



## ARAŞTIRMA / RESEARCH

# Evaluation of upper airway collapsibility in obstructive sleep apnea patients presenting with complaints of snoring

Horlama şikayeti ile başvuran obstruktif uyku apnesi hastalarında üst hava yolu kollapsibilitesinin değerlendirilmesi

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### Abstract

**Purpose:** The aim of this study was to determine the most appropriate diagnostic method for the detection of the site and configuration of obstructed regions for the successful management of patients with obstructive sleep apnea. **Materials and Methods:** The study included 40 patients with snoring complaints who underwent septoplasty surgery followed by polysomnography. Evaluation was made in respect of age, gender, Epworth Sleepiness Scale, bodymass index (BMI), modified Mallampati scoring, Müller's maneuver, and sleep endoscopy data. Patients with collapse of >50% in Müller's maneuver and sleep endoscopy were considered as serious obstructions.

**Results:** No significant difference was observed between the assessments of Mallampati scoring and sleep endoscopy in the laryngeal region. In the comparison of sleep endoscopy and Müller's maneuver, significant differences were observed in the lateral band, uvulopalatal region and tongue base.

**Conclusion:** Sleep endoscopy is increasingly preferred since it enables the observation of important changes during sleep. The data of the current study support the view that sleep endoscopy is a more advantageous method at the upper levels as useful information is provided for upper airway evaluation.

**Key words:** Sleep endoscopy, Müller's maneuver, Mallampati scoring, uvulopalatal region

### Öz

**Amaç:** Tıkayıcı uyku apnesi sendromu olan hastalarda başarılı cerrahi için obstrüksiyon alanlarının ve obstrüksiyon boyutunun değerlendirilmesi ve tesbiti için en uygun tanısal yöntemi saptamaktır.

**Gereç ve Yöntem:** Çalışmamıza horlama şikayeti ile başvuran septoplasti operasyonu sonrası polisomnografisi de yapılan 40 hasta dahil edildi. Hastaların yaş, cinsiyet, Epworth uyku skalası, vücut kitle endeksi, modifiye Mallampati skoru, Müller manevrası ve uyku endoskopisi değerlendirildi. Hastaların Müller manevrasında ve uyku endoskopisinde tıkanıklığı %50 üzerinde olanlar ciddi obstrüksiyon olarak değerlendirildi.

**Bulgular:** Laringeal bölgede uyku endoskopisi ile modifiye mallampati skorları arasında anlamlı farklılık tesbit edilmedi. Uyku endoskopisi ve Müller manevrası değerlendirildiğinde iki yöntem arasında uvulopalatal bölgede, lateral faringeal band ve dil kökünde anlamlı farklılık izlendi.

**Sonuç:** Uyku sırasında önemli değişiklikleri gözlemlenmesinden dolayı uyku endoskopisi daha sık olarak tercih edilmektedir. Çalışmamızda üst seviyelerde uyku endoskopisinin avantajlarını destekleyen ve öğreten veriler elde edilmiştir. Uyku endoskopisi üst hava yollarının değerlendirilmesinde daha faydalı bilgiler verir.

**Anahtar kelimeler:** Uyku endoskopisi, Müller manevrası, Mallampati skoru, Uvulopalatal alan.

## INTRODUCTION

Airway obstruction is observed at various levels in obstructive sleep apnea syndrome (OSAS). It

primarily results from the palate and retrolingual oropharynx regions<sup>1</sup>. There is no gold standard method for the evaluation of airway obstruction in patients with OSAS<sup>2</sup>. The first examination to be

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applied to these patients should be a detailed ear-nose-throat examination, and evaluation of the oropharynx is especially important. Friedman et al. modified the Mallampati classification system for this purpose and argued that this modified classification could be of guidance in determining problems of oropharynx and tongue base origin in patients with OSAS<sup>3</sup>. Müller's maneuver is a frequently used evaluation method to assess pharyngeal collapse in a patient with OSAS. The method is based on exertion of inspiratory effort against a closed airway by a fiber-optical endoscope when the patient is awake<sup>4,5</sup>. The success of surgical treatment is not sufficiently appreciated, as it is performed in a sitting position and in an awake state<sup>5,6</sup>. Plain radiography cephalometry and CT scans provide information on bone structure in the evaluation of the upper respiratory tract, but do not give important information about soft tissue. As with Müller's maneuver, these methods are performed when the patient is awake, and are not very beneficial in terms of patient radiation risk<sup>2</sup>.

Woodson established that the physiological features of the upper airway tract are different during sleep and being awake. Thus, in recent years, the prevailing opinion has been that the evaluation methods to be used for OSAS patients should essentially reveal changes during sleep<sup>7</sup>. With this in mind, Pringle and Croft developed a sleep endoscopy system for the first time in 1991, based on imaging of the upper airways using a fiber-optic endoscope during sleep<sup>8</sup>. The main aim is to determine the obstruction pattern in terms of surgery. However, anatomical evaluation of the upper airway is limited in the awake state, and upper airway movements cannot be demonstrated clearly in comparison to the sleeping state. Sleep endoscopy gives useful information in particular for the evaluation of the upper airway<sup>1</sup>. Recently, changes in terminology, such as no obstruction, partial obstruction, and complete obstruction, have been made by evaluating the velum, oropharyngeal lateral wall, tongue base, and epiglottis in the VOTE classification which is performed during sleep endoscopy<sup>9</sup>.

Comparative studies have been conducted in the years following the development of sleep endoscopy and these have emphasized that this method is the closest to physiological sleep and is therefore the best method to determine changes in the upper airway<sup>6,7,8</sup>. In various studies, sleep endoscopy has

been separately compared with Müller's maneuver, Mallampati scoring, and tonsil dimension.

Accurate assessment of sleep endoscopy and Müller's maneuver is very important for surgical choice. In this study, the method of evaluation of obstruction sites and the success of the subsequent surgery are discussed.

## MATERIALS AND METHODS

### Study population

All the subjects signed an informed consent form according to the Helsinki II Declaration, with approval for the study granted by Kahramanmaraş Sutcu Imam University Ethics Committee, prior to the launch of the study (dated: 11.07.2013, protocol number:04).

This study included 40 patients with snoring complaints who underwent a septoplasty operation, followed by polysomnography, in Kahramanmaraş Necip Fazıl City Hospital second Otorhinolaryngology Clinic between May and August 2014. Patients aged over 30 years with snoring complaints and body mass index (BMI)>25 were examined in the study with the suspicion of OSAS. Sleep endoscopy was performed on patients who were admitted to the clinic with complaints of snoring and were recommended for septoplasty surgery before polysomnography. Following the application of polysomnography, the patient was scheduled for appropriate OSAS surgery.

Detailed medical histories of the participating patients were taken, and detailed head and neck examination electrocardiography (ECG) and laboratory examinations were made. The Epworth Sleepiness Scale (ESS) was completed. Detailed information about the study was given to all patients, and informed consent forms were signed. Height and weight measurements were taken, and BMI was calculated. The relationship of the soft palate and tongue base in the sitting position was evaluated using the modified Mallampati classification<sup>3</sup>. For all patients, the tongue base was classified from Grade 1 to Grade 4.

Grade1: Soft palate, uvula and plica can be clearly seen

Grade 2: Uvula, plica and the upper pole of the tonsils can be seen

Grade 3: Only the soft palate is seen; the uvula,

uvula base, tonsils and plica cannot be seen  
Grade 4: Only the hard palate is seen

The patients included were those who underwent polysomnography and subsequent septoplasty, with AHI <30, and complete fiber-optic nasal endoscopy records. Exclusion criteria included patients operated on for a diagnosis of OSAS, those with central type apnea, chronic obstructive pulmonary disease (COPD) or maxillomandibular retrognathia on lateral cephalometric examination. A total of 50 OSAS patients were evaluated and 10 were excluded; 4 patients did not accept a septoplasty operation and 6 patients had incomplete hospital records. Therefore, the study evaluation was completed with 40 patients.

### **Determination of the areas of obstruction using Müller's maneuver and sleep endoscopy**

Flexible endoscopic examination of each patient was performed in a sitting position and in an awake state in order to display the whole upper respiratory tract. The Müller's maneuver was performed to determine the tendency of the upper respiratory tract to collapse under negative intraluminal pressure. Topical anesthetics and cotton wadding impregnated with decongestives were placed in the nasal cavities of the patients. The upper respiratory tract was examined starting from the nasopharynx to the larynx by entering the nasal passage with a flexible endoscope of 0° 3.4 mm (Karl Storz, Germany). Müller's maneuver was applied at the level of the uvulopalatal, lateral pharyngeal band, tongue base and laryngeal region and it was determined whether there was any collapse at these levels. The collapse degree was defined as:

0+: 25%–50%

1+: 50%–75%

2+: > 75%; Of these values, Grades 1 and 2 were recorded as significant obstructions.

Sleep endoscopy was performed under operating room conditions with an accompanying anesthetist. Before the sedation process, cotton wadding impregnated with topical decongestive and anesthetic was placed into the nasal passage, and midazolam (0.03 mg/kg) was to start sedation. Propofol (1mg/kg IV dosage) was administered to provide deep sedation in divided doses that enabled snoring. Nasal oxygen was given at 4 L/min during this process. The obstructions

that developed in the nasal, palatal, oropharynx, hypo-pharynx, and larynx regions during snoring, and apneas were determined with a flexible endoscope, and records were taken. The obstruction regions were evaluated as four basic regions: the uvulopalatal, lateral pharyngeal band, tongue base, and laryngeal regions.

### **Sleep study and polysomnography scoring**

Polysomnography was performed using polysomnography hardware (Respiranics ALICE 5, 55-channel sleepware G3, USA). Electroencephalography (EEG), electro-oculography (EOG), submental electromyography (EMG), ECG, finger pulse oxymetry, thoracic and abdominal movements, body position, and bilateral anterior tibial EMG were recorded. An oronasal thermistor and nasal cannula were used to detect apnea and hypopnea. All signals were digitized and stored on a personal computer. Scoring was applied according to the recommendations of Rechtschaffen and Kalles and the AASM regulations<sup>10, 11</sup>.

The severity of OSAS was expressed using the apnea hypopnea index (AHI). Hypopnea is defined as a reduction of at least 50% in airflow, and a fall of 3% in SaO<sub>2</sub> or accompanying arousal. Apnea is defined as a reduction of at least 90% in airflow amplitude, respiratory events lasting at least 10 seconds and lasting for at least 90% of the duration of the reduction in amplitude event. The apnea hypopnea index (AHI) is the mean number of apneas and hypopneas per hour of sleep and signifies the severity of OSAS. An AHI of 5 - 15 indicates mild OSAS, AHI of 15-30 is moderate OSAS, and AHI >30 is severe OSAS, as assessed by polysomnography<sup>12,13</sup>.

Images were recorded and evaluated by two surgeons. The first surgeon completed the examinations by recording Müller's maneuver and sleep endoscopy (NB). These records were then checked by the second surgeon (AS)

### **Statistical analysis**

Statistical analyses were performed using the Statistical Package for Social Sciences Statistical Software, release 21 (SPSS Windows Version 21, SPSS, Inc., Chicago, IL, USA). Descriptive statistics were presented as mean±standard deviation and median (min-max) for continuous variables, and as frequency (percentages) for categorical variables. A

value of  $p < 0.05$  was considered statistically significant. Correlations between variables were analyzed using Spearman's correlation coefficient and the McNemar test was used for categorical variables.

## RESULTS

The 40 patients comprised 36 (90%) males and 4 (10%) females with a mean age of  $34.35 \pm 10.89$  years (males:  $34.14 \pm 11.12$  years, females:  $36.25 \pm 9.6$  years, overall range, 30-55 years). The average BMI was  $28.11 \pm 4.65$  (females:  $29.19 \pm 1.82$ , males:

$27.99 \pm 4.86$ ). The Epworth Sleepiness Scale values varied between 1 and 22, with a mean  $8.75 \pm 3.69$  for females and  $7.39 \pm 5.59$  for males (Table 1). The average apnea-hypopnea index was  $22.82 \pm 3.92$  overall, at  $23.8 \pm 5.9$  for females and  $24.9 \pm 7.1$  for males. The mean modified Mallampati score was  $2.3 \pm 0.9$ . According to the modified Mallampati scoring (MMS) 23% (n=9 patients) of the patients were evaluated as Grade 1, 30% (n=12) as Grade 2, 40% (n=16) as Grade 3, and 8% (n=3) as Grade 4. There was severe obstruction in 19 patients (48%) (Table 2)

**Table 1. Age, Body-Massindex, Epworth Sleepiness Scale, AHI averages of the patients.**

Values	Females (n:4)	Males (n:36)	Total average	Median
Age (years)	$36.25 \pm 9.6$	$34.14 \pm 11.12$	$34.35 \pm 10.89$	34 (18-67)
Body Massindex	$29.19 \pm 1.82$	$27.99 \pm 4.86$	$28.11 \pm 4.65$	26.4(20.5-41.7)
Epworth Sleepiness Scale	$8.75 \pm 3.69$	$7.39 \pm 5.59$	$7.53 \pm 5.41$	7 (0-22)
AHI	$22 \pm 4.76$	$22.92 \pm 3.94$	$22.82 \pm 3.97$	23.5 (15-30)

**Table 2. Patient numbers according to MMS (MMS: Modified Mallampati Score).**

MMS grade	Number of patients
Grade 1	9 (23%)
Grade 2	12 (30%)
Grade 3	16 (40%)
Grade 4	3 (8%)

Using the Müller's maneuver, obstruction over 50% (Grade 1, 2) was determined in 4 patients (10%) in the uvulopalatal region, in 4 patients (10%) in the lateral pharyngeal region, in 1 patient (2.5%) in the tongue base, and in 1 patient (2.5%) in the laryngeal region.

Using sleep endoscopy, severe obstruction was determined in 22 patients (55%) in the uvulopalatal region, in 26 patients (65%) in the lateral pharyngeal band, in 5 patients (12.5%) in the tongue base, and in 11 patients (27.5%) in the laryngeal region (Table 3).

**Table 3: Patient ratios in Müller's Maneuver and sleep endoscopy according to the regions.**

Regions	Müller's maneuver	Sleep endoscopy
Uvulopalatal region	4 (10%)	22 (55%)
Lateral pharyngeal band	4 (10%)	26 (65%)
Tongue base	1 (2.5%)	5 (12.5%)
Laryngeal	1 (2.5%)	11 (27.5%)

Obstruction was detected in more than one region in sleep endoscopy. Obstructions in both the uvulopalatal region and the lateral pharyngeal band region were determined in 11 (32.5%) patients; 6 patients (15%) had obstructions in the lateral band and laryngeal region; 3 patients (7.5%) in the lateral pharyngeal band and tongue base; 1 patient in the uvulopalatal region, lateral pharyngeal band, and tongue base; 1 patient (2.5%) in the uvulopalatal

region, lateral pharyngeal band, and laryngeal region; and 1 patient (2.5%) had obstructions in all 4 regions (Table 4). In 5 patients, obstruction was determined in the tongue base with sleep endoscopy. Of these patients, 4 had MMS of Grade 1 and 2, and 1 was Grade 0. No statistically significant correlation was determined in patients with obstruction in the tongue base level in terms of MMS grading ( $r=0.16$ ;  $p=0.33$ ).

**Table 4. Regions of more than one obstruction with sleep endoscopy**

Regions	Number of patients
Uvulopalatal + lateral pharyngeal band	11 (32.5%)
Lateral pharyngeal band + larynx	6 (15%)
Lateral pharyngeal band + tongue base	3 (7.5%)
Uvulopalatal egiön + lateral pharyngeal band + tongue base	1 (2.5%)
Uvulopalatal region, lateral pharyngeal band, and laryngeal region	1 (2.5%)
Obstructions in all of the regions	1 (2.5%)

Of the 36 patients evaluated as grade 0 in the uvulopalatal region with Müller's maneuver, 19 (47.5%) were assessed as Grades 1 or 2 in the sleep endoscopy examination. Statistically significant differences were detected between these two areas ( $p = 0.0001$ ). When lateral pharyngeal bands were evaluated with Müller's maneuver, 23 (57.5%) of 36 patients at grade 0 were diagnosed as Grade 1 or 2 in the sleep endoscopy and a statistically significant difference was found between these two methods at the lateral pharyngeal band level ( $p = 0.0001$ ). Of 39 patients with Müller's maneuver Grade 0 at the level of tongue base, 1 was evaluated as Grade 1 or 2 in the sleep endoscopy. A statistically significant difference was determined between Müller's maneuver and sleep endoscopy ( $p: 0.125$ ). Of 39 patients with Grade 0 Müller's maneuver in the laryngeal region, 10 were evaluated as Grade 1 or 2 in the sleep endoscopy. A statistically significant difference was determined between the two methods in the laryngeal region ( $p: 0.002$ ).

When the obstructions in these four areas were evaluated with sleep endoscopy and Müller's maneuver, a moderate positive correlation was found in the uvulopalatal region ( $r=0.44$ ;  $p=0.0001$ ), and a moderate significantly positive correlation in the lateral pharyngeal band ( $r=0.46$ ;  $p=0.0001$ ). A moderate significantly positive correlation was determined between sleep endoscopy and obstruction in the tongue base ( $r=0.51$ ;  $p=0.0001$ ). No correlation between the two methods was detected in the laryngeal region ( $r=0.22$ ;  $p=0.17$ ).

A statistically moderate positive significant correlation was found between the ESS and Müller's maneuver in the uvulopalatal region ( $r=0.31$ ;  $p=0.05$ ) and the lateral pharyngeal band ( $r=0.42$ ;  $p=0.01$ ). A statistically weak positive significant correlation was found between ESS and sleep endoscopy in the lateral pharyngeal band ( $r=0.36$ ;

$p=0.02$ ). There was a statistically weak correlation between BMI and MMS ( $r=0.39$ ;  $p=0.01$ ) using Müller's maneuver in the tongue base ( $r=0.35$ ;  $p=0.03$ ). A positive moderate significant correlation was determined between BMI and sleep endoscopy in the tongue base ( $r=0.43$ ;  $p=0.01$ ).

## DISCUSSION

In addition to clinical examinations, the determination of regions causing obstruction during sleep is of vital importance in planning the surgical operations to be applied to these patients. The primary approach is the careful examination of the upper respiratory tract, especially the oropharynx. Examination of the size of the tongue base and soft palate has a special significance in the evaluation of oropharynx. Thus, Mallampati classification was first utilized in the evaluation of difficult intubation and later modified by Friedman et al<sup>3</sup>. As this classification, which is based on the relationship of the tongue base and soft palate, is still controversial in determining the pathology in patients with OSAS, many studies have been conducted on this subject. In a study by Liistro et al, a close relationship was determined between MMS and apnea-hypopnea index values and the authors defended the view that MMS is a risk factor for patients with OSAS<sup>14</sup>. Danny et al. concluded that the size of the tongue base is significant for retrolingual collapse as determined by Müller's maneuver, although it is independent of tonsil size<sup>15</sup>. In contrast, Den Herder et al. determined obstruction at the level of the tongue base in patients with low Mallampati grades when they investigated the relationship between findings of sleep endoscopy and Mallampati grading<sup>16</sup>. In the current study, retrolingual obstruction was detected in only 5 patients with high MMS during sleep endoscopy. No significance was established between MMS and sleep endoscopy. Retrolingual obstruction was not

considered to be significant in patients with high MMS in sleep endoscopy.

Müller's maneuver is another examination method to determine the probable obstruction regions of the upper respiratory tracts of patients with OSAS. Here, the aim is to identify the regions that have a tendency to collapse in the upper respiratory tract by creating negative intraluminal pressure. However, there are arguments that evaluation made by Müller's maneuver would not really reflect the obstruction observed during sleep. One of the opinions set forth as a reason is that Müller's maneuver is applied when the patient is awake and frequently is in a sitting position. Another reason is the fact that not every patient can create sufficient negative pressure. Terris et al. established that evaluations prepared by Müller's maneuver changed from clinician to clinician, and that patients could not always provide the negative pressure that creates obstructions<sup>17</sup>.

In a study comparing Müller's maneuver and sleep endoscopy, Pringle et al. determined collapse especially in the oropharyngeal level with sleep endoscopy in patients for whom no obstruction was detected with Müller's maneuver<sup>8</sup>. Danny et al. did not detect any difference between sleep endoscopy and Müller's maneuver in the evaluation of the uvulopalatal region, although they established that sleep endoscopy was more effective in determining obstruction in the retrolingual region<sup>15</sup>. On the other hand, Süslü et al. specified that findings obtained in Müller's maneuver and findings of sleep endoscopy were not consistent with each other, and it was stated that Müller's maneuver was inadequate for evaluation<sup>18</sup>. In the current study, obstruction assessment using sleep endoscopy was found to be more efficient. Obstruction assessment in the uvulopalatal region, lateral pharyngeal band, and tongue base was observed to be significant. However, no difference was determined in the laryngeal region evaluations between Müller's maneuver and sleep endoscopy.

Belgü et al. did not find a correlation between ESS and sleep endoscopy<sup>19</sup>. In the current study, a positive correlation was determined between Müller's maneuver in the uvulopalatal region, Müller's maneuver in the lateral pharyngeal band, and sleep endoscopy in the uvulopalatal region. The correlation between these procedures can be considered to be consistent with patient complaints, and this demonstrates the reliability of these

procedures.

Opinions concerning sleep endoscopy being more efficient in revealing obstructions in comparison to Müller's maneuver are supported by studies conducted to determine the effects on surgical success rates. Camilleri et al. argued that the application of sleep endoscopy before an operation is an efficient way to improve the success rate of uvulopalatopharyngoplasty (UPPP)<sup>20</sup>. In a study by Hessel et al. which investigated the effects of Müller's maneuver and sleep endoscopy on the success of UPPP operation, the results obtained by sleep endoscopy were reported to provide higher success rates compared to Müller's maneuver<sup>21</sup>. Gillespie et al. established that sleep endoscopy is the best guiding method in operation planning for patients with OSAS<sup>2</sup>. Since sleep endoscopy is a dynamic evaluation method, it enables direct monitoring of regions from which apneas and snoring originate during sleep, thus providing correct localization of obstructive pathology. Thus, an important advantage is obtained on the subject of preventing unnecessary surgery and inadequate surgical operation. Another outcome obtained from the current study was that a large proportion of the patients had obstructions at more than one level. The regions where obstruction was observed most were the uvulopalatal and lateral pharyngeal band levels. Pringle and Croft determined more obstructions, especially in the uvulopalatal region<sup>8</sup>, and Hewitt et al. also determined that the uvulopalatal region was the most frequent snoring region in patients subjected to sleep endoscopy. In the same study, however, no correlation was determined between sleep endoscopy and Müller's maneuver, and the maneuver was seen to be correctly applied in only a very small number of patients<sup>22</sup>. In laryngeal and hypopharyngeal obstructions in OSAS patients, Bachar et al. determined that the uvulopalatal region was the region where obstructions were most frequently detected, at 89%, followed by the tongue base, hypopharynx, and larynx regions. They also stated that obstruction was determined in more than one region in 72% of the patients, and this fact is important for the selection of the surgical operation to be applied<sup>23</sup>. Kezirian et al. determined the palatal and hypopharyngeal regions as the two most frequent obstruction regions in the examinations they conducted with sleep endoscopy, and obstruction was identified in more than one region<sup>1</sup>. In the current study, obstruction in more than one

region was identified with sleep endoscopy. The regions of obstruction were identified as most frequent in the uvulopalatal region and the lateral pharyngeal band.

Limitations of the current study could be considered to be that it was a cross-sectional study and that the number of patients was low. In this study, Müller's maneuver and sleep endoscopy were evaluated in terms of the severity of obstruction. However, changes in the obstruction areas according to the patient position and depth of sleep were not evaluated. Therefore, there is a need for more studies on this subject to make further contributions to literature.

It is very important to correctly determine the anatomic obstruction regions in order to improve the success rate of surgery applied for complaints of snoring. Sleep endoscopy has become increasingly preferable since it enables the determination of anatomic obstruction regions that are the closest to the obstruction in the upper respiratory tract that occur during sleep. As a conclusion, that sleep endoscopy is the most advantageous method in determining the obstruction region.

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