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Review Article

Intraoral Appliances for the Treatment of Obstructive Sleep Apnoea Hypopnoea Syndrome

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Received: October 23, 2018; **Published:** November 26, 2018

Abstract

Obstructive (Peripheral) Sleep Apnoea Hypopnoea Syndrome (OSAHS) is an increasing breathing problem, caused by the repetition of upper airway narrowing during sleep due to anatomical or pathophysiological effects. There are different treatment modalities available for curing or minimizing the problems associated with this condition, both surgical and non-surgical techniques. This article intends to facilitate and improve the understanding of the use of intra-oral appliances in the treatment of OSAHS. The article groups all intra-oral devices and put them into an easily accessible format for the reader.

Keywords: *Sleep apnoea; Intra-oral appliances; Snoring, Hypersomnolence*

Introduction

The management of OSAHS depends on the severity of symptoms, the magnitude of clinical complications and the etiology of the upper airway obstruction. The treatment of OSAHS is divided into non-surgical and surgical procedures. The non-surgical methods include the elimination of aggravating factors; weight reduction; training; pharmacological therapy; electrical stimulation of the upper airway; ENT assessment plus any necessary treatment; CPAP- the Gold standard; intra-oral appliances and nasal-valve dilator. The surgical procedures involve tracheostomy; nasal surgery; pharyngeal surgery (Uvulo-palato-pharyngoplasty UPPP); maxillofacial surgery; tonsillectomy and adenoidectomy; tongue reduction and bariatric surgery.

Intra-oral appliances are one of the non-invasive procedure for the treatment of OSAHS. Since the description of the monobloc appliance by Pierre Robin in 1902 for the treatment of glossoptosis (tongue falling back and closing the airway) in infants, many tools have appeared for the treatment of upper airway obstruction. The term 'oral appliance' is used as a generic term for devices fitted in the oral cavity to modify the position of the mandible, the tongue and other structures in the upper airway for the purpose snoring or sleep apnoea.

This aim of this review is to facilitate and improve the understanding of the non-invasive intra-oral appliances for the treatment of OSAHS.

Five basic groups of dental devices used for the treatment of OSAHS are given in table 1.

Mandibular advancement appliances	Nocturnal airway patency appliance (NAPA)
	Sleep and nocturnal obstructive apnoea reducer (SNOAR)
	Snore guard
	Jasper Jumper, twin block, Forsus, Power-scope... etc.
Tongue repositioners	Tongue retainers Tongue retaining device (TRD). Tongue locking device (TLD).
	Tongue posture trainers Tepper oral proprioceptive stimulator (TOPS). Tongue positioner and exerciser (TPE).
Soft palate lifters	
The equalizer	
Magnetic appliances	

Table 1: *Intra-oral appliances for the treatment of OSAHS.*

Mandibular Advancement Appliances (MAAs): MAAs are non-invasive like CPAP and therefore a reversible form of treatment, and worn only during sleep. The rationale for the use of MAAs is that they may increase the size of the pharyngeal airway by pulling the tongue and soft palate forwards and thus maintain its patency during sleep.

A selected twenty-two patients with confirmed diagnosis of obstructive sleep apnoea based on initial nocturnal polysomnography [1]. A mandibular repositioner designed for all patients to hold the mandible antero-inferiorly. Six months later, a polysomnographic outcome study recorded for each patient with the appliance in place. Lateral cephalometric radiographs in the upright position obtained before and after six months of treatment. The apnoea-hypopnoea index (AHI) decreased in 21 patients with the appliance in place. The mean respiratory disturbance index (RDI) of the 22 patients dropped significantly from 40.3 to 11.7 events per hour ($P < .01$). Some 59.1% of subjects were considered a treatment success with follow-up RDI < 10 times per hour. The mean blood oxygen saturation level during sleep also improved significantly from 73.4% to 81.3% with a p-value < 0.01 [1].

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 nocturnally, 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 [2]. Because the contraction of the genioglossus opens the airway, so airway obstruction is prevented. The increased vertical dimension achieved with these appliances acts to improve tonicity of the tongue, thereby reducing the risk of airway occlusion [3].

The MAA has many different design variations. It is fabricated of transparent acrylic resin, together with retentive Adams' clasps.

The guideline for the optimal amount of forwarding movement is between 50% and 75% of the patient's maximum protrusive distance. This forward position 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 [2]. An essential feature of this appliance is that anterior air holes are necessary to allow oral respiration, especially for those with restricted nasal airflow (Figure 1).

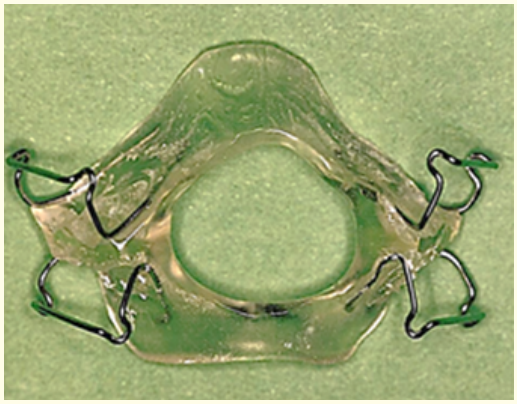

Figure 1: *Mandibular advancement appliance (MAA).*

Commonly used designs include the cribbed activator [4], vacuum-formed devices, the Nocturnal Airway Patency Appliance [5] and the Sleep Nocturnal Obstructive Apnoea Reducer [6].

Nocturnal airway patency appliance (NAPA): NAPA described as a modified activator that forwarded the lower jaw 6 mm anteriorly and 9 mm inferiorly for one patient and significantly reduced the AHI [5]. The device has 8 Adams clasps with overlapping acrylic on the facial and lingual surfaces of the teeth. It is designed to protrude the mandible about ¾ 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 AHI documented in subsequent studies [7,8].

Sleep and nocturnal obstructive apnoea reducer (SNOAR): SNOAR is an open airway appliance is an acrylic mandibular advancement appliance the mandible 6 to 9 mm and opens it vertically 17 mm or more. The mean AHI reduced from 45.5 to 9.7 and snoring was absent after the SNOAR appliance was inserted [6].

Snore guard (Dental orthosis): Snore guard is a prefabricated appliance position the mandible 3 mm behind the maximum protrusion with 7mm opening. It covers only the anterior teeth and coated with a soft polyvinyl resin for the comfort of the patients. It is easy to place and adjust directly to the patient and appears well tolerated.

In two initial studies, snoring was decreased significantly or eliminated [9,10]. More recent reports found a significant decrease in AHI, particularly among mild apnoeic patients [11,12].

For patients with active bruxism and those who feel restricted by the rigid fixation of their jaws with the one-piece design, an alternative, more ideal, design involves constructing separate maxillary and mandibular appliances. Connecting the upper and lower devices is accomplished with inter-arch elastics and buccal tube and rod attachments (e.g. Herbst appliance, Jasper Jumper, Forsus and Powerscope), or a single hook latch in the anterior area (e.g. Thorton Adjustable Positioner). The objective of this design is to restrict all retrusive movements while still allowing the patient to move the mandible forward and side to side, as well to open the mouth if necessary.

An additional advantage of the two-pieces appliances is the ability to systematically pinpoint the exact mandibular position that benefits each patient the most. It is possible to start at 50% of maximum protrusion at the first appointment and then gradually advance the mandible unit all signs and symptoms disappear entirely. On the other hand, these devices, because of their construction, may be complicated for the patient to manage.

The Herbst Mandibular Advancement Splint is a logical option in selected subjects with sleep-related breathing disorders [13].

Jasper Jumper and Twin Block: Only one preliminary evaluation of this appliance for the treatment of OSAHS has completed [14], where eleven patients with varying degrees of OSAHS identified. Seven of the 11 patients tested before and after appliance, insertion had reduced AHI values, but there were no significant differences. Even after the use of vertical elastics, only half of the subjects tested showed a reduced AHI. This appliance tolerated efficiently than the more rigid mandibular advancement appliances, but additional studies with different vertical and anteroposterior positions of the lower jaw are required to verify its effectiveness.

Tongue Repositioners: Tongue Repositioners subclassified into tongue retainers and tongue posture trainers. Tongue retainers are subclassified into a tongue retaining device (TRD) and Tongue locking device (TLD). The TRD is designed to reposition the tongue forward during sleep; thereby reducing the risk of obstruction at this level [15].

The device secures the tongue through negative pressure in a soft plastic bulb; a flange, which fits between the lips and teeth, holds the device and tongue anteriorly in the oral cavity. This appliance also modifies mandibular pressure at least by forwarding rotation. The 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 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 conjunction with other forms of therapy [15]. The TRD appears benefitable, either alone or in combination with other treatments, for improving patients with a severe apnoea, provided that the apnoea is more severe in the supine position and the patient's weight is not greater than 50% of the ideal [2].

Comparing to the most commonly performed CPAP, the TRD is more easily tolerated and has fewer long-term compliance problems.

Tongue locking device (TLD): TLD is a simple preformed elastic appliance available in small, medium and large sizes that provide a garage for the tongue and holds it anteriorly with a self-created vacuum during sleep. Lateral breathing holes assist airflow if nasal obstruction occurs. The TLD is easy to fit directly on patients and is inexpensive.

An earlier study of 10 OSAHS subjects and found that five individuals had a reduction in AHI and five patients became worse [16].

Tongue posture trainers subclassified into Tepper oral proprioceptive simulator (TOPS) and Tongue positioner and exerciser (TPE).

Tepper oral proprioceptive simulator (TOPS): TOPS is an appliance which adheres 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. According to Dr. Tepper: its prime use is for those patients who snore, have apnoea, have problems of abnormal tongue posture or function and for those who have loss of muscle tonus of the soft palate and pharynx. All these abnormalities corrected by proprioceptive means wherein 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 OSAHS is not yet available [17].

Tongue positioner and exerciser (TPE): TPE is a custom-made appliance that has been used to treat snoring [18]. Patients have accustomed to position the tongue above the ramp; according to the inventor, this 'retrains the muscles of the tongue and lip to be in the ideal rest position and saliva swallowing pattern'.

Adjustable soft palate lifter (ASPL): The adjustable soft palate lifter (ASPL) device is designed to raise the soft palate gently and prevent it from vibrating in the airway during sleep. The ASPL 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 OSAHS [19]. However, another researcher found that the soft palate lifters were insufficient for the treatment of snoring [20].

Haze in 1987 introduces the equalizer appliance which is constructed of vinyl material with the mandible in a position of "neuromuscular balance" as determined by a myo-monitor, a transcutaneous electroneutral stimulator [21].

The magnetic appliance is recently developed which is fabricated for the treatment of snoring patients with or without obstructive sleep apnoea [22]. 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. Long-term evaluation of the treatment result needed before routine use of the magnetic device in apnoeic patients.

The Scottish Intercollegiate Guidelines Network (SIGN) report (2003) on OSAHS which is also endorsed by the British Thoracic Society concluded that: intra-oral devices are an appropriate therapy for snorers and patients with mild OSAHS with normal daytime alertness; are a suitable alternative therapy for patients who are unable to tolerate CPAP; the use of intra-oral devices monitored following initiation of treatment to allow device adjustment and assessment of OSAHS control and symptoms [23].

The advantages of oral appliance therapy are simplicity, reversibility, and cost-effectiveness. It may also become the primary treatment in patients who cannot tolerate nCPAP or who are poor surgical risks due to other medical complications. Most patients accept it readily, and it can even supplement other procedures in the small percentage of cases in which the dental devices alone do not bring sufficient relief of symptoms.

Disadvantages of Oral Appliances could be of immediate or 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 [10,24], 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 Intra-Oral Devices (IODs) use [25].

Later complications might include TMJ discomfort and changes in occlusion and have been reported as reasons for discontinuing treatment [26]. To eliminate all these problems the design should use full-arch occlusal coverage to tie all the teeth firmly together [24]. It means that the appliance will no longer fit if any individual tooth moves.

However, TMJ dysfunction and occlusal changes are relatively uncommon occurrences, but the long-term risk of these complications is not well defined [26].

There was one report of TMJ problems after 15 months wear, which settled after adjustment of the splint [27].

Reported success rates of the efficacy of intraoral Appliances vary, as do the authors' criteria for its achievement. If a reduction in the number of apnoeic events of 50% or higher is adequate, then success rates are as high as 87% [28]. The most comprehensive review of 20 publications, reporting the effects of oral appliances on OSAHS has shown an improvement in average AHI with a dental device. Success equated with fewer than ten apnoeic events per hour. The statistic showed a decrease in AHI to be significant ($P < 0.05$), and the mean AHIs before (42.6) and with treatment (18.8), an average reduction of 56%. Improvement in oxygen saturation was also noted, and the time of sleep with oxygen saturation <90% reduced from 4.4% to 3.1% [26].

Two recent prospective crossover trials compared MRAs and CPAP in patients with mild to moderate OSAHS. The success rate with the oral device was 55% in both tests, though the improvement in AHI reduction was more significant when the continuous positive airway pressure was used [29,30].

A meta-analysis of patients' treatment preference (CPAP and IODs) in three crossover studies, mild to moderate OSAHS showed a significant patient preference for IODs (OR 9.5, 95% Cl 4 to 21), despite lesser nocturnal efficacy for breathing pauses (-7 per hour, 95% Cl -10 to -5) [31]. The preference not confirmed in a later study [32]. Patients' preference for IODs is essential, but it does not mean that they feel symptomatically better when using IODs or whether they find the concept of an unobstructed intra-oral device preferable to using obstructive CPAP device [23].

One research study has compared the effectiveness of IOD against UPPP in a parallel group, longitudinal follow-up study, with the latest report at four years' post-randomization [33]. In this, 72 of 95 patients with mild to moderate OSAHS have returned for polysomnography, which showed bigger effect size (> 1.0 SDs) significantly favoring IOD over UPPP for improvements in AHI and desaturation index, but no significant differences in snoring duration between treatments. A more recent study found that IOAs reduces the nasal resistance and increase the inspiratory and expiratory total air [34,35]. Research of the immediate effect of the twin block functional appliance (a type of MAA) found the hyoid bone to move superiorly in a sample of adolescents patients with Class II skeletal base [36].

A formal survey of the cost of the devices and services not performed for oral appliances. The production cost of the appliance varies depending on whether a dental laboratory required for custom fitting or prefabricated unit adapted to the clinician's practice. When cephalometric radiographs or other airway studies performed as part of the procedure, the cost increases accordingly. It is unclear whether CPAP or IODs have the higher cost-effectiveness and the answer may vary with OSAHS severity. The primary cost of many IODs is less than the price of a CPAP machine. Some adjustable IODs are more expensive than CPAP, especially when the rate of multiple dental visits to adjust the IOD are included [23].

Data on long-term compliance is limited in number and based on patient reports. The experience with nasal CPAP, however, indicates that self - reports may significantly overestimate objectively determined actual use [37]. The overall compliance rates vary from (50 to 100%) in different studies and may be related to the length of follow-up [26]. The reasons for discontinuing the appliance, include the side effects and complications noted above and lack of efficacy.

Conclusion

Among all IOAs the MRAs are the best and the most comfortable devices used for the treatment of mild to moderate cases and for patients who cannot withstand the CPAP or surgery. 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.

Recommendation

We recommend conducting a systematic review and meta-analysis which would give more evidence-based medicine in the use of IOAs for the treatment of snoring and OSAHS.

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Volume 17 Issue 12 December 2018