GMJ 2024;35:59-63

DOI: 10.4274/gmj.galenos.2023.3845

Does Anterior Palatoplasty Performed in Addition to Expansion Sphincter Pharyngoplasty During Multilevel Surgery Affect the Results of Surgery in OSAS Patients?

OSAS Hastalarında Çok Düzeyli Cerrahi Sırasında Ekspansiyon Sfinkter Faringoplastisine Ek Olarak Yapılan Ön Palatoplasti Ameliyatı Sonuçlarını Etkiler mi?

Ayşe İriz[1], Mehmet Düzlü[1], Süleyman Cebeci[1], Recep Karamet[1], Oğuz Köktürk[2]

[1]Gazi University Faculty of Medicine, Department of Otorhinolaryngology Head and Neck Surgery, Ankara, Türkiye
[2]Gazi University Faculty of Medicine, Department of Pulmonary Disease, Ankara, Türkiye

ABSTRACT

Objective: Multilevel surgery (MLS) has become one of the most preferred surgical methods for the treatment of obstructive sleep apnea syndrome (OSAS).

In this study, we aimed to present our results for MLS together with modified expansion sphincter pharyngoplasty (MESP) for the treatment of OSAS. We also investigated whether performing anterior-palatoplasty (AP) affected surgical results in these patients.

Methods: Fifty patients diagnosed with moderate-to-severe OSAS after polysomnography (PSG) were prospectively included in the study. The patients underwent MLS comprising; nasal surgery, MESP, and ablation of the tongue base with radiofrequency. In addition, AP was performed in 30 patients. Surgical success was determined using PSG data and Epworth sleepiness scale (ESS) scoring performed before and after surgery.

Results: There was a statistically significant improvement in ESS scores and postoperative PSG findings compared with preoperative means (p<0.001). Surgical success was achieved in 40 patients (80%) according to the Sher criteria. Surgical success ratio revealed exactly same (p=1.000) compared with the patients who were not performed AP. Preoperative apnea index, apnea/hypopnea index (AHI), and supine AHI were significantly higher in surgically unsuccessful cases (p<0.05).

Conclusion: MLS, including MESP, performed together with nasal surgery and tongue base RF is an alternative procedure in the surgical treatment of OSAS with a postoperative success rate of 80%, according to our study results. In addition to MESP, AP may not affect the results of multilevel surgery.

Keywords: Obstructive sleep apnea syndrome, multilevel surgery, expansion sphincter pharyngoplasty and anterior palatoplasty

ÖZ

Amaç: Çok düzeyli cerrahi (MLS), obstrüktif uyku apne sendromunun (OSAS) tedavisinde en çok tercih edilen cerrahi yöntemlerden biri haline gelmiştir. Bu çalışmada OSAS tedavisinde modifiye ekspansiyon sfinkter faringoplasti (MESP) ile birlikte MLS sonuçlarımızı sunmayı amaçladık. Ayrıca bu hastalarda anterior-palatoplasti (AP) uygulamasının cerrahi sonuçları etkileyip etkilemediğini de araştırdık.

Yöntemler: Polisomnografi (PSG) sonrası orta-ağır TUAS tanısı alan 50 hasta prospektif olarak çalışmaya dahil edildi. Hastalara MLS uygulandı; burun ameliyatı, MESP ve dil kökünün radyofrekans ile ablasyonu. Ayrıca 30 hastaya AP uygulandı. Cerrahi başarı, ameliyat öncesi ve sonrası yapılan PSG verileri ve Epworth uykululuk skalası (ESS) skorlaması kullanılarak belirlendi.

Bulgular: ESS skorlarında ve postoperatif PSG bulgularında preoperatif ortalamalara göre istatistiksel olarak anlamlı iyileşme görüldü (p<0,001). Sher kriterlerine göre 40 hastada (%80) cerrahi başarı sağlandı. Cerrahi başarı oranı AP yapılan ve yapılmayan hastalarda tamamen aynı (p=1,000) bulundu. Ameliyat öncesi apne indeksi, apne/hipopne indeksi (AHİ) ve sırt üstü AHİ cerrahi başarısız olgularda anlamlı olarak yüksekti (p<0,05).

Sonuç: Çalışma sonuçlarımıza göre, burun ameliyatı ve dil kökü RF ile birlikte yapılan MESP'yi de içeren MLS, OSAS'nin cerrahi tedavisinde ameliyat sonrası başarı oranı %80 olan alternatif bir işlemdir. MESP'ye ek olarak AP, çok düzeyli cerrahi sonuçlarını etkilemeyebilir.

Anahtar Sözcükler: Obstrüktif uyku apne sendromu, çok düzeyli cerrahi, ekspansiyon sfinkteri faringoplasti ve ön palatoplasti

Address for Correspondence/Yazışma Adresi: Ayşe İriz MD, Gazi University Faculty of Medicine, Department of Otorhinolaryngology Head and Neck Surgery, Ankara, Türkiye
E-mail / E posta: ayseiriz@gmail.com
ORCID ID: orcid.org/0000-0003-1495-0667

Received/Geliş Tarihi: 03.04.2023
Accepted/Kabul Tarihi: 10.05.2023

INTRODUCTION

Obstructive sleep apnea syndrome (OSAS) is a serious disease that may cause systemic side effects. Patients with untreated moderate-to-severe OSAS may suffer severe cardiovascular and central nervous system disorders and neurocognitive, psychiatric, and social problems (1); therefore, OSAS should always be diagnosed and treated promptly. Positive airway pressure (PAP) therapy is an effective treatment modality for patients with moderate-to-severe OSAS; however, the high number of patients who refuse or cannot tolerate PAP treatment poses a significant challenge (2). Various surgical procedures and oral appliances serve as alternative treatment methods for these patients.

There is an ongoing discussion in the literature regarding the appropriate surgical treatment modality for OSAS. Recurrent obstruction in the upper airway occurring during sleep is the major cause of OSAS symptoms. Therefore, single or multiple obstruction levels in the upper airway can be addressed in OSAS surgery. The efficiency of multilevel surgery (MLS) has been supported by various clinical studies in recent years (3). Multilevel OSAS surgery is a combination of surgical procedures addressing the nasal cavity, pharyngeal isthmus, and base of the tongue (4,5). However, there is still no consensus on the type of surgical procedure.

In most patients, OSAS symptoms are aggravated in the supine position because of nasopharyngeal, oropharyngeal, and hypopharyngeal collapse. Therefore, more than half of OSAS patients are supine position dependent (6). Evaluation of postoperative surgical success differs in clinical studies. Some authors suggested that the number of preoperative apnea and the presence of tonsillectomy in OSAS surgery are the main determinants of surgical success (7). AP is performed to reduce anterior-posterior collaps at the level of the soft palate (8). MESP is performed to reduce lateral feengeal collapse in patients with OSAS. MESP also provides anterior, superior, and lateral expansion at the level of the soft palate (9). In the literature, MLS is applied in various ways. However, no study has demonstrated the contribution of AP procedure performed together with MESP during MLS on surgical success. In this study, we aimed to investigate the effectiveness of a multilevel surgical modality comprising nasal surgery, modified expansion sphincter pharyngoplasty, and tongue base radiofrequency for the treatment of OSAS. We also investigated whether it changes the surgical results in patients in whom AP was added during MLS for the first time. In addition, we aimed to outline the possible factors affecting surgical success and discuss our findings with the literature data.

MATERIALS AND METHODS

This study was performed by the Gazi University Faculty of Medicine, Department of Otorhinolaryngology between 2015 and 2020. This study was approved by the Gazi University Local Ethics Committee (approval number: 549, date: 07.09.2020). The Epworth Sleepiness Scale (ESS) was used and symptom scores were calculated. All patients underwent a standard full-night PSG study in our sleep laboratory. ESS and PSG tests were performed in all patients preoperatively and postoperatively on average at 5 months. According to apnea -hypopnea indexes (AHI), the patients were classified as having mild (AHI >5 and <15), moderate (AHI >15 and <30), or severe (AHI >30) OSAS. Primarily, PAP treatment was recommended for all patients with moderate to severe OSAS. The surgical procedure was planned for patients who refused or could not tolerate PAP therapy.

All subjects underwent a thorough otorhinolaryngology examination, including flexible endoscopic examination and Müller's maneuver, and the surgical treatment modality was planned according to the findings of this examination. Sleep endoscopy was performed in only five cases and did not change the previous decision for surgical modality. We could not perform sleep endoscopy for the remaining cases because of technical insufficiency.

Inclusion Criteria: Patients with moderate-to-severe OSAS (AHI >15) with prominent septum deviation, lower turbinate hypertrophy, and significant retropalatal obstruction with grade 3 to 4 tonsillar hypertrophy were included in the study. Patients with anterior-posterior retropalatal collapse of more than 50% and/or prominent lateral pharyngeal collapse (more than 50%) in the tongue base were subjected to Müller's maneuver.

Exclusion Criteria: Subjects with prominent maxillofacial anomalies, severe chronic obstructive pulmonary disease, morbid obesity [body mass index (BMI) over 35], severe diabetes mellitus, or serious gastroesophageal reflux, along with those suffering from other sleep disorders such as periodic limb movement disorder, were excluded from the study. Patients identified with retropalatal or retrolingual circular constriction of more than 90% during Müller's maneuver were excluded from surgical treatment.

Surgical treatment was performed by the first author using the same surgical technique. The control PSG study and ESS scoring were performed in the earliest 3 months (mean: 5.2 range: 3-8 months) after the operation. Surgical success based on the Sher criteria; That is in the literature, the Sher criteria are accepted as the success criterion for OSAS surgery. AHI of less than 20 and 50% reduction in AHI are considered a success (10).

Sleep Study

The sleep records of consecutive subjects referred for overnight polysomnography to rule out OSAS at the Sleep Center of Gazi University Hospital were evaluated. Standard overnight polysomnography was performed on all subjects using the Noxturnal A1 system, version 2.0 (Nox Medical ehf Katrinartuni 2 IS-105 Reykjavík, Iceland). Polysomnography includedsix electroencephalogram channels, electrooculogram, electromyograms of the submentalis and bilateral tibialis anterior muscles, and position sensors to record body position and movements. In addition to simultaneous video recording, respiratory monitoring included nasal and oral airflow measures (oronasal cannula), tracheal microphone, and thoracic and abdominal breathing efforts (piezo arches). At the same time, finger pulse oximetry and electrocardiogram recording were performed. Sleep staging was performed according to the standard criteria established by the American Academy of Sleep Medicine (11). AHI was defined as the number of apnea and hypopnea episodes per sleep hour.

Surgical procedure

All patients underwent classical closed technique septoplasty, lower turbinate radiofrequency, and out-fracture. Thus, nasal obstruction was eliminated. Oropharyngeal surgery consists of modified expansion sphincter pharyngoplasty (MESP) and tongue base

ablation with radiofrequency and anterior palatoplasty, if required.

Modified expansion sphincter pharyngoplasty (MESP); was performed as previously described by Ulualp (12). Tonsillectomy was performed using bipolar electrocautery. The palatopharyngeus muscle was identified and dissected from the tonsillectomy cavity after cutting the lower end. The free end of the palatopharyngeus muscle was then rotated superolaterally through the submucosal pocket created in the soft palate and fixed to the pterygoid hamulus with a mattress suture. We added AP operation in patients whose retropalatal plane could not achieve adequate anterior posterior expansion with MESP.

Anterior palatoplasty: Mucous and submucosa were removed in a rectangular approximately 3x2 cm^2 area is removed from the middle of the soft palate. The incision line was closed afterward as described by Pang et al. (8).

Radiofrequency ablation of the tongue base was performed. The tongue base was given 500-700 joules of radiofrequency energy through three selected points, one around the circumvallate papilla on the midline and two points one cm lateral to this one (13).

Statistical Analysis

SPSS version 20.0 (IBM Inc., Chicago, IL, USA) was used for statistical analysis. Descriptive statistics are presented as mean ± standard deviation. Continuous variables were tested for normality using the Shapiro-Wilk test. Categorical variables were compared using the chi-square test. Paired samples t-test was used to compare parametric variables. The Wilcoxon signed rank test was used to compare pre-operative and postoperative PSG findings. Spearman correlation analysis was used to investigate the relationship between various PSG parameters and surgical success. P<0.05 was considered statistically significant.

RESULTS

Ten females (20%) and 40 males (80%), 50 patients, were included in the study. The mean age of the subjects was 42.1±11.0 years. Preoperative demographic data are shown in Table 1. The mean BMI before and after surgery were found to be 29.1±3.3 and 28.3±4.5, respectively (p=0.083). Preoperative and postoperative PSG findings, mean ESS scores, and snoring loudness of the patients are shown in Table 2. In the follow-up, the mean duration for the control PSG study and ESS scoring was 5.2±1.6 months (range 3-8 months). The mean pre-operative and postoperative AHI were found to be 32.8±16.6 and 12.5±16.0, respectively. The preoperative mean oxygen desaturation index was 18.1±13.7. It decreased to 5.9±12.2 postoperatively. The mean pre-operative and postoperative ESS scores were shown to be 17.4±5.2 and 6.6±4.4, respectively (p<0.001). There was a statistically significant improvement in all postoperative PSG findings compared the preoperative means (p<0.001, Table 2). Surgical success based on the Sher criteria was achieved in 40 (80%) patients. The surgical success ratios were 90% and 77.5% in females and males, respectively. No statistically significant difference was found between genders (p=0.377). Likewise, no significant difference was found between patients with moderate and severe OSAS in terms of surgical success (p>0.05). Thirty (60%) patients additionally underwent anterior palatoplasty. The surgical success ratio was the same (p=1.000) compared with the patients who didn't undergo anterior palatoplasty. Preoperative ESS and PSG data were compared between surgically successful and unsuccessful cases. Preoperative AI, AHI, and supine AHI were significantly higher in the surgically unsuccessful group (Table 3). Likewise, the relationship between preoperative PSG data and surgical success was analyzed using Spearman correlation analysis. Preoperative AHI (r=-0.326, p=0.021) supine AHI (r=-0.392, p=0.005), and apnea index (r=-0.345, p=0.014), were found to be weakly and negatively correlated with surgical success. We did not observe any major morbidity such as severe infection or compromised airway postoperatively. Six patients (12%) developed mild bleeding from the tonsillectomy cavity in the second postoperative week, which was managed with bipolar electrocauterization after local anesthesia. Only one patient required general anesthesia. Two patients (4%) suffered velopharyngeal insufficiency for one month postoperatively.

Table 1. Demographic features of the patients

	Minimum-maximum	Mean ± SD
Age	25-70	43.1±11.5
Gender (male/female)	28/8	3.5/1
BMI	23.2-35.9	29.2±2.9
Epworth sleepiness scale	5-27	18.2±5.1

BMI: Body mass index, SD: Standard deviation.

DISCUSSION

The need for MLS in the same session is evident, especially in patients with multilevel obstruction, and it accounts for more than 60% of OSAS patients. Many surgical procedures described for the treatment of OSAS are available in the literature. Surgical treatment is considered especially in patients who refuse or cannot tolerate PAP treatment regularly. In our clinic, PAP treatment was recommended as the primary treatment for patients diagnosed with moderate to severe OSAS, and some of them were titrated. Surgical treatment was offered to patients who refused or could not tolerate

Table 2. Preoperative and postoperative PSG findings and ESS scores

	Pre-operative	Postoperative	p-value*
AHI	28.6±15	11.2±17	<0.001
Supine AHI	45.5±18	18.7±22	<0.001
REM AHI	24.5±17	9±18	<0.001
pO_2 desaturation ratio	17.5±14	6.4±13	<0.001
Hypopnea index	13.4±7	8±10	<0.001
Apnea index	15.4±9	3.6±8	<0.001
Snoring loudness (dB)	72.7±9	53.5±25	<0.001

*Wilcoxon signed rank test, PSG: Polysomnography, ESS: Epworth sleepiness scale, AHI: Apnea/hypopnea index.

Table 3. Comparison of preoperative BMI, ESS, and PSG data between surgically successful and unsuccessful patients

	Successful	Unsuccessful	p-value
BMI	29.2±3.5	28.2±2.5	0.406**
ESS	17.2 5.2	18.2±5.5	0.723*
AHI	28.9±12.7	48.2±21.7	**0.023***
Supine AHI	41.7±18.3	62.5±22.9	**0.006***
REM AHI	23.1±13.4	32.5±25.3	0.376*
ODI	16.3±12.0	25.4±17.9	0.087*
Hypopnea index	13.6±6.0	18.9±11.7	0.280*
Apnea index	15.4±9.5	26.6±13.6	**0.016***
Snoring loudness (dB)	73.0±5.2	73.9±5.2	0.472*

*Mann-Whitney U-test, **Independent samples t-test, PSG: Polysomnography, ESS: Epworth sleepiness scale, AHI: Apnea/hypopnea index, BMI: Body mass index.

PAP treatment.

MLS has been widely discussed among various surgical procedures for the treatment of OSAS. Clinical studies investigating the efficiency of MLS in OSAS treatment have increased in recent years (14,15).

The role of nasal surgery in sleep surgery is controversial. Septoplasty is most commonly performed to attenuate snoring or reduce resistance to PAP therapy. If patients undergo a multilevel surgery, nasal surgery must be considered as a part of it (16). In this study, we did not perform nasal surgery before the PSG study in cases of OSAS suspicion. If we offer PAP treatment after the PSG study, nasal surgery may reduce nasal resistance to PAP therapy. In case of patient refusal or intolerance to PAP treatment, we perform nasal surgery as part of the multilevel surgical treatment. Therefore, we believe that this approach is useful in terms of time, cost, and patient comfort. We most commonly perform endonasal septoplasty, inferior turbinate RF, lateralization, and concha bullosa surgery as a part of nasal surgery in multilevel OSAS surgery. Binar et al. (17) reported the results of a single-stage MLS addressing velopharyngeal and hypopharyngeal levels for OSAS surgery. The tongue base is one of the obstruction levels in OSAS; radiofrequency ablation of the tongue is a minimally invasive procedure used to target this obstruction level in OSAS surgery (13,18). Therefore, we performed radiofrequency ablation of the tongue base as part of MLS. We did not observe any significant complications that can be seen after tongue base surgery, including infection, hematoma, or hypoglossal nerve paralysis.

A multi-factor regression analysis conducted in the study of 144 MLS participants revealed that surgical success was mostly affected by preoperative AHI and tonsillectomy (7). We performed tonsillectomy in all 50 patients who underwent multi-level surgery. In contrast, in the correlation analysis, the most important parameter affecting surgical success was found to be preoperative AHI in our study.

Expansion sphincter pharyngoplasty has been successfully performed as a part of OSAS surgery since its introduction by Pang and Woodson (19) in 2007 (20). It is based on the anterolateral rotation and hanging of the palatopharyngeal muscle after classical tonsillectomy. Later, MESP modifications were developed (12,20). Lorusso et al. (21) reported a success rate of 65% in their series of 20 patients who underwent MLS with expansion sphincter pharyngoplasty. The surgical procedure we performed was MESP as described by Ulualp (12).

The reported results of surgical success for multilevel OSAS surgery vary between 42% and 78% in the literature (4). It has been shown that MLS is consistent with single-level surgeries in terms of reliability; therefore, they are preferable surgical modalities. Lin et al. (22) reviewed 49 articles regarding MLS for OSAS. The surgical success rate for MLS was found to be 66.4% after re-calculation of the findings of those studies. We performed a standard full-night PSG test at the same sleep center before and after the surgical procedure in our clinic. According to Sher's criterion, 80% of our cases achieved surgical success in the early postoperative period (mean: 5.2 range: 3-8 months). In addition, symptomatic improvement in all patients was demonstrated by ESS.

Various postoperative complications may develop after OSAS surgery. The largest series on this issue is a review study of 487 cases. In this study, the postoperative complication rate has not been shown to increase in MLS (15). In our case series, all patients were hospitalized for one night postoperatively. No major complications or severe respiratory problems were observed. Six patients (12%) developed mild bleeding from the tonsillectomy cavity, and two patients (4%) suffered velopharyngeal insufficiency for one month postoperatively.

Anterior palatoplasty is a simple and effective method for the treatment of mild-to-moderate OSAS and can be a part of single-stage MLS for OSAS (8). Pang et al. (23) showed that the combination of expansion pharyngoplasty and anterior palatoplasty is a better surgical option than uvulopalatopharyngoplasty. However, in the literature, there is no study comparing the cases in which AT and MESF operations were performed together with the cases in which only MESF was performed. For the first time in this study, the addition of AP to the MESH operation in our MLS procedure did not provide any additional benefit for surgical success.

CONCLUSION

In conclusion, we achieved 80% surgical success in our series of 50 patients who underwent MLS including MESP, nasal surgery, and RF reduction of the tongue base for the treatment of moderate-to-severe OSAS. This type of surgery is a reliable and successful alternative to PAP treatment. In addition to MESF, anterior palatoplasty did not affect the results of MLS in patients with moderate-to-severe OSAS. Therefore, we claim that for moderate-to-severe OSAS cases with prominent retropalatal obstruction, anterior palatoplasty does not provide additional surgical success when performed together with expansion sphincter pharyngoplasty for OSAS treatment. We believe that further studies investigating the efficiency of MLS may be helpful in predicting the short- and long-term results for MLS in OSAS treatment and to clearly reveal the criteria affecting surgical success.

Ethics

Ethics Committee Approval: This study was performed by the Gazi University Faculty of Medicine, Department of Otorhinolaryngology

between 2015 and 2020. This study was approved by the Gazi University Local Ethics Committee (approval number: 549, date: 07.09.2020).

Informed Consent: It was obtained.

Peer-Review: Externally peer-reviewed.

Authorship Contributions

Concept: A.İ., M.D., S.C., R.K., O.K., Design: A.İ., M.D., S.C., R.K., O.K., Data Collection or Processing: A.İ., M.D., S.C., R.K., O.K., Analysis or Interpretation: A.İ., M.D., S.C., R.K., O.K., Literature Search: A.İ., M.D., S.C., R.K., O.K., Writing: A.İ., M.D., S.C., R.K., O.K.

Conflict of Interest: No conflict of interest was declared by the authors.

Financial Disclosure: The authors declared that this study received no financial support.

REFERENCES

1. Partinen M, Guilleminault C. Daytime sleepiness and vascular morbidity at seven-year follow-up in obstructive sleep apnea patients. Chest 1990; 97: 27-32.
2. Meurice JC, Dore P, Paquereau J, Neau JP, Ingrand P, Chavagnat JJ, et al. Predictive factors of long-term compliance with nasal continuous positive airway pressure treatment in sleep apnea syndrome. Chest 1994; 105: 429-33.
3. Richard W, Kox D, den Herder C, van Tinteren H, de Vries N. One stage multilevel surgery (uvulopalatopharyngoplasty, hyoid suspension, radiofrequent ablation of the tongue base with/without genioglossus advancement), in obstructive sleep apnea syndrome. Eur Arch Otorhinolaryngol 2007; 264: 439-44.
4. Verse T, Baisch A, Maurer JT, Stuck BA, Hörmann K. Multilevel surgery for obstructive sleep apnea: short-term results. Otolaryngol Head Neck Surg 2006; 134: 571-7.
5. Friedman M, Lin HC, Gurpinar B, Joseph NJ. Minimally invasive single-stage multilevel treatment for obstructive sleep apnea/hypopnea syndrome. Laryngoscope 2007; 117: 1859-63.
6. Richard W, Kox D, den Herder C, Laman M, van Tinteren H, de Vries N. The role of sleep position in obstructive sleep apnea syndrome. Eur Arch Otorhinolaryngol. 2006; 263: 946-50.
7. Tschopp K, Zumbrunn T, Knaus C, Thomaser E, Fabbro T. Statistical model for postoperative apnea-hypopnea index after multilevel surgery for sleep-disordered breathing. Eur Arch Otorhinolaryngol 2011; 268: 1679-85.
8. Pang KP, Tan R, Puraviappan P, Terris DJ. Anterior palatoplasty for the treatment of OSA: three-year results. Otolaryngol Head Neck Surg 2009; 141: 253-6.
9. Woodson T,Sitton M, Jacobowitz O. Expansion Sphingter Pharyngoplasty and palatal advancement pharyngoplasty: Airway evaluation and surgical techniques. Operative techniques in Otolaryngology 2012; 23: 3-10.
10. Sher AE, Schechtman KB, Piccirillo JF. The efficacy of surgical modifications of the upper airway in adults with obstructive sleep apnea syndrome. Sleep 1996; 19: 156-77.
11. Berry RB, Budhiraja R, Gottlieb DJ, Gozal D, Iber C, Kapur VK, et al. Rules for scoring respiratory events in sleep: update of the 2007 AASM Manual for the Scoring of Sleep and Associated Events. Deliberations of the Sleep Apnea Definitions Task Force of the American Academy of Sleep Medicine. J Clin Sleep Med 2012; 8: 597-619.
12. Ulualp SO. Modified expansion sphincter pharyngoplasty for treatment of children with obstructive sleep apnea. JAMA Otolaryngol Head Neck Surg 2014; 140: 817-22.
13. Riley RW, Powell NB, Li KK, Weaver EM, Guilleminault C. An adjunctive method of radiofrequency volumetric tissue reduction of the tongue for OSAS. Otolaryngol Head Neck Surg 2003; 129: 37-42.
14. Bostanci A, Bozkurt S, Turhan M. The relationship between the duration of obstructive respiratory events and outcomes of multilevel upper airway surgery in patients with obstructive sleep apnea. Eur Arch Otorhinolaryngol 2016; 273: 2651-7.
15. Pang KP, Siow JK, Tseng P. Safety of multilevel surgery in obstructive sleep apnea: a review of 487 cases. Arch Otolaryngol Head Neck Surg 2012; 138: 353-7.
16. El-Anwar MW, Amer HS, Askar SM, Elsobki A, Awad A. Could Nasal Surgery Affect Multilevel Surgery Results for Obstructive Sleep Apnea? J Craniofac Surg 2018; 29: 1897-9.
17. Binar M, Karakoc O, Akcam T, Asik B, Gerek M. Various combinations of velopharyngeal and hypopharyngeal surgical procedures for treatment of obstructive sleep apnea: Single-stage, multilevel surgery. Am J Otolaryngol 2017; 38: 571-5.
18. Masood A, Phillips B. Radiofrequency ablation for sleep-disordered breathing. Curr Opin Pulm Med 2001; 7: 404-6.
19. Pang KP, Woodson BT. Expansion sphincter pharyngoplasty: a new technique for the treatment of obstructive sleep apnea. Otolaryngol Head Neck Surg 2007; 137: 110-4.
20. Pang KP, Pang EB, Win MT, Pang KA, Woodson BT. Expansion sphincter pharyngoplasty for the treatment of OSA: a systemic review and meta-analysis. Eur Arch Otorhinolaryngol 2016; 273: 2329-33.
21. Lorusso F, Dispenza F, Modica DM, Gallina S. The Role of Modified Expansion Sphincter Pharyngoplasty in Multilevel Obstructive Sleep Apnea Syndrome Surgery. Int Arch Otorhinolaryngol 2018;22: 432-6.
22. Lin HC, Friedman M, Chang HW, Gurpinar B. The efficacy of multilevel surgery of the upper airway in adults with obstructive sleep apnea/hypopnea syndrome. Laryngoscope 2008; 118: 902-8.
23. Pang KP, Piccin O, Pang EB, Pang KA, Chan YH, Rotenberg BW. Combined Expansion Pharyngoplasty and Anterior Palatoplasty for the Treatment of OSA. Indian J Otolaryngol Head Neck Surg 2016; 68: 528-33.