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Inferior Nasal Concha Elongation Is Associated with Obstructive Sleep Apnea Syndrome

Concha Nasalis Inferior Uzamasının Obstrüktif Uyku Apne Sendromu ile İlişkisi

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Abstract

Background: Upper airway anatomy plays a crucial role in the pathophysiology of obstructive sleep apnea syndrome (OSAS). Most previous studies have focused on pharyngeal or craniofacial factors, while detailed morphometric data regarding the inferior nasal concha remain scarce. The aim of this study was to evaluate the morphology and morphometry of the inferior nasal concha in patients with OSAS and to examine its relationship with posterior choanal extension.

Materials and Methods: Retrospective cranial CT images of 82 polysomnography-confirmed OSAS patients (41 females, 41 males) were analyzed. Using three-dimensional multiplanar reconstruction, the maximum anteroposterior length of the inferior nasal concha was measured bilaterally, and posterior choanal extension was recorded. All measurements were analyzed by side and sex and statistically compared according to choanal extension.

Results: There was no significant difference in inferior nasal concha length between males and females on either side. Similarly, the frequency of choanal extension did not differ significantly between sexes. However, in both males and females, on both sides, the inferior nasal concha was significantly longer in cases with choanal extension than in those without ($p<0.05$). No significant association was found between age and conchal length.

Conclusions: The findings of this study indicate that, in patients with OSAS, inferior nasal concha length is not associated with sex or age but is closely related to posterior choanal extension. A longer inferior nasal concha appears more likely to project into the choana, which may contribute to posterior nasal airway narrowing. However, because this study did not include a non-OSAS control group, these findings should be interpreted as anatomical associations within an OSAS cohort rather than as OSAS-specific morphological features.

Keywords: Obstructive Sleep Apnea Syndrome (Osas), Inferior Nasal Concha, Computed tomography

Öz

Amaç: Üst hava yolunun anatomik yapısı, obstrüktif uyku apne sendromunun (OUAS) patofizyolojisinde önemli bir rol oynamaktadır. Önceki çalışmaların büyük bir bölümü farengeal ya da kraniyofasiyal faktörlere odaklanmış olup, inferior nazal konkaya ait ayrıntılı morfometrik veriler sınırlıdır. Bu çalışmanın amacı, OUAS tanılı hastalarda concha nasalis inferior'un morfolojik ve morfometrik özelliklerini değerlendirmek ve bu bulguların koanal uzanım ile ilişkisini incelemektir.

Materyal ve metod: Polisomnografi ile OUAS tanısı doğrulanan 82 hastaya (41 kadın, 41 erkek) ait kraniyal BT görüntüleri retrospektif olarak analiz edildi. Üç boyutlu multiplanar rekonstrüksiyon kullanılarak inferior nazal konkanın maksimum anteroposterior uzunluğu bilateral olarak ölçüldü ve posterior koanal uzanım varlığı kaydedildi. Tüm ölçümler taraf ve cinsiyete göre analiz edildi ve bulgular koanal uzanım varlığına göre istatistiksel olarak karşılaştırıldı.

Bulgular: Her iki tarafta da concha nasalis inferior uzunluğu açısından kadınlar ve erkekler arasında anlamlı bir fark saptanmadı. Benzer şekilde, koanal uzanım sıklığı da cinsiyetler arasında anlamlı farklılık göstermedi. Buna karşılık, hem kadınlarda hem erkeklerde ve her iki tarafta, koanaya uzanım gösteren olgularda concha nasalis inferior uzunluğunun, uzanım göstermeyenlere göre anlamlı derecede daha uzun olduğu bulundu ($p<0,05$). Yaş ile konka uzunluğu arasında anlamlı bir ilişki saptanmadı.

Sonuç: Bu çalışmanın bulguları, OUAS'lı hastalarda concha nasalis inferior uzunluğunun cinsiyet ve yaş ile ilişkili olmadığını, ancak posterior koanal uzanım ile yakından ilişkili olduğunu göstermektedir. Daha uzun concha nasalis inferior'un koanaya doğru uzanım gösterme olasılığının daha yüksek olduğu ve bunun posterior nazal hava yolunun daralmasına katkıda bulunabileceği düşünülmektedir.

Anahtar Kelimeler: Obstrüktif Uyku Apne Sendromu (OUAS), Concha Nasalis Inferior, Bilgisayarlı tomografi

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Introduction

Obstructive sleep apnea (OSAS) is a common sleep-related breathing disorder characterized by recurrent episodes of partial or complete upper airway obstruction during sleep, leading to intermittent hypoxia and sleep fragmentation (1,2). These events result in excessive daytime sleepiness, impaired quality of life, and an increased risk of metabolic comorbidities (1). Epidemiological studies indicate that OSAS affects approximately 24% of middle-aged men and 9% of women, underscoring its substantial public health impact (1). The disorder imposes a substantial economic burden on society and increases medical costs (2). Furthermore, OSAS is considered an independent risk factor for various cardiovascular diseases, including hypertension, coronary artery disease, stroke, and heart failure (3).

The pathophysiology of OSAS is complex and multifactorial, involving an imbalance between negative inspiratory pressure and the activity of upper airway dilator muscles during sleep (4). Contributing factors include reduced upper airway dilator muscle activity during sleep, decreased end-expiratory lung volume, ventilatory control instability, and rostral fluid shifts (2). Anatomical variations also play a significant role; risk factors for OSAS in adults include obesity, male gender, and craniofacial dysmorphia (5). Recent CT-based morphometric studies have demonstrated that several craniofacial bony structures exhibit significant variability across age, sex, and cranial morphology, underscoring that the craniofacial skeleton is not a static framework (6-8). Specific anatomical features such as a small maxilla and mandible, or increased soft tissue volume, can result in a reduced airway size (2).

Among upper airway structures, the nasal cavity represents the initial segment of airflow and may contribute significantly to overall airway resistance (5,9,10). Increased nasal resistance has been shown to exacerbate upper airway collapsibility and may negatively affect sleep quality and breathing stability during sleep (4,5,11). The inferior nasal concha, due to its rich vascular and erectile tissue content, plays a pivotal role in regulating nasal airflow, humidification, and resistance (12-14). Morphological alterations or hypertrophy of the inferior nasal concha can lead to nasal obstruction, potentially influencing the pathophysiology and severity of OSAS (13,15,16).

Despite the recognized importance of nasal anatomy in sleep-disordered breathing, most studies investigating nasal contributions to OSAS have focused on septal deviation, overall nasal resistance, or subjective measures of nasal obstruction (4,5,11,15,16). Detailed morphological and morphometric evaluations specifically targeting the inferior nasal concha in patients with OSAS remain limited (13,14,17). Furthermore, the extent to which structural characteristics of the inferior nasal concha differ between individuals with OSAS and healthy controls has not been sufficiently clarified in the existing literature (12,18,19).

Therefore, the present study was undertaken to provide a detailed morphological and morphometric assessment of the inferior nasal concha in patients with obstructive sleep apnea syndrome. In particular, we examined whether increased inferior nasal concha length was associated with posterior choanal extension, a feature that may be relevant to narrowing of the posterior nasal airway in this population. By focusing on these anatomical relationships, the study aimed to clarify the potential structural contribution of inferior nasal concha morphology to the pathophysiological framework of OSAS. Rather than proposing a morphology specific to OSAS, our objective was to characterize variation within an OSAS cohort.

Materials and Methods

This retrospective study used cranial computed tomography (CT) images of patients diagnosed with Obstructive Sleep Apnea Syndrome (OSAS) and followed at Zonguldak Bülent Ecevit University Faculty of Medicine Hospital. Ethical approval was obtained from the Zonguldak Bülent Ecevit University Non-Interventional Clinical Research Ethics Committee prior to the study (approval no: 2020/11-4, date: May 27, 2020). Due to the study's retrospective nature, informed consent was waived. A total of 82 (41 females and 41 males) patients were included in the study, consisting of 41 males and 41 females. All patients were diagnosed with obstructive sleep apnea syndrome based on overnight polysomnography, in accordance with established clinical criteria. An apnea-hypopnea index (AHI) ≥ 5 events/hour was used to diagnose OSAS. Patients with a history of nasal or sinonasal surgery, craniofacial anomalies, nasal tumors, sinonasal polyposis, acute sinonasal infection, or significant facial trauma were excluded from the study. No non-OSAS control group was included, as the primary objective of the study was to evaluate the posterior choanal extension patterns within a polysomnography-confirmed OSAS cohort. The CT images were retrieved from the hospital's radiology archive system and evaluated retrospectively. CT scans were obtained in the supine position using standard acquisition parameters, with a slice thickness of 2 mm. All CT datasets were transferred to Horos v4.0.0 (free, open-source software) for morphometric analysis.

Morphometric Measurements

The morphometric measurements were performed by anatomists with expertise in the relevant anatomical field. All measurements were obtained under blinded conditions to minimize observer-related bias. To ensure standardization and reproducibility, the following detailed protocol was employed. All CT datasets were reoriented using multiplanar reconstruction with the reference plane parallel to the hard palate (palatum durum) (Figure 1). The measurement plane was selected as the axial section showing the maximal anteroposterior extent of the inferior nasal concha. Anterior landmark was determined as the most anterior point where the inferior nasal concha first becomes clearly identifiable within the nasal cavity on the reconstructed axial plane. Posterior landmark is determined as the terminal tip of the conchal free end at its posterior limit. The linear distance between these two landmarks was measured using Horos built-in caliper tools and recorded to the nearest 0.01 cm. Posterior choanal extension was considered present when the posterior end of the inferior nasal concha projected into the choanal lumen. All measurements were performed separately for the right and left sides (Figure 1). This CT-based morphometric approach is consistent with previously published quantitative studies of craniofacial skeletal structures (6-8,20). All measurements were performed by a single experienced observer who was blinded to the patients' gender and age. To assess intraobserver reliability, the same observer repeated all measurements on a random subset of 20% of the images after a two-week interval. The intraclass correlation coefficient (ICC) was calculated as 0.82 (95% CI: 0.71-0.90), indicating high measurement stability and reproducibility. Interobserver reliability was not assessed in this study.

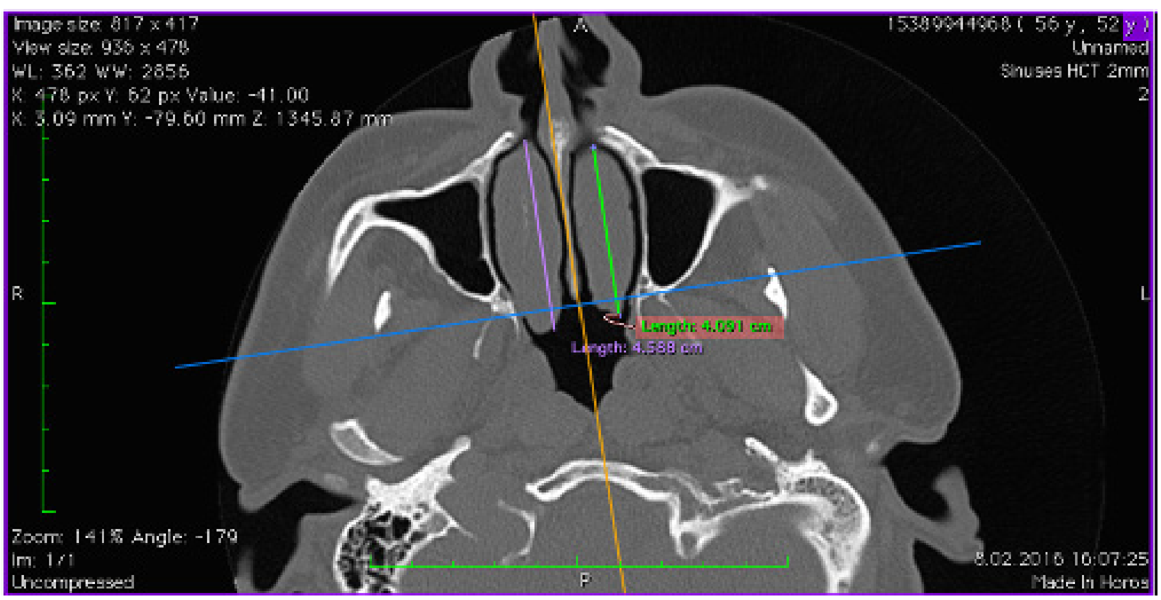

Figure 1. Morpholmetric evaluation and assessment of the right and left inferior nasal concha lengths and their extension into the choanae using Horos v4.0.0.'

Statistical Analysis

Statistical analyses were performed using SPSS software (version 19.0; IBM Corp., Armonk, NY, USA). Normality assumptions were evaluated using the Shapiro-Wilk test, and statistical tests were selected accordingly. In addition to p values, effect size estimates and/or 95% confidence intervals were reported to improve interpretation of the magnitude of group differences. Descriptive statistics were expressed as mean ± standard deviation or median (minimum-maximum), as appropriate. Categorical variables were presented as frequencies and percentages.

A sensitivity power analysis was performed using G*Power 3.1 for the sex-based comparison of inferior nasal concha length with a two-tailed independent-samples t test. Assuming an alpha level of 0.05, a power of 0.80, and 41 participants in each group, the minimum detectable standardized effect size was Cohen's d=0.626, indicating that the sample size was sufficient to detect differences of approximately moderate magnitude between female and male participants.

Comparisons were performed according to sex, side (right and left), and the presence or absence of choanal extension of the inferior nasal concha. Independent samples t-test was used for normally distributed continuous variables, while the chi-square test was applied for categorical variables. A p-value of < 0.05 was considered statistically significant.

Artificial Intelligence Use

AI-based language tools were used solely for translation and language refinement. No AI tools were used for data collection, statistical analysis, image generation, or interpretation of results. All content was reviewed and approved by the authors, who take full responsibility for the final manuscript.

Results

A total of 82 patients (41 males and 41 females) diagnosed with Obstructive Sleep Apnea Syndrome at Zonguldak Bülent Ecevit University Faculty of Medicine Hospital were included in the study. Descriptive statistics of inferior nasal concha lengths for both sides and both genders are presented in Table 1. All continuous variables showed normal distribution, justifying the use of parametric tests.

In female patients, the median length of the inferior nasal concha was 4.48 cm (range: 3.31-5.91) on the left side and 4.43 cm (range: 3.40-5.78) on the right side. In male patients, the median inferior nasal concha length was 4.75 cm (range: 2.00-5.85) on the left side and 4.73 cm (range: 2.08-6.25) on the right side. There was no statistically significant difference between males and females in terms of inferior nasal concha length on either side (left: p=0.394; right: p=0.452).

Table 1. Lengths of the right and left inferior nasal concha in females and males. Independent-samples t-test.

	Female (n=41)			**Male (n=41)**			**p**
	Median (cm)	**Min (cm)**	**Maks (cm)**	**Median (cm)**	**Min (cm)**	**Maks (cm)**	
Left inferior nasal concha	4.48	3.31	5.91	4.75	2.00	5.85	.394
Right inferior nasal concha	4.43	3.40	5.78	4.73	2.08	6.25	.452

The frequency of choanal extension of the inferior nasal concha was 56.1% on the left side and 61.0% on the right side in females, and 46.3% on both sides in males. Although choanal entry of the inferior nasal concha appeared slightly more frequent in females on both sides, no statistically significant sex-related difference was observed on either the left (p=0.507) or the right (p=0.268) side (Table 2).

Table 2. Distribution of choanal entry of the inferior nasal concha according to sex and side. Chi-square test with Yates' correction

		Left		**p**	**Right**		**p**
		Choanal entry present	**Choanal entry absent**		**Choanal entry present**	**Choanal entry absent**	
Male	n	19	22	.507	19	22	.268
	%	46.3%	53.7%		46.3%	53.7%	
Female	n	23	18		25	16	
	%	56.1%	46.3%		61.0%	39%	

When patients were grouped according to the presence or absence of choanal extension, a statistically significant difference in inferior nasal concha length was observed in both sexes and on both sides of the nose. In both males and females, the inferior nasal concha length on the left side was significantly greater when the inferior nasal concha entered the choana than when it did not. In males, the median inferior nasal concha length was 4.97 cm in the choanal entry group versus 4.52 cm in the non-entry group (p=0.013). Similarly, in females, the median length was 4.75 cm in the choanal entry group and 4.20 cm in the non-entry group (p=0.016). On the right side, inferior nasal concha length was also significantly greater in cases with choanal entry compared to those without entry in both sexes. In males, the median length was 4.98 cm in the choanal entry group and 4.60

cm in the non-entry group (p=0.016). Similarly, in females, the median inferior nasal concha length was 4.65 cm in the choanal entry group and 3.97 cm in the non-entry group (p=0.001), indicating an even more pronounced difference (Tables 3 and 4).

Table 3. Comparison of inferior nasal concha length according to left-sided choanal entry status in males and females. Independent-samples t-test

	Left choanal entry present			Left choanal entry absent			p
	Median (cm)	**Min (cm)**	**Max (cm)**	**Median (cm)**	**Min (cm)**	**Max (cm)**	
Male	4.97	4.00	5.85	4.52	2.00	5.57	.013
Female	4.75	3.31	5.91	4.20	3.35	5.78	.016

Table 4. Comparison of inferior nasal concha length according to right-sided choanal entry status in males and females. Independent-samples t-test

	Left choanal entry present			Left choanal entry absent			p
	Median (cm)	**Min (cm)**	**Max (cm)**	**Median (cm)**	**Min (cm)**	**Max (cm)**	
Male	4.98	4.26	6.25	4.60	2.08	5.73	.016
Female	4.65	4.04	5.78	3.97	3.40	5.77	.001

No statistically significant correlation was found between age and inferior nasal concha length on either the right or the left side (p > 0.05).

Discussion

The inferior nasal concha plays a pivotal role in nasal physiology, contributing significantly to the regulation of nasal airflow, humidification and heating of inspired air (13). Its structural or mucosal abnormalities are frequently implicated in the pathophysiology of nasal obstruction and Obstructive Sleep Apnea Syndrome (OSAS).

In this study, we evaluated the dimensions of the inferior nasal concha in patients with OSAS. Our results demonstrated four key findings: (1) there were no significant differences in inferior nasal concha length between males and females on either side; (2) there was no significant association between sex and the presence of choanal extension; (3) inferior nasal concha length was significantly greater in cases with choanal extension compared to those without, regardless of sex or side; and (4) there was no significant correlation between patient age and inferior nasal concha length. Taken together, these findings suggest that posterior morphological variations of the inferior nasal concha are common in patients with OSAS and may represent an anatomically relevant feature within this population. Because the present study was confined to patients with OSAS, these findings should be interpreted as morphometric relationships within this clinical population rather than as evidence of a feature unique to OSAS.

Our finding that inferior nasal concha length does not differ significantly between sexes contrasts with some existing literature on nasal dimensions. For instance, Turhan et al. (2019) used cone-beam computed tomography (CBCT) and stereological methods to demonstrate that the nasal cavity and concha volumes were significantly larger in males than in females inferior nasal concha (19). Additionally, older epidemiological data has established that OSAS is more prevalent in men than women, with a ratio often estimated at 2:1 or higher in clinical populations (2,21). The lack of sexual dimorphism in inferior nasal concha length in our study, despite the known volumetric differences reported by Turhan et al. (2019) suggest that while males may have bulkier turbinates volumetrically or larger nasal cavities overall, the linear anterior-posterior extent of the inferior turbinate bone itself may be a more conserved anatomical feature (19). This implies that the male predisposition to OSAS may be driven more by pharyngeal airway collapsibility, fat distribution, or soft-tissue volume rather than the linear length of the nasal conchae (2).

A key finding of the present study is the association between choanal extension and increased CNI length. This posterior extension is clinically relevant because the posterior aspect of the inferior nasal concha is a critical site for nasal obstruction. The inferior nasal concha extends along the entire length of the nasal cavity (22), and its posterior tail is located in the choana (109. This area contains significant erectile tissue and venous sinusoids, which are subject to congestion [9]. According to the Starling resistor model, an upstream obstruction in the nose can generate increased negative intraluminal pressure downstream in the oropharynx during inspiration, thereby precipitating upper airway collapse (4,16). Therefore, elongation of the CNI into the choana serves as a distinct anatomical obstruction at the posterior nasal aperture, potentially increasing nasal resistance and contributing to the pathophysiology of sleep-disordered breathing. Hypertrophy of the posterior portion of the inferior nasal concha is a recognized contributor to nasal obstruction, necessitating targeted management (13). Regarding age, our study found no significant correlation between age and CNI length. This is an interesting finding given that the prevalence of OSAS is known to increase with age (1,21). Turhan et al. (19) reported that nasal cavity and concha volumes were larger in adults than in children, but our cohort consisted of adults whose skeletal growth had ceased. Previous imaging-based studies have shown that OSAS is associated with measurable structural airway differences; for example, CBCT analyses have demonstrated smaller upper airway dimensions in OSA patients than in controls, supporting the broader concept that radiologically detectable anatomic narrowing contributes to sleep-disordered breathing (23). Similarly, a recent CBCT study reported that nasal passage volume was significantly reduced in OSA patients compared with healthy controls and that lower nasal passage volume was associated with higher AHI, suggesting that nasal cavity morphology may have clinically relevant implications in OSA beyond the pharyngeal airway alone (24). However, not all radiological nasal measurements appear to correlate directly with OSA severity; Makkonen et al. (25) reported that the minimal cross-sectional areas of the anterior nasal cavity on CBCT were not significantly associated with AHI, indicating that localized nasal anatomy may influence symptoms or treatment tolerance without necessarily mirroring polysomnographic severity. In this context, our findings emphasize a posterior and localized anatomical feature, as opposed to a generalized reduction in nasal dimensions. This specificity may explain the clinical significance of this variation, notwithstanding its evasion of detection in comprehensive volumetric or anterior cross-sectional evaluations. The lack of correlation suggests that the linear length of the CNI is a stable anatomical parameter in adulthood. The age-related increase in OSAS prevalence is therefore likely attributable to other factors, such as loss of tissue elasticity, increased parapharyngeal fat deposition, or changes in neuromuscular control, rather than elongation of the turbinate bone itself (1,2).

Clinical and Radiological Implications

The detection of significant inferior nasal concha elongation and choanal extension underscores the importance of comprehensive radiological assessment in patients with OSAS. While anterior rhinoscopy provides information mainly about the anterior nasal cavity, imaging modalities such as CT or CBCT are indispensable for evaluating the posterior nasal cavity and ethmoidal regions (22). Given that the nasal cavity constitutes an important component of total upper airway resistance, posterior extension of the inferior nasal concha into the choanal region may contribute to nasal airflow limitation and increase downstream inspiratory negative pressure, thereby facilitating upper airway collapsibility during sleep (23). Although isolated nasal surgery is not considered a primary curative treatment for OSA, recent evidence suggests that alleviating nasal obstruction can improve subjective symptoms, reduce required CPAP pressures, and enhance CPAP tolerance and adherence, thereby increasing the clinical relevance of identifying posterior turbinate-related narrowing on CT (23). Moreover, objective evaluation of nasal airway resistance may help tailor surgical planning in OSAS patients with nasal obstruction, indicating that radiologically detected choanal extension may be particularly meaningful when interpreted together with functional airflow assessment, especially in candidates for turbinate surgery (24). Surgical management of inferior nasal concha hypertrophy varies, including turbinectomy, submucous resection, and radiofrequency ablation (13) In this context, our findings suggest that in patients with choanal extension, surgical strategies should specifically address the posterior portion of the turbinate in order to achieve a more effective reduction in airway resistance. Furthermore, the recognition and management of nasal obstruction are clinically important because they may improve compliance with Continuous Positive Airway Pressure (CPAP) therapy, even when they do not necessarily result in a substantial reduction in the Apnea-Hypopnea Index (11,16).

Study Limitations

This study has several limitations. First, the retrospective, single-center design limits the generalizability of the findings. Second, the lack of a non-OSAS control group prevents us from definitively concluding that choanal extension is more prevalent in OSAS patients than in the general population, although we know nasal obstruction is a risk factor for sleep-disordered breathing. Third, we relied on anatomical measurements without functional correlations such as rhinomanometry. It has been noted that anatomical abnormalities do not always correlate perfectly with subjective nasal obstruction or functional airflow limitation. Fourth, although intraobserver reliability analysis was performed and demonstrated satisfactory reproducibility, interobserver reliability was not assessed. Finally, we measured linear length rather than volume; volumetric analysis might have revealed different associations regarding sex and age as seen in other studies.

Conclusion

Our study confirms that choanal extension of the inferior nasal concha significantly increases its length, potentially serving as an anatomical barrier in the posterior nasal airway of OSAS patients. This elongation appears independent of sex and age. Future studies should employ a prospective design with a control group and integrate volumetric analysis to better characterize turbinate hypertrophy. Additionally, correlating these anatomical findings with functional airway measurements and CPAP compliance would provide greater insight into the clinical significance of choanal extension in the management of OSAS.

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Ethical Approval: *Ethical approval was obtained from the Zonguldak Bülent Ecevit University Non-Interventional Clinical Research Ethics Committee prior to the study (approval no: 2020/11-4, date: May 27, 2020).*

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Concept: K.A., C.M.Ö., A.Z.Y.K., M.Ç.B.

Literature Review: K.A., C.M.Ö., A.Z.Y.K., M.Ç.B.

Design: K.A., C.M.Ö., A.Z.Y.K., M.Ç.B.

Data acquisition: K.A., C.M.Ö., A.Z.Y.K., M.Ç.B.

Analysis and interpretation: K.A., C.M.Ö., A.Z.Y.K., M.Ç.B.

Writing manuscript: K.A., C.M.Ö., A.Z.Y.K., M.Ç.B.

Critical revision of manuscript: K.A., C.M.Ö., A.Z.Y.K., M.Ç.B.

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