Chapter

Surgical Treatment Options for Obstructive Sleep Apnea

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Abstract

Given the increased prevalence of obstructive sleep apnea (OSA) multiple treatment modalities including medical and surgical have been developed. First-line therapy for most of the people with obstructive sleep apnea (OSA) consists of behavioral modification, including weight loss if appropriate, and positive airway pressure (PAP) therapy. Patients who fail or do not tolerate PAP therapy, treatment options include oral appliances and surgical therapy. Surgical therapies have variable efficacy and are very important tool on OSA management in selected patients. This chapter will review the current surgical approaches sleep specialists use when other treatment options fail to accomplish the valuable outcome.

Keywords: obstructive sleep apnea (OSA), continuous positive airway pressure (CPAP), role of surgery, surgical treatment, follow up and monitoring

1. Introduction

Positive airway pressure (PAP) is considered the gold standard treatment for patient with OSA [1]. Multiple studies showed the effectiveness of the CPAP therapy with reducing subjective symptoms of OSA, and cardiovascular and neurocognitive risks [2, 3].

The efficacy of CPAP treatment is limited due to patient's compliance to therapy. Patient will achieve normal functioning with greater nightly CPAP durations [4]. Patient who fail or intolerant to CPAP therapy should consider alternative treatment options which surgery one of them.

Surgical procedures aim to improve airway patency by recognizing the location(s) of obstruction. Patients need to be selected in awareness of the individual underlying pathology, pathophysiology and anatomy, and severity of the disease and comorbidities.

The anatomical cause of OSA is generally heterogeneous, with multiple potential levels of airway obstruction; therefore, many different surgical procedures have been developed for the treatment of OSA [5].

2. Presurgical evaluation

Polysomnogram (PSG) and home sleep testing do not provide information about the location of the obstruction. Therefore, a complete history that include the chief complaint, other significant symptoms, past medical history and surgical history are helpful. Some symptoms can help identify potential surgical approaches.

Components	Classification
Structures	V–velum, including soft palate, uvula or lateral pharyngeal wall
	O–oropharyngeal walls (including palatine tonsils and lateral wall tissue)
	T–tongue base
	E–epiglottis
Degree of obstruction	0–No obstruction
	1–Partial obstruction
	2–Complete obstruction
	X–Not visualized
Configuration of collapse	Anteroposterior
	Lateral
	Concentric

Adapted from Ref. [11].

Table 1.
VOTE classification system [11].

The history should also include the patient past experience with continuous positive airway pressure (CPAP), an oral appliance, and/or weight loss.

Thorough physical exam to evaluate the structures that impact the upper airway. The nasal airway is evaluated in detail, checking for external deformity, nasal valve collapse, septal position, turbinate size, and nasal polyps.

Oral cavity and oropharynx examination provide information into the protentional upper airway surgery. It provides insight of the tongue size and position, dental health, and palate position.

Trans-nasal flexible laryngoscopy provides adequate evaluation of the lower pharyngeal and laryngeal airway. It gives great view of the entire upper airway while the tongue in native position.

Drug induce sleep endoscopy (DISE) using mild sedation (midazolam or propofol) required in some upper airway procedures like upper airway stimulation therapy [6]. It has been shown to be a valid assessment of the upper airway, with moderate-to-substantial test-retest reliability and moderate-to-substantial inter-rater reliability. It allows the evaluation of the airway in a situation as close to sleep as possible [7, 8].

VOTE (Velum, Oropharynx, Tongue base, and Epiglottis) system specifies grades for the degree of obstruction at the velum, oropharynx, tongue base, and epiglottis, as well as the type of collapse (**Table 1**).

Several other diagnostic modalities have showed some value to supplement a physical examination, including lateral cephalogram, 3-dimensional cone beam computed tomographic scan, sleep endoscopy, or cine-magnetic resonance imaging (MRI) [9, 10].

A comprehensive counseling should be undertaken prior to the surgery, discussing potential site of the obstruction and non-surgical treatments options.

3. Surgery selection

There are different surgical procedures used to treat OSA. American Academy of Sleep Medicine recommends that patient should be advised about potential surgical success rates and complications, the availability of alternative treatment options. The desired outcomes of treatment include resolution of the clinical signs and symptoms of obstructive sleep apnea and the normalization of sleep quality, the apnea-hypopnea index, and oxyhemoglobin saturation levels [12, 13].

3.1 Nasal procedures

Nasal obstruction has identified as an important target in the treatment of OSA. The main goal is to relive the obstruction as an adjunctive measure to improve the outcomes of continuous positive airway pressure (CPAP) by reducing CPAP pressure requirements, an oral appliance, or other surgery. Although nasal surgery in isolation does not have a consistent effect on the apnea-hypopnea index in OSA patients, it does have strong evidence on improving snoring, subjective sleep quality, daytime sleepiness, sleep-related quality of life measures, and other important OSA outcome measures [14, 15].

- Turbinate reductions reduce the obstruction caused by inferior turbinate.
- Septoplasty straightening a deformity of the nasal septum.
- Nasal valve surgery improves the airflow in patient with nasal valve obstruction.
- Rhinoplasty corrects any anatomical deformities that compromise the nasal airway.

The most common adverse outcomes for most of the intranasal procedures are postoperative temporary bleeding and temporary nasal congestions. More serious adverse effects could also occur but rare like cerebrospinal fluid leak.

3.2 Upper pharyngeal procedures

3.2.1 Tonsillectomy

The extent to which tonsillar hypertrophy contributes to OSA in adults remains unclear. Tonsillectomy with adenectomy is the first line treatment in pediatric patients with severe OSA and adenotonsillar hypertrophy. It also showed substantial improvement in AHI severity, oxyhemoglobin saturation and sleep quality in obese patient with OSA [16]. Patients who undergo tonsillectomy often experience significant reduction in the CPAP pressure required [17]. The most common postoperative complains include postoperative hemorrhage. Other risks such as pain, fever, and infection could also occur.

3.2.2 Uvulopalatopharyngoplasty (UPPP)

It represented as the first surgical procedure specifically designed to treat obstructive sleep apnea (OSA) and remains the most commonly performed surgical procedure to treat OSA.

There are multiple approaches have been introducing to address the narrowing or collapse of the retropalatal region (**Table 2**). It traditionally involved removal of the uvula, a portion of the soft palate, tonsils and closure of the tonsillar pillars. All the new techniques involve resection or repositioning of the palatal tissues and pharyngeal walls to increase the dimension of the pharyngeal airway to reduce obstruction.

To determine the likelihood for successful resolution of OSA after UPPP, a staging system was developed based on tonsil size, tongue-palate position, and BMI (**Table 3**) [18].

Relocation pharyngoplasty	Advancing the soft palate and splinting the lateral pharyngeal wall
Lateral pharyngoplasty	Microdissection of the superior pharyngeal constrictor muscle within the tonsillar fossa, sectioning of this muscle, and suturing of the created laterally based flap of that muscle to the same side palatoglossus muscle
Zetapalatopharyngoplasty (Z-palatoplasty)	Widen the space between the palate and posterior pharyngeal wall, between the palate and tongue base, and either to maintain or even widen the lateral dimensions of the pharynx
Expansion sphincter pharyngoplasty	Consist of tonsillectomy, expansion pharyngoplasty, rotation of the palatopharyngeal muscle, a partial uvulectomy, and closure of the anterior and posterior tonsillar pillars
Palatal advancement	Soft palate is elevated by advancing it towards the hard palate.

Table 2.
UPPP different procedure approaches.

Stage	Friedman palate position (Figure 1)	Tonsil size (Figure 2)	BMI
I	1–2	3–4	<40
II	1–2 3–4	0–1-2 3–4	<40 <40
III	3–4	3–4	<40
IV	Any	any	>40

Adapted from Ref. [18] and Figures are adapted from Ref. [18].

Table 3.
Friedman clinical staging system for sleep-discorded breathing.

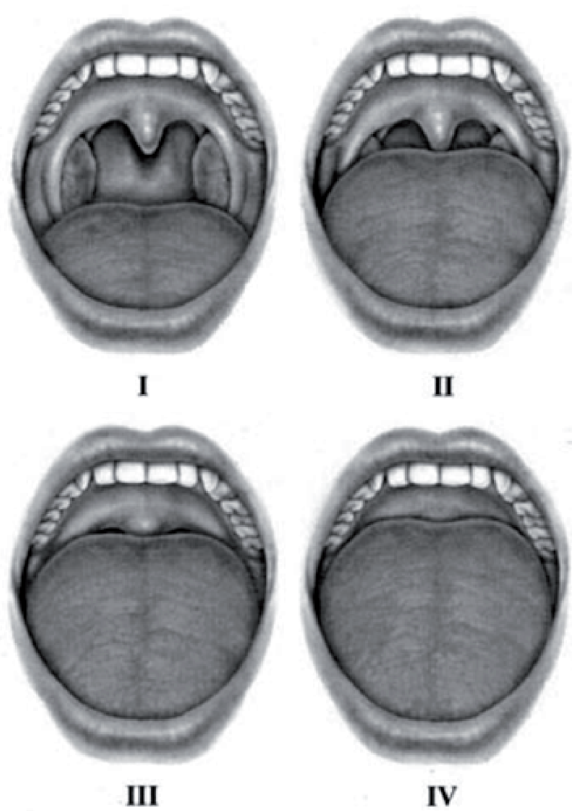

Figure 1.
The Friedman Palate Position is based on visualization of structures in the mouth with the mouth open widely without protrusion of the tongue. Palate grade I allows the observer to visualize the entire uvula and tonsils. Grade II allows visualization of the uvula but not the tonsils. Grade III allows visualization of the soft palate but not the uvula. Grade IV allows visualization of the hard palate only. Adapted from Ref. [18].

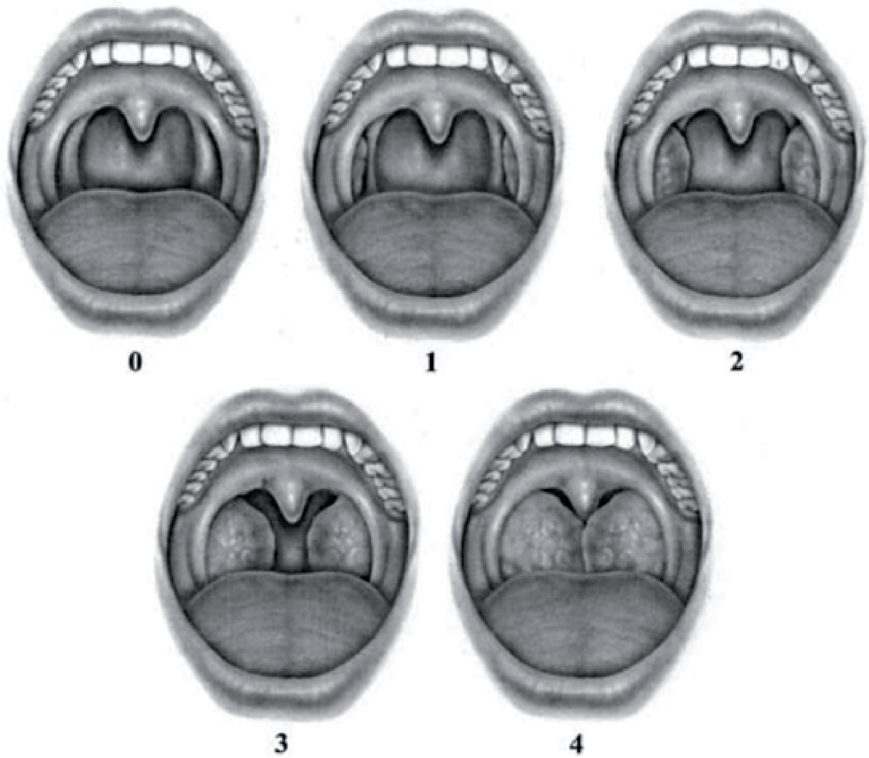

Figure 2.
Tonsil size is graded from 0 to 4. Tonsil size 0 denotes surgically removed tonsils. Size 1 implies tonsils hidden within the pillars. Tonsil size 2 implies the tonsils extending to the pillars. Size 3 tonsils are beyond the pillars but not to the midline. Tonsil size 4 implies tonsils extend to the midline. Adapted from Ref. [18].

Patients with stage I found to have successful outcome of 80% when treated with UPPP. Stage II patients has success rate of 37.9% and only 8.1% for patients with stage III [18].

In a study where they used DISE to evaluate the site of the obstruction with the Friedman clinical staging system for patients selected for UPPP. There was a significant success rate. The result of the surgery as defined by 50% reduction in preoperative AHI with postoperative AHI < 20/h was seen to be 95.2%. There were significant changes in major presenting symptoms (e.g., snoring, excessive daytime sleepiness, disturbed sleep, morning headaches, dry mouth, and forgetfulness) documented 6 months after surgery. Postoperative change in AHI done after 6-month interval was seen to be statistically significant with P value <0.00 [19].

Most common adverse effects of UPPP are severe transient throat pain and chronic subjective dysphagia [20, 21]. Trouble with smell and taste, pharyngeal dryness, globus sensation, voice change, and pharyngonasal reflux were presented after UPPP [20]. The new technique used in UPPP like radiofrequency tissue volume reduction (RFTVR) is safer and less painful than resection technique [20].

For patients, who may still need a CPAP therapy after UPPP surgery, important considerations may include compromise CPAP therapy by increasing mouth air leak and reducing the maximal level of pressure that can be tolerated, especially in procedures with greater resection of soft palate [22, 23].

4. Lower pharyngeal and laryngeal procedures

Multiple procedures were designed to improve the obstruction in the lower pharyngeal airway.

4.1 Tongue reduction procedures

Multiple techniques to improve lower pharyngeal airway by decreasing the volume of the tongue tissues:

1. Radiofrequency tissue ablation: It is a minimal invasive procedure. Application of a temperature-controlled radiofrequency probe to multiple locations in the base of the tongue. It generates submucosal scar tissues that anticipated to reduce the tongue volume.

2. Lingual tonsillectomy: Improves airway by removing obstructing lingual tonsil tissue.

3. Partial midline glossectomy: Resection of the midline tongue base tissue.

4. Submucosal lingualplasty: Resection of submucosal lingual tissue of the tongue base.

4.2 Tongue advancement

Multiple procedures tend to improve lower pharyngeal airway by advance or stabilize the tongue base and pharyngeal muscular:

1. Tongue-base suspension: stabilize the tongue and prevent retrolingual collapse by placing a suture to the anterior mandible to create a tongue base sling.

2. Genioglossus advancement: Advancing the genial tubercle of the anterior mandible forward and create an osteotomy around it.

3. Hyoid suspension: Suspend the hyoid bone to the thyroid cartilage or mandible by using permanent suture. It helps stabilize the base of the tongue and lower pharynx.

Multiple studies showed the effectiveness of lower pharyngeal and laryngeal procedures. It demonstrates improvements in respiratory physiology during sleep, daytime somnolence and quality of life. Successful sleep study outcomes defined as a reduction in AHI of 50% or more and an AHI of less than 20, was achieved in 35–62% of patients [24].

Adverse effects reported were based on the surgical techniques that been used. Pain, hemorrhage, tongue infection airway complications, taste change and dysphagia seen in partial glossectomy, lingualplasty and lingual tonsillectomy [26].

Postoperative pain and submandibular edema were the two most common complications followed radiofrequency tissue ablation [25].

4.3 Maxillomandibular advancement

The maxilla and the mandible are advanced together with both upper and lower teeth to widen the retrolingual and the retropalatal segments of the upper airway. It is beneficial mainly for patients with craniofacial issues, but it is not limited for patients with this problem. The maxilla is moved by a Le fort I osteotomy and the mandible by a sagittal split osteotomy. It is a major operation but showed a significant increase in the pharyngeal airway dimensions and decrease AHI score below the threshold of 20.

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4.4 Hypoglossal nerve stimulation

New treatment for OSA by Implantable neurostimulator device was approved by US Food and Drug Administration in 2014. It keeps the lower pharyngeal airway open during sleep by activates the protrusion muscles of the tongue via the hypoglossal nerve.

Eligibility criteria include:

- Age > = 21 years old
- Moderate or severe OSA (AHI > 20 but less than 65 events per hour)
- Predominantly obstructive events (central and mixed apneas <= 25 percent of AHI).
- Unable to tolerate CPAP
- DISE shows no concentric velopharyngeal collapse or any other anatomical findings.
- BMI < 32 kg/m^2

Hypoglossal Nerve Stimulation showed 68% decrease in AHI score, oxygen desaturation index score decreased by 70%, and improved quality of life [27].

Most common reported adverse outcomes are infection, hemorrhage, and tongue weakness. It is still unknown whether there are long term risks.

4.5 Tracheostomy

The most immediate, effective and definitive treatment for OSA is placing a permanent cannula in the neck to bypassing the upper pharyngeal airway. Patient will be able to breath, speak and eat by capping the tube during waking time and open the cannula during sleep. Tracheostomy significantly decreases apnea index, oxygen desaturation index, sleepiness, and mortality in OSA patients [28].

It requires a long-term care to reduce complications (e.g., pneumonia, mucus plugging, peristomal infections). Therefore, it is recommended primarily for patient with sever and life threating OSA who failed all the other treatment options and in morbid obese patients.

5. Weight loss by bariatric surgery

OSA is seen in about 45% of bariatric patients [28]. Surgically induced weight loss showed significantly improves obesity-related sleep apnea. It decreased the mean RDI to 15 ± 2 from 51 ± 4 (preoperatively). In addition, oxygen saturation, sleep efficiency, repaid eye movement latency and the requirement for continuous positive airway pressure [29].

6. Multilevel surgery

Patient with OSA could have multiple locations of collapse in upper and lower pharyngeal tracts. Those patients would benefit from multilevel surgery. DISE is now a standard procedure during the presurgical evaluation which gives the surgeon personalized anatomical information. A combination of multilevel procedures improved the outcome compare to single-site procedure.

In a meta-analysis that used 49 multilevel surgery articles showed success rate of 66.4% for mixed multilevel surgeries (reduction in the AHI of 50% or more and an AHI of less than 20) [30].

7. Follow up and monitoring

Surgical follow up is based on the type of the surgery. It should include wound management and complications. Patient also needs a long-term follow up by a sleep specialist to evaluate the need for adjunctive use of positive airway pressure or other therapies.

8. Conclusion

There has been a significant improvement in the current surgical techniques for the treatment of the OSA. Surgical management is usually warranted in appropriately selected patients who could not or failed CPAP or other alternative therapies. Also, for patient with anatomical abnormalities that can be corrected. Currently DISE is very useful method and widely used to determine the levels of collapse.

A comprehensive discussion between surgeon and patient prior to the surgery is warranted, discussing realistic expectations of the treatment benefits and complications. Surgical treatments showed long-term benefits in appropriately selected patients but no complete elimination of OSA.

Patient who undergo any surgical procedure will require long term monitoring for recurrence or worsening of OSA.

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