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Oral Devices for the Management of Snoring and Obstructive Sleep Apnea

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WHAT ARE ORAL DEVICES AND HOW DO THEY WORK?

An oral device for the management of snoring and obstructive sleep apnea (OSA) is a small plastic dental appliance, similar to an orthodontic retainer or an athletic mouthguard. It is worn in the mouth during sleep to prevent the oropharyngeal tissues and base of tongue from collapsing and obstructing the airway. Most of the literature refers to these oral devices as dental appliances; therefore, throughout this chapter the terms will be used interchangeably.

Most oral devices may be held in place by gripping the teeth with wire clasps or with the flexible plastic material of which they are constructed. This is usually a methylmethacrylate, polyvinyl, or other thermoplastic material that has been FDA-approved for intraoral use. Tongue-retaining devices are held in place by the appliance's conformity to the contour and position of the dental arches. The tongue is held in the tongue-retaining bulb by suction.

Oral devices essentially function in three ways. First, by bringing the mandible and base of tongue forward or by acting as scaffolding to support a drooping soft palate and uvula. A "combination" appliance may perform two or more of these functions simultaneously. Second, by stabilizing the mandible and preventing it from opening during sleep. This assists the geniohyoid muscle in dilating the airway through protraction of the hyoid bone (1). Third, by altering mandibular position through downward rotation, thereby causing an increase in baseline genioglossus muscle activity which, it is postulated, is related to maintenance of a patent airway (2-4).

OVERVIEW AND HISTORICAL PERSPECTIVES

A detailed examination of the evolution of these dental appliances and OSA can be found in an article by Clark (5), who notes that the first reported use of a dental

appliance was in 1934, when Pierre Robin described a monoblock functional appliance that was used to pull the jaw and, therefore, tongue forward. Robin's appliance was utilized for cases of micrognathia in both children and adults. One limitation of the intraoral appliance approach that Robin noted was that it was not usable in the newborn without any teeth (6).

The concept of directly pulling the tongue forward to prevent airway obstruction was first published by Shukowsky (7) in 1911. His article described micrognathia with airway obstruction in infants and related a 1903 case where he sutured the tongue to the lower lip to tie the tongue forward. In 1982 Cartwright and Samelson (8) published a paper describing a dental appliance that nonsurgically accomplished what Shukowsky had accomplished utilizing sutures 79 years earlier. This appliance, the tongue-retaining device (TRD), captured the tongue, by suction, within a small plastic bulb and held it in the forward position.

In 1984, Meier-Kwert et al. (9) reported on treatment of OSA with a mandibular protracting device. In 1985 Soll and George (10) reported effective treatment with a similar type of appliance, the nocturnal airway patency appliance (NAPA). In 1988 Schmidt-Nowara, Meade, and others (11,12) reported effective treatment of snoring and OSA with another modification of an anterior mandibular positioner, the Snore Guard. Also, in 1988 Viscomi, Toone, and others (13) reported successful treatment of five cases with yet another modification of a mandibular anterior positioner, the sleep and nocturnal apnea reducer (SNOAR). Again in 1988, Rider (14) and Clark et al. (15) separately reported successful treatments with still another appliance (an adaptation of the Herbst, a functional orthodontic appliance) that anteriorizes the mandible.

Throughout the remainder of the 1980s and into the present, additional studies of the above-noted dental appliances, and other variations of them, have been reported. These are discussed in greater depth by Alan Lowe in Meier Kryger's 1993 revised edition of *The Principles and Practice of Sleep Medicine* (16).

One can expect ongoing modification, variation, and improvement in the design of these dental appliances coming from practicing dentists. In an attempt to coordinate this with therapy, the Sleep Disorders Dental Society (SDDS) was formalized as an organization in 1991.

The objective of the SDDS is to further dental appliance therapy as an integral part of overall therapy. Its goal is to facilitate a coordinated approach to research, education, and treatment with the medical community.

There are four basic types of oral devices: the soft palate lifters, the TRDs, the mandibular repositioning devices (MRDs), and the tongue posture training devices. There are differences in the way each of these devices functions. Within these types there are variations in design that also affect the workability of each. Needed research will provide information that will enhance the effectiveness of oral devices. What we presently know and suspect about the four basic types of appliances will be conveyed by elaborating on them individually.

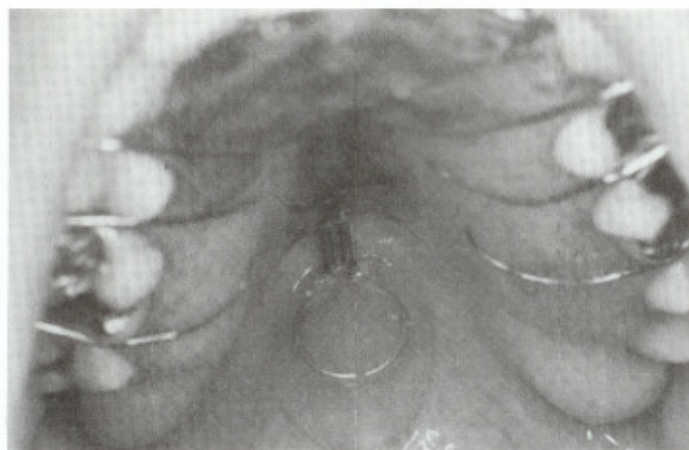


FIG. 1. Adjustable soft palate lifter. The acrylic button supporting the soft palate can be adjusted in three dimensions. (Courtesy of Herb Paskow, Longboat, Florida.)

SOFT PALATAL LIFTERS

Soft palatal lifting appliances act as scaffolding, reaching back and supporting the soft palate. This reduces the vertical drooping of the soft palate and uvula, and minimizes the fluttering effect and snoring noise. This may reduce the possibility of a long uvula getting trapped between the back of the tongue and the posterior pharyngeal wall and narrowing or occluding the oropharyngeal space. The inventor of the adjustable soft palate lifter (ASPL) (Fig. 1), Herbert Paskow, stated that he believes that the device is effective in reducing or eliminating snoring but not in treating OSA (17). To date, there are no published data on the ASPL.

TONGUE RETAINERS

The TRD (Fig. 2) and tongue-locking device (TLD) grasp the tip of the tongue and hold it forward between the front teeth. The tongue actually fits into a small flexible bulb, the size of which is related to the degree the tongue can protrude, unstrained, beyond the front teeth. When excess air is expressed from this bulb (like squeezing a bulb of a turkey baster), a suction is created. This suction holds the tongue in place. Research shows an increase in genioglossus activity directly correlated to wearing a TRD (18). It is theorized, but not yet substantiated, that TRDs are most effective when obstructions are predominantly in the oropharyngeal area. Clinicians also believe that the TRD is more suited for patients with large tongues. Studies have shown TRDs to be more effective with positional-related OSA. The TRD is a custom-made appliance, whereas the TLD is preformed (sold off the shelf). To date, there are at least six published studies on the TRD (19–24); there are no published studies on the TLD.

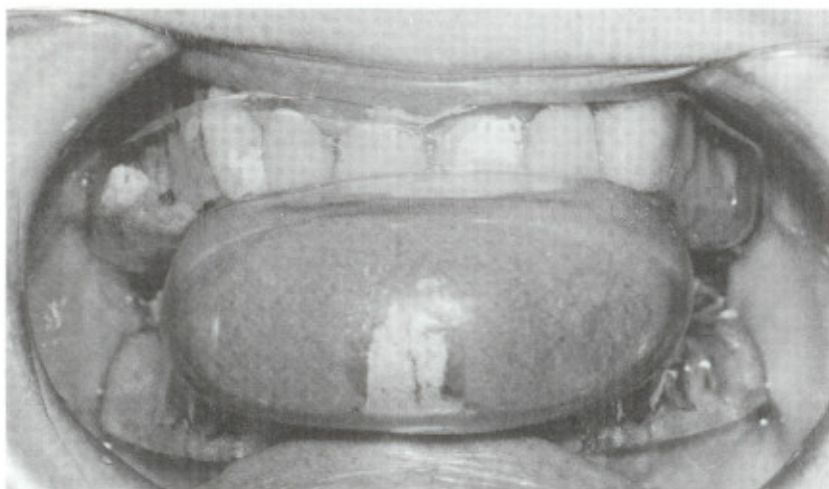


FIG. 2. Tongue-retaining device. Supplemental plastic tubes can be added to the sides to facilitate oral breathing. (Courtesy of Michael Alvarez, Freemont, California.)

MANDIBULAR REPOSITIONERS

Mandibular repositioning devices indirectly anteriorize the tongue and base of tongue by mechanically protruding the mandible. They are made of a rigid or semi-rigid plastic that conforms to the contour of the maxillary and mandibular arches (and teeth) and maintains them in a specific relation to one another. The devices are anchored to the teeth either by the fit and grip of wire clasps or by flexible plastic material.

The consensus on how far to anteriorize the mandible ranges from no protrusion to 1–3 mm short of the maximum unstrained protrusive range.

There are many variations in the vertical opening of the appliances. This ranges from a 5- to 7-mm interincisal distance, a minimal opening required for oral breathing, to a 13- to 17-mm interincisal distance, the opening of the SNOAR appliance (Fig. 3).

Other differences in the MRDs relate to the degree of fixation of the mandible. This ranges from total fixation of a NAPA (Fig. 4) to complete freedom of lateral and vertical movement anterior to the most protruded position of the snore guard (Fig. 5). Dr. Peter George, inventor of the NAPA, has observed return of symptoms when these appliances have become loose. He has seen these symptoms disappear again upon regaining fixation of the mandible, by tightening the grip of the NAPA clasps on the teeth. An explanation of this is described in an abstract written by George (1). In it he relates horizontal and vertical force vectors affecting the protraction of the mandible and base of tongue to vertical distance of the hyoid bone from the inferior border of the mandible. George also believes that a study by Suratt

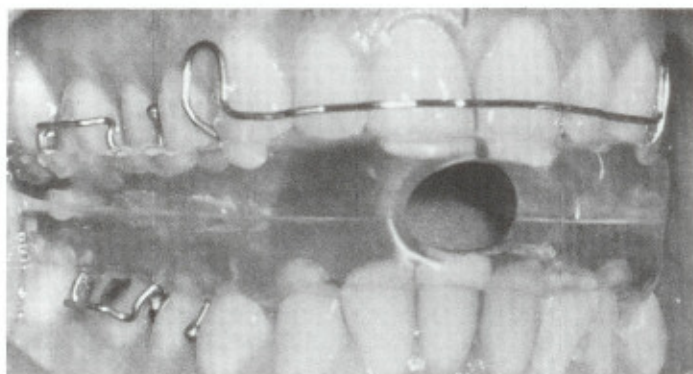


FIG. 3. Sleep and nocturnal apnea reducer. Note the larger interincisal distance of 13–17 mm. (Courtesy of Joseph Cain, Oklahoma City, Oklahoma.)

and co-workers (25) on respiratory-related recruitment of the masseter illustrates a relationship between stabilization of the mandible and the ability of an activated genioglossus muscle to dilate the upper airway.

Adjustability differs too. This ranges from nonadjustability of a mandibular repositioner monobloc-type appliance (Fig. 6) to adjustability of the Herbst appliance (Fig. 7) through incremental anteriorizing of the mandible.

There have been published studies of the above-noted mandibular anterior positioners, treating from mild to severe OSA. Combining and averaging the results shows an average reduction in mean apnea index (AI) from 45 to 16 and in mean respiratory disturbance index (RDI) from 48 to 23. Oxygen saturation and reduction of subjective symptoms seem to correlate with improvement of the AI and RDI.

TONGUE POSTURE TRAINERS

Two appliances have been designed to treat snoring and OSA by treating problems of abnormal tongue posture by strengthening the dorsal muscles of the tongue

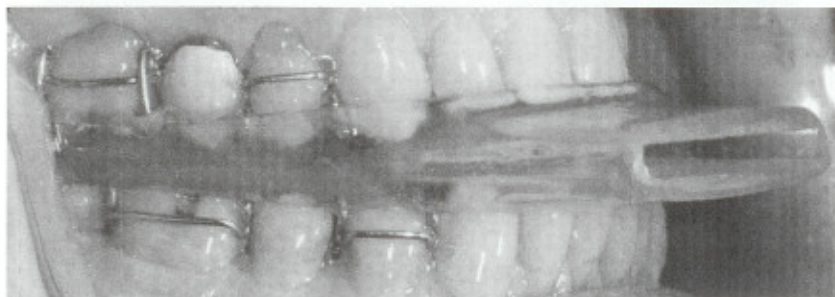


FIG. 4. Nocturnal airway patency appliance. Hollow beak facilitates oral breathing, and wire clasps grip teeth and provide total fixation of mandible. (Courtesy of Peter George, Honolulu, Hawaii.)



FIG. 5. Snore guard. Mandible is held forward by plastic ramp, extends behind lower front teeth, and allows some anterior, vertical, and lateral movement of mandible.

(styloglossal and palatoglossal muscles). The inventors of these appliances, the Tepper Proprioceptor Stimulator (TOPS) (Fig. 8) and the tongue positioner and exerciser (TPE), believe that they facilitate repositioning of the tongue to the soft and hard palate through proprioceptive means. The tongue then remains in a rest position so as to increase the airway space as well as the resting muscle tone. Harry Tepper, inventor of the TOPS appliance, has observed a rehabilitative effect of the appliance. To date, published data on the efficacy of these appliances are not available.

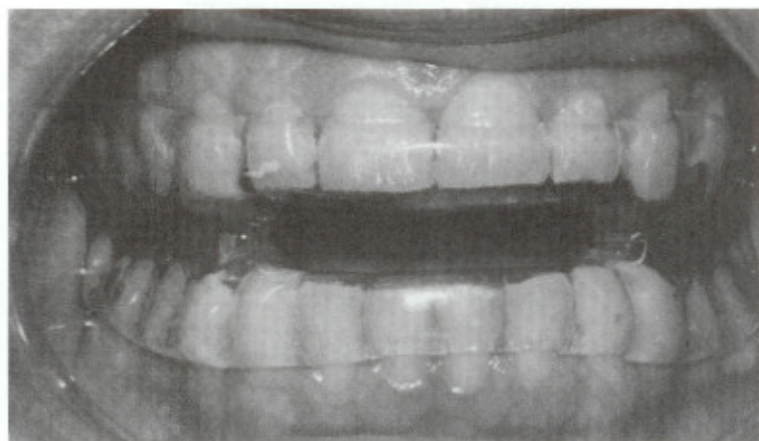


FIG. 6. A mandibular repositioner monoblock-type appliance, the "P M positioner," made of an almost-rigid thermoplastic material that anchors to teeth without clasps, not readily adjustable. (Courtesy of Jonathan Parker, St. Louis Park, Minnesota.)



FIG. 7. Herbst appliance. Lateral metal tubes facilitate incremental anteriorization of the mandible. (Courtesy of Glen Clark, Los Angeles, California.)

DENTAL APPLIANCE THERAPY

When dentists who were utilizing more than one type of appliance in treatment began to collaborate and share their observations through the SDDS, they recognized that some dental appliances worked differently than others. They found a need to distinguish between them to determine which would be most suitable for a particular patient and condition, and why. It was also recognized that to appropriately treat patients, clinicians should be proficient in the use of the basic types of appliances.

Published studies suggest that OSA can be effectively treated by TRDs and anterior MRDs. They show a direct correlation of the degree and frequency of treatment success to the mildness of the apnea. Observations indicate that while some patients

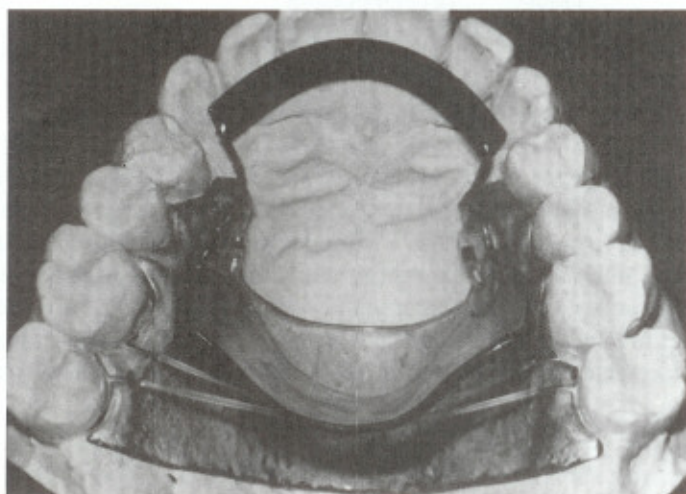


FIG. 8. Tepper proprioceptor stimulator, which is retained by adaptation to the hard palate and gingival contours of the teeth. Tension from rubberband provides secondary ramp resistance for rehabilitative reposturing of tongue. (Courtesy of Harry Tepper, Santa Monica, California.)

can benefit from both types of appliances (TRD and MRD), others can only benefit from one or the other. Consequently, a treatment protocol for dental appliances (Fig. 9) was established to provide a therapy to select and tailor the most appropriate appliance for each patient. The appliance is customized to the patient rather than the patient having to, by chance, fit the particular appliance.

PATIENT SELECTION

The therapeutic process begins with appropriate patient selection. To facilitate the success of this, the attending physician or sleep specialist must understand what dental appliances are and how they work. They should know, statistically, when dental appliances are most effective and impart this information to the patient. For example: Dental appliances have a track record of eliminating or reducing "benign snoring" 95% of the time (12); they are most effective in treatment of mild and moderate OSA and are least effective in treatment of severe OSA (12).

The SDDS has available a brochure that explains dental appliance therapy to the lay person. The brochure is helpful to the dentist and physician/sleep disorders specialist in explaining dental appliance therapy. It is a useful supplement to other brochures on snoring and OSA available through ASDA and the American Academy of Otolaryngology—Head and Neck Surgery. It can be ordered by contacting

Sleep Disorders Dental Society
Wexford Professional Building, Suite 204
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Wexford, PA 15090
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THE REFERRAL PROCESS

It is the position of the SDDS that snoring and sleep apnea are medical disorders that must be diagnosed by a physician or appropriate sleep specialist. The dentists' role is an adjunctive one and requires a written request from the attending physician. Accompanying information to the dentist should include the following: diagnostic history, sleep studies, prior and other anticipated treatment, and the objectives the physician has in mind for dental appliance therapy. An appropriately trained dentist is able to understand and discuss this information to collaborate in the overall treatment.

THE INITIAL VISIT

At the initial visit, patients begin a screening process, which includes their assessment of whether they are able or willing to wear any removable dental appliance while sleeping. They have an opportunity to observe and handle sample appliances.

SLEEP DISORDERS DENTAL SOCIETY

**Clinical Protocol for Dental Appliance Therapy
for
Snoring and/or Obstructive Sleep Apnea**

The following therapy sequence is suggested by the SDDS for the management of dental appliances in patients who are being treated for snoring and/or OSA.

1. Medical assessment by the attending physician or sleep specialist
2. Overnight polysomnogram as required by physician or sleep specialist
3. Written referral or prescription and diagnostic report sent to dentist
4. Dental Examination
 - A. medical/dental histories
 - B. soft tissue/intra-oral assessment
 - C. periodontal evaluation
 - D. TMJ/occlusal examination
 - E. intra-oral habit assessment
 - F. examination of teeth and restorations, including prosthesis
 - G. initial dental radiographic survey
 - (1). panoramic and/or full mouth survey
 - (2). baseline cephalometric radiographic survey
 - H. diagnostic models
5. Trial appliances
 - A. design, fabrication, fitting, instructions and training
 - B. trial and evaluation (wear three to seven nights for each appliance)
 - C. final appliance design selection
 - (1). subjective symptom assessment
 - (2). cephalometric radiographic examination as required
 - (3). sleep study by attending physician as required
6. Final appliance design, fabrication, fitting and placement
7. Final appliance evaluation over 2-3 months of regular use
 - A. final adjustments to appliance
 - B. adjustment of patient to wearing appliance
 - C. subjective symptom evaluation
 - D. cephalometric radiographic examination (optional)
8. Refer patient back to attending physician for repeat overnight study
9. Possible modification, redesign or remake of appliance as required
10. Repeat adjustment and evaluation process
11. Refer back to physician for ongoing evaluation
12. Recall appointments and maintenance as requested by patient and/or physician

FIG. 9. Dental appliance therapy treatment protocol. (Courtesy of Sleep Disorders Dental Society, Wexford, Pennsylvania.)

Next, the dental condition and its relation to fitting and wearing a dental appliance must be considered. Are there enough sound teeth in strategic locations to hold or anchor the dental appliance in place? Are there dental conditions [temporo-mandibular joint (TMJ) dysfunction, tooth decay, periodontal disease] that may be aggravated by the use of an intraoral device?

Patients are provided with feedback regarding the relation between their current dental condition and the potential fit, including comfort and stability of various dental appliances. They also may obtain feedback on how dental treatment might affect or be affected by dental appliances. All of this assists them in their screening.

TRIAL PROCEDURES (TRIAL APPLIANCE THERAPY)

Trial procedures often begin at the initial visit and culminate in the design of a definitive appliance. Ongoing feedback is required throughout the trial process, including training and orientation sessions. This provides information for modifying the trial devices (trial TRD and trial MRD) to maximize the effectiveness. The patient can assess the relative comfort and convenience associated with wearing the trial device and interpolate this to wearing the definitive counterpart. Clinical effectiveness may be assessed through empirical feedback (observed snoring and breathing cessation, reduction of excessive daytime sleepiness, morning headaches, and other signs and symptoms), review of voice-activated tape recordings while sleeping with the trial devices and without them, and interpretation of overnight sleep studies while wearing them.

During trial procedures, patients also have the opportunity to get used to wearing a dental appliance. This includes experiencing excessive salivation or a dry mouth for a time period of a few days to a few weeks, as their body adapts to the appliance.

DEFINITIVE DENTAL APPLIANCE FABRICATION, FITTING, PLACEMENT

The process of fabrication of the definitive dental appliance is usually accomplished in a dental laboratory. Each device is custom made according to the dentist's prescription. It fits models of the teeth and gums (made of dental stone) that have been oriented in a maxillary to mandibular relationship (bite) determined through the trial procedures. When fitting the appliance, the dentist may need to modify and adjust its contour or shape for comfort and function. After wearing the appliance for several nights, the patient may return for further minor modifications. Adjustments continue until, through subjective symptom assessment, it is equal to or better than the optimized trial device. Throughout this adjustment process, clinical effectiveness can be evaluated through tests used in the trial procedures.

DEFINITIVE APPLIANCE EVALUATION

A 3-month adaptation period of nightly wearing the adjusted device should provide enough time for maximizing the effects of therapy. This occurs through habituation and through physical benefits derived from the shrinkage of previously edematous oropharyngeal tissues. The patient is then referred back to the attending physician for reevaluation including an overnight sleep study while wearing the device.

FOLLOW-UP CARE

Because these appliances are custom-fitted to the teeth and dental arches, changes in the teeth and tissues can affect their fit and necessitate adjustment. Most often the patient will be aware of symptomatic changes that can be associated with the device. An example of this may be a return of snoring or apnea symptoms associated with movement of the mandible and narrowing of the airway. This can occur with loosening of an appliance that has been locking the mandible into a static position. Further loss of muscle and tissue tone can also decrease the airway size.

Side effects, characterized by symptoms such as pain of the TMJ or masticatory muscles or a change in the bite, may necessitate temporarily or permanently discontinuing use of the device and/or modifying the design of the device.

Other side effects may be less obvious. Therefore, it is prudent for the patient to be examined by the attending dentist initially semiannually and then annually. Here, assessment of the fit of the oral device and its side effects helps determine whether modification of the device or the therapy is indicated. Some harmful side effects that may not be obvious to the patient are: changes in the bite, loosening of teeth, tissue hyperplasia, dental caries, or periodontal disease.

SUMMARY

Oral devices are similar in appearance to orthodontic retainers and athletic mouthguards. Two particular types have demonstrated effectiveness in treating OSA. They are the tongue-retaining device (TRD) and the mandibular repositioning device (MRD). Both are most effective in treating primary snoring and mild and moderate apnea.

Their designs can be modified and combined. To maximize the effectiveness of therapy, one should customize the type and design of the appliance to the patient. The treatment protocol that facilitates this involves a diagnostic process of testing the patient with trial TRDs and trial MRDs. The designs of these trial devices are modified to maximize their individual effectiveness. The trial device type and design that appears to most effectively treat the apnea becomes the basis for constructing the final/definitive appliance.

Oral devices are most often used alone. However, they also have been used in conjunction with surgery and nasal continuous positive airway pressure (CPAP).

They provide a substitute for nasal CPAP, on occasions when CPAP is inconvenient. They also may provide a means for assessing the potential success of surgery.

The treatment is reversible and noninvasive. Research to date suggests that the effect of oral devices occurs only while they are being worn. No appliance has demonstrated a carry-over effect to non-use nights.

Because snoring and OSA are medical conditions, primary responsibility for diagnosis and care falls under the jurisdiction of the physician/sleep specialist. The role of the dentist is secondary and adjunctive. Therefore, the commencement of dental appliance therapy requires a written prescription by the attending physician/sleep specialist.

REFERENCES

1. George PT, Pearce JW, Kapuniai LE, Crowell DH. Stabilization of the mandible in the prevention of snoring and obstructive sleep apnea [Abstract]. *Sleep Res* 1992;21:202.
2. Lowe AA. Neural control of tongue posture. In: Taylor A. *Neurophysiology of the jaws and teeth*. London: McMillan Press, 1990;322-368.
3. Lowe AA, Fleetham J, Ryan J, Matthews B. Effects of a mandibular repositioning appliance used in the treatment of obstructive sleep apnea on tongue muscle activity. In: Suratt PM, Remmers JE, eds. *Sleep and respiration*. New York: Wiley-Liss, 1990;395-405.
4. Lowe AA. The tongue and airway. *Otolaryngol Clin North Am* 1990;23:677-698.
5. Clark GT. OSA and dental appliances. *Calif Dent Assoc J* 1988;16:26-33.
6. Robin P. Glossoptosis due to atresia and hypotrophy of the mandible. *Am J Dis Child* 1934;48:541-547.
7. Shukowski W. Zur atologie des stridor inspiratorius congenitus. *Jahrb Kinderheilk* 1911;73:459-474.
8. Cartwright RD, Samelson CF. The effects of a nonsurgical treatment for obstructive sleep apnea—the tongue retaining device. *JAMA* 1982;248:707-709.
9. Mier-Ewert K, Schafer H, Kloss W. Treatment of sleep apnea by a mandibular protracting device. *Berichtsband 7th Eur Congr Sleep Res Munchen* 1984:217.
10. Soll BA, George PT. Treatment of obstructive sleep apnea with a nocturnal airway-patency appliance. *N Engl J Med* 1985;313:386.
11. Schmidt-Nowara WW, Meade TE, Wiggins RV. Treatment of snoring with a dental orthosis [Abstract]. *Am Rev Respir Dis* 1988;137:312.
12. Schmidt-Nowara WW, Meade TE, Hays MB. Treatment of snoring and obstructive sleep apnea with a dental orthosis. *Chest* 1991;99:1378-1385.
13. Viscomi VA, Walker JM, Farney RJ, Toone K. Efficacy of a dental appliance in patients with snoring and sleep apnea [Abstract]. *Sleep Res* 1988;17:266.
14. Rider EA. Removable Herbst appliance for treatment of obstructive sleep apnea. *J Clin Orthod* 1988;22:256-257.
15. Clark GT, Arand D, Chung E. Respiratory distress index changes with an anterior mandibular positioning device for obstructive sleep apnea. *Soc Neurosci Abstr* 1988;#1762.
16. Lowe AA. Dental appliances for the treatment of snoring and/or obstructive sleep apnea. In: Kryger M, ed. *The principles and practice of sleep medicine*, 2nd ed. 1992.
17. Paskow H, Paskow S. Dentistry's role in treating sleep apnea and snoring. *J NJ Dent Assoc* 1991; 88:815-817.
18. Ono T, Par EK, Lowe AA. Tongue retaining device effects on genioglossus muscle activity. *J Dent Res* 1993;72:261.
19. Cartwright RD. Predicting response to the tongue retaining device for sleep apnea syndrome. *Arch Otolaryngol* 1985;111:385-388.
20. Cartwright RD, Samelson CF, Lilie J, Kravitz H, Knight S, Stefoski D, Caldarelli D. Testing the tongue retaining device for control of sleep apnea [Abstract]. *Sleep Res* 1986;15:111.

21. Samelson CF. Successful use of the TRD in replacing a 27 month tracheostomy, a case report [Abstract]. *Sleep Res* 1986;15:159.
22. Cartwright RD, Stefoski D, Caldarelli D, Kravitz H, Knight S, Lloyd S, Samelson CF. Toward treatment logic for sleep apnea: the place of the tongue retaining device. *Behav Res Ther* 1988; 26:121-126.
23. Samelson CF. A survey of the effectiveness of the tongue retaining device for the control of snoring and/or obstructive sleep apnea [Abstract]. *Sleep Res* 1989;18:229.
24. Cartwright RD, Ristanovic R, Diaz F, Caldarelli D, Alder G. A comparative study of treatments for positional sleep apnea. *Sleep* 1991;14:546-552.
25. Hollowell DE, Pradmore RB, Funsten AW, Suratt PM. Respiratory-related recruitment of the masseter: response to hypercapnia and loading. *J Appl Physiol* 1991;70(6):2508-2513.