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ORIGINAL ARTICLE

Role of sleep endoscopy in obstructive sleep apnea syndrome

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KEYWORDS

Obstructive sleep apnea;
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Abstract *Aim:* There are limited data about the role of sleep endoscopy in obstructive sleep apnea syndrome (OSAS). The aim of this study was to evaluate the level, degree and shape of obstruction of the upper airway in patients with OSAS by sleep endoscopy and their relation to OSAS severity.

Patients and methods: Fifty consecutive patients with OSAS were prospectively enrolled in this cross sectional analytic study. All patients underwent history, a full night-attended polysomnography and sleep endoscopy. The degree of pharyngeal narrowing (grades I–IV) was evaluated at retropalatal, retroglossal and hypopharyngeal levels. Shape of pharyngeal collapse was classified into circular, lateral or antero-posterior at retropalatal and retroglossal levels. Shape of the epiglottis was also observed.

Results: All patients showed multisegmental levels of obstruction. Moderate OSAS had a higher percentage of grade II obstruction but a lower percentage of grade I at hypopharyngeal level compared to mild OSAS ($P < 0.05$). Also, in moderate OSAS, tongue base obstruction was 47.4% which was significantly higher comparing to mild OSAS (16.7%) ($P < 0.05$). There was no significant difference between different grades of obstruction at all anatomical levels in polysomnographic parameters. Omega shaped epiglottis was associated with the highest apnea hypopnea index, desaturation index, lowest average and minimum O_2 level.

Conclusion: Sleep endoscopy is a useful tool for the assessment of level, degree and shape of the upper airway obstruction during sleep in OSAS and this could be helpful in preoperative evaluation.

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Presence of obstruction at hypopharyngeal level or tongue base obstruction is an indicator of OSAS severity.

Introduction

Obstructive sleep apnea hypopnea syndrome (OSAHS) is a disorder characterized by repetitive episodes of complete (apnea) or partial (hypopnea) upper airway [UA] obstruction that occurs during sleep [1]. The current diagnostic test for OSAS is polysomnography (PSG), which provides information about the severity of OSAS and the degree of sleep fragmentation, but it does not provide any information regarding the level or degree of pharyngeal narrowing [2].

A number of investigative methods have been used to understand the pathophysiology of upper airway obstruction in patients with OSAS including lateral cephalometry, awake or sleep nasopharyngoscopy, fluoroscopy, CT scanning, MRI scanning, manometry, and acoustic reflections. In particular, nasopharyngoscopy using the modified Muller's maneuver helps to evaluate the level and degree of upper-airway narrowing during forced inspiration with the subject's mouth and nose closed. However, there is some evidence that the sites of obstruction detected with the Muller's maneuver do not reliably reflect the sites of obstruction as demonstrated through a comparison with sleep video endoscopy [3,4].

Croft and Pringle [5] introduced the technique of sleep endoscopy for use in the assessment of snoring to aid proper cases of surgical intervention. The attraction of sleep endoscopy lies in its ability to provide a dynamic visualization of the anatomic areas responsible for the generation of noise or obstruction under conditions that mimic sleep [6]. However, there are limited data about role of sleep endoscopy in OSAS.

The objective of this study was to evaluate level, degree and shape of upper airway obstruction in patients with obstructive sleep apnea syndrome (OSAS) by sleep endoscopy and their relation to OSAS severity.

Patients and methods

A total of 50 consecutive patients with obstructive sleep apnea-hypopnea syndrome (OSAS) were prospectively enrolled in this cross sectional study. An informed written consent was obtained from all the patients and the study was approved by the Faculty of Medicine Ethics Committee, Assiut University.

Exclusion criteria

(1) OSAS patients were associated with other pulmonary diseases such as COPD, asthma, interstitial lung disease, bronchiectasis etc. They were excluded by clinical history, clinical examination, chest X-ray and pulmonary function tests.
(2) Morbid obesity (BMI > 40).
(3) American Society of Anesthesiology (ASA) Classification III, IV [7].

All patients underwent a comprehensive clinical assessment, an overnight attended polysomnogram and sleep endoscopy.

Clinical assessment

(A) Medical history was taken from the patients:Attention was given to history suggestive of obstructive sleep apnea syndrome: Night symptoms of OSAS (Snoring, chocking and witnessed apnea, bad dreams and nocturea) and daytime symptoms (Morning headache, excessive day time sleepiness; assessed using the Epworth sleepiness scale).
(B) Physical examination including:
(a) Anthropometric measures: Height, weight, body-mass index (BMI), neck circumference and waist circumference were recorded.
(b) ENT examination: ENT examination is done by an ENT consultant. It includes:
(1) *Nasal inspection:* It is recommended in Sleep Breathing Disorder (SBD) patient. Nasal ala description and anterior rhinoscopy will help to diagnose valve anomalies, septum deviation or hypertrophic turbinates.
(2) *Tonsil size:* It is graded as follows [8]:Grade 1: the tonsils are in the tonsillar fossa, barely seen behind the anterior fossa.Grade 2: the tonsils are visible behind the anterior pillars.Grade 3: the tonsils are extended three quarters of the way to the midline.Grade 4: the tonsils are completely obstructing the airway.
(3) *Modified Mallampati score (MMP):* Friedman et al. [8] described a modified Mallampati score examining the oropharynx without protruding the tongue. The patient just opens his mouth without protruding the tongue. Grades of MMP are as follows:Grade I: the tonsils, pillars and soft palate are clearly visible.Grade II: the uvula, pillars and upper pole are visible.Grade III: the soft palate is partly visible; while the tonsils, pillars and base of uvula are all invisible.Grade IV: the hard palate only is visible.

Polysomnography

All patients underwent full night attended polysomnography (Somnstar 4100, Sensor-Medics Co., Yorba Linda, CA, USA) in the sleep laboratory of the Assiut university hospital. The polysomnogram systematically monitors the electroencephalogram (EEG) (C3-A2,C4-A1), electro-oculogram (EOG), electromyogram of the chin (EMG), electrocardiogram (EKG), body positions, nasal and oral airflow, thoracic and abdominal effort, limb movements, pulse oximetry, and snoring sound level. The polysomnograms were all scored manually according to the American academy of sleep medicine [1].

Apnea was defined as a complete cessation of airflow for more than 10 s.

Obstructive apnea is an apnea with preserved respiratory effort.

Central apnea is an apnea with absent respiratory effort.

Hypopnea requires an event of at least 10 seconds duration in association with a $\geqslant$30% drop in the baseline amplitude and a $\geqslant$4% desaturation from the baseline saturation.

The **AHI** was calculated as the number of apnea and hypopnea events per hour of sleep. The patients were then classified based on the following frequencies of apnea–hypopnea episodes during total sleep time into: mild; 5 to 15 events/hour, moderate; 15 to 30 events/hour and severe > 30 events/hour [1].

Desaturation was detected by a drop of at least 4% below the baseline.

Table 1 Demographic data of the study group (N = 50).

Variable	(N = 50)
Age "years"	39.28 ± 9.94
Sex: Male: Female	42 (84%): 8 (16%)
BMI (Kg/m^2)	30.58 ± 4.28
OSAS severity	
Mild	18 (36%)
Moderate	19 (38%)
Severe	13(26%)

Data expressed as number and percentage (%) or mean ± SD.
N = number; BMI = body mass index; OSAS = obstructive sleep apnea syndrome.

Sleep endoscopy

Instrument used.

(1) Flexible endoscope: Xion (EFN14-n14), 4.2 mm diameter. Using a computerized system including:
   (a) Camera: Xion (CH01-D).
   (b) Light source: ExplorENT (HAL250).

(2) Pulse oximeter: In order to monitor the patient in terms of arterial saturation of oxygen and heart beat.

Technique of sleep endoscopy. The procedure was carried out in the operating room, day case surgery. The patient was placed in supine position with an intravenous line in place. An anesthetist then induced sleep by intravenous administration of propofol. The mean dose required was (30–50 mg) titrated individually and given gradually. Further 10 mg boluses of propofol were administered as necessary to maintain a satisfactory level of sedation. The sedation was maintained so that the patient was able to respond to verbal stimuli, just as he could during physiological sleep. Propofol has the advantage of its sufficiently short half-life. Moreover, it does not affect breathing drive and muscle tone [9]. The examination started when the patient had started snoring, direct inspection of upper airway was performed. It started through the retropalatal level, then the retroglossal level and finally the hypopharyngeal level. Evaluation of the degree of collapse of the pharynx was done at different levels. This was graded separately for each region

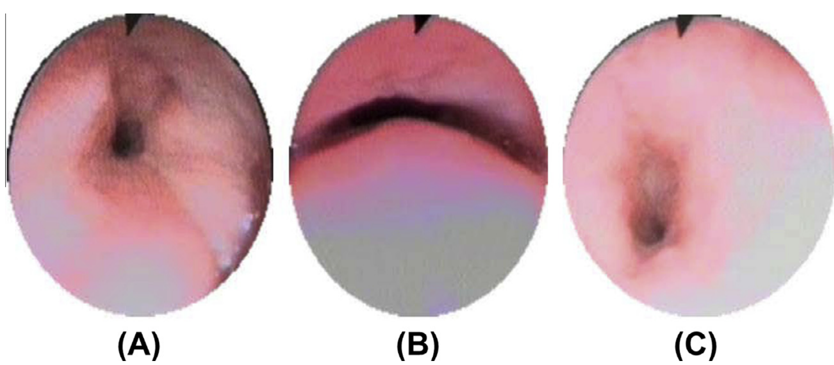

Figure 1 Shapes of obstruction at the retropalatal level. (A): Retropalatal circularcollapse; (B): Retropalatal anteroposterior collapse; (C): Retropalatal lateral collapse.

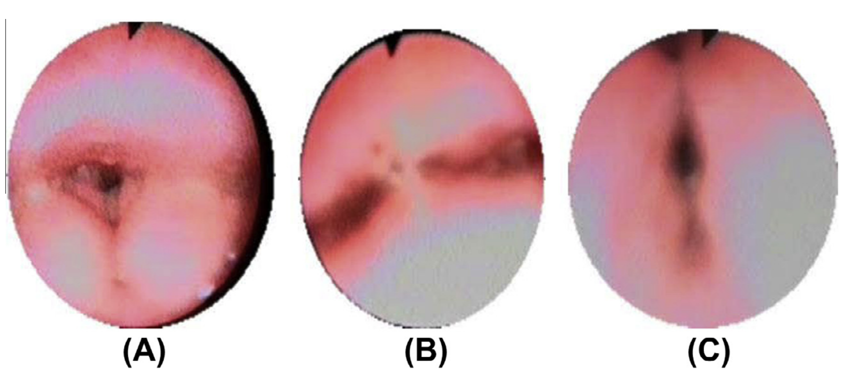

Figure 2 Shapes of obstruction at the retroglossal level. (A): Retroglossal circular collapse; (B): retroglossal anteroposterior collapse; (C): retroglossal lateral collapse.

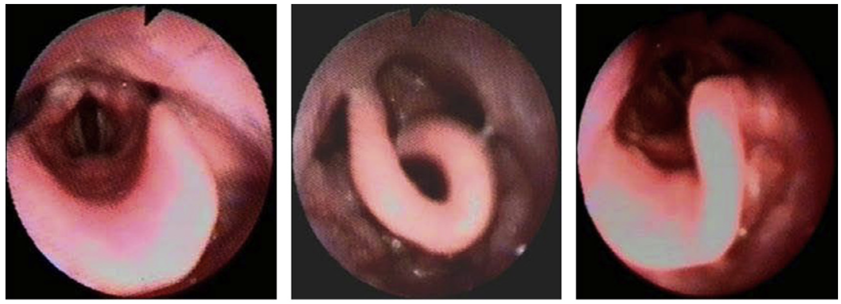

Figure 3 Shapes of epiglottis (A): flat epiglottis; (B): omega shaped epiglottis; (C): curled epiglottis.

in an ordinal fashion [5]; Grade I: <25%, Grade II: 25–50%, Grade III: 50–75% and Grade IV: >75% obstruction. Evaluation of the shape of closing of pharyngeal walls was done as follows: circular, lateral or antero-posterior [10] at retropalatal and retroglossal levels. Also evaluation of the shape of epiglottis whether flat, curled or omega was done. Further evaluation of the areas of vibration and snoring generation, position of soft palate and of uvula in relation to oropharynx walls and position of tongue base was done. During the procedure, heart rate, blood pressure and oxygen saturation were monitored continuously. Preoxygenation and delivery of oxygen, either through the nasal cannula or face mask in a "blow-by" fashion, during the procedure helped maintaining acceptable oxygen saturations during the periods of desaturation. The procedure took about 15 min and then the patient was woken up spontaneously and followed for about 30 min and then discharged.

Table 2 Sleep endoscopic evaluation of OSA patients.

Variable	(N = 50)
Presence of Adenoid hypertrophy	36 (78%)
Presence of Lingual tonsil	14 (28%)
Retropalatal level	
Degree of obstruction	
• Grade 1	0
• Grade 2	0
• Grade 3	2 (4%)
• Grade 4	48 (96%)
Shape of obstruction	
• Circular	7 (14%)
• Lateral	32 (64%)
• Anteroposterior	11 (22%)
Retroglossal level	
Degree of obstruction	
• Grade 1	1 (2%)
• Grade 2	9 (18%)
• Grade 3	11 (22%)
• Grade 4	29 (58%)
Shape of obstruction	
• Circular	15 (30%)
• Lateral	29 (58%)
• Anteroposterior	6 (12%)
Hypopharyngeal level	
Degree of obstruction	
• Grade 1	30 (60%)
• Grade 2	13 (26%)
• Grade 3	7 (14%)
• Grade 4	0

Data expressed as number (%).

Statistical analysis

Statistical Package for the Social Sciences (SPSS-version 20) software was used for analysis of results. Results in this study were expressed as mean ± standard deviation or number and percentage. Proportions were compared with chi-square tests. Comparison between 2 groups was done using t-test and one way ANOVA test for comparison between more than 2 groups. The difference was considered significant when $P < 0.05$.

Results

The demographic data are shown in Table 1. By sleep endoscopic evaluation, 43 (86%) of patients with OSAS had grade I and II tonsils and 7 (14%) had grade III and IV tonsils. All of them showed a multisegmental level of obstruction but with different degrees and shapes as shown in Figs. 1–3 (Table 2). At retropalatal level, the most common shape of obstruction was the circular one (64%). The lateral shape of obstruction (58%) was the most common one at the retroglossal level (Table 2).

As regards the degree of obstruction as assessed by sleep endoscopy among OSAS groups, Table 3 showed that patients with moderate OSAS had a significant lower grade I but higher grade II obstruction at the hypopharyngeal level when compared to mild OSAS ($P < 0.05$ for each). Moreover, in moderate OSAS tongue base obstruction was noticed in 47.4% which was significantly higher when compared to mild OSAS (16.7%). However, there were no statistically significant differences in the shapes of obstruction at different levels among OSAS groups ($P > 0.05$ for each).

As regards the relation between degree of obstruction and polysomnographic parameters, there were no statistically significant differences in polysomnographic parameters between different grades of obstruction at both retroglossal and hypoparyngeal levels ($P > 0.05$ for each).

Table 3 Relation between degree of obstruction, tongue base obstruction and shape of obstruction as evaluated by sleep endoscopy and obstructive sleep apnea severity ($N = 50$).

Level of obstruction	OSAS groups			P-value[1]	P-value[2]	P-value[3]
	Mild ($N = 18$)	Moderate ($N = 19$)	Severe ($N = 13$)			
Degree of obstruction						
Retropalatal						
Grade III	0 (0.0%)	2 (10.5%)	0 (0.0%)	0.491	–	0.642
Grade IV	18 (100%)	17 (89.5%)	13 (100%)			
Retroglossal						
Grades I & II	5 (27.8%)	4 (21.1%)	1 (7.7%)	0.926	0.349	0.598
Grade III	3 (16.7%)	4 (21.1%)	4 (30.8%)	1.000	0.354	0.835
Grade IV	10 (55.6%)	11 (57.9%)	8 (61.5%)	0.886	0.739	0.837
Hypopharyngeal						
Grade I	15 (83.3%)	7 (36.8%)	8 (61.5%)	0.004*	0.341	0.169
Grade II	1 (5.6%)	8 (42.1%)	4 (30.8%)	0.027*	0.165	0.780
Grade III	2 (11.1%)	4 (21.1%)	1 (7.7%)	0.709	0.751	0.598
Tongue base obstruction						
Not pushing	15 (83.3%)	10 (52.6%)	11 (84.6%)	0.046*	0.924	0.136
Pushing	3 (16.7%)	9 (47.4%)	2 (15.4%)			
Shape of obstruction						
Retropalatal						
Circular	9 (50.0%)	15 (78.9%)	8 (61.5%)	0.065	0.524	0.499
Lateral	3 (16.7%)	1 (5.3%)	3 (23.1%)	0.557	0.656	0.341
Anteroposterior	6 (33.3%)	3 (15.8%)	2 (15.4%)	0.390	0.477	0.975
Retroglossal						
Circular	6 (33.3%)	6 (31.6%)	3 (23.1%)	0.909	0.826	0.900
Lateral	10 (55.6%)	10 (52.6%)	9 (69.2%)	0.858	0.691	0.348
Anteroposterior	2 (11.1%)	3 (15.8%)	1 (7.7%)	0.677	1.000	0.892
Epiglottis						
Flat	14 (77.8%)	14 (73.7%)	8 (61.5%)	0.772	0.561	0.734
Omega	2 (11.1%)	3 (15.8%)	4 (30.8%)	0.677	0.365	0.568
Curled	2 (11.1%)	2 (10.5%)	1 (7.7%)	0.954	1.000	1.000

Data expressed as number (%).
P1: mild versus moderate P2: mild versus severe P3: moderate versus severe.
* Significant.

On analysis of the shape of obstruction and polysomnographic parameters, lateral shape was associated with the highest mean AHI, supine AHI, desaturation index, the lowest minimum and average oxygen level and the longest T90 at both retropalatal and retroglossal levels, but with no statistically significant differences ($P > 0.05$) when compared with the other shapes of obstruction (Table 4).

However, omega shaped epiglottis was associated with significantly higher mean AHI, lateral AHI, REM AHI, NREM AHI, lower minimum and average oxygen level when compared to other shapes ($P < 0.05$) as shown in Table 5.

Discussion

The present study demonstrated that, all patients had multiple levels of obstruction. Also, patients with moderate OSAS had a significant lower grade I but higher grade II obstruction at hypopharyngeal level when compared to mild OSAS. Moreover, there was no statistically significant difference between degree of obstruction at different levels and polysomnographic parameters (AHI and oxygen indices). However, the percentage of tongue base obstruction was found to be significantly higher in moderate as compared to the mild group. This was confirmed in previous studies. The study of Farmer and Giudici [11] seems to prove that the AHI predicts neither the area of obstruction nor the severity of the OSAS. Rama et al. [12] on their study to find the area of obstruction causing the apneas, show that there is a possibility of a multiple level collapse at all degrees of severity of the OSAS. Also, Abdullah et al. [13] reported that most patients with OSA had multilevel obstructions thus it is not strange not to find a relation between the area of obstruction seen in the sleep endoscopy and the AHI. Moreover, Ozdas et al. [14] showed that the degree of obstruction of the soft palate and the lateral pharyngeal walls had no statistically significant correlation with AHI when examined at the level of the soft palate.

On the other hand, many studies found a good correlation of the narrowing at each anatomic site with the severity of OSAS. Pang et al. [15] revealed that all 3 levels (palatal, lateral pharyngeal wall, and base of tongue) correlated very well with the severity of OSA. Hori et al. [16] reported that there was a significant correlation between the degree of narrowing of the retropalatal and apnea index. Also, Kim et al. [17] reported that the degree of retroglossal pharyngeal narrowing was significantly correlated with total AHI and supine AHI and the degree of retropalatal pharyngeal narrowing was significantly correlated with the lateral AHI. Abdullah et al. [18] found

Table 4 Relation between shape of obstruction at retropalatal and retroglossal levels and polysomnographic parameters (N = 50).

Variable	Shape			P-value[1]	P-value[2]	P-value[3]
	Circular (N = 32)	Lateral (N = 7)	Anteroposterior (N = 11)			
	Mean ± SD	Mean ± SD	Mean ± SD			
Shape of obstruction at retropalatal level						
AHI (event/h)	23.29 ± 16.47	28.29 ± 23.15	18.78 ± 12.61	0.504	0.414	0.273
Supine AHI	30.84 ± 20.47	36.43 ± 30.28	29.82 ± 16.87	0.553	0.882	0.558
Lateral AHI	18.25 ± 23.27	13.86 ± 20.91	10.82 ± 10.60	0.648	0.315	0.687
NREM AHI	26.40 ± 17.43	35.30 ± 25.49	19.38 ± 9.19	0.268	0.211	0.074
REM AHI	27.48 ± 18.03	32.41 ± 22.96	20.22 ± 12.25	0.536	0.224	0.159
DI (event/h)	17.97 ± 16.41	28.29 ± 27.80	15.55 ± 8.32	0.195	0.643	0.168
Average O_2 (%)	90.65 ± 5.10	89.21 ± 5.43	92.05 ± 1.75	0.509	0.381	0.124
Minimum O_2 (%)	81.16 ± 9.49	78.43 ± 13.94	82.36 ± 5.55	0.531	0.693	0.409
T90 (min)	12.06 ± 17.46	19.43 ± 28.66	19.18 ± 30.40	0.376	0.346	0.987
Shape of obstruction at retroglossal level						
AHI(event/h)	20.85 ± 16.69	24.60 ± 17.53	20.60 ± 13.64	0.498	0.974	0.603
NREM AHI	24.71 ± 15.01	28.08 ± 20.08	20.02 ± 9.40	0.571	0.488	0.437
REM AHI	27.43 ± 21.24	26.98 ± 17.08	22.43 ± 13.07	0.940	0.600	0.544
Supine AHI	32.07 ± 19.25	32.79 ± 23.58	23.00 ± 7.82	0.919	0.284	0.327
Lateral AHI	20.20 ± 30.65	14.79 ± 15.74	11.33 ± 9.99	0.441	0.502	0.611
DI(event/h)	15.00 ± 11.69	21.86 ± 20.42	14.17 ± 6.94	0.237	0.873	0.373
Average O_2 (%)	91.23 ± 2.84	90.48 ± 5.66	90.90 ± 2.54	0.634	0.809	0.861
Minimum O_2 (%)	82.27 ± 9.41	80.62 ± 10.27	80.00 ± 4.60	0.607	0.584	0.887
T90 (min)	10.47 ± 18.11	17.14 ± 25.97	13.17 ± 7.65	0.380	0.731	0.716

P1: Circular versus lateral, P2: circular versus anteroposterior, P3: lateral versus anteroposterior.
AHI = apnea hypopnea index, T90 = time spent below 90% in minutes, DI = desaturation index.

Table 5 Relation between shape of epiglottis and polysomnographic parameters (N = 50).

Variable	Shape of epiglottis		P-value
	Flat/Curled (N = 41)	Omega (N = 9)	
	Mean ± SD	Mean ± SD	
AHI (event/h)	20.63 ± 15.54	33.78 ± 18.30	0.031*
NREM AHI	24.46 ± 17.24	33.58 ± 18.53	0.163
REM AHI	23.84 ± 16.95	39.03 ± 16.83	0.018*
Supine AHI	29.41 ± 19.90	40.44 ± 24.54	0.155
Lateral AHI	12.73 ± 13.83	30.89 ± 36.98	0.016*
DI (event/h)	17.05 ± 15.32	27.22 ± 23.17	0.108
Average O_2 (%)	91.44 ± 3.77	87.62 ± 6.83	0.023*
Minimum O_2 (%)	82.46 ± 8.11	74.56 ± 12.45	0.021*
T90 (min)	13.88 ± 22.00	18.22 ± 24.28	0.601

Data expressed as mean ± SD.
AHI = apnea hypopnea index, T90 = time spent below 90% in minutes, DI = desaturation index.
* Significant.

that, at the supine retropalatal, average oxygen saturation has significant association with the severity of obstruction. At the retroglossal region, only gender has a predictor value of sleep apnea severity.

As regards tongue base obstruction, Pang et al. [13] noted that there was a significant difference in the frequency and degree of base of tongue collapse in patients with severe OSA. They reported that only 6.9% of patients with mild OSA had a ⩾50% collapse of the base of the tongue region, as compared to 65.9% of patients with severe OSA. However, Ozdas et al. [14] reported that the obstruction degree of the tongue base had no statistically significant correlation with AHI when examined by Müller's maneuver.

The present study showed that, lateral shape of obstruction either at retropalatal or retroglossal level is associated with the highest mean AHI, supine AHI, desaturation index, the lowest minimum and average oxygen level and the longest T90 but the difference is not statistically significant. In contrast, Rodenstein et al. [19] reported that a reduced pharyngeal transverse diameter may be related to the risk of sleep-related breathing disorder and it has significant inversed correlation with AHI. Kim et al. [17] showed more severe OSAS (a higher AHI) in the patients with lateral narrowing type than those with anteroposterior type. However this is inconsistent with Cosentini et al. [20] who examined obese severe OSA patients with MRI imaging during wakefulness and they reported that airway shape had no correlation with sleep apnea severity. Several studies have suggested that orientation of the elliptically shaped upper airway differs between individuals with and without OSA. They suggest that in individuals with OSA, the long axis of the ellipse is oriented anteroposteriorally, making the lateral pharyngeal walls more susceptible to collapse, whereas in subjects without OSA, the long axis of the ellipse is oriented transversely [19–21]. However, numerous other studies report airway shape to be similar in apneics and non-apneic controls [21–23].

The shape of the epiglottis is a point of interest. Normally, the posterior surface of the epiglottis is slightly concave as seen from above. In the current study, we noticed that the epiglottis was deeply concave (omega shaped) in some cases. Patients with omega shaped epiglottis were associated with more significantly higher AHI and more severe oxygen indices when compared with other OSAS patients. This was noted in a previous study carried out by Gazayerli et al. [24]. When they performed esophagogastroduodenoscopy on patients with a variety of body mass indexes ranging from 21 to 63, they noticed a significant correlation between BMI and the degree of concavity of the posterior epiglottal surface. The posterior surface of the epiglottis in patients with normal BMI was minimally concave. However, the extent of concavity increased proportionally with the increase in BMI, to the point at which total closure of the epiglottis was observed in extreme cases. They concluded that as BMI is correlated with OSAS severity, the abnormally shaped epiglottis is related to OSAS severity.

Conclusion

Sleep endoscopy is a useful tool for the assessment of level, degree and shape of upper airway obstruction during sleep in OSAS and this could be helpful in preoperative evaluation. Presence of obstruction at the hypopharyngeal level or tongue base obstruction is an indicator of OSAS severity.

Conflict of interest

There was no conflict of interest.

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