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ORAL APPLIANCES USED FOR OBSTRUCTIVE SLEEP APNEA: A review

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Abstract

Obstructive sleep apnea is a sleep disorder in which a person stops breathing periodically throughout the night due to physical obstructions of the airway with a predilection among middle aged males. Oral appliances are devices that can be used to treat mild or moderate obstructive sleep apnea, as well as snoring. The treatment of OSA depends on the severity of symptoms, magnitude of clinical complications, and etiology of upper airway obstruction. It can be treated by lifestyle modifications, CPAP - continuous positive airway pressure, surgery or oral appliances. Oral appliances which are of recent development, work by positioning the mandible in a protruded position during sleep. Oral appliances are of several types: Mandibular Advancement Splints (MAS), Mandibular Advancement Devices (MAD), Mandibular Repositioning Appliances (MRA), or Tongue Retaining Devices (TRD) which hold your tongue in place to keep your airway open while asleep and Adjustable Soft palate lifters. The comparison between oral appliances of different designs and the literature of sleep apnea provides better evidence for the efficacy of this treatment modality and thus more scope for its development. The aim of this article is to review literature regarding the various types of oral appliances in the treatment of sleep apnea syndrome, their mechanism of action, factors affecting their performance, complications and patient compliance.

Keywords: Obstructive sleep apnea, Oral appliances, dental practitioners, mandibular advancement appliances

1. Introduction

Obstructive sleep apnea (OSA) is a prevalent disorder, particularly among the middle-aged (Young et al., 1993). It is marked by recurring or complete occlusion of the upper airway during sleep, resulting in oxyhemoglobin desaturation and arousal (Gotsopoulos et al., 2002). There is now a considerable body of literature documenting the pathophysiology and consequences of

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more severe OSA; however, the morbidity, benefits of treatment, and optimal mode of management of mild to moderate OSA remain a clinical dilemma (Barnes et al., 2004). It is a common disorder that may affect at least 2 to 4% of the adult population (Pandi-Perumal et al., 2017). The treatment of OSA depends on the severity of symptoms, magnitude of clinical complications, and etiology of upper airway obstruction (Ferguson et al., 1996). Treatment of sleep-disordered breathing (i.e. snoring, upper airway resistance syndrome, sleep apnea syndrome) can be divided into four general categories. These include: (1) oral appliances, (2) Continuous positive airway pressure (CPAP), (3) lifestyle modification, i.e. weight loss, cessation of evening alcohol ingestion, sleep position training, and (4) upper airway surgery. Although the former category provides the most reliable therapeutic modality and is the most widely used method to treat sleep disordered breathing today—it is also the most cumbersome one. Young patients, particularly non-apneic snorers, find it intolerable and unappealing. The only other non-invasive substitute, which can produce positive results within a short time, is oral appliances (Hoffstein, 2007).

Oral appliances which are of recent development, work by positioning the mandible in a protruded position during sleep (Barnes et al., 2004). The mode of action is unclear but is probably multifactorial, involving both a structural change with enhancement of the caliber of the airway and triggering of stretch receptors, which activate the airway support muscles (Ng et al., 2003). Unarguably, the knowledge about oral appliances among general physicians and dentists varies geographically. This difference in practice and knowledge is higher in large urban centers, which provide more educational opportunities locally (Hoffstein, 2007).

Previously our department has published extensive research on prosthetic dentistry (Ajay et al., 2017; Ashok & Suvitha, 2016; Duraisamy et al., 2019; Ganapathy et al., 2016; Jain et al., 2018; Jyothi et al., 2017; Kannan & Others, 2017; Ranganathan et al., 2017; Venugopalan et al., 2014), on effect of various drugs (Selvan & Ganapathy, 2016; Subasree et al., 2016), oral hygiene status of women (Basha et al., 2018), on the effect of impregnated gingival retraction cords (Kannan & Venugopalan, 2018), on the medical management of cellulitis (Vijayalakshmi & Ganapathy, 2016), this vast research experience has inspired us to study this topic. This review will summarize our current state of knowledge of the efficacy of oral appliances for the treatment of snoring and obstructive sleep apnea and additionally examine the side-effects and patient compliance.

2. History

Dentistry was pivotal in the earliest elucidation of sleep apnea. In 1932 the well-known French dental surgeon, Pierre Robin, described a breathing impairment during sleep caused by pharyngeal obstruction in children with micrognathia and glossoptosis (P. Robin, 1923). He initially described a device called the “monoblock”, for the treatment of glossoptosis. More than 30 years later, he used an oral appliance to reposition the mandible (Pierre Robin, 1934). The need for convenient methods of treating sleep apnea has stimulated advances in dental sleep science. The rather barbaric features of standard medical therapy, continuous positive airway pressure (CPAP), spurred dentists to invent dental appliances that might relieve pharyngeal obstruction during sleep by protruding the mandible (Dentists &

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Apnea, 2014). However, in 1903, micrognathic infants benefitted when the tongue was sutured forward to the lower lip and helmets and chin straps were used to reposition the mandible forward by the year 1930. For the next 50 years, little work was done in this field. Another five decades was required to start using oral appliances for the treatment of snoring and sleep apnea when Cartwright and Samelson (Cartwright & Samelson, 1982) described the tongue retaining device in 1982.

3. Types of Appliances

Since their introduction in the 1980s, a variety of dental devices has been developed for the management of obstructive sleep apnea and simple snoring. These intraoral devices, commonly known as oral appliances, aim at relieving upper-airway obstruction and preventing snoring by modifying the position of the mandible, tongue, and other (oro-)pharyngeal structures. Based on the mode of action, oral appliances may be roughly divided into tongue-retaining appliances, mandibular repositioning appliances and soft palate lifters. However, soft palate lifters are currently no longer used and mandibular repositioning or advancement devices are the most commonly used. (Hoffstein, 2007) Tongue-retaining appliances reposition the tongue in a forward position by securing it with negative pressure in a soft plastic bulb or with a plastic depressor that comes into direct contact with the base of the tongue (Hoekema et al., 2004). Tongue retaining devices (TRDs) affect genioglossus muscle activity in patients with OSA (awake or asleep). A TRD worn during sleep with the tongue in the bulb decreased genioglossus EMG activity (Ono, Lowe, Ferguson, & Fleetham, 1996; Ono, Lowe, Ferguson, Pae, et al., 1996). Mandibular advancement appliances work by protruding the mandible forward and thus preventing or decreasing the chance of upper airway collapse during sleeping. Protrusion distance may vary depending on the patient and the appliances are of two types, fixed and variable wherein the protrusion cannot be changed in the former and can be modified in the latter. The final protrusion distance is an essential factor as it decides if it is causing a good effect or a side effect. For this very reason, it is crucial for the oral appliances to be constructed and fitted by a dentist with adequate practical knowledge in this area and has access to a sleep laboratory where the objective efficacy can be verified. (Hoffstein, 2007) Mandibular advancement appliances can be further divided into nocturnal airway patency appliance (NAPA), sleep and nocturnal obstructive apnea reducer (SNOAR), snore guard, Jasper Jumper, twin block, forsus, power-scope etc whereas tongue repositioners can be majorly of two types mainly, tongue retainers and tongue posture trainers. Other devices such as the equaliser and magnetic appliances have come into existence in recent years. (Mageet, 2018)

The NAPA is a modified activator that forwards the position of the mandible 6mm anteriorly and 9 mm inferiorly (Soll & George, 1985). The appliance is made up of 8 Adams clasp with overlapping acrylic on the facial and lingual surfaces of teeth. It is designed to protrude the mandible about three fourths of the distance between centric occlusion and maximum protrusion. The lower jaw is stretched vertically just enough to permit an opening between the incisors. The NAPA rigidly stabilizes the lower jaw in both the horizontal and vertical directions. The effects of the NAPA in reducing the Apnea-Hypopnea Index (AHI) documented in subsequent studies (George, 1987, 1989). The SNOAR is an open airway appliance made up of acrylic which opens the mandible

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17mm or more in the vertical direction and protrudes it 6 to 9 mm and the mean AHI was seen to be reduced from 45.5 to 9.7 and excellent results were obtained post using this appliance. Snoring was absent after the SNOAR appliance was inserted for the patients in study done by Viscomi et al . (Viscomi et al., 1988) A snore guard, on the other hand is a prefabricated appliance which positions the mandible 3mm behind the level of maximum protrusion and with an opening of 7mm. It covers only the anterior teeth and is coated with a soft polyvinyl resin to enhance comfort of the patients and is known to be well tolerated (Bushell et al., 1991; Menn et al., 1996; Schmidt-Nowara, 1988; Schmidt-Nowara et al., 1991) and ceases snoring completely or is decreased significantly and can be used in mild apneic snorers.

Among tongue repositioners, tongue locking devices are a preformed elastic appliance available in small, medium and large sizes that provide a garage-like section for the tongue and hold it in anteriorly with a self-created vacuum during sleep. Lateral breathing holes assist airflow if nasal obstruction occurs. The tongue locking device is easy to fit directly on patients and is inexpensive. Other tongue posture trainers like Tepper oral proprioceptive simulator (TOPS) and Tongue positioner and exerciser (TPE) have also come into use.

4. Mechanism of action of oral appliances used in obstructive sleep apnea

Mandibular advancement appliances (MAA), like CPAP are non invasive and are therefore a reversible form of treatment, and worn only during sleep. The theory for the use of MAAs is that there is a chance of it increasing the size of the pharyngeal airway by tugging the tongue and soft palate forwards and thus maintaining its patency during sleep. The mechanism by which these appliances work appears simple. The MAAs prevent the tongue collapsing against the posterior pharyngeal wall nocturnally, by mechanical means in that the origin and insertion of genioglossus are at the hyoid bone and mandibular symphyseal region respectively. Thus, by advancing the mandible, the tongue is held in a more anterior position during the night while sleeping, hence increasing the airway space. A second consideration found that, in man, the voluntary passive opening of the mandible produces definite enhancement of genioglossus EMG through activation of receptors located in the temporomandibular joint (LOWE & A, 1994). This is due to the fact that the contraction of the genioglossus opens the airway, thus preventing airway obstruction. The increased vertical dimension achieved with these appliances acts to improve tonicity of the tongue, thereby reducing the risk of airway occlusion (Lowe, 1990). It has various design variations and can be fabricated of transparent acrylic resin or together with retentive Adams' clasps.

The guideline to be followed for the optimal amount of mandibular protrusion is said to be in the range of 50% and 75% of the patients' maximum protrusive distance. This forward position is maintained by the use of one-piece or fixed appliance that holds the maxilla and mandible together. The protrusion requires some concomitant opening, and it is essential that devices do not rotate the lower jaw downwards and back (LOWE & A, 1994). An essential feature of this appliance is that anterior air holes are necessary to allow oral respiration, especially for those with restricted nasal airflow. The most commonly used designs among dentists are the nocturnal

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airway patency appliance and the sleep nocturnal obstructive apnea reducer.

Tongue repositioners work by securing the tongue through negative pressure in a soft plastic bulb (a flange) which fits between the lips and teeth and holds the device and the tongue in an anterior position. This appliance also modifies mandibular pressure at least by forwarding rotation. The tongue retaining device (TRD) fabricated from dental impressions, but a prefabricated version suitable for molding to the patient's teeth in the clinic is now available; it is also used for edentulous patients. For those patients with blocked nasal passages, a modified TRD with lateral airway tubes is also available. The benefit of the TRD is that the tongue is not always held forward because surface adhesion of the tongue in the bubble is lost after time, and the patient must then awaken and relocate the tongue into the balloon. An aesthetic drawback is that the tongue must slightly protrude between the teeth. The TRD is the only appliance that studied in various body positions and in conjunction with other forms of therapy (Cartwright, 1982). TRDs seem to be helpful usually in combination with other treatments for improving the condition in patients with severe obstructive sleep apnea provided the patient's body weight is not greater than 50% of the ideal BMI (LOWE & A, 1994).

Tepper oral proprioceptive simulator (TOPS) is an oral device which stays fixed to the maxillary arch with a posterior tongue extension held inferiorly with an elastic band. A padded forward bar lingual to the incisors is included to direct correct tongue position. It is stated to be used for patients who snore, function and for those who have loss of muscle tonus of the soft palate and pharynx have apnoea or have problems with abnormal tongue posture. All these abnormalities corrected by proprioceptive means the receptors stimulated by the hinged portion of the device sitting on the dorsum of the tongue. By increasing the resistive power of the elastics, we can strengthen the dorsal muscles of the tongue. Thus by correct repositioning of the tongue to the hard and soft palate; it can increase the airway volume. Information on its effectiveness for the treatment of obstructive sleep apnea is not yet available (Tepper, n.d.)

The adjustable soft palate lifter device is designed to raise the soft palate gently and prevent it from vibrating in the airway during sleep. It consists of a removable maxillary device with two Adams clasps on the molars and an acrylic button that extends distally to the midpoint of the soft palate. Patients who gag are 'desensitized' with palatal exercises that consist of contact with the end of a spoon or toothbrush 5 or 6 times a day. Paskow claimed a 60% success rate for snoring but felt the appliance is not is not indicated for the treatment of obstructive sleep apnea (M. Marklund & Franklin, 1996; Paskow & Paskow, 1991).

The equaliser appliance is made up of vinyl material and is constructed with the mandible in a position of neuromuscular balance as determined by a myo-monitor, a transcutaneous electroneutral stimulator (Haze, 1987). The magnetic appliance has been recently developed which is fabricated for the treatment of snoring patients with or without obstructive sleep apnoea (Bernhold & Bondemark, 1998). A magnetic device may be more effective than the conventional 'passive' functional appliance because the magnet forces prevent the closing by providing direct and continuous mandibular advancement. More studies are required on the usage of magnetic appliances to form a solid opinion. (Mageet, 2018)

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5. Variables Affecting Oral Appliances' Efficacy

There are collectively four variables or factors which play an important role in deciding the efficacy of the oral appliances used in the treatment of the obstructive sleep apnea; the severity of the sleep apnea, the amount of mandibular protrusion by the appliance, the presence of positional sleep apnea (higher AHI in the supine than in the lateral sleep position), and the body mass index (BMI).

5.1 Severity of obstructive sleep apnea:

It is obvious that the treatment of OSA depends on the severity and differs among patients. Several studies have been done on the usage of oral appliances to treat OSA (Liu & Lowe, 2000; Lowe et al., 2000; M. Marklund, Persson, et al., 1998; Menn et al., 1996; Neill et al., 2002; O'Sullivan et al., 1995; Pancer et al., 1999; Randerath et al., 2002; Rose, Staats, Schulte-Mönting, et al., 2002)

Majority of the studies reported a low success rate in the treatment of OSA, which is decided by estimating AHI. The success rates in mild to moderate OSA ranged from 57% to 81% whereas in severe cases, the success rate reduced to a mere 14%. There cannot be a proper comparison as the patients co-morbidities and design of appliances vary. Different inclusion criteria and different treatment protocols may have affected the success rates in different studies using the same device. Overall, better success rates were seen in patients with lower AHI (Ferguson et al., 2006).

5.2 Positionality of Sleep Disordered Breathing

Based on several studies (Fransson et al., 2003; M. Marklund, Persson, et al., 1998; Marie Marklund et al., 2004; Neill et al., 2002; Yoshida, 2000) evaluating the severity of OSA, the rate of respiratory events varied in different sleep positions. Out of these, the majority of the studies stated a greater likelihood of success with oral appliances when the patient reported with a supine dependent OSA rather than a lateral position.

5.3 Effect of Body Mass Index

A higher body mass index (BMI) is usually associated with lower efficacy and success rate of oral appliances as stated by several studies (Liu & Lowe, 2000; Rose, Staats, Schulte-Mönting, et al., 2002; M.-L. Walker-Engström et al., 2003). Similarly, weight gain during the treatment course was associated with adverse efficacy of oral appliances (Marie Marklund et al., 2004)

5.4 Degree of mandibular protrusion

Among the different types of mandibular advancement appliances, the extent of mandibular protrusion varies. The degree of protrusion of the mandible varied from 6 to 10 mm. or from 50 to 75% of the maximum the patient could protrude the mandible on request. More the extent of protrusion, greater the reduction of AHI (Esaki et al., 1997; M. Marklund, Franklin, et al., 1998; Rose, Staats, Virchow, et al., 2002; M.-L. Walker-Engström et al., 2003). Some studies assessed the amount of vertical opening of the OA and its impact on efficacy or side effects. The appliance with the greater opening was slightly more effective at lowering the AHI (Bondemark, 1999; Pantin et al., 1999; Pitsis et al., 2002; Rose, Staats, Virchow, et al., 2002). The effect of the amount of vertical opening on efficacy and complications is unclear and further investigations are required.

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6. Side Effects And Complications Of Oral Appliances

The disadvantages of using oral appliances can appear spontaneously or have a later effect. Excessive salivation and temporary discomfort in the muscles of mastication for a brief time after awakening are commonly reported with initial use and may prevent early acceptance of oral appliances (O'Sullivan et al., 1995; Schmidt-Nowara et al., 1991), but with regular use and adjustment of fit, these symptoms subside. A reported study found that hypersalivation and teeth/ gum discomfort are the early side effects but usually decline if patients can persevere with the oral appliances (Pantin et al., 1999). Delayed effects include occlusal changes , temporomandibular joint dysfunction, headache, tongue or jaw discomfort which are relatively uncommon and do not cause the patients to stop using the appliances (Hoffstein, 2007).

7. Compliance

Compliance with oral appliances depends strictly on the balance between the perception of benefit and side effects. Most patients treated with oral appliances have relatively mild sleep apnea and relatively few daytime symptoms; the main reason for treatment was snoring. Consequently, the perception of benefit is generally that of the bed partner, whereas the side effects are experienced by the wearer of the appliance. This is why the assessment of compliance is a complex issue. In some cases, although the appliance is quite comfortable, the patient may stop wearing it if the bed partner is no longer present or no longer complains of snoring. Based on several studies (Almeida et al., 2006; Clark et al., 1993; Eveloff et al., 1994; Menn et al., 1996; Nakazawa et al., 1992; Pantin et al., 1999; Schmidt-Nowara et al., 1991; Shadaba et al., 2000; M. L. Walker-Engström et al., 2000; Yoshida, 2000) the percentage of compliance among patients using oral appliances ranged from 56–68%.

8. Conclusion

The evidence available at present indicates that oral appliances successfully "cure" mild-to-moderate sleep apnea in 40–50% of patients, and significantly improve it in additional 10–20%. They reduce, but do not eliminate snoring. Side effects are common, but are relatively minor. Provided that the appliances are constructed by qualified dentists, 50–70% of patients continue to use them for several years. Their effectiveness is inferior to CPAP. It is similar to surgical procedures, but these are invasive, (although not particularly dangerous) and irreversible. Among the various types of appliances with different mechanisms, the mandibular advancement appliances are the best and most comfortable device used for the treatment of mild to moderate cases of OSA. Their use in the severe cases will minimize the risk of complication till further surgical procedure is carried out and does not prevent the use of CPAP. The decision regarding treatment in each individual patient is best made by medical practitioners with experience in sleep medicine who are aware of all options, and who are preferably a part of a specialized sleep disorders center. The area of the knowledge and practice of oral appliances was not explored in extent and a similar pattern was observed in various papers. There is an increasing need for dentists to know their role when it comes to obstructive sleep apnea.

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10. Conflict of interest

The authors declare that there is no conflict of interests regarding the publication of this paper.

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