Review Article

JRAD Journal of Research and Advancement in Dentistry

J Res Adv Dent 2021;11:3:369-379.

Orthodontists Role in Obstructive Sleep Apnea: An Overview

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ABSTRACT

Background: Obstructive sleep apnea (OSA) is currently a common sleep associated breathing disorder, which have profound effects on the health and quality of life. It is characterized by the cessation of air flow during sleep due to an obstruction in the nasopharyngeal/oropharyngeal region. The orthodontics specialty involves much more than just moving teeth, and the management of sleep apnea bears witness to this. There is a significant role of orthodontist, both in screening for obstructive sleep apnea and as a key player of the multidisciplinary team, in the management of OSA in both children and adults. As an Orthodontist, one has expertise in science of facial growth and development and their knowledge of oral appliances such as mandibular advancement devices make orthodontists well suited to collaborate with other allied health providers in the treatment of OSA. This article highlights the key role of orthodontist in the diagnosis and treatment of OSA patients.

Keywords: Obstructive sleep apnea, Snoring, Orthodontics, Oral appliance.

INTRODUCTION

Obstructive sleep apnea (OSA) is a sleep-associated breathing disorder with a reduction or complete obstruction of airflow despite an ongoing effort by patient for breathing. It usually occurs during sleep, as muscles undergo relaxation and causes collapse of the soft tissues in the back of the throat which leads to blockage of upper airway. This creates repetitive episodes of obstruction of the upper airway causing a loss of breath, at least for10 seconds or longer. When this occurs, blood oxygen level drops, and blood pressure & heart rate rises.[1] The brain ultimately sends a distress signal that partially or fully wakes the person from sleep and alerts the body to breathe, causing the patient to gasp for air. The standard OSA severity measuring system is called the apnea-hypopnea index (AHI), which is defined as the number of apnea plus hypopnea per hour of sleep.[2] OSA can be defined clinically by, the daytime sleepiness, loud snoring, breathing interruptions, awakening due to gasping or choking in the presence of at least 5 obstructive respiratory events per hour of sleep.[3]

Despite of OSA being a common medical condition, more than 85% of patients with clinically significant OSA have never been diagnosed of it and this reflects the fact that many patients with symptoms of OSA are not aware of their nocturnal arousals and loud snoring. The apnea-hypopnea index (AHI) is an index of severity that combines apneas and hypopneas (slow or shallow breathing) i.e., recording of the numbers of apnea and hypopnea episodes per hour of sleep in order to analyse them and determine the degree of sleep apnea severity in the patient. The AHI has been used to classify patients as either having OSA or being normal (AHI < 5 events per hour of sleep), as well as to classify the severity of OSA.[3]

Received: Mar. 13, 2021: **Accepted**: May. 7, 2021
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Email: Not Disclosed

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pISSN 2278-0076
eISSN 2321-9270

The American Academy of Sleep Medicine has classified OSA severity depending on AHI as – (Table 1)

Table 1: OSA classification

Severity	AHI
mild sleep apnea	5–15 events per hour of sleep
moderate sleep apnea	15–30 events per hour of sleep
severe sleep apnea	>30 events per hour of sleep

Pathophysiology:

The main culprit in OSA is narrowing/occlusion of the upper airway space, usually at the level of the oropharynx.[4] The resulting apnea leads to progressive asphyxia until there is a brief, unnoticed arousal from sleep, whereupon airway patency is restored and normal airflow resumes. The patient then returns to normal sleep, and this cycle of events is repeated many times (Figure 1). Another consideration is that, individuals with OSA have impairment in function of genioglossus muscle of tongue.

This causes prolapse of the tongue against posterior pharyngeal wall, when there is inspiratory effort during sleep. It leads to pharyngeal wall invagination and occlusion of the airway during sleep.[5,6,7,8] The immediate factor leading to collapse of the upper airway in OSA is the production of critical sub-atmospheric pressure during inspiration that exceeds the potential of the airway dilator and abductor muscles to maintain airway stability. Obesity frequently contributes to the reduction in the size of upper airway, either by increasing fat deposition in the soft tissues around the pharyngeal airway or by compressing the pharynx by superficial fat masses in the neck. Snoring, a high-frequency vibration of the palatal and pharyngeal soft tissues that results from the decrease in size of the upper airway lumen, may aggravate the narrowing by producing edema of the soft tissues.[9,10,11,12]

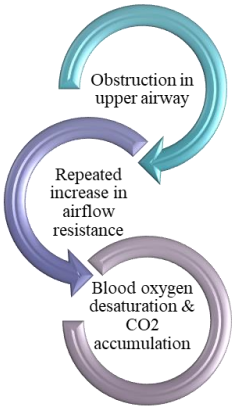

Figure 1: Schematic illustration of Pathophysiology

Risk Factors

Table 2: Predisposing factors of OSA[13,14,15,16] are as follows.

Modifiable	Non-Modifiable
Obesity	Increasing Age
Smoking and alcohol consumption	Genetic factors like craniofacial anatomy
Sedatives	Control or obesity genes
Diabetes	Male gender
Hypertension	Presence of structural abnormalities that causes upper airway obstruction
Hypothyroidism	
Pregnancy	
Retrognathic mandible / Maxilla	
Micrognathia	
Adenoid Hypertrophy	
Enlarged tonsils	
Enlarged tongue	
Increased lower face height	
Elongated soft palate	
Inferiorly positioned hyoid bone	

Etiology:

As listed above, any of the risk factors individually or in combination can contribute to the blocking or collapse of the airway. (Figure 2) OSA occurs as a result of increased collapsibility of the upper airway. The pharyngeal critical closing pressure (P crit) is the pressure at which the upper airway collapses, this collapsibility is influenced again by impaired neuromuscular tone. As a result, respiratory effort increases to maintain airflow

through a constricted airway, accompanied by hypercarbia and hypoxemia. This causes a cortical arousal from sleep, which in turn raises sympathetic neural activity, causing increased heart rate and blood pressure. Due to the cortical arousal from sleep comes resumption of normal airflow, with subsequent return to sleep. This disruption in breathing can occur multiple times per hour for the entire duration of the patient's sleep cycle.

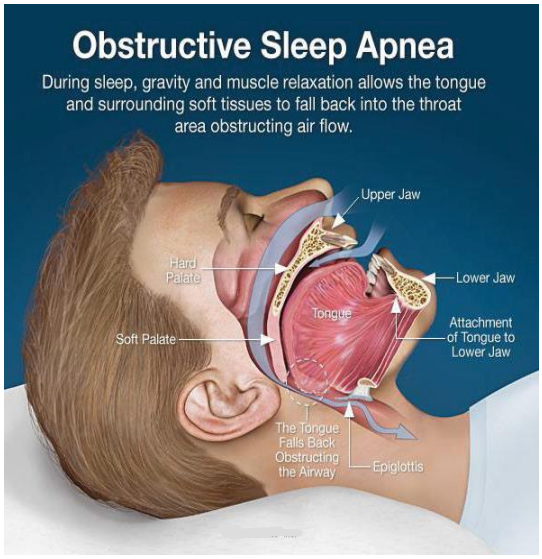

Figure 2: Figure showing etiological events

Clinical Features :

Table 3: Symptoms of OSA[17,18,19,20] has been mentioned.

Snoring	Excessive day time sleepiness, morning headaches
Abrupt awakenings accompanied by gasping or choking during night	Chronic nasal congestion
Fragmentation of sleep	Fatigue
Bruxism (nocturnal tooth grinding)	Poor school performance
Walking during sleep	Poor concentration, and distraction
Nocturnal and daytime enuresis	Behavioral disturbances (Mood changes, irritabitility, frustration, impatience, depression, anxiety,
Neck hyper extension	aggression and hyperactivity)
Mouth breathing & dryness in mouth	Intellectual impairment

Effects of OSA:

The consequences of OSA are shown in figure 3.[21]

Figure 3: Effects of OSA.

What is the Role of Orthodontist?

The spectrum of Orthodontists typically have a broad patient population, right from children, adolescents, to adults; with regular visits over a long period of time. Moreover, orthodontists already have a productive history of working with other specialities in dentistry as well as medicine to provide collaborative care for patients with special needs, such as cleft lip & palate, syndromic craniofacial anomalies and orthognathic surgery. In routine OPD, orthodontist is well positioned to perform an OSA screening assessment of at-risk patients. As cited earlier, OSA is associated with numerous craniofacial abnormalities, and orthodontists are involved in improvement of dento-facial morphology, so it will have a positive impact on diagnosing potential OSA patients as well as actively planning and facilitating treatment of them. Thus, the specialized knowledge, skill, and experience of an orthodonist can be utilised to address the pathology at its earliest stage so as to cure it with easier modes of treatment options. Finally, interdisciplinary professional communication is crucial for the success of OSA management.

Orthodontist plays an important role in diagnosis as well as treatment of OSA patients as explained below -

Role In Diagnosis:

Obstructive sleep apnea and other sleep related breathing disorders (SRBDs) can be definitively diagnosed only by a physician. But Orthodontist have a definitive role in primary screening and identifying high risk patients who can develop OSA.

History taking -

Orthodontists play an important role in identifying at risk patients for OSA and associated diseases with OSA, as part of their routine dental & medical examinations. Orthodontists are familiar with abnormal anatomy & the signs and symptoms of OSA patients. As a part of history taking, following important information is gathered that whether patient is having any history of – nasal obstruction, mouth breathing, observed episodes of pauses in breathing, difficulty staying asleep, restlessness during sleep, sweating, choking or gasping respirations during sleep, habitual or loud snoring, bruxism, abrupt awakening and shortness of breath, enuresis or unexplained nocturia, awakening with dry mouth or sore throat, morning headaches, alterations in performance, disordered mood, attention, or memory problems, fatigue during the day or excessive daytime sleepiness, previous diagnosis of OSA, previous diagnosis of other forms of sleep related breathing disorders (SRBDs), high blood pressure, type 2 diabetes, allergy, medication (Sedatives, Muscle relaxant, etc.), smoking, alcohol intake.

The patient should be asked the following specific questions:

- Are you falling asleep regularly against your will?
- Are you often feeling sleepy while driving?
- Are you having difficulty while working?
- Is surgery for snoring being performed?

For pediatric evaluation, following questions should be asked to parents:

loud snoring, mouth breathing during sleep, poor school performance, aggressive behavior, medications, developmental delays, bed wetting that is not age appropriate, attention problems, hard to wake up in the morning, trouble breathing during sleep, morning headaches, pauses in breathing during sleep, fall asleep quickly, and rule out attention deficit–hyperactivity disorder.

Physical Examination:

General examination findings of age, sex, height, weight, body mass index (BMI), neck circumference, blood pressure, mouth breathing, Intra nasal examination & Intra oral inspection for Malocclusion and palatal morphology should be noted. Orthodontists can identify certain characteristics of the craniofacial structural abnormalities that are found to be common in patients with OSA. These include tonsillar/adenoid hypertrophy especially in children, enlarged soft palate, elongated uvula, nasal obstruction, macroglossia with dental impressions at the edge of the tongue, bimaxillary retrusion, mandibular deficiency, short cranial base, increased lower anterior facial height, reduced cranial base angle and mandibular length, craniocervical angulations, inferiorly positioned hyoid.[22] In addition to regular orthodontic screening, the orthodontist can use the modified Mallampati (MM) classification (Figure 4) to evaluate the patency of the oral airway.[23]

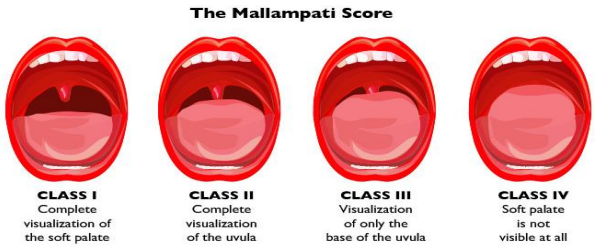

Figure 4: Mallampati Classification

Malocclusion association with OSA is another area of interest to the orthodontist. It has been proven that narrow maxillary dentition acts as a predisposing factor for OSA because a narrow upper dental arch is also thought to diminish the oropharyngeal volume available for the tongue.[24] From an orthodontist point of view, narrower upper & shorter lower dental arch, reduced overbite, crowding in the mandibular arch and Class II malocclusion were reported as dental features that were associated with OSA patients.[25,26] Specifically, increased overjet and lateral crossbite are more

frequently seen in OSA patients. Overjet was also found to be associated with the severity of OSA in nonobese patients, and this finding suggest that malocclusion may play an important role in the development of sleep apnea/hypopnea.[27] In addition to the above mentioned dental features, the associations of malocclusions class and obstruction of the upper airways have been suggested. This implies that these malocclusion characteristics may have a predisposing anatomical factor for these problems. Other dental features which is reported frequently in OSA patients is a palatal morphology. Palatal morphology of V shape and decrease in the upper arch length & inter first upper premolar distance were also reported to be associated with snoring.[28] BMI ≥ 30 kg/m2 and a neck circumference >17 inches in men and >16 inches in women are habitually used as critical values.[29] Objective STOP-Bang questionnaire is good screening tool in adults, a validated tool for OSA risk assessment.[30,31] This is a simple and easy tool which asks yes or no questions based on its acronym: snoring (S), tiredness (T), observed pauses in breathing (O), high blood pressure (P), BMI .35 kg/m2 (B), age .50 years (A), neck circumference of 17 inches in men, or 16 inches in women (N), and male gender (G).

The inference can be gathered as following-

Low risk for OSA - more than 2 “yes” answers,

Intermediate risk for OSA - 3 or 4 “yes” answers,

High risk for OSA - 5 or more “yes” answers.

The patient is also considered at high risk if there are 2 “yes” answers from the STOP section and combined with either male gender, high BMI, or large neck size. This STOP-Bang questionnaire has a high sensitivity for identifying patients with moderate to severe OSA and can be completed in a few minutes as part of an orthodontist's workflow.

Investigations:

As assessing some radiographs is part of their routine work, orthodontists have a fundamental role in OSA recognition and screening. A panoramic radiograph is useful because of its ability to display a wide variety of structures in a single view with minimum irradiation.

Cephalometric analysis:

It is also useful in the evaluation of the airway dimension, cranial or skeletal structures, or planning for orthognathic surgery. Lateral cephalometry (Figure 5) is one of them and it is readily available, inexpensive, and reliable technique for assessing the pharyngeal airways, whereby details of skeletal and soft tissue structures can be accurately measured and compared.[32] A low position of the hyoid bone when measured from the inferior border of the mandible has been shown to be an indicator of low muscle tonicity and has been linked with OSA. In anteroposterior plane, both the face and anterior cranial base tend to be retruded and the cranial base angle is reduced in OSA patients, which leads to a reduction in the airway space. In the vertical plane, increases in lower face height and maxillomandibular planes angle has been observed.[33] Other features seen on cephalometry, associated with OSA are smaller than normal SNA and/or SNB; increased Frankfort mandibular plan angle and/or maxillary mandibular plan angle.[34]

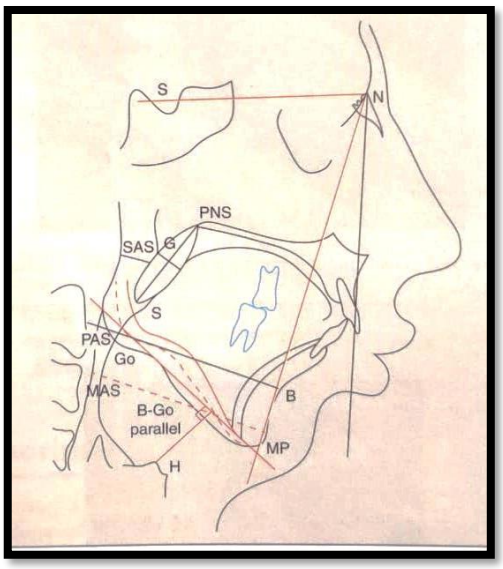

Figure 5: Lateral cephalogram in OSA patient

Other Imaging modalitities –

Cone beam computed tomography (CBCT)
Magnetic resonance imaging (MRI)
Fluoroscopy

Nasopharyngoscopy
Acoustic reflexion

Definitive diagnosis:

When an orthodontist has a clinical suspicion that a patient may have OSA, it is strongly recommended that referral to a physician be made and a sleep medicine physician is preferred. The definitive diagnosis of OSA should be made by a physician.

Polysomnography (PSG):

Diagnostic confirmation of OSA is performed by a sleep medicine specialist with the use of the gold standard, in-center overnight sleep study, polysomnography. It records patterns of sleep and breathing together. It involves an overnight sleep in the laboratory with multichannel monitoring or multiple physiologic variables in the presence of a technician throughout the study. PSG requires about 30-60 min set up time before sleep and about 30 minutes detachment time in the morning. It involves the evaluation of continuity of sleep, sleep staging, airflow and respiratory effort, arterial oxygen saturation, electrocardiogram, body position, and periodic limb movements.[35]

Oximetry:

It is used for detection and calculation of the differential absorption of light by presence of oxygenated and deoxygenated haemoglobin in blood. Pulse oximetry and portable monitoring of cardiopulmonary channels are the alternatives to polysomnography, if polysomnography is not available.

Role in treatment –

If the patient is found to have OSA, the physician will prescribe the appropriate course of action; the orthodontist should consider working in a collaborative way with the physician, providing related orthodontic treatment when necessary and when it does not interfere with medical treatment.

Treatment modalities of OSA can be divided into surgical and non-surgical treatment to which adjunctive therapies can be associated. Less invasive treatment should be selected whenever possible. Also,

Informed consent:

Before initiating treatment, informed consent appropriate to OSA must be obtained. The patients must be advised about the availability of alternative options and their levels of effectiveness. The proposed treatment plan should be described in detail, such as describing the benefits, risks, short- and long-term side-effects, and complications that might arise. The need for compliance, long-term monitoring, and follow-up care should be discussed. An estimate of the nightly duration of oral appliance (OA) therapy use should be provided, and a realistic estimate of the probability of success with the treatment protocol should be presented. Given the serious nature & morbidity of untreated OSA, it is recommended that the orthodontist should carefully document the informed consent process primarily.

Non Surgical:

Behavioral modifications or conservative treatments :

Behavioral strategy includes practices that enhance hygiene & life routines. It consists weight loss, ideally to a BMI of 25 kg/m2 or less, positional therapy, avoidance of smoking & alcohol and sedatives 3hour before sleep. Improvement of AHI in obese patients is seen after weight loss, that's why It is recommended for all overweight OSA. Supine position while sleeping can affect airway size and patency with a decrease in the area of the lateral dimension of upper airway. Positional therapy by positioning any device like pillow, back-pack or tennis ball is an effective secondary therapy or can be a supplement to primary therapies for OSA in patients who have a low AHI in the non-supine position. Pharmacological treatment should be given for hypothyroidism, hypertension and diabetes.

Oral appliances (OAs):

Oral devices were used since long as a non-invasive treatment for OSA. Pierre Robin was the first orthodontist to have used oral appliances in the 1900s for glossoptosis. OAs are recommended ideally for mild to moderate OSA patients and as an alternative therapy to continuous positive airway pressure (CPAP) for following cases –

Patients with snoring, non responding to behavioral therapy

Prefer it over CPAP
CPAP resulted in adverse effects
Patients not compliant to CPAP
Those who refuse surgery.

OAs aid in maintaining an open and unobstructed airway by repositioning or stabilizing the lower jaw, tongue, soft palate, or uvula. This therapy has proven to be effective in reducing the apnea and hypopnea index (AHI), improving oxygen saturation during sleep, and reducing snoring. Orthodontic appliances should be fabricated in a way that it can be worn by the patient either in a permanent or removable manner depending upon the condition of the patient. Oral appliances are used during sleep, and it repositions the lower jaw, tongue, soft palate to maintain an open and unobstructed airway. These appliances bring the mandible and tongue forward, opens up the lower pharynx and allows continuous breathing during sleep.[36,37] When used in appropriately selected patients, this form of therapy is reported to be completely effective in 36%-70% of OSA cases. The ideal properties of removable appliances include low bulk, simple to apply, lip seal maintenance, proper tongue space, non interfering with sleep, lateral freedom and low cost. The patient selection criteria for these appliances need to have certain features for the appliance to exhibit the best possible results. These features include reduced lower anterior facial proportions, proportionate maxilla & mandible, high position of hyoid, normal soft palate area & tongue proportion, and relatively normal post lingual & post palatal airway.[38]

Oral appliances include -

Mandibular advancement devices (MADs) and tongue-retaining devices (TRD).

Some examples of mandibular repositioning or advancement devices (Figure 6) are Herbst appliance, snoregard and tongue repositioning devices (Figure 7) like snorex, soft palate lifters, tongue trainers.

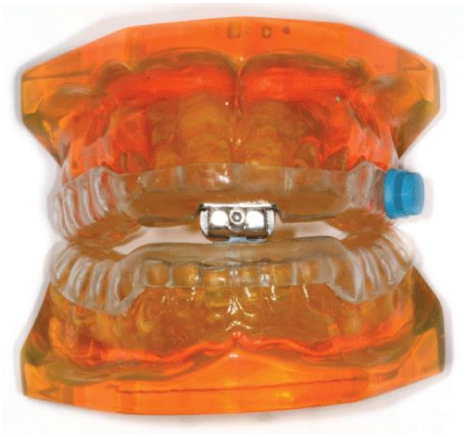

Figure 6: Mandibular advancement device.

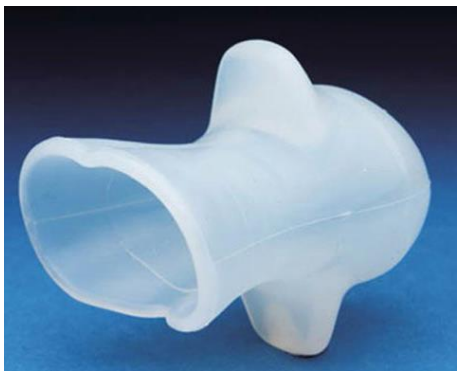

Figure 7: Tongue retaining device

Of the above two, MADs are most commonly used and evaluated in the literature. Orthodontists design the most appropriate MADs for each patient, depending on dental history and complete examination of the stomatognathic system i.e. dental occlusion, soft tissues, masticatory muscles and the temporomandibular joint. The device covers upper and lower teeth and hold the mandible in an advanced position with respect to the resting position. It is constructed, adjusted, and gradually advanced forward over several weeks until the daytime sleepiness & snoring are reduced to an acceptable level, or till the patient cannot tolerate further advancement. They are worn during sleep and they act by moving the mandible & tongue anteriorly and then the activation of airway dilator muscles to result in enlargement of obstructed upper airway. Cephalometric analysis is used to evaluate craniofacial changes induced by OA. Significant modifications were reported: Retroclination of the maxillary incisors, proclination of the mandibular incisors, increased lower facial height, and changes in molar relationship. In addition, some cephalometric predictors like longer

maxilla, shorter soft palate and decreased distance between mandibular plane & hyoid bone have been related to successful mandibular appliance treatment of OSA.[29]

Advantages of Oral appliances are

• Significant reduction in breathing pauses

• Improvement of airflow for some patient with apnea

• Reduction in the snoring and

• High compliance level as compared to CPAP

Disadvantages of oral appliance :

Dry mouth due to reciprocal forces generated on the teeth and jaw, gum soreness, excessive salivation, tooth griding, myofascial pain, jaw discomfort & headaches.[39,40] However, they are frequently reported as mild, acceptable, and transient. OA related malocclusion is seen when OSA patients being treated with the use of OAs by nonorthodontists. To avoid this, orthodontists can be helpful in providing our medical & dental colleagues valued oversight, and sometimes treatment, of unexpected and unwanted occlusal changes occurring with long-term OA use.

Orthodontists can also have a role in the treatment of OSA consequences especially those with nocturnal bruxism, which differs from stress-related bruxism. Sleep bruxism has been shown to be prevalent in children, and correlated with sleep disturbances (microarousals). It is characterized by rhythmic masticatory muscle activity and may be related to the patients' attempt to improve airway patency during episodes of oxygen desaturation via co-activation of jaw opening and closing muscles. Its management requires use of night splints and restorative dentistry.

For Pediatric OSA:

In the growing child, management of OSA is dramatically different than for the adult. It is recommended that orthodontists should be aware of the vast array of potential treatment modalities available and that they work in unison with other medical and dental practitioners whenever essential. The plan for treating pediatric OSA should be based on consideration of the patient's individual needs and treatment goals. The orthodontic treatment plan for pediatric patients with OSA should follow the same orthodontic principles for correction of dental and skeletal deformities. Two orthodontic procedures for pediatric OSA that may change upper airway physiology are –

Rapid maxillary expansion (RME) and

Mandibular advancement appliances for Class II correction.

With both types of interventions, the primary objective of the orthodontic appliance should be to improve the occlusion and address the underlying skeletal discrepancy. It would be appropriate, for example, to recommend rapid maxillary expansion (RME) for patients diagnosed with maxillary transverse deficiency. In this situation, the primary treatment goals would be to normalize the transverse width of the maxilla and establish a normal occlusion. Secondary effects of this treatment may result in reduction of nasal airway resistance and increase in the volume of the nasopharynx and nasal cavity. Both secondary effects of RME have the potential to improve OSA. Though low level, there is growing evidence, that in mixed-dentition patients who are properly diagnosed with OSA, RME can decrease AHI in the short and long terms.[41] In patients of mandibular advancement devices for mandibular retrognathia, the primary goals should be to correct the skeletal discrepancy and the Class II molar relationship. A secondary effect of mandibular advancement devices may be the increase in the caliber of the oropharyngeal airway. The same principle applies to maxillary advancement appliances used in the treatment of Class III malocclusions.

Continuous Positive Airway Pressure (CPAP) –

It is considered as ideal treatment option in tolerated patients of moderate to severe grade. CPAP is a continuous positive airway pressure machine with a mask that fits snugly over the nose of patient. It transmits a continuous flow of air & keeps the throat open throughout the night. It delivers compressed air into the airway to keep it open during sleep, by positive pressure across the airway walls and pneumatic splinting effect. CPAP can be applied through oral, nasal or oro-nasal interface; and the optimal level of positive airway

pressure is determined by full-night, attended in-laboratory PSG. Successful therapy with CPAP depends greatly on individual patient acceptance and compliance Thus, CPAP prescription should include explanation of benefits and medical reasons for its use. Key benefits of CPAP in OSA patients are, it improves quality of sleep, relieves daytime sleepiness, reduces the risk of heart diseases and improves the overall quality of life. Compared to old ones, newer CPAP devices are quite small, light and available with different mask sizes to achieve a good fit for all patients.[42,43] Patients should also be informed about the function and maintenance of equipment. Problems with CPAP includes functioning noise, discomfort, feelings of claustrophobia, and skin irritation. However, CPAP remains at present the preferred treatment for OSA, as it could effectively reduce AHI and arousal index scores, and increase the minimum oxygen saturation.

Surgical treatments for OSA:

Surgery is considered when noninvasive therapy such as CPAP and oral appliances has been not successful. It is done in a situation when there is any deformity in anatomic structure that can be later on corrected to eliminate the breathing problems. It addresses the problem by reduction of tissue from the soft palate, uvula, tonsils, adenoids or tongue.[44]

Many different surgical approaches have been used in the treatment of OSAHS as follows

Tracheostomy
Nasal surgery (turbinate reduction, deviated septum correction, functional rhinoplasty, nasal valve surgery & nasal polypectomy)
Adenoidectomy
Tonsillectomy
Tongue reduction/ partial glossectomy
Uvulopalatopharyngoplasty (UPPP)
Palatal advancement pharyngoplasty
Maxillo- mandibular advancement (MMA)
Genioglossus advancement (GGA)
Bariatric Surgery (Weight reduction surgery)

Of the above, most widely performed procedure is the uvulopalatopharyngoplasty with a success rate in a period of 6 months to be 80% patients.[45]

CONCLUSION

OSA is a common breathing disorder with serious public health problem, affecting all age groups. Adverse consequences of OSA have alteration in quality of life, decreased economic potential and increased morbidity and mortality in affected patients. Though not primary treating specialists, orthodontists play a vital role in both screening and treatment of OSA. Identifying at risk patients for OSA, referring them to physician for final diagnosis and planning as well as executing treatment of OSA are some of the important functions of orthodontist. Mandibular advancement appliances are effective in changing the three-dimensional size of airway tube. Oral appliances have an effect on the tongue muscles by advancing the mandible, holding the tongue forward, or changing its vertical position, thus affecting the baseline tongue activity. Performing coordinated assessment and good communication with attending physician, a significant number of patients with snoring or mild-to-moderate OSA can be treated successfully with oral appliances given by orthodonitist. As the bi-directional cause and effect relationship between OSA and craniofacial abnormalities remains to be proven, early identification and treatment of dentofacial disorders by orthodontist may enhance OSA management with respect to preventive and curative approaches.

CONFLICTS OF INTEREST

The authors declare they have no potential conflict of interests regarding this article.

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