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Results of Tailor-Made Multilevel Surgery in Patients with Obstructive Sleep Apnea

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Background and Objective The concept of tailor-made, multilevel surgery, including the nasal cavity, a multiple level of the pharynx, should be required to overcome the collapse at multiple levels of the upper airway because most patients show multilevel airway obstruction. The objective of this study was to evaluate the surgical results when the surgery was performed at the multilevel of the pharynx and in a tailor-made manner in obstructive sleep apnea (OSA) patients with multilevel obstruction in various evaluations of the obstruction site.

Methods This is a retrospective analysis of data prospectively gathered on 86 OSA patients treated with multilevel surgery. Patients were evaluated with a questionnaire preoperatively and postoperatively at 1 month and more than 6 months, respectively. A polysomnography was used to evaluate the surgical results postoperatively at more than 6 months.

Results Postoperative values for the questionnaire of both daytime and nighttime symptoms were significantly reduced after surgery. Daytime sleepiness checked by Epworth Sleepiness Scale (ESS) was significantly improved. The postoperative value of apnea-hypopnea index (AHI) was significantly improved after treatment. When the successful outcome was defined as a postoperative AHI < 5, 43.3% of patients met the criteria. The success rates of surgery among the groups according to severity were not statistically significant.

Conclusions Multilevel surgery in a tailor-made manner shows relatively good results. This can be a solution for OSA patients when medical therapy, including nasal continuous positive airway pressure, is not tolerable. Precise and tenacious evaluation of the obstruction site is the key for increasing surgical success. **Sleep Med Res 2012;3:27-31**

Key Words Obstructive sleep apnea, Surgery, Multilevel treatment.

INTRODUCTION

Nasal continuous positive airway pressure (CPAP) is considered the gold standard and the primary treatment for obstructive sleep apnea syndrome (OSAS). However, the therapeutic use of nasal CPAP is seriously limited by low long-term compliance, treatment duration and even aggravation of the condition of OSA.[1] Numerous types of surgical techniques have been developed by many surgeons. However, most of them showed variable success rate except bimaxillary surgery. Several surgical techniques, such as uvulopalatopharyngoplasty (UPPP), uvulopalatal flap and radiofrequency-induced thermotherapy of the soft palate, have been widely used for the treatment of velopharyngeal obstruction in OSAS. The available tongue base procedures which alleviate obstruction of the lower pharynx include radiofrequency tongue base reduction (RTBR), mandibular osteotomy with genioglossus advancement (GA), hyoid suspension and maxillomandibular advancement. To choose the surgical technique for OSA patients, multiple factors should be considered, such as obstruction level, severity, age, medical conditions, patient preference, and so on. The concept of tailor-made, multilevel surgery, including nasal cavity, a multiple level of the pharynx, should be required to overcome the collapse at multiple levels of the upper airway because most patients show multilevel airway obstruction. The objective of this study was to evaluate the surgical results when the surgery was performed at a multilevel of the pharynx and in a tailor-made manner in OSA patients with multilevel obstruction in various evaluations of the obstruction site.

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METHODS

Study Design

This is a retrospective analysis of data prospectively gathered on 86 OSA patients treated with multilevel surgery at Kyung Hee University Hospital in Korea. The exclusion criteria were AHI < 5 of total sleep time and age < 18 and > 65. Patients were evaluated with the questionnaire preoperatively and postoperatively at 1 month and more than 6 months, respectively. A polysomnography was used to evaluate the surgical results postoperatively at more than 6 months.

Questionnaire

Patients' nighttime symptoms, such as snoring, abnormal motor activity during sleep, awake, apnea, reflux, nycturia and excessive nocturnal sweating, along with daytime symptoms, such as headache, sleepiness, feeling tired, phantom, personality change, trouble of sex life and unrefreshing sleep, were assessed using a traditional 10 cm Visual Analogue Scale ranging from 0 (no problem) to 10 (severe problem). All questionnaires were evaluated preoperatively and postoperatively at 1 month and more than 6 months, respectively. Daytime sleepiness was evaluated independently with the Epworth Sleepiness Scale (ESS) at 6 months both preoperatively and postoperatively.

Physical Examination

All patients underwent a full head and neck examination. The body mass index (BMI), a rank for obesity and important criterion for OSAS, was calculated by dividing the weight (kg) by the square of height (m^2). Friedman staging was applied.[2] Tonsil size was graded on a scale of 0 to 4. Friedman palate position was graded on a scale of 1 to 4. Stage I was defined as those patients with palate position I or II, tonsil size 3 or 4 and BMI of less than 40. Stage II was defined as palate position I or II and tonsil size 0, 1 or 2, or palate position III and IV with tonsil size 3 or 4 and BMI of less than 40. Stage III was defined as palate position III or IV, tonsil size 0, 1 or 2, and BMI of less than 40. All patients with a BMI of greater than 40 were included in stage IV. No patients were included in stage IV. Tongue base surgery was performed in patients who were included in stages II and III.

Cephalometry

Patients were seated with their heads oriented in the Frankfort horizontal plane and stabilized with a head holder. Patients were instructed to place their teeth in habitual occlusion, keeping the mouth closed and the tongue relaxed on the floor of the mouth. Exposures were taken at the end of expiration.

The following three parameters were obtained preoperatively: posterior airway space (PAS), the minimal distance between the tongue base and the posterior pharyngeal wall; PNS-P, the distance from the posterior nasal spine to the lowest point on the soft palate; and mandibular plane to hyoid, the distance from the mandibular plane to the most anterosuperior point of the hyoid bone. PAS was used as a parameter to choose tongue base surgery. If PAS was less than 10 mm, tongue base surgery was considered.

Fiberoptic Nasopharyngoscopy with Mueller's Maneuver

Nasopharyngoscopy was performed with the subjects in the supine position after being given topical nasal anesthesia. A flexible nasopharyngoscope was inserted through the nasal cavity to the hypopharynx. First, measurements were taken at end-expiration. The severity of the obstruction was divided into four scales (1 to 4). Second, measurements were taken during a maximal inspiratory effort against a closed mouth and occluded nose (Mueller's maneuver). During the examination, airway size was assessed separately in both the retropalatal (upper pharynx) and retroglossal (tongue base, supraglottic) segment. Collapse during MM was rated using the following classification: 1 +, 0% to 25%; 2 +, 26% to 50%; 3 +, 51% to 75%; and 4 +, > 76%. Tongue base surgery was considered in patients whose end-expiration grade was more than grade 3 + or maximal inspiratory grade was more than 3 in the tongue base level.

Polysomnography

All patients underwent a one-night polysomnographic study at the hospital. The polysomnographic study included an electroencephalogram (C3/A1, C4/A2, O1/A1, O2/A2), electrooculogram, chin and leg electromyogram and electrocardiogram (Embla Co., Broomfield, CO, USA). Respiration was measured by oronasal airflow as well as thoracic and abdominal movements (inductive plethysmography); oxyhemoglobin saturation was measured with pulse oximetry. Apnea was defined as the absence of airflow on the nasal cannula lasting for more than 10 seconds. Hypopnea was defined as a decrease of 50% or more in airflow from the baseline value lasting at least 10 seconds, or a clear amplitude airflow reduction lasting ≥ 10 seconds and associated with either an oxygen desaturation of > 3% or an arousal. Apnea index and hypopnea index were defined as the number of apneas and hypopneas per hour of total sleep time (TST), respectively. Apnea-hypopnea index (AHI) denotes the total number of apneic plus hypopneic events divided by total sleep time in hours. Arousal index is defined as the number of arousal per hour of TST. Subjects were divided according to the AHI in simple snorers (AHI < 5), with mild sleep apnea being AHI equal to 5 to 15; moderate sleep apnea, AHI equal to 15 to 30; and severe sleep apnea, AHI greater than 30. GA was considered as a tongue base surgery in the severe group.

Multilevel Surgery

Nasal surgeries, such as septoplasty and inferior turbinoplasty, were performed in patients with nasal obstruction, subjectively, and septal deviation or turbinate hypertrophy, objectively.

The palatal surgery was carried out with a modified uvulopalatal flap in a similar manner to Li's technique.[3] Tonsillectomy was performed first. The oral surface of soft palate mucosa and submucosa were debrided, and the palatopharyngeus, palatoglossus and uvula muscles were preserved as much as possible. The uvular tip was trimmed. The palate was then reflected anteriorly and superiorly, and the anterior and posterior tonsillar pillars were trimmed and reoriented to create a more retropalatal airway space.

A single-session RTBR using Celon ProSleep® (Celon AG Medical Instruments, Berlin, Germany) was used to accomplish the stiffening and volume reduction of the base of the tongue. Nine points were selected for treatment. Three points were at the midline of the circumvallate papillae and 1 cm anterior and posterior to the middle of the circumvallate papillae. The next six lesions were 1 cm right and left of the first three lesions. A power setting on the power control unit was 10 W. The application time varied between 4 to 6 seconds per puncture, and was terminated by an acoustic 'end-indication' along with an autostop facilitated by a thermister and tissue impedance measurement at the probe tip. The delivery energy at this power setting was approximately 60 joules per punctum.

The GA was completed intraorally. The mucosal incision was made approximately 10 to 15 mm below the mucogingival junction, and a subperiosteal flap was developed to expose the symphysis. A rectangular osteotomy encompassing the estimated location of the genial tubercle and genioglossus musculature was performed. The superior horizontal bone cut was more than 5 mm below the root apices, and the inferior horizontal bone cut was approximately 10 mm above the inferior border. The vertical bone cuts were made just medial to the canine tooth in order to avoid root injury. The bone flap was advanced and rotated about 90° to 45°. The outer cortex and marrow were removed whereas the inner cortex was rigidly fixed with a lag screw. The mentalis muscles and mucosal closure were performed by one layered suture.

The numbers of patients regarding the types of surgical combination are listed in Table 1.

Statistics

Preoperative and postoperative parameters, such as subjective symptoms, ESS and polysomnographic parameters, were compared using Wilcoxon signed rank tests. Statistical significance was accepted at $p < 0.05$. All statistical analyses were performed using SPSS for Windows Version 11.5 (SPSS, Inc, Chicago, IL, USA).

RESULTS

Eighty-six patients were followed up postoperatively at more than 6 months. There were seventy-eight men and eight women. The ages ranged from 23 to 64 years (mean age ± SD: 44.7 ± 10.6). The BMI of the patients was 27.6 ± 3.4 kg/m^2. Postoperative values for the questionnaire of both daytime and night-time symptoms were significantly reduced after surgery (Table 2). Daytime sleepiness checked by ESS was significantly im-

Table 1. Types of combined operations in the subjects

Type of operations	n
Sep + Tur + UPF	4
Sep + Tur + UPF + Ton	12
Sep + Tur + UPF + Ton + RTBR	19
Sep + Tur + UPF + Ton + GA	6
Tur + UPF + Ton	12
Tur + UPF + RTBR	4
Tur + UPF + Ton + RTBR	5
Tur + UPF + Ton + GA	6
UPF + RTBR	12
UPF + Ton + GA	6
Total	86

Sep: septoplasty, Tur: turbinoplasty, UPF: uvulopalatal flap, Ton: tonsillectomy, RTBR: radiofrequency tongue base reduction, GA: genioglossus advancement.

Table 2. Comparison of preoperative and postoperative values for the visual analog scale of both daytime and night-time symptoms

Symptoms	Preoperative value	Postoperative value	p-value
Night-time			
Snoring	8.36 ± 2.04	4.14 ± 2.60	p < 0.01
Abnormal motor activity	6.78 ± 2.41	3.95 ± 2.50	p < 0.01
Awake	5.71 ± 2.98	2.81 ± 2.38	p < 0.01
Apnea	5.15 ± 3.35	1.59 ± 2.19	p < 0.01
Reflux	2.40 ± 2.82	1.56 ± 2.57	0.063
Nycturia	2.57 ± 2.45	1.99 ± 2.55	0.179
Nocturnal sweating	4.40 ± 3.52	2.96 ± 3.00	0.012
Daytime			
Headache	2.61 ± 2.75	1.39 ± 1.72	0.006
Feel sleepy	5.94 ± 3.01	3.22 ± 2.32	p < 0.01
Tired feeling	5.24 ± 3.17	3.37 ± 2.39	0.001
See a phantoms	0.65 ± 1.25	0.61 ± 1.45	0.886
Sharpened personality	4.48 ± 3.03	2.12 ± 2.38	p < 0.01
Sex life trouble	2.31 ± 2.62	1.62 ± 2.62	0.150
Unrefreshing sleep	5.73 ± 3.32	2.50 ± 2.53	p < 0.01

Table 3. Results of ESS and polysomnographic data

	Preoperative value	Postoperative value	p-value
AI	14.3 ± 16.2	11.1 ± 18.3	0.320
HI	14.7 ± 12.9	12.8 ± 20.4	0.527
AHI	30.7 ± 20.3	21.8 ± 22.8	0.021*
MSAT	92.8 ± 3.3	93.9 ± 2.1	0.037*
LSAT	76.6 ± 7.6	82.4 ± 13.4	0.043*
ESS	12.4 ± 4.4	8.2 ± 3.6	p < 0.01*

*p < 0.05.
ESS: Epworth Sleepiness Scale, AI: apnea index, HI: hypopnea index, AHI: apnea-hypopnea index, MSAT: mean saturation of oxygen, LSAT: lowest saturation of oxygen.

proved (Table 3). However, when the normal ESS score was defined as less than 8, normalized patients were 58.9% among abnormal patients, preoperatively. Daytime sleepiness was still a problem in many patients, even though their OSA was successfully treated. The postoperative values of respiratory parameters were significantly improved after treatment (Table 3). When the successful outcome was defined as postoperative AHI < 5, 43.3% of the patients met the criteria. The success rates of surgery among the groups by severity were not significantly different. When the successful outcome was defined as AHI < 20 and 50% reduction compared to preoperative AHI, the success rate was 66.7%. The mean BMI (27.4 ± 3.2 kg/m^2) at the time of the postoperative PSG did not significantly vary from its preoperative value.

DISCUSSION

This study showed a relatively good success rate in patients of OSA in terms of strict success criteria, AHI < 5 with a tailor-made surgical treatment, according to the results of the obstruction site evaluation. In the tailor-made approach, choosing the surgical techniques seems very complicated and chaotic. However, this result reflects that the phenotypes of OSA are highly variable. Various combinations are possibly applied to OSA patients, according to the obstruction site and surgeon's favor. Further, it is very difficult to make a success rate for each surgical combination.

Obstruction sites in the airway of OSA patients are usually multilevel especially in severe OSA patients. This is confirmed by various methods of evaluation techniques. Abdulla and van Hasselt[4] confirmed the high incidence of the multilevel disease; 87% of their 893 patients had a multilevel obstruction by video sleep nasoendoscopy. Therefore, the results of one level surgery in these patients may be disappointing and a multilevel surgery should be mandatory.[5] Surgery in these patients must be performed in a tailor-made manner. Multilevel treatment generally includes the palate, tonsil area and the hypopharynx. Often, a nasal surgery can be included as well. Published manner on a multilevel surgery can be divided into four groups. The first group includes those patients who had UPPP as a basic technique with a second invasive procedure designed to improve the hypopharyngeal airway.[6-8] The second group of patients reported in the literature had undergone a multilevel treatment with more invasive and more radical hypopharyngeal surgery, such as open tongue base resection.[9] The third group of multilevel surgery for OSA includes patients undergoing bimaxillary advancement as part of the multilevel surgery. The last group includes patients who underwent multilevel minimally invasive techniques, such as radiofrequency (RF) ablation.[10] In this study, the result of the tailor-made multilevel surgery in OSA was evaluated in a subjective and objective manner. Subjectively, symptom scores were much improved after surgical treatment. In addition, the cure rate according to the criteria, AHI < 5, was 43.3%. This criterion is absolutely strict criteria. When the successful outcome was defined as AHI < 20 and a 50% reduction compared to preoperative AHI, the success rate was 66.7%. This is the most commonly used criteria for the evaluation of surgical results in previous studies.[5] The determination of the success in surgical treatment of OSA remains controversial.

In our results, the success rate was not influenced by OSA severity (data not shown). There are some studies indicating that mild disease is not easier to correct than severe disease.[11] Our results suggest that surgery may be a possible treatment method if we can find and correct all the obstruction sites, regardless of PSG severity. The main obstacles to enhance surgical success rate are to find out the obstruction site as well as a clear indication of the choice of surgical procedures, not the severity of disease. In this study, we performed tongue base surgery in patients with Friedman stage II and III (we could not find stage IV patients.), with more than 50% narrowing in nasopharyngoscopy, more than grade 3 in Mueller's maneuver and PAS < 10 mm in cephalometry. Radiofrequency tongue base reduction had been performed in patients with any of these criteria. Radiofrequency therapy is highly accepted due to its ability to create lesions in the areas containing nearby critical anatomic features[12] and minimal complication rate. Currently, RF therapy is considered as one of the most commonly performed surgical techniques for snoring and mild to moderate grade of OSAS.[13] GA was usually performed in the severe group, especially in young patients. Therefore, RTBR has been performed for patients who showed any possible evidence of tongue base obstruction in the various evaluation methods.

As reported, compliance of CPAP is usually less than 50%.[1] The compliance rate may decrease as time passes. Surgical results in a tailor-made multilevel surgery are not better than CPAP compliance, but not worse than that. It is very clear that surgical success can be higher if the next step, such as bimaxillary surgery, is combined. As a matter of course, relapse can happen postoperatively as time passes. Most studies on the multilevel treatment of OSA reported short-term surgical results at 6 months or less after surgery. Neruntarat performed an uvulopalatal flap in conjunction with GA in 46 patients and followed the short-term (6 months after surgery) and long-term (at least 37 months postoperatively) outcome.[14] The short-term and long-term success rates were 78.3% and 65.2%, respectively. Therefore, further study will be needed for true long-term data.

This study has several limitations. There is no report for the success rate in each surgical technique because the number of patients in each surgical procedure is too small. We did not evaluate the obstruction site in the sleep state, which may affect the success rate of the surgical treatment. The success rate of the tailor-made surgical treatment may be higher than our study if the obstruction site evaluation is carried out during the sleep state.

In conclusion, a multilevel surgery in a tailor-made manner shows relatively good results. This can be a solution for OSA patients, particularly for those whose medical therapy, including CPAP, is not tolerable. Precise and tenacious evaluation of the obstruction site is the key for increasing surgical success.

Conflicts of Interest

The authors have no financial conflicts of interest.

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