

The efficacy of nasal surgery in obstructive sleep apnea syndrome: a prospective clinical study

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Abstract The aim of this study was to investigate the effects of surgical intervention for nasal pathologies on obstructive sleep apnea syndrome (OSAS) and continuous positive airway pressure (CPAP) titrations in patients with OSAS. The study was designed as a prospective case control study. Between December 2007 and June 2010, 31 patients (26 men and 5 women) who were diagnosed with OSAS with polysomnography and confirmed to have obstructive nasal pathology were enrolled in the study. The average age of the patients was 53 ± 9.6 (range 33–68 years) and the body mass index ranged from 22 to 40.6 kg/m^2 with an average of 30.3 ± 4.1 . The patients were evaluated with Epworth Sleepiness Scale, OSAS Complaints Questionnaire, visual analog scale, and CPAP titration before and 3 months after nasal surgery. As three patients did not attend the control polysomnography, data analysis was performed on 28 patients. Although there was a significant improvement in the nasal passage and subjective complaints, namely, snoring frequency, apnea and daytime sleepiness, the difference between preoperative

and postoperative AHI values was not statistically significant. Postoperative CPAP titration results indicated a decrease both in pressures and in AHI in comparison to preoperative values. These reductions were not statistically significant, although the decrease in CPAP pressures was close to significance ($p = 0.062$). Nasal pathologies should be treated in all patients with OSAS, particularly those undergoing CPAP treatment. However, patients should be counseled that favorable results might not be achieved after nasal surgery.

Keywords Obstructive sleep apnea syndrome · Nasal surgery · Continuous positive airway pressure · Polysomnography

Introduction

Obstructive sleep apnea syndrome (OSAS) is characterized by repetitive episodes of obstruction at one or more levels of upper airway during sleep. OSAS, which affects nearly 2–4% of the population [1], is associated with long-term hypoxia, daytime and overnight symptoms, and sleep fragmentation [1, 2]. It has been shown that snoring frequency varies depending on age; approximately, 10% of men under 30 years of age snore, while 60% of men over 60 years of age do [3]. OSAS and even snoring are known to be associated with many systemic diseases such as hypertension, congestive heart failure, cerebrovascular incidents, pulmonary hypertension, depression and obesity [4, 5]. Moreover, daytime sleepiness due to OSAS has been reported to increase the risk of having traffic accidents [6]. Thus, patients with OSAS should be treated effectively to reduce symptoms and consequences of OSAS (e.g., associated diseases causing morbidity).

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Since 1981, continuous positive airway pressure (CPAP), which is a kind of compressor used to squeeze the room air and pump it via nasal airway, has been considered as the gold standard for the treatment of OSAS [7]. However, the usage of CPAP is limited because of the discomfort caused by the mask and the compressed air it pumps.

Surgical management of OSAS is aimed to enlarge and prevent the collapse of the airway, which is an onerous task as it may require multilevel intervention. It is not only the level and grade of obstruction that determine the success of the surgical treatment, but the associated medical condition of the patient as well. Upper airway surgery may be a feasible treatment option in selected patients with OSAS and it has been shown to be as effective as CPAP therapy in the long term [8]. Moreover, surgery may be compulsory in those who cannot tolerate CPAP. The role of nasal surgery in the OSAS is still disputable as controversial results have been reported in the literature. Nasal surgery is considered at least as a worthwhile adjunct treatment modality [9]. On inspiration, up to two-thirds of upper airway resistance is created by the nasal apparatus and any pathology associated with these structures leading to nasal obstruction causes increased negative pharyngeal intraluminal pressure and compliance failure of oropharyngeal tissues. Artificial nasal obstruction was shown to cause an increase in apnea and hypopnea values [10]. Additionally, patients with nasal pathologies often have associated snoring and obstructive sleep apnea symptoms [11].

The purpose of the present study was to evaluate the effects of nasal surgery in patients with obstructive sleep

apnea syndrome diagnosed by polysomnography (PSG) in OSAS patients and CPAP users.

Materials and methods

The study was conducted at the Departments of Otolaryngology and Pulmonary Medicine, Uludağ University Medical School between December 2007 and June 2010. The study protocol was approved by the ethics committee. Patients who were admitted to the department of pulmonary medicine with OSAS complaints and had an AHI value greater than five at PSG underwent a detailed ENT examination including Müller's maneuver and flexible endoscopic examination (Table 1). Patients who had obstructive nasal pathologies (septum deviation, turbinate hypertrophy, nasal polyposis and nasal valve problem) were included in the study. Patients with a previous nasal surgery or medical problems interfering with surgery or with significant weight gain or loss ($> \pm 10\%$ of the pre-treatment value) were excluded from the study. In total, the study group consisted of 26 men (83.9%) and 5 women (16.1%) with an average age of 53 ± 9.6 years (range 33–68 years). The body mass index of all 31 patients ranged from 22 to 40.6 kg/m^2 with an average of 30.3 ± 4.1 . Each participant signed an informed consent form before taking part in the study.

Before surgery, all patients and their bed partners were queried for history of OSAS complaints in which they were asked to assess the severity and duration of the following

Table 1 The physical examination findings of the patients other than nasal pathologies

Nasopharynx	Normal	Lenfoid tissue	Tumor		
	27	1	–		
Soft palate	Normal	Elongated	Very long		
	21	7	–		
Uvula	Normal	Long (1–2 cm)	Very long (>2 cm)		
	18	10	–		
Mallampati	Type 1	Type 2	Type 3	Type 4	
	12	8	6	2	
Tonsil ^a	0	1+	2+	3+	4+
Right	1	24	3	–	–
Left	1	23	4	–	–
Lingual tonsil ^b	Grade 1	Grade 2	Grade 3	Grade 4	
	15	13	–	–	
Müller's maneuver ^c	<25%	25–50%	50–75%	>75%	
Retropalatal	17	8	2	1	
Retrolingual	18	9	1	–	

^a 0 Tonsils are in the tonsillar fossa, no airway narrowing, 1+ tonsils cause less than 25% airway narrowing, 2+ tonsils cause 25–50% airway narrowing, 3+ tonsils cause 50–75% of airway narrowing, 4+ tonsils cause more than 75% airway narrowing

^b Grade 1 anterior commissure can be seen, Grade 2 arytenoids can be seen, Grade 3 epiglottis can be seen, Grade 4 base of tongue can be seen

^c The percentage of narrowing in the pharyngeal passage before and after the maneuver

symptoms: snoring, choking sensation during sleep, sleep fragmentation, daytime fatigue, morning headaches, daytime sleepiness, nasal obstruction and mouth dryness. Patients and their bed partners were also asked to grade snoring, daytime sleepiness, daytime fatigue and apnea by visual analog scale (VAS). Epworth Sleepiness Scale (ESS) was used to report the patients' tendency to fall asleep in eight different circumstances. Participants underwent a detailed ENT assessment, including nasal endoscopy and anterior rhinoscopy. Each nasal passage was evaluated with an arbitrary grading system (<10%, 10–50%, 50–90%, >90%). Patients who had at least 50% nasal obstruction on one side were operated. Finally, CPAP titration was carried out on all patients.

Polysomnography

Overnight polysomnography was performed in all patients using the Compumedics sleep pursuit system (Compumedics p-series: Compumedics, Melbourne, Australia). Each patient was admitted to the sleep disorder laboratory at 20:30 h and the polysomnography recording consisting of two electroencephalography (EEG) (C3/A2 and O2/A1), two electrooculogram (EOG), one submental electromyogram (EMG) and one electrocardiogram (ECG) started immediately after the patient fell asleep. Respiratory monitoring was performed using a computerized system, which recorded oronasal airflow by an oronasal thermistor, oxygen saturation of hemoglobin by a pulse oximeter, SaO₂ by a nail oximeter and chest wall movement by a respiratory inductive plethysmograph (RIP) belt and body position. Polysomnographic recordings were classified according to the standard criteria of American Academy of Sleep Medicine.

Nasal airflow was analyzed carefully to assess ventilation during sleep. Apnea was defined as the complete cessation of airflow for a minimum of 10 s. On the other hand, a decrease of 50% or more in thermistor signal for at least 10 s associated with an arousal or a fall of 3% in basal oxygen saturation was characterized as hypopnea [2]. The apnea–hypopnea index (AHI) was calculated by dividing the total number of apneas and hypopneas by the number of hours of sleep.

Preoperative CPAP titration was performed on all patients but one who did not tolerate CPAP. Titrations were performed using an automatic CPAP device.

Patients were treated according to their nasal pathologies with five different surgical interventions: (1) three patients with septoplasty, (2) two with septorhinoplasty, (3) 18 with septoplasty and radiofrequency ablation of the inferior turbinate, (4) four with endoscopic sinus surgery along with septoplasty and radiofrequency ablation of the inferior turbinate and (5) four with radiofrequency surgery to the inferior turbinates bilaterally.

After 3 months following nasal surgery, patients were reevaluated with the same OSAS questionnaire, visual analog scale and ESS. PSG with CPAP titration and nasal examination were also repeated to compare the postoperative results with the preoperative ones. The changes in body weight were recorded.

All statistical analyses were carried out using SPSS v.16.0 for Windows (SPSS inc. Chicago, USA). McNemar test was used for the analysis of categorical data of the dependent groups. Shapiro–Wilk's normality test was used to analyze whether the quantitative data were normally distributed or not. Paired samples *t* test was employed for the analysis of dependent variables with normal distributed quantitative data. Wilcoxon test was used for the analysis of dependent variables with ordinal or quantitative data that were not normally distributed.

Results

Three patients did not attend control PSG, so that analysis was performed on 28 patients. All patients gained weight during the postoperative period and the average body weight gain of the group was 1.5 kg ± 2.5. However, the change in body weight was not significant (> ±10%) in any of the cases.

After surgery, the nasal passage was found to be significantly improved on anterior rhinoscopic examination (Fig. 1) The results obtained from the OSAS questionnaire showed an improvement in all complaints but for the choking sensation. This overall improvement was also supported by VAS. The mean ESS scoring, which was initially 9.3 ± 5.1 (in the range 1–20), was significantly (*p* < 0.001) decreased to 5.9 ± 3.9 (in the range 1–15) after the surgery (Table 2).

Polysomnographic findings showed that both the preoperative and postoperative total sleep duration were sufficient in all patients (Table 3). AHI was decreased in 12 of 28 patients, while the remaining 16 showed an increase in AHI. If we assume a change in AHI greater than ten points as a dramatic change, there was a dramatic increase in AHI in 4 of 16 (25%) patients, whereas we encountered a dramatic decrease in 7 out of 12 (58%) patients. AHI values decreased to less than 5 in five patients, which meant the cure of OSAS (Fig. 2). Moreover, respiratory activities during sleep showed that the total apnea and hypopnea time was significantly shortened (*p* = 0.039).

No significant changes were observed in mean oxygen saturation level and in the percentages of REM sleep and stage 1–2 non-REM sleep (Table 3). However, stage 3–4 non-REM sleep was found to be improved significantly (*p* = 0.013) after surgery.

In the preoperative period, the mean CPAP pressure was 11.2 ± 1.2. Patients who had an AHI <5 after surgery were

Fig. 1 The evaluation of nasal passage narrowness on anterior rhinoscopic examination

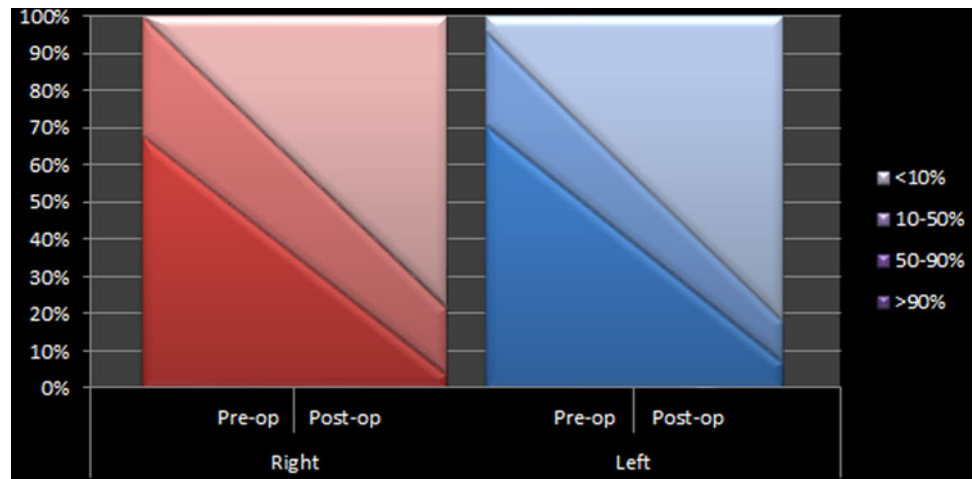


Table 2 OSAS Complaints Questionnaire results (in percentage), VAS results (out of 10 points) and ESS score (out of 24) and the difference between the preoperative and postoperative periods

	Preoperative				Postoperative				Difference (<i>p</i>)
	Never	Seldom	Frequently	Always	Never	Seldom	Frequently	Always	
OSAS Complaints Questionnaire									
Frequency of snoring	4	–	21	75	4	39	39	18	<0.001
Witnessed apnea	7	22	39	32	25	25	39	11	0.015
Sense of choking	29	35	29	7	46	18	29	7	0.051
Sleep fragmentation	14	29	32	25	18	43	28	11	0.03
Morning tiredness	21	21	21	36	32	29	32	7	0.033
Morning headache	32	47	14	7	57	35	4	4	0.011
Mouth dryness	7	25	25	43	21	46	18	14	0.003
Nasal obstruction	11	21	43	25	68	21	11	–	<0.001
Visual analog scale									
Daytime fatigue	5.4 ± 2.7				3.1 ± 3				0.002
Daytime sleepiness	5.5 ± 2.3				3.8 ± 2.2				<0.001
Snoring	8.6 ± 2.3				4.9 ± 2.3				<0.001
Apnea	6.5 ± 2.5				3.2 ± 2.6				<0.001
ESS score	9.3 ± 5.1				5.9 ± 3.9				<0.001

exempted from control CPAP trial. Postoperative CPAP pressures 10.4 ± 1.4 were lower than their preoperative counterparts (Table 3). The difference between preoperative and postoperative CPAP pressures (Fig. 3) was close to significance ($p = 0.062$). The mean AHI under CPAP was lower than the preoperative values, but this difference was not statistically significant ($p = 0.148$) (Table 3).

Discussion

Previous studies suggested that sleep breathing disorders might be triggered by different consequences of nasal obstruction such as (1) transition to mouth respiration, (2) disturbance of nasal reflexes causing dysrhythmic

contraction, and (3) increase of negative pressure during inspiration leading to collapse [12]. There exist various clinical and experimental studies showing that nasal inflammation triggers OSAS symptoms by increasing nasal resistance [13, 14]. In addition, some studies showed that artificial nasal obstruction decreased the quality of sleep and increased the number of arousals, apnea, and hypopnea in healthy men [15, 16].

A number of prospective trials in the literature investigated the efficacy of nasal surgery in patients with OSAS and revealed variable results regarding this issue. In most of these trials, no significant improvement was observed in the objective measures of PSG. Discrepant results in AHI and oxygen saturation level were revealed in previous studies (Table 4) [9, 17–22]. Our study showed no significant

Table 3 Preoperative and postoperative PSG values

	Preoperative	Postoperative	Difference (<i>p</i>)
Total sleep duration (min)	401.8 ± 41.3	375.7 ± 43.8	0.019
Sleep efficacy (%)	82.3 ± 11.2	84.8 ± 9.8	0.086
Sleep latency (min)	25.1 ± 26.3	32.4 ± 28.5	0.146
Sleep pattern			
REM sleep (%)	16.9 ± 7.5	19.3 ± 18.3	0.628
Non-REM grade 1–2 (%)	71.9 ± 10	72.9 ± 9.1	0.973
Non-REM grade 3–4 (%)	8.6 ± 6.3	11.6 ± 7.4	0.013
Oxygen saturation			
Mean O ₂ saturation	91.2 ± 3.8	92.1 ± 3.1	0.142
Mean O ₂ desaturation	7.3 ± 3	7.2 ± 3.1	0.987
O ₂ saturation (<90%) (min)	41.4 ± 67.4	27.6 ± 36.1	0.1
O ₂ saturation (<80%) (min)	4.6 ± 12.6	3.2 ± 7	0.909
Respiratory activities during sleep			
Number of apnea	170.6 ± 138.4	149.1 ± 137.4	0.305
Number of hypopnea	48 ± 42.6	52 ± 77.7	0.22
Apnea duration ^a (min)	81.8 ± 81.9	70.9 ± 82.3	0.145
Hypopnea duration ^a (min)	21.2 ± 24.9	20.4 ± 35.2	0.054
Apnea + hypopnea duration ^a (min)	100.8 ± 87.3	91.2 ± 86.4	0.039
Apnea hypopnea index	32.5 ± 22.6	32.4 ± 24.6	0.69
Arousal	25.8 ± 13.5	26.5 ± 14.3	0.673
CPAP titration			
AHI under CPAP	8.5 ± 6.4	5.6 ± 3	0.148
CPAP pressure	11.2 ± 1.2	10.4 ± 1.4	0.062

Bold values are statistically significant
 Min minute
^a Mean ± standard deviation

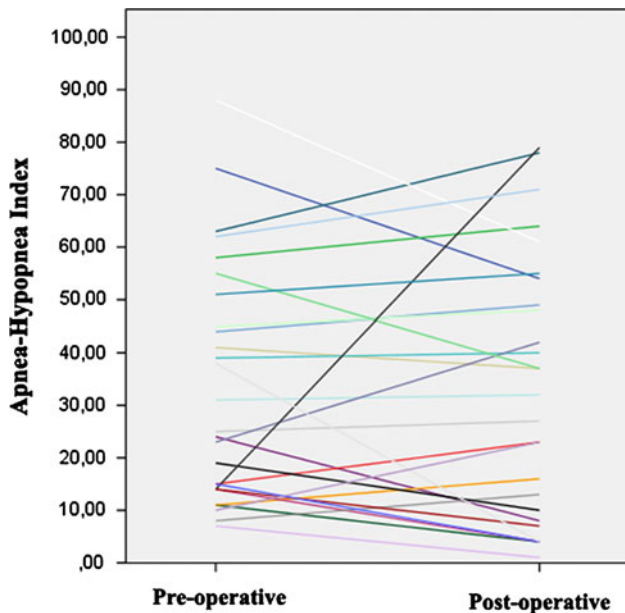


Fig. 2 The change between preoperative and postoperative AHI

change in AHI (preoperative: 32.5, postoperative: 32.4, *p* = 0.69) and in mean oxygen saturation (preoperative: 91.3, postoperative: 92.1, *p* = 0.149). As OSAS is a multifactorial condition which emanates from pathological

obstruction affecting multiple levels, it would not be realistic to expect nasal surgery to cure all the patients. However, increase in the severity of the OSAS is an unexpected phenomenon that is constantly being encountered in the studies. As encountered in the present study, deeper level of sleep (non-REM stage 3–4), induced by improved nasal breathing in patients, might possibly have led to an increase in the upper airway collapse [16, 17, 23].

Nasal surgery was shown to decrease nasal resistance and improved tolerance to CPAP [24]. Reduced CPAP pressures were consistently reported in the literature (Table 5) [8, 17, 25–28]. Concordant with the earlier studies, the present study revealed an almost significant difference (*p* = 0.062) between the preoperative (11.2 ± 1.2) and postoperative (10.4 ± 1.4) CPAP pressures. If we had assumed that five patients who did not undergo control CPAP had an improved CPAP level, we might have attained a significant decrease in the CPAP pressures. Although there was no significant change in postoperative AHI values, decreased nasal resistance improved CPAP titration pressures, which enabled more patients to be successfully treated with CPAP. Moreover, with lower pressure levels, the tolerance to CPAP is expected to be improved.

Various experimental and clinical studies showed that improved nasal respiration eventually prevented sleep

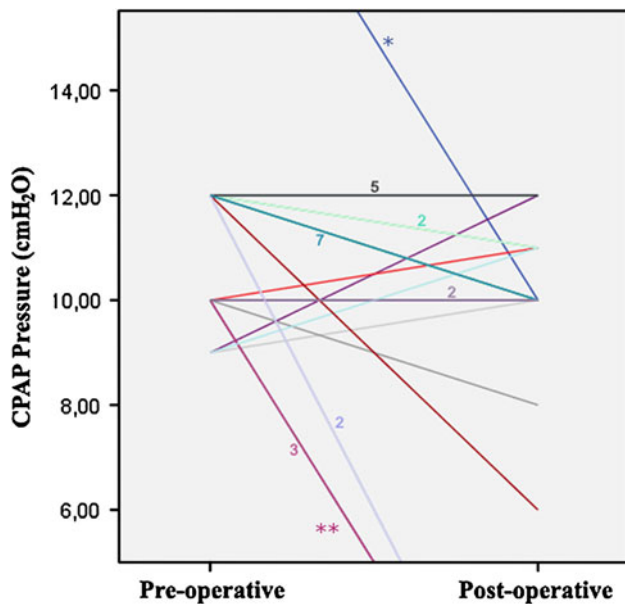


Fig. 3 The difference between preoperative and postoperative CPAP pressures. Patients reflecting the same pattern were represented with a single annotated line; the annotation corresponds to the number of those patients. The line marked with *represents the patient who could not tolerate preoperative CPAP titration. The lines marked with **represent the patients with an AHI <5 for whom postoperative CPAP titration was not applied

fragmentation and promoted a better quality sleep [29, 30]. REM sleep was shown to increase from 11.5 to 14% after nasal surgery [10]. Nakata et al. [18] reported an increase in REM and non-REM stage 2 and also increased sleep efficacy. Although insignificant, an increase in the percentage of REM sleep was also observed in our study. On the other hand, the percentage of stage 3–4 non-REM sleep was significantly increased; which implied the positive effect of nasal surgery on sleep architecture.

Recent studies showed that nasal surgery relieved subjective symptoms of OSAS patients. Friedman et al. [17] pointed out that nasal surgery provided improvement in

subjective symptoms, nevertheless, with no significant change in PSG findings. Verse et al. [9] reported reduction in ESS (independent of AHI), and arousal index and sleep quality were found to be improved. Similarly, Nakata et al. [18] reported a significant decrease in the ESS score after surgery. In the study of Li et al. [22] which assessed the improvement in the quality of life of OSAS patients after nasal surgery, a significant improvement in the snoring outcome survey, bed partner survey, and ESS were found. The analysis of our subjective findings correlated with the previous studies. Our study showed significant decrement in almost all symptoms of OSAS. Especially, the mean scores of daytime sleepiness and morning fatigue were found to be significant and this is thought to be related to the increase in the deeper levels of sleep.

It was shown that nasal surgery had a positive effect on snoring complaints of OSA patients. Fairbanks [31] reported that snoring was relieved in 77% of patients after nasal surgery. Loth et al. [32] showed that the use of nasal dilators significantly improved snoring complaints. Akcam et al. [33] performed nasal valve surgery in 37 patients and found a 65% decrease in snoring in a retrospective evaluation. In our study, there was a significant improvement in snoring complaints of patients.

Although nasal examination of patients and evaluation of nasal patency were carried out by the same expert surgeons, the objective measurement of nasal passage could be performed by rhinometric testing. This fact can be considered as a shortcoming of the present study.

Conclusion

AHI and mean oxygen saturation values did not significantly improve, but the subjective complaints were found to be improved after nasal surgery alone. As only a small number of patients experience a cure of their disease, nasal surgery should not be offered as the primary treatment for

Table 4 The effect of nasal surgery on the severity of obstructive sleep apnea

Author	Number of patients	Pre-op AHI	Post-op AHI	Pre-op LSaO ₂	Post-op LSaO ₂
Verse et al. [9]	26	31.6	28.9	40.3 ^a	39.7 ^a
Friedman et al. [17]	50	31.6	39.5	82.5	84.3
Nakata et al. [18]	49	49.6	42.5	76.2	78.8
Koutsourelakis et al. [19]	27	31.5	31.5	94.3 ^b	94.5 ^b
Kim et al. [20]	21	39	29	48 ^a	32 ^a
Virkkula et al. [21]	40	13.6	14.9	16.0 ^a	16.7 ^a
Li et al. [22]	51	37.4	38.1	78.3	79.5

AHI Apnea Hypopnea Index, *pre-op* preoperative, *post-op* postoperative, *LsaO₂* Lowest oxygen saturation

^a oxygen desaturation index

^b average oxygen saturation

Table 5 The effect of nasal surgery on continuous positive airway pressure treatment

	Author	Number of patients	Pre-op CPAP pressure (cmH ₂ O)	Post-op CPAP pressure (cmH ₂ O)
CPAP continuous positive airway pressure, <i>pre-op</i> preoperative, <i>post-op</i> postoperative	Masdon et al. [8]	35	9.7	8.9
	Friedman et al. [17]	22	9.3	6.7
	Mayer-Brix et al. [25]	3	9.7	6.0
	Dorn et al. [26]	5	9.3	6.7
	Nakata et al. [27]	5	16.8	12
	Zonato et al. [28]	17	12.4	10.2

OSAS. However, the subjective benefit achieved and ease in CPAP use due to decreased pressure levels clearly mark the important role of nasal surgery in this group of patients. However, a few patients enjoyed a complete recovery (with an AHI below 5) after nasal surgery. Thus, surgical management of nasal pathology should be considered in patients with OSAS even if they are known to be treated with CPAP.

Conflict of interest All authors declare that they have no conflict of interest.

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