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Original Article

Evaluation of Paranasal Anatomical Variations with Multidetector CT in Turkish Population

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Abstract

Aim: The aim of our study was to determine the prevalence of the paranasal sinus (PNS) variations/aspects of healthy population in Turkey with multidetector computed tomography and to evaluate the relationship of these variations/aspects with each other and difference according to gender and side.

Materials and methods: Twenty-four different PNS variations/aspects of 234 healthy patients and a total of 468 bilateral sides were evaluated. Patients were compared with Pearson's chi-squared test (χ^2) according to gender and side. Also, all variations were compared with each other in the same way, and correlated variations were found ($p<0.05$ was considered significant).

Results: The prevalence of prominent aspects of PNS are as following: tuberculum septi nasi anterior (TSNA) in 93.6%, ethmoid bulla (EB) in 72.65%, nasal deviation (ND) in 65.4%, agger nasi cell (AG) in 63.25% of the patients. There was no statistically significant difference in terms of gender and between right and left sides. *P*-values of correlated variations/aspects were: EB/uncinate process type (UPT) 2: 0.001; ND/concha bullosa (CB): 0.03; AG/Onodi cell (OC): 0.04; uncinate process deviation (UPD)/maxillary hypoplasia (MH): 0.04.

Conclusions: The most common aspects were TSNA, EB, ND, and AG. The percentages of these anatomical structures mentioned above are far too high to be classified as a variation. They can be described as basic anatomical structures or dominant aspects. There was no difference in the incidence of variations according to gender or side, but significant correlations were found between EB and UPT 2, between ND and CB, between AG and OC, and between MH and UPD.

Keywords

anatomic variations, computed tomography, maxillofacial, paranasal sinus

INTRODUCTION

Paranasal sinuses (PNS) are one of the regions in the body where the variations are most frequent. It is important to know the patient's variations/aspects before functional endoscopic sinus surgery.[1] Radiology is an auxiliary method in the evaluation of the PNS region. The patients are evaluated with radiological methods before and after the operation. In practice, X-ray radiography, such as Water's sinus and Caldwell radiography, is used for simple evaluation, sonography for superficial evaluation, contrast-enhanced computed tomography (CT), and magnetic resonance imaging (MRI) for the masses and malignancies. However, the preferred radiological method in the diagnosis of PNS' variations/aspects and diseases remains non-contrast PNS CT. Coronal plane has been defined as a more effective method in CT evaluation.[2,3] Although there are many articles on this subject that draw anatomic maps of each country, only some of the variations/aspects are included in these studies. To the best of our knowledge,

there is no study in the literature that includes almost all of the variations and compares them with one another.

AIM

The aim of this study was to determine the prevalence of the paranasal sinus (PNS) variations/aspects of the healthy population with multidetector CT (MDCT) in Turkey and to evaluate the relationship of these variations/aspects with each other and difference according to gender and side.

MATERIALS AND METHODS

First of all, ethic approval was obtained from the local university's Human Research Ethics Committee (Muğla Sitki Koçman University) with the document number 200026-2020. Power analysis was performed with G-power test. The sample group was between 141 and 172 for 80% power and 0.05 alfa parameter. The PNS MDCT scans of 288 patients were evaluated in bone and soft tissue windows. We excluded 54 patients from the study for the following medical reasons: polyposis, sinusitis, a history of facial trauma, malignity, or operation. 234 patients (mean age ± standard deviation: 36.6±14 years; age range was 18 to 83 years; 115 males and 119 females) were included in the study. PNS CT images were performed in a 256-slice multi-detector CT scanner (Somatom, Siemens Healthcare, Erlangen, Germany). The CT protocol was applied: Patient position – prone, the head in extension, slice thickness – coronal 1.5 mm, axial 1 mm, position – 90 degree perpendicular to the infraorbital meatal line, dose parameters – 100 KVp 40 MAs, window width (WW) – 2000-2400, window length (WL) – 400-450.

Bilaterally, 468 sides were evaluated. The 24 different variations/aspects were taken into account. The subjects were selected from the MDCT images obtained between March 2018 and June 2020. The images were assessed over the picture archiving and communication system (PACS).

All of the images were assessed by the two authors who have a long-term experience in head and neck radiology. The double-blinding method was used. Each radiologist evaluated CTs on the coronal, axial, and sagittal planes independently. In case of contradictory results, the images were evaluated by both radiologists together. The data were entered in Microsoft Office Excel file (Excel 2010, Microsoft). Statistical software (SPSS, version 22.0, IBM) was used for analysis. Continuous variables were expressed as mean ± SD (standard deviation) values. Qualitative variables were expressed as counts and percentages. All of the data were statistically compared according to gender and side. Finally, the PNS variations were compared cross-match to evaluate the correlation. Pearson's chi-squared test were used for comparison. $P<0.05$ values were considered statistically significant.

RESULTS

Findings

Nasal deviation (ND) was found in 65.4% (153/234) of the patients. It was deviated towards the right in 29.9% (70/234), towards the left in 35.5% (83/234) of the patients. The remaining 34.9% (81/234) were neutral.

Concha bullosa (CB) was found in 23.1% of the patients. It was seen on the right side in 7.7% (18/234), on the left side in 9% (21/234), bilaterally in 6.4% (15/234) of the patients. The remaining 76.9% (180/234) were normal.

Paradoxical middle turbinate (PMT) was found in 24.8% (58/234) of the patients. It was seen on the right side in 4.7% (11/234), on the left side in 4.7% (11/234), bilaterally in 15.4% (36/234) of the patients. The remaining 75.2% (176/234) were normal.

Superior turbinate pneumatization (STP) was found in 31.2% (73/234) of patients. It was seen on the right side in 10.7% (25/234), on the left side in 8.55% (20/234), bilaterally in 11.95% (28/234) of the patients. The remaining 68.8% (161/234) were normal.

Superior concha agenesis (SCA) was found in 6.8% (16/234) of the patients. It was seen on the right side in 1.7% (4/234), on the left side in 2.55% (6/234), bilaterally in 2.55% (6/234) of the patients. The remaining in 93.2% (218/234) were normal.

Suprema nasal concha (SNC) was observed in 9.4% (22/234) of the patients. It was seen on the right side in 3% (7/234), on the left side in 2.55% (6/234), bilaterally in 3.85% (9/234) of the patients. The remaining 90.6% (212/234) were normal.

Uncinate process pneumatization (UPP) was found in 7.8% (19/234) of patients. It was seen on the right side in 3.85% (9/234), on the left side in 2.55% (6/234), and bilaterally in 1.4% (4/234) of the patients. The remaining 91.9% (215/234) were normal

Uncinate process deviations (UPD) were found medialized in 9.55% (23/234), lateralized in 8.25% (20.234) of the patients.

Among medialized deviations, it was seen on the right side in 4.3% (10/234), on the left side in 3.85% (9/234) of the patients.

Among lateralized deviations, it was seen on the right side in 4.3% (10/234), on the left side in 2.55% (6/234); bilaterally, on the right side in 1.4% (4/234), on the left side in 1.4% (4/234) of the patients. The remaining 81.6% (191/234) were normal.

Uncinate process types (UPT) were found as type 1 in 20.9% (49/468), as type 2 in 28.2% (132/468), as type 3 in 6.8% (32/468), as type 4 in 19.4% (91/468), as type 5 in 21.4% (100/468), and as type 6 in 13.8% (64/468) of the patients.

Ethmoid bulla (EB) was observed in 72.65% (170/234) of patients; it was seen on the right side in 2.15% (5/234), on the left side in 3% (7/234), and bilaterally in 67.5% (158/234) of the patient. The remaining 27.35% (64/234) were normal.

Maxillary hypoplasia (MH) was found in 3.85% (9/234) of the patients. It was seen on the right side in 2.15% (5/234), on the left side in 0.4% (1/234), bilaterally in 1.3% (3/234) of the patients. The remaining 96.15% (225/234) were normal.

Haller cell (HC) was found in 29.9% (70/234) of the patient. It was seen on the right side in 6.4% (15/234), on the left side in 12.8% (30/234), and bilaterally in 10.7% (25/234) of the patients. The remaining 70.1% (164/234) were normal.

Accessory maxillary ostia (AMO) was found in 37.6% (88/234) of the patients. It was seen on the right side in 11.5% (27/234), on the left side in 7.7% (18/234), and bilaterally in 18.4% (43/234) of the patients. The remaining 62.4% (146/234) were normal.

Maxillary septa (MS) was found in 26.5% (62/234) of the patients. It was seen on the right side in 4.3% (10/234), on the left side in 5.55% (13/234), and bilaterally in 16.65% (39/234) of the patients. The remaining 73.5% (172/234) were normal.

Tuberculum septi nasi anterior (TSNA) was found in 93.6% (219/234) of the patients. It was seen on the right side in 6.4% (20/234), on the left side in 8.55% (21/234), bilaterally in 9% (178/234) of the patients. The remaining 76.05% (15/234) were normal.

Crista galli pneumatization (CGP) was found in 4.3% (10/234) of the patients. The remaining 95.7% (224/234) were normal.

Fovea ethmoidalis (FE). Based on the Keros classification, FE was observed bilaterally to be type I (FEK1) in 36.8% (172/468), type II (FEK2) in 59% (276/468), type III (FEK3) in only 4.2% (20/468) of the patients.

Frontal hypoplasia (FH) was found in 10.7% (25/234) of the patients, of which 1.3% (3/234) were on the right side and 9.4% (22/234) on the left side. No bilateral FH was found. The remaining 89.3% (209/234) were normal.

Agger nasi cell (AG) was found in 63.25% (148/234) of patients. It was seen on the right side in 14.5% (34/234), on the left side in 7.3% (17/234), bilaterally in 41.45% (97/234) of the patients. The remaining 36.75% (86/234) were normal.

Khun cells (KH) was found in 40.6% (95/234) of the patients. Kuhn cells were observed to be type 1 (KHT1) in 63.15% (60/95), type II (KHT2) in 9.5% (9/95), type III (KHT3) in 26.3% (25/95), and type IV (KHT4) in 1.05% (1/95) of the patients.

Supraorbital cells (SOC) were found in 37.2% (87/234) of the patients. It was seen on the right side in 6% (14/234), on the left side in 17.1% (40/234), bilaterally in 14.1% (33/234) of the patients. The remaining 62.8% (147/234) were normal.

Sphenoid sinus was presellar (SSPrc) in 24.35% (57/234), sellar (SSSel) in 73.5% (172/234), postsellar (SSPtc) in only 2.15% (5/234) of the patients.

Clinoid pneumatization (CP) was found in 31.6% (74/234). It was seen on the right side in 6.8% (16/234), on the left side in 11.25% (27/234), and bilaterally in 13.55% (31/234) of the patients. The remaining 68.4% (160/234) were normal.

Pterygoid plate pneumatization (PPP) was found in 59.8% (140/234) of the patients. It was seen on the right side in 11.1% (26/234), on the left side in 15.4% (36/234), and bilaterally in 33.3% (78/234) of the patients. The remaining 40.2% (94/234) were normal.

Onodi cell (OC) was found in 30.8% (72/234) of the patients. The remaining 69.2% (162/234) were normal **(Table 1)**.

DISCUSSION

PNSs are a group of four pairs of air-filled cavities named according to the bone in which they are located. They perform varying functions including lightening the weight of the head, contributing to the respiratory dynamics, and preventing the damage to vital organs in trauma. They also moisturize the air and help the sound resonance.[4] Interpreting and reporting PNS variations as well as detecting pathologies are some of the duties of the radiologist who evaluate the PNS CT. Knowing anatomical variations/aspects correctly before an operation, especially the functional endoscopic sinus surgery, helps to avoid possible complications. For example, in the case of the presence of UPs adhered to the ethmoid roof, the roof can be damaged because it is strongly pulled in the surgery.[5,6] MS poses a risk for Schneiderian membrane injury.[7] Knowing the relationship between the SOC and the anterior ethmoid artery prevents vascular damage.[8] These examples can be listed in this way by pages.

MDCT allows a highly detailed evaluation of the variations in PNS. It has technical advantages such as rapidly collecting data making simultaneous improvements in spatial resolution and volume coverage.[9]

Based on the results of our study, the most common PNS aspects in the Turkish population are TSNA (93.6%), EB (72.65%), ND (65.4%), AG (63.25 %), and PPP (59.8%). Given the frequency of these entities, the calculated percentages are quite high to constitute a variation. Terminologically, it can be erroneous to describe them as a variation. Indeed, they are the dominant aspects of paranasal anatomy.

TSNA, also known as the swelling body or the septal turbinate, is a structure that is often overlooked, less known and in need of more research. Although it is generally classified as a variation, this structure is thought to be a chemoreceptor organ with different functions. As proof, its participation in nasal cycles has been demonstrated. Its high incidence suggests that it is a basic anatomical structure rather than a variation.[10,11]

EB was the second most common aspect in the Turkish population. It is important because of the location in the middle of the lateral part during embryological development. EB affects and is affected by peripheral structures. Excessive bullous EBs can lead to narrowed sinus recesses and canals since their location is the key point of the hiatus semilunaris.[12]

NDs were placed in third place among the common PNS aspects. In studies, ND rates have been reported in quite different values. This situation is probably related to the definition criteria of the ND. Some studies don't accept angulations up to 2 mm from the midline as ND.[13,14]

Table 1. Summary of study findings

Variations and common findings	Type	Number	Percentage	*P* value (gender)	*P* value (side)
Nasal deviation	Neutral	81	34.9%	0.52	-
	Right	70	29.9%		
	Left	83	35.5%		
Concha bullosa	Non	180	76.9%	0.73	0.62
	Right	18	7.7%		
	Left	21	9%		
	Bilateral	15	6.4%		
Paradoxical middle turbinate	Non	176	75.2%	0.64	0.27
	Right	11	4.7%		
	Left	11	4.7%		
	Bilateral	36	15.4%		
Superior turbinate pneumatization	Non	161	68.8%	0.14	0.44
	Right	25	10.7%		
	Left	20	8.55%		
	Bilateral	28	11.95%		
Superior concha agenesis	Non	218	93.2%	0.36	0.31
	Right	4	1.7%		
	Left	6	2.55%		
	Bilateral	6	2.55%		
Suprema nasal concha	Non	212	90.6%	0.32	0.19
	Right	7	3%		
	Left	6	2.55%		
	Bilateral	9	3.85%		
Uncinate process pneumatization	Non	215	91.9%	0.81	0.42
	Right	9	3.85%		
	Left	6	2.55%		
	Bilateral	4	1.4%		
Uncinate process deviations	Non	191	81.6%	0.24	-
	Right medialized	10	4.3%		
	Right lateralized	10	4.3%		
	Left medialized	9	3.85%		
	Left lateralized	6	2.55%		
	Bilateral medialized	4	1.4%		
	Bilateral lateralized	4	1.4%		
Uncinate process types	Type 1	49	20.9%	0.32	-
	Type 2	132	28.2%		
	Type 3	32	6.8%		
	Type 4	91	19.4%		
	Type 5	100	21.4%		
	Type 6	64	13.8%		
Ethmoid bulla	Non	64	27.35%	0.19	0.53
	Right	5	2.15%		
	Left	7	3%		
	Bilateral	158	67.5%		
Maxillary hypoplasia	Non	225	96.15%	0.24	0.48
	Right	5	2.15%		
	Left	1	0.4%		
	Bilateral	3	1.3%		

Haller cell	Non	164	70.1%	0.44	0.22
	Right	15	6.4%		
	Left	30	12.8%		
	Bilateral	25	10.7%		
Accessory maxillary ostia	Non	146	62.4%	0.48	0.19
	Right	27	11.5%		
	Left	18	7.7%		
	Bilateral	43	18.4%		
Maxillary septa	Non	172	73.5%	0.67	0.52
	Right	10	4.3%		
	Left	13	5.55%		
	Bilateral	39	16.65%		
Tuberculum septi nasi anterior	Non	15	6.4%	0.21	0.89
	Right	20	8.55%		
	Left	21	9%		
	Bilateral	178	76.05%		
Crista galli pneumatization	Non	224	95.7%	0.46	0.43
	Yes	10	4.3%		
Fovea ethmoidalis	Keros 1	172	36.8%	0.57	-
	Keros 2	276	59%		
	Keros 3	20	4.2%		
Frontal hypoplasia	Non	209	89.3%	0.39	0.29
	Right	3	1.3%		
	Left	22	9.4%		
	Bilateral	0	0%		
Agger nasi cell	Non	86	36.75%	0.67	0.43
	Right	34	14.5%		
	Left	17	7.3%		
	Bilateral	97	41.45%		
Khun cells	Type I	139	62.8%	0.24	-
	Type II	22	9.4%		
	Type III	71	30.35%		
	Type IV	2	0.85%		
Supraorbital cells	Non	147	62.8%	0.67	0.55
	Right	14	6%		
	Left	40	17.1%		
	Bilateral	33	14.1%		
Sphenoid types	Sellar	57	24.35%	0.49	-
	Presellar	172	73.5%		
	Postsellar	5	2.15%		
Clinoid pneumatization	Non	160	68.4%	0.57	0.21
	Right	16	6.8%		
	Left	27	11.55%		
	Bilateral	31	13.25%		
Pterygoid plate pneumatization	Non	94	40.2%	0.27	0.53
	Right	26	11.1%		
	Left	36	15.4%		
	Bilateral	78	33.3%		
Onodi cell	Non	162	69.2%	0.73	0.42
	Yes	72	30.8%		

The variations were compared to one another. Statistically significant P values were as follow: EB/UPT2: 0.001[a], ND/CB: 0.03[a], AG/OC: 0.04[a], UPD/MH: 0.04[a]. There was no statistically significant relationship between other variations/aspects.

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The AG was another common aspect in the Turkish population. AGs are the most anterior located ethmoid cells. They are clinically important because it can lead to ethmoid sinusitis by narrowing the frontal recess. Also, it is essential to know this anatomical structure in the interventions because incomplete removal of AG can cause an iatrogenic disease.[15]

The differences of PNS variations/aspects according to gender and side were evaluated. There was no statistical difference.

The association of all variations/aspects with each other was also evaluated. There was a statistically significant association between EB and type 2 UP **(Fig. 1)**, between ND and CB **(Fig. 2)**, between AG and OC **(Fig. 3)**, as well as between MH and UPD **(Fig. 4)**. There was no relationship between other variations.

There is a strong relationship between EB and type 2 UP, but in fact, this is only an incident originating from technique. According to the Stamberg staging, type 2 UP variant is the adhesion of UP to a cell adhering to the orbit. This cell is most of the time the EB.[16]

The relation of ND with CB is known. The result of our article is in this direction. If concha hypertrophy is added to CB and ND, it aggravates the clinical picture by narrowing the nasal passage.[17]

According to the results of our study, there was a correla-

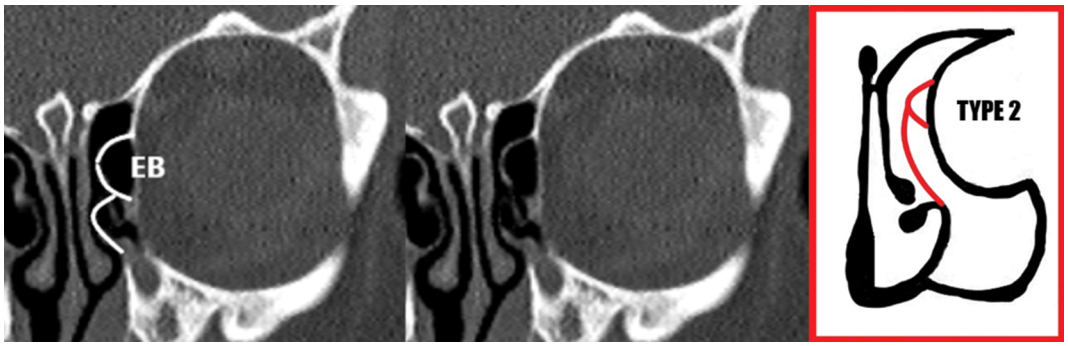

Figure 1. When UP is attached to the cell, it is classified as type 2 according to Stamberg classification. Coronal CT image showed the relationship between EB and UP.

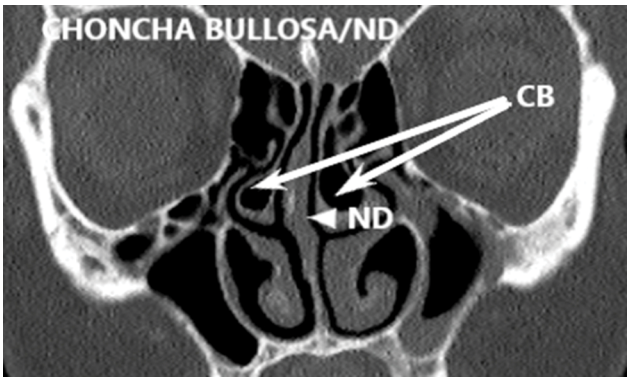

Figure 2. Association between ND and CB was shown in coronal MDCT image.

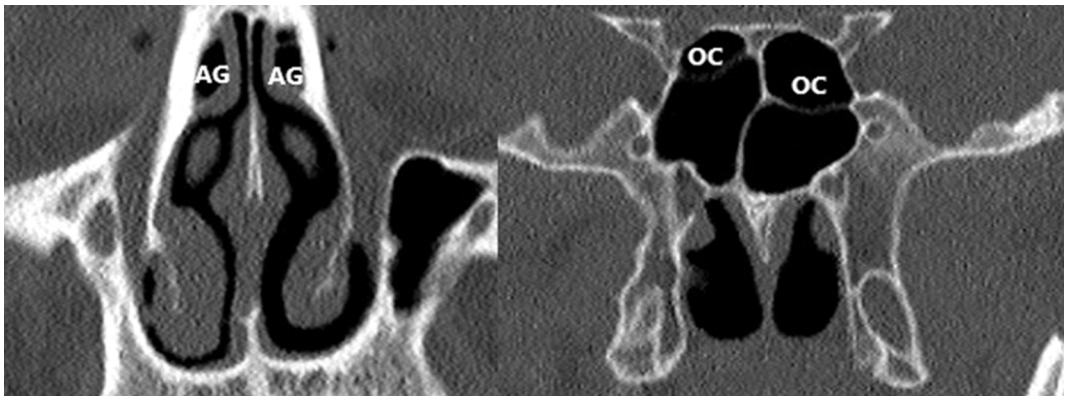

Figure 3. A statistically significant correlation between AG and OC was found. These two variations were shown in coronal MDCT images.

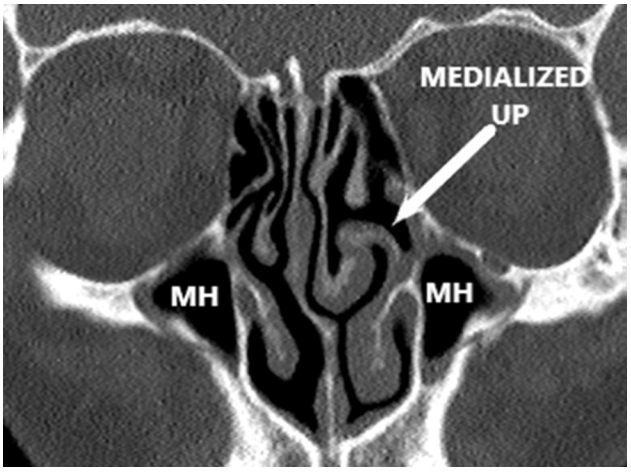

Figure 4. Absence of uncinate process or deviations of UP frequently accompanies MH. The relationship between these two variations was shown in coronal MDCT images.

tion between the AG and OC. AGs are the most anteriorly located ethmoidal cells while OCs are the most posterior. It is very important for surgery since the OC is associated with the free optic nerve.[18,19] This correlation is probably related to the embryological process in the development period of ethmoidal cells. The ethmoid bone develops from the olfactory capsule or paleosinus and extends to anterior and posterior with the epithelial extension.[20] This embryological process of ethmoid cells is reflected in our statistics in this way.

MH is classified according to the Bolger classification. In this classification, uncinate pathologies are ranging up to the absence of UP accompanying the MH. If UP is present in the MH, the most common variation in this case is UP deviation.[21]

CONCLUSIONS

Evaluation of variations/aspects is an important part of PNS' CT routine. The most common aspects in the Turkish population are TSNA, EB, ND and AG. Although TSNA or swelling body is generally classified among variations, it is actually a chemoreceptor organ. Recent research on its functions has sparked interest. EB is located in the central of the osteomeatal complex and this location affects directly the drainage of sinuses. Since ND operations are one of the most common surgeries in ENT routine, it is important to visualize this entity well. AGs are the most anterior located ethmoid cells. When AG is prominent, it can lead to sinusitis by narrowing the recess of the frontal sinus.

In fact, the percentages of these anatomical structures mentioned above are quite high for terminologically calling them a variation. They can be described as basic anatomical structures or dominant aspects.

There is no difference in the incidence of variations/aspects according to genders or sides. Given our results, there is a statistically significant relationship between EB and type 2 UP, ND and CB, AG and OC, MH and UPD.

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Оценка параназальных анатомических вариаций с помощью мультидетекторной КТ у населения Турции

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Резюме

Цель: Целью нашего исследования было определить распространённость вариаций/аспектов параназальных сиусов (ПНС) у здорового населения Турции с помощью мультидетекторной компьютерной томографии и оценить взаимосвязь этих вариаций/аспектов друг с другом и различия в зависимости от пола и стороны.

Материалы и методы: Были оценены 24 различных варианта/аспекта ПНС у 234 здоровых пациентов и в общей сложности 468 билатеральных сторон. Пациентов сравнивали с помощью критерия хи-квадрат Пирсона ($\chi 2$) в зависимости от пола и стороны. Кроме того, все вариации сравнивались друг с другом таким же образом, и были обнаружены коррелирующие вариации (значимым считалось $p<0.05$).

Результаты: Распространённость выраженных аспектов ПНС следующая: передний бугорок перегородки носа (tuberculum septi nasi anterior (TSNA) у 93.6%, решетчатая булла (РБ) у 72.65%, назальная девияция (НД) у 65.4%, клетка „аггер нази“ (АН) у 63.25 % больных. Статистически значимых различий по полу и между правыми и левыми сторонами не было. Значения *P* коррелированных вариаций/аспектов были следующими: РБ/тип крючковидного отростка (ТКО) 2: 0.001; НД/буллезная раковина (БР): 0.03; НД/ячейка Оноди (ЯО): 0.04; крючковидное отклонение отростка (КОО)/гипоплазия верхней челюсти (ГВЧ): 0.04.

Заключение: Наиболее распространёнными аспектами были TSNA, РБ, НД и АН. Процент этих анатомических структур, упомянутых выше, слишком высок, чтобы классифицировать его как вариацию. Их можно описать как основные анатомические структуры или доминирующие аспекты. Не было различий в частоте вариаций в зависимости от пола или стороны, но были обнаружены значимые корреляции между РБ и ТКО 2, между НД и БР, между АН и ЯО, а также между КОО и ДКИ.

Ключевые слова

параназальный синус, анатомические варианты, компьютерная томография, челюстно-лицевая