

Effectiveness of nasal surgery alone on sleep quality, architecture, position, and sleep-disordered breathing in obstructive sleep apnea syndrome with nasal obstruction

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ABSTRACT

Background: The goal of this study was to evaluate the effect of nasal surgery alone on sleep quality, architecture, position, and sleep-disordered breathing (SDB) (including obstructive apnea and snoring) in adult patients with obstructive sleep apnea syndrome (OSAS) and nasal obstruction.

Methods: A total of 22 consecutive male patients (mean age, 41.3 ± 10.9 years) with OSAS and nasal obstruction, who underwent nasal surgery alone, were enrolled in the study. We compared polysomnographic data related with sleep quality (sleep efficiency [SE] and arousal index [ArI]), sleep architecture (stages N [nonrapid eye movement], 1, 2, and 3, and R [rapid eye movement]), the distribution of sleep positions, and SDB (apnea-hypopnea index [AHI], apnea index [AI], minimum arterial oxygen saturation [SaO_2], and snoring) before and after nasal surgery.

Results: SE (from $86.6 \pm 6.3\%$ to $89.7 \pm 7.1\%$; $p = 0.039$), stage R (from $15.3 \pm 4.8\%$ to $18.6 \pm 5.4\%$; $p = 0.016$) and snoring (from $32.2 \pm 16.4\%$ to $25.8 \pm 18.6\%$; $p = 0.045$) significantly changed after nasal surgery. However, there were no significant changes in ArI, other sleep stages, the proportion of sleep time spent in the supine position, AHI, AI, and minimum SaO_2 after nasal surgery.

Conclusion: Nasal surgery alone was partially effective in improving sleep quality, architecture, and snoring, but it had no effect on the change of the distribution of sleep positions and obstructive apnea in patients with OSAS and nasal obstruction.

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Obstructive sleep apnea syndrome (OSAS) is characterized by repeated partial or complete obstructions of the upper airway (nasal cavity, pharynx, and larynx) during sleep. The pathophysiology of OSAS is complex and involves multiple contributing factors such as anatomic abnormality, neuromuscular dysfunction, genetic factors, hormonal change, etc. Among these contributing factors, anatomic abnormality should be initially suspected because the inspection of various anatomic features in the breathing pathway (e.g., nasal septal deviation, inferior turbinate hypertrophy, nasal polyp or mass, adenoid vegetation, tonsillar hypertrophy, large tongue, etc.) may help guide further evaluation and treatment (e.g., continuous positive airway pressure, oral appliance, surgery, etc.) for OSAS.¹

Nasal obstruction caused by a structural abnormality is one of the most common symptoms in OSAS patients along with snoring. Impaired nasal breathing may affect sleep quality and architecture and also the occurrence or aggravation of sleep-disordered breathing (SDB) such as obstructive apnea and snoring.^{2–4} There are several hypothetical mechanisms (e.g., increased airway resistance, elevated inspiratory suction, contribution to unstable oral breathing, effect on nasal reflexes, etc.) that nasal obstruction may cause or worsen SDB.⁵ However, to date, the exact relationships between obstructed nasal airways and sleep, including quality, architecture, obstructive apnea, and snoring, have not been fully established.

Previous studies have suggested that the treatment of impaired nasal breathing may influence sleep quality, architecture, obstructive apnea, and snoring in patients with OSAS and nasal obstruction.^{6–13} However, the effect of surgical correction of nasal obstruction on sleep quality,^{7,11} architecture,^{7,11,13} obstructive apnea,^{6–11,13} and snoring^{10,12,13} is controversial. Moreover, to our knowledge, no information is available regarding the association between nasal surgery alone and the distribution of sleep positions in OSAS with nasal obstruction. Therefore, the purpose of this study was to investigate the efficacy of nasal surgery alone on (1) sleep quality, (2) architecture, (3) position, and (4) SDB, including obstructive apnea and snoring, as measured by polysomnography in patients with OSAS and nasal obstruction.

MATERIALS AND METHODS

Subjects

The study was reviewed and approved by the Institutional Review Board of Korea University Ansan Hospital and informed consent was obtained from subjects. The study population included adults (age ≥ 18 years) who (1) complained of symptoms and/or signs suggestive of OSAS (habitual snoring, witnessed apnea or breathing interruptions, daytime sleepiness, etc.) and nasal obstruction, (2) had been diagnosed with OSAS (apnea-hypopnea index [AHI] of ≥ 5 /hour of total sleep time [TST]) as a result of diagnostic standard polysomnography, (3) had anatomic nasal problems (chronic sinusitis, nasal polyp, nasal septal deviation, inferior turbinate hypertrophy, etc.), (4) did not improve with medical treatment including topical nasal steroids for nasal obstruction or diseases, (5) were treated with nasal surgery, and (6) were evaluated with follow-up standard polysomnography three months after surgery. Subjective excessive daytime sleepiness was assessed using the Epworth sleepiness scale (ESS).

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Polysomnography

All participants underwent a standard (overnight, attended, and laboratory based) polysomnographic evaluation with a computerized polysomnographic device (Alice 4; Respironics, Atlanta, GA). The recorded physiological signals included electroencephalogram, electrooculogram, submental and leg electromyogram, electrocardiogram, airflow at the nose and mouth, chest and abdominal respiratory movements, arterial oxygen saturation (SaO₂) measured with pulse oximetry, snoring, and body position. A sleep technician observed the behaviors of the participants and confirmed their sleep positions using an infrared camera positioned inside the room. All sleep studies were manually interpreted by a sleep technician according to the standard criteria of the American Academy of Sleep Medicine *Manual for the Scoring of Sleep and Associated Events* and were reviewed by certified physicians.¹⁴ Apnea was defined as an absence of airflow for a period lasting at least 10 seconds and hypopnea was defined as an at least 30% reduction in airflow associated with a 4% or greater decrease in SaO₂. The apnea index (AI) was defined as the number of apneic episodes per hour of TST, and the AHI was defined as the number of episodes of apnea and hypopnea per hour of TST. The arousal index (Ari) was defined as the number of arousals per hour of TST. The proportions of time spent in supine and nonsupine sleep positions were expressed as percentages of TST. The proportion of snoring duration was expressed as percentages of TST.

Surgical Treatment

All participants with OSAS and nasal obstruction were treated with nasal surgery. Nasal surgery included endoscopic sinus surgery, septal surgery, and turbinate surgery (submucosal resection with lateralization). Nasal packing was done postoperatively to control bleeding and support the nasal structure (such as nasal septum or sinus). The nasal packing was removed within 2 days after surgery. Four patients with chronic sinusitis, nasal septal deviation, and inferior turbinate hypertrophy were treated with endoscopic sinus, septal, and turbinate surgery. One patient with chronic sinusitis and inferior turbinate hypertrophy underwent endoscopic sinus and turbinate surgery. Seventeen patients with nasal septal deviation and inferior turbinate hypertrophy were treated with septal and turbinate surgery.

Statistical Analysis

All of the data obtained in this study are presented as the means $\pm$ SD (median, interquartile range) for continuous variables. Comparisons between preoperative and postoperative variables were conducted with the paired *t*-test for parametric comparisons and the Wilcoxon signed-rank test for nonparametric comparisons. Statistical analysis was performed using the Statistical Package for the Social Sciences (SPSS) Version 12.0 (SPSS, Inc., Chicago, IL), and a value of $p < 0.05$ was considered statistically significant.

RESULTS

Twenty-two consecutive eligible male patients with a mean age $\pm$ SD of 41.3 ± 10.9 years and a mean body mass index $\pm$ SD of 25.5 ± 2.9 kg/m² were finally included in this study. After nasal surgery alone, ESS score significantly decreased (from 8.8 ± 3.3 [8.0, 3.8] to 6.3 ± 3.3 [6.0, 5.8]; $p = 0.001$) and body mass index did not change (from 25.5 ± 2.9 [25.3, 4.0] to 25.2 ± 2.8 [24.9, 3.6] kg/m²; $p = 0.106$) in patients with OSAS and nasal obstruction.

Sleep Quality Parameters

The sleep quality parameters in patients with OSAS and nasal obstruction before and after nasal surgery are presented in Table 1. Significant increases were found in time in bed (TIB), TST, and sleep efficiency (SE) after nasal surgery. However, there was no significant difference between the preoperative and postoperative Ari.

Table 1 Sleep quality parameters in patients with obstructive sleep apnea syndrome and nasal obstruction before and after nasal surgery ($n = 22$)

Sleep Quality Parameters	Before	After	<i>p</i> Value
Time in bed (min)	455.5 $\pm$ 40.6 (453.5, 58.3)	480.9 $\pm$ 24.8 (479.0, 35.1)	0.009*
Total sleep time (min)	394.0 $\pm$ 40.1 (409.3, 55.8)	430.8 $\pm$ 34.9 (429.3, 47.3)	0.001*
Sleep efficiency (%)	86.6 $\pm$ 6.3 (86.7, 8.8)	89.7 $\pm$ 7.1 (91.4, 8.6)	0.039*
Arousal index (events/hr of TST)	40.4 $\pm$ 16.5 (37.7, 22.6)	36.1 $\pm$ 16.9 (30.3, 16.8)	0.168

Data are means $\pm$ SD (median, interquartile range), * $p < 0.05$.
TST = total sleep time.

Table 2 Sleep architecture parameters in patients with obstructive sleep apnea syndrome and nasal obstruction before and after nasal surgery ($n = 22$)

Sleep Architecture Parameters (% of total sleep time)	Before	After	<i>p</i> Value
Stage N1	28.7 $\pm$ 16.9 (25.2, 19.3)	28.0 $\pm$ 14.5 (24.8, 18.9)	0.760
Stage N2	55.2 $\pm$ 15.6 (59.0, 21.1)	52.3 $\pm$ 11.2 (51.0, 13.9)	0.245
Stage N3	0.7 $\pm$ 1.6 (0, 0.3)	1.1 $\pm$ 2.7 (0, 0.5)	0.284
Stage R	15.3 $\pm$ 4.8 (15.8, 7.7)	18.6 $\pm$ 5.4 (17.9, 6.3)	0.016*

Data are means $\pm$ SD (median, interquartile range), * $p < 0.05$.
N = nonrapid eye movement; R = rapid eye movement.

Sleep Architecture Parameters

The sleep architecture parameters in patients with OSAS and nasal obstruction before and after nasal surgery are shown in Table 2. After nasal surgery, a significant increase in stage R was observed. However, stages N1, N2, and N3 did not change significantly.

Distribution of Sleep Positions

There was no significant change in the proportion of sleep time spent in the supine (from 73.6 ± 23.9 [76.9, 41.6] to 71.5 ± 23.5 [72.5, 36.1]; $p = 0.556$) position after nasal surgery.

SDB Parameters

The SDB parameters in patients with OSAS and nasal obstruction before and after nasal surgery are summarized in Table 3. After nasal surgery, a significant reduction was found in snoring. There were no significant differences in AHI (total, rapid eye movement [REM], non-REM, supine, and nonsupine), AI, or minimum SaO₂.

DISCUSSION

This study confirmed that sleep quality, architecture, and snoring were partially improved, whereas the distribution of sleep positions and obstructive apnea were not changed in OSAS patients with nasal obstruction after nasal surgery alone. In addition, nasal surgery alone significantly improved subjective daytime sleepiness as measured by ESS. As mentioned previously, an ongoing controversy exists regarding the effect of nasal surgery alone on sleep quality, architecture, obstructive apnea, and snoring in OSAS with nasal obstruction.

Table 3 Sleep-disordered breathing parameters in patients with obstructive sleep apnea syndrome and nasal obstruction before and after nasal surgery (*n* = 22)

Sleep-Disordered Breathing Parameters	Before	After	<i>p</i> Value
AHI (events/hr of TST)			
Total	28.9 ± 20.4 (26.1, 25.7)	26.1 ± 21.9 (16.2, 23.0)	0.445
REM	35.9 ± 19.8 (34.6, 32.5)	28.4 ± 20.1 (24.6, 34.3)	0.062
NREM	27.6 ± 21.8 (25.3, 27.9)	25.3 ± 23.2 (17.8, 28.0)	0.592
Supine	35.3 ± 21.6 (31.6, 31.9)	33.4 ± 21.6 (30.0, 33.3)	0.582
Nonsupine	9.4 ± 15.4 (1.3, 11.5)	4.1 ± 8.3 (0.5, 4.5)	0.157
AI (events/hr of TST)	17.6 ± 16.4 (12.5, 17.6)	17.9 ± 14.8 (12.5, 23.1)	0.820
Minimum SaO ₂ (%)	80.6 ± 7.1 (81.5, 8.5)	79.8 ± 8.2 (81.5, 12.5)	0.563
Snoring (%)	32.2 ± 16.4 (29.8, 23.2)	25.8 ± 18.6 (24.4, 30.6)	0.045*

Data are means ± SD (median, interquartile range); **p* < 0.05.

AHI = apnea-hypopnea index; TST = total sleep time; REM = rapid eye movement; NREM = nonrapid eye movement; AI = apnea index; SaO₂ = arterial oxygen saturation.

Sleep quality may be broadly associated with TST, SE, ARI, sleep architecture, and SDB, including obstructive apnea and snoring. However, among these parameters, SE is thought to be a representative indicator of sleep quality or disturbance. SE is defined as the percentage of minutes the person is actually asleep while in bed and is expressed as the ratio of TST to TIB. In this study, SE significantly increased by 3.1% (from 86.6 to 89.7%) after nasal surgery because TST was longer than TIB, while ARI did not significantly change postoperatively. These findings are in accordance with the results of Nakata *et al.*¹¹ who reported that sleep quality (including SE) was significantly improved by isolated nasal surgery in patients with obstructive sleep apnea and nasal obstruction. However, our results are different from those of Series *et al.*⁷ who found that although TST was significantly lengthened, SE did not significantly increase after nasal surgery.

It has also been reported that the effect of nasal surgery alone on sleep architecture in OSAS with nasal obstruction may be variable.^{7,11,13} In the present study, stage R significantly increased by 3.3% (from 15.3 to 18.6%), whereas other stages did not significantly change after surgical treatment of impaired nasal breathing. These outcomes can be explained by two hypotheses. The first is that increased TST as well as SE after surgery may influence the duration of stage R. The other hypothesis is that a reduced postoperative AHI-REM may result in a prolonged stage R because the decreased degree (7.5, from 35.9 to 28.4) of AHI-REM was larger than those (2.3, from 27.6 to 25.3) of AHI-non-REM before and after surgery. A combined effect of the two hypotheses may contribute to the results of the current study. However, our findings are consistent with those of Nakata *et al.*¹¹ but distinct from those of Series *et al.*⁷ Recently, Li *et al.*¹³ showed that no significant changes in any sleep stage were found in OSAS patients with nasal obstruction after nasal surgery alone.

The changes in the distribution of sleep positions before and after surgery is very important because the fluctuation of sleep positions may confound therapeutic outcomes in patients with OSAS.¹⁵ However, to our knowledge, no study that has tried to evaluate the effectiveness of nasal surgery alone on the distribution of sleep positions in OSAS with nasal obstruction. In this study, no significant

changes were observed in the proportion of sleep time spent in the supine and nonsupine position before and after surgery. These results indicated that (1) nasal surgery alone may have no impact on the distribution of sleep positions in OSAS with nasal obstruction and (2) a comparison of various outcomes of the present study may be relatively reliable because there was no bias related to the change of sleep positions after surgery.

Most literature (including this study) that has investigated the effect of nasal surgery on obstructive apnea has reported that there were no significant changes in AI or AHI in patients with OSAS and nasal obstruction after surgery.^{6-9,11,13} In contrast, two other studies reported significant improvement in AI or AHI postoperatively.^{10,16} Rubin *et al.*¹⁶ and Kim *et al.*¹⁰ found that the AI or AHI was significantly reduced after nasal surgery alone. Recently, Li *et al.*¹⁷ evaluated the outcomes of nasal surgery alone for OSAS using meta-analysis and reported that the pooled success rate of nasal surgery alone in managing OSAS was 16.7%. They concluded that nasal surgery alone is insufficient to successfully treat OSAS. Although some clinical research has examined the effect of nasal surgery alone on snoring in OSAS patients with nasal obstruction, little information evaluated by objective assessments (such as polysomnography) is available regarding snoring.^{10,12,13} One of the strengths of our study is that snoring, which was assessed by objective standard polysomnography, was compared before and after surgery. In this study, snoring was significantly reduced (from 32.2 to 25.8%) after nasal surgery. These results support studies that suggested that nasal surgery alone is effective to improve snoring in OSAS with nasal obstruction.^{12,13} However, another study reported that there was no change between preoperative and postoperative snoring.¹⁰ Therefore, further clinical research is needed to clarify the effect of nasal surgery alone on SDB including obstructive apnea and snoring in OSAS patients with nasal obstruction.

This study has a few limitations including the small sample size, the inclusion of various nasal surgeries, and the lack of subjective outcome measures except excessive daytime sleepiness. However, we believe that these objective outcomes in this study contribute to our understanding of the partial effects of nasal surgery alone for OSAS with nasal obstruction.

In conclusion, these findings provide evidence that nasal surgery alone partially influenced the improvement of sleep quality, architecture, and snoring, whereas it did not affect change in the distribution of sleep positions and obstructive apnea in OSAS patients with nasal obstruction.

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