

OBJECTIVE ASSESSMENT OF NASAL OBSTRUCTION IN SNORING AND OBSTRUCTIVE SLEEP APNEA PATIENTS: EXPERIENCE OF A POLICE AUTHORITY HOSPITAL

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Background: The role of nasal airflow resistance in the pathogenesis of obstructive sleep apnea (OSA) syndrome remains contentious. The aim of this study was to investigate the changes in apnea index in response to nasal surgery, as guided by acoustic rhinometry.

Patients and Methods: Forty-five patients were referred for complaints of snoring and nasal obstruction. The patients were divided into two groups according to the severity of nasal obstruction: group 1 (nasal obstruction was the predominant symptom) included 21 patients, and group 2 (snoring was the predominant symptom) included 24 patients. In group 1, nasal surgery was performed as a first surgical procedure and was followed after 10-12 weeks by palatal surgery. In group 2, palatal surgery was performed as the primary procedure and was followed after 10-12 weeks by nasal surgery.

Results: The results showed a clear relationship between the correction of nasal obstruction and the severity of OSA, as indicated by measuring the apnea index (AI). However, in none of the group 1 cases was nasal surgery alone capable of reducing the AI by 50%. In group 2, palatal surgery effectively reduced AI, and when followed by nasal surgery, the reduction in AI was again statistically significant.

Conclusion: This indicates that nasal obstruction could be considered a contributing factor to the severity of OSA, but not a causative factor in the production of OSA. It also indicates that nasal surgery and palatal surgery combined are effective in improving snoring and OSA in properly selected patients.
Ann Saudi Med 2002;22(3-4):158-162.

Key Words: Nasal obstruction, snoring, sleep apnea.

The nose acts as a variable resistor, and may account for as much as 40% of total airway resistance.¹ The efficiency of the nose as an airway can be expressed from the following formula: $R = K(PLVN/D^4)$, (where R = resistance, K = constant, P = gas density, L = tube length, N = velocity of flow, V = volume of the tube, and D = tube diameter).¹ As described by Poiseuille's law, airflow through the nose is proportional to the radius of the nasal passages raised to the 4th power. Thus, small changes in the cross sectional area may, theoretically, lead to exponential effects on nasal resistance.²

As regards the pathogenesis of obstructive sleep apnea (OSA), there are two basic important elements involved: one is related to upper airway function (the interaction of intraluminal pressure of the pharynx and the action of upper airway dilator muscles); and the second is related to upper airway anatomical obstruction (decreased cross-sectional

critical value.^{3,4} Evidence of the role of nasal obstruction in OSA has appeared in the literature as early as the late 1800s. In 1892, Carpenter noted the association between disturbed sleep and impairment of daytime intellectual performance and memory. He attributed this impairment to nasal obstruction. In 1898, Wells described OSA patients in whom daytime hypersomnolence was improved when their nasal obstruction was corrected,⁴ however, the role of nasal obstruction in the etiology of sleep apnea remains controversial in the literature.⁵ In 1992, Kerr et al⁶ studied the effect of nasal vasoconstrictor and insertion of vestibular stents to dilate the valvular area, and showed no improvement of the architecture of sleep, incidence of apnea periods, or blood oxygenation. No significant correlation between nasal resistance and snoring was also reported by Milijeteig et al in 1993,⁷ and nasal surgery was less successful in the management of OSA.⁸ On the other hand, nasal surgery was reported to reduce snoring, subjectively in 77% of patients with nasal obstruction,⁹ and in variable ratios in a number of other studies.^{3,10,11}

Nasal obstruction is basically a matter of degree that is still expressed in many ENT clinics in a "+" on a numerical scale. Nasal endoscopy and medical imaging, although providing valuable information as to the anatomical variations of the nose, do not quantify nasal obstruction. Therefore, correlating the objective parameters of respiratory disturbances during sleep (apnea index and/or apnea/hypopnea index) to objective parameters of nasal obstruction (minimal cross-section area, nasal resistance)

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Accepted for publication 25 March 2002. Received 13 October 2001.

area).³ In general, pharyngeal collapse occurs when the subatmospheric pharyngeal pressure generated during inspiration exceeds by some critical value the stabilizing forces generated by contraction of the upper airway dilator muscles. The airflow resistance upstream to the pharynx (nasal resistance) is of importance in the generation of this

should alleviate statistical bias and help to reach a valid and reliable relationship. The aim of this study was to investigate the changes in respiratory disturbance parameter (apnea index) in response to nasal surgery as guided, objectively, by acoustic rhinometry.

Patients and Methods

This study comprised 45 patients who were referred for the complaints of snoring and nasal obstruction. The patients were divided into two groups according to the severity of nasal obstruction: group 1 comprised 21 patients in whom nasal obstruction was a predominant symptom for more than two years; and group 2 comprised 24 patients in whom snoring was a predominant symptom, with less predominant nasal obstruction of less than two years. All patients went through the following process:

- Questionnaire: during the initial review, the attending physician completed a questionnaire which included questions on duration of nasal obstruction, symptoms of nasal allergy or infection, specific questions on snoring (how loud), daytime sleepiness (evaluated using an Arabic translation of Epworth Sleepiness scale), cognitive and neuropsychological symptoms, sleep history and sleep habits and history of risk factors (cardiovascular problems, endocrine disturbances, chest problems, etc). Postoperative subjective evaluation was performed 4-6 weeks after completing each surgical procedure with attention to the symptoms of snoring, daytime sleepiness and nasal obstruction.
- General examination: for height, weight, body mass index (BMI), blood pressure, neck size and facial skeletal abnormalities.
- ENT examination: complete ENT examination with flexible naso-endoscopy when needed.
- Lateral cephalometry (LCR): both bone and soft tissue windows.¹²
- Muller’s maneuver: the Muller maneuver consists of forced inspiratory effort with the mouth and nose closed during fiberoptic-nasopharyngoscopy.
- Acoustic rhinometry: used to measure the minimal nasal cross-section area (MCA) and nasal resistance equivalent (Req), before and after nasal surgery.
- Polysomnography: using portable system (Intercare Technologies, SAM System). It records nasal airflow, respiratory effort, oxygen saturation, pulse rate, snoring, apneas (obstructive, mixed and central) and desaturations. Results are analyzed by IBM compatible computer software to give a number of reports. Apnea index is defined as the number of apneas per hour for the entire analyzed patient file. Polysomnography was performed before and 4-6 weeks after the first surgical maneuver and 4-6 weeks after the second surgical maneuver.

Criteria for Patient Selection

1. BMI for all patients selected was below 30 (mean BMI was 27.3)
2. No facial skeletal abnormality as evidenced by clinical examination and LCR.
3. Muller’s maneuver of grade 1 or 2
4. Objective evidence of nasal obstruction as shown by acoustic rhinometry as evidenced by decrease of minimal cross-section area at I or C notch below normal limits, with corresponding increase of nasal resistance equivalent (Req).
5. Apnea index (AI) is $\neq < 25$ per hour of sleep with no or minimal central apnea index.

Surgical Techniques

1. Laser-assisted uvulopalatoplasty (LAUP)¹³: In snorer non-apneic patients and mild OSA patients who performed tonsillectomy at an earlier occasion.
2. Uvulopalatopharyngoplasty (UPPP): with or without tonsillectomy in mild to-moderate OSA (mild OSA where AI=5-10/hour and moderate OSA= 10-40/hour^{14,15}).
3. Laser-assisted outpatient septoplasty (LAOS)¹⁶: for septal deviations obstructing less than 1/2 the nasal cavity.
4. Corrective septoplasty^{17,18}: for septal deviations obstructing more than 1/2 the nasal cavity.
5. Laser inferior turbinate mucotomy¹⁹: where the inferior turbinates were the cause of nasal obstruction, either primary or associated with deviated septum on the wide side.

In group 1, nasal surgery was performed as a first surgical procedure and was followed after 10-12 weeks by palatal surgery, while in group 2, palatal surgery was performed as the primary procedure and was followed 10-12 weeks by nasal surgery. Postoperative polysomnography done during the primary procedure was considered as the preoperative reading to the second procedure, i.e, three polysomnography settings were performed per patient.

Results

Subjective Evaluation

In group 1, snoring was improved in 15 patients (71.4%) after primary nasal surgery, and continued to

TABLE 1. Basic statistics for patients included in group 1.

	Mean	SD
MCA-preoperative	0.272	0.0650
Req-preoperative	6.193	1.948
AI-prenose	14.619	3.879
AI-postnose	11.619	2.655
MCA-postoperative	0.665	0.122
Req-postoperative	1.685	0.591
AI-post LAUP	6.286	2.513

TABLE 2. Basic statistics for patients in group 2.

	Mean	SD
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MCA-prenose	0.590	0.146
Req-prenose	2.114	0.968
AI-pre LAUP	8.292	1.398
AI-post LAUP	4.833	1.049
MCA-postnose	0.789	0.166
Req-postnose	1.061	0.443
AI-postnose	2.000	1.216

improve (95.2%) after palatal surgery. Fifteen patients in this group gave positive preoperative history of daytime sleepiness, seven patients (46.7%) reported improvement after nasal surgery, after secondary palatal surgery, and 13 patients (86.7%) reported improved daytime sleepiness.

In group 2, 21 patients (87.5%) reported improved snoring after primary palatal surgery, after secondary nasal surgery, and 22 patients (91.7%) reported improved snoring. Daytime sleepiness was reported preoperatively in 12 patients, of whom eight (66.7%) reported improvement after primary palatal surgery. Ten patients (83.3%) reported improved daytime sleepiness after secondary nasal surgery.

Objective Evaluation

Basic statistical results for group 1 patients are as shown in Table 1.

Statistical analysis was done using Jandel Sigma Stat (version 2) software. Mann-Whitney Rank Sum test was applied to test the significance of postoperative changes and in all cases $P=$ or <0.005 , indicating statistically significant changes. Comparing apnea index before and after nasal surgery, $P=0.005$, indicating a statistically significant reduction of the number of apneas per hour sleep. Apnea index was reduced significantly after performing palatal surgery ($P<0.001$). Regression analysis is the method whereby the links between variables are estimated.²⁰ Multiple regression analysis was applied to test the relationship between apnea index after nasal surgery (as a dependent factor) and minimal cross-section area of the nose (MCA) and resistance equivalent (req.) as independent factors. It showed that the dependent variable can be predicted from a linear combination of the independent variables power of performed test, with $\alpha=0.050$: 0.211. The power of the performed test (0.211) is below the desired power of 0.800 (where normality test was Passed ($P=0.426$) and Constant Variance Test was Passed ($P=0.097$)).

Basic statistical results for group 2 patients are as shown in Table 2.

Mann-Whitney Rank Sum test was applied to test the significance of apnea index before and after palatal surgery. P was <0.001 , indicating a statistically significant change. Comparing apnea index before and after nasal surgery, $P<0.001$, indicating a significant change in apnea index in response to nasal surgery. Multiple regression analysis was performed to test the relationship between nasal parameters for nasal obstruction (MCA and Req.) as independent variables, and apnea index after nasal surgery as a

dependent variable. It showed that the dependent variable can be predicted from a linear combination of the independent variables with normality test Passed ($P=0.159$) and constant variance test Passed ($P=0.167$). The power of the performed test (0.115) is below the desired power of 0.800, i.e. a significant relationship exists between nasal obstruction and apnea index.

Discussion

Investigations on the pathophysiology of obstructive sleep apnea (OSA) since the late 1970s have enhanced our understanding of the etiology of the condition, but to date, no single pathophysiologic mechanism has been identified. Thus, it is understood that the cause of OSA is multifactorial in any one individual or differs in different patients. A questionnaire as a measure of symptoms is subjective and its reliability can be suspicious,^{21,22} however it is believed that explaining the objective parameters of the different diagnostic tests in the light of the patient's own evaluation of his symptoms adds to the patient's convenience and satisfaction of the results obtained.

Total nasal resistance does not change on transition from wakefulness to sleep,²³ therefore, correlating objective parameters of nasal obstruction measured in the awake patient to respiratory disturbance indices measured during sleep would be of value in assessing the role played by nasal obstruction in the pathogenesis of OSA.

The effect of nasal spurs in changing airflow patterns, possibly leading to local turbulence and ciliary stasis, has to be considered and if eddying in proximity to a septal spur is of such an extent to alter nasal physiology, the components of nasal airflow turbulence might be expected to increase and for this to reveal itself as an increase in airway resistance.²⁴

Acoustic rhinometry has been proved to be suitable for the evaluation of the nasal cavity in cases of septal deviations and inferior turbinate hypertrophy, as well as for the postoperative follow-up. Moreover, acoustic rhinometry can clearly determine the exact size and location of the different stenoses in the nasal cavity that contribute to increased nasal resistance.²⁵⁻²⁷ (Figures 1,2).

The results of this study show a clear relationship between the correction of nasal obstruction and the severity of OSA as indicated by measuring the apnea index (AI).

FIGURE 1. Acoustic rhinogram of a snoring patient with inferior turbinate hypertrophy.

FIGURE 2. Acoustic rhinogram of a snoring patient with marked deviation of the septum.

However, in none of the cases in group 1 was nasal surgery alone capable of reducing the AI by 50%, indicating that nasal surgery alone, even when nasal obstruction is the predominant symptom, may not be enough to produce a recognizable improvement. In group 2,

palatal surgery effectively reduced AI, and when followed by nasal surgery, the reduction in AI was again statistically significant. This indicates that nasal obstruction could be considered a contributing factor to the severity of OSA but not in itself a causative factor. This was explained by Hudge²⁸ in terms of the differences between the mechanical behavior of the nasal and pharyngeal airways in that, whereas the pharyngeal resistance changes on transition from wakefulness, nasal resistance does not. Moreover, nasal resistance within the right and left sides of the nose may fluctuate in a fashion independent of gravity (nasal cycle), but since the two nasal cavities are arranged in parallel, a large increase in resistance on one side of the nose will not, effectively, affect total nasal resistance.

A review of the literature²⁹⁻³³ and the results of this study show that nasal surgery and palatal surgery combined are effective in improving snoring and OSA in properly selected patients. The beneficial effects of nasal surgery on OSA have been reported by others.³²⁻³⁵ These reports, together with the findings of this study indicate that a careful assessment and management are required in any case of obstruction of the upper airways.

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