RESEARCH ARTICLE

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Sinonasal Anatomic Variations in Headache Etiology

ABSTRACT

Objective: Headache is a frequent clinical symptom with multiple etiologies. Our purpose is to investigate the correlation between variations in sinonasal anatomy and headaches.

Method: We retrospectively evaluated the paranasal computed tomography (CT) scans of patients with and without headaches. 118 patients presenting with headaches were included in the study group and 63 patients without headaches were included in the control group. Eight common anatomic variations were clarified and recorded in both groups regardless of whether unilateral or bilateral. Statistical analyses were performed with NCSS (Number Cruncher Statistical System) 2007 software. The results were evaluated at a significance level of $p<0.05$.

Results: Among the variations we investigated in our study agger nasi cells were observed as the most commenly encountered variation. Our study highlighted a statistically significant correlation between headaches and some anatomical variations. These variations including of Haller cell, septum-lateral nasal wall contact, and agger nasi cell.

Conclusions: Headaches have complex pathophysiological mechanisms and may be associated with sinonasal anatomic variations. The recognition of these variations will contribute to the management of the headache.

Keywords: Computed Tomography, Headache, Anatomical Variation.

Baş Ağrısı Etyolojisinde Sinonazal Anatomik Varyasyonlar

ÖZET

Amaç: Baş ağrısı çoklu etiyolojileri olan sık görülen bir klinik semptomdur. Amacımız sinonazal anatomideki varyasyonlar ile baş ağrısı arasındaki ilişkiyi araştırmaktır.

Yöntem: Baş ağrısı olan ve olmayan hastaların paranazal bilgisayarlı tomografi (BT) taramaları retrospektif olarak değerlendirildi. Baş ağrısı ile başvuran 118 hasta çalışma grubuna, baş ağrısı olmayan 63 hasta ise kontrol grubuna dahil edildi. Sekiz yaygın anatomik varyasyon, tek veya çift taraflı olmasına bakılmaksızın her iki grupta da var veya yok şeklinde değerlendirildi ve kaydedildi. İstatistiksel analizler NCSS (Number Cruncher Statistical System) 2007 yazılımı ile yapıldı. Sonuçlar $p<0.05$ anlamlılık düzeyinde değerlendirildi.

Bulgular: Çalışmamızda incelediğimiz varyasyonlar arasında agger nasi hücreleri en sık rastlanan varyasyon olarak gözlendi. Çalışmamız baş ağrısı ile bazı anatomik varyasyonlar arasında istatistiksel olarak anlamlı bir korelasyon olduğunu ortaya koymuştur. Bu varyasyonlar arasında Haller hücresi, septumun lateral burun duvarı ile teması ve agger nasi hücresi yer almaktadır.

Sonuç: Baş ağrıları karmaşık patofizyolojik mekanizmalara sahiptir ve sinonazal anatomik varyasyonlarla ilişkili olabilirler. Bu varyasyonların tanınması baş ağrısının yönetimine katkıda bulunacaktır.

Anahtar Kelimeler: Bilgisayarlı Tomografi, Baş Ağrısı, Anatomik Varyasyon.

INTRODUCTION

Headache is a common health issue arising from the interaction of various factors such as genetic traits, environmental influences, and anatomical variations. Headache encompasses various variable etiological factors, thus necessitating a multidisciplinary approach in research on its etiology. From the point of an otolaryngologist rhinogenic headaches are important. Rhinogenic headaches refer to the pain that originates from the nose. The most common causes of rhinogenic headaches are acute sinusitis, chronic sinusitis, and contact of septum to nasal wall (1). The terms "sinus headache" and "rhinogenic headache" are frequently mistakenly used in place of each other. The term "sinus headache" is a patient complaint rather than an accurate description of an underlying pathologic process (1). Rhinosinusitis develops when one or more paranasal sinuses become infected. The sinuses connect with the nasal passages through ostia, and blockage of the ostiomeatal complex leads to sinus problems in the maxillary, frontal, and ethmoid regions (2).

Embryologically all sinuses begin to develop in utero. Ethmoidal sinuses are the only sinuses that can be seen on imaging at birth. Ethmoid sınuses which are 2-4 cells at birth reach their size by the age of 12. Certain cells in the ethmoid bone have been assigned specific names due to their clinical significance. Ethmoid bulla, Agger nasi cells, Haller cells, and Onodi cells are cells that belong to ethmoid cells (3).

The maxillary sinus can be seen radiographically 5 months after birth. It enlarges first at the age of 3 and then between the ages of 7 and 12 years. It continues to grow until adulthood.

Frontal and sphenoidal sinuses are the last ones to complete their development in late teens and adulthood respectively (4).

Endonasal examination and CT contribute greatly to evaluating headache patients. With the use of CT scans, medical professionals may now see anatomical variations, major blockage locations, posterior sinuses, and the degree of pneumatization (5). Variations in the sinonasal region include concha bullosa, paradoxical curvature of the middle turbinate, septal deviation, frontal sinus aplasia, and some ethmoid cell variations (6). This study seeks to explore anatomical variations and their potential correlation with headaches.

MATERIAL AND METHODS

The paranasal sinus CT of 181 patients who admitted to Şehit Prof. Dr. İlhan Varank Training and Research Hospital between January 2019 and May 2022 were retrospectively analysed. A total of 118 patients who were suffering from headaches were included in the study group, and patients without headache constituted the control group. CT scans were performed with 5 mm sections and without contrast using a multidetector Canon TSX-035A CT Scanner. The study obtained ethical approval (2023/45) from the Ethics Committee of Sancaktepe Şehit Prof. Dr. İlhan Varank Training and Research Hospital. Patients with nasal polyps, sinusitis, and migraine are excluded from the study. Also patients under age 18 are not included. The coronal, axial, and sagittal sections of paranasal sinus CT were evaluated in terms of predetermined anatomical variations by two clinicians, and a radiologist. Anatomical variations noted included septal deviation, septum-lateral nasal wall contact , concha bullosa, Onodi cell, Agger nasi cell, Haller cell, paradoxical middle turbinate, and frontal sinus aplasia. Anatomical variations were recorded as present or absent regardless of whether they were unilateral or bilateral.

Statistical Analysis: Statistical analyses were performed with the NCSS (Number Cruncher Statistical System) 2007 program. The chi-square test was used for comparisons of qualitative data and OR (Odds Ratio) was used to determine risk. The results were analyzed at the significance level of $p<0.05$.

RESULTS

The study group included 78 females (66.1%) and 40 males (33.9%) with a mean age of 38,1 years and the control group included 33 females (52.4%) and 30 males (47.6%) with a mean age of 36,17 years. Regarding age and gender, there was no statistically significant difference between the two groups (p=0.303, p=0.071) (Table 1).

Table 1. Patient demographics

		StudyGroup	Control Group	p
Age		38±11.50	36.1±12.77	0.303
	Male	33.90%	47.6%	
Sex	**Female**	66.10%	52.3%	0.071

Nasal septal deviation was seen in 91 (77,1%) patients in the study group and in 41 (65%) patients in the control group. In comparison to the control group, the research group had 1.95 (1.02-3.74) times more contact points between the septum and lateral nasal wall. The difference was statistically significant (p=0,041).

Concha bullosa incidence was 48,3% in patients with headache, and 39,6 in patients with no headache.

Agger nasi cells were observed in 95,7% of the study group, and in 76,1 of the control group, respectively.

The Haller cell presence in the study group was found to be statistically higher than in the control group (p=0.018). The risk of Haller cell presence in the study group was two times higher than in the control group.

The presence of septum nasal wall contact (p=0.041), the Agger nasi cells (p=0.0001), and the Haller cells (p=0.018) were significantly more frequent in patients with headaches. When other anatomical variations were analyzed, no statistically significant difference was observed between the two groups (Table 2).

CT images showing anatomical variations of our patients are illustrated in figures 1-4.

Table 2. Frequency of anatomic variations

		Study Group		Control group		
		n	%	n	%	P value*
Nasal Septal Deviation	+	91	77,1	41	65,0	
	-	27	22,8	22	34,9	0,082
Contact between septum&concha	+	54	45,7	19	30,1	
	-	64	54,2	44	69,8	**0,041**
Concha bullosa	+	57	48,3	25	39,6	
	-	61	51,6	38	60,3	0,267
Onodicell	+	26	22,0	18	28,5	
	-	92	77,9	45	71,4	0,329
Agger nasi cell	+	113	95,7	48	76,1	
	-	5	4,2	15	23,8	**0,0001**
Haller cell	+	59	50,0	20	31,7	
	-	59	50,0	43	68,2	**0,018**
Paradoxical middle concha	+	20	16,9	5	7,9	
	-	98	83,0	58	92,0	0,094
Frontal sinusaplasia	+	8	6,7	8	12,7	
	-	110	93,2	55	87,3	0,181

The chi-square test was used; n: number of patients; *Significant at 0.05 level; + Present; - Absent

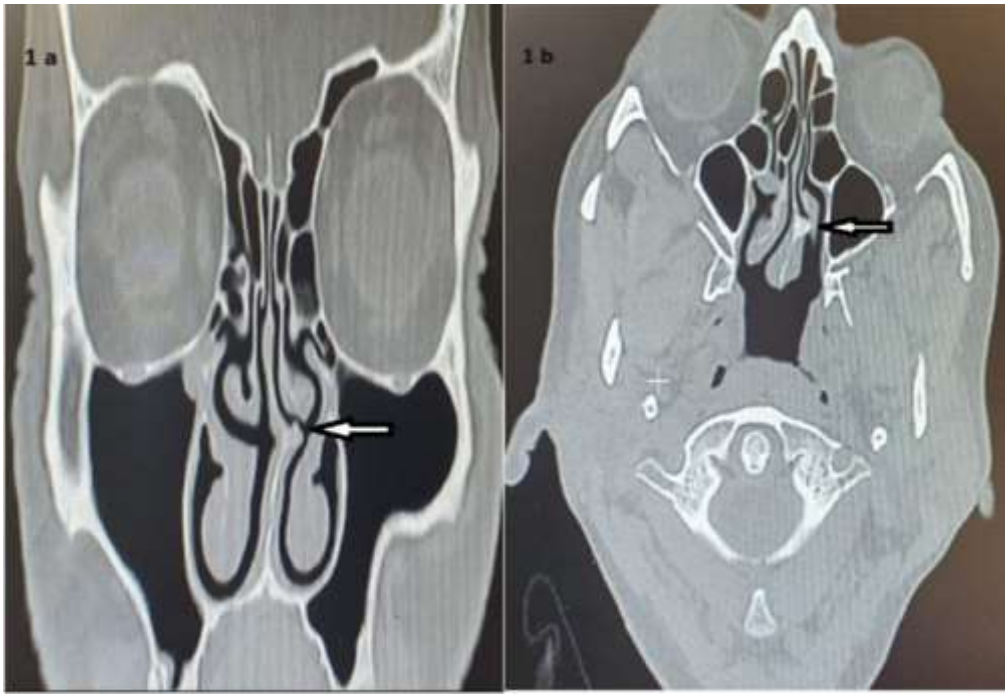

Figure 1 CT images showing nasal septal deviation. 1-a Coronal CT image showing:Leftward deviation of nasal septum (arrow). 1-b Axial CT image of the same patient showing:Leftward deviation of septum and contact of septum to lateral nasal wall (arrow).

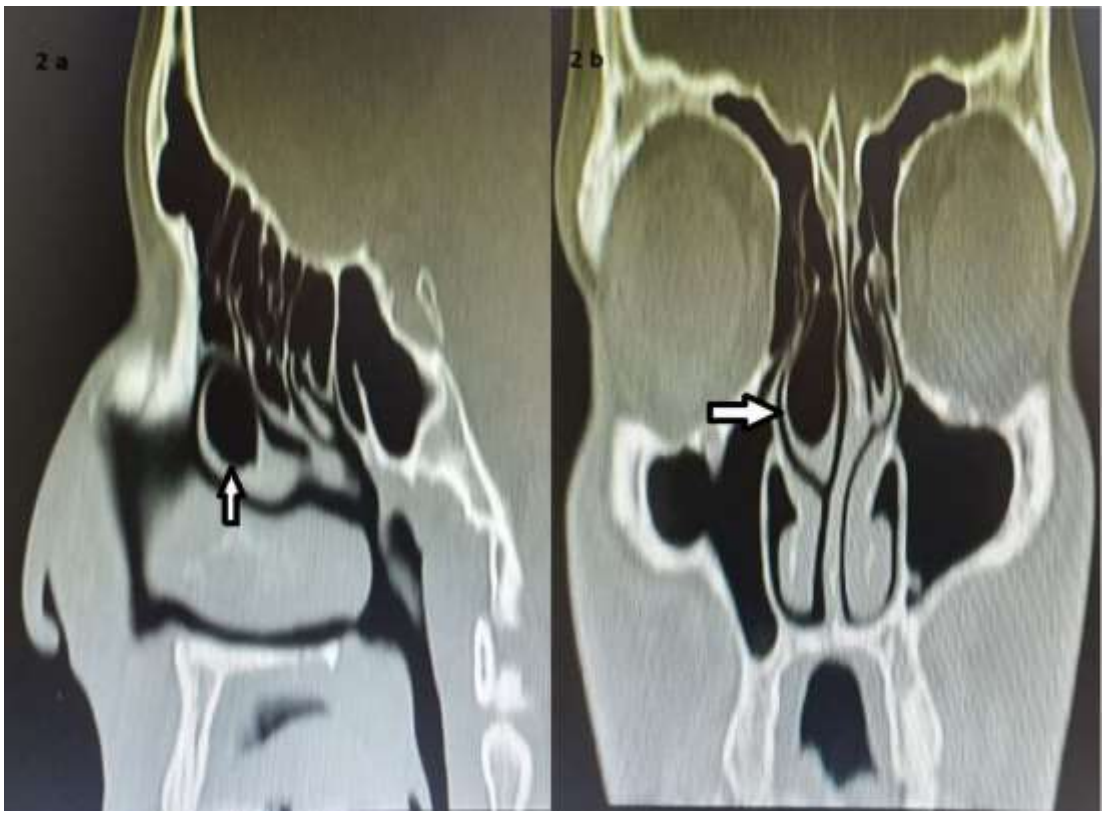

Figure 2. CT images showing concha bullosa cells. 2-a Saggital CT image showing concha bullosa (arrow). 2-b Coronal CT image of the same patient showing right concha bullosa cell (arrow)

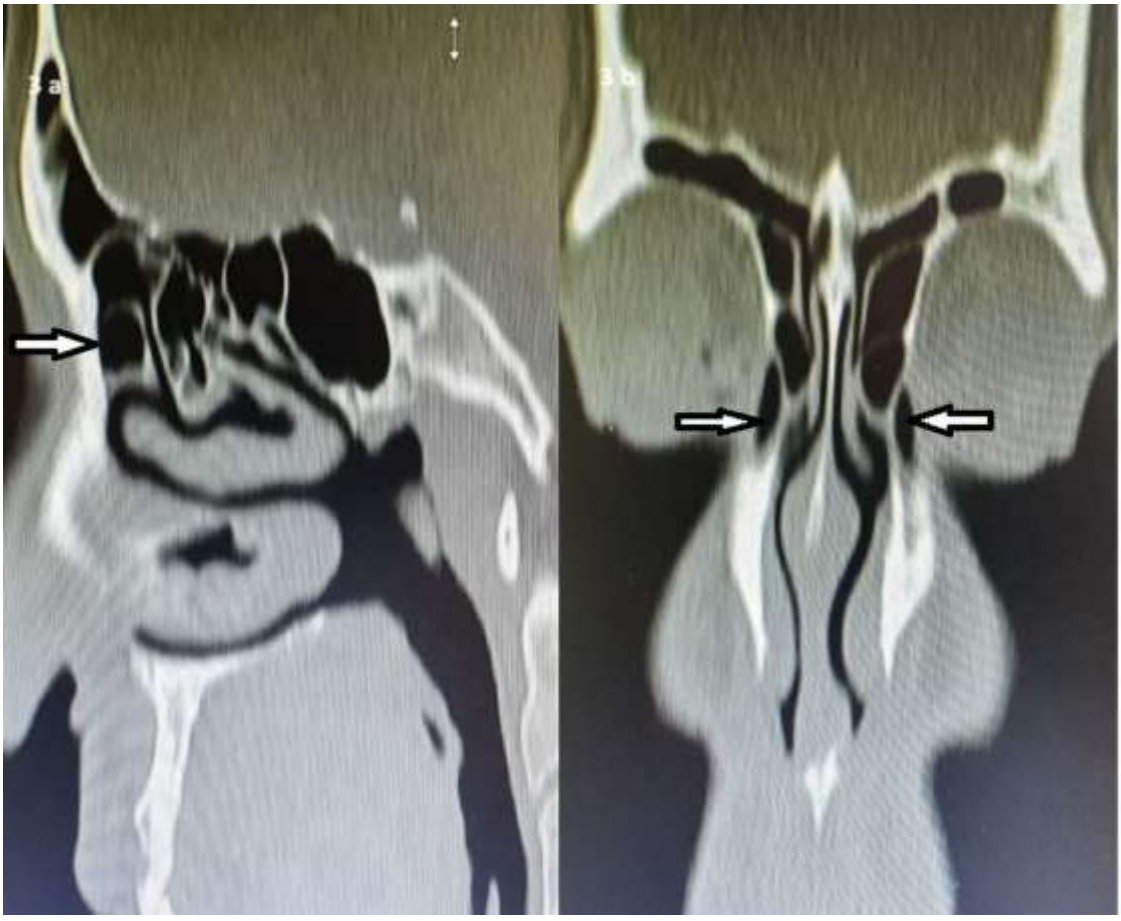

Figure 3. CT images showing agger nasi cells. 3-a Saggital CT image of the showing agger nasi cell (arrow). 3-b Coronal CT image of the same patient showing bilateral agger nasi cells (arrows).

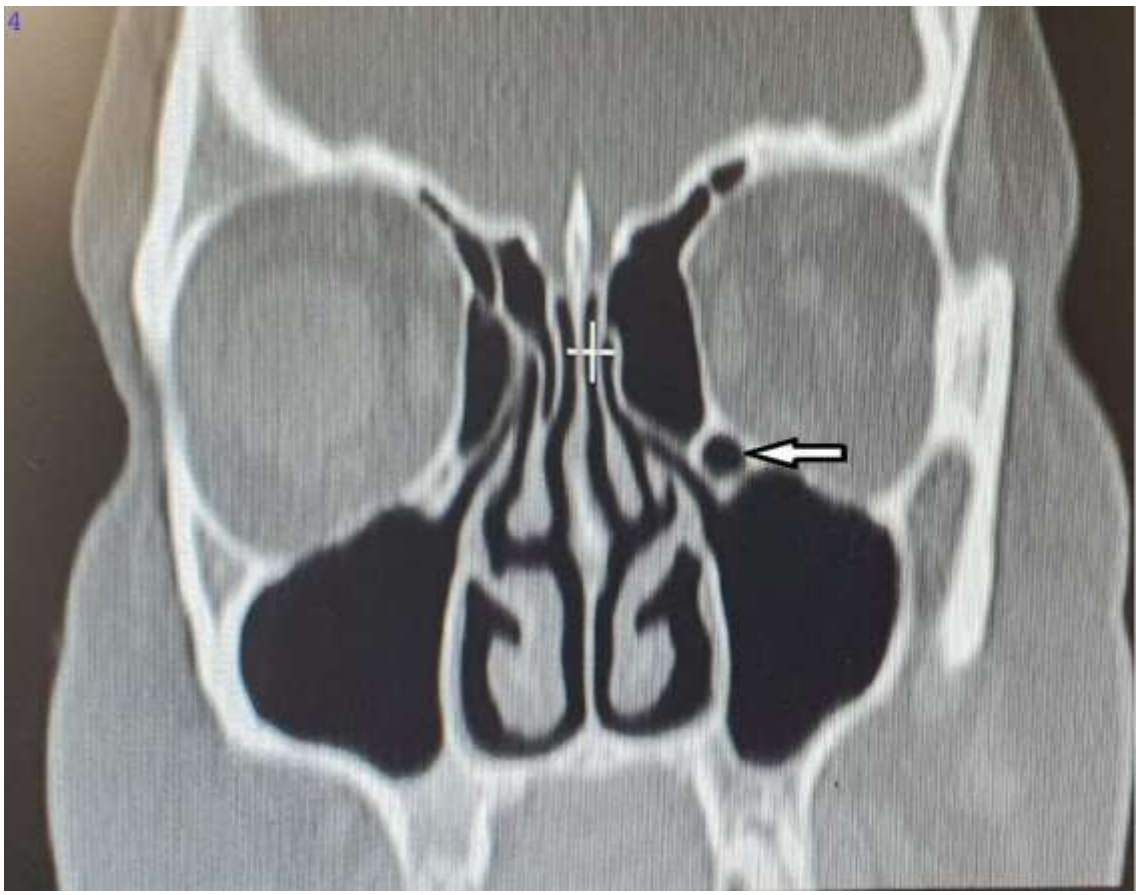

Figure 4. Coronal CT image of a patient showing left Haller cell (arrow)

DISCUSSION

There are limited number of studies that reveal the relationship between headache and anatomical variations. The current study is the first to suggest that agger nasi cells and Haller cells may be significant in headache etiology.

Septal Deviation and Septum-Lateral Nasal Wall Contact: Prior research has indicated a correlation between nasal septal deviation and rhinosinusitis (7,8). Also, the frequency of concha bullosa is found to be high in deviated nasal septum (8). The role of the deviated septum in the etiology of headaches has not been fully clarified. Septal deviation is found to be correlated with headaches in only a recent cohort study. Patients with septal deviation were found to have a higher risk of headache with a 1,37 adjusted hazard ratio and septoplasty was reported as the first-line treatment option (9).

The literature indicated a prevalence of septal deviation ranging from 40% to 96.9% (10). In 77,1% of patients with headaches and 65% of patients without headaches, the nasal septal deviation was discovered. Nevertheless, p=0.082 indicates that there was no statistically significant difference between the groups.

Stammberger and Wolf were the first ones who hypothesized contact point headaches. This suggests that when the septum comes into touch with the lateral nasal wall, substance P, a neurotransmitter, is released, which causes referred pain via unmyelinated C fibers (11). Surgical treatment of contact points resulted in symptom relief in most patients (12). Also, It has been shown that 85 percent of patients with headaches had pain relief after surgery (13). However, a systemic review including a wide range of studies concluded that most patients with contact points are asymptomatic and contact point has no effect on headaches (14). Also in another retrospective study, they found no correlation between mucosal contact points and headache (15). In the present study, contact of the septum to the lateral nasal wall is 1,95 times more frequent in the study group than it is in the control group ($p<0.041$). This result confirms the hypothesis of Stammberger and Wolf (11). The only deficiency of our study regarding this result may be that we evaluated the contact points according to CT and did not verify it with the endoscopic nasal examination.

Concha Bullosa: The presence of an air cell within the turbinate causes concha bullosa. The word "concha bullosa" is typically used to describe the middle turbinate's pneumatization. Concha bullosa of superior and inferior turbinates is rarely seen. It has three types 1- lamellar type involving vertical lamella 2-bulbous type involving the inferior part of concha 3-extensive type involving

both lamella and inferior part (16). The incidence varies between 14-53% (17).

Cantone E. et al investigated headache patients who had concha bullosa with mucosal contact points. They found improvement in headache symptom scores in patients after treatment for concha bullosa. The surgically treated group benefited more than the medically treated group (18). No correlation was found between concha bullosa and headache in this study. This result may be due to our inclusion criteria comprehending all types of concha bullosa, regardless of type, size, and contact point.

Paradoxical Middle Turbinate: Middle concha is generally laterally deviated, if it medially deviates it is called paradoxical middle concha. It is clinically important as it can narrow the osteomeatal complex and may cause rhinosinusitis (19). Its incidence varies between 3-26,1% (20). Incidence was 16,9% in patients with headache and 7,9% in patients with no headache. There are very few studies about paradoxical middle turbinate in headache etiology. Paradoxical middle turbinate deviation showed no association with headaches in our study.

Onodi Cell: The Onodi cell, which is located above the sphenoid sinus, is the most posterior ethmoid air cell. The presence of Onodi cells varies between 8-13%. There is no known direct correlation between headache and Onodi cells in the literature. In the current investigation, there was no association found between headache and Onodi cells.

Agger Nasi Cell: The most anterior ethmoid cell is the agger nasi cell. It is located anteriosuperior to the lateral nasal wall's middle turbinate insertion (11). In the literature, it shows a broad range of variability, from 2% to 100% (21). Ethnic differences may influence the incidence of variation.

In many studies, it has been reported that the agger nasi cell may expand posteriorly and narrow the frontal ostium and cause frontal sinusitis (22,23). In the study investigating the relationship between agger nasi cell size and frontal sinus ostium diameter, it was concluded that agger nasi cell size did not have a strong effect on frontal sinus ostium diameter (24). Comprehensive studies are needed to reveal the relationship between agger nasi cell and frontal sinusitis.

In the literature, the number of studies revealing the relationship between agger nasi cell and headache is limited. In a study comparing the anatomical variations of migraine patients with the control group, the incidence of agger nasi cells in the control group was higher than in the migraine group, so there was no correlation between migraine and agger nasi cell (20). In a recent study investigating anatomical variations that may cause rhinogenic headache; type 2, type 3 fronto ethmoidal cells and concha bullosa cell were found to be associated with headache. Agger nasi cell was not included in the anatomical variations evaluated (25). In the present study, the incidence of agger nasi was 76,1% in patients without symptoms and 95,7% in patients with a headache. There was a statistically significant correlation between agger nasi cells and headache and none of the patients had sinusitis. To our knowledge, this correlation is the first in the literature up to now. The possible mechanism may be due to limited unrecognized inflammatory mucosal diseases in the frontal recess or by completely a different physiopathology.

Haller Cell: Haller cells are ethmoidal cells that develop into the medial floor of the orbit. They mostly originate from anterior ethmoidal cells and rarely from posterior ethmoidal cells. They are of clinical importance as they can cause sinusitis by narrowing the infundibulum and ostium. Unlike other anatomical variations, it is difficult to diagnose Haller cells with endoscopic examination. The incidence rate of Haller cells varies between 2-51% in the literature (19). Haller cells were observed in 59(50%) of patients in the study group and 20(31,7%) of patients in the control group.

The presence of Haller cells was found to be statistically significantly higher in patients with headaches in the present study. The association of headache with Haller cells is poorly defined in the literature.

A previous study reported that Haller cell incidence was significantly high in migraine patients (20). Vanamaker also reported a case of a child with refractory headaches unresponsive to medical treatment. He had isolated opacification of Haller cell bilaterally and his headache dramatically improved after exenteration of Haller cell by bilateral functional endoscopic surgery (26). Haller cells may cause pressure on the infraorbital nerve, may cause sinusitis via the obstruction of the ostium, or may cause headache through contact with the infundibulum (27). Although the mechanism is not known Haller cell is the key anatomic variation in headache etiology with or without sinusitis. This study will guide future research exploring the significance of Haller cells in causing headaches.

Frontal Sinus Aplasia: Many people with frontal sinüs aplasia are asymptomatic. Frontal sinüs aplasia incidence has a wide range variety. This is explained by ethnic differences, gender, and environmental factors. Canadian Eskimos have unilateral frontal aplasia at 43%, while Germans have 3,4%. Females generally have higher incidences. Aydınoglu A. et al. found unilateral frontal cell aplasia in 3,8% of males, and in 5,9% of females in the Turkish population (28,29). Frontal sinüs aplasia incidence was 6,7% in the study and 12,7% in the control group. There was no association between frontal cell aplasia and headache.

There are limitations to our study. The first limitation is single ethnic subjects. Multi-ethnicity would provide less variable results. The study's second limitation is its single-center design, which could limit the generalizability of the findings to other settings.

CONCLUSION

These findings will contrubute to physicians in the evaluation and treatment of patients with headaches. Further comprehensive studies are needed to investigate the role of Haller cells and agger nasi cells in the etiology of headaches.

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