Original Article

Sinonasal Anatomic Variations in the Adult Population: CT Examination of 1200 Patients

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Received: 16-Apr-2024; **Revision:** 02-Jun-2024; **Accepted:** 06-Jun-2024; **Published:** 26-Aug-2024

Abstract

Background: The nasal cavity and paranasal sinuses are one of the most frequently anatomically varied regions. Their size and shape vary from person to person, and ethnic origin may have a role in this variety. Recognizing this variations is so important for ear nose throat (ENT) specialists because they predispose to sinonasal pathologies and affect the complication rate and success of endoscopic sinus surgery. **Aim:** This study aimed to determine the frequency of sinonasal anatomic variations on paranasal sinus computed tomography (CT) in the Turkish population. **Methods:** Patients who had undergone paranasal sinus CT with any complaints between 2013 and 2020 and aged over 18 years were included in the study. A total of 1209 patients who had undergone paranasal sinus CT were examined for coronal, axial, and sagittal plans retrospectively by two ENT professionals, and anatomical variations were evaluated. To assign the frequency of anatomic variations in a healthy population, patients who had previously undergone paranasal sinus and nasal surgery, who had nasal polyposis, and for whom CT evaluation was not possible due to intense sinusitis were excluded from the study. **Results:** Among 1209 patients, 644 were male and 565 were female. The mean age of the patients was 33.7 years. The most common sinonasal anatomical variations were nasal septal deviation and agger nasi cells, while the least common variation is the supreme turbinate. No variation was found in 48 (3.9%) CTs. **Conclusion:** Almost all patients had at least one sinonasal anatomical variation. These variations should be known by the professionals who have interest in sinonasal disease and surgery.

Keywords: *Anatomical variations, computed tomography, paranasal sinus*

Introduction

The nasal cavity and paranasal sinuses are one of the most frequently anatomically varied regions. Their size and shape vary from person to person.[1] This is because it is formed by the combination of many structures in embryonic life. These anatomical variations are very important because they predispose to sinonasal pathologies and affect the complication rate and success of endoscopic sinus surgery.[2,3] These variations can be evaluated by endoscopic examination and various radiologic imaging methods. Paranasal sinus computed tomography (CT) is the most commonly used tool for the detection of sinonasal diseases and evaluation of anatomical variations. Nowadays, preoperative imaging before an endoscopic sinus surgery is a routine procedure and very important for guiding the surgeon during surgery.

This study aimed to investigate sinonasal anatomical variations on paranasal CT in a large cohort.

Material and Method

Following the approval of the ethics committee (date: 22.03.2020 and reference number: 05/08), paranasal

Access this article online	
Quick Response Code:	Website: www.njcponline.com
	DOI: 10.4103/njcp.njcp_275_24

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How to cite this article: Ağcayazı S, Salcan İ, Erşahan AA, Seçkin E. Sinonasal anatomic variations in the adult population: CT examination of 1200 patients. Niger J Clin Pract 2024;27:990-4.

sinus CTs taken between 2013 and 2020 in a single ear, nose, and throat (ENT) clinic at a tertiary referral center were retrospectively evaluated. Patients aged over 18 years were included in the study. Patients who had previously undergone paranasal sinus and nasal surgery, who had nasal polyposis, and for whom CT evaluation was not possible due to intense sinusitis were excluded from the study. The examinations were performed with a 64-slice Multi Slice Toshiba Aquilion Tomography Device. Tomographs were evaluated in axial, coronal, and sagittal planes. Images, stored in DICOM format, were retrieved from the radiology database. Two experienced ENT professionals examined CTs. The presence of agger nasi, Haller, and Onodi cells; lamellar, bullous, and extensive types of middle turbinate bullosa; pneumatized uncinate process; paradoxical middle and inferior turbinate; pterygoid process; anterior clinoid process; and crista galli, nasal septum, and upper turbinate pneumatization and supreme turbinate was evaluated. The collected data were transferred to the Statistical Program for Social Scientists (SPSS) for Windows 22.0 (IBM Corp Released 2013 IBM SPSS Statistics for Windows, Version 22.0 Armonk NY: IBM Com) statistical package program and analyzed. Numerical variables are expressed as mean and standard deviation; categorical variables are expressed as number and percentage. Pearson Chi-square analysis was used for categorical variables. The statistical significance level was set as $P < 0.05$.

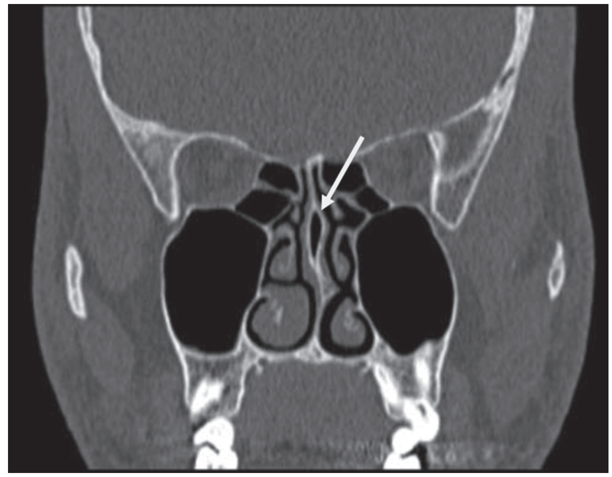

Figure 1: Coronal CT shows nasal septum pneumatization

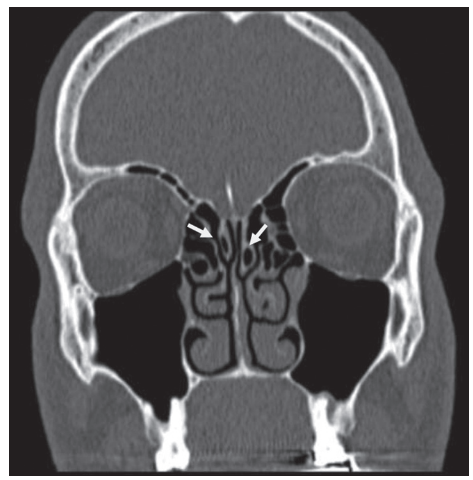

Figure 2: Coronal CT shows bilateral pneumatized upper turbinate

Figure 3: Coronal CT shows bilateral paradoxical middle turbinate

Results

Of the 1209 patients included in the study, 644 were male (53.3%) and 565 (46.7%) were female. The median age in our study was 33.7 years (range: 18–65).

Among 1209 cases, nasal septal pneumatization was identified in 308 (25.5%) [Figure 1].

Among the ethmoid cell variations, in 799 (66.1%) patients agger nasi cells, in 106 (8.8%) patients Haller cells, and in 256 (21.2%) patients Onodi cells were identified. No significant statistical difference was identified in the frequency of agger nasi ($P = 0.943$), Haller cells ($P = 0.922$), and Onodi cells ($P = 0.712$) between the right and left sides.

Among turbinate variations, 536 (43.3%) patients had concha bullosa, 229 (18.9%) patients had pneumatized upper turbinate [Figure 2], 164 (13.6%) patients had paradoxical middle turbinate [Figure 3], 38 (3.2%) patients had paradoxical lower turbinate [Figure 4], and 22 (%1.8) had suprema turbinate [Figure 5]. All turbinate variations were shown to be statistically symmetrical ($P = 0.967$ for concha bullosa, $P = 0.254$ for pneumatized upper turbinate, $P = 1.01$ for paradoxical lower turbinate, $P = 0.093$ for paradoxical middle turbinate, and $P = 0.125$ for suprema turbinate).

Figure 4: Coronal CT shows right paradoxical lower turbinate

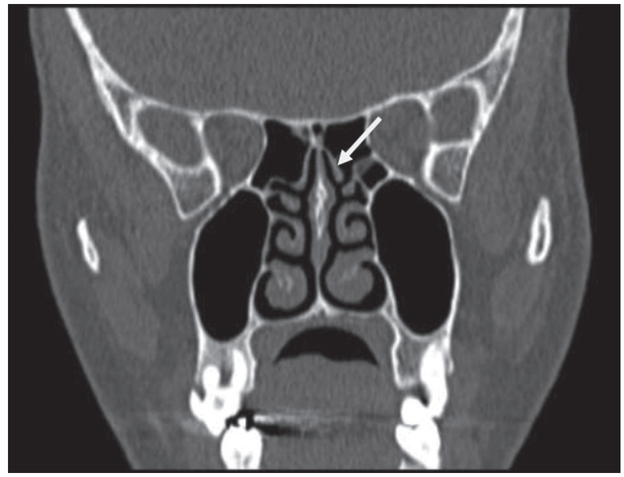

Figure 5: Coronal CT shows left suprema turbinate

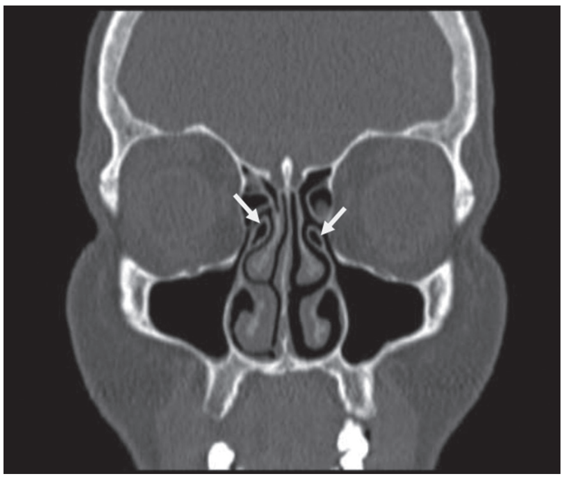

Figure 6: Coronal CT shows bilateral uncinate process pneumatization

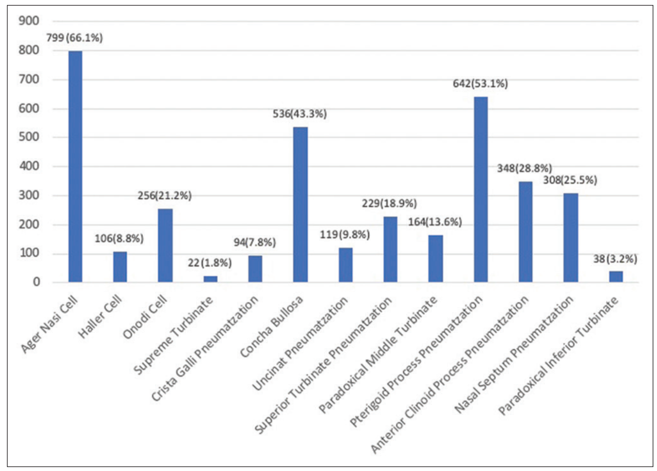

Figure 7: Sinonasal anatomic variation rates

Among the sphenoid sinus variations, pneumatization of the pterygoid process was observed in 642 (53.1%). There was no significant statistical difference between the right and left sides (P = 0.48). Anterior clinoid pneumatization was observed in 348 (28.8%). There was no significant statistical difference between the right and left sides (P = 0.087). Anterior clinoid pneumatization was identified in 32% of males (n = 208) and 18% of females (n = 104). It was observed statistically significantly higher in males (P = 0.004).

Among the other variations, 119 (9.8%) had uncinate process pneumatization [Figure 6]. There was no significant statistical difference between the right and left sides (P = 0.78), and 94 (7.8%) had pneumatized crista galli.

Figure 7 shows all variation rates in one graphic. In 1209 cases, no variation was found in only 48 (3.9%) cases.

Discussion

This study analyzed sinonasal anatomic variations in the Turkish population. In our study, it is seen that a very large proportion of the population has at least one sinonasal variation. The most common sinonasal anatomical variations were nasal septal deviation and agger nasi cells, while the least common variation is the supreme turbinate. While this situation is so common, it is obvious that ENT physicians who are interested in paranasal sinus diseases and surgery should have a full command of these variations. There was no statistically significant difference in the frequency of any sinonasal anatomical variations between the right and left sides, and only anterior clinoid pneumatization had a difference in terms of gender.

Ethmoid cell variations

Agger nasi air cells are among the anterior ethmoidal air cells located within the nasal cavity. They are situated anterolateral and inferior to the frontal sinus and anterior and above the attachment of the middle turbinate. The anatomical positioning of the agger nasi cell is located on the floor of the frontal sinus, while the frontal recess is located posteriorly to the posteromedial wall of the agger nasi cell. If agger nasi cells are pneumatized, they can potentially obstruct the frontal recess, leading to frontal sinus disease. They also have significant importance during endoscopic frontal sinus surgical procedures in this region. Agger nasi cells were the most common sinonasal anatomic variation according to our study with a prevalence rate of 66.1%.

This was followed by the *Onodi cell* and *Haller cell with prevalence rates of 21.2% and 8.8%*, respectively. Onodi cells are located posteriorly and extend superolateral to the sphenoid sinus. These cells are significantly important during sphenoid sinus surgery. It is in close relationship with the optic nerve and internal carotid artery. Also, it may be a landmark for the transsphenoidal approach if it is identified. To avoid complications, it should necessarily be evaluated before sphenoid sinuses surgery. The Haller cell, which is the infraorbital ethmoid cell, may predispose to maxillary sinusitis. In the literature on this subject, the incidence of agger nazi cells was reported as 95.6% in a study by Dedeoğlu *et al*.[4] The Onodi and Haller cell rates were found to be 32% and 48%, respectively. Kantarci *et al*.[5] studied 512 cases; the rate of ager nasi cells was found to be 47%. In a study by Kaya *et al*.,[6] the incidence of ager nasi cells was 72%. Onodi and Haller cells were found in 72% and 25%, respectively. All three studies included Turkish populations. In a study by Nautiyal *et al*.,[7] these rates were found to be 6% and 23%, respectively. A study was done in India, but the ethnicities of the patients were not specified in the study. Although the rates vary in the literature, it is obvious that the ager nazi cell, which is an important anatomical variation, especially in frontal sinus surgery, is seen quite frequently. In addition, it is thought that the difference in the rates in the studies varies according to the characteristics of the race studied, the plans of the tomography examined, and the number of sections.

Turbinate variations

The most common *turbinate variation* is the middle turbinate bullosa, which can obstruct the middle meatal complex and cause recurrent sinusitis. In a study by Arslan *et al*.,[8] the presence of middle turbinate bullosa was found to be 30%. Dedeoğlu *et al*.[4] found a high rate of middle turbinate bullosa, as high as 80% in the Turkish population. As is known, there are three types of turbinate bullosa: lamellar, bullous, and extensive. Although the literature data show differences according to the type included in the study, it is obvious that concha bullosa is a common variation in the community. Other turbinate variations are relatively rare. Lower turbinate pneumatization was not found in any patient in our series. In the study by Nautiyal *et al*., paradoxical middle turbinate, which may obstruct the middle meatal complex, was found to be 1.82% and upper turbinate pneumatization was found to be 6.36%.[7] It was reported as 12.2% by Kayalioglu *et al*.[9] in the Turkish population. Symptomatic upper turbinate pneumatization is very rare. If there is a huge pneumatization, it might lead to mechanical obstruction, mucosal contact, and in association with this head ache and sinusitis. It is thought that these differences in the literature are related to the curve ratio of the researchers to name the turbinate as paradoxical. Although there are publications on the presence of supreme turbinate in the literature, there are no clear data on its frequency in the population.[10] The clinical importance of supreme turbinate is not fully known. If it was recognized, it may be a landmark during sphenoid surgery. Sphenoid ostium is located medial to supreme turbinate's posteroinferior attachment and behind its vertical part.[11] We identified 1.8% to supreme turbinate in the Turkish population. Paradoxical inferior turbinate, which may cause nasal obstruction, is another rare turbinate variation. The study by Dasar *et al*.[12] is one of the rare studies giving the frequency of this variation in the community, and the rate was found to be 2.5% in the Turkish population.

Other variations

Nasal septum pneumatization is a relatively rare pathology and is also described as posterior septal air cell or septal turbinate in some publications. It may effect respiration and smelling. Devaraja *et al*.[13] found the rate of septum pneumatization to be 27.1% in the Indian population. This rate is nearly the same with ours.

Pterygoid process pneumatization (PPP) forming a lateral recess *in the sphenoid sinus* is the most common sphenoid sinus variation. Although anterior clinoid process pneumatization (ACP) is rarer, it was found in 28% of patients in our study. In order to access sellar and parasellar areas, clinoid processes are mostly excised; therefore, identifying this pneumatization has an importance to safety of parasellar area surgery.[14] Akbar *et al*. found PPP in 50% and ACP in 26% of patients in their study on sphenoid sinus variations.[15] The ethnicity of this study was Indian, and the data of these and other studies in the literature are similar to the results of our study.

Other rare variations found in our study were crista galli pneumatization and uncinate process pneumatization, which may cause recurrent maxillary sinusitis. Mazza *et al*. and Adeel *et al*. found the rate of pneumatized uncinate process to be 5% in their studies.[16,17] These results are lower than the results in our study. Although it is not clear with which ethnicity the studies were designed, they were conducted in Italy and Pakistan, respectively. That is why their results were different from ours. Crista galli pneumatization originated from primarily frontal sinuses and then ethmoid sinuses is important during anterior skull base surgery.[18] It was found between 3.3% and 22% in different series including different ethnic origins in the literature.[19]

Limitations

Since our study aimed to determine the frequency of sinonasal variations in the Turkish population, we retrospectively evaluated patients without sinonasal pathology on paranasal sinus CT. Studies including study groups with sinonasal pathology are necessary to better demonstrate the importance of the variations in clinical practice and to determine their relationship with sinonasal diseases. Patients were selected from a single center in a single province of Turkey. Multicenter studies may better reflect the diversity.

Advantages of study

Our series will contribute to the literature both in terms of the number of patients and by compiling 13 different variations in a single study.

Conclusion

Of the 1209 paranasal sinus CTs analyzed during our study, 96.1% had at least one variation in Turkey. These ratios appear to be as high as other studies in the literature. The most common anatomical variations are ager nasi cells and nasal septum deviation.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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