

## Airway Orthotics:

# Normalizing the Pathological Airway



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*Acoustic evaluation of airway normalization can improve the efficiency in which airway orthotic therapy is provided leading to savings in time and resources.*

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The term “airway orthotic” (AO) is derived from the belief that these tooth-retained oral devices work by manipulating the jaw into the posture that best stabilizes the airway, thus normalizing airway behavior. Several studies have demonstrated their ability to normalize both airway structure and function through manipulation of mandibular posture.<sup>1-4</sup> Although officially condoned for the treatment of sleep-disordered breathing (SDB) by the American Academy of Sleep Medicine in 1995,<sup>5</sup> to date, issues such as AO candidacy selection, construction parameters, and titration settings continue to be dealt with through mostly anecdotal findings and subjective evaluation.

The practice of testing for normalization of pathological characteristics in order to determine therapeutic success is commonplace. Standard polysomnography, considered necessary to objectively confirm the efficacy of an AO, is actually evaluating the ability of an AO to normalize pathological airway behavior. Nocturnal pulse oximetry, demonstrated to be useful in the diagnosis and/or screening of sleep apnea in the general population,<sup>6</sup> has also been used to determine end-

point AO titration; this process involves determining if the AO has normalized oxygen desaturation. More recently, acoustic reflection (AR), demonstrated to be useful in evaluating upper airway dynamics with and without an AO in place,<sup>7-12</sup> has been used to provide immediate, chairside evaluation of the ability of an AO to normalize pathological airway behavior at various mandibular postures.

Depending on outcome criteria, an AO has been demonstrated to successfully treat SDB in approximately 48% to 69% of cases.<sup>13-15</sup> However, the clinical setting is not bound by the random selection protocol employed in these studies. The ability to establish candidacy for AO therapy by determining its ability to normalize airway structure and function prior to orthotic fabrication would isolate those individuals most likely to benefit from this therapy, potentially resulting in a dramatic increase in successful treatment. Obtaining immediate feedback regarding the degree of success in normalizing airway behavior of the pathological airway would aid in determining AO construction, titration, and maintenance parameters.

**Awake vs Asleep Airway:** Studies involving both AR<sup>7-12</sup> and other modalities<sup>16,17</sup> demonstrate a significant relationship between pharyngeal

characteristics of the awake and asleep airway. A recent publication<sup>17</sup> evaluating two collapsibility measurement techniques in normal and apneic subjects, during both wakefulness and sleep, concluded that “upper-airway collapsibility measured during wakefulness does provide useful physiologic information about pharyngeal mechanics during sleep and demonstrates clear differences between individuals with and without sleep apnea.” The existence of this relationship suggests that the ability of an AO to normalize airway pathology while the patient is awake provides insight into the ability of an AO to normalize airway pathology during sleep.

**Acoustic Reflection:** The Eccovision Pharyngometer (E. Benson Hood Laboratories, Pembroke, Mass) objectively evaluates and documents the pharyngeal cavity through the use of acoustic reflection. Its accuracy and reproducibility have been well documented.<sup>18-22</sup> These citations along with the manufacturer’s manual<sup>23</sup> adequately review the technology in general and its technique of use.

The Pharyngometer boasts two unique capabilities, making it an ideal diagnostic modality to evaluate airway structure and function.

- The ability to repeat readings at 0.2-second intervals, thus facilitating the study of airway compliance (collapsibility);
- The ability to evaluate the airway in three dimensions, providing an accurate accounting of the lateral increase in caliber that accompanies mandibular advancement,<sup>3</sup> thus allowing a more accurate assessment of cross-sectional area than that obtained from two-dimensional modalities such as the lateral radiograph.

**Normalizing the Airway:** Isono et al<sup>2</sup> studied 13 obstructive sleep apnea (OSA) patients under general anesthesia with total muscle paralysis, and demonstrated through video-endoscopy the following airway normalization with mandibular advancement:

- Increase in airway caliber at the palatal and tongue levels;
- Decrease in airway compliance demonstrated by the increase in negative pressure required to cause collapse of the airway.

These authors suggested that tension transmitted along the palatoglossus muscles to the soft palate may have been responsible for the witnessed airway normalization.

Abnormal behavior of the pathological airway in the awake state is well documented:

- Apneic pharyngeal airway caliber is significantly smaller than that in controls<sup>7,8</sup>
- Number of apneas per hour of sleep correlates significantly to pharyngeal cross-sectional area during wakefulness<sup>8</sup>
- Awake obese apneics demonstrate a smaller airway caliber and higher compliance when compared to controls<sup>10</sup>
- Non-obese apneics demonstrate a smaller airway caliber and a similar compliance when compared to controls<sup>9</sup>
- Paradoxical inspiratory narrowing at the glottis has been demonstrated in obese apneics<sup>11</sup>

Acoustic reflection has demonstrated normalization of pathological airway characteristics as they present in the awake airway post therapeutic intervention:

- Hypopharyngeal changes produced by mandibular advancement in the awake patient related significantly to improvement or absence of improvement in airway collapse with mandibular advancement during sleep<sup>12</sup>
- Positional therapy has been demonstrated to result in an increased airway caliber<sup>24</sup>
- Improvement in both pharyngeal structure and function has been demonstrated post successful uvulopalatopharyngoplasty (UPPP) surgery<sup>25</sup>

Our current knowledge base regarding the structure and function of the apneic airway as documented through AR in the awake state, along with norms of airway caliber established by Kamal,<sup>26</sup> can guide us in determining if an AO is in fact normalizing the characteristics of a pathological airway in the awake state.

A distinct continuum of airway characteristics from apnea to snoring to controls has been demonstrated in the literature.<sup>7-11</sup> Although caliber and compliance alternate in their role to distinguish patients at each level, obesity appears to influence airway dynamics

in the awake airway as documented through AR, and thus the relative importance of these characteristics. The objective of an AO is to prevent airway collapse during sleep, thus normalizing its behavior. The established relationship between the airway dynamics of the awake and asleep airway<sup>7,12,16,17</sup> suggests that the ability of an AO to normalize airway behavior during wakefulness can provide us with an assessment of its ability to normalize airway behavior during sleep.

**Candidacy:** Although it is difficult to determine whether an AO stabilizes the pharyngeal airway by increasing caliber or decreasing compliance, a chairside fabricated temporary bite-jig can be used prior to fabrication of an AO to evaluate these pathological airway characteristics at various mandibular postures. Comparison to literature-documented normal<sup>26</sup> and pathological<sup>7-11</sup> airway characteristics affords the ability to determine the effect of mandibular repositioning on that individual's airway. Normalization of structure and function in the awake state provides an objective evaluation of the ability of an AO to do so during sleep, which is useful in the determination of AO candidacy.

**Construction:** It has been popular to minimize vertical opening when constructing an AO. However, some patients appear to benefit from the varying of vertical posture of the mandible beyond that associated with mandibular protrusion. The temporary bite-jig discussed in the previous section facilitates the manipulation of mandibular posture in both the protrusive-retrusive and vertical dimensions, providing real-time evaluation of the level of airway normalization at each posture—useful in the determination of ideal construction parameters.

**Titration:** The question of how much mandibular advancement is necessary to ensure therapeutic efficacy is elusive. Current protocol involves advancement guided predominantly by subjective feedback from the patient. However, unnecessary mandibular advancement may result in hyperextension of the masticatory and cervical muscles. Of equal concern, reduction in airway caliber has been demonstrated in some patients with advancement past 75% of full protrusive.<sup>27</sup> The answer to this elusive question is “as much as

necessary, but as little as possible.” Clearly, the less we alter the patient's mandibular posture from that which they have become accustomed to, the fewer the side effects and the greater the long-term compliance. AR provides immediate evaluation of the orthotic's ability to normalize pathological airway characteristics at various mandibular postures, thus ensuring titration that results in the most ideal management of the airway, helping to minimize the possibility of inadvertent advancement past the ideal point of effectiveness, or into a position that would unnecessarily strain the masticatory and cervical muscles.

**Maintenance:** Regular follow-up is regarded as mandatory whenever ongoing therapy is prescribed; a recent publication demonstrated that patients attending regularly for adjustments and follow-up visits experience a better long-term effect than patients continuing to use their original AO.<sup>28</sup> An acoustic examination at these regular follow-up visits provides objective verification that the AO is still ideally titrated to optimize airway normalization.

**Conclusion:** We have discussed the concept of normalizing airway structure and function through repositioning mandibular posture with an AO, and the rationale for use of AR to evaluate the level of airway normalization. Although a substantial number of studies have been published that support these concepts, further validation is warranted and would benefit this area of practice. The ability to isolate those individuals most likely to benefit from an AO prior to orthotic construction would reduce or potentially eliminate treatment failures for those patients prescribed this therapy. The ability to obtain immediate feedback regarding the degree of airway normalization using either a chairside fabricated bite-jig or the actual AO would provide valuable information regarding construction, titration, and maintenance parameters. Finally, acoustic evaluation of airway normalization would improve the efficiency with which airway orthotic therapy is provided, leading to meaningful savings in time and resources for both the patient and practitioner. [SR](#)

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**Biography:** *John S. Viviano, BSc, DDS, obtained his credentials from the University of Toronto and has maintained a private practice of general dentistry in Ontario, Canada, since 1983. He maintains a special interest in the treatment of snoring, sleep apnea, and sleep-disordered breathing. He is a member of various sleep organizations, is credentialed by the certifying board of the Academy of Dental Sleep Medicine, and has lectured on behalf of various organizations regarding the treatment of snoring and sleep apnea. Dr Viviano utilizes a variety of appliance designs in his conservative treatment of sleep-disordered breathing.*

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