Chapter

The Evaluation and Treatment of Obstructive Sleep Apnea Syndrome

Abdullah Alhelali

Abstract

The pharynx is composed of complex soft structures such as muscles and lymphoid tissues. These soft tissues cause the pharynx to collapse during sleep, eventually causing narrowing and obstructive apneas. Recently, sleep obstructive apneas have received increasing attention because many serious consequences can occur. Systemic diseases such as hypertension, coronary artery diseases, and cognitive dysfunction can occur. Despite its low adherence rate, continuous positive airway pressure is considered the most recommended management strategy for adults. In children, adenotonsillectomy is the primary intervention. Many other surgical interventions have been utilized. This chapter will cover the most essential types of pharyngeal surgery used to manage obstructive sleep apnea syndrome.

Keywords: pharynx, sleep, obstructive, apnea, sleep surgery

1. Introduction

Obstructive sleep apnea syndrome (OSAS) is one of the common conditions encountered by otolaryngologists. During sleep, many episodic cessations or decreases in breathing (apnea or hypopnea) occur repeatedly in patients diagnosed with OSAS [1–4]. It affects all ages, with a higher incidence in adults [5]. The prevalence of sleep apnea ranges from 2% and 14% [6]. Many sequelae of this disease have been reported. Systemic diseases such as diabetes, hypertension, and heart diseases have been reported [7]. The treatment of OSAS has been associated with significant improvements in hypertension [8, 9], motor vehicle collisions [10], and many psychosocial functions [11]. Establishing the diagnosis of OSAS requires a combination of sleep studies (polysomnography PSG) and a record of daytime symptoms. An apnea-hypopnea index (AHI) equal to or greater than five events in one hour in adults [12] and equal to or more than one event per hour in children [13] is considered abnormal. During the day, individuals with OSAS may feel fatigued or unrested and may have vigilance and cognitive function impairments, as well as on-road and occupational accidents [14].

The pharyngeal airway plays the major role in airway narrowing during sleep. Many surgical and nonsurgical treatments have been proposed and used. Nonsurgical management includes behavioral changes, weight loss, the use of medications, continuous positive airway pressure (CPAP) and oral appliances. Surgical treatment includes tracheostomy, uvulopalatopharyngoplasty, mandibular advancement, and hypoglossal nerve stimulation [15].

In adults, CPAP is considered the first choice for management. It is useful in decreasing daytime sleepiness and improving quality of life measures [16]. CPAP works by splinting the airway, particularly the pharyngeal airway, during sleep. The main drawback of CPAP is poor adherence reported in the literature. Compliance was defined as a minimum of 4 hours of use per night. Nonadherence reports in the literature range from 46% to 83% [17].

2. Drug-induced sleep endoscopy, DISE

An endoscopic evaluation of the airway during sleep induced by anesthetic agents is a commonly used method to determine the area of obstruction. The ability to tailor the surgical intervention for each patient individually is paramount in determining the success rate. The main significant difference between awake and sleep endoscopic airway assessments is that the latter provides a thorough dynamic evaluation of airway and pharyngeal collapse in situations mimicking natural sleep. In one systematic review, over 50% of surgeries planned based on the awake examination were changed after DISE [18]. DISE is indicated before any sleep surgical intervention in adult patients with OSAS who is unable to tolerate CPAP [19], with socially impacting primary snoring [20], and in whom previous surgery was unsuccessful in curing OSAS [21]. The procedure can be performed safely in an office-based setting or operating room. The main requirements are a quiet and comfortable room with dim light simulating natural sleep. The procedure is performed by an endoscopist who inserts a thin flexible scope in the presence of an anesthetist with basic cardiac, oxygen saturation, and blood pressure monitoring [22]. The depth of sedation should mimic natural sleep. It can be assessed by observation and snoring. The bispectoral index, BIS, is currently a very commonly used tool to monitor the depth of sedation. The targeted depth of sleep is still a topic of debate. A range from 50 to 70 is recommended [20]. BIS monitoring and clinical observations must be combined to achieve the optimal depth of sedation. Many agents have been used for DISE. Midazolam, propofol, and dexmedetomidine are commonly used. Recent studies preferred dexmedetomidine in terms of safety and a lower induction of airway collapsibility during DISE [23–25]. The flexible endoscopic evaluation started from the nasal cavity, assessing the nasal airway, nasopharynx, velopharynx, lateral pharyngeal wall collapse, tonsils, tongue base, hypopharynx and larynx. A widely accepted classification to grade the obstruction is not available. Many classifications have been used [26, 27]. Most importantly, the chosen classification should document the level, degree, and configuration of the obstruction [20].

3. Pharyngeal surgeries for treating OSAS

3.1 Adenotonsillectomy

In children, hypertrophied adenoids and tonsils are the leading cause of OSAS [28]. Most children benefit from adenotonsillectomy. The cure rate (AHI < 1/hour) after adenotonsillectomy ranges from 25% to 71% [29–31]. Many factors affect the resolution of OSAS after adenotonsillectomy. Obesity, an older age, and severe preoperative AHI are among these factors [29, 31].

Adenotonsillectomy is one of the most widely performed surgeries. It is a safe, easy, and effective surgical intervention. Tonsillectomy is a very widespread procedure that is utilized to treat OSAS in adults alone or in combination with

other surgical procedures. However, it is the first line of management in children with OSAS [29]. Despite a major improvement in OSAS in the majority of children who underwent tonsillectomy, some children might experience persistent OSAS. The incidence of persistent OSAS after adenotonsillectomy varies in the literature according to the definition of cure after adenotonsillectomy and the study population, ranging from 10 to 77% [32]. A clinician should consider persistent OSAS after tonsillectomy if symptoms of snoring, mouth breathing, restless sleep, enuresis, and daytime sleepiness do not improve. In patients with a suspicion of residual disease, PSG should be repeated [33, 34]. Other levels contributing to the obstruction should be re-evaluated. Regrowth of adenoids in children, the lingual tonsils, tongue base, soft palate and prolapsing epiglottis and supra-glottic structures are among the causes of unresolved OSAS after tonsillectomy. Awake endoscopy can help to re-evaluate the upper airway. Then, a dynamic assessment of the airway during sleep is recommended to tailor the surgical intervention accordingly. DISE and sleep cine-magnetic resonance imaging (MRI) are the most commonly used tools.

3.2 Lingual tonsillectomy

Large lingual tonsils can cause or contribute with other factors to cause OSAS. Lingual tonsillectomy can be performed as the primary surgery or for persistent OSAS after adenotonsillectomy in children. Different surgical techniques have been used, such as LASER, radiofrequency ablation, microdebrider, and suction electrocautery [35]. Many surgeons do not perform this procedure in combination with adenotonsillectomy because the desire to avoid creating a large, circular raw area that may subsequently cause oropharyngeal stenosis [36].

3.3 Uvulopalatoplasty, UPPP

Uvuloplatoplasty (UPPP), either with or without tonsillectomy, is one of the most frequently performed sleep surgeries. It was first described by Fujita et al. in 1979 [37–39]. The procedure is performed by cutting the edge of the soft palate and uvula with or without tonsillectomy [40, 41]. The main aim of this procedure is to decrease retropalatal obstruction and prevent pharyngeal collapse. The best candidate for this surgery is a patient with obstruction at the velum level. One meta-analysis from two randomized controlled trials (RCTs) found that UPPP was significantly more effective at reducing AHI than no treatment [39]. However, the results of long-term follow-up vary between studies [42–44]. The result tends to be better in a patient with a lower body mass index BMI [45–47]. A multiple staging system was established by Friedman et al. [48] based on the palate position, tonsil size and BMI, and the success rate in patients with Friedman stage 1 was 80.6%, but it decreased in patients with higher stages. In patients with stages 2, 3, and 4, the success rates were 37.9% and 8.1%, respectively [48]. One recent meta-analysis compared short-term to long-term outcomes and found that UPPP is an effective intervention, but the efficacy decreases over time [49].

3.4 Expansion pharyngoplasty

Lateral pharyngeal wall collapse is one of the most challenging issues for surgeons to address. In 2007, Pang and Woodson described expansion pharyngoplasty (EPP). The surgery starts with bilateral tonsillectomy, followed by antero-superolateral rotation of the superiorly based palatopharyngeus muscle to be attached to arching fibers of the soft palate [50]. Since then, many modifications have been

proposed [51–53]. Many noncomparative studies reported its success in treating OSAS [54, 55]. One systematic review with a meta-analysis showed a significantly better EPP result than other traditional surgeries [56]. In 2009, Li et al. [57] described the relocation pharyngoplasty technique in 10 patients. This technique enables advancement of the soft palate and splinting of the lateral pharyngeal wall [57]. In 2012, Mantovani et al. [58] described the velo-uvulo-pharyngeal lift technique to lift, shorten, and advance the soft palate. The soft palate is lifted by threads anchored to fibro-osseous structure at the level of the posterior nasal spine and bilateral pterygoid hamuli [58].

4. Conclusions

Obstructive sleep apnea syndrome is a complex condition with many sequelae. Patient signs and symptoms must be combined with sleep studies to diagnose this condition. Nonsurgical treatments, such as weight reduction, oral application and CPAP, are the first treatments of choice in adults. Surgery such as adenotonsillectomy is the treatment of choice for clearly enlarged adenoids and tonsils in children. DISE is a very useful tool for directing surgical intervention to the most obstructed level. Many surgical interventions have been studied and used to address obstructions with good results.

Conflict of interest

The authors declare no conflict of interest.

Author details

Abdullah Alhelali
Otolaryngology Department, Aseer Central Hospital, Abha, Saudi Arabia

*Address all correspondence to: alhelaliii@hotmail.com

References

[1] Balk EM, Moorthy D, Obadan NO, Patel K, Ip S, Chung M, Bannuru RR, Kitsios GD, Sen S, Iovin RC, Gaylor JM, D'Ambrosio C, Lau J. Diagnosis and Treatment of Obstructive Sleep Apnea in Adults. Rockville (MD): Agency for Healthcare Research and Quality (US); 2011

[2] Greenstone M, Hack M. Obstructive sleep apnoea. BMJ. 2014;348:g3745. DOI: 10.1136/bmj.g3745

[3] Qaseem A, Dallas P, Owens DK, Starkey M, Holty JE, Shekelle P, Clinical Guidelines Committee of the American College of Physicians. Diagnosis of obstructive sleep apnea in adults: A clinical practice guideline from the American College of Physicians. Annals of Internal Medicine. 2014;161:210-220. DOI: 10.7326/M12-3187

[4] Bratton DJ, Stradling JR, Barbe F, Kohler M. Effect of CPAP on blood pressure in patients with minimally symptomatic obstructive sleep apnoea: A meta-analysis using individual patient data from four randomised controlled trials. Thorax. 2014;69:1128-1135. DOI: 10.1136/thoraxjnl-2013-204993

[5] Qaseem A, Holty JE, Owens DK, Dallas P, Starkey M, Shekelle P, Clinical Guidelines Committee of the American College of Physicians. Management of obstructive sleep apnea in adults: A clinical practice guideline from the American college of physicians. Annals of Internal Medicine. 2013;159:471-483. DOI: 10.7326/0003-4819-159-7-201310010-00704

[6] Myers KA, Mrkobrada M, Simel DL. Does this patient have obstructive sleep apnea? The Rational Clinical Examination systematic review. JAMA. 2013;310:731-741. DOI: 10.1001/jama.2013.276185

[7] Robichaud-Halle L, Beaudry M, Fortin M. Obstructive sleep apnea and multimorbidity. BMC Pulmonary Medicine. 2012;12:60. DOI: 10.1186/1471-2466-12-60

[8] Becker HF, Jerrentrup A, Ploch T, Grote L, Penzel T, Sullivan CE, Peter JH. Effect of nasal continuous positive airway pressure treatment on blood pressure in patients with obstructive sleep apnea. Circulation. 2003;107:68-73. DOI: 10.1161/01.cir.0000042706.47107.7a

[9] Martinez-Garcia MA, Gomez-Aldaravi R, Soler-Cataluna JJ, Martinez TG, Bernacer-Alpera B, Roman-Sanchez P. Positive effect of CPAP treatment on the control of difficult-to-treat hypertension. European Respiratory Journal. 2007;29:951-957. DOI: 10.1183/09031936.00048606

[10] George CF. Reduction in motor vehicle collisions following treatment of sleep apnoea with nasal CPAP. Thorax. 2001;56:508-512. DOI: 10.1136/thorax.56.7.508

[11] McFadyen TA, Espie CA, McArdle N, Douglas NJ, Engleman HM. Controlled, prospective trial of psychosocial function before and after continuous positive airway pressure therapy. European Respiratory Journal. 2001;18:996-1002. DOI: 10.1183/09031936.01.00209301

[12] Kapur VK, Auckley DH, Chowdhuri S, Kuhlmann DC, Mehra R, Ramar K, Harrod CG. Clinical practice guideline for diagnostic testing for adult obstructive sleep apnea: An American academy of sleep medicine clinical practice guideline. Journal of Clinical Sleep Medicine. 2017;13:479-504. DOI: 10.5664/jcsm.6506

[13] Sateia MJ. International classification of sleep disorders-third edition: Highlights and modifications.

Chest. 2014;146:1387-1394. DOI: 10.1378/chest.14-0970

[14] Jackson ML, Howard ME, Barnes M. Cognition and daytime functioning in sleep-related breathing disorders. Progress in Brain Research. 2011;190:53-68. DOI: 10.1016/B978-0-444-53817-8.00003-7

[15] Chang HP, Chen YF, Du JK. Obstructive sleep apnea treatment in adults. The Kaohsiung Journal of Medical Sciences. 2020;36:7-12. DOI: 10.1002/kjm2.12130

[16] Antic NA, Catcheside P, Buchan C, Hensley M, Naughton MT, Rowland S, Williamson B, Windler S, McEvoy RD. The effect of CPAP in normalizing daytime sleepiness, quality of life, and neurocognitive function in patients with moderate to severe OSA. Sleep. 2011;34:111-119. DOI: 10.1093/sleep/34.1.111

[17] Weaver TE, Grunstein RR. Adherence to continuous positive airway pressure therapy: The challenge to effective treatment. Proceedings of the American Thoracic Society. 2008;5:173-178. DOI: 10.1513/pats.200708-119MG

[18] Certal VF, Pratas R, Guimaraes L, Lugo R, Tsou Y, Camacho M, Capasso R. Awake examination versus DISE for surgical decision making in patients with OSA: A systematic review. Laryngoscope. 2016;126:768-774. DOI: 10.1002/lary.25722

[19] Vanderveken OM. Drug-induced sleep endoscopy (DISE) for non-CPAP treatment selection in patients with sleep-disordered breathing. Sleep and Breathing. 2013;17:13-14. DOI: 10.1007/s11325-012-0671-9

[20] De Vito A, Carrasco Llatas M, Vanni A, Bosi M, Braghiroli A, Campanini A, de Vries N, Hamans E, Hohenhorst W, Kotecha BT, Maurer J, Montevecchi F, Piccin O, Sorrenti G, Vanderveken OM, Vicini C. European position paper on drug-induced sedation endoscopy (DISE). Sleep and Breathing. 2014;18:453-465. DOI: 10.1007/s11325-014-0989-6

[21] Kezirian EJ. Nonresponders to pharyngeal surgery for obstructive sleep apnea: Insights from drug-induced sleep endoscopy. Laryngoscope. 2011;121:1320-1326. DOI: 10.1002/lary.21749

[22] Chong KB, De Vito A, Vicini C. Drug-induced sleep endoscopy in treatment options selection. Sleep Medicine Clinics. 2019;14:33-40. DOI: 10.1016/j.jsmc.2018.11.001

[23] Yoon BW, Hong JM, Hong SL, Koo SK, Roh HJ, Cho KS. A comparison of dexmedetomidine versus propofol during drug-induced sleep endoscopy in sleep apnea patients. Laryngoscope. 2016;126:763-767. DOI: 10.1002/lary.25801

[24] Chang ET, Certal V, Song SA, Zaghi S, Carrasco-Llatas M, Torre C, Capasso R, Camacho M. Dexmedetomidine versus propofol during drug-induced sleep endoscopy and sedation: A systematic review. Sleep and Breathing. 2017;21:727-735. DOI: 10.1007/s11325-017-1465-x

[25] Padiyara TV, Bansal S, Jain D, Arora S, Gandhi K. Dexmedetomidine versus propofol at different sedation depths during drug-induced sleep endoscopy: A randomized trial. Laryngoscope. 2020;130:257-262. DOI: 10.1002/lary.27903

[26] Kezirian EJ, Hohenhorst W, de Vries N. Drug-induced sleep endoscopy: The VOTE classification. European Archives of Oto-Rhino-Laryngology. 2011;268:1233-1236. DOI: 10.1007/s00405-011-1633-8

[27] Vicini C, De Vito A, Benazzo M, Frassineti S, Campanini A, Frasconi P,

Mira E. The nose oropharynx hypopharynx and larynx (NOHL) classification: A new system of diagnostic standardized examination for OSAHS patients. European Archives of Oto-Rhino-Laryngology. 2012;269:1297-1300. DOI: 10.1007/s00405-012-1965-z

[28] Marcus CL, Brooks LJ, Draper KA, Gozal D, Halbower AC, Jones J, Schechter MS, Ward SD, Sheldon SH, Shiffman RN, Lehmann C, Spruyt K, American Academy of Pediatrics. Diagnosis and management of childhood obstructive sleep apnea syndrome. Pediatrics. 2012;130:e714–e755. DOI: 10.1542/peds.2012-1672

[29] Bhattacharjee R, Kheirandish-Gozal L, Spruyt K, Mitchell RB, Promchiarak J, Simakajornboon N, Kaditis AG, Splaingard D, Splaingard M, Brooks LJ, Marcus CL, Sin S, Arens R, Verhulst SL, Gozal D. Adenotonsillectomy outcomes in treatment of obstructive sleep apnea in children: A multicenter retrospective studyQ. American Journal of Respiratory and Critical Care Medicine. 2010;182:676-683. DOI: 10.1164/rccm.200912-1930OC

[30] Tauman R, Gulliver TE, Krishna J, Montgomery-Downs HE, O'Brien LM, Ivanenko A, Gozal D. Persistence of obstructive sleep apnea syndrome in children after adenotonsillectomy. The Journal of Pediatrics. 2006;149:803-808. DOI: 10.1016/j.jpeds.2006.08.067

[31] Mitchell RB. Adenotonsillectomy for obstructive sleep apnea in children: Outcome evaluated by pre- and postoperative polysomnography. Laryngoscope. 2007;117:1844-1854. DOI: 10.1097/MLG.0b013e318123ee56

[32] Boudewyns A, Abel F, Alexopoulos E, Evangelisti M, Kaditis A, Miano S, Villa MP, Verhulst SL. Adenotonsillectomy to treat obstructive sleep apnea: Is it enough? Pediatric Pulmonology. 2017;52:699-709. DOI: 10.1002/ppul.23641

[33] Roland PS, Rosenfeld RM, Brooks LJ, Friedman NR, Jones J, Kim TW, Kuhar S, Mitchell RB, Seidman MD, Sheldon SH, Jones S, Robertson P, American Academy of Otolaryngology-Head Neck Surgery Foundation. Clinical practice guideline: Polysomnography for sleep-disordered breathing prior to tonsillectomy in children. Otolaryngology Head and Neck Surgery. 2011;145:S1-S15. DOI: 10.1177/0194599811409837

[34] Aurora RN, Zak RS, Karippot A, Lamm CI, Morgenthaler TI, Auerbach SH, Bista SR, Casey KR, Chowdhuri S, Kristo DA, Ramar K, American Academy of Sleep Medicine. Practice parameters for the respiratory indications for polysomnography in children. Sleep. 2011;34:379-388. DOI: 10.1093/sleep/34.3.379

[35] Cielo CM, Gungor A. Treatment options for pediatric obstructive sleep apnea. Current Problems in Pediatric and Adolescent Health Care. 2016;46:27-33. DOI: 10.1016/j.cppeds.2015.10.006

[36] Prager JD, Hopkins BS, Propst EJ, Shott SR, Cotton RT. Oropharyngeal stenosis: A complication of multilevel, single-stage upper airway surgery in children. Archives of Otolaryngology--Head & Neck Surgery. 2010;136:1111-1115. DOI: 10.1001/archoto.2010.197

[37] Kezirian EJ, Maselli J, Vittinghoff E, Goldberg AN, Auerbach AD. Obstructive sleep apnea surgery practice patterns in the United States: 2000 to 2006. Otolaryngology-Head and Neck Surgery. 2010;143:441-447. DOI: 10.1016/j.otohns.2010.05.009

[38] Kezirian EJ, Weaver EM, Yueh B, Deyo RA, Khuri SF, Daley J, Henderson W. Incidence of serious complications after

uvulopalatopharyngoplasty. Laryngoscope. 2004;114:450-453. DOI: 10.1097/00005537-200403000-00012

[39] Stuck BA, Ravesloot MJL, Eschenhagen T, de Vet HCW, Sommer JU. Uvulopalatopharyngoplasty with or without tonsillectomy in the treatment of adult obstructive sleep apnea - A systematic review. Sleep Medicine. 2018;50:152-165. DOI: 10.1016/j.sleep.2018.05.004

[40] Practice parameters for the treatment of obstructive sleep apnea in adults: The efficacy of surgical modifications of the upper airway. Report of the American sleep disorders association. Sleep. 1996;19:152-155. DOI: 10.1093/sleep/19.2.152

[41] Sundaram S, Bridgman SA, Lim J, Lasserson TJ. Surgery for obstructive sleep apnoea. Cochrane Database of Systematic Reviews. 2005:CD001004. DOI: 10.1002/14651858.CD001004.pub2

[42] Walker-Engstrom ML, Wilhelmsson B, Tegelberg A, Dimenas E, Ringqvist I. Quality of life assessment of treatment with dental appliance or UPPP in patients with mild to moderate obstructive sleep apnoea. A prospective randomized 1-year follow-up study. Journal of Sleep Research. 2000;9:303-308. DOI: 10.1046/j.1365-2869.2000.00210.x

[43] Browaldh N, Friberg D, Svanborg E, Nerfeldt P. 15-year efficacy of uvulopalatopharyngoplasty based on objective and subjective data. Acta Oto-Laryngologica. 2011;131:1303-1310. DOI: 10.3109/00016489.2011.616912

[44] Boot H, van Wegen R, Poublon RM, Bogaard JM, Schmitz PI, van der Meche FG. Long-term results of uvulopalatopharyngoplasty for obstructive sleep apnea syndrome. Laryngoscope. 2000;110:469-475. DOI: 10.1097/00005537-200003000-00027

[45] Dickson RI, Blokmanis A. Treatment of obstructive sleep apnea by uvulopalatopharyngoplasty. Laryngoscope. 1987;97:1054-1059. DOI: 10.1288/00005537-198709000-00011

[46] Laffont F, Lecendreux B, Minz M, Josse MO, Waisbord P, Fleury M, Chabolle F, Cathala HP. Efficacy of uvulopalatopharyngoplasty (UPPP) and modifications in sleep structure in the sleep apnea syndrome (SAS). Neurophysiologie Clinique = Clinical Neurophysiology. 1989;19:477-488. DOI: 10.1016/s0987-7053(89)80004-8

[47] Gislason T, Lindholm CE, Almqvist M, Birring E, Boman G, Eriksson G, Larsson SG, Lidell C, Svanholm H. Uvulopalatopharyngoplasty in the sleep apnea syndrome. Predictors of results. Archives of Otolaryngology–Head & Neck Surgery. 1988;114:45-51. DOI: 10.1001/archotol.1988.01860130049013

[48] Friedman M, Ibrahim H, Bass L. Clinical staging for sleep-disordered breathing. Otolaryngology—Head and Neck Surgery. 2002;127:13-21. DOI: 10.1067/mhn.2002.126477

[49] He M, Yin G, Zhan S, Xu J, Cao X, Li J, Ye J. Long-term Efficacy of Uvulopalatopharyngoplasty among adult patients with obstructive sleep apnea: A systematic review and meta-analysis. Otolaryngology—Head and Neck Surgery. 2019;161:401-411. DOI: 10.1177/0194599819840356

[50] Pang KP, Woodson BT. Expansion sphincter pharyngoplasty: A new technique for the treatment of obstructive sleep apnea. Otolaryngology—Head and Neck Surgery. 2007;137:110-114. DOI: 10.1016/j.otohns.2007.03.014

[51] Vicini C, Montevecchi F, Pang K, Bahgat A, Dallan I, Frassineti S, Campanini A. Combined transoral

robotic tongue base surgery and palate surgery in obstructive sleep apnea-hypopnea syndrome: Expansion sphincter pharyngoplasty versus uvulopalatopharyngoplasty. Head & Neck. 2014;36:77-83. DOI: 10.1002/hed.23271

[52] Sorrenti G, Piccin O. Functional expansion pharyngoplasty in the treatment of obstructive sleep apnea. Laryngoscope. 2013;123:2905-2908. DOI: 10.1002/lary.23911

[53] Ulualp SO. Modified expansion sphincter pharyngoplasty for treatment of children with obstructive sleep apnea. JAMA Otolaryngology–Head & Neck Surgery. 2014;140:817-822. DOI: 10.1001/jamaoto.2014.1329

[54] Plaza G, Baptista P, O'Connor-Reina C, Bosco G, Perez-Martin N, Pang KP. Prospective multi-center study on expansion sphincter pharyngoplasty. Acta Oto-Laryngologica. 2019;139:219-222. DOI: 10.1080/00016489.2018.1533992

[55] Pinto JA, Godoy LBM, Nunes H, Abdo KE, Jahic GS, Cavallini AF, Freitas GS, Ribeiro DK, Duarte C. Lateral-expansion pharyngoplasty: Combined technique for the treatment of obstructive sleep apnea syndrome. International Archives of Otorhinolaryngology. 2020;24:e107-e111. DOI: 10.1055/s-0039-1695026

[56] Pang KP, Pang EB, Win MT, Pang KA, Woodson BT. Expansion sphincter pharyngoplasty for the treatment of OSA: A systemic review and meta-analysis. European Archives of Oto-Rhino-Laryngology. 2016;273:2329-2333. DOI: 10.1007/s00405-015-3831-2

[57] Li HY, Lee LA. Relocation pharyngoplasty for obstructive sleep apnea. Laryngoscope. 2009;119:2472-2477. DOI: 10.1002/lary.20634

[58] Mantovani M, Minetti A, Torretta S, Pincherle A, Tassone G, Pignataro L. The velo-uvulo-pharyngeal lift or "roman blinds" technique for treatment of snoring: A preliminary report. Acta Otorhinolaryngologica Italica. 2012;32:48-53