

Dental Therapy for Obstructive Sleep Apnea

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ABSTRACT

This article reviews the history of dental therapy as it has led up to currently available options for the treatment of sleep-related breathing disorders with an emphasis on oral appliance therapy. Over the last 20 years and in particular the last 5 to 7 years the contribution as well as the effectiveness of oral appliances has impacted the treatment of sleep apnea and at the same time provides an alternative for many patients. The focus here is to examine oral appliances and the role they have as it may be delivered by the dentist with an interest as well as the expertise in dental sleep medicine.

KEYWORDS: Oral appliance(s), mandibular repositioner(s), tongue retaining device, functional appliance, obstructive sleep apnea syndrome, sleep-related breathing disorder(s)

Objectives: Upon completion of this article, the reader will understand the role of oral appliances as an option in the management of sleep-related breathing disorders by both dentists and physicians who have a special interest in the management of sleep apnea.

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Dental therapy's role in relation to the management of obstructive sleep apnea syndrome (OSAS) has an extended history dating back to a time when appliances were used primarily to enhance craniofacial growth and development and at the same time were found to improve the airway. At the current time dental therapy primarily involves the use of oral appliances (OAs) to reposition the mandible in such a manner that the airway is improved and the potential for collapse during sleep is significantly reduced. More dentists are becoming aware of the prevalence of snoring and sleep apnea and are also becoming involved in the management of sleep-related breathing disorders (SRBDs) by utilizing OAs. In addition, over the last few years the effectiveness of these appliances has improved, making them a reasonable alternative in select circumstances for the management of OSAS.

HISTORY OF ORAL APPLIANCES

The role of the dentist as it relates to repositioning of the mandible to enhance growth in cases of mandibular retrusion (retrognathia) dates back to the late 1800s when Kingsley described a maxillary appliance that was designed to advance the lower jaw. In the early 1900s in France, Robin described an appliance that was called the Monobloc and was used to treat mandibular retrognathia, which in turn had an impact on the patient's airway.¹

Over the next 40 to 50 years a variety of appliances were developed in an effort to effect lower jaw growth. These appliances were referred to mainly as activators because of their effect on the activation of muscle function, which in turn affected growth. In the 1950s an orthodontist in Germany developed the

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Bionator appliance, which was designed to enhance mandibular growth while treating the malocclusion through a variety of functions, such as widening the dental arches, effecting the eruption of teeth, and repositioning or advancement of the mandible to correct the skeletal aspect of the malocclusion. These appliances became known as functional appliances (FA) because of their effect on the musculature and by virtue of the effect they had on the airway and the patient's ability to breathe, especially while using the appliance during sleep.

In the late 1970s FR were becoming more common in the United States as a way to address malocclusions. In addition the effect of these appliances on the airway was observed. Functional-type appliances were found to impact vertical development of the face and the dentition, which in turn resulted in an overall improvement in breathing and especially nasal breathing. In the 1960s and 1970s research by Linder-Aronson in Sweden and Woodside in Canada substantiated the use of functional appliances and their effect on growth and on the airway.²

Another form of orthodontic treatment that had been used to correct crossbites, referred to as palatal expansion, was becoming associated with improved nasal breathing. These appliances were being used mainly in the maxilla and were designed to widen the maxillary arch while at the same time they were affecting the nasal airway. Cistulli et al found that with maxillary expansion there was an improvement in a patient's sleep apnea, presumably due to improved nasal airway breathing.³

THE DENTIST'S ROLE

The role of the dentist as it relates to SRBD became more evident in the late 1970s and early 1980s. At this time a small number of individuals were becoming aware of the impact an OA might have on snoring.

The first well-recognized appliance to manage snoring and sleep apnea was the Tongue Retaining Device (TRD) created by Samelson, a psychiatrist who was known to be a loud snorer.⁴ He developed a device that was very much like an athletic mouth guard, with a pliable bulb in the front that was designed to hold the tongue forward during sleep. The concept at that time was to bring the tongue forward so that it would not collapse back into the airway. By doing so the airway would be expanded or opened allowing air to pass through with less resistance and thus the snoring would be prevented.

In the early 1980s the use of FAs and their effect on the airway was becoming better known and more widely accepted. Many general dentists and orthodontists were utilizing FAs and recognized the effect they had on growth, respiration, snoring, and sleep. Several of these dentists recognized the opportunity for management of SRBD and particularly the opportunity for

appliances to be a form of treatment for OSAS. The first appliances used were mandibular repositioners (MR), which became available over the remainder of the 1980s. At this time the primary focus was on mandibular advancement and its effect on the airway. Most of the effect was observed with the use of cephalometric radiographs that were taken before and after the use of an appliance. These images revealed that the anterior-posterior dimension of the airway was increased when the mandible was repositioned anteriorly and opened vertically. At this time the major effect was believed to be due to anterior repositioning and very little effect was attributed to the vertical opening that also was necessary for the appliance to be utilized. During this time the appliances were of one-piece construction, which allowed for repositioning and locked the mandible into a predetermined position.

In addition, many dentists were also doing splint therapy for temporomandibular joint disorders (TMJ) or temporomandibular joint dysfunction (TMD), which consisted of an appliance that fit over the teeth in either the maxilla or the mandible. Many of the dentists that were experienced with this type of therapy were comfortable with the use of appliances to treat SRBD along with the dentists who had experience with FAs.

In the early 1990s more appliances became available. At this time the appliances were improving in sophistication and design and a large number were now separate upper and lower units that were attached in some fashion to allow for adjustability, for jaw mobility, and for added patient comfort, all of which demonstrated improved effectiveness. In addition a few appliances that had been used for orthodontics primarily were now being reconfigured for use with patients who were diagnosed as having OSAS. Most notable was the Herbst appliance, which has an upper and lower component and uses a metal bar that goes from top to bottom and holds the mandible forward.

Through this period and even now the predominant philosophy has been to open the bite vertically a minimal amount, usually 2 to 5 mm of separation between the front teeth, and to advance the jaw between 60 and 70% of the maximum amount the jaw can protrude. Anterior repositioning continues to be the primary focus by which these appliances function.

To summarize the development of OAs one might look at them in phases as outlined in Table 1.

The dentist's involvement today takes on two distinct roles based on a desire to be involved with patients who may have or have been diagnosed with OSAS or may snore. The two levels of involvement are either indirect or direct.⁵ In the indirect approach the dentist may recognize the signs of an SRBD and advise the patient accordingly. In doing so the dentist might advise the patient of the findings and their consequences and would then refer the patient to a physician or to a

Table 1 Summary of the Development of OA

Phase	Time Line	Major Attributes
I	1980–1988	Tongue retainer as the first appliance Functional appliances adapted into use All appliances were one-piece construction Focused on anterior repositioning
II	1988–1995	Upper and lower were separate units Upper and lower attached by various means Appliance was adjustable Limited amount of vertical opening Focused on anterior repositioning
III	1995 to present	Continued two-piece construction Attachment of the two pieces allowed for increased jaw mobility Ability to alter jaw position Attention to the effect of vertical opening on the airway being recognized

sleep center for the appropriate therapy. In this situation the dentist may not have the expertise or desire to be directly involved in the patient's care.

The second means of involvement is referred to as the direct approach. In this situation the dentist would be able to assist the patient with management of the SRBD or OSAS once a formal diagnosis is made, primarily with the use of an OA. Here the dentist may have assisted the patient with the recognition of the condition and is available to treat the patient or to accept a new patient for treatment. Regardless, in this situation the dentist who is involved directly will recognize the presence of an SRBD or possible OSAS, will refer the patient appropriately, and is also available to participate in the management of the patient. The role of the dentist is continually expanding as is witnessed by the growing interest in the dental profession, the number of articles that appear in the dental literature,⁶ the number of continuing education seminars available, the growth of the Academy of Dental Sleep Medicine (ADSM), and the formation of an OA section within the American Academy of Sleep Medicine (AASM).

CURRENT STATUS OF ORAL APPLIANCE THERAPY

At the present time there are over 40 OAs available to manage SRBD and OSAS. Currently the Food and Drug Administration (FDA) maintains a listing of these appliances and classifies them as accepted for snoring alone or for snoring and sleep apnea. In April 2002 the FDA revised the classification of these appliances from

Table 2 Oral Appliances for the Management of Snoring and Sleep Apnea

Appliance (common name)	FDA Clearance For	
	Snoring	Sleep Apnea
Elastic Mandibular Advancement (EMA)	Yes	Yes
Thornton Anterior Repositioner (TAP)	Yes	Yes
Snoreguard	Yes	No
Nocturnal Oral Airway Dilator (Norad)	Yes	Yes
Silencer	Yes	Yes
Silent Night	Yes	No
Klearway	Yes	Yes
PM Positioner (adjustable)	Yes	Yes
Tongue Retaining Device (TRD)	Yes	No
Tongue Stabilizing Device	Yes	Yes
Therasnore	Yes	No
Herbst	Yes	Yes
Hilson Adjustable Appliance	Yes	No
Nocturnal Airway Patency Appliance (NAPA)	Yes	Yes
Snore_X	Yes	No

class I to class II (special controls).⁷ This change in the classification now views OAs as regulated medical devices that demonstrate a reasonable assurance of safety and are also considered reasonably effective for treating snoring and sleep apnea. Within this same document the appliances are designated as three basic designs: mandibular repositioners, tongue retaining devices and palatal lifting devices. In addition the FDA has assigned product codes to OAs as Anti-Snoring Device (product code LRK) and Jaw Repositioning Device (product code LQZ).

A current listing of appliances as designated by the FDA is presented in Table 2. It must be recognized that this list includes the appliances currently cleared by the FDA but does not include all of the appliances being marketed and sold nor does it include OAs that some dentists make privately in their office or have fabricated by a dental laboratory.

FUNCTION OF ORAL APPLIANCES

The basic function of an OA is to open or dilate the airway by repositioning the mandible. There are a wide variety of theories as to how this is accomplished; however, the exact mechanism and the effects on the related craniofacial structures are not well understood. What is known is that for an OA to be successful the lateral dimension of the airway is the critical factor.

White et al illustrated in 1985 that the airway in OSAS patients was narrower during sleep than that of patients without sleep apnea.⁸ In addition Schwab has demonstrated with imaging that the lateral walls of the airway play an important role in improving the airway in the sleep apnea patient.⁹ There is general agreement that OA therapy stabilizes the tongue and the action of the hyoid bone while contributing to an overall increase in airway volume.

It has been proposed that OAs affect the caliber and volume of the airway by the actions they have on a variety of muscles in the airway. OAs may be beneficial because they act to increase the tone of upper airway musculature thereby stabilizing the airway. George reported that airway opening and support are mediated through the palatoglossus muscle by the action of jaw opening.¹⁰ With jaw opening, this muscle along with other muscles related to the pharyngeal airway, such as the hyoglossus, styloglossus, stylohyoid, stylopharyngeus, and palatopharyngeus, as well as the superior, middle, and inferior pharyngeal constrictors, all exert an effect on the airway that appears to improve airway dimension and stabilize the airway. In addition the pull on the palatoglossus places tension on the soft palate, which decreases the likelihood of its collapse and also lessens the potential for vibration during snoring. Tsuiki et al described the impact of the mandible being repositioned and its impact on the velopharyngeal area, which in turn impacted the patient's ability to nose breathe.¹¹ With an improvement in the ability to nose breathe the ability to tolerate an OA is improved and contributes to the success of the OA.

One method for determining an OA's effectiveness uses acoustic reflection imaging or pharyngometry. This device uses sound waves that are projected into the airway utilizing a mouth piece attached to a device called a wave tube. A mouthpiece similar to one used for snorkeling is placed inside the lips and in front of the teeth with the lips forming a seal around it. The sound waves are projected through the tube into the airway as far down as the hypopharynx and are reflected back to the tube, which has a microphone that picks up the sound and creates a computer-generated image as a wave form superimposed over a graph, which allows for visualization of airway volume as well as cross-sectional dimension. This technology has the ability to:

1. Determine the approximate site of airway collapse
2. Measure the volume of the airway
3. Determine the area of collapse, which is the area of greatest constriction in the airway, and assess it in centimeters squared
4. Determine the improvement in the airway volume and in the area of greatest constriction with mandibular repositioning. Overall this can help to determine potential effectiveness and prognosis for OA therapy.

5. Assist in determining the potential effectiveness of vertical opening, anterior repositioning, and what combination may affect the airway optimally

Although this technology is relatively new in its application, within dental practices that provide OA therapy there is a growing awareness of its value and application.

QUALITIES OF ORAL APPLIANCE THERAPY

For OAs to be most effective they need to fulfill six basic criteria. These criteria assist them in maximizing outcome and reducing side effect occurrence, and aid in providing ongoing care over a long period of time.

1. *Adjustability.* This allows the OA the ability to be modified over time should the need arise. This would be important in a situation where dental care has been done that might affect the fit or retention of the appliance (e.g., a new crown, replacement of a missing tooth, a large restoration done on a tooth)
2. *Titratability.* This refers to the ability to alter jaw position easily without having to undertake a large amount of change to or remaking of the OA. Under these conditions the ability to alter the vertical opening or change the degree of anterior repositioning should be accomplished easily with the existing appliance. Frantz reported that when the vertical opening was increased the effectiveness of the appliance and its impact was significantly improved.¹² This change was made to the existing appliance.
3. *Posterior support.* In this situation the OA has some type of support in the posterior aspect of the appliance, which allows for contact between the upper and lower arches. The importance of this is mainly to offer support for the TMJs during use. In addition this affords the patient support much like a TMJ splint would for those that also have sleep bruxism (SB). Because the occurrence of SB is fairly common in patients with SRBD, support of the joints helps to reduce the occurrence of TMD in this patient group.¹³
4. *Full tooth coverage.* All of the teeth should be covered to prevent the potential for tooth movement or eruption. It has been found that this may occur even when the teeth are fully protected but is often not significant.^{14,15}
5. *Jaw mobility.* This allows the mandible some degree of movement during sleep. Many people will move their jaw during sleep for a variety of reasons (e.g., SB, swallowing, licking the lips) or they may have the need to alter jaw position during positional changes. Patients who have had a one-piece OA that did not allow for jaw mobility often could not tolerate the rigidity of their mandible being held in one position.

6. *Patent nasal passages.* It is generally agreed that for an OA to be successful the user should be able to breathe comfortably through the nose. This facilitates improvement in oxygen levels and reduces mouth breathing.¹⁶

EFFECTIVENESS OF ORAL APPLIANCES

A variety of studies have increasingly looked at OAs and their effectiveness in the management of SRBD and OSAS. The TRD, as was discussed previously, was one of the first appliances reported to be helpful with snoring and sleep apnea. Since then several studies have been done that support OAs, mostly utilizing repositioning as the means of therapy, as an effective means of management. Schmidt-Nowara reported in 1999 that the use of OAs should no longer be viewed as an “experimental procedure” and that their potential role in managing SRBD has been adequately demonstrated.¹⁷

The published studies are too numerous to mention in the context of this chapter. To cite a few more current studies, it can readily be seen that the role of OAs is steadily increasing as well as improving. One such study from Henke et al reported in 2000 that the elastic mandibular advancement (EMA) appliance was effective in managing OSAS.¹⁸ It was demonstrated that patients with a respiratory disturbance index (RDI) of 52.6 ± 28.2 experienced an improvement in their RDI to 21.9 ± 19.3 with this OA.

Menn et al reported in 1996 that a mandibular repositioning device (MRD), which was a fixed-position appliance that did not allow for any mandibular movement, proved to be effective in the management of OSAS.¹⁹ In this study 23 of the initial 29 patients were compliant and had a follow-up sleep study with the device. It was found that their RDI went from 37 ± 23 to 18 ± 20 and 16 of the 23 patients or 69% were viewed as responders because their RDI decreased by 50% or more and the RDI was 20 or less. With long-term follow-up 16 of the 23 patients continued to use the appliance for 3 or more years. The outcome of this study indicates that appliances used to reposition the mandible are useful for long-term management in patients with mild to moderate OSAS.

Marklund et al studied 33 patients using OAs and found 19 of them had a satisfactory short-term outcome where the RDI was less than 10.²⁰ At a period defined as long term (5.2 ± 0.4 years) the RDI went from 22 ± 17 to 4.9 ± 5.1 . A key factor in this study indicates that success with the OA was based on continuous adjustment or replacement as needed. In addition it was felt that following the patient in the short term has an impact on establishing long-term benefit and thereby improving outcomes and success.

A crossover study was done comparing the results of an OA that advanced the mandible and a control oral

plate that had no effect on the mandible.²¹ The outcome demonstrated that 96% of the 28 patients who utilized an OA that advanced the mandible experienced subjective improvement. The control plate had no effect on the RDI or the oxygen saturation levels. The outcome of this study indicated that mandibular advancement was effective either completely or partially in 62.5% of the patients studied, which included patients with moderate and even severe OSAS.

Comparison of OAs to CPAP In studies that looked at the comparison of OAs to CPAP the general outcomes demonstrated that CPAP in most cases is more effective.^{22–24} However in the same studies the patients preferred the OA over the CPAP and in several cases demonstrated a higher level of compliance over a greater period of time with OA.

Comparison of OAs to Surgery In two studies that looked at the use of OAs in relation to surgery it was found that OAs provide an improved outcome when compared with surgery and may also provide reasonable management of OSAS in the case of failed surgery.^{25,26} Based on these findings and results it seems prudent to consider the use of OAs prior to performing surgery because they are less invasive and totally reversible. As discussed previously with the use of pharyngometry the location of the area of collapse can often be localized. Should the area of collapse be located in an area that is not typically amenable to surgery an OA would be a reasonable initial treatment and would additionally lessen the chances for an inadequate surgical result.

INDICATIONS FOR ORAL APPLIANCES

Based on publications from the AASM (formerly the American Sleep Disorders Association or ASDA) in the form of a review and practice parameters published by the Standards of Practice Committee there are several specific indications for OA therapy as well as patient selection^{27,28}:

1. For primary snoring where it has been determined that OSAS is not present
2. For mild OSAS where weight loss or positional therapy is not a viable option
3. In moderate to severe OSAS patients who are intolerant of or refuse CPAP therapy
4. In patients who are not candidates for or have refused tonsillectomy and adenoidectomy, craniofacial surgery, or tracheostomy

CONTRAINDICATIONS

The same guidelines as cited previously apply here as well. In addition the ADASM has established criteria that

Table 3 Myofascial Trigger Point Referral

Muscle	Common Area of Pain Referral
Temporalis	Forehead and over the eye Upper teeth (anterior portion to the front teeth, middle to the bicuspid and posterior to the molars)
Masseter	Ear and around the TMJ area Over the eye Lower posterior teeth
Lateral pterygoid	TMJ area Midfacial area and under the eye
Medial pterygoid	TMJ area and the surrounding area Posterior face/jaw
Digastrics	
Anterior	To the front teeth
Posterior	Neck, under the mandible at the posterior aspect Throat (may feel like a sore throat)
Sternocleidomastoids (SCMs)	
Superficial belly (sternal segment)	Face, over the eye, back and top of the head, under the jaw
Deep belly (clavicular segment)	Ear, behind the ear, forehead (can refer across the midline to the other side of the forehead)
Posterior cervicals	Face and TMJ area Forehead and temples Back of the head
Upper trapezius	Back and side of the head Angle of the mandible Posterior neck region

TMJ, temporomandibular joint.

should be followed as well. There are three major areas of concern:

1. OAs are not indicated for those patients with central sleep apnea.
2. OAs are not advisable in patients with loose teeth, diseased or broken teeth, or inadequate teeth to support or retain an OA.
3. In patients with TMJ or TMD. The clinician who provides OA treatment should also be familiar with these conditions and be able to address this as well during OA treatment so that in cases where this exists the patient may derive a dual benefit from the OA.

In the edentulous patient where there may be a concern about mandibular advancement the option of using the TRD may be the best option. An alternative may be the fabrication of appliances that are similar in appearance to dentures without the teeth that have flat pads in the posterior to reposition the jaw to a more open position vertically. In these situations creating an attach-

ment that is designed to advance the mandible is often not practical because of difficulties with adequate retention of the prosthesis. In this case the goal is to create an increase in tongue space and to facilitate airway dilation through the musculature as previously discussed. In some instances simply having the patient wear the dentures during sleep, which most dentists do not recommend, has been shown to improve the apnea.²⁹

SIDE EFFECTS AND THEIR MANAGEMENT

Wearing an OA can produce side effects in some patients, the most common of which include:

1. *Excess salivation*, which usually subsides within a week after using the OA.
2. *Dry mouth*, which is related to ongoing mouth breathing and may be associated with a lack of nasal breathing. This can be improved with the use of nasal dilation such as Breathe Rite strips.
3. *Bite changes*, which are usually temporary upon removal of the OA in the morning. These changes usually resolve within 30 to 60 minutes after removal of the OA.
4. *Tooth movement*, which may occur because of the forces used with repositioning of the mandible. This may be minimized by focusing on vertical opening as opposed to anterior repositioning; however, this has not been researched and is based on clinical experience. Many of the changes are considered minor and usually do not impact the use of the OA.¹⁴ In addition there may be circumstances where tooth movement is suspected when in fact it is more related to minor changes in the bite or occlusion.
5. *Jaw pain and/or TMJ/TMD*, which may occur in association with mandibular repositioning. This can be minimized as well as managed by using an OA that has posterior support using bite pads in the posterior part.

Jaw pain and the occurrence of TMJ/TMD is a major concern among dentists, patients, and physicians who refer patients for treatment with OA. Most of the time the symptoms of TMJ or TMD are related to activation of trigger points in the muscles of the head and neck that are associated with MR. Travel and Simons have identified these points in various muscles and have mapped the areas to which they may refer pain.³⁰ Table 3 lists the muscles most commonly involved as well as the predominant areas to which they refer. As can be seen several of them refer to an area around or near the TMJs.

Over time and with continued use of the OA issues related to the TMJs generally resolve as the muscles become more accustomed to the repositioning that is done. In addition these problems can be managed

in the short term with anti-inflammatory medications or muscle relaxers. Also, transdermal medications can be compounded that contain these same medications and can be applied directly over the painful area without the need to take the medication(s) orally, thus reducing any potential side effects associated with them.

CONCLUSION

Dental therapy utilizing OAs in the treatment of a medical condition has become an effective means to address SRBD. It is becoming more widely accepted for patients intolerant to CPAP and to those with mild to moderate OSAS. In addition, OAs are most likely the best means by which snoring can be managed in the absence of OSAS. As improvements in OAs continue and dentists gain more experience, along with a better understanding through continued research to improve OA effectiveness, the application and awareness of these devices for the management of SRBD will continue to grow and mature.

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