Original Article / Çalışma - Araştırma

Otorhinolaryngologic examination in obstructive sleep apnea syndrome: the correlation between the severity of sleep disorder and physical examination

Tıkayıcı uyku apne sendromunda kulak burun boğaz muayenesi: Uyku bozukluğunun şiddeti ve fiziki muayene arasındaki ilişki

Baran Acar, M.D.,[1] Mehmet Ali Bababdemez, M.D.,[1] Hayriye Karabulut, M.D.,[2] Bülent Çiftçi, M.D.,[1] Emre Günbey, M.D.,[1] Rıza Murat Karaşen, M.D.[1]

[1]*Department of Otolaryngology, Keçiören Training and Research Hospital, Ankara, Turkey*
[2]*Department of Chest Surgery, Atatürk Chest Diseases and Chest Surgery Training and Research Hospital, Ankara, Turkey*

Objectives: The aim of this study was to compare nasopharyngeal examination findings with those of polysomnography, which is considered to be the gold standard, in positional and nonpositional obstructive sleep apnea syndrome (OSAS) patients.

Patients and Methods: The study included 374 patients (215 males, 159 females; mean age 44.9 years; range 11 to 77 years) presenting with OSAS or simple snoring. Patients underwent polysomnography recordings and otorhinolaryngologic examination including fiberoptic nasopharyngoscopy with the Müller maneuver. The correlation of the data scored-with the polysomnographic findings and body mass index (BMI) was investigated. The findings were assessed using the Mann Whitney U-test (anatomic findings) and Student t-test (Müller maneuver).

Results: Body mass index was correlated with apnea-hypopnea index (AHI), AHI-Lateral AHI-supine, the grade of the tongue base and neck circumference ($p<0.05$). In general, the dominant level of obstruction was at the soft palate level in patients with severe OSAS. There was a positive correlation between the grade of lateral obstruction at the soft palate level and AHI and AHI-lateral ($p=0.01$, $p=0.02$, respectively). The grade of anteroposterior obstruction at the tongue base level had a significant correlation with AHI- total and AHI-supine ($p<0.05$). The grade of the tonsillar hypertrophy revealed significant correlation with AHI-total and AHI-supine ($p<0.05$). There was no significant correlation between the degree of the nasal septal deviation and AHI ($p>0.05$).

Conclusion: When upper airway obstruction is evaluated, AHI and positional AHI values should be used separately.

Key Words: Müller maneuver; polysomnography; sleep apnea; sleep position.

Amaç: Bu çalışmada pozisyonel ve pozisyonel olmayan tıkayıcı uyku apne sendromlu (TUAS) hastalar için altın standart olarak kabul edilen polisomnografi ve nazofarengeal muayene bulguları karşılaştırıldı.

Hastalar ve Yöntemler: Bu çalışmaya TUAS veya basit horlama tanılı 374 hasta (215 erkek, 159 kadın; ort. yaş 44.9 yıl; dağılım 11-77 yıl) dahil edildi. Polisomnografi kayıtları alınan hastaların, kulak burun boğaz muayeneleri ile Müller manevrasını da içeren fiberoptik nazofarengoskopik muayeneleri yapıldı. Skorlanan bu verilerin polisomnografi bulguları ve vücut kütle indeksleri (VKİ) ile ilişkisi araştırıldı. Sonuçlar Mann Whitney U-testi (anatomik bulgular) ve Student t-testi (Müller manevrası) kullanılarak değerlendirildi.

Bulgular: Vücut kütle indeksleri ile apne hipopne indeksi (AHİ), AHİ-lateral, AHİ-supin, dil kökü büyüklüğü ve boyun kalınlığı arasında ilişki bulundu ($p<0.05$). İleri derece TUAS hastalarında genel olarak yumuşak damak seviyesinde daralma vardı. Yumuşak damak seviyesindeki lateral daralmanın büyüklüğü ile AHİ ve AHİ-lateral arasında pozitif bir ilişki vardı (sırasıyla, $p=0.01$, $p=0.02$). Dil kökündeki ön arka daralmanın derecesi ile AHİ-total ve AHİ-supin arasında anlamlı bir ilişki vardı ($p<0.05$). Tonsil büyüklüğünün derecesi ile AHİ-total ve AHİ-supin arasındaki ilişki anlamlıydı ($p<0.05$). Septum deviasyonun derecesi ile AHİ arasında herhangi bir ilişki bulunamadı ($p>0.05$).

Sonuç: Üst hava yolundaki daralma değerlendirilirken AHİ ve pozisyonel AHİ değerleri ayrı ayrı kullanılmalıdır.

Anahtar Sözcükler: Müller manevrası; polisomnografi; uyku apnesi; uyku pozisyonu.

Received / *Geliş tarihi:* May 18, 2009 Accepted / *Kabul tarihi:* September 15, 2009

Correspondence / İletişim adresi: Baran Acar, M.D. Keçiören Eğitim ve Araştırma Hastanesi Kulak Burun Boğaz Kliniği, 06310 Keçiören, Ankara, Turkey.
Tel: +90 312 - 356 90 00 Fax *(Faks):* +90 312 - 356 90 22 e-mail *(e-posta):* drbaranacar@gmail.com

Obstructive sleep apnea syndrome (OSAS) is characterized by recurrent episodes of upper airway obstruction during sleep and it is generally associated with arterial oxygen desaturation. The obstructive sleep apnea syndrome has a prevalence of 2% to 4% in the general population and it is a disease of increasing importance because of its neurocognitive and cardiovascular sequelae.[1,2] Abnormalities in the anatomy of the pharynx, the physiology of the upper airway dilator muscle and the stability of ventilatory control are important causes of repetitive pharyngeal collapse during sleep.

The obstructive sleep apnea syndrome can be diagnosed on the basis of the characteristic history (snoring, daytime sleepiness) and physical examination, but a polysomnography (PSG) is needed to confirm the presence of the disorder. Although the PSG represents the type and degree of the sleep disorder, it does not inform about the degree and level of obstruction at the upper airways. To comprehend the pathophysiology of the upper airway obstruction in OSAS, some evaluation methods are being used such as lateral cephalometry, sleep and awake nasopharyngoscopy, fluoroscopy, computed tomography scanning and magnetic resonance imaging, manometry and acoustic reflectometry. Nevertheless, the modified Müller maneuver, applied with forced inspiration during the fiberoptic nasopharyngoscopy with the mouth and nose closed, provides more detailed information about the level and degree of the narrowing at the upper airways. A flexible nasopharyngoscopy with Müller maneuver (FNMM) has also a predictive value about the results of the uvulopharyngoplasty (UPP).[3,4]

The main purpose of this study was to identify the effect of the degree, type and level of the narrowing at the upper airways on the PSG parameters in obstructive sleep apnea (OSA) patients and simple snorers.

PATIENTS AND METHODS

In this retrospective study were enrolled 374 patients (215 males 159 females; mean age 44.9 years; range 11 to 77 years), who underwent a PSG between August 2007 and September 2008 and had OSAS or simple snoring diagnoses, and who presented to our ear nose throat (ENT) clinic with snoring as the chief complaint accompanied by other symptoms of sleep apnea. All patients underwent a detailed otorhinolaryngological examination, including flexible endoscopy and the Müller maneuver and lateral cephalometry (decided by the Keçiören Training and Research Hospital sleep council incorporating ENT specialists, a pulmonologist who analyzed the polysomnograms and an orthodontist). The patients who had an operation history because of the OSAS, central type apneas, chronic obstructive pulmonary disease or maxillomandibular retrognathia on the lateral cephalometric evaluation were excluded from the study.

Sleep study

The sleep records of consecutive subjects referred for overnight PSG at the Sleep Center of Atatürk Hospital for Chest Diseases in order to rule out OSAS were evaluated. Standard overnight PSG's were performed in all subjects using the Compumedics Voyager Digital Imaging E-series system (Compumedics®, Melbourne, Victoria, Australia). The PSG included the following variables: four electroencephalogram channels, electro-oculogram, bipolar surface electromyograms of the submentalis and bilateral anterior tibialis muscles, and position sensors to record body position and movements. In addition to simultaneous video recording, the respiratory monitoring consisted of nasal and oral airflow measures (oronasal cannula), a tracheal microphone, thoracic and abdominal respiratory efforts (Piezo belts), finger pulsoxymetry and an electrocardiogram.

Sleep staging was performed according to the standard criteria set by the American Academy of Sleep Medicine.[5] Apnea was defined as a complete cessation of airflow for at least 10 seconds. Hypopnea was defined as a decrease in airflow of at least 50% accompanied by 3% desaturation and a reduction in chest wall movement and/or arousal. The apnea-hypopnea index (AHI) was defined as the number of apneas and hypopneas per hour of sleep.

Patients were classified into mild (5<AHI<15), moderate (16<AHI<30) and severe (30<AHI) OSAS according to the severity of disease. An apnea-hypopnea index value lower than five indicated simple snoring. For all the patients, the AHI during total sleep, during supine (AHI-supine) and lateral positions (AHI-lateral), during rapid eye movement (REM), (AHI-REM) and non-REM sleep (AHI-NREM), minimum oxygen saturation values were recorded.

Height, weight, body mass index (BMI) and neck circumference were recorded. Nasal and pharyngeal configurations were assessed for each patient. In all patients, the tongue size was classified from grade 1 to 4 (1: Uvula and palatine tonsils visible; 2: Uvula

visible, but tonsils not visible; 3: Soft-palate visible but uvula not visible; 4: Only hard palate visible), while in neutral position, palatine tonsils were classified from grade 0 to 3 (0: tonsils, pillars, and soft palate were clearly visible; 1: the uvula, pillars, and upper pole were visible; 2: only part of the soft palate was visible; the tonsils, pillars, and base of the uvula could not be seen; 3: only the hard palate was visible) using the Friedman classification.[6] Then, the nasal endoscopic examination was done with 0° rigid endoscope and septal deviation was classified from grade 0 to 3 according to the Dreher classification (0: no deviation; 1: slight deviation; 2: moderate deviation; 3: severe deviation). The hypertrophy of the inferior turbinates was classified from grade 0 to 2 (0: no hypertrophy; 1: slight hypertrophy; 2: severe hypertrophy).[7] Pathologies about middle turbinate, nasopharynx and also the adenoid hypertrophies were noted, if any. Subsequently, each patient underwent a flexible nasopharyngoscopy and firstly, the size of the tongue base was graded from 0 to 3 (0: vallecula completely visible; 1: vallecula partly visible; 2: tongue base touching to epiglottis; 3: tongue base pushing epiglottis), followed by the Müller maneuver to estimate the degree of obstruction at the oropharynx, the base of the tongue and the velum. The degree of the obstruction was graded from 1 to 4 (1: 0%-25%; 2: 25%-50%; 3: 50%-75%; 4: 75%<) for two directions as lateral, anteroposterior at the soft palate and tongue base levels.

Descriptive analysis was performed for demographic and clinical characteristics of the patients. Student's t-test or Mann Whitney U-test was used for the comparison of the numeric variables between the two groups. Chi-square test was used for a comparison of the ratios between the groups. Anatomic and functional findings were correlated with the AHI using the Spearman correlation analysis. Statistical analysis was performed with the SPSS 15.0 software (SPSS, Inc; Chicago, USA). P<0.05 values were considered statistically significant.

Table 1. Correlation analysis of the correlation between the body-mass index and neck circumference, the grade of the tongue base, AHI-total, AHI-supin and AHI-lateral

Body-mass index	r	*p*
Neck circumference	0.10	0.02
The grade of the tongue base	0.14	0.005
AHI-total	0.2	<0.001
AHI-supine	0.10	0.02
AHI-lateral	0.2	<0.001

RESULTS

The mean BMI (calculated as weight in kilograms divided by the square of height in meters) was 29.85 (range: 17 to 46) and the mean AHI was 21.3 (range: 0.5 to 110). Forty-six (12.3%) of the subjects were simple snorers, 116 (31%) had mild OSAS, 128 (34.2%) had moderate OSAS and 84 subjects (22.5%) had severe OSAS.

The Spearman correlation showed a strong relationship between the BMI, and AHI and AHI-lateral (p<0.001). The body mass index was also correlated with the AHI-supine, the grade of the tongue base and the neck circumference (Table 1).

There were significant associations between the degree, level and type of the upper airway obstruction and the AHI-total or the positional AHI (the AHI-supine and AHI-lateral).

We analyzed the dominant level of obstruction at the soft palate level in severe cases of OSAS. More patients displayed a lateral obstruction rather than an anteroposterior at the soft palate level and this was correlated with the AHI (p<0.01) (Fig. 1). The mean AHI and the mean AHI-lateral were higher in the patients whose degree of lateral obstruction at the soft palate level was higher than 50%, and this correlation was statistically significant. Therefore, the lateral-narrowing type at the soft palate level is more significantly associated with the mean AHI-total as compared with the anteroposterior-narrowing type. No significant difference was found between the degree of the obstruction at the soft palate level and the supine AHI (p>0.05; Table 2).

Furthermore, the grade of the tongue base and the grade of the anteroposterior obstruction at the

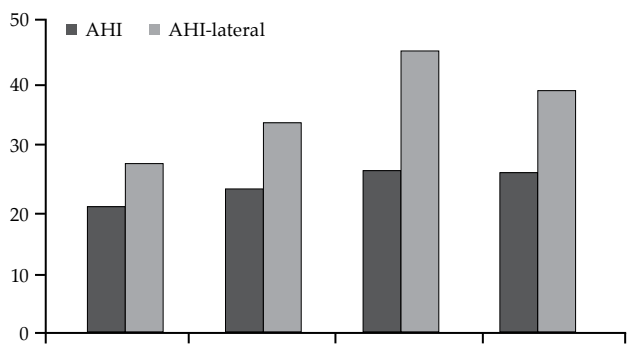

Fig. 1. *The relationship between the grade of lateral obstruction (grade 1-4) at the velum level and AHI and AHI-lateral.*

Table 2. Correlation analysis of the correlation between the obstruction at the soft palate level and AHI-total, AHI-supine and AHI-lateral

Lateral obstruction at the soft palate level	r	*p*
AHI-total	0.13	0.001
AHI-supine	0.05	0.26
AHI-lateral	0.11	0.02
Anteroposterior obstruction at the soft palate level		
AHI-total	0.09	0.07
AHI-supine	0.004	0.93
AHI-lateral	0.08	0.08

Table 3. Correlation analysis of the correlation between the anteroposterior obstruction at the tongue base level, the grade of the tongue base and AHI-total, AHI-supine, AHI-lateral

Anteroposterior obstruction at the tongue base level	r	*p*
AHI-total	0.16	0.001
AHI-supine	0.11	0.02
AHI-lateral	0.03	0.45
The grade of the tongue base		
AHI-total	0.16	0.001
AHI-supine	0.10	0.03
AHI-lateral	0.05	0.62

tongue base level had a significant correlation with the AHI-total and AHI-supine ($p<0.05$; Table 3). The correlation between the AHI, AHI-supine and the grade of the tongue base and the grade of the obstruction at the tongue base level for the anteroposterior narrowing type are shown in the Fig. 2 and Fig. 3.

Also, the grade of the tonsillar hypertrophy revealed significant correlation with the AHI-total and AHI-supine values ($p=0.048$, $p=0.045$). There was no significant correlation between the degree of the nasal septal deviation and the AHI ($p>0.05$).

DISCUSSION

The physical evaluation including endoscopic examination, correlated with the polysomnographic findings, has an important role in the approach to the OSA patients and on the choice of treatment. Viner et al.,[8] Friedman et al.,[6] and Zonato et al.[9] concluded that it would be possible to identify the patients with OSAS based on the physical examination findings. The Müller maneuver was first introduced by Borowiecki et al.,[10] and it requires an inspiratory effort against a closed mouth and sealed nose. Advantages of the FNMM include simplicity, time- and cost-effectiveness, and it also has a predictive value for the outcome of surgery. However, its use may induce criticisms including poor interobserver agreement; and it is performed in the awake patient, which remains an indirect observation of obstruction that occurs during sleep.[11,12] Kim et al.[13] have shown that the grade of the obstruction at each anatomic level was confirmed after agreement of the at least two out of three physicians to reduce the interpersonal variance. Many studies have evaluated different correlations between clinical examination findings, the grade of the obstruction at each anatomic level on Muller maneuver and severity of OSAS. Different correlations have been observed between the clinical examination findings, the grade of the obstruction at each anatomic level on the Muller maneuver and the severity of the OSAS. For example, Hori et al.[14] have reported that there was a significant correlation between the grade of obstruction of the soft palate level and AHI. On

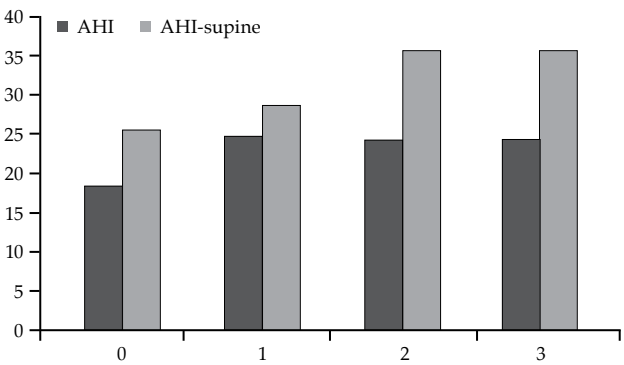

Fig. 2. *The relationship between the grade of tongue base (grade 0-3) and AHI and AHI-supine.*

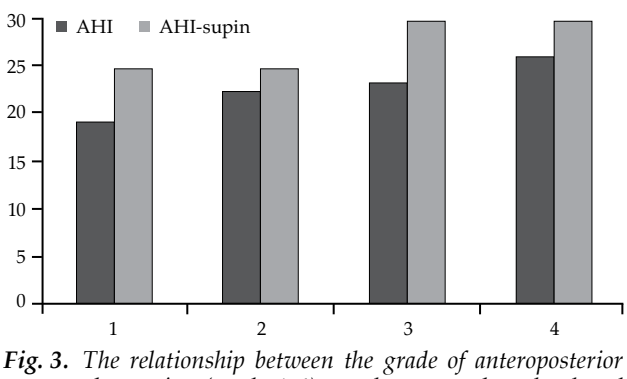

Fig. 3. *The relationship between the grade of anteroposterior obstruction (grade 1-4) at the tongue base level and AHI and AHI-supine.*

the other hand, Pang et al.[15] have revealed that the OSAS severity was strongly correlated with the collapse of the region at the base of tongue. In the present study, the association between the obstruction at each anatomic level and the positional AHI was determined.

It is a well-accepted fact that the BMI and the neck circumference are used as clinical predictors of OSAS. Previous studies have indicated that obesity and high BMI increase the severity of the OSAS.[16,17] Also Friedman et al.[18] described a staging based on the Friedman tongue position, BMI and tonsil size to predict the success of UPPP. In the present study, the BMI was predictive of the severity of the OSAS. The present study also revealed a statistically significant correlation between the BMI and the AHI, AHI-supine, the grade of the tongue base and the neck circumference, and this is in agreement with the previously published reports.

At the soft palate level, which was found to have a correlation with the AHI and the lateral AHI, the obstruction is assumed to be caused by more severe fat deposition and thickening in the lateral pharyngeal wall of the OSAS patients.[13] In the lateral position, the tongue is likely to be displaced less posteriorly and less collapse and less increase in the upper airway resistance is expected. Thus, one would expect that the tendency for the airway to occlude would be less in the lateral position. However, it is known that pharyngeal shape of the OSA patients is characterized by the reduced size of lateral diameter,[19] and that the lateral position can cause further reduction in lateral diameter. Therefore it is possible that lateral position causes reduced pharyngeal cross-sectional area.[20,21] The present study also showed that the lateral-narrowing type at the soft palate level is more strongly associated with the AHI-total and the AHI-lateral. In a review of the previous studies concerned with the direction of the airway obstruction, Rodenstein et al.[19] reported that a reduced pharyngeal transverse diameter may be related to the risk of developing sleep-related disordered breathing, and it also has a significant inverse correlation with the AHI. It is not clear why patients with the lateral-narrowing type have more severe OSAS, but lateral fat deposition in the OSAS patients may play a role.

The grade of the tongue base and the grade of the anteroposterior obstruction at the tongue base level have been found to be predictive factors of OSAS. It has been shown that the upper airway resistance increases in the supine posture. Although Woodson and Naganuma[22] did not find a significant positive correlation between a tongue base hypertrophy and AHI, in the present study, this significant correlation was observed between the tongue base hypertrophy and AHI, and AHI-supine. Also, the grade of the anteroposterior obstruction at the tongue base level was revealed to show a significant correlation with the total and the AHI-supine values. These results can be explained by the airway obstruction at the tongue base level during supine positioning mainly due to the posterior movement of the tongue via the gravitational force and also due to the reduced muscular activity in the OSA patients as compared to the normal controls. During sleep, the upper airway muscle tone is reduced in a way to increase the resistance. In addition to this, a further increase in relation to change from upright to supine posture occurs, and the total resistance may be substantially elevated. The tongue base corresponds to the insertion of the genioglossus muscle, which pulls the tongue forward and opposes pharyngeal collapse when activated; therefore, the AHI and AHI-supine should be separately used to evaluate the hypopharyngeal airway obstruction.[23] Suratt et al.[24] and Mezzanotte et al.[25] have reported that patients with OSAS have more phasic genioglossus muscle activity while awake and asleep compared with that seen in the control subjects. Douglas et al.[26] demonstrated that the activity of the genioglossus muscle was higher in the supine than in the upright position in both patients and control subjects. The cessation of this control mechanism during sleep, which maintains tongue posture and protects upper airway patency, may cause apnea/hyopnea.

The influence of nasal obstruction in OSAS is controversial. While Lavie et al.[27] and McNicholas et al.[28] found a positive correlation between nasal obstruction and AHI, such a correlation was refused by Miljeteig et al.[29] and Atkins et al.[30] the results of the present study support the latter findings.

Enlarged tonsils can cause OSAS and surgical removal usually results in a cure. Friedman et al.[6] found a positive correlation between tonsillary enlargement and the presence of OSAS. Cuhadaroğlu et al.[31] showed that when the tonsils are hypertrophic, the severity of the breathing

patterns is worsened by the supine position. Our study also confirmed such a correlation.

In conclusion, this study was designed with a large sample in order to observe the correlation between physical evaluation and PSG findings. Our study suggests that otolaryngologists must take care to surgically address not only the soft palate, but also the base of the tongue in the OSAS patients. Finally, the measurement of the AHI values separately for pre- and postoperative, on-supine positions is a preferable method, yielding more consistent results with better repeatability, instead of a single, overall AHI measurement for the whole night.

REFERENCES

1. Young T, Palta M, Dempsey J, Skatrud J, Weber S, Badr S. The occurrence of sleep-disordered breathing among middle-aged adults. N Engl J Med 1993;328:1230-5.
2. Gislason T, Almqvist M, Eriksson G, Taube A, Boman G. Prevalence of sleep apnea syndrome among Swedish men-an epidemiological study. J Clin Epidemiol 1988; 41:571-6.
3. Sher AE, Thorpy MJ, Shprintzen RJ, Spielman AJ, Burack B, McGregor PA. Predictive value of Müller maneuver in selection of patients for uvulopalatopharyngoplasty. Laryngoscope 1985;95:1483-7.
4. Aboussouan LS, Golish JA, Wood BG, Mehta AC, Wood DE, Dinner DS. Dynamic pharyngoscopy in predicting outcome of uvulopalatopharyngoplasty for moderate and severe obstructive sleep apnea. Chest 1995;107:946-51.
5. Iber C, Ancoli-Israel S, Chesson A, Quan SF. The AASM manual for the scoring of sleep and associated events: rules, terminology and technical specifications. 1st ed. Westchester: American Academy of Sleep Medicine; 2007.
6. Friedman M, Tanyeri H, La Rosa M, Landsberg R, Vaidyanathan K, Pieri S, Caldarelli D. Clinical predictors of obstructive sleep apnea. Laryngoscope 1999; 109:1901-7.
7. Dreher A, de la Chaux R, Klemens C, Werner R, Baker F, Barthlen G, et al. Correlation between otorhinolaryngologic evaluation and severity of obstructive sleep apnea syndrome in snorers. Arch Otolaryngol Head Neck Surg 2005;131:95-8.
8. Viner S, Szalai JP, Hoffstein V. Are history and physical examination a good screening test for sleep apnea? Ann Intern Med 1991;115:356-9.
9. Zonato AI, Bittencourt LR, Martinho FL, Júnior JF, Gregório LC, Tufik S. Association of systematic head and neck physical examination with severity of obstructive sleep apnea-hypopnea syndrome. Laryngoscope 2003;113:973-80.
10. Borowiecki B, Pollak CP, Weitzman ED, Rakoff S, Imperato J. Fibro-optic study of pharyngeal airway during sleep in patients with hypersomnia obstructive sleep-apnea syndrome. Laryngoscope 1978;88:1310-3.
11. Katsantonis GP, Maas CS, Walsh JK. The predictive efficacy of the Müller maneuver in uvulopalatopharyngoplasty. Laryngoscope 1989;99:677-80.
12. Terris DJ, Hanasono MM, Liu YC. Reliability of the Muller maneuver and its association with sleep-disordered breathing. Laryngoscope 2000;110:1819-23.
13. Kim HY, Bok KH, Dhong HJ, Chung SK. The correlation between pharyngeal narrowing and the severity of sleep-disordered breathing. Otolaryngol Head Neck Surg 2008;138:289-93.
14. Hori Y, Shizuku H, Kondo A, Nakagawa H, Kalubi B, Takeda N. Endoscopic evaluation of dynamic narrowing of the pharynx by the Bernouilli effect producing maneuver in patients with obstructive sleep apnea syndrome. Auris Nasus Larynx 2006;33:429-32.
15. Pang KP, Terris DJ, Podolsky R. Severity of obstructive sleep apnea: correlation with clinical examination and patient perception. Otolaryngol Head Neck Surg 2006;135:555-60.
16. Kushida CA, Efron B, Guilleminault C. A predictive morphometric model for the obstructive sleep apnea syndrome. Ann Intern Med 1997;127:581-7.
17. Dixon JB, Schachter LM, O'Brien PE. Predicting sleep apnea and excessive day sleepiness in the severely obese: indicators for polysomnography. Chest 2003; 123:1134-41.
18. Friedman M, Ibrahim H, Bass L. Clinical staging for sleep-disordered breathing. Otolaryngol Head Neck Surg 2002;127:13-21.
19. Rodenstein DO, Dooms G, Thomas Y, Liistro G, Stanescu DC, Culée C, et al. Pharyngeal shape and dimensions in healthy subjects, snorers, and patients with obstructive sleep apnoea. Thorax 1990;45:722-7.
20. Pevernagie DA, Stanson AW, Sheedy PF 2nd, Daniels BK, Shepard JW Jr. Effects of body position on the upper airway of patients with obstructive sleep apnea. Am J Respir Crit Care Med 1995;152:179-85.
21. Nakano H, Ikeda T, Hayashi M, Ohshima E, Onizuka A. Effects of body position on snoring in apneic and nonapneic snorers. Sleep 2003;26:169-72.
22. Woodson BT, Naganuma H. Comparison of methods of airway evaluation in obstructive sleep apnea syndrome. Otolaryngol Head Neck Surg 1999;120:460-3.
23. Acar B, Karabulut H, Babademez MA, Ciftci B, Karasen RM. Evaluation of submucosal minimally invasive lingual excision technique for treatment of obstructive sleep apnea/hypopnea syndrome. Otolaryngol Head Neck Surg 2009;140:281.
24. Suratt PM, McTier RF, Wilhoit SC. Upper airway muscle activation is augmented in patients with obstructive sleep apnea compared with that in normal subjects. Am Rev Respir Dis 1988;137:889-94.
25. Mezzanotte WS, Tangel DJ, White DP. Waking genioglossal electromyogram in sleep apnea patients versus normal controls (a neuromuscular compensatory mechanism). J Clin Invest 1992;89:1571-9.
26. Douglas NJ, Jan MA, Yildirim N, Warren PM, Drummond GB. Effect of posture and breathing route on genioglossal electromyogram activity in normal subjects and in patients with the sleep apnea/hypopnea syndrome. Am Rev Respir Dis 1993;148:1341-5.
27. Lavie P, Gertner R, Zomer J, Podoshin L. Breathing disorders in sleep associated with "microarousals" in patients with allergic rhinitis. Acta Otolaryngol 1981; 92:529-33.
28. McNicholas WT, Tarlo S, Cole P, Zamel N, Rutherford

R, Griffin D, et al. Obstructive apneas during sleep in patients with seasonal allergic rhinitis. Am Rev Respir Dis 1982;126:625-8.
29. Miljeteig H, Savard P, Mateika S, Cole P, Haight JS, Hoffstein V. Snoring and nasal resistance during sleep. Laryngoscope 1993;103:918-23.
30. Atkins M, Taskar V, Clayton N, Stone P, Woodcock A. Nasal resistance in obstructive sleep apnea. Chest 1994;105:1133-5.
31. Cuhadaroglu C, Keles N, Erdamar B, Aydemir N, Yucel E, Oguz F, et al. Body position and obstructive sleep apnea syndrome. Pediatr Pulmonol 2003;36:335-8.