Ear, Nose & Throat Journal
2020, Vol. 99(8) 537–542

DOI: 10.1177/0145561319840818
journals.sagepub.com/home/ear
SAGE

Investigation of the Effectiveness of Surgical Treatment on Respiratory Functions in Patients With Obstructive Sleep Apnea Syndrome

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Abstract

Objective: Obstructive sleep apnea syndrome (OSAS) is a problem that involves many bodily systems and its effects on the respiratory system deserve special attention. Although many studies exist that investigate respiratory functions in patients using continuous positive airway pressure (CPAP) for the treatment of sleep apnea, there is a lack of research regarding the effect of OSAS surgery on respiratory function in the literature, which has motivated us to perform such a study. **Materials and Methods:** Thirty-two patients diagnosed with OSAS with an apnea hypopnea index ranging between 15 and 30 and had undergone robotic tongue base resection and uvulopharyngoplasty were included as study participants. Pulmonary function tests were performed on all participants 1 day prior to, and at 3 and 6 months after the operation. Weight and body mass indices (BMIs) were also recorded at the same intervals for all participants. Data were electronically recorded and analyzed through SPSS 22.0. Values of $P < .05$ have been considered as statistically significant. **Results:** Average age of the 32 participants was 43.2 ± 10.7, average body weight was 94.1 ± 12.6, and average BMI was 31.4 ± 4.7. Decreases in body weight and BMI values recorded at 3 and 6 months postoperatively had statistical significance when compared with values recorded preoperatively ($P < .05$). Comparisons made in terms of pulmonary functions revealed a statistically significant increase in 3 and 6-month postoperative values of FVC, FEV1, FEV1/FVC, PEF, and FEF 25-75 ($P < .05$). **Conclusion:** Our study shows the positive effects of robotic tongue base resection and uvulopharyngoplasty operation on respiratory function parameters. This suggests that surgical treatment in OSAS patients is as effective as CPAP on respiratory function.

Keywords

obstructive sleep apnea syndrome, transoral robotic surgery, pulmonary function test

Introduction

Obstructive sleep apnea syndrome (OSAS) is a condition characterized by recurrent total or partial obstruction in the upper respiratory tract during sleep and decrease in oxygen levels of blood.[1] The gold standard for diagnosis of OSAS is polysomnography (PSG). Polysomnography is indicated in patients with a suspected OSAS. Polysomnography should also be used routinely to investigate OSAS in preoperative clinical evaluation in patients who are planned for uvulopalatopharyngoplasty.[2] It is required for continuous positive airway pressure (CPAP) titration to be applied to patients with respiratory problems during sleep. Follow-up PSG should be performed for the examination of treatment outcomes.[2,3]

Three important factors play a role in the development of obstruction in the upper airway; the anatomy of the upper airways, the negative pressure generated during breathing, and the loss of activation in the muscles that expand the pharyngeal airway.[4] In patients with OSAS, shortness of the mandibular size, inferior localization of the hyoid bone, and retroposition of maxilla have been described with radiological studies.[5]

In studies with more advanced imaging modalities (computerized tomography, magnetic resonance imaging), pharyngeal

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airway space was narrower than the control group and therefore more prone to collapse.[4,5] To explain that the upper airway anatomy poses a risk for OSAS, Scwab et al. performed three-dimensional measurements with MRI. In these measurements, the lateral pharyngeal wall, tongue, and soft tissue were measured larger in patients with OSAS and explained that they were the important risk factors for sleep apnea.[6] The large tongue volume, tongue base size, posterior placement of the mandible, and inferior sagging of the soft palate have been shown to be crucial for OSAS, and the lateral walls of the upper airways are important in collapse in recent years.[7,8]

In the otorhinolaryngology practice, robotic surgery has gained popularity and with more frequent indications in recent times. Robotic surgery for the treatment of OSAS was first utilized by Vicini et al.[9] in the pathology related to tongue base in 2010. Studies involving more cases were reported by the same group in 2011 and 2012, where OSAS surgery in the form of transoral robotic surgery (TORS) approach to tongue base showed statistically significant improvements in Epworth Sleepiness Scale, oxygen saturation, and apnea hypopnea index (AHI). Additionally, there was no reported increase of complications such as bleeding or airway deterioration during the application of this technique.[9]

The pulmonary function test (PFT) is a common diagnostic method in clinical studies of respiratory diseases. It is an objective technique used in the evaluation of the ventilation, diffusion, and physical steps of the respiratory system. In the mid-1800, Hutchinson was able to measure vital capacity volume with a device similar to a spirometer. Spirometric tests are the most commonly used diagnostic tests in evaluating pulmonary function.[10]

Although a number of studies have examined pulmonary function parameters in patients using CPAP for the treatment of OSAS, it is noteworthy that a study investigating the effect of OSAS surgery on respiratory functions is currently not available in the literature.

The aim of our study is to investigate the efficacy of surgical treatment on respiratory functions in patients with OSAS and to demonstrate the positive effects of surgical treatment on pulmonary functions, similar to the effects of CPAP.

Materials and Methods

Our study was carried out in the Otorhinolaryngology and Head and Neck Surgery Clinic of the Istanbul Medipol University Hospital as per the ethics committee decision number 125 of the Istanbul Medipol University Clinical Research Local Ethics Committee.

Thirty-two patients (30 males and 2 females) who had undergone robotic tongue base resection and uvulopharyngoplasty between the dates of January 1, 2015, to December 31, 2015, were included as study participants. Patients included in this study had presented to our clinic with the complaints of snoring, apnea during sleep, daytime fatigue, and falling asleep. Preliminary examination and evaluation revealed that study participants ranged between grade 2 and 4 on the Friedmann tonsil hypertrophy classification, grade 2 and 4 on the Mallampati classification, and all participants were grade 2 (oropharyngeal-hypopharyngeal) on the Fujita classification for airway obstruction. During the modified Muller maneuver performed on the endoscopic examination at the preoperative stage of the surgery, there was a 50% or more circumferential narrowing in the entire patient population.

In addition, according to the Epworth Sleepiness Scale questionnaire performed preoperatively, patients scored between 13 and 20 points. Polysomnography test was performed on all study participants, with a resulting AHI ranging between 15 and 30. Sleep endoscopy (or sedated endoscopy) performed on the day of the operation revealed a level of obstruction which included the palatal, oropharyngeal, and tongue base in all patients, further supporting the diagnosis of obstructive sleep apnea. After all these evaluations, all patients underwent surgery for robotic tongue base resection and uvulopharyngoplasty.

The inclusion criteria for the study were an AHI score of 15 to 30, and a level of obstruction which involves the palate, oropharynx, and tongue base altogether. Exclusion criteria for the study were considered to be the presence of any lung disease and any condition that would contraindicate the administration of general anesthesia.

Pulmonary function test s were performed on all participants 1 day prior to and at 3 and 6 months after the operation with Winspro Spirolab III. Weight and body mass indices (BMIs) were recorded at the same intervals for all participants using the Welch Allyn Health-O-Meter. The following parameters of PFT were measured and recorded 1 day prior to and at 3 and 6 months after the operation: FVC, FEV1, FEV1/FVC, PEF, and FEF25-75.

Participants included in the study were placed under general anesthesia and nasotracheal intubation, followed by placement of the Feyh-Kastenbauer retractor. Maryland dissector was placed in one of the robotic arms for grasping and dissecting the tissues, a monopolar cautery in the second arm, and a 30° endoscope in the third arm. Circumvallate papillae and epiglottis were included within the angle of vision at the base of the tongue. Subsequently, approximately 2×4 cm from the medial part, the tongue base was excised with the aid of a robotic monopolar cautery. Following bleeding control, participants were placed in an appropriate position for jaw-opening with Davis Boyle, and uvulopalatopharyngoplasty operations were performed. All operations were performed by the same surgeon.

Statistical Method

Mean, standard deviation, median, lowest, highest, frequency, and ratio values were used in the descriptive statistics of the data. The distribution of the variables was measured by the Kolmogorov Smirnov test. Mann-Whitney U test was used for quantitative analysis. Paired t test and Wilcoxon test were used for analysis of recurrent measurements. Spearman correlation

Table 1. Preoperative and Postoperative Weight and BMI Changes.

	Min-Max	Median	Mean (SD)	P^a	P^b
Weight (kg)					
Preop	78.0–125.0	92.5	94.1 (12.6)		
Postop third month	69.0–116.0	88.0	89.2 (11.7)	.000[c]	[c]
Postop sixth month	70.0–114.0	87.5	88.5 (10.3)	.000[c]	.303[c]
BMI					
Preop	23.1–41.7	30.7	31.4 (4.7)		
Postop third month	21.9–39.6	29.4	29.7 (4.5)	.000[d]	
Postop sixth month	22.8–39.9	28.9	29.5 (4.1)	.000[d]	.349[d]

[a] Difference according to preoperative period.
[b] Difference according to postoperative third month.
[c] Wilcoxon test
[d] Paired sample *t* test.
Note. Bold values indicate that both third and sixth month postoperative results showed a significant difference according to preoperative results.

analysis was used for correlation analysis, and SPSS 22.0 software was used for the analysis.

Results

Thirty-two patients (30 males, 2 females) who had undergone robotic tongue base resection and uvulopharyngoplasty were included in this study. The mean age of the patients was 43.2 ± 10.7. Patients included in the study had an average body weight measurement of 94.1 ± 12.6 kg, with body weight measurements ranging from 78 to 125 kg. The mean BMI value of the patients was 31.4 ± 4.7. There was a statistically significant difference between preoperative body weight measurements and third-/sixth-postoperative-month body weight measurements ($P < .05$). However, there was no statistically significant difference between third-postoperative month and sixth-postoperative month body weight measurements ($P > .05$; Table 1).

A statistically significant difference was found between the preoperative BMI values and third-/sixth-postoperative month BMI values of all patients in the study ($P < .05$). Once again, there was no statistically significant difference between third- and sixth-postoperative month BMI values ($P = .05$; Table 1).

Preoperative respiratory function test parameters were compared with third- and sixth-postoperative month parameters. The third- and sixth-postoperative month values were compared with the preoperative values of forced vital capacity (FVC), forced expiratory volume 1 (FEV1), FEV1/FVC, peak expiratory flow (PEF), and forced expiratory flow 25-75 (FEF 25-75). Statistically significant increases in these values have been demonstrated ($P < .05$; Table 2).

When statistical results were evaluated, there was no statistically significant correlation between preoperative/third-postoperative month BMI change and preoperative/third-postoperative-month FVC, FEV1, FEV1/FVC change ($P > .05$; Table 3).

There was a statistically significant negative correlation between preoperative/third-postoperative month BMI change and preoperative/third-postoperative month PEF change

Table 2. Preoperative and Postoperative pulmonary function test (PFT) Parameters.

	Min–Max	Median	Mean (SD)	P^a	P^b
FVC					
Preop	56.0–120.0	89.5	88.8 (12.5)		
Postop third month	57.0–121.0	91.0	90.4 (12.4)	**.000**[c]	
Postop sixth month	56.0–119.0	90.5	90.2 (12.2)	**.000**[c]	.366[c]
FEV1					
Preop	66.0–114.0	92.0	92.6 (12.6)		
Postop third month	65.0–133.0	94.0	94.7 (14.0)	**.003**[d]	
Postop sixth month	67.0–130.0	92.5	94.4 (13.4)	**.042**[d]	.290[d]
FEV1/FVC					
Preop	92.0–127.0	107.5	109.2 (7.9)		
Postop third month	95.0–127.0	109.0	110.2 (7.7)	**.001**[d]	
Postop sixth month	96.0–126.0	108.0	109.5 (7.8)	.390[d]	**.031**[d]
PEF					
Preop	38.0–127.0	87.0	87.7 (19.3)		
Postop third month	38.0–128.0	89.0	89.0 (19.4)	**.000**[c]	
Postop sixth month	37.0–126.0	88.5	88.4 (19.0)	**.012**[c]	.082[c]
FEF 2575					
Preop	48.0–151.0	100.0	98.9 (26.5)		
Postop third month	49.0–149.0	101.5	99.9 (25.8)	**.003**[d]	
Postop sixth month	52.0–152.0	101.0	99.7 (25.6)	**.036**[d]	.460[d]

[a] Difference according to preoperative period.
[b] Difference according to postoperative third month.
[c] Paired sample *t* test.
[d] Wilcoxon test.
Note. Bold values indicate that both third and sixth month postoperative results showed a significant difference according to preoperative results.

Table 3. Correlation of body mass index (BMI) Change With pulmonary function test (PFT) Values at Third Month.

	Preop-/Postop-Third Month PFT Values				
	FVC	FEV1	FEV1/FVC	PEF	FEF2575
Preop-/postop-third month BMI					
r	−0.138	−0.102	0.040	−0.459	0.397
P	.451	.578	.827	***.009***	***.025***

Note. There was a statistically significant correlation between the preoperative/third postoperative month BMI change and the preoperative/third postoperative month PEF and FEF 25-75 change. Because PEF and FEF 25-75 values give better information about large and medium airway obstruction.

Table 4. Correlation of body mass index (BMI) Change with pulmonary function test (PFT) Values at Sixth Month.

	Preop/postop Sixth Month PFT Values				
	FVC	FEV1	FEV1/FVC	PEF	FEF2575
Preop-/postop-sixth month BMI					
r	−0.222	−0.230	−0.140	−0.248	0.204
P	.222	.206	.446	.171	.262

(P <.05; Table 3). Also, there was a statistically significant positive correlation between the preoperative/third-postoperative month BMI change and the preoperative/third-postoperative month FEF 25-75 change ($P < .05$; Table 3).

However, there was no statistically significant correlation between preoperative/sixth-postoperative month BMI change and preoperative/sixth-postoperative-month FVC, FEV1, FEV1/FVC, PEF, and FEF25-75 change ($P > .05$; Table 4). Between third and sixth month, although the BMI values of patients have increased slightly, the improvement in PFT values continues at postoperative sixth month (Table 4).

Discussion

Obstructive sleep apnea syndrome is a syndrome characterized by recurrent partial or complete upper respiratory tract obstruction resulting in hypoxia during sleep. Socioeconomic outcomes are extremely important in terms of community health. Obstructive sleep apnea syndrome is an important risk factor for hypertension, myocardial infarction, and stroke as well as impairment of the quality of life of the patient.[9]

Pathophysiology in many areas such as velopharynx, oropharynx, tongue base, and epiglottis may cause upper respiratory tract obstruction and cause OSAS. The obstruction at the level of the tongue base is one of the most common causes of sleep apnea. Obstructive sleep apnea syndrome is a multisystemic disease affecting all body systems, especially the cardiovascular system, and has a negative effect on the quality of life. While positive airway pressure is an effective treatment option in OSAS treatment, a significant proportion of patients cannot tolerate this treatment method and alternative treatment methods are frequently sought. Transoral robotic tongue base surgery is a new technique in the surgical treatment of patients with OSAS.[9]

Obstructive sleep apnea syndrome is a relatively neglected disease that is difficult to treat and is a main cause of major health problems. There are 2 options in treatment: ventilation and surgery. Before surgery, each patient must be well-assessed and the pathology leading to obstruction should be determined correctly.[11]

The anatomy of the base of the tongue, the complex relationship with the surrounding tissues, and the critical physiological function complicate the surgical intervention and increase the rate of complications.[11]

Techniques developed for surgical treatment of tongue base hypertrophy leading to OSAS include genioglossus advancement, tongue base radiofrequency ablation, and hyoid suspension. The traditional method for transoral approaches to the tongue base is to use an endoscope or a surgical microscope. However, in these techniques, the view of the surgical field is rather limited and the sense of depth is lost. Cervical approaches have also been described by performing pharyngotomy in the approach to the tongue base, but morbidity can be seriously high in these approaches.[12]

The use of TORS in the surgical treatment of tongue base-related OSAS was first described by Vicini.[9] The most important advantage of a TORS is the ability to provide three-dimensional views and tissue resection on all planes. The lack of external incision is another advantage over open approaches. The fact that the operation time is shorter and the lack of need for opening the tracheotomy make TORS superior to other techniques.[12] In the TORS method, it has been reported that the pain is similar to nonrobotic methods in the postoperative period. The disadvantages of TORS include lack of tactile sensation, difficulty in controlling bleeding in some cases, and heavy economic burden.[11]

None of the 32 patients who underwent robotic surgery during our study had complications such as bleeding, respiratory failure, or airway injury. Respiratory problems are commonly seen in patients with OSAS before or after surgery. There is evidence of many OSAS patients suffering from chronic obstructive pulmonary disease (COPD) in the literature. This association is called overlap syndrome (OVS). It was first described by Flenley in 1985. Likewise, asthma, cystic fibrosis, and respiratory system diseases such as interstitial pulmonary fibrosis are other conditions associated with OVS. The issue of whether COPD is more frequent in patients with OSAS or vice versa is still controversial.[13] Chaouat et al. investigated the prevalence of OVS due to COPD in patients with OSAS and found a high value of 11%. Patients with OVS have been found to be at very high risk for respiratory failure and pulmonary hypertension even with a low degree of obstruction. The rates of hypoxemia, hypercapnia, and pulmonary hypertension in patients with OSAS were 27%, 10%, and 17%, respectively, whereas in the OVS group, the corresponding values were 57%, 27%, and 42%.[13]

Prevalence is thought to be higher in patients with more severe COPD. It has been suggested that the occurrence of OVS at such a high rate is probably due to the similarity of known risk factors for both diseases. Because nocturnal oxygen desaturation is more prominent in association with COPD + OSAS, it should not be forgotten that patients with COPD with OVS pointed to poor prognosis, and clinically rapid progression should be evaluated for a possible association of OSAS.[13]

The purpose of performing PFTs on all our OSAS study participants was in hopes to reveal any such relationship. It is widely known that sleep apnea could trigger an asthmatic attack in patients with OSAS suffering from associated asthma. Hypoxia, which we often observe in patients with OSAS, can lead to reflex bronchospasm through the stimulation of carotid bodies, and asthma attacks are associated with marked reduction in upper airway caliber and are common in OSAS.

Interestingly, it has been suggested that patients with this association may also have bronchial hyperreactivity which decreases with CPAP treatment.[14] We also found that respiratory function parameters in patients with OSAS were negatively affected in our study. Large-scale studies are needed to better understand the relationship between OSAS-bronchial hyperreactivity and the outcomes of CPAP or surgical treatment.

Although a number of studies have already examined pulmonary function parameters in patients with sleep apnea and those using CPAP for sleep apnea, we performed this study due to a lack of research regarding the effect of OSAS surgery on respiratory function in the literature.

The first method that should be applied algorithmically to patients with respiratory complaints is PFTs. The PFT plays a role in determining the outcome of the disease, following the course of the disease, by identifying the current functional impairment and degree, illuminating the physiopathological mechanisms responsible for the impairment of function. Respiratory function has 4 main components: 1-ventilation, 2-diffusion, 3-perfusion, and 4-breathing control. Any disease that affects the respiratory system may disrupt one or more of these functions, leading to symptoms of the disease. Tests for PFTs, ventilatory function of the lung and chest wall, tests for gas exchange, and respiratory control tests are separated. In clinical practice, tests related to ventilation and gas exchange are most commonly used.[15]

Based on all this information, PFTs were utilized in our study in order to evaluate the lung function of patients with obstructive sleep apnea and multilevel surgery. The relationship between respiratory function and sleep apnea has been investigated several times in the literature. Many studies have also been conducted to explain the relationship between respiratory functions and sleep apnea in nonsmoker patients without any lung disease.[16]

The first study was performed by Sanders et al. All 11 patients with sleep apnea showed inspiratory and/or expiratory flow oscillations.[17] In addition, in 14 of 35 patients with sleep apnea, extrathoracic upper respiratory tract obstruction was detected in a study conducted by Haponik et al.[18] The number of patient groups in these 2 studies was limited. In later studies, the patient population was higher. Smoking was not overlooked. However, flow-volume curves were not very useful due to low sensitivity, low positive, and negative predictive values.[17,18]

In a study with 170 patients, Zerah-Lancner et al. found a significant decrease in FEV1/FVC, V50 (maximum flow rate in 50% of FVC), V25 related to OSAS severity (individuals with BMI $\geq$35 were removed from study and the history of smoking was not questioned).[19]

However, Gold et al. worked with 35 apneic patient groups and 17 nonapneic control groups with appropriate demographic characteristics. Forced expiratory volume 1/forced vital capacity values were not different between the 2 groups.[20]

In our study, we took measurements of the 5 basic parameters (FEV1, FVC, FEV1/FVC, PEF, and FEF 25-75) from the group of 32 apneic patients and found significant improvement after surgery. Stauffer et al. had not demonstrated any differences in FEV1/FVC and FEF 25-75 between 15 apneic and 10 nonapneic control patients.[21]

In a study on the use of CPAP—one of the treatment modalities of OSAS—De Miguel et al. had demonstrated that there may be a relationship between spirometry and OSAS in OVS. In this study, OSAS treatment with CPAP showed significant improvement in FEV1 values at 6 months.[22] Parallel to this study, we also found a significant increase in FEV1 after surgery.

There were no significant differences between pre- and post-treatment FEV1 and FEV1/FVC values in 2 studies in which spirometric evaluation was performed by Lin et al. after 4 weeks and 8 weeks of nasal CPAP therapy.[23] In our study, we performed spirometric measurements at 3 and 6 months postoperatively and found significant improvement compared to preoperative values.

On the other hand, prognostic effect of FEV1 was demonstrated in patients with OSAS who received nasal CPAP therapy.[13] In our study, a significant improvement of FEV1 was detected in the PFT performed at third- and sixth-postoperative months. Similar to CPAP, surgical treatment also has positive effects on the respiratory function and hence on the overall prognosis of OSAS.[13,23]

Conclusion

In our study to evaluate pulmonary function before and after robotic tongue base resection and uvulopharyngoplasty in patients diagnosed with OSAS, we utilized PFTs, which are the gold standard for assessing pulmonary function. Significant improvements were obtained in all 5 postoperative parameters (FVC, FEV1, FEV1/FVC, PEF, and FEF 25-75) in these results. This study demonstrates the positive effect of robotic tongue base resection and uvulopharyngoplasty on respiratory function in the treatment of sleep apnea. In our study, surgical treatment of OSAS showed positive effects on respiratory functions, similar to the effects of CPAP. There is, however, a need for further and broader multicentered research on this topic.

Authors' Note

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Informed consent was obtained from all individual participants included in the study, followed by a detailed explanation of the objectives and protocol of the study.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

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