



Article

The Impact of Breathing Pattern (Nasal vs. Oral) on the Severity of Obstructive Sleep Apnea

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Abstract

Background: Nasal obstruction has been implicated in the pathophysiology of obstructive sleep apnoea (OSA), potentially contributing to upper airway instability and impaired breathing during sleep. However, its precise role in determining disease severity remains unclear. This study aimed to evaluate the relationship between patients' subjective perception of breathing patterns (nasal vs. oral) and OSA severity, as well as the impact of structural nasal abnormalities and their anatomical location. **Methods:** This cross-sectional study was conducted at the University Hospital Center Osijek, Croatia, between May 2024 and September 2025. Sixty adult patients with diagnosed moderate-to-severe OSA (apnoea–hypopnoea index [AHI] ≥ 15 events/hour) were included. All participants underwent polysomnography and otorhinolaryngological evaluation, including anterior rhinoscopy and nasal endoscopy. Structural abnormalities assessed included septal deviation and inferior turbinate hypertrophy, classified according to a modified Cottle system. Statistical analyses were performed using non-parametric tests and correlation methods, with significance set at $p < 0.05$. **Results:** The study included 60 patients (median age 56 years; 71.7% male), of whom 23% had moderate and 77% severe OSA (median AHI 39.4). No significant association was found between subjective breathing pattern and OSA severity ($p = 0.8$), although patients with predominantly oral breathing exhibited higher median AHI values. Oral breathing was significantly associated with the presence of septal deviation ($p < 0.001$) and inferior turbinate hypertrophy ($p < 0.001$). Structural deformities in oral breathers were most frequently localized in the nasal valve region (Area II) ($p < 0.001$). However, neither the presence nor the anatomical location of nasal deformities showed a significant relationship with AHI values ($p = 0.93$). **Conclusions:** Subjective breathing pattern was not significantly associated with OSA severity, although oral breathing tended to be linked with higher AHI values. Structural nasal abnormalities were significantly more prevalent among oral breathers but did not influence disease severity. These findings suggest that nasal obstruction plays a limited role in determining OSA severity, while remaining clinically relevant as a potentially modifiable factor influencing breathing patterns and treatment adherence. Further research is warranted to evaluate the impact of interventions targeting nasal breathing in the comprehensive management of OSA.

Keywords: breathing; nasal obstruction; obstructive sleep apnoea; septal deformation



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1. Introduction

The nose is the first component of the upper airway. Nasal breathing serves important physiological functions, including humidification, heating and air filtration [1]. Airflow and resistance in the nasal cavity play an important role in the breathing process. A normal nose can sustain 20 to 30 L of air flow per minute and the nasal airway accounts for more than half of the total airway resistance [2]. Nasal obstructions can be caused by nasal congestion due to chronic rhinosinuitis with or without nasal polyps, allergies or structural abnormalities, such as deviated nasal septum and enlarged turbinates or adenoid [3]. It is defined by the sensation of insufficient airflow through the nose.

Obstructive Sleep Apnoea (OSA) is a sleep-related breathing disorder characterised by recurrent episodes of partial or complete upper airway obstruction during sleep lasting at least 10 s. This leads to either partial (hypopnoea) or complete (apnoea) cessation of breathing, resulting in hypoxia in the body's cells (moj rad medicina 4). OSA is characterised by night snoring with excessive daytime sleepiness and is commonly associated, if it is left untreated, with a reduced quality of life, an increased risk of cardiovascular disease, cognitive dysfunction, and hearing loss [4,5].

Multilevel anatomical obstruction may play a role in OSA. Nasal obstruction leads to mouth breathing, which is thought to destabilise the upper airway and aggravate OSA. Many pathophysiologic mechanisms have been described to explain the relationship between nasal airflow and breathing during sleep: the Starling resistor model, the unstable oral airway proposition, the nasal ventilation reflex and the role of nitric oxide (NO) [1]. In this paper, we will focus on the first model. According to the Starling resistor model, which states that the upper airway is a hollow tube, apnea can occur when nasal obstruction generates enough negative intraluminal pressure downstream to cause the compliant soft tissues of the oropharynx to collapse [1,6,7]. During inspiration, an increased resistance at the level of the nose, due to the Bernoulli effect, will favor the collapsibility of the pharyngeal soft tissues. In the normal airway, there will be no collapse, but in OSA patients, after overcoming the critical closing pressure (P_{crit}), a partial or total airway collapse will happen.

Unstable oral breathing causes a higher total upper airway resistance and exacerbates tongue base collapse. Reduced nasal breathing leads to deactivation of nasal receptors, inhibition of the nasal ventilatory reflex, and further decreased spontaneous ventilation [8].

Numerous studies have examined the impact of nocturnal nasal obstruction on OSA. A consistent finding across the literature is that impaired nasal breathing adversely affects OSA and is associated with reduced adherence to, as well as diminished therapeutic efficacy of, continuous positive airway pressure (CPAP) therapy. However, the precise contribution of nasal obstruction—particularly that resulting from structural nasal deformities—to overall disease severity remains insufficiently elucidated. In routine clinical practice, patients frequently report symptoms of nasal obstruction despite the absence of identifiable structural abnormalities on physical examination. Conversely, a subset of patients with clearly demonstrable structural deformities may remain asymptomatic. Objective assessment of nasal airway resistance is currently feasible using rhinomanometry.

The aim of this study was to evaluate the relationship between patients' subjective perception of their habitual breathing patterns and the severity of OSA, as well as to assess the influence of the anatomical location and type of structural nasal deformities—specifically septal deviation and turbinate hypertrophy—on disease severity.

2. Materials and Methods

This study was designed as a cross-sectional study and was conducted at the University Hospital Center Osijek, Croatia. The study period extended from May 2023 to

September 2025. Subjects eligible for the study were initially selected from patients referred to our Department of Neurology with suspected OSA. All patients underwent polysomnography (PSG) for the diagnosis of the pathology. A total of 60 adult patients with newly diagnosed moderate-to-severe obstructive sleep apnoea, defined as an apnoea–hypopnoea index (AHI) ≥ 15 events per hour, were included in the study. All patients were referred to an ENT specialist in our Department of Otorhinolaryngology and Head and Neck Surgery. The diagnosis of nasal respiratory obstruction was performed by clinical evaluation (self-reported sensation of breathing pattern during daytime, anterior rhinoscopy and nasal endoscopy with 2.7 mm 0° rigid endoscope) to evaluate the features of nasal structures: septum deformation and hypertrophy of the inferior turbinate. Subjective assessment of nasal breathing was chosen because it provides insight into the individual perception of nasal patency and the presence of respiratory difficulties, which we consider an important aspect of the participants' functional status. The subjective sensation of impaired nasal breathing does not always correspond completely with objective findings; therefore, subjective assessments have considerable clinical and research value, particularly with regard to evaluating symptoms and their association with quality of life and daily functioning.

For the purposes of diagnosis and documentation, as well as correlating pathology with clinical symptoms, this study employed a division of the nasal cavity into four areas. This classification was based on the five-area system proposed by Cottle in 1961, which was partially adapted to reflect surgical anatomy (Table 1). Area I represents the nostril (external ostium), formed by the alar rim, the lateral border of the columella, and the floor of the vestibule. Area II represents the nasal valve area. Area III represents the attic and the anterior half of the nasal cavity, including the heads of the turbinates and the infundibulum or ostiomeatal complex (Area III and IV in Cottle classification). Area IV represents the posterior half of the nasal cavity, including the tails of the turbinate (Area V in Cottle classification) [9].

Table 1. Classification of nasal cavity.

Cottle Classification (1961)	Study Classification
Area I—Nostril	Area I
Area II—Nasal valve	Area II
Area III—Anterior nasal cavity	Merged into Area III
Area IV—Ostiomeatal region	Merged into Area III
Area V—Posterior nasal cavity	Area IV

Inclusion criteria were as follows: adults over 18 years of age with moderate or severe OSA. Patients who had undergone nasal or rhinosinusal surgery were excluded from the study. Also, patients who were receiving topical or systemic steroids or other nasal therapies were excluded from the study.

Clinical data, including age, gender, medical history (surgery, therapy), AHI, self-reported sensation of breathing during the daytime and results of endonasal examination were initially collected for each patient.

Data Analysis

Data were described using descriptive statistics. Numerical data were presented as the median and interquartile range. The normality of the distribution of numerical data was tested with the Shapiro–Wilk test. Differences in categorical variables were tested with the χ^2 test and, if necessary, with Fisher's exact test. Differences in numerical variables between two independent groups were tested with the Mann–Whitney U test, and between three or more groups with the Kruskal–Wallis test (Post hoc Conover). The association of numerical variables was assessed, due to deviation from the normal distribution, with

Spearman's correlation coefficient ρ (rho). All p values are two-sided. The significance level was set at Alpha = 0.05. The statistical package MedCalc® Statistical Software version 23.3.7 (MedCalc Software Ltd., Ostend, Belgium; <https://www.medcalc.org>; accessed on 7 January 2025) was used for statistical analysis.

3. Results

A total of 60 patients (43 males and 17 females, median age 56 years, interquartile range 45–61 years) were included in the study.

Fourteen (23%) patients had moderate apnea and 46 (77%) had severe apnea with a median AHI of 39.4 (interquartile range 28.8–70.3). Patients who primarily had oral-type breathing had a higher median AHI (40.5, interquartile range 29.3–78.1) than patients who primarily had nasal-type breathing (36.4, interquartile range 31–66.1), but there was no significant difference between the two groups of patients (Mann–Whitney U test, $p = 0.8$).

There was no significant difference in severity of apnea regarding the type of breathing (Table 2).

Table 2. Patients according to the type of breathing and the severity of apnea.

	Number (%) According to the Severity of Apnea			p^*
	Moderate	Severe	Total	
Oral breathing	7 (50)	21 (46)	28 (47)	0.8
Nasal breathing	7 (50)	25 (54)	32 (53)	
Total	14 (100)	46 (100)	60 (100)	

* Fisher's exact test.

Significantly more patients with oral-type breathing have a septal deformity present (Table 3).

Table 3. Patients regarding to the type of breathing and the presence of septal deformation.

	Number (%) Regarding the Presence of Septal Deformity			p^*
	Yes	No	Total	
Oral breathing	28 (78)	0 (0)	28 (47)	<0.001
Nasal breathing	8 (22)	24 (100)	32 (53)	
Total	36 (100)	24 (100)	60 (100)	

* Fisher's exact test.

Significantly more patients who breathe orally have inferior nasal turbinate hypertrophy (Table 4).

Table 4. Patients according to type of breathing and presence of inferior nasal turbinate hypertrophy.

	Number (%) with Respect to the Presence of Inferior Nasal Turbinate Hypertrophy			p^*
	Yes	No	Total	
Oral breathing	19 (76)	9 (25)	28 (47)	<0.001
Nasal breathing	6 (24)	26 (75)	32 (53)	
Total	25 (100)	35 (100)	60 (100)	

* Fisher's exact test.

There is a significantly higher number of deformities in area II in patients who breathe orally, and in area IV in patients who breathe nasally (Table 5).

Table 5. Patients with regard to the type of breathing and the position of the septal deformation.

	Number (%) According to the Position of the Septal Deformity						p *
	No Deformity	Area II	Area IV	Area III	Area II i III	Area I i II	
Oral breathing	0 (0)	15 (94)	1 (17)	1 (25)	9 (100)	2 (100)	<0.001
Nasal breathing	23 (100)	1 (6)	5 (83)	3 (75)	0 (0)	0 (0)	
Total	23 (100)	16 (100)	6 (100)	4 (100)	9 (100)	2 (100)	

* χ^2 test.

There is no significant difference in AHI level with respect to the position of the nasal septal deformity (Kruskal–Wallis test, $p = 0.93$).

4. Discussion

Most people have experienced sleeping difficulty during episodes of virally induced nasal congestion and during nose packing after nasal surgery. Even Hippocrates in “*Morbis Popularibus*” noted that nasal polyps were associated with restless sleep [10]. Septal deformations and hypertrophied turbinate are a static type of obstruction in OSA patients.

There is evidence that nasal obstruction may significantly contribute to the pathogenesis of OSA, exacerbate snoring, reduce patients’ quality of life, and negatively affect adherence to CPAP therapy. Numerous studies conducted over the years have supported this hypothesis [1,11–18]. Additionally, authors have investigated the impact of nasal surgery as a primary treatment modality for OSA on the course of the disease, and the results of these studies have been further evaluated in meta-analyses. A consistent conclusion across these analyses is that isolated nasal surgery does not significantly affect the apnea–hypopnea index (AHI), but it does improve quality of life and adherence to CPAP therapy [3,19].

CPAP therapy is currently considered the gold standard in the treatment of OSA; however, due to poor adherence and high discontinuation rates, alternative treatment options are increasingly being explored. These include mandibular advancement devices (MADs), positional therapy, and upper airway surgery, particularly nasal surgery. For the treatment to be considered effective, the patient must use the device for at least 4 h during night-time sleep on at least 70% of nights. CPAP adherence was assessed using the Centers for Medicare and Medicaid Services (CMS) definition, which considers patients adherent if the device is used for at least 4 h per night on at least 70% of monitored nights. Patient compliance with proper use of the device is around 70% [4,20,21].

Nasal breathing is considered physiological. As inspired air passes through the nasal cavity, it is warmed, humidified, and filtered [22]. Oral breathing is regarded as a compensatory mechanism in situations requiring increased airflow, whereas a predominantly oral breathing pattern is considered pathological. Oral (mouth) breathing has been identified as a risk factor for OSA. It also worsens OSA by narrowing the airway and increasing obstruction [23–25]. Nasal breathing is strongly influenced by nasal anatomy; however, it is well recognized that some patients with significant anatomical deformities may not report subjective nasal obstruction, while others with minimal abnormalities may experience substantial symptoms. In their study, Malgiulo et al. found that among 55 patients with OSA, 40% of those with isolated structural nasal deformities reported no symptoms of nasal obstruction [6].

In the present study, we aimed to evaluate the impact of patients’ subjective assessment of their daytime breathing pattern (nasal vs. oral) on OSA severity, as well as the influence of the presence or absence of structural nasal deformities (septal deviation and inferior turbinate hypertrophy) on this subjective assessment. Additionally, we sought to determine

whether the location of the deformity affects disease severity. The objective was to clarify the role of the nose in OSA severity and to assess whether identification of a subjective daytime breathing pattern could represent a modifiable risk factor for OSA, amenable to conservative or surgical intervention. This study may serve as a basis for future interventional research (e.g., nasal breathing rehabilitation and its impact on AHI values).

In this study, no association was demonstrated between breathing pattern and the severity of OSA. Patients who reported predominantly oral breathing exhibited higher mean AHI values compared with those who primarily breathed through the nose; however, this difference did not reach statistical significance. A review of currently available literature in major medical databases reveals no studies addressing the relationship between subjectively assessed breathing patterns and OSA severity.

One possible explanation for the absence of statistically significant differences between the groups is the relatively small sample size, particularly in the moderate OSA subgroup ($n = 14$). The limited number of participants may have reduced the statistical power of the study, increasing the risk of a Type II error and limiting the ability to detect subtle associations between breathing pattern and OSA severity. This imbalance in group sizes reflects the characteristics of the patient population presenting to our clinic during the predefined study period and was not the result of selective recruitment. Therefore, although no significant association was identified, the possibility that a true relationship exists cannot be entirely excluded. Future studies including larger and more evenly distributed patient cohorts are warranted to further investigate this issue. Consequently, our findings should be interpreted with caution, particularly regarding the moderate OSA subgroup.

Patients who reported predominantly oral breathing more frequently presented with nasal septal deviation. In addition, inferior turbinate hypertrophy was more common among oral breathers. In our study, we did not demonstrate a relationship between AHI values and the anatomical location of the deformity. In contrast to our findings, Miyamura et al. reported that only anterior septal deviations have a significant impact on OSA [26].

A notable finding of the present study was the strong association between subjective breathing pattern and the anatomical location of septal deformity. Patients with septal deviations involving area II, either in isolation or in combination with adjacent regions, were significantly more likely to report predominant oral breathing, whereas all patients without septal deformity reported nasal breathing. This finding suggests that the location of septal deviation may have a greater influence on perceived nasal airflow than the mere presence of a septal deformity. The particularly strong association observed for area II deformities is anatomically plausible. Area II corresponds to the region of the nasal valve, which represents the narrowest segment of the nasal airway and contributes substantially to total nasal airflow resistance. Even relatively small structural abnormalities within this region may result in a disproportionate increase in airflow resistance and a greater subjective sensation of nasal obstruction. Consequently, patients with deformities affecting this area may be more likely to adopt oral breathing as a compensatory mechanism. In contrast, septal deformities confined to other regions of the nasal cavity, particularly areas III and IV, appeared less strongly associated with oral breathing. Although such deformities may be readily identifiable during clinical examination, their functional impact on nasal airflow may be less pronounced. This observation highlights the importance of considering the anatomical location and potential physiological consequences of septal abnormalities rather than simply documenting their presence or absence. These findings may have important clinical implications. Subjective oral breathing could serve as a simple clinical indicator of functionally significant anterior septal deformities, particularly those involving the nasal valve region. Patients reporting predominant oral breathing may therefore benefit

from a more detailed otorhinolaryngological evaluation, including nasal endoscopy, to identify anatomical abnormalities that could contribute to impaired nasal airflow.

Although correction of nasal obstruction alone is unlikely to substantially alter OSA severity, recognition and treatment of clinically significant septal deformities may improve nasal breathing, patient comfort, and adherence to CPAP therapy.

Structural nasal abnormalities in patients with OSA are most commonly discussed in the context of nasal surgery as a therapeutic option, either as primary treatment or as an adjunctive approach. However, evidence from the current literature remains controversial regarding whether isolated correction of nasal obstruction can influence the clinical course and severity of OSA. In their meta-analysis of 21 studies, Schoustra et al. concluded that, in most cases, isolated nasal surgery does not significantly affect AHI values and therefore should not be considered a first-line treatment [3]. Conversely, Miyamura et al. reported that specific surgical techniques targeting anterior septal deformities may play a significant role in the management of OSA [26]. Tsai et al. emphasized the importance of nasal surgery in reducing snoring [27].

The present study found no significant association between subjective breathing pattern and OSA severity. Patients who reported predominantly oral breathing or impaired nasal breathing did not exhibit higher AHI values than those reporting normal nasal breathing. This finding is consistent with the current understanding of OSA pathophysiology, whereby the severity of disease is determined primarily by pharyngeal collapsibility and its interaction with multiple anatomical and non-anatomical factors, including upper airway muscle responsiveness, ventilatory control instability, and arousal threshold. Although nasal obstruction may increase upper airway resistance and promote oral breathing, its contribution to OSA severity appears to be indirect and relatively limited compared with pharyngeal mechanisms.

Nevertheless, an important finding of our study was the association between subjective breathing pattern and structural nasal abnormalities. Patients who reported predominantly oral breathing or difficulty breathing through the nose were more likely to exhibit clinically relevant anatomical alterations of the nasal cavity. This suggests that subjective assessment of breathing pattern may provide useful clinical information regarding the presence of underlying nasal pathology. Given that detailed nasal examination is not routinely incorporated into all sleep medicine evaluations, patients reporting chronic nasal obstruction or predominant oral breathing may benefit from targeted otorhinolaryngological assessment, including nasal endoscopy.

The clinical relevance of this observation may extend beyond its relationship with OSA severity. Although current evidence suggests that isolated nasal surgery has limited effects on AHI and should not be considered a primary treatment for OSA, management of nasal obstruction may play an important role in optimizing CPAP therapy. Previous studies have demonstrated improved CPAP tolerance and adherence following surgical correction of nasal obstruction, likely through reduction of nasal resistance, lower therapeutic pressure requirements, and improved patient comfort. Bican et al. and Elway et al. independently reported improved CPAP tolerance following surgical intervention [17,28]. Similarly, the aforementioned meta-analysis by Schoustra et al. also noted improved compliance with CPAP therapy after nasal surgery [3]. Improved nasal airflow may also facilitate the use of nasal masks, which are generally better tolerated than oronasal interfaces. Therefore, while subjective nasal symptoms may not predict OSA severity, they may help identify patients who are more likely to experience difficulties with CPAP treatment and who could benefit from further evaluation and management of nasal dysfunction [29].

Several limitations should be acknowledged. The assessment of breathing pattern was based on subjective patient reports rather than objective measures of nasal patency.

Consequently, objectively significant but subjectively unrecognized nasal obstruction may have resulted in some degree of misclassification. However, the primary objective of this study was to evaluate perceived nasal breathing, which represents a clinically relevant outcome in its own right. Future studies incorporating both subjective and objective assessments of nasal airflow are warranted to further clarify their relationship with OSA severity, CPAP adherence, and treatment outcomes.

5. Conclusions

This study did not demonstrate a statistically significant association between subjectively assessed breathing patterns (oral versus nasal) and the severity of OSA, although patients with predominantly oral breathing exhibited higher AHI values. In contrast, oral breathing was found to be significantly associated with the presence of structural nasal abnormalities, particularly septal deviation and inferior turbinate hypertrophy, with deformities most commonly localized in the nasal valve region (Area II). However, neither the presence nor the anatomical location of structural nasal deformities showed a significant impact on OSA severity, suggesting a complex and multifactorial pathophysiology in which the nose plays a limited role in determining disease severity. These findings support existing evidence that nasal obstruction primarily affects breathing quality and ventilatory patterns, but does not necessarily influence OSA severity as measured by the AHI.

From a clinical perspective, the identification of oral breathing may serve as an indicator of underlying nasal obstruction and a potentially modifiable factor amenable to targeted treatment. Based on these findings, clinicians should consider a more comprehensive nasal evaluation (e.g., nasal endoscopy) in patients with obstructive sleep apnea (OSA) who report predominantly mouth breathing or significant nasal breathing difficulties. Although isolated nasal surgery may not result in a substantial reduction in the apnea–hypopnea index (AHI), it can significantly improve the effectiveness of and adherence to continuous positive airway pressure (CPAP) therapy by facilitating lower therapeutic pressure requirements and enhancing nasal airflow. Furthermore, it enables patients to use a nasal mask exclusively, which is generally more comfortable and better tolerated than an oronasal mask. In conclusion, these results highlight the need for an individualized approach to patients with OSA and underscore the importance of further research investigating interventions aimed at improving nasal breathing, including both conservative and surgical strategies, as part of a multimodal treatment approach to OSA.

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Abbreviations

The following abbreviations are used in this manuscript:

OSA	Obstructive sleep apnoea
AHI	Apnoea–hypopnoea index
L	Liter
NO	Nitric oxide
CPAP	Continuous positive airway pressure
PSG	Polysomnography
Pcrit	Critical closing pressure
MADs	Mandibular advancement devices

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