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Original Research

Computed Tomography Based Evaluation of the Anterior Group of the Paranasal Sinuses

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ABSTRACT

Objective: The study aims to ascertain the prevalence of paranasal sinus variations among healthy adults in the Turkish population, as well as to analyze the symmetry of these variations.

Methods: The CTIs of 200 adult patients who did not have any trauma, carcinoma, tumor, surgery, or a condition that could affect the paranasal anatomy, such as chronic rhinosinusitis, were included. The prevalences of the Agger nasi cell (ANC), supraorbital ethmoid cell (SOEC), Haller's cell (HC), middle turbinate pneumatization, and frontal sinus (FS) agenesis variations in the adult Turkish population were revealed.

Results: Bilateral SOECs were found 38.5% of 200 patients, and at least 53% of patients had SOECs on one side. In 21.5% of instances, LCs were observed on both sides; in 35% of instances, they were observed on at least one side. ANCs were observed bilaterally in 68.5% of the total, the rate of patients with ANC on at least one side was 84.5%. The rate of bilaterality of the HC was 24%, it was observed at least one side in 43% of the cases. Bilateral concha bullosa (CB) were observed in 19% while CB variation on at least one side was 42%. Bilateral absence of the FS was found to be 8.5%, and unilateral absence was 2.5%.

Conclusion: The most common paranasal sinus variation was ANC, while the least was FS agenesis. Bilateral inheritance was found to be most prevalent in SOEC. The findings of our study hold significance for interventional procedures involving the paranasal region.

Keywords: Paranasal sinuses; Anatomic variations; Paranasal sinus diseases; Conchae nasales; Frontal sinuses

INTRODUCTION

Paranasal sinuses are a highly variable group of air-filled cells surrounding the nasal cavity. Radiological evaluation of the structures is a prerequisite for defining the location and involvement in several paranasal maladies and pre-operational treatment planning, such as endonasal endoscopic sinus surgery [1]. This variability may cause clinical findings that affect the quality of life and require surgical intervention [2]. The ability to perform interventions in the paranasal region with fewer complications has been facilitated by advances in radiological imaging options and surgical techniques, as well as a greater comprehension of regional anatomy [3]. The variations and complex three-dimensional structure of thin bone plates close to one another can be quite challenging for novices lacking anatomical knowledge, as well as experts familiar with the highly variable anatomy of the paranasal region [4]. Many anatomical variations related to the paranasal sinuses have been reviewed before and besides posterior group sinonasal region anomalies (like sphenoidal sinus agenesis or sphenoethmoidal recess anomalies [5, 6] septum nasi deviations, frontal sinus agenesis, agger nasi cells (air cell located in the anterior part of the superior portion of the middle turbinate), concha bullosa (pneumatization of the middle turbinate), lamellar cells (aeration of the vertical lamella), Haller cells (aerial cell located in the inferior of the inferior orbital wall) and, supraorbital ethmoid cells (located in the superior part of orbital wall) are reported to be common variations [7] and genetics, environmental factors, age, gender and ethnicity are seen as the main determinants of these variations [8]. Although most of the variations with congenital features are coincidental, it is possible that the paranasal sinuses are affected or affect in a lesion involving the surrounding soft tissues [9]. Regional variations or anomalies should be studied in detail in order to investigate the effect of a disease involving the important soft tissues around the paranasal sinuses on the sinonasal region tissues [9, 10].

Studies in this area have mostly focused on the incidence of a certain variation or common clinical findings such as sinusitis [3-8]. Although these variations have been studied in studies conducted in Türkiye, the number of studies in which gender, age group and symmetry analysis has been done is very few [6, 10, 11].

Main Points;

- 38.5% of patients had bilateral supraorbital ethmoid cells (SOECs), and at least 53% had SOECs on one side.
- The most common paranasal sinus variation observed was agger nasi cell (ANC), while frontal sinus (FS) agenesis was the least common.
- Bilateral inheritance was most prevalent in supraorbital ethmoid cells (SOECs).
- 91.5% of the population had bilateral frontal sinuses, and 3.5% had frontal sinus agenesis on both sides.
- Lamellar cells (LCs) were present bilaterally in 21.5% and at least on one side in 33.5% of cases.
- Agger nasi cells (ANCs) were observed bilaterally in 68.5%, and at least one side had ANCs in 84.5% of cases.
- The findings have significance for interventional procedures involving the paranasal region and highlight the importance of radiological evaluation and pre-operational treatment planning.

The study aims to describe the anatomical formation of the paranasal sinus in individuals whose anterior sinonasal region is intact in the adult Turkish population and to reveal the frequency of these variations, age, gender, and symmetry analysis with retrospective assessment of CTI.

MATERIALS AND METHODS

This research involves human participants and ethical approve was taken from the Ethical Committee of Ege University under project number 20-7.1T/12.H.

Patients

Images obtained from two hundred patients who underwent CTI scans for various reasons (not paranasal sinus related) at University Hospital between June 2011 and January 2018 were evaluated retrospectively (mean age 46, range 18-70, 100 females, 100 males). The patients included in the study were not subjected to any trauma, carcinoma, tumor, surgery, or chronic rhinosinusitis that might alter paranasal sinus anatomy and under 18 years old. The patients were divided into two groups according to their age as Group-I (18-45 ages) and Group II (46-70 ages).

Imaging

Examinations were performed using CTI equipment (Discovery CT750 HD CT scanner). Paranasal CTI examinations were performed at 120-400 mA and 100kV, and CT slices 0.6 – 1.5 mm in thickness were obtained. Approximately 120-300 images per CTI were evaluated. In all cases, the imaging was performed using bone filter technique. It covered the entire paranasal sinuses within the sinonasal region, both axially, sagittally, and coronally. CT images were analyzed using Sectra IDS7 software, version 21.2.15.6346©2019. All evaluation was carried out; images were evaluated by three specialists (two anatomists (FY, IC) and one radiologist (OS) using PACS (picture archiving and communicating system).

Cases with disagreement were evaluated together with all observers and data entry was made by reaching a consensus.

Paranasal Sinuses

Frontal Sinus (FS): The frontal sinus is situated between the two laminae of the frontal bone, behind the superciliary arch. The two hourglass-shaped frontal sinuses are separated by a bone septum, rarely located in the anatomic midline [11] (Figure 1).

Agger nasi cell (ANC): The agger nasi cell is located in the anterior part of the superior portion of the middle turbinate. It is placed laterally below the frontal sinus, anterior to the middle turbinate on the coronal images [12]. Coronal and sagittal CTIs are most helpful in identifying the agger nasi [13] (Figure 2).

Supraorbital ethmoid cell (SOEC): Owen and Khun, in 1997 [14] (Figure 3) defined supraorbital ethmoid cells as pneumatization of the orbital plate of the frontal bone lateral to the most medial plane of the lamina papyracea.

Haller's cell (HC): The Haller's (or infraorbital) cells are an extension of ethmoid pneumatization to the orbital wall, located just beneath or inferolateral to the ethmoid bulla [15] (Figure 4).

Pneumatized Middle Turbinate: The middle turbinate attaches superiorly to the anterior skull base and posteriorly to the lamina papyracea. The posterior attachment called the basal or ground lamella and has an oblique course. This lamella is an important surgical landmark and marks the boundary between the anterior and posterior ethmoidal air cells [16]. Pneumatization of the inferior bulbous portion of the turbinate is called a concha bullosa (CB). If the pneumatization is above the level of the osteomeatal unit complex, it is called a lamellar cell (LC) or a conchal neck air cell [17] (Figures 1, 2, 3).

Statistical Analysis

Statistical analysis was performed using a dedicated software tool (SPSS 25.0 for Windows, IBM, USA). Variables were expressed as mean values, standard deviation, and range. A p-value of 0.05 was considered statistically significant, and two-sided tests were used. It was analyzed with the Brunner-Langer F2-LD-F1 model to determine whether the binary variables (existing or not) differed according to gender and age groups. Sub-analyses were performed for interacting parameters. The triple interaction between the variables, sides, genders, and age groups was evaluated using the Brunner-Langer F1-LD-F1 model using the non-parametric method, and F-statistic to obtain p-value and calculated <0.1 significant [18]. The Pearson chi-square test was used in the required sub-analysis, while the Mann-Whitney U test was utilized for other measurements. Between the binary variables, the agreement on the right and left sides was determined using the coefficients of understanding of "percent agreement, Cohen's, Conger's, and Gwet AC2 [18]. All coefficients are presented with 95% confidence intervals. Mainly due to the problems encountered with the Kappa coefficient, the Gwet AC1 coefficient, with more consistent and reliable results, was preferred. Still, Kappa and percent coefficients were also given to present more than one coefficient of agreement according to the published guide [19]. The interpretation was carried out by Gwet's probabilistic method according to the Landis and Koch scale [20]. Whether the classifications are symmetrical or not was tested with the coefficients of fit above and the exact McNemar Bowker test.

RESULTS

A total of two hundred patients met the inclusion criteria, aged between 18 and 75 (half of these were male and half were female) (Tables 1 and 2). The mean age of the patients was 46, and 49% of the patients were in Group I, and 51% were in Group II. Bilateral frontal sinuses were found 91.5% of the population, while 3.5% had frontal sinus agenesis on both sides. While 38.5% of 200 patients had bilateral SOEC, this variation was observed in 53% of the cases on at least one side (Figure 3). LCs were observed on both sides in 21.5% of the cases; they were present on at least one side in 33.5%. While ANCs were observed bilaterally in 68.5% of cases, the rate of patients with ANCs on at least one side was 84.5% (Figure 2). While the rate of bilateral HC was 24% in 200 cases, it was observed on at least one side in 43% of the cases. Bilateral concha bullosas (CBs) were observed in 19% of the cases, while CB variation on at least one side was 42%. When paranasal sinus variation on one side was detected in a patient, it was wondered if it was on the other side or vice versa. Thereby, the compatibility between the right and left sides of the patients was checked. While studying compatibility, previous studies were evaluated to obtain the optimal result by using many coefficients. Table 1 summarizes the comparison of paranasal sinus variations according to gender, age groups, and right and left sides.

Frontal sinuses were found in 189 (94.5%) on the right side and 187 (93.5%) on the left side, for a total of 376 (94%) (Table 2). The total number of absent FS was 13 (6.5%) on the right side, 11 (5.5%) on the left side, and, 24 (6.0%) in total. A slight difference between the two sides was not statistically significant (p = 0.524). There was also no statistically significant difference between genders (p = 0.989). According to age groups, sinus frontalis was present in 185 (94.4%) of the patients in Group I, and 191 (93.6%) patients in Group II. There was no statistically significant difference between Group I and Group II in terms of frequency (p = 0.803). Regardless of age and gender differences, the presence of FS was highly symmetrical (Table 2).

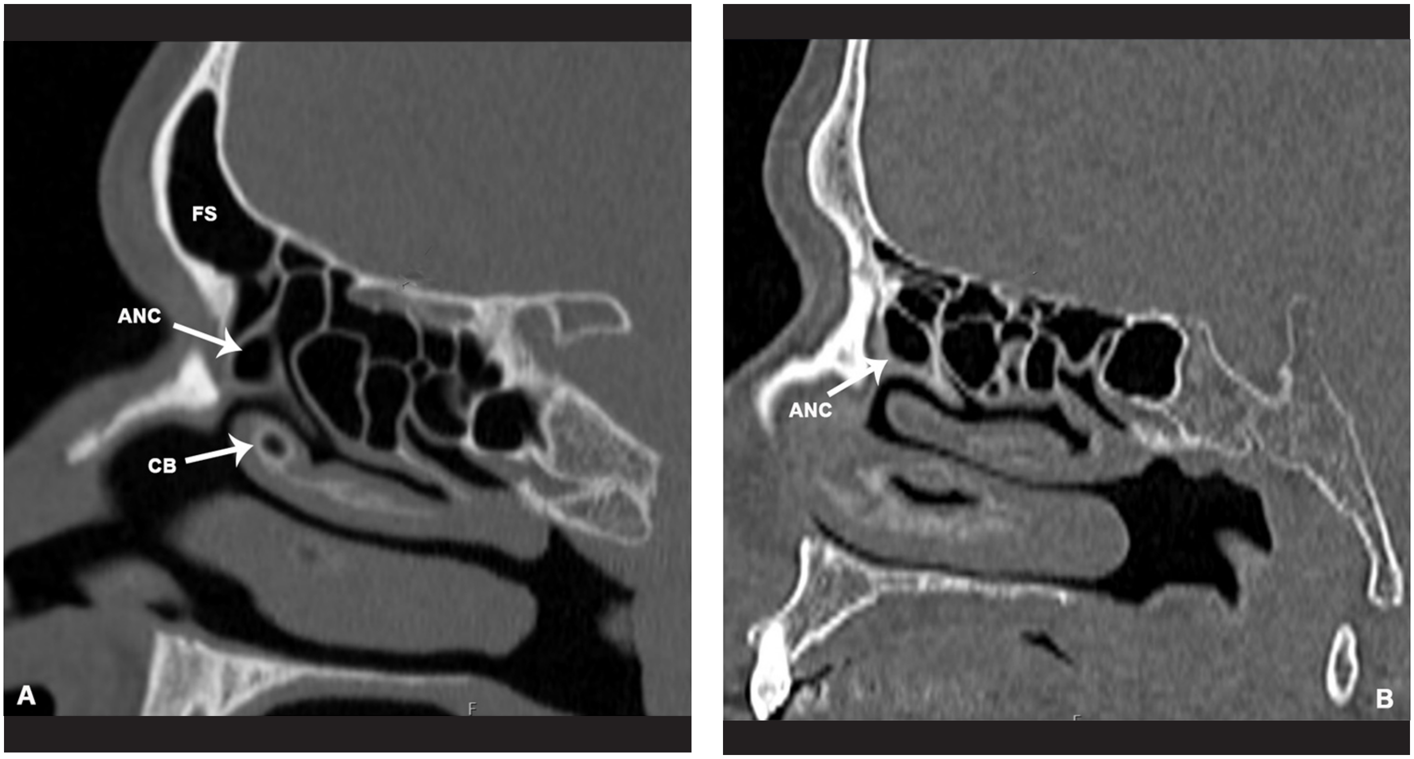

Figure 1. Sagittal cross section view of two different patients' paranasal sinus CTI.

A: Agger nasi cell (ANC), small-sized concha bullosa (CB), and frontal sinus (FS) can be seen.

B: Agger nasi cell (ANC) and frontal sinus agenesis (red asterisk). The attachment of uncinate process to the ANC is remarkable.

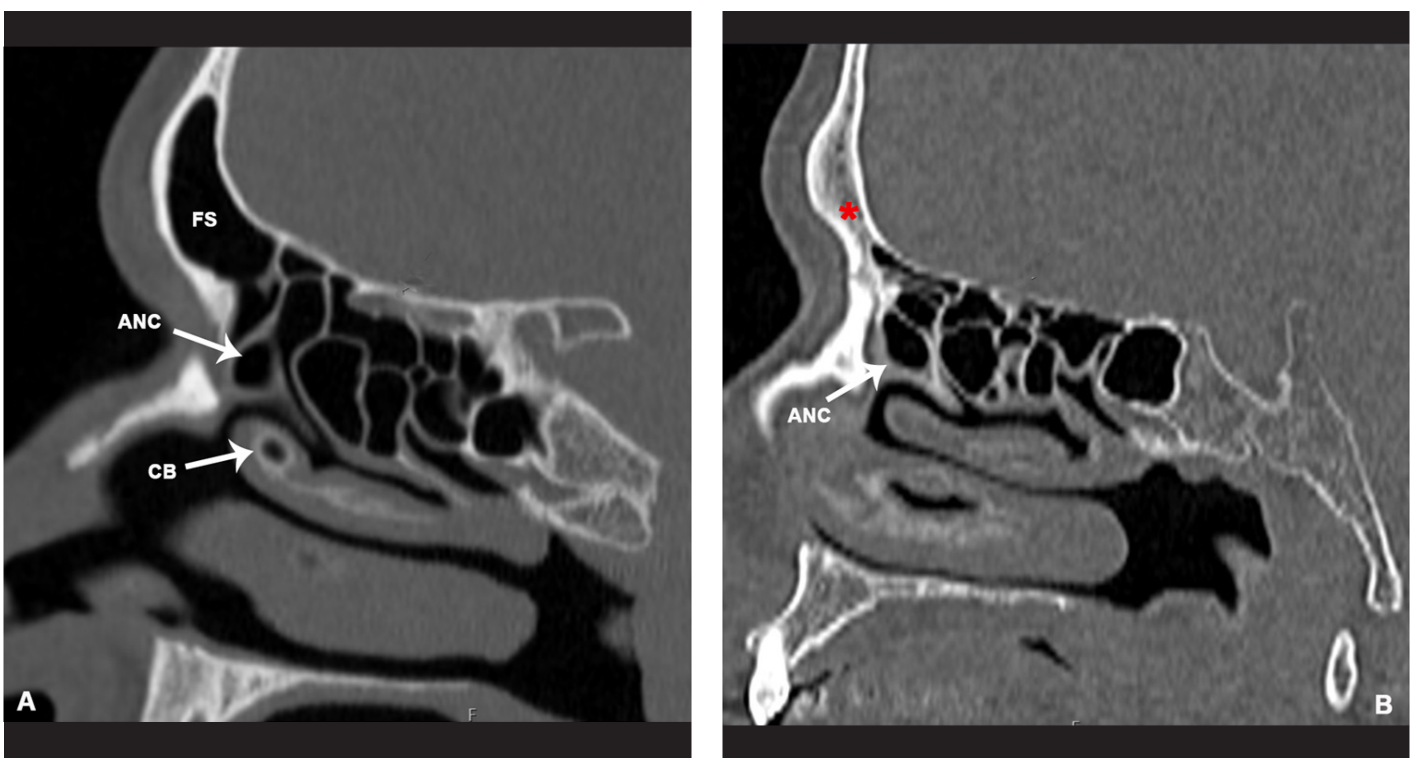

Figure 2. Sagittal (A) and coronal (B) section view of a paranasal sinus CTI. A large-sized concha bullosa (CB) and agger nasi cell (ANC) can be noticed.

SOECs were defined in 183 cases (45.8%). Eighty-five of these were on the right side (42.5%), and 98 were on the left side (49%). Approximately 42% of the total were females, and 49.5% were males. SOECs were found with a higher frequency on the left side (p = 0.017). Group I (43.9%) and Group II (47.5%) had no state differences. There was no statistical difference in terms of gender. Although the presence of SOECs has a high coefficient of agreement between the right and left sides of the same individual, the fact of significant symmetry cannot be claimed ($p < 0.05$) (Table 2).

A total of 306 ANC (76.5%) were identified, with an equal distribution of 50% on the right side and 50% on the left side. Among these 306 ANCs, 78.5% were female, and 74.5% of these were associated with ANC. The study observed a high level of symmetry agreement (89%) between the right and left sides in males. Group I consisted of 155 cases (79.1%), while Group II had 151 cases (74%). There were no significant differences in the presence of ANC based on age groups, sides, and genders ($p > 0.05$) as shown in Table 2. The presence of ANC was accompanied by strong symmetry (89%) between the right and left sides.

Haller's cells were found in 134 of 400 samples (33.5%). Sixty-eight (34%) of these cells were on the right, and 66 (33%) were on the left side. There were 71 HCs (35.5%) in the female group and 63 HCs (31.5%) in the male group. In age groups, there were 70 (35.7%) HCs in Group I and 64 (31.4%) HCs in Group II. There was no statistically significant difference when the presence of HCs was evaluated independently by side, gender, and age groups ($p > 0.05$). However, when the interaction of the groups with each other was examined, it was fewer (9.4%) on the left side in Group II, which was statistically significant (p = 0.089). The incidence of HC on the right side in Group II is 11.1%, which was higher in the female group. On the left side, there was no significant difference. This interaction between the variables was statistically significant (p = 0.046). Symmetry on the sides without HCs were found in 114 samples (86%). Contrastingly, HCs were present in 48 (71%) bilaterally, and the agreement between the two sides was high (p = 0.871) (Table 2).

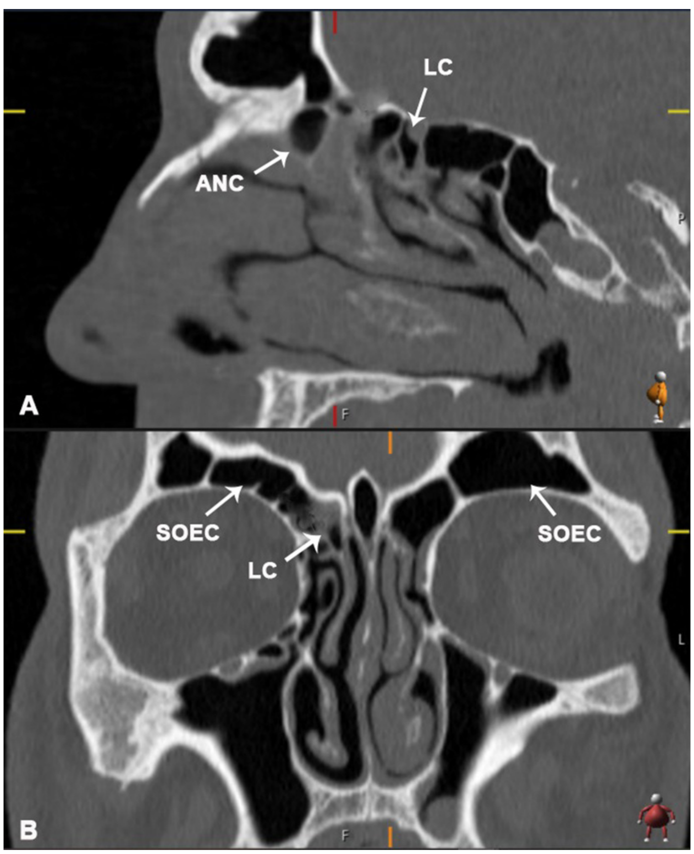

Figure 3. Sagittal (A) and coronal (B) section view of a paranasal sinus CTI. **A:** Lacrimal cell (LC) is apparent in superior attachment of middle nasal concha. **B:** Bilateral large size supraorbital ethmoid cells (SOEC) and lacrimal cell (LC) can be seen.

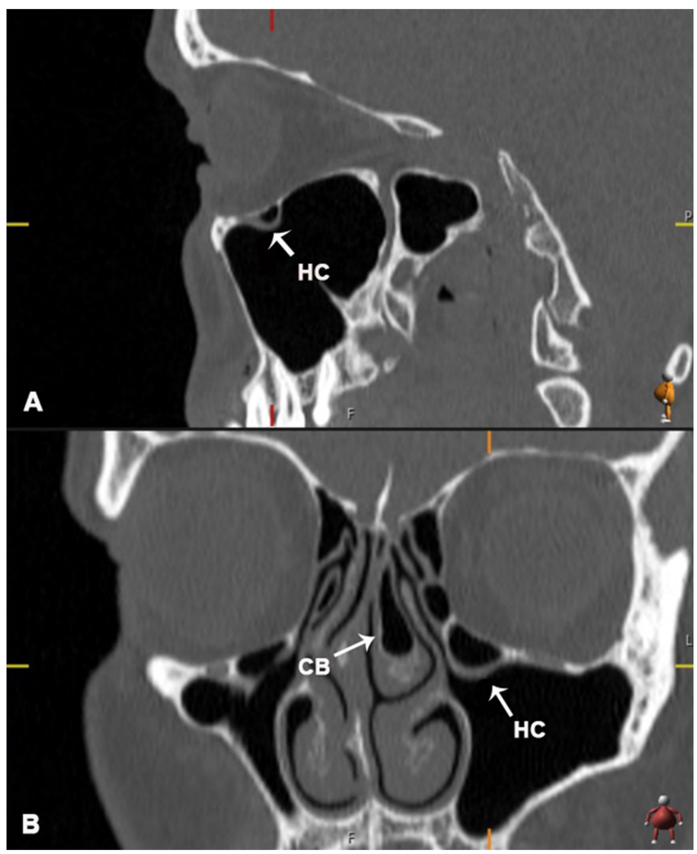

Figure 4. Sagittal (A) and coronal (B) section view of a paranasal sinus CTI. **A:** A white arrow indicates a Haller cell (HC) located at the inferior wall of the bony orbit on the left side. **B:** A well-developed concha bullosa (CB) can be seen medial to Haller cell.

Table 1. Comparison of data on paranasal sinus variations according to gender, age groups, right and left sides.

Paranasal sinuses	Gender		Age groups		Sides		Total
n (%)	Female	Male	18-45	46-70	Right	Left	
FS	188 (94.0)	188 (94.0)	185 (94.4)	191 (93.6)	189 (94.5)	187 (93.5)	376 (94.0)
SOEC	84 (42.0)	99 (49.5)	86 (43.9)	97 (47.5)	85 (42.5)*	98 (49.0)*	183 (45.8)
ANC	157 (78.5)	149 (74.5)	155 (79.1)	151 (74.0)	153 (76.5)	153 (76.5)	306 (76.5)
LCs	54 (27.0)	56 (28.0)	52 (26.5)	58 (28.5)	55 (27.5)	55 (27.5)	110 (27.5)
HCs	71 (35.5)	63 (31.5)	70 (35.7)	64 (31.4)	68 (34.0)	66 (33.0)	134 (33.5)
CB	67 (33.5)	55 (27.5)	61 (30.5)	61 (30.5)	62 (31.0)	60 (30.0)	122 (30.5)

*p<0,05. *FS: Frontal sinus, SOECs: Supraorbital ethmoidal cells, AN: Agger nasi cells, LCs: Lamellar cells, HCs: Haller's cells, CB: Concha bullosa.*

Table 2. Data on the bilaterality of the paranasal sinuses.

Paranasal sinuses, Right		Left		Compliance		Symmetry
		0	1	Coefficients*	Compliance Degree	P-value**
FS	0	7	*6*	0.950	0.8-1.0	0.754
	1	*4*	183	0.556	0.2-0.4	
				0.943	0.8-1.0	
SOEC	0	94	*21*	0.855	0.8-1.0	0.024***
	1	*8*	77	0.709	0.6-0.8	
				0.712	0.6-0.8	
LC	0	133	*12*	0.880	0.8-1.0	1,000
	1	*12*	43	0.699	0.6-0.8	
				0.800	0.6-0.8	
ANC	0	31	*16*	0.840	0.6-0.8	1.000
	1	*16*	137	0.555	0.4-0.6	
				0.750	0.6-0.8	
HC	0	114	*18*	0.810	0.6-0.8	0.871
	1	*20*	48	0.574	0.4-0.6	
				0.657	0.4-0.6	
CB	0	116	*22*	0.770	0.6-0.8	0.883
	1	*24*	38	0.458	0.2-0.4	
				0.601	0.4-0.6	

* From top to bottom are Percent Agreement, Cohen/Conger's Kappa, Gwet's AC, respectively.

Among 400 samples, 122 CB (30.5%) were identified. Of these, 55 (27.5%) were males, and 67 (33.5%) were females. 60 (30%) were on the left side, and 62 (31%) were on the right side. The numbers in the CB were equal between age groups. There was no statistically significant difference between gender, side, and age groups. 63% of CBs were bilateral, and the symmetry shown on the right and left sides was found to be statistically in moderate agreement (Table 2).

Lamellar cells were present in 110 samples (27.5%), found in equal numbers on the right and left sides. LCs were identified in 27% of female and 28% of male, and detected in 52 (26.5%) of 196 samples in Group I and 58 (28.5%) of 204 samples in Group II. There was no significant difference between gender, side, and age groups ($p > 0.005$). Symmetrical concordance of LCs, of which 78% were bilateral, was found to be statistically high (Table 2).

DISCUSSION

The sinonasal region is one of the more complex areas of the body, in which most anatomical variations are frequently seen. Most ANCs are anterior to the uncinate process. Still, the posterior half of the ANC has an intimate relationship with the upward extension of the uncinate process (Figure 1). They are frequently seen bilaterally and come into prominence clinically by narrowing the frontal recess opening and disrupting its drainage [21]. There is a relationship between chronic frontal rhinosinusitis, frontoethmoidal pain, and ANCs. Patients with agger nasi extension into the nasofrontal canal were reported to be twice as likely to require surgical treatment [7, 22] (Figure 1b). When patients undergoing revision functional endoscopic sinus surgery were evaluated with sinus CTI, a strong association was identified between variations due to ANCs and frontal sinus diseases [23]. The prevalence of the ANC variations has been reported to be between 7 and 98% [24]. The fact that quite different results could be obtained in studies conducted in similar ethnic communities also suggests the variability of the region. Tiwari and Goyal [25] evaluated chronic rhinosinusitis cases both with CTI and nasal endoscopy and found the prevalence to be 7%. In the study of Lien et al. [26] the prevalence was found to be 89 percent in the group of patients with paranasal sinus related disorders such as rhinosinusitis, anosmia, headache, nasal tumor, cerebrospinal fluid leak, and maxillofacial fractures. In a study conducted in Turkey [27] it was found that the most common paranasal region variation after septal deviation was ANC, and its prevalence was revealed to be 63.8%. In another CTI study conducted in Turkey [28], patients with septal deviation were examined, and the ANC was also found to have the most common variations (82%). In our study, the ANC was also found to be the most common variation, with 76% of the patient group without any disease affecting the paranasal sinus region (Table 1).

In 1942, Van Alyea described the SOEC as an ethmoid cell invading (most anteriorly) the supraorbital plate of the frontal bone [29] (Figure 3a). The frontal bone's orbital plate's air cells are known as SOECs, and a bony septum is the only thing that separates them from the frontal sinus. They are situated lateral to the lamina papyracea's most medial portion [30] (Figure 3b). The prevalence of SOECs has been reported in previous studies to range from 5.4 to 42.4% [13]. In the study of Zhang et al. [31], spiral CTIs of 202 patients were examined in sections passing through three planes; 22 SOECs were identified (5.4%), and it was stated that all SOECs arose from anterior ethmoidal cells. They also found significant correlation between frontal sinus septation and SOECs. Interestingly, Comer reported that the presence of SOEC is also associated with orbital proptosis in patients with chronic rhinosinusitis [32]. It is also seen that ethnic differences may be effective in the relationship between the presence of SOEC and frontal sinus septation [32, 33].

The unilateral or bilateral presence (symmetry) of SOEC is of clinical importance but there are few studies focusing on this point. Comer et al. [32] found the prevalence of the bilateral SOEC 12%. In their study, it was emphasized that the incidence of bilateral SOEC is higher in patients with proptosis and chronic rhinosinusitis. Elvan et al. [34], it was suggested that the presence of unilateral SOEC may be associated with migraine. In the current study, SOEC was found bilaterally in 72.6% of the patients. However, when we analyzed the cases statistically, it was understood that the probability of the presence of SOEC bilaterally in the same case was not significantly high (Table 2). The clinical importance of bilateral SOEC was emphasized in Comer's study and it was shown that proptosis and chronic rhinosinusitis were highly correlated with bilaterality. On the contrary, in Elvan's study, the presence of unilateral SOEC was shown to be associated with migraine [32].

A Swiss anatomist named Albert von Haller first described HCs in 1765 [35]. HCs, also called infraorbital cells, are air cells along the roof of the maxillary sinus, under the ethmoid bulla, and in the lowest part of the lamina papyracea, including the air cells in the ethmoid infundibulum (Figure 4). HCs have been implicated as a potential etiologic factor in recurrent maxillary sinusitis due to their negative influence on sinus ventilation. There are many studies in the literature emphasizing the relationship between HCs and various pathologies such as chronic rhinosinusitis, mucocele, and persistant headaches [7]. Studies using CTIs to identify HCs have higher detail in detecting variations than studies using panoramic radiographs because they provide a 3D examination of the region, and the prevalence appears to be higher in these cases. In 2018, Nedunchezhian et al. [36] found the prevalence of the HCs at 28.6% from panoramic radiographs of 600 patients from the Indian population. In a study conducted on 300 people with the same methodology, the prevalence of the HCs was found to be 10% in India; in another research conducted in 2021, it was figured out to be 22.1% [37]. On the contrary, HCs prevalence was found between 2.5% and 60% in the studies evaluated from CTIs of the patients [39]. HCs were found at 33.5% (134 out of 400) in the current study (Table 1).

Of these, 68 (34%) were on the right and 66 (33%) were on the left. We found that 43% of 200 patients had HCs; 24% of these were bilateral and 19% unilateral (Table 2). Chaudhari et al. [37] found the HCs' prevalence to be 10% (30 out of a total of 300 Indian adults); 14 of these (4.7%) were unilateral, and 16 of these (5.3%) were bilateral. In Wanamaker's [40] study, HCs were found bilaterally in 11% of the cases and unilaterally in 9%. In another study conducted by Ahmad et al., bilaterality of the HCs was found to be 18.5% and unilaterality was 19.7% [41]. In our study, HCs were found mostly bilateral, and the prevalence of cases with unilateral HCs was higher compared to the literature (Tables 1-2). This difference may be a specific situation of the population used in the study, or it may be due to differences in detail in radiological imaging or differences in the anatomical definition of HC [36].

The middle turbinate is an essential part of the ethmoidal labyrinth. Although it is reported to be a necessary landmark for endoscopic sinus surgery, it is controversial due to variations in size, shape, and symmetry [17]. Concha bullosa variations are often regarded as a variation rather than a pathological condition. Although the posterior ethmoidal cells are a rare origin of the pneumatization, CB's air is mainly derived from the anterior ethmoid cells. Basically, three CB groups are widely known, which are named by Bolger et al. as lamellar, bulbous, and extensive [42]. The lamellar type is the pneumatization of the vertical lamella, the bulbous type is the pneumatization of the bulbous part, and extensive CB is the pneumatization of both lamellar and bulbous segments [42]. In our study, we examined the lamellar type as LC and the other two types as CB. Since they are mostly asymptomatic and detected incidentally; the frequency of those is between 13-56% [34] and most of them are found bilaterally. Although a small pneumatization is not clinically significant, a large CB might be associated with a septal deviation that obstructs the drainage pathway of the antrum by distorting the uncinate process and narrowing the infundibulum, resulting in chronic sinusitis and headache [43]. Bolger [42] stated that the most common type was the lamellar type (46.6%), and the second most common was the extensive type (44%). In another study, the prevalence of lamellar cells was found to be 47%; one-third of them were unilateral (14.9%) and two-thirds (32.8%) were bilateral [44]. In our study, the prevalence of the LC was 27.5% and the CB was 30.5%. The prevalence of cases with bilateral CB was found to be 62.3%, which is less common than bilateral LC occurrence (78.2%) and this result is compatible with the results of the study conducted by Calvo-Henriquez. Bulbous and extensive types were identified as CB in the current study, in which 23% were unilateral and 19% bilateral, so the results of our study differ from those mentioned before [34].

The pneumatization process of frontal sinus cells (FSs) takes place primarily within the first four months of life. These cells become visible on radiological images around the seventh year of life, and their development reaches maturity at approximately 20 years of age [45]. The FSs develop from the posterior part of the frontal or suprabullar recess, and, each sinus develops separately; therefore, a remarkable asymmetry may occur between the left and right sinuses in the same person [15]. Variations in the frontal sinus cells are of clinical importance due to their close relationship with the frontal recess and ostium, which may restrict the frontal sinus outflow [46, 47]. They can be found unilaterally, bilaterally absent or completely agenesic [46]. Although the absence of frontal sinus has been reported in various syndromes (i.e. Micrcornea-glaucoma-absent frontal sinuses syndrome), it has been reported that the frequency of these cases may vary with ethnicity and gender [46]. In addition, some researchers suggest that mechanical stress caused by chewing, local inflammations, and geographical conditions may affect frontal sinus development [48]. The prevalence of absent frontal sinus in the Turkish population was found 0.78-6.4 [11]. In the current study, bilateral absence of the FS was found to be 8.5%, and unilateral absence was 2.5%. In the study of Çakır et al. [11] in which they examined 410 patients in Turkey, the prevalence of bilateral frontal sinus agenesis was 0.73%; unilateral frontal sinus agenesis was 1.22%. In the study of Danesh-Sani et al. [46] in Iran, 565 adults were examined, and the prevalence of bilateral FS agenesis was 8.32% and the prevalence of unilateral agenesis was 5.66%. In a study conducted in China, 196 patients were evaluated, and it was observed that the FSs were absent on one side in 12.9% [33] (Figures 1, 3, 4).

Retrospective design of the study was the major limitation. Patients defined as healthy adults that apply to the clinic with a specific complaint and an undiagnosed pathology may have been affected by the anatomy of the sinonasal region. However, this limitation was minimized by excluding people with a medical history and new diagnoses of diseases that may affect the anatomy of the paranasal sinus. At last, other rare variations due to the study design were not discussed. The results of our study should be supported by prospective studies in healthy population. Examining the relationships of cases with variation with clinical findings that change with age and gender will be important in guiding clinical interventions.

In conclusion, paranasal sinus variations and bilateral-unilateral presence patterns in healthy adult Turkish population were investigated in our study. The most common paranasal sinus variation was ANC. SOEC was the second most common and followed by the HC and LC. The rarest variation was frontal sinus agenesis. The variation with the highest prevalence of bilateral is SOEC. In addition, the bilateral incidence of LC is higher than the others. The results of our study differ from the literature, as the prevalence of HC is found to be close to the prevalence of bilateral occurrence. Considering the results of our study during preoperative image evaluation in paranasal region surgery is important in terms of reducing complications and increasing the success of the procedure.

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