Use of Portable Monitoring for Sleep-Disordered Breathing Treated with an Oral Appliance

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KEYWORDS

• Oral appliances • Portable monitoring • Home sleep study
• Screening • Titration

The potential use of a portable monitor to assess the outcome of treatment with an oral appliance would ideally be performed by the dentist who is managing the patient's sleep-disordered breathing. A sleep medicine physician or sleep center may also perform such a study. The dentist may be using portable monitoring as a means of assessing the response to the oral appliance after an initial titration period along with assessment of the patient's symptom resolution before referral back to the patient's physician, sleep medicine specialist, or for a follow-up polysomnogram. Portable monitoring may be one of the most cost-effective ways for the treating dentist to assess the outcome or effect of the oral appliance, to determine if further adjustment/modification to the appliance is needed, and to retest to determine the current status following any adjustment or modification.

This article emphasizes the use of portable monitors primarily for follow-up care and assessment as opposed to diagnosis or, as it is sometimes referred to, screening. Many have advocated the use of portable monitor type devices as a means by which the dentist can screen patients who might be at risk for sleep apnea.[1,2] This is clearly a diagnostic procedure for a potential medical condition that is not within the scope of dental practice at this time. Portable monitors, specifically level 3 devices, have limited use as an alternative to the overnight polysomnogram (level 1) as an effective instrument for the diagnosis of sleep apnea.[3]

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HISTORY AND CURRENT STATUS: A CASE REPORT

A 54-year old man presents to a dentist who has advanced training and is competent in dental sleep medicine and the use of oral appliances for managing sleep-disordered breathing. He was referred to the dentist by the sleep center where the polysomnogram was done and his primary care physician, mainly because he was unable to tolerate continuous positive airway pressure (CPAP) despite trying numerous masks. He had a consultation with an otolaryngologist about possible surgery and was also informed that an oral appliance would be more appropriate at this time. His Epworth Sleepiness Scale score was 13 (the normal value is >10) and the apnea/hypopnea index (AHI) was 21 per hour of sleep. His body mass index is 28 kg/m^2 and his neck size is 40 cm. He has been diagnosed with hypertension, which is controlled with Lisinopril and hydrochlorothiazide. With medication, his blood pressure is 121/82. He denies having any other health-related issues, specifically cardiovascular disease or diabetes. He reports that his sleep onset is within 15 minutes but his sleep is restless with multiple awakenings (2–3 per night) and he gets 6 hours of sleep a night on average. He reports that he has snored for more than 20 years; and in the last 5 years the snoring has become more problematic and observed apnea has occurred.

A formal orofacial and airway evaluation was performed as has been described and recommended for the dentist who performs this type of service.[4] This also included an evaluation of the nasal airway. During the evaluation, he denied being a mouth breather at night and has no difficulty breathing through the nose. However, nasal dilation (commonly known as the Cottle test) improved the patient's ability to nose breath. He did report trying nasal strips for nasal dilation but they were not effective for the snoring and did not seem to affect his sleep.

By virtue of testing, it was determined that with the mandible repositioned, which included opening the vertical approximately 5 mm and advancing the mandible 2–3 mm, he believed his airway was improved and he would not snore. At this point, an oral appliance was determined to be an appropriate treatment and the necessary records were obtained for the fabrication of the oral appliance.

At the first follow-up 2 weeks after receiving the oral appliance, he reports that the snoring is significantly improved, he feels his sleep and feeling of being tired and sleepy during the day are improved. He also feels he is more productive at work and not as tired at the end of the day. Some adjustment to the oral appliance is done mainly for comfort and he is reappointed in a month. He has had the oral appliance for 6 weeks and reports that his symptoms continue to improve and his snoring is present but much improved. Because of the snoring, his mandible is advanced approximately 2 mm and with this change he feels his breathing is also improved. He is reappointed for a follow-up visit in another month.

At the third follow-up visit he reports that the snoring is no longer present according to his wife and he continues to believe that he has improved energy levels and is sleeping through the night. He awakens rested and wakes up without an alarm most mornings. By report, his initial complaints and neurocognitive symptoms are improved (**Table 1**). At this point no further adjustment is deemed necessary and he is reappointed for a follow-up visit in 2 months.

He has now had the oral appliance for more than 4 months and is satisfied with the results. At this time a portable monitoring sleep study to assess the effect of the oral appliance and to determine if any further adjustment is needed, is arranged. It is explained that this is not the same type of sleep study that he had initially. This study is not for diagnosis of sleep apnea (this has already been done) but to determine if the

Table 1
Case report: symptoms of obstructive sleep apnea before and after use of an oral appliance

Symptom	Before Oral Appliance Use	With Oral Appliance Use
Snoring	Present	Resolved
Epworth Sleepiness Scale score	13	5
Excessive daytime sleepiness	Present	Reduced/improved
Drowsy driving	Present	Eliminated
Concentration	Difficult	Improved
Energy levels	Low	Improved/resolved
Observed apnea	Present at times	None
Mood swings/irritable	Present	Resolved
Restless sleep	Present	Resolved
Awakenings each night	2 to 3	None now
Headaches	Occasional (2–3 a week)	None

appliance is managing the apnea adequately. The appropriate consent forms are completed and he is scheduled to have the study done.

The portable monitoring study is completed after the patient is instructed on the use and application of the equipment. He will do a 1-night study and return the equipment to the office the next day. At that time, the data will be downloaded for review. The results of the portable monitoring study reveal that the AHI is now 7 and his blood oxygen levels are in the 90% or greater range, nearly 100% of the time. His Epworth Sleepiness Scale score is now 5. At this time he seems to be deriving a reasonable outcome with the oral appliance. A report is generated and will be sent to the referring physician, to the sleep center where the initial sleep study was performed, and to any other physicians who are directly involved with the patient's care. A decision will be made regarding the need for an attended level 1 sleep study to further substantiate the effect of the oral appliance and his current level of apnea.

Portable Monitoring for Diagnosis Before Oral Appliance Therapy

The dental sleep medicine practitioner is the one who will most likely be providing an oral appliance. However, the use of portable monitoring to screen for sleep-disordered breathing in those patients who may be at risk for sleep apnea is not within the scope of practice by the dentist. Despite the advanced training the dentist may have in sleep medicine, they, like most primary care physicians, are not well-versed in the recognition of coexisting sleep disorders that may present as the same type of symptoms as sleep-disordered breathing.[5] Even with advanced training, the level 3 portable monitor will not provide adequate information to allow for the diagnosis of comorbid sleep disorders such as central sleep apnea, periodic limb movements (PLMs), parasomnias, various circadian rhythm sleep disorders, or narcolepsy. In addition, the portable monitor is not indicated for use as a general screening device in an asymptomatic population. The more appropriate action is to identify those patients who are at risk for sleep-disordered breathing. Once it is established that the patient is at risk, the patient should be referred to their primary care physician or to a sleep center for a polysomnogram.

In general, the use of the level 3 portable monitor is not accepted as the optimal method for diagnosing sleep-disordered breathing at the present time. The gold standard continues to be the overnight polysomnogram.[3] However, there are numerous

articles that support the use of these portable monitors for patients with high pretest probability of being at risk for sleep-disordered breathing.[6,7]

The main issue is that the sensitivity and specificity of these devices at an AHI less than 15 is not as good compared with an AHI greater than 15. One study did find that portable monitoring was most reliable at an AHI of 10 or more.[8] In addition, portable monitors may actually underestimate the severity of sleep apnea. This is related to the computation of the AHI and more specifically, the respiratory disturbance index (RDI) per hour of recording time because of the difference in total sleep time versus total recording time.[9]

Another issue related to diagnosis using a portable monitor, even if it is being used to assess just snoring, is if the outcome is negative (RDI >5), then the patient may not seek or obtain treatment. Who then assumes the liability for the medical consequences of the sleep apnea? Given that the portable monitor may underestimate the degree of sleep apnea, this is of particular concern in patients who are asymptomatic and may only perceive the issue as snoring, not sleep apnea.

The role of the dentist, regardless of the level of training, is to perform risk assessment for a sleep-disordered breathing condition. Risk assessment is initially done by having an awareness of the following[4]:

1. Assessment of findings through questions in the health history (screening)
2. Assessment of the most common symptoms of sleep-disordered breathing
3. Awareness of existing medical conditions that indicate the possible risk for sleep-disordered breathing
4. Use of standard questionnaires such as the Epworth Sleepiness Scale or the Berlin questionnaire
5. Findings from the head/oral/airway clinical evaluation.

Based on the assessment of risk and comorbid conditions, the patient is referred to a sleep medicine specialist or for a sleep study. That study would most likely be a polysomnogram.

Portable Monitoring for Progressive/Follow-Up Testing with Oral Appliance Therapy

The use of level 3 portable monitoring based on published clinical guidelines has been recommended (consensus) for the purpose of determining the effectiveness of oral appliance therapy for sleep-disordered breathing.[3] This is stated as follows:

> *Sect 1.4 PM: "Portable Monitoring (PM) may be indicted to monitor the response to non-CPAP treatments for obstructive sleep apnea, including oral appliances, upper airway surgery, and weight loss."*

Furthermore, the use of level 3 portable monitors for assessment of the effectiveness of an oral appliance after the final adjustment is a practice parameter guideline.[10] A more practical point of view would potentially use the portable monitor at various points in the titration process of the treatment to determine if added adjustment or modification is needed before a more definitive sleep study. Assuming that the level 3 portable monitor is reliable, its use would contribute to improvement in consistent and successful use of the oral appliance for the management of sleep apnea.[8] In some cases, the level 3 portable monitoring study may actually be satisfactory in determining that the oral appliance is adequately addressing the sleep-disordered breathing. This is a decision that ultimately should be made by the sleep medicine specialist, not the treating dentist.

The American Academy of Dental Sleep Medicine (AADSM) in 2005 also established a position as it relates to the use of portable monitoring.[11] The position that has been taken is that the use of portable monitoring should be restricted to use for titration of the oral appliance (the need for adjustment and modification) for an enhanced effect and to document the effectiveness of the treatment. Furthermore, the use of portable monitors "as a screening tool" designed to identify those patients who may require an overnight polysomnogram is not endorsed at this time. In 2009, the AADSM published a treatment protocol for oral appliances that indicated that portable monitoring was applicable for gathering objective data for the purpose of oral appliance titration.[12]

Based on studies that have looked at the use of level 3 portable monitors compared with polysomnograms for diagnosis, it seems that the portable monitor should provide information to determine that the oral appliance is adequately resolving the sleep-disordered breathing and has also improved the patient's symptoms. Concern for the recognition of other coexisting sleep disorders is not an issue with the use of this technology because these conditions have most likely been recognized (diagnosed) from the original polysomnogram and their management is being considered aside from the use of the oral appliance for the sleep-disordered breathing. Consequently, not all of the parameters of the sleep study are needed to ascertain that the oral appliance is effectively managing the sleep-disordered breathing. The parameters of greatest value in evaluating the effectiveness of the oral appliance are listed in **Table 2**.

Assessment of the AHI based on the use of a thermistor may underestimate the number of hypopneas.[13] Measurement of nasal pressure is more sensitive but may be subject to signal loss. More importantly, mouth breathing will also decrease the effectiveness of this measuring device. The presence of mouth breathing in patients with sleep apnea is a significant issue that is often underevaluated and insufficiently addressed. Before any testing using the portable monitor, an effort should be made to address mouth breathing when using an oral appliance and strategies should be used to improve the nasal airway and nasal breathing while using the appliance. This is best done using nasal rinses, nasal dilation, and in some cases, nasal airway surgery. Myofunctional tongue therapy has also been shown to be helpful with improvement of the tongue posture and by achieving a lip seal, which may improve nasal breathing during sleep.[14] If the patient continues to be predominately a mouth breather, this needs to be considered when the level 3 portable monitor is being

Table 2
Parameters of value to determine effectiveness of an oral appliance with portable monitoring

Parameter Being Tested	Significance
AHI	Needs to be less than 10 and ideally less than 5 (not always possible due to sensitivity and specificity for $\leq$10 or $\leq$15) based on the device
Snoring	Need to evaluate presence or resolution If present, for what period of time
Oxygen saturation	Ideally needs to be in the 90% range nearly 100% of the time Need to distinguish parameter of desaturation (3% vs 4%)
Sleep position	Not always available on all devices
Sleep bruxism (optional)	Ideal from the standpoint of the dentist and as a coexisting condition Not available on portable monitors; can be adapted on selected devices

used for titration. In this type of situation, the oral appliance should be titrated to an optimum outcome and the patient should have an overnight polysomnogram to better ascertain the effectiveness of the oral appliance.

A poster presentation at the AADSM annual meeting in June 2010 addressed the use of portable monitoring (home sleep monitoring) for the purpose of guiding the titration of the oral appliance. The study looked at 32 subjects who had been diagnosed with moderate to severe sleep apnea. The testing device reported the AHI, the amount of time that the oxygen saturation was less than 90% and the O_2 nadir.[15] By using such a system it was determined that the oral appliance was effective in 71% of the patients. It was also found that the O_2 nadir increased by 4.5% and the percent of time the oxygen saturation was less than 90% improved by 64%. This was also correlated to the patient's symptoms; there was a significant improvement in quality of life and daytime sleepiness was improved in 90% of the patients in the study. The conclusion here is that once the patient has experienced a subjective improvement in the initial symptoms, the portable monitor can be used to determine if there is also improvement objectively.

When the results of the portable monitoring testing are found to be satisfactory, there should also be adequate resolution of the symptoms that were present before the use of the oral appliance. When symptoms continue to be present, it may be due to other coexisting sleep disorders and not due to the sleep-disordered breathing. This is possibly the case with conditions such as sleep bruxism, insomnia, and PLM disorder. In these cases, the portable monitoring data may indicate improvement of the sleep apnea, which requires the investigation of other coexisting sleep disorders, often requiring a referral to the sleep medicine specialist.

The use of the portable monitor offers advantages that allow for ongoing assessment of the impact of the oral appliance that cannot be assessed through simple questioning of the patient. By testing at various intervals in the treatment/titration process, the oral appliance can be adjusted and modified based on both subjective as well as objective data. In addition, the issue of improving the nasal airway during sleep can be ongoing in an effort to minimize or eliminate any mouth breathing, and as that therapy progresses the portable monitor will be able to assess the impact on the sleep apnea and how well the oral appliance is performing.

Advantages to use of the level 3 portable monitor include:

1. Ease of use by both the patient and the doctor
2. Cost-effective for determination of the need for oral appliance adjustment and modification (titration)
3. Testing can be done on multiple occasions to allow for ongoing titration of the oral appliance before a more detailed sleep study
4. Results of the study are quickly available.

Disadvantages to use of the level 3 portable monitor include:

1. A lead may come loose and data are lost or not recorded
2. Device may simply not record properly
3. Device may be turned off or be taken off during sleep and thus there are no data recorded
4. Cost of disposables may be a factor in the per test cost
5. Patient may have difficulty hooking up the portable monitor.

The assessment of the successful effect of the oral appliance using portable monitoring may not be totally accurate based on the limitations of these devices as well as

the specific limitations of the patient and of coexisting sleep disorders. For these reasons, the outcome of the level 3 portable monitoring study should be shared with the sleep medicine specialist and the patient's primary care physician. The clinical guidelines indicate that when level 3 portable monitors are being used for diagnosis, the results need to be interpreted by a sleep medicine specialist. However, when these same devices are being used for titration, the need for interpreting the results is not defined. At this point, the resolution of the validity of this would best be achieved by a clinical study where an oral appliance is being used that compares the simultaneous use of the level 3 portable monitor and the polysomnogram. These data would determine the usefulness of the portable monitor for titration of the oral appliance as well as its use for confirmation of the effectiveness of the oral appliance in the management of the sleep apnea.

Another issue related to the use of the portable monitor by the nonphysician, in this case the dentist, is the cost. This applies to both the cost of the device, the cost for each test, and any related billing for the testing. The initial outlay for the portable monitor may be a concern. However, this has to be considered in relation to the potential savings in time that may be derived from being able to titrate the oral appliance more effectively and hence, decrease the number of follow-up visits for adjustment and modification, and may ultimately lead to more effective treatment outcomes. The situation as it relates to the cost for each test is directly related to the ability to charge or bill for the test. It is not advisable for the dentist to bill for any type of test that involves a diagnostic code for any type of sleep study or test. However, the cost to perform each test can adequately be absorbed into the fee for either the oral appliance or for the follow-up visit, depending on the fee structure or insurance contracted rates. The cost of each test needs to be considered when evaluating the various level 3 portable monitors that are available.

SUMMARY OF THE USE OF LEVEL 3 PORTABLE MONITORING RELATED TO ORAL APPLIANCE THERAPY

The following should be considered as it applies to the use of level 3 portable monitors related to the use of oral appliances:

1. The level 3 portable monitor is not to be used for initial screening or evaluation of patients with sleep-disordered breathing, particularly and solely by the dentist, who is advocating the use of an oral appliance for the management of this condition.
2. The level 3 portable monitor can be used as an objective measurement device for the titration (adjustment and modification) of the oral appliance to achieve an optimum and effective outcome.
3. The portable monitor could be used at a future time to reevaluate the quality of sleep of the patient who is using an oral appliance when symptoms related to sleep-disordered breathing recur.
4. The portable monitor could be used to retest an oral appliance at various intervals in time to be certain that it is continuing to perform optimally. This might be done every 3 to 5 years.
5. The portable monitor can be used at the time when a replacement oral appliance is needed. It could be used to titrate the replacement oral appliance or to determine that it is functioning at the same level as the previous one. In this situation, the results of the testing would be compared with the subjective symptoms and their improvement.

6. The use of the portable monitor to evaluate the effect of the oral appliance ideally should also be able to test for sleep bruxism. A few devices currently may be able to do this but this is not part of the standard process.

These points are not meant to serve as guidelines but to begin to offer direction for the use of the level 3 portable monitor as it relates to both the dental sleep medicine practitioner and the use of oral appliances. Over time, clinical studies and continued development of level 3 portable monitors will support the development of more and better-defined guidelines and eventually will evolve into practice parameters that will better direct the use of the testing device. This will then enhance the effectiveness as well as the acceptance of oral appliances as a treatment of sleep apnea.

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