantly affect the safety of surgical procedures.¹⁴⁻¹⁶

CBCT is a novel imaging modality with a higher modulation transfer function than CT, leading to higher spatial resolution. Furthermore, CBCT has a lower patient radiation dose and cost than CT. With these advantages, CBCT

can provide accurate information about maxillofacial anatomy.^{7,10}

Previous studies have reported the prevalence of anatomical variations in this region to be 64%-98%. The prevalence of anatomical variations was found to be 5.2%-90.4% in our study. This discrepancy may be due to differences in age, race, and the type of imaging modality used.¹³

In the present study, the prevalence of concha bullosa was 32.8%, in agreement with the results of Roman et al. (35%) and Mamatha et al. (15%).^{7,17} However, no significant correlation exists between sinusitis and concha bullosa unless the concha bullosa is large enough to cause airway obstruction.^{12,16} The prevalence of paradoxical middle turbinate was 16.8% in our study, which is in agreement with the results of Dasar and Gokce (15.8%), Adeel et al. (18.2%), and Al-Abri et al. (13%).^{3,13,18}

Knowledge of uncinate process variations in patients undergoing functional endoscopic sinus surgery is imperative for the surgeon. During uncinectomy, if the uncinate process is attached to the ethmoid roof or the middle turbinate, the surgeon must be careful not to apply excessive tensile or torsional force on its superior tip. If it is unintentionally damaged, cerebrospinal fluid rhinorrhea or brain damage may occur. In some cases, the free margin of the uncinate process is attached to the orbital floor or the inferior surface of the lamina papyracea and is often associated with a hypoplastic maxillary sinus, which is frequently opaque due to obstruction of the infundibulum. When the orbital floor of the same side is low due to maxillary sinus hypoplasia, the risk of penetration into the orbit during surgery increases. During the preoperative assessment, it is important to pay close attention to anatomical variations. Furthermore, an abnormal shape or position may play a role in the development of sinusitis.^{5,12,13}

Table 3. Correlations between anatomical variations (chi-square test; $P=0.05$)

Anatomical variation	Pneumatization of the nasal septum		Nasal septal spine		Haller cell		Onodi cell		Agger nasi cell		P value
	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	
Nasal septum deviation	142 (62.8%)	84 (37.2%)	85 (37.6%)	141 (62.4%)	60 (26.5%)	166 (73.5%)	83 (36.7%)	143 (63.3%)	124 (54.9%)	102 (45.1%)	0.21
Pneumatization of the nasal septum	****	****	47 (31.3%)	103 (68.7%)	41 (27.3%)	109 (72.7%)	63 (42.0%)	87 (58.0%)	83 (55.3%)	67 (44.7%)	0.5
Nasal septal spine	47 (31.3%)	103 (68.7%)	****	****	18 (25%)	54 (75%)	115 (50.9%)	111 (49.1%)	53 (39.6%)	81 (60.4%)	0.09
Haller cell	41 (27.3%)	109 (72.7%)	18 (25%)	54 (75%)	****	****	26 (36.1%)	46 (63.9%)	29 (40.3%)	43 (59.7%)	0.04
Onodi cell	63 (42%)	87 (58%)	115 (50.9%)	111 (49.1%)	26 (36.1%)	46 (63.9%)	****	****	54 (58.1%)	39 (41.9%)	0.27
Agger nasi cell	83 (55.3%)	67 (44.7%)	53 (39.6%)	81 (60.4%)	29 (40.3%)	43 (59.7%)	54 (58.1%)	39 (41.9%)	****	****	****
Asymmetry of the ethmoid roof	47 (31.3%)	103 (68.7%)	18 (27.7%)	47 (72.3%)	17 (23.6%)	55 (76.4%)	76 (50.7%)	74 (49.3%)	44 (47.3%)	49 (52.7%)	0.09
Accessory maxillary sinus ostium	36 (24%)	114 (76%)	112 (49.6%)	114 (50.4%)	14 (19.4%)	58 (80.6%)	40 (43%)	53 (57%)	38 (28.4%)	96 (71.6%)	0.36
Superior orbital cell	75 (50%)	75 (50%)	48 (55.2%)	39 (44.8%)	32 (44.4%)	40 (55.6%)	43 (46.2%)	50 (53.8%)	73 (54.5%)	61 (45.5%)	0.06
Middle turbinate morphology	80 (53.3%)	70 (46.7%)	42 (58.3%)	30 (41.7%)	47 (54%)	40 (46%)	51 (54.8%)	42 (45.2%)	79 (59%)	55 (41%)	0.87
Uncinate process morphology	76 (50.7%)	74 (49.3%)	30 (41.7%)	42 (58.3%)	50 (57.5%)	37 (42.5%)	44 (47.3%)	49 (52.7%)	68 (50.7%)	66 (49.3%)	0.80

Table 3. Continued

Anatomical variation	Asymmetry of the ethmoid roof		Accessory maxillary sinus ostium		Superior orbital cell		Middle turbinate morphology		Uncinate process morphology		P value
	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	
Nasal septum deviation	56 (24.8%)	170 (75.2%)	57 (25.2%)	169 (74.8%)	111 (49.1%)	115 (50.9%)	47 (31.3%)	103 (68.7%)	112 (49.6%)	114 (50.4%)	0.66
Pneumatization of the nasal septum	47 (31.3%)	103 (68.7%)	36 (24%)	114 (76%)	75 (50%)	75 (50%)	80 (53.3%)	70 (46.7%)	76 (50.7%)	74 (49.3%)	0.79
Nasal septal spine	18 (27.7%)	47 (72.3%)	112 (49.6%)	114 (50.4%)	48 (55.2%)	39 (44.8%)	42 (58.3%)	30 (41.7%)	30 (41.7%)	42 (58.3%)	0.09
Haller cell	17 (23.6%)	55 (76.4%)	14 (19.4%)	58 (80.6%)	32 (44.4%)	40 (55.6%)	47 (54%)	40 (46%)	50 (57.5%)	37 (42.5%)	0.08
Onodi cell	76 (50.7%)	74 (49.3%)	40 (43%)	53 (57%)	43 (46.2%)	50 (53.8%)	51 (54.8%)	42 (45.2%)	44 (47.3%)	49 (52.7%)	0.51
Agger nasi cell	44 (47.3%)	49 (52.7%)	38 (28.4%)	96 (71.6%)	73 (54.5%)	61 (45.5%)	79 (59%)	55 (41%)	68 (50.7%)	66 (49.3%)	0.80
Asymmetry of the ethmoid roof	****	****	14 (21.5%)	51 (78.5%)	31 (47.7%)	34 (52.3%)	36 (55.4%)	29 (44.6%)	80 (53.3%)	70 (46.7%)	0.76
Accessory maxillary sinus ostium	14 (21.5%)	51 (78.5%)	****	****	42 (64.6%)	23 (35.4%)	29 (44.6%)	36 (55.4%)	35 (53.8%)	30 (46.2%)	0.47
Superior orbital cell	31 (47.7%)	34 (52.3%)	42 (64.6%)	23 (35.4%)	****	****	68 (57.1%)	51 (42.9%)	68 (57.1%)	51 (42.9%)	0.03
Middle turbinate morphology	36 (55.4%)	29 (44.6%)	29 (44.6%)	36 (55.4%)	68 (57.1%)	51 (42.9%)	****	****	44 (47.3%)	49 (52.7%)	0.51
Uncinate process morphology	80 (53.3%)	70 (46.7%)	35 (53.8%)	30 (46.2%)	68 (57.1%)	51 (42.9%)	44 (47.3%)	49 (52.7%)	****	****	0.51

In our study, the prevalence of anatomical variations in the morphology of the uncinat process was 50%, which is in agreement with the results of Khojastepour et al. (54.8%), and Mamtha et al. (65%).^{5,17}

Nasal septal deviation is another common anatomical variation, with a prevalence of 14.1%-80%.^{1,12} It has been reported that nasal septal deviation can cause infection of all paranasal sinuses, due to narrowing of the airway, weak mucociliary clearance, and mucus drainage.^{1,18} In the current study, the prevalence of nasal septal deviation was 90.4%, which is in agreement with the results of Aramani et al. (75%).¹⁶

The nasal septum was almost always deviated away from either a unilateral concha or the dominant concha if there were bilateral conchae. The septum was not pushed by the concha, as the air channel between them was maintained. There appears to be some type of an inductive relationship between the presence of concha bullosa and deviated septum.¹²

In the present study, a correlation between middle turbinate morphology and nasal septum deviation was detected, which is validated by the study of Koo et al.¹

A spine may be present on the nasal septum, which is often located at the interface of the perpendicular plate of the ethmoid bone and the upper surface of the vomer. In some cases, the nasal spine is located over the concave or convex part of the deviated nasal septum and can be tangent to the turbinate or the lateral nasal wall. There appears to be a relationship between the presence of a nasal septal spine and deviated septum, although in this study a correlation was found between nasal septum deviation and a nasal septal spine.¹²

The prevalence of a nasal spine was 34.8% in our study, which is in accordance with the results of Dasar and Gokce (42.3%). Approximately half of patients with nasal spine have been reported to have sinonasal mucosal diseases, but no such association was confirmed in this study.¹³ Moreover, 36% of patients had both nasal septal deviation and a nasal spine in our study, which is in agreement with the findings of Earwaker (34%).²¹ When nasal septal deviation and a nasal spine are both present, the nasal meatus path is narrowed, impairing the function of nasal endoscopy and functional endoscopic sinus surgery (FESS).^{13,19,20}

Some authors believe that Haller cells are responsible for the recurrence of maxillary sinusitis, but their effect on the prevalence of sinusitis is still a matter of debate.^{12,16} In the current study, the prevalence of Haller cells was 28.8%. In the literature, the reported prevalence ranges from 2% to 70%. This broad range may be due to controversies in the

definition of Haller cells and differences in the mean age of patients, their race, and the imaging protocols used.^{14,21-23}

Nonetheless, a correlation was detected in this study between Haller cells and nasal septum deviation was detected, as validated by Dasar and Gokce's study.¹³

Onodi cells often extend close to the carotid canal and optic nerve, further adding to the significance of this anatomical variant during surgical procedures. Invasive procedures should be avoided in this area. Additionally, in the preoperative assessment, surgeons should pay close attention to Onodi cells to prevent any problems in FESS.¹ The presence of an Onodi cell can result in traumatization of the olfactory nerve during surgical procedures. Additionally, infections of Onodi cells can compress the optic nerve and cause periorbital swelling.¹³ The reported prevalence of Onodi cells ranges from 3.4% to 51%, and the prevalence found in the present study was 30.8%, in agreement with the results of Dasar and Gokce (25.3%).^{12,13}

Evidence has shown that the larger size of agger nasi cells can narrow the drainage path of the frontal sinus and impair drainage. However, other studies have found no significant association between agger nasi cells and frontal sinus infection.^{13,17}

The presence of an asymmetrical ethmoid sinus roof is among the most common anatomical variants of the sinonasal region; it has a significant correlation with chronic sinusitis and is seen in over 80% of patients with sinusitis.¹²

During surgical procedures, any asymmetry in the height of the ethmoid roof should be taken into account because during endoscopic surgery of the sinus, these anatomical variations increase the risk of penetration into the brain in the lower side of the roof.¹² This variation had a prevalence of 26% in our study, in agreement with the results of Fadda et al. (25%), and Al-Abri et al. (32%).^{3,24}

Anterior ethmoidal cells can pneumatize the orbital floor as supraorbital ethmoidal cells. Not noticing the diseased condition of these cells can cause frontal sinus surgical procedures to fail.³

The prevalence of supraorbital cells was 26% in our study, in line with the results of Dasar and Gokce (15%).¹³ The prevalence of accessory maxillary sinus ostium has been reported to be 15%-40%, and this variant structure often drains into the infundibulum or, even more commonly, the fontanel.¹¹ In our study, the prevalence of accessory maxillary sinus ostium was 26%, similar to the value reported by Dasar and Gokce (21.8%).¹³

Patients' age and sex showed no significant correlations with anatomical variations in our study, similar to the findings of Khojastepour et al.⁵

We conclude that the high prevalence of anatomical variations in the ostiomeatal complex and their correlations mean that they are very important considerations when establishing a diagnosis or treatment plan. Radiologists must focus on anatomical variants in the preoperative evaluation, and it is important for surgeons to be aware of these variations.

Acknowledgements

The authors would like to thank the Vice-Chancellor for Education and the Vice-Chancellor for Research and Technology of Hamadan University of Medical Sciences, and to express special thanks to Dr. Samira Saati, an oral and maxillofacial radiologist, who was the third observer for evaluating the images.

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