ORIGINAL ARTICLE

Sleep Science

Evaluation of sleep quality and risk of obstructive sleep apnea in patients referred for aesthetic rhinoplasty

Lucas Kenzo Miyahara[1]
Renato Stefanini[1]
Vinicius Magalhães Suguri[1]
Guilherme Henrique Wawginiak[1]
Rafael de Andrade Balsalobre[1]
Fernanda Louise Martinho Haddad[1]

[1] Universidade Federal de São Paulo, Department of Otolaryngology and Head and Neck Surgery - São Paulo - São Paulo - Brazil.

ABSTRACT

Importance: Aesthetic rhinoplasty is the fifth surgical procedure most performed worldwide by plastic surgeons. With the growing demand for rhinoplasty, there is an unmet need for research into the profile of patients who seek aesthetic nasal surgery in an attempt to improve not only cosmetic dissatisfactions, but also the manifestations of other, possibly interrelated disorders, especially sleep disturbances. **Objective:** To evaluate the sleep quality and the risk of Obstructive Sleep Apnea in patients referred for aesthetic rhinoplasty, as well as the association of these conditions with nasal symptoms. Design: Cross-sectional study performed at the period of June/2016 to August/2017. Setting: Department of Otolaryngology and Head and Neck Surgery - Universidade Federal de São Paulo. Participants: Patients of both sexes, aged 18 to 65 years, who were referred for aesthetic rhinoplasty. We evaluated 46 patients, two of whom were excluded because they were outside the inclusion age criteria. Main Outcome(s) and Measure(s): Anterior rhinoscopy and the following validated surveys were used. Pittsburgh Sleep Quality Index; Epworth Sleepiness Scale; Nasal Obstruction Symptom Evaluation scale; Berlin Questionnaire. The visual analog scale for snoring was also used. **Results:** Of the 44 participants, 18 (41%) were males and 26 (59%) were females. 82% had poor sleep quality. 46% presented excessive daytime sleepiness. There was a high risk for Obstructive Sleep Apnea in 27%. Regarding to nasal symptoms, the mean score in the Nasal Obstructive Symptoms Evaluation was 66.25±25.38. When comparing the groups with good and poor sleep quality, we observed a higher risk for Obstructive Sleep Apnea (p=0.05) in patients with poor sleep quality. Patients at high risk for Obstructive Sleep Apnea had higher scores on the Nasal Obstructive Symptoms Evaluation (p=0.001) and on the analogue snoring scale (p<0.001) compared to patients at low risk. **Conclusions:** We observed a high occurrence of poor sleep quality in participants. All participants who were at high risk for obstructive sleep apnea were also classified as having poor sleep quality. An association was also observed between the presence of high risk for obstructive sleep apnea and presence of nasal symptoms.

Keywords: Rhinoplasty; Sleep; Sleep Apnea, Obstructive.

Corresponding author:
Lucas Kenzo Miyahara.
E-mail: lkenzomiya@gmail.com
Received: June 12, 2018; Accepted: August 24, 2019.

DOI: 10.5935/1984-0063.20190077

INTRODUCTION

Aesthetic rhinoplasty is becoming increasingly popular, and is currently the fifth surgical procedure most performed worldwide by plastic surgeons, according to the International Society of Aesthetic Plastic Surgery (ISAPS). It is often observed that patients referred for rhinoplasty have not only cosmetic impairments, but also craniofacial and nasal abnormalities commonly found in patients with sleep-disordered breathing, particularly the obstructive sleep apnea (OSA)[1-5].

Patients with OSA have a higher incidence of hypertension and are at higher risk of heart disease (including atrial fibrillation and heart failure) and cerebrovascular disease (specifically stroke)[6-8], in addition to poor sleep quality, which leads to cognitive impairments and excessive daytime sleepiness; these, in turn, have a negative impact on quality of life.

Poor sleep quality, which has a prevalence of 8 to 18% in the general population[9] is itself strongly associated with cardiovascular diseases (CVD)[10,11] and all-cause mortality[12-14]. Studies suggest that poor sleep quality is a risk factor for worsening of CVD, and may also be an important marker of cardiovascular health[11]. There are proven relationships between poor quality and duration of sleep and a number of independent risk factors for coronary artery disease[15], such as hypertension[16], diabetes mellitus[17], and obesity[18].

With the growing demand for rhinoplasty, there is an unmet need for research into the profile of patients who seek aesthetic nasal surgery in an attempt to improve not only cosmetic dissatisfactions, but also the manifestations of other, possibly interrelated disorders, especially sleep disturbances. There is a dearth of studies on this ever-growing patient population. Few studies have been published focused on patients who presented with symptoms suggestive of OSA and were found to have functional alterations in nasal anatomy which warranted aesthetic-functional rhinoplasty. Conversely, the impact of such abnormalities on sleep quality in patients who seek treatment with a primary complaint of aesthetic dissatisfaction is unknown.

The objective of this study was to evaluate sleep quality and risk of OSA in patients referred for rhinoplasty with a primary complaint of aesthetic dissatisfaction, as well as to evaluate the association of poor sleep quality and increased risk for OSA with nasal symptoms.

METHODS

This was a cross-sectional, observational study of patients referred consecutively to the outpatient Otorhinolaryngology and Head and Neck Surgery clinic of Escola Paulista de Medicina - Unifesp, São Paulo, Brazil, for rhinoplasty. Data were collected from June 2016 to August 2017. Patients of both sexes, aged 18 to 65 years, who were referred for rhinoplasty with a major complaint of aesthetic dissatisfaction and had no decompensated clinical or psychiatric conditions were eligible for recruitment. Patients with a history of treatment for OSA in the preceding 3 months, current use of sedative or stimulant medications, and any decompensated organic disease were excluded.

Participation in the study was voluntary. Those who accepted to participate in the study signed an informed consent form approved by the Ethics Committee of Universidade Federal de São Paulo (UNIFESP) under CAAE no. 62650916.7.0000.5505 (approval issued in opinion no. 1,907,733).

All participants were assessed before rhinoplasty. During the initial assessment, anterior rhinoscopy was performed to evaluate for nasal septal deviation, which, if present, was classified as grade I, II, or III. Deviations in which the septum did not touch the inferior turbinate were classified as grade I; those in which the septum touched the inferior turbinate, as grade II; and those in which the septum compressed the inferior turbinate and touched the lateral nasal wall, as grade III. Grade II and III deviations were considered obstructive. Weight and height were also measured for calculation of the body mass index (BMI).

Patients then completed the following questionnaires: Pittsburgh Sleep Quality Index (PSQI)[19], Epworth Sleepiness Scale (ESS)[20], Nasal Obstruction Symptom Evaluation (NOSE) scale[21], Berlin Questionnaire (BQ)[22], and a visual analogue scale for Snoring.

The PSQI is an instrument designed to provide a subjective evaluation of sleep quality. The questionnaire consists of 19 self-administered questions and 5 items to be scored by bedmates roommates. The latter are only used for clinical information. The 19 questions are grouped into 7 components, with weights distributed on a scale of 0 to 3. These components are: subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleep medication, and daytime dysfunction. The scores of these components are added to yield a score, ranging from 0 to 21; higher scores indicate worse sleep quality. A PSQI score <5 denotes "good sleep quality", while PSQI ≥ 5 indicates "poor sleep quality".

The ESS is a subjective questionnaire used to assess daytime sleepiness. A score equal to or greater than 10 denotes "excessive daytime sleepiness".

The NOSE is a validated questionnaire used to determine the subjective perception of nasal obstruction. The questionnaire includes five items related to nasal congestion, nasal obstruction, difficulty breathing through the nose, difficulty sleeping, and limitations to the practice of physical activity. The patient rates each item from 0 to 4, according to symptom severity. The sum of the item score is multiplied by 5 to yield a result on a scale of 0 to 100, which is easier to interpret.

The BQ screens for OSA. This questionnaire includes 10 items organized into three categories: snoring and apnea events (5 items), daytime sleepiness (4 items), and hypertension/obesity (1 item). A patient is considered to be at high risk of OSA if two or more categories have a positive score, or low risk when only one or no category has a positive score.

In the present, study, a visual analogue scale was also used for subjective evaluation of snoring. On this scale, patients are asked to mark their subjective state on a continuous straight line graded from 0 to 10. The intensity and presence of snoring

was evaluated according to the score selected by each participant.

On the basis of the data obtained from each of the applied instruments, participants were classified as having "good" or "poor" sleep quality. Excessive daytime sleepiness was categorized dichotomously as present or absent. Finally, patients were stratified as having high or low risk for OSA.

Statistical analysis was performed in IBM SPSS Statistics for Windows, Version 21.0 (Armonk, NY: IBM Corp), considering 95% confidence intervals and a significance level of 5% ($p<0.05$). Continuous data were expressed as means and standard deviations using the general linear model (GLM). Categorical data were represented as absolute and relative frequencies and compared by the chi-square test. Pairwise comparisons were carried out between participant groups with good *vs.* poor sleep quality; with *vs.* without excessive daytime sleepiness; and at high *vs.* low risk of OSA.

RESULTS

Overall, 46 patients were recruited. Two were excluded because they were outside the target age group and did not meet the inclusion criteria. Of the 44 participants enrolled in the study, 18 (40.9%) were men and 26 (59.1%) were women, with a mean age of 29.13±11.26 years and a mean BMI of 23.40±3.80; thus, the sample consisted predominantly of young adults in their optimal weight range.

On the PQSI, 36 participants (81.8%) had poor sleep quality (score >5). The mean PQSI score was 7.68±3.83. As for the Epworth Sleepiness Scale, 20 participants (45.5%) were classified as having excessive daytime sleepiness (score >9). The mean ESS score was 9.02±4.80. The mean visual analogue scale score of snoring was 3.88±2.83. The Berlin Questionnaire identified a high risk of OSA in 12 participants (27.3%). Regarding nasal symptoms, the mean NOSE score was 66.25±25.38. Nine participants (20.5%) had grade II nasal septal deviations, and 25 (56.8%) had grade III deviations.

Clinical data and instrument scores for the sample as a whole are shown in Table 1.

Comparison of the groups with good *vs.* poor sleep quality revealed a significantly greater number of women ($p=0.03$) and a higher risk of OSA, as assessed by the Berlin sleep questionnaire ($p=0.05$), in participants with poor sleep quality (Table 2).

Patients at high risk of OSA had higher scores on the NOSE instrument ($p=0.001$) and visual analogue scale of snoring ($p<0.001$) as compared to patients with low risk of OSA (Table 3).

However, when the groups with and without excessive daytime sleepiness were compared, there were no statistically significant differences in any parameters, except for a greater number of women in the excessive daytime sleepiness group ($p=0.05$) (Table 4).

Table 1. Description of the subjects referred for rhinoplasty.

Sample	n = 44
Gender, n (%)	
Female	26 (59)
Male	18 (41)
Age, mean (SD), years	29.1 (11.3)
BMI[a], mean (SD), Kg/m^2	23.4 (3.8)
ESS[b], mean (SD)	9 (4.8)
PSQI[c], mean (SD)	7.7 (3.8)
NOSE[d], mean (SD)	66.3 (25.4)
Visual Analog Scale, mean (SD), cm	3.9 (2.8)
Septal deviation, n (%)	
Grade II	9 (21)
Grade III	25 (57)
Berlim [+e], n (%)	12 (27)

[a] BMI=body mass index
[b] ESS=Epworth sleepiness scale
[c] PSQI=Pittsburgh sleep quality index
[d] NOSE=Nasal obstruction symptom evaluation
[e] Positive Berlin questionnaire

DISCUSSION

Poor sleep quality was highly prevalent in this sample of patients referred for aesthetic rhinoplasty. This supports investigation of possible sleep disorders in this patient population. It is well established that poor sleep quality can be multifactorial[19,23]. However, nearly one-third of patients in the sample were at high risk of OSA, all of whom were allocated to the "poor sleep quality" group, suggesting that the sleep symptoms reported by these patients who sought rhinoplasty for purely aesthetic complaints were at least partly attributable to the presence of sleep-disordered breathing.

An association was also observed between the presence of high risk for OSA (positive BQ) and presence of nasal symptoms (assessed by the NOSE questionnaire). This finding suggests that nasal abnormalities could be one of the factors related to the possible presence of sleep-disordered breathing in these patients. The role of nasal function in the pathogenesis of sleep apnea is not entirely clear, but some theories may explain this possible association.

One such theory is that the increased inspiratory effort that occurs in patients with nasal obstruction increases negative pressure, leading to pharyngeal collapse[24]. Another theory takes into account the concept that nasal obstruction leads to a pattern of mouth breathing; this pattern, when chronic, causes the mandible to displace inferiorly and posteriorly, so that the pharynx becomes narrower and elongated[24,25]. This shape generates faster-than-normal airflow and increases intraluminal negative pressure, again leading to airway collapse.

The high prevalence of poor sleep quality and increased risk of OSA is particularly striking given the age group represented in the present study. The prevalence of OSA is highest between the fourth and fifth decades of life, while our sample

Table 2. Comparison of the groups with good vs. poor sleep quality.

	Good sleep quality (n = 8)	Poor sleep quality (n = 36)	*p*
Age, mean (SD), years	31.4 (12.2)	28.6 (11.2)	0.54
BMI[a], mean (SD), Kg/m^2	22.4 (3.5)	23.6 (3.9)	0.43
ESS[b], mean (SD)	9.23 (4.9)	9 (4.8)	0.88
NOSE[c], mean (SD)	62.5 (17.1)	67.1 (27)	0.65
Visual Analog Scale, mean (SD), cm	3.4 (3)	4 (2.8)	0.57
Gender, n (%)			
Female	2 (25)	24 (67)	0.03*
Male	6 (75)	12 (33)	
Berlim +[d], n (%)	0	12 (33)	0.05*
Septal deviation, n (%)			
Grade II	2 (10)	18 (90)	0.19
Grade III	1 (11)	8 (88)	0.53

[a] BMI=body mass index.
[b] ESS=Epworth sleepiness scale.
[c] NOSE=Nasal obstruction symptom evaluation.
[d] Berlin +=Positive Berlin questionnaire.
*p<0.05

Table 3. Comparison of the groups with vs. without high risk for obstructive sleep apnea (OSA).

	Low risk for OSA (n = 32)	High risk for OSA (n = 12)	*p*
Age, mean (SD), years	30.2 (12)	26.3 (8.7)	0.31
BMI[a], mean (SD), Kg/m^2	22.8 (3.5)	25.1 (4.1)	0.07
ESS[b], mean (SD)	8.9 (4.9)	9.3 (4.7)	0.79
PSQI[c], mean (SD)	7.1 (4.1)	9.3 (2.7)	0.08
NOSE[d], mean (SD)	58.9 (24.6)	85.8 (15.6)	0.001*
Visual Analog Scale, mean (SD), cm	2.9 (2.5)	6.5 (1.8)	< 0.001*
Gender, n (%)			
Female	20 (63)	6 (50)	0.45
Male	12 (37)	6 (50)	
Septal deviation, n (%)			
Grade II	14 (70)	6 (30)	0.71
Grade III	5 (56)	4 (44)	0.19

BMI=body mass index
[b] ESS=Epworth sleepiness scale
[c] PSQI=Pittsburgh sleep quality index
[d] NOSE=Nasal obstruction symptom evaluation
*p<0.05

was composed of younger individuals. This finding suggests that younger adults may have factors that might precipitate the onset of sleep-disordered breathing and, if left untreated, might lead to worse presentations in the future. It is believed that chronic nasal obstruction may lead to the development of myofunctional changes over the life course, and that these changes could be risk factors for the development of OSA in adulthood, as observed in an epidemiological study conducted by Oliveira et al. in 2015[26]. The association between the high risk for OSA (Berlin-positive status) and presence of nasal symptoms in our sample also corroborates the findings of Young et al. (1997)[27] who suggested that nasal obstruction is a risk factor for sleep disorders, although there is no linear association between the degree of obstruction and the severity of these disorders.

Although it is well known that nasal changes may be part of the pathophysiology of OSA, nasal surgical procedures are associated with improvement in sleep quality, but limited impact on respiratory events (apnea and hypopnea). Some studies[28-31], including a meta-analysis conducted in 2011[28], have endorsed significant improvement in subjective parameters of daytime sleepiness and snoring in patients with OSA, but there is no polysomnographic benefit of isolated nasal surgery when considering the Apnea–Hypopnea Index (AHI). These results support the theory that OSA is multifactorial; therefore, rhinoplasty alone would not be enough to "cure" it in terms of minimizing the AHI. Proper selection of patients who would benefit from nasal surgical treatment is extremely important overall and particularly crucial for surgical success. Li et al.[32] showed that patients with lower BMI, less daytime sleepiness, and lower Friedman tongue position grade had better surgical success rates than others. Shuaib et al.[33] also observed a greater reduction in apnea and hypopnea events and a higher rate of surgical success in patients with a BMI <30 kg/m^2. There are no published studies of aesthetic rhinoplasty in patients with OSA.

Table 4. Comparison of the groups with vs. without excessive daytime sleepiness.

	Without daytime sleepiness (n = 24)	With daytime sleepiness (n = 20)	*p*
Age, mean (SD), years	29.5 (12.1)	28.7 (10.5)	0.81
BMIa, mean (SD), Kg/m^2	23.7 (3.7)	23 (4)	0.56
PSQIb, mean (SD)	7.4 (3.5)	8 (4.3)	0.62
NOSEc, mean (SD)	69 (25.5)	63 (25.5)	0.44
Visual Analog Scale, mean (SD), cm	43.8 (29.5)	33 (26.4)	0.21
Gender, n (%)			
Female	11 (46)	15 (75)	0.05*
Male	13 (54)	5 (25)	
Berlin +[d], n (%)	7 (29)	5 (25)	0.75
Septal deviation, n (%)			
Grade II	13 (65)	7 (35)	0.20
Grade III	4(44)	5 (56)	0.49

[a] BMI=body mass index.
[b] PSQI=Pittsburgh sleep quality index
[c] NOSE=Nasal obstruction symptom evaluation.
[d] Berlin +=Positive Berlin questionnaire.
*p<0.05.

To the best of our knowledge and our review of the literature, this was the first study to focus on screening for possible sleep disturbances in patients seeking to undergo rhinoplasty for exclusively aesthetic reasons. Limitations included the fact that polysomnography was not performed (which would have enabled a more accurate diagnosis of sleep-disordered breathing) and the small sample size.

Nevertheless, our findings support the need for future studies focusing on this ever-growing population of patients who seek surgical correction of an aesthetic dissatisfaction, but who may have underlying symptoms with a negative impact on quality of life. In addition, it is important to identify functional nasal alterations and symptoms in patients seeking to improve nasal esthetics, to prevent functional worsening, which can cause or aggravate sleep disorders. A complete evaluation of the nasal cavities, including endoscopic examination, considering the assessment of the turbinates, could have contributed to more informations for the study and should be included in future research.

CONCLUSION

Poor sleep quality was highly prevalent in this sample of patients referred for aesthetic rhinoplasty. All participants who were at high risk for OSA, as determined by the Berlin questionnaire, were also classified as having poor sleep quality, suggesting that the sleep symptoms they reported were at least partly attributable to the presence of obstructive sleep-disordered breathing. An association was also observed between the presence of high risk for OSA (positive BQ) and presence of nasal symptoms (assessed by the NOSE questionnaire).

Funding

There was no source of funding.

Conflict of interest

There was no conflicts of interest.

REFERENCES

1. Davies SF, Iber C. Obstructive sleep apnea associated with adult-acquired micrognathia from rheumatoid arthritis. Am Rev Respir Dis. 1983;127(2):245-7.
2. Li KK, Riley RW, Powell NB, Kushida C, Troell RJ. Obstructive sleep apnea syndrome (OSAS) in the Asian patient. Otolaryngol Head Neck Surg. 1999;121(2 Suppl):127.
3. Robinson A, Guilleminault C. Obstructive sleep apnea syndrome. In: Chokroverty S, eds. Sleep disorders Medicine: basic science, technical considerations, and clinical aspects. 2nd ed. Woburn: Butterworth Heinemann; 1999. p. 331-54.
4. Sakakibara H, Tong M, Matsushita K, Hirata M, Konish Y, Suetsugu S. Cephalometric abnormalities in non-obese and obese patients with obstructive sleep apnoea. Eur Respir J. 1999;13(2):403-10.
5. Smirne S, Iannaccone S, Ferini-Strambi L. Muscle fiber type and habitual snoring. Lancet. 1991;337(8741):597-9.
6. Young T, Finn L, Peppard PE, Szklo-Coxe M, Austin D, Nieto FJ, et al. Sleep disordered breathing and mortality: eighteen-year follow-up of the Wisconsin sleep cohort. Sleep. 2008;31(8):1071-8.
7. Gottlieb DJ, Yenokyan G, Newman AB, O'Connor GT, Punjabi NM, Quan SF, et al. Prospective study of obstructive sleep apnea and incident coronary heart disease and heart failure: the sleep heart health study. Circulation. 2010;122(4):352-60.
8. Redline S, Yenokyan G, Gottlieb DJ, Shahar E, O'Connor GT, Resnick HE, et al. Obstructive sleep apnea-hypopnea and incident stroke: the sleep heart health study. Am J Respir Crit Care Med. 2010;182(2):269-77.
9. Ohayon MM. Epidemiology of insomnia: what we know and what we still need to learn. Sleep Med Rev. 2002;6(2):97-111.
10. Bagai K. Obstructive sleep apnea, stroke, and cardiovascular diseases. Neurologist. 2010;16(6):329-39.
11. Sabanayagam C, Shankar A. Sleep duration and cardiovascular disease: results from the National Health Interview Survey. Sleep. 2010;33(8):1037-42.
12. Grandner MA, Hale L, Moore M, Patel NP. Mortality associated with short sleep duration: The evidence, the possible mechanisms, and the future. Sleep Med Rev. 2010;14(3):191-203.
13. Kojima M, Wakai K, Kawamura T, Tamakoshi A, Aoki R, Lin Y, et al. Sleep patterns and total mortality: a 12-year follow-up study in Japan. J Epidemiol. 2000;10(2):87-93.
14. Tamakoshi A, Ohno Y; JACC Study Group. Self-reported sleep duration as a predictor of all-cause mortality: results from the JACC study, Japan. Sleep. 2004;27(1):51-4.

15. Greenland P, Knoll MD, Stamler J, Neaton JD, Dyer AR, Garside DB, et al. Major risk factors as antecedents of fatal and nonfatal coronary heart disease events. JAMA. 2003;290(7):891-7.
16. Vgontzas AN, Liao D, Bixler EO, Chrousos GP, Vela-Bueno A. Insomnia with objective short sleep duration is associated with a high risk for hypertension. Sleep. 2009;32(4):491-7.
17. Spiegel K, Knutson K, Leproult R, Tasali E, Van Cauter E. Sleep loss: a novel risk factor for insulin resistance and Type 2 diabetes. J Appl Physiol (1985). 2005;99(5):2008-19.
18. Watanabe M, Kikuchi H, Tanaka K, Takahashi M. Association of short sleep duration with weight gain and obesity at 1-year follow-up: a large-scale prospective study. Sleep. 2010;33(2):161-7.
19. Buysse DJ, Reynolds CF 3rd, Monk TH, Berman SR, Kupfer DJ. The Pittsburgh Sleep Quality Index: a new instrument for psychiatric practice and research. Psychiatry Res. 1989;28(2):193-213.
20. Johns MW. A new method for measuring daytime sleepiness: the Epworth sleepiness scale. Sleep. 1991;14(6):540-5.
21. Stewart MG, Witsell DL, Smith TL, Weaver EM, Yueh B, Hannley MT. Development and validation of the Nasal Obstruction Symptom Evaluation (NOSE) scale. Otolaryngol Head Neck Surg. 2004;130(2):157-63.
22. Senaratna CV, Perret JL, Matheson MC, Lodge CJ, Lowe AJ, Cassim R, et al. Validity of the Berlin questionnaire in detecting obstructive sleep apnea: A systematic review and meta-analysis. Sleep Med Rev. 2017;36:116-24.
23. Mollayeva T, Thurairajah P, Burton K, Mollayeva S, Shapiro CM, Colantonio A. The Pittsburgh sleep quality index as a screening tool for sleep dysfunction in clinical and non-clinical samples: A systematic review and meta-analysis. Sleep Med Rev. 2016;25:52-73.
24. Georgalas C. The role of the nose in snoring and obstructive sleep apnoea: an update. Eur Arch Otorhinolaryngol. 2011;268(9):1365-73.
25. Lee SH, Choi JH, Shin C, Lee HM, Kwon SY. How does open-mouth breathing influence upper airway anatomy? Laryngoscope. 2007;117(6):1102-6.
26. Oliveira MC, Tufik S, Haddad FL, Santos-Silva R, Gregório LC, Bittencourt L. Systematic Evaluation of the Upper Airway in a Sample Population: Factors Associated with Obstructive Sleep Apnea Syndrome. Otolaryngol Head Neck Surg. 2015;153(4):663-70.
27. Young T, Finn L, Kim H. Nasal obstruction as a risk factor for sleep-disordered breathing. The University of Wisconsin Sleep and Respiratory Research Group. J Allergy Clin Immunol. 1997;99(2):S757-62.
28. Li HY, Wang PC, Chen YP, Lee LA, Fang TJ, Lin HC. Critical appraisal and meta-analysis of nasal surgery for obstructive sleep apnea. Am J Rhinol Allergy. 2011;25(1):45-9.
29. Verse T, Maurer J, Pirsig W. Effect of nasal surgery on sleep-related breathing disorders. Laryngoscope. 2002;112(1):64-8.
30. Friedman M, Tanyeri H, Lim JW, Landsberg R, Vaidyanathan K, Caldarelli D. Effect of improved nasal breathing on obstructive sleep apnea. Otolaryngol Head Neck Surg. 2000;122(1):71-4.
31. Nakata S, Noda A, Yasuma F, Morinaga M, Sugiura M, Katayama N, et al. Effects of nasal surgery on sleep quality in obstructive sleep apnea syndrome with nasal obstruction. Am J Rhinol. 2008;22(1):59-63.
32. Li HY, Lee LA, Wang PC, Fang TJ, Chen NH. Can nasal surgery improve obstructive sleep apnea: subjective or objective? Am J Rhinol Allergy. 2009;23(6):e51-5.
33. Shuaib SW, Undavia S, Lin J, Johnson CM Jr, Stupak HD. Can functional septorhinoplasty independently treat obstructive sleep apnea? Plast Reconstr Surg. 2015;135(6):1554-65.