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Review Article

TREATMENT OPTIONS FOR OBSTRUCTIVE SLEEP APNEA

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Obstructive sleep apnea (OSA) is sleep-disordered breathing caused by the collapse of the upper airway. Because anatomical abnormalities of the narrow upper airway are undoubtedly the most critical cause of OSA, the available treatment methods for OSA mostly focus on these anatomical problems.

The collapse of the respiratory tract is associated with different levels of upper airway obstruction. The obstruction of the airway can be divided into three parts: the nasal cavity, retropalatal region, and retrolingual region. This article summarizes some common OSA treatment methods, their underlying theories, and their effect on the upper airway. (Taiwanese Journal of Orthodontics. 32(1): 17-24, 2019,2020)

Keywords: obstructive sleep apnea; oral appliance; maxillary expansion; Powell-Riley surgical protocol.

INTRODUCTION

Obstructive sleep apnea (OSA) is a sleep disorder where breathing repeatedly stops or weakens because of upper airway collapse during sleep. This airway collapse results from anatomical abnormalities and low pharyngeal dilator muscle tone during sleep. Upper airway collapse during sleep results in snoring, sleep fragmentation, and hypoxemia, leading to symptoms such as excessive daytime sleepiness, inattention, memory loss, anxiety, and depression. Thus, it may increase the incidence of car accidents. OSA may also lead to heart disease, high blood pressure, stroke, or type 2 diabetes. This makes OSA a serious threat to the health and quality of life of patients.

Diagnosis

The diagnosis of OSA is based on physical examinations, a sleep test, and the medical history of a patient.

Polysomnography (PSG) is the standard sleep test for OSA. It involves electroencephalography, electrooculography, chin electromyography, electrocardiography, and measurements of the patient’s airflow, oxygen saturation, respiratory effort, and heart rate.

The most crucial piece of information in PSG is the Apnea-Hypopnea Index (AHI), defined as the number of apneas or hypopneas per hour of sleep. If the AHI> 5 for a patient who has signs and symptoms of disturbed sleep, the diagnosis of OSA is confirmed.
The severity classification of OSA, defined by the American Academy of Sleep Medicine, is as follows: mild (if $5 \leq \text{AHI} < 15$), moderate (if $15 \leq \text{AHI} \leq 30$), and severe (if $\text{AHI} > 30$).

**Site of upper airway obstruction**

PSG can diagnose the severity of OSA, but it cannot distinguish the obstruction site in OSA. Oral examination, fiberoptic nasopharyngolaryngoscopy (with Müller’s maneuver), lateral cephalometric analysis, computed tomography, and magnetic resonance imaging should be used to identify the site of obstruction.

The potential site of upper airway obstruction can be divided into three main areas: nasal cavity, retropalatal region, and retrolingual region (Table 1).

The severity of OSA and the location of airway obstruction must be confirmed prior to treatment to establish a treatment baseline and make a reasonable treatment plan.

**Treatment of OSA**

**Reduce the body weight**

Obesity is a significant risk factor for OSA. Excessive adipose tissue in the upper respiratory tract accumulates in the tongue, pharyngeal wall, and soft palate and may increase the risk and severity of OSA. Significant OSA is present in 40% of obese individuals and 70% of OSA patients are obese.

Weight loss is an effective method for the nonsurgical treatment of OSA. Diet modification, medication, and surgical weight loss can improve the condition of patients with OSA. Diet control and weight loss of 9%–20% can reduce AHI by 30%–75%.

**Continuous positive airway pressure**

Continuous positive airway pressure (CPAP) is the first-line treatment for moderate to severe OSA. It provides pressure to open the airway that collapses when sleeping, which can effectively reduce AHI and maintain the blood oxygen concentration in the patient. It is largely proven to be efficacious in reducing sleepiness, blood pressure, and cardio/cerebrovascular risk.

CPAP is suitable for patients with mild, moderate, and severe OSA and is effective regardless of the site of airway obstruction. When patients use CPAP, they can eliminate apneas and hypopneas, and the blood oxygen concentration can be maintained in the normal range.

However, adherence to CPAP has always been a problem. On average, 10.7% of patients cannot tolerate CPAP. The average duration of nighttime use is only 4.7 h.

**Table 1. The potential sites of upper airway obstruction and their causes.**

<table>
<thead>
<tr>
<th>Obstruction site</th>
<th>Cause</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nasal</td>
<td>septal deviation, turbinate hypertrophy, alar collapse or sinonasal masses</td>
</tr>
<tr>
<td>Retropalatal</td>
<td>posteriorly elongated palate and uvula, tonsil and adenoid hypertrophy</td>
</tr>
<tr>
<td>Retrolingual</td>
<td>macroglossia, retrognathia and micrognathia, inferior displacement of hyoid</td>
</tr>
</tbody>
</table>
The overall CPAP non-adherence rate was reported to be 34.1%, which may not allow CPAP treatment to reach the therapeutic threshold, thus casting a doubt on its efficacy.\textsuperscript{24} 

**Oral appliances**

The two main types of oral appliances (OAs) are mandibular repositioning appliances and tongue retaining devices.\textsuperscript{2} The function of an OA is to advance the lower jaw or tongue to help opening the upper airway; in essence, OA is more effective for patients with prevalent retrolingual obstruction and retrognathia.\textsuperscript{25,26,27} On the other hand, nasal obstruction may reduce patients’ tolerance to the OA and have a negative influence on treatment response. Increased nasal resistance is associated with a higher proportion of oral breathing during sleep.\textsuperscript{28} Because the mouth opening may be limited by OAs, mouth breather (nasal obstruction) tend not to tolerate the OA.\textsuperscript{29} Higher nasal resistance also associated with pharyngeal and lingual collapse, reduce the effect of OA.\textsuperscript{29} It was reported that the non-responders to OAs have higher nasal resistance than the responders.\textsuperscript{25} Thus, nasal obstruction should be treated before using OA.

OA has been suggested for patients with mild (SIGN guideline\textsuperscript{30}) to moderate OSA and for those who cannot tolerate CPAP therapy or prefer alternate therapy.\textsuperscript{31,32,33} OA has also been recommended to alleviate simple snoring.\textsuperscript{31} The mean reduction in AHI by OA was 13.60 events/h.\textsuperscript{31}

**Maxillary expansion for pediatric OSA**

Pediatric OSA is classified as mild if $1 \leq \text{AHI} < 5$, moderate if $5 \leq \text{AHI} \leq 10$, and severe if $\text{AHI} > 10$.\textsuperscript{36} The most common cause of pediatric OSA is the enlargement of tonsils and/or adenoids.\textsuperscript{37,38} The modalities of treatments for pediatric OSA are adenotonsillectomy, CPAP, weight loss, and medications.\textsuperscript{36,39,40}

Rapid maxillary expansion (RME) is another option for treating pediatric OSA. RME stretches and widens the maxilla and nasal floor by distraction osteogenesis to reduce nasal obstruction.\textsuperscript{41,42} It is suitable for children and adolescents with a narrow palate and dental crossbite.\textsuperscript{32,43} RME creates more space for the tongue to raise, thus indirectly enlarging the pharyngeal airway.\textsuperscript{44} After RME treatment, the mean reduction in AHI was 6.86 events/h.\textsuperscript{45}

**Maxillary expansion for adult OSA**

Maxillary expansion can also help adult patients reduce AHI and OSA symptoms.\textsuperscript{35} However, an adult maxillary bone has ceased the growth and the midpalatal suture is closed. Thus, RME achieves only dental expansion in adults and does not effectively enlarge the palatal bone. Therefore, it has traditionally been possible to rely on surgically assisted rapid palatal expansion (SARPE) to achieve maxillary expansion in adults. SARPE improves transverse discrepancy with a tooth-borne expander with horizontal and vertical osteotomy. It also improves OSA symptoms and decreases AHI by 56%.\textsuperscript{46}

The tooth-borne expander of SARPE acts on the teeth, which renders the device’s force unable to be directly transmitted to the midpalatal suture. This in turn causes side effects from the dental expansion, resulting in a relapse rate of SARPE of up to 64%.\textsuperscript{47}

Maxillary expansion by distraction osteogenesis is a technique involving the use of a bone-borne expander with horizontal and vertical osteotomy. Mini-implants are
placed in the maxillary bone along the midpalatal suture to deliver the force exerted by the expander, and Le Fort I osteotomy and vertical osteotomy are subsequently performed to open the midpalatal suture and reduce the resistance of maxillary expansion.48

Miniscrew-assisted RPE (MARPE) is another non-surgical treatment option involving the complete or partial use of a bone-borne expander. Bone screws are used to deliver force directly from the expander to the maxillary bone to split the midpalatal suture. MARPE has been reported to expand the nasal cavity and the upper half of the pharynx, thus reducing upper airway resistance. Therefore, MARPE may also be an effective treatment option for OSA.49 The success rate of MARPE for young adults range from 84.2% (mean age= 20.1 years) to 86.96% (mean age = 20.9 years).50 However, the failure rate seems to increase with age, it’s about 15% in the patients’ 20s and 50% in the 30s.51

**Surgical treatment**

The Powell–Riley surgical protocol is a logical two-phase surgical treatment protocol for OSA.6 This protocol emphasizes the need to clearly diagnose the obstruction site of the upper airway. Surgery can be performed to target the site of anatomical obstruction, thus avoiding wide range of surgery.

**Phase I surgery**

Conservative operation on soft tissue does not change the patient’s facial bones or the occlusion. Table 2 illustrates the surgery for each upper airway obstruction site.

The overall success rate of phase I surgery is 61%, ranging from 42% to 75% depending on the severity of the disorder.6,53

**Phase II surgery**

After phase I surgery, the obstruction of the retrolingual area (base of the tongue) may still not be completely treated. Subsequent treatment options can be phase II surgery or other alternative treatment modalities including tracheotomy, nasal CPAP,6 and OA.

The second stage of surgery involves maxillomandibular advancement osteotomy, which reduces the collapse of the retrolingual airway by creating more space for the tongue in the oral cavity;6 tongue reduction can be used as adjuvant therapy.6

The success rate of phase II surgery is more than 90%, whereas the success rate of phase II surgery that is subsequent to phase I treatment is more than 95%.44

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**Table 2. Conservative surgery for each obstruction site.**

<table>
<thead>
<tr>
<th>Obstruction site</th>
<th>Phase I surgery</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nasal</td>
<td>Septoplasty, turbinate reduction, nasal valve grafting masses</td>
</tr>
<tr>
<td>Retropalatal</td>
<td>Tonsillectomy, uvulopalatopharyngoplasty (UPPP) or uvulopalatal flap (UPF)</td>
</tr>
<tr>
<td>Retrolingual</td>
<td>Genioglossus advancement, hyoid myotomy and suspension of hyoid</td>
</tr>
</tbody>
</table>
CONCLUSION

Many treatment options are available for OSA. However, no treatment solution covers every situation. Detailed diagnosis and clear identification of the upper airway obstruction guide the choice of correct treatment.

Basing on severity, OA can be selected as the first-line treatment for mild OSA. For patients with moderate to severe OSA, the first-line of treatment is CPAP. Surgery can be used to treat the patients who have more severe OSA, poor response to previous treatment, or are unable to cope with conservative treatment.

With regard to the patient's airway obstruction site, CPAP and weight loss are not site-specific treatment options, OAs are more effective for patients with retrolingual obstruction. Palatal expansion can help to reduce the nasal resistance. Surgical treatment should be administered according to the site of airway obstruction, thus improving airway anatomy with a good therapeutic effect.

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