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Effect of endoscopic endonasal skull base surgery on snoring

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Abstract

Background: As the number of endoscopic skull base surgeries has increased, postoperative changes in quality of life require attention, including evaluation of whether snoring symptoms change.

Objective: To investigate the effect of endoscopic endonasal skull base surgery on snoring and nasal symptom scores.

Methods: Between February 2009 and September 2018, 510 patients underwent skull base tumor resection via an endoscopic endonasal approach and were included in this study. Nasal symptoms were scored using the Nasal Obstruction Symptoms Evaluation (NOSE) scale and snoring symptoms were subjectively scored from 0 to 10 by partners using a visual analog scale (VAS). Computational fluid dynamics (CFD) was employed for pilot patient analysis.

Results: A pituitary adenoma was the most common surgical pathology encountered over the past 10 years (81.6% of all tumors). The NOSE scores increased significantly after surgery (pre-surgery, 3.28 ± 3.18; post-surgery, 4.09 ± 3.61; $P < .001$). The snoring VAS score decreased significantly postoperatively (pre-surgery, 2.91 ± 2.74; post-surgery, 2.43 ± 2.45; $P < .001$). A positive correlation was apparent between the NOSE and snoring score changes ($r = 0.374$; $P < .001$).

Conclusions: Snoring improved after endoscopic endonasal skull base surgery, associated with changes in nasal symptoms.

Level of Evidence: 4.

KEYWORDS
endonasal, endoscopic, skull base, snoring

1 | INTRODUCTION

Endoscopic endonasal skull base surgery is commonly used to resect sellar and parasellar tumors. Compared to microscopic approaches, the results are similar, but with fewer complications, shorter hospital stays and surgery times, and less patient discomfort.[1,2] As the number of such surgeries has increased, the postoperative quality of life becomes more important.[3-5] Anatomical changes in the nasal cavity and associated structures are inevitable after surgery.[6] However, few studies have explored the effects of surgery on symptoms, other than olfactory or nose-related changes.[7,8]

Snoring is an audible breathing sound emanating from the upper airway during sleep and generally occurs during inspiration. Snoring prevalence varies widely in the general population (15%-54%), mainly because most studies rely on subjective reports.[9-12] The social problems caused by snoring are underestimated, because snoring is a stigmatizing symptom that is frequently denied; self-perception of snoring is imprecise.[13,14] Females living with male snorers are more

likely to report daytime sleepiness, morning headaches, and fatigue than females who live with non-snorers.[15] Apart from the social problems caused by snoring, upper airway vibration during snoring may trigger pharyngeal neurogenic disease,[16] progression of carotid arterial sclerosis when vibrations are locally transmitted,[9] and sleep disruption associated with respiratory-related wakenings.[17]

During 10 years of experience with endoscopic endonasal skull base surgery, we observed that many patients reported changes in snoring symptoms. Therefore, we investigated the effect of such surgery on snoring and nasal symptom scores.

2 | MATERIALS AND METHODS

This study, and the retrospective chart review, were approved by the institutional review board of our hospital (approval no. KC17RESI0354). Between February 2009 and September 2018, all patients who underwent skull base tumor resection via an endoscopic endonasal approach were included. Revision cases, those undergoing emergency operations, and patients who underwent combined tumor resection and septoplasty or endoscopic sinus surgery were excluded. Of the remaining 663 cases, those lost to follow-up or who did not complete questionnaires were also excluded. Finally, 510 patients were enrolled. Endoscopic endonasal skull base surgeries were performed with two-nostrils/four-hands technique.[18] During surgery, all turbinates including the inferior, middle, and superior turbinates were preserved and lateralized. The posterior portion of the perpendicular plate of the ethmoid bone, the vomer, and the anterior portion of the sphenoidal sinus were removed for better exposure. Septoplasty was not done concomitantly, and the most posterior ethmoid air cells were all removed for a wider sphenoid exposure. All surgeries were performed by S.W. Kim. The anatomical changes result in the surgery was presented in the previous report.[6]

We used Korean National Health and Nutrition Examination Survey for comparing age-matched body mass index analysis between study group and general population. Korean National Health and Nutrition Examination Survey is a nationwide non-institutionalized civilian population-based survey in South Korea. Stratified multistage cluster random sampling designed by the rolling-survey sampling method was used in the survey.[19]

We explored nasal symptom changes using the Nasal Obstruction Symptoms Evaluation (NOSE) scale (total score: 0-20, each category 0-4).[20] The NOSE scale is composed of five categories including nasal congestion or stuffiness, nasal blockage or obstruction, trouble breathing through my nose, trouble sleeping and unable to get enough air through my nose during exercise or exertion ("0" not a problem, and "4" indicated severe problem).

Snoring symptoms were scored subjectively by partners using a visual analog scale (VAS; total score: 0-10). Higher scores indicated more severe snoring. Symptom questionnaires were completed preoperatively and at 6 months postoperatively.

Computational fluid dynamics (CFD) analysis exploring airflow physiology was performed using ICEM-CFD software for grid generation (ANSYS Inc., Canonsburg, Pennsylvania) and 3D CAD software (Rapid Form; INUS Tech. Inc., Suwon, Korea) to degrade the resolution; we also employed a commercial software package (Fluent; ANSYS Inc.). The detailed methods for computational fluid dynamics modeling were conducted according to the previous report.[21]

All data are expressed as means ± SDs. The paired Student's *t* test was used to compare pre- and post-operative changes, and Pearson correlation coefficients were calculated to reveal relationships between changes in NOSE and snoring scores. The Student's *t* test was conducted for analysis the age-matched body mass index. A *P*-value <.05 was considered to indicate statistical significance. All statistical analyses were performed using SAS software (ver. 9.3; SAS Institute, Cary, North Carolina).

3 | RESULTS

The mean patient age was 49.7 ± 15.0 years. There were 268 (52.5%) males (mean age: 50.2 ± 14.8, body mass index: 26.1 ± 4.2) and 242 (47.5%) females (mean age: 49.1 ± 15.3, body mass index: 23.9 ± 4.2) (Table 1). The body mass index of the study groups showed no

TABLE 1 Demographics of enrolled patients

	Male	Female	Total
Enrolled patients (n)	268	242	510
Age	50.2 ± 14.8	49.1 ± 15.3	49.7 ± 15.0
body mass index	26.1 ± 4.2	23.9 ± 4.2	25.0 ± 4.3

TABLE 2 Age-matched body mass index analysis between study group and general population

	Sex	Study group	General population[a]	*P*-value
BMI	Male	26.1 ± 4.2	25.3 ± 2.7	.286
	Female	23.9 ± 4.2	24.8 ± 4.6	.136

[a]Derived from Korean National Health and Nutrition Examination Survey (https://knhanes.cdc.go.kr/knhanes).

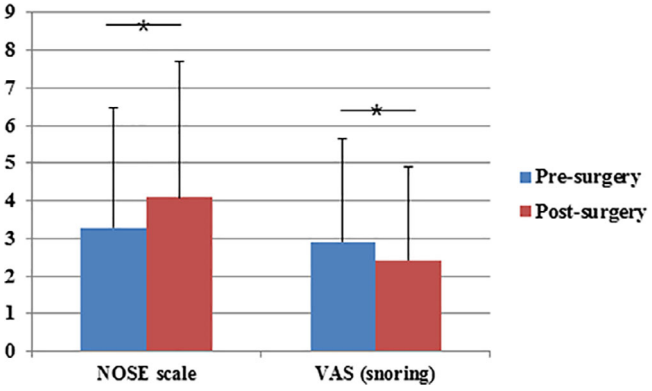

FIGURE 1 Changes in NOSE and VAS scores in patients treated via endoscopic endonasal skull base surgery. *P-value <.001. NOSE: Nasal Obstruction Symptoms Evaluation; VAS: visual analog scale

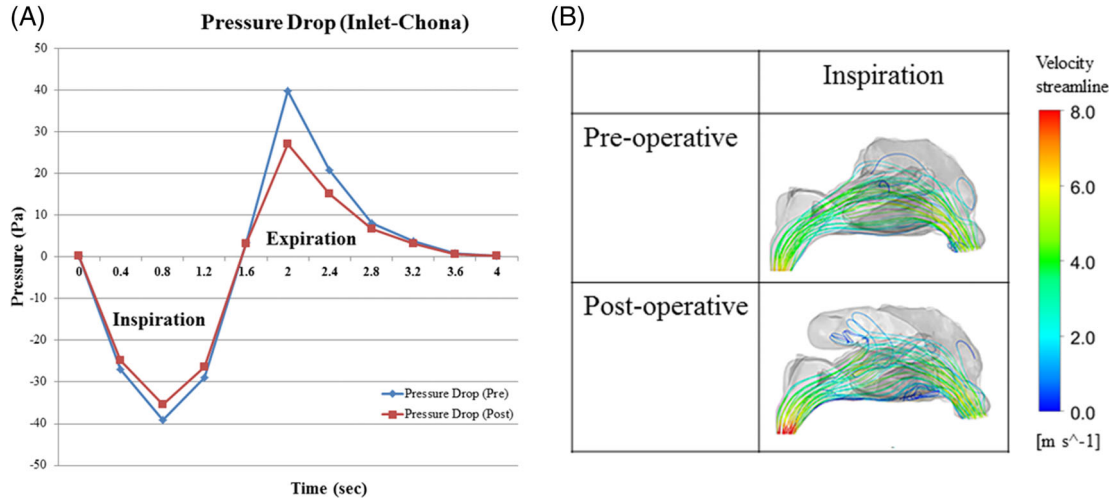

FIGURE 2 Computational fluid dynamics pilot study model before and after surgery on patients in whom snoring improved after surgery. Higher pressure drop and more velocity streamlining during inspiration were calculated especially in the nasopharyngeal area after surgery

statistically differences compared to general Korean body mass index (male; P = .286, female; P = .136) (Table 2). The NOSE scores were significantly elevated after surgery (pre-surgery, 3.28 ± 3.18; post-surgery, 4.09 ± 3.61; P < .001). A total of 134 patients reported improvement in nasal symptoms after surgery, whereas 138 showed no change and 238 showed worsening symptoms. The snoring VAS scores decreased significantly postoperatively (pre-surgery, 2.91 ± 2.74; post-surgery, 2.43 ± 2.45; P < .001). We found a positive correlation between the NOSE and snoring score changes (r = 0.374; P < .001) (Figure 1).

We performed a CFD pilot study before and after surgery on patients in whom snoring improved after surgery. This pilot study showed that pressure drop during inspiration decrease after surgery (Figure 2A). Also, although we observed a turbulent airflow in the anterior portion of the nasal cavity, continuous velocity streamlining was persisted during inspiration (Figure 2B).

4 | DISCUSSION

The nasal cavity anatomy changes after endoscopic endonasal skull base surgery; it is essential to create a secure space for manipulation of surgical instruments, and to establish a visual field. The nasal cavity volume increases significantly after inferior, middle, and superior turbinate outfracture, and tumor removal.[22] Endoscopic sinus surgery and turbinoplasty widen the nasal cavity to some extent; there have been several reports of improved snoring and sleep quality after nasal surgery.[23-25] Endoscopic endonasal skull base surgery changes the nasal cavity to a greater extent than septoturbinoplasty or endoscopic sinus surgery,[6] and thus may also affect sleep quality and snoring.

However, an enlarged nasal cavity does not always yield good results. In most cases, although the nasal cavity mucosa heals by 6 months postoperatively, patients usually complain of nasal stuffiness after such surgery, possibly reflecting a dry nasal mucosa. After the nasal cavity is enlarged, the amount of inspired air in contact with the nasal mucosa decreases. Thus, air may be inadequately humidified during passage through the nasal cavity. Therefore, patients could experience nasal stuffiness symptom in this aspect.

Alternatively, surgery may render inspiration turbulent. The typically linear alignment of the turbinates renders the inspired airflow near-laminar. However, anatomical changes may create some turbulence. This CFD pilot study might explain, at least in part, the effects of surgery-induced changes in the nasal anatomy on snoring. However, this does not explain the positive correlation between nasal symptom and snoring changes. More work on the relationship between subjective symptom changes and changes in airflow dynamics is required.

The strengths of our study include the fact that the same surgeon performed the same procedure on a relatively large number of patients. Thus, surgical techniques and operator variables that might affect the results were controlled. The limitations include the fact that questionnaires were completed only once (at 6 months), and the retrospective nature of the study; the results are thus less reliable than those of randomized control studies.

Additional work is required to objectively evaluate changes caused by nasal endoscopic cranial surgery on sleep apnea; this might also allow development of a nasal cavity treatment exploiting airflow and volume changes.

5 | CONCLUSION

Snoring often improved after endoscopic endonasal skull base surgery, associated with nasal symptom changes. A larger study including aerodynamic modeling and polysomnographic evaluation could identify the mechanism underlying both nasal anatomical and sleep-related changes.

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CONFLICT OF INTEREST

The authors declare no potential conflict of interest.

DISCLOSURE OF INTERESTS

The sponsors had no role in the study design, data collection and analysis, decision to publish, or preparation of the article.

AUTHOR CONTRIBUTIONS

D.H.K.: study conception and design, acquisition of data, analysis and interpretation of data, drafting the article and revisions, final approval of article; M.H.L.: study conception and design, analysis and interpretation of data, drafting the article and revisions, final approval of article; J.L.: acquisition of data, analysis and interpretation of data, drafting the article and revisions, final approval of article; S.W.K.: study conception and design, acquisition of data, analysis and interpretation of data, drafting the article and revisions, final approval of article.

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