August 1998 JOURNAL OF THE CALIFORNIA DENTAL ASSOCIATION

Feature Article

Comparisons of Oral Devices for Snoring

Nineteen types of oral appliances for snoring/obstructive sleep apnea are reviewed.

By James E. Eckhart, DDS

abstract

A study was performed on 19 types of oral appliances for snoring/obstructive slee The appliances were categorized into two groups, mandibular advancers and tong advancers. A set of limited criteria was developed by which an appliance could be evaluated, and the criteria were weighted. Evaluations were then performed on th appliances, and they were rated according to satisfaction of criteria. The rating ta should help a dentist in selecting an appliance that will be accepted by the patient effective in treating snoring/obstructive sleep apnea.

A dentist considering treating a patient for snoring might not be aware of the broad variety devices available. Even if aware, he or she might still be perplexed at which appliances m best in different circumstances. This paper is intended to familiarize the dentist with the cl and to help in the selection of snoring treatment devices. The patient should be provided v appliance that is comfortable and does its job. If this is done, the field of medicine may m quickly increase its acceptance of dentistry's helpful role in sleep medicine. However, for to accept dentistry's role, dentistry must understand enough sleep medicine to meet the sta care set by medicine.[1] A dentist entering this field must be aware that snoring itself has ce morbidities[2-8] and that it may be a sign of upper airway resistance syndrome or obstructiv apnea, whose symptoms, associated morbidities, and diagnostic protocols the dentist must know. This paper does not directly address the question of efficacy at treating obstructive apnea with oral devices, which can best be evaluated by polysomnography after delivery device. No polysomnographies were performed as part of this study. However, this paper guidance regarding which appliances are most favorable from both the dentist's and patien viewpoints relative to comfort, convenience, and the stopping of snoring. The more highly devices might be considered preferable for treating snoring and perhaps as logical starting for selection of appliances to treat obstructive sleep apnea.

For this study, it was decided to exclude oral devices that depend on contact with the soft dorsal surface of the posterior tongue, because they produce gagging responses and do not in any important way with the devices studied herein. It was also decided to exclude appli are not offered commercially and to exclude a few commercially available appliances that relatively ineffective or require too much effort compared to the benefit to be gained. Furt study may have examined an appliance from one vendor that is available from more than vendor, and might therefore present only a partial view of the truth about an appliance.

Categories of Appliances

Effective, readily accepted oral appliances for snoring/obstructive sleep apnea work by m
either the mandible or the tongue forward. The following classification of appliances fit th
commercially available appliances.

Mandibular Advancers

One-Piece

* Boil-and-bite -- Snore Guard (**Figures 1a and b**) and Snore Free (**Figures 2a and b**).

Figure 1a. (above) Snore Guard, front view.

Figure 1b. (below) Snore Guard, side view.

Figure 2a. Snore Free, front view.

Figure 2b. Snore Free, side view.

* Lab-fabricated -- MIRS (**Figures 3a and b**), SNOAR (**Figures 4a and b**), Mandibular Repositioner (**Figures 5a and b**), Elastomeric (**Figure 6a and b**), and NAPA (**Figures 7a c**).

Figure 3a. MIRS, front view.

Figure 3b. MIRS, side view.

Figure 4a. SNOAR, front view.

Figure 4b. SNOAR, si

Figure 5a. Mandibular Repositioner, front view.

Figure 5b. Mandibular side view.

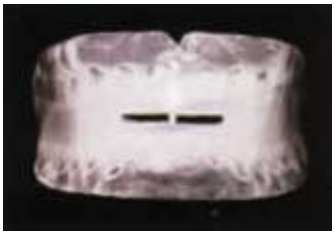

Figure 6a. Elastomeric, front view.

Figure 6b. Elastomeric

Figure 7a. NAPA, front view.

Figure 7b. NAPA, side view.

Figure 7c. NAPA, top view.

Two-Piece

* Boil-and-bite -- Thera Snore (**Figures 8a, b, and c**).

Figure 8a. Thera Snore, front view.

Figure 8b. Thera Snore, side view.

Figure 8c. Thera Snore, front view (disarticulated).

* Lab-fabricated -- Silent Nite (**Figures 9a and b**), Herbst (**Figures 10a and b**), Restore (**11a, b, c, and d**), TAP (**Figures 12a, b, c, and d**), PM Positioner (**Figures 13a and b**), S (**Figures 14a and b**), EMA (**Figures 15a and b**), Klearway (**Figures 16a, b, anc d**), and (**Figures 17a, b, and c**).

Figure 9a. Silent Nite, front view.

Figure 9b. Silent Nite, side view.

Figure 10a. Herbst, front view.

Figure 10b. Herbst, sic

Figure 11a. Restore, front view.

Figure 11b. Restore, side view.

Figure 11c. Restore, top view (disarticulated).

Figure 11d. Restore, front view (closeup).

Figure 12a. TAP, front view.

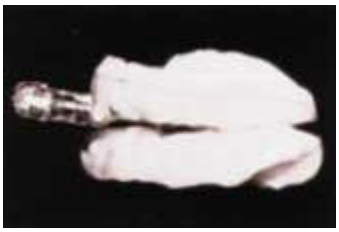

Figure 12b. TAP, side view.

Figure 12c. TAP, rear view. (disarticulated).

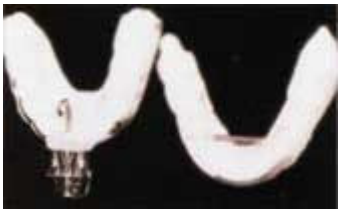

Figure 12d. TAP, top view (disarticulated).

Figure 13a. PM Positioner, front view.

Figure 13b. PM Positioner, side view.

Figure 14a. Silencer, front view.

Figure 14b. Silencer, s

Figure 15a. EMA, front view.

Figure 15b. EMA, side

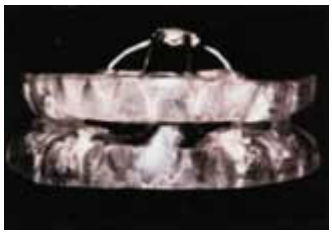

Figure 16a. Klearway, front view.

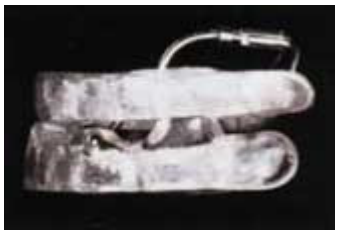

Figure 16b. Klearway, side view.

Figure 16c. Klearway, inferior view.

Figure 17a. Hilsen, front view.

Figure 17b. Hilsen, side view.

Figure 17c. Hilsen, top view (disarticulated).

Tongue Advancers

* Off-the-shelf -- Snore X (**Figures 18a, b, and c**).

Figure 18a. Snore X, front view.

Figure 18b. Snore X, side view.

Figure 18c. Snore X, inferior view.

* Lab-fabricated -- Tongue Retainer Device (**Figures 19a and b**).

Figure 19a. Tongue Retaining Device, front view.

Figure 19b. Tongue Retaining Device, side view.

Description of Categories

Mandibular Advancers

Figure 20. Inclined planes behind lower anterior alveolar process. From top: Thera Snore, Snore Free, and Snore Guard.

In most cases, these devices are secured in the mouth by being teeth- the upper teeth. Most also attach snugly to the lower teeth; however, the boil-and-bite types do not secure snugly to the lower teeth but re on an inclined plane behind the lower anterior alveolar process to ho mandible forward (**Figure 20**). The amount of forward repositioning with the appliance and the clinician. Also, the amount of vertical ope the mandible varies with the appliance. The rationale behind these a is that since the tongue attaches to the back of the mandibular symph moving the mandible forward also pulls the tongue forward, thereby the backside of the tongue away from the posterior wall of the throat **21**). Further, because the palatoglossus muscle attaches from the side tongue to the soft palate, pulling the mandible and tongue forward al the soft palate forward, separating it from the back of the throat (**Fig**

The mandibular advancers may be made of elastomer material or hard acrylic, or thermoplastic. They may create their retention on the teeth by friction fit of plastic in undercuts, which is most common, or by clasps.

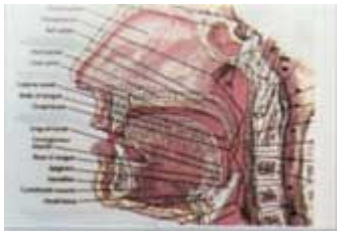

Figure 21. Anatomy of tongue and throat.

Figure 22. Palatoglossus

They may use many different mechanisms to create and adjust the mandibular advancement, and the amount of advancement varies from a little to more tha patient can actively produce, depending on the patient's severity of snoring and ability to t jaw joint stretch. Frequently an advancement begins at about 70 percent of a patient's max active protrusive ability.

Tongue Advancers

These devices are secured in the mouth by forming a suction on the tip of the tongue via a bulb that is braced against either the teeth or the lips. The size of the suction bulb is select measuring the thickness and width of the anterior quarter of the tongue when protruded pa teeth.

The rationale for these appliances is similar to the mandibular advancers in that the tongue

palate are advanced away from the back wall of the throat. These tongue advancers can be when the jaw joints do not tolerate stretching or when there are insufficient teeth to suppo mandibular advancer. These devices tend to take longer to become accustomed to than ma advancers.

Criteria of Evaluation of Oral Appliances

Substantial experience in treating patients with oral snore devices and comparison of the f more than 20 devices were used to develop a set of criteria to help dentists in selecting an appliance.

Those criteria are presented here for both the experienced and novice snore clinician to co

Reliability at Stopping Snoring

This is the most important criteria. If it is not met, the patient is not satisfied, the dentist h his or her time and lost the patient's confidence, and the profession has lost credibility in t medicine. Medicine has additional criteria, which include reduction of obstructive sleep a reduced oxygen desaturation, and decrease in daytime sleepiness; but these were not evalu the present study. A dentist must keep in mind that these medical criteria must be conside care of some patients, in addition to the criteria discussed in this paper. The evaluation of medical criteria are discussed elsewhere.[9,10]

In general, the adjustable two-piece mandibular advancers are most reliable. They can be easily to increase the mandibular advancement until airway patency is sufficient.

Many of the one-piece lab-fabricated mandibular advancers are reliable, because even if t needs further advancing, they are easily cut apart and luted back together. An exception to the Elastomeric device, which is not easily cut apart nor re-luted.

Titratability

This term describes the easy ability to fine-tune the amount of mandibular advancement t airway open without excessively stretching the temporomandibular joint. This criterion ha similarity with the first criterion of reliability, but this criterion specifically monitors the e the gradiency of adjustments. A high score here means fewer remakes and easier delivery

Figure 23. Accessible titration mechanisms.

In general, the adjustable two-piece mandibular advancers score well. and Restore devices are designed to be titrated while the patient is asl sleep lab without the devices being removed from the mouth (**Figure** EMA and Silent Nite appliances, using straps with prepunched holes, have as smooth a gradient of adjustments as the screw devices, but the resiliency of the EMA's straps compensates for this disadvantage (**Figure 24**).

None of the one-piece mandibular advancers, nor the tongue advancers, are easily titratable. Some

From top: TAP and Restore.

clinicians may point out that the boil-and-bite devices could be reheated and advanced, but with the exception of the two-piece Thera Snore, this is not particularly easy.

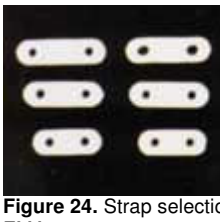

Figure 24. Strap selectio EMA.

Simplicity of Delivery

To be considered simple to deliver in this study, an appliance should not require more tha minutes of chairtime, including initial impressions, whether delivered at the first appointm as boil-and-bite devices or Snore X, or at the second appointment, like the other devices.

For most of the one-appointment deliveries, the boil-and-bite devices require a source of v water and considerable trimming and polishing of the soft material once molded. The sim the single appointment delivery is offset by the amount of chairtime fitting and adjusting appliance, compared to the ease of trying in a completed lab-fabricated appliance at a sec appointment.

Most of the commercially available devices scored highly in simplicity of delivery; and, a practitioner gains experience, even those that might not be easy for a novice to deliver wo become fairly easy.

Low Bulk

The absence of bulk makes an appliance more comfortable and therefore more likely to be The feeling of excess bulk can be from the size of the appliance, the extent of its flanges, protuberance of its working parts. The perception of bulkiness may be experienced in the cheeks, or tongue. This criterion is more subjective than the first ones and depends on var individual appliances as well as tolerance from the individuals wearing them. Others evalu similar appliances might report different findings than presented here.

The low-bulk appliances are evenly divided among the one-piece and two-piece mandibul advancers.

Lip Seal

Figure 25. Violations of lip seal. Clockwise from upper left: NAPA, TRD, Snore X, Restore, TAP, and SNOAR.

Similar to the low-bulk criterion but sufficiently different to warrant criterion of its own is the concept of lip seal. Appliances that allow tl close are more likely to be accepted by patients and are easier to get Appliances that pinch the lips or have protuberances into or beyond t and appliances made at excessive vertical opening violate this concep although acceptable to some patients, are not as universally agreeable **25**).

Tongue Space

For the tongue to be able to move away from the back wall of the throat, it helps if the area lingual to the incisors and between the upper and lower incisors is kept free of any

appliance. This provides for no irritation to the tip of the tongue and allows it to advance, which it will do if the space is provided (**Figure 26**). Appliances that provide an open space between the upper and lower incisors are superior for the above reason, rather than because they allow oral breathing, which many snorers do not need once the pharyngeal airway is held open.

Figure 26. L
of anterior to
freedom. Fro
Hilsen, PM F
and Mandibu
Positioner.

Non-interference With Sleep

Some devices can be worn and easily accommodated, without initially disturbing sleep. This criterion is similar to the low-bulk criterion but sufficiently different to warrant being a distinct criterion. These findings are very subjective and not necessarily generalizable to a large population; but some appliances, by their presence, cause many awakenings during the night and tended either to be bulky or to violate lip seal or tongue space. Most of these problem overcome by repetitive nights of wearing, but the investigation was intended to discover v appliances were easy to adapt to.

Temporomandibular Joint or Tongue Symptoms Easily Adjusted

This criterion is similar to the reliability of stopping snoring criterion and to the titratabilit criterion. If the TMJ gets sore from being stretched, the appliance needs to be easily adjus adjustable unilaterally if necessary.

The developer of the TAP appliance states that unilateral adjustability of TMJ stretch has necessary in more than 1,000 cases treated, provided that posterior occlusion is not allowe appliance. However in the author's experience, in some cases the ability to adjust the bite the TMJ.

The two tongue advancing devices, since they do not stretch the mandible, are exempt fro TMJ criterion, as TMJ symptoms would not be expected from these two devices. Howeve two devices can cause soreness to the tongue tip due to the suction, and this can also caus difficulty in accommodation.

Low Cost

Low purchase price is also a factor that influences a practitioner's thinking. Appliance cos from $60 to $500. Most fall between $100 and $200. If an appliance costs less than $100, arbitrarily considered low-cost. The cost of chairtime to deliver these appliances should al considered, and that is discussed under simplicity of delivery.

Lateral Freedom

A frequently mentioned criterion, but a poorly studied one, perhaps less necessary than co believed, is lateral freedom. It is argued that bruxers need lateral freedom. The author has lateral freedom to many patients but found they were happier when the appliance was con a one-piece by luting the two splints together. This property needs to be considered for so

patients but probably not most.

Weighting of Criteria

The criteria discussed above are not all of equal value or importance. It is probable they a decreasing importance in the order they were discussed, but this opinion could vary for so patients and for other clinicians. The weighting of the criteria might be as shown in **Table**

Other criteria that were not studied but which might deserve consideration include reliabil stopping obstructive sleep apnea, durability, and avoidance of bite changes or teeth move

Circumstances can change the hierarchy of criteria. An edentulous patient would probably TRD. A TMJ patient might move criterion 8 higher on the list. A bruxer might move No. If the doctor wants to try a patient's tolerance to a type of device without great expense, cr might move higher. If a dentist wants to advance the mandible extremely far, as in a sever obstructive sleep apnea case, then reliable retention to the teeth and absence of TMJ symp would both be the most important goals, and the TAP appliance would be more likely to b considered.

Table 1.

Weighting of Criteria.

Possible	Points
1. Reliability of stopping snoring	4
2. Titratability	2
3. Simplicity of delivery	2
4. Low bulk	2
5. Lip seal	2
6. Tongue space	1
7. Non-interference with sleep	1
8. TMJ or tongue symptoms easily adjusted	1
9. Low cost	1
10. Lateral freedom	1

Evaluation of Appliances

Nearly all the vendors of the appliances included in this study provided an appliance at no

order to facilitate this study. This study is a report of the author's evaluation of each appli himself. The author was considerably experienced in treating snoring, with experience in several devices prior to this study.

Those who object to these findings on the basis that it is not a randomized clinical trial of magnitude are welcome to perform such a study, but in the meantime these findings are o

Also, these findings may be disputed by some clinicians who prefer to use devices not hig here. In some cases (TRD, Snore Guard, TAP, Klearway, Mandibular Repositioner, Silen TheraSnore, EMA), there is data and published literature elsewhere showing efficacy of a not highly rated here.[11-18] It is to be hoped that interested individuals will use this evaluat choose from among the better appliances and provide even better treatment to more patie order to continue improving dentists' confidence and medicine's respect.

Table 2 lists the appliances along with their evaluations.

The Hilsen appliance was extremely easy to deliver and very comfortable and effective. T of the Velcro was bothersome to the tongue until it was trimmed with an acrylic bur.

The SML Herbst was well-designed. The buccal hooks and Herbst axle positions were ca chosen to be maximally comfortable to the lips. It lacked posterior bite blocks, so the vert dimension was small. Its retention and advanceability probably would make it good for o sleep apnea.

The EMA appliance had great lateral freedom. The rubber straps came off too easily. The interchangeable with straps of different length and tension.

The Silent Nite appliance also had excellent lateral freedom. It was of very low bulk but p had insufficient tooth retention for severe mandibular advancement in obstructive sleep a cases. The spare nylon straps could probably be more useful if shorter ones were available only provides one shorter replacement pair than the pair they install, and this only allows protrusive adjustment). The absence of posterior bite blocks makes this appliance unsuita bruxers.

The PM Positioner was comparatively bulky and extremely tight-fitting on the teeth initia would probably be a good choice for obstructive sleep apnea cases requiring firm retentio greater mandibular advancement.

The MIRS appliance was of low bulk and pleasant to wear. Its mandibular ramp seemed unnecessary because the mandible was held forward by friction fit on the lower teeth.

The GLO Herbst had an unnecessary transpalatal arch and uncomfortable position of the axles but was a good appliance, with sufficient retention and advanceability to probably b obstructive sleep apnea.

The Specialty Herbst was effective but had its hooks and axles in uncomfortable position would probably be effective for obstructive sleep apnea.

The Mandibular Repositioner was an excellent appliance, but because it is one-piece, it re great accuracy with the wax bite and lab procedure. It was quite comfortable. It was made clasps that were probably unnecessary because of the tightness of the acrylic.

The Silencer required fairly complex procedures at the impression appointment and was b most expensive. It was a very well-made appliance.

The Klearway was comfortable on the teeth with good lateral freedom, but the transpalata advancement screw was quite bothersome to the tongue.

The Thera Snore had no firm retention on the lower teeth but relied on a lingual ramp to n mandible forward. This was quite uncomfortable and ineffective compared to other devic

The TAP fit the teeth extremely well and was capable of great advanceability and retentio probably making it good for obstructive sleep apnea. Its lingual hook mechanism was bot to the tongue, and its titration knob protruded out the lips.

The Restore fit the teeth very well and would probably be good for obstructive sleep apne anterior hook mechanism sometimes pinched the lips.

The Snore Free was soft and comfortable but also had a lingual ramp instead of lower teet retention and was therefore less effective at holding the mandible forward. Its price is low

The NAPA was quite similar to the Mandibular Repositioner, except that it had a beak-lik protruding through the lips. The beak seemed unnecessary.

The Elastomeric appliance could have benefited from a larger air hole (which the tongue protrude into). It was comfortable and effective but very difficult to grind, which was nec because the flanges rubbed the gums.

The TRD was comfortable but much more difficult to get used to than the mandibular adv

The Snore Guard seemed too small to be effective and relied on a lingual ramp to hold the mandible forward, instead of retention on the lower teeth.

The Snore X was simple to wear but produced a very sore tongue tip the next day.

The SNOAR appliance was made at a very large vertical opening, making lip seal impos making the appliance difficult to wear.

Discussion

The criteria for evaluating oral devices presented in this paper do not include efficacy in r obstructive sleep apnea or daytime sleepiness, and certainly the field of medicine would b interested in such results if available. This paper focuses more on snoring.

The criteria for selection presented here also do not include durability of the appliances, p because durability has not been studied yet. However, the following comments reflect the experience.

To keep the appliances closed, the Herbst appliances need vertical elastics that must be ch occasionally. The vendors did not supply elastics. Nor did the Herbst vendors supply adv shims unless requested. The EMA appliance needs its elastic straps changed occasionally (frequency unknown). The Hilsen seems to fit more loosely over time, and the Velcro stri to partly tear loose but they are secured with monofilament thread. The PM Positioner is s subject to breakage where the jackscrews are attached to the splints, especially if the appli removed improperly. Silent Nite splints are somewhat thin and have a history of some bre which may be resolved by now. The Silent Nite nylon straps are also thicker than they we

previously, and they are now adjustable by the dentist in that straps of different lengths ar provided along with instructions on how to change them. Also, the Silent Nite can be mad different (thicker and softer) material if the doctor notifies the lab that the patient is a brux Restore jackscrew broke off once when the appliance was assembled incorrectly but it wa repaired with self-cure acrylic. The NAPA sometimes produced a whistling sound througl The TAP is very much improved and simpler to deliver.

Another factor that has not been studied here is the tendency for appliances to move teeth change the bite permanently. It has been suggested at Sleep Disorders Dental Society mee the thermoplastic appliances may be more likely to move teeth than their rigid plastic cou has also been said that shallow bites or open bites are more likely to change from wearing devices than deep bites.

There is a wide range of behavior of the thermoplastics used in these devices, from the ve boil-and-bite devices to the medium-soft acrylic in the Hilsen, to the very firm material in Positioner. Devices using thermoplastic include PM Positioner, Hilsen, Silencer, Klearwa Snore, Restore, Snore Free, TAP, and Snore Guard.

There have been people who have advocated using the less expensive devices as trial devi if the patient can tolerate a dental appliance, and then replacing the trial device with a mo permanent long-term device. For example, it is often suggested that a Snore Free be used patient can tolerate and benefit from mandibular advancement. Also, the Snore X was dev see if a patient can tolerate and benefit from a tongue advancing device. In reviewing the ratings, one can re-evaluate those suggestions. The Snore Free appliance is so inferior to t mandibular advancers, particularly in reliability at stopping snoring and in not disturbing a patient who did not do well with the Snore Free still might do fine with a better applianc trial appliance therefore served no purpose.

However, in the case of the Snore X, which is a trial device preceding a TRD, the ratings close that there is no reason not to do the Snore X first. If a person could not tolerate nor t from a Snore X, there is some likelihood that that might be true of a TRD too.

Table 3 is a list of snore appliance vendors. There are probably additional vendors for the Mandibular Repositioner, and PM Positioner, but this is a listing of vendors who were kin to provide appliances to be studied. No deliberate exclusion of other vendors was intende

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Author

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