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Definitions, Abbreviations, and Acronyms of Sleep Apnea

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Understanding the most commonly used definitions, terms, and acronyms in medicine as they relate to sleep-related disorders is a crucial first step for all practitioners interested in caring for patients who suffer from such conditions. We have chosen several important terms, definitions, and acronyms for this article. Many other terms are discussed in each individual article.

Apnea: Literally means "no breath." A cessation, or near cessation, of respiratory airflow that lasts 10 seconds or longer.

Obstructive sleep apnea (OSA): Cessation of breathing during sleep because of a mechanical obstruction, such as a partially collapsed trachea, retropositioning of the tongue in the airway, which blocks airway passage, or a large amount of tissue in the upper airway (Fig. 3). It is a common respiratory sleep disorder characterized by snoring and episodes of breathing cessation or absence of respiratory airflow ($\geq$10 seconds) during sleep despite respiratory effort.

Hypopnea: A disturbance in respiratory airflow that does not meet the defined criteria of apnea but still results in a physiologic consequence, such as an oxygen desaturation and/or an arousal from sleep (Fig. 2). More specific definitions vary widely; for example, a 20% to 50% or more reduction in airflow associated with an arousal and/or a 3% to 4% drop in oxygen saturation. The physiologic consequences of hypopneas are equivalent to those of apneas. It is generally accepted as 50% loss of airflow for 10 or more seconds caused by the lack of thoracic and abdominal effort.

Central sleep apnea: Cessation of breathing (respiratory effort) during sleep as a function of neurologic failure. Simply, the body "forgets" to breathe.

Mixed sleep apnea: The combination of central and obstructive sleep apnea in one patient.

Snoring: A noise produced primarily on inspiration during sleep that is caused by vibration of the soft palate and the pillars of the oropharyngeal inlet (Figs. 1 and 4). Snoring implies incomplete obstruction of the upper airway.

Somnolence: Difficulty in maintaining alert wakefulness so that a person falls asleep if not actively aroused. Also called hypovigilance, sleepiness.

Lowest oxyhemoglobin saturation (LSAT): A measure of the lowest level of arterial oxygen in the blood during sleep. Normal oxyhemoglobin saturation is 95% to 98%.

Basic sleep cycle: Progression through orderly succession of sleep states and stages. For the healthy adult, the first cycle begins by going from wakefulness to non–rapid eye movement (NREM) sleep. The first REM period follows the first period of NREM sleep, and the two

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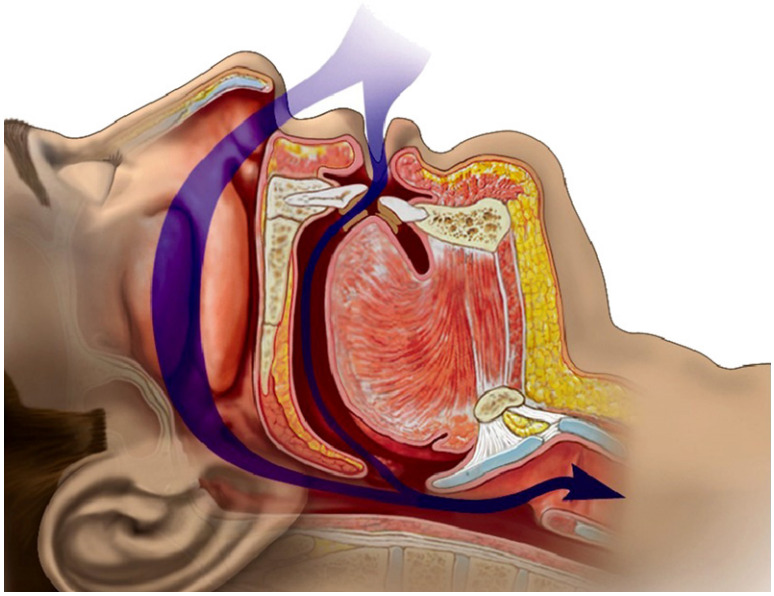

Fig. 1. Normal airway: normal position and size of tongue, hard and soft palate, epiglottis, geniohyoid, and genioglossus muscles, as well as position of the jaws and hyoid bone plus an open nasal passage allows airflow without obstruction through the upper airway. (*Courtsey of* Mansoor Madani, DMD, MD, Bala Cynwyd, PA, all rights reserved; with permission.)

sleep states continue to alternate throughout the night, with an average period of 90 minutes. A night of normal human sleep usually consists of four to six NREM/REM sleep cycles.

NREM (non-REM stages of sleep): Major states of sleep with the exception of REM sleep. It comprises four stages of sleep. **Sleep Stage 1:** A stage of NREM sleep that occurs after

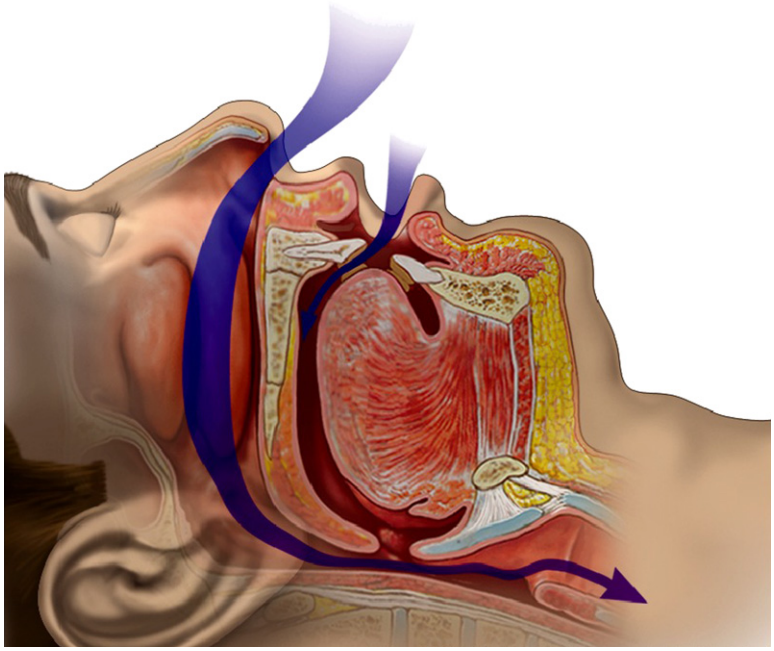

Fig. 2. Hypopnea: enlargement of tongue, elongation of the uvula and soft palate, and partial upper airway obstruction creates a disturbance in respiratory airflow. Although this partial obstruction differs from complete blockage of the airway (apnea), it still results in physiologic consequences, such as oxygen desaturation and/or arousal from sleep and snoring. (*Courtsey of* Mansoor Madani, DMD, MD, Bala Cynwyd, PA, all rights reserved; with permission.)

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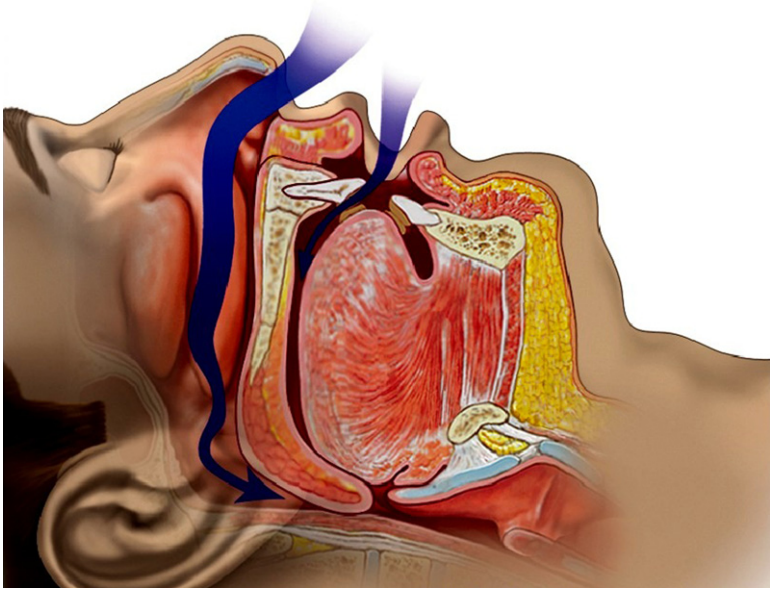

Fig. 3. Obstructive sleep apnea: a combination of several factors causing complete upper airway obstruction leading to cessation of airflow for at least 10 seconds (and more), if repeated more than 5 times per hour then is described as obstructive apnea. The structures blocking the upper airway include: enlarged tongue and retropostioning of tongue base in the pharynx, elongated and edematous uvula, obstructive tonsils and nasal passages, hypertrophic pharyngeal walls, and in general constricted oropharynx. (*Courtsey of* Mansoor Madani, DMD, MD, Bala Cynwyd, PA, all rights reserved; with permission.)

waking. Its criteria consist of a low-voltage electroencephalogram (EEG) with slowing to theta frequencies, alpha activity less than 50%, EEG vertex spikes, and slow rolling eye movements; no sleep spindles, K-complexes, or REMS. Stage 1 normally comprises 4% to 5% of total sleep. **Sleep Stage 2:** A stage of NREM sleep characterized by sleep spindles and K-complexes against a relatively low-voltage, mixed-frequency EEG background; high-voltage delta waves may comprise up to 20% of stage 2 epochs. Stage 2 usually accounts for 45% to 55% of total sleep time. **Sleep Stage 3:** A stage of NREM sleep defined by at least 20% and not more than 50% of the period (30-second epoch) consisting of EEG waves less than 2 Hz and more than 75 uV (high-amplitude delta waves); a "delta" sleep stage. With stage 4, it constitutes "deep NREM sleep." Stage 3 usually comprises 4% to 6% of total sleep time. **Sleep Stage 4:** All statements concerning NREM stage 3 apply to stage 4 except that high-voltage, slow EEG waves cover 50% or more of the record. Somnambulism, sleep terrors, and sleep-related enuresis episodes generally start in stage 4 or during arousals from this stage. Deep sleep refers to combined NREM sleep stages 3 and 4 in sleep studies. EEG delta waves (EEG activity with a frequency <4 Hz) also are prevalent or predominant during these two stages of sleep. This period is called "delta sleep," and it appears usually only in the first third of the sleep period. Stage 4 usually takes up 12% to 15% of total sleep time.

REM: The fifth stage of sleep, in which brain activity is extensive, brain metabolism is increased, and vivid hallucinatory imagery or dreaming occurs. It is a state of sleep that recurs cyclically several times during a normal period of sleep, and it is characterized by increased neuronal activity of the forebrain and midbrain, depressed muscle tone, and—especially in humans—dreaming, REM, and vascular congestion of the sex organs. Also called "paradoxical sleep," because in the face of this intense excitation of the central nervous system and presence of spontaneous REM, resting muscle activity is suppressed. The EEG is a low-voltage, fast-frequency, non-alpha record. REM usually comprises 20% to 25% of total sleep time.

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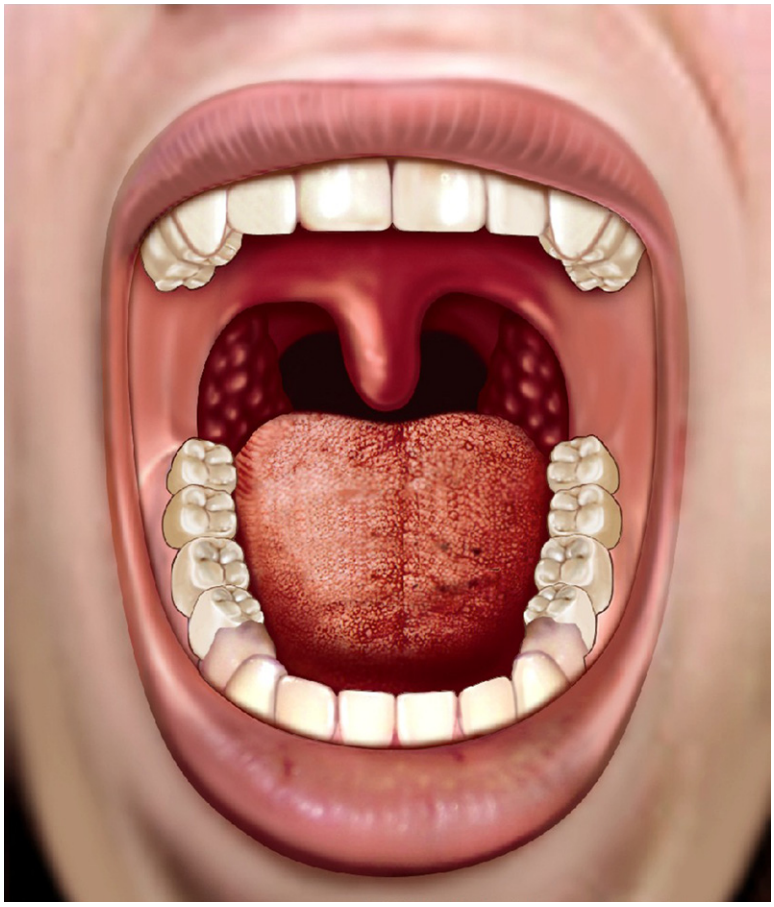

Fig. 4. Surgical treatment always begins in a comprehensive evaluation of the oral and nasal cavity. The size and position of tongue, tonsils, soft palate, uvula, and the jaws, as well as the pharyngeal opening, are of crucial assessment in this view. (*Courtsey of* Mansoor Madani, DMD, MD, Bala Cynwyd, PA, all rights reserved; with permission.)

Polysomnograph/Polysomnogram: Biomedical instrument for measuring multiple physiologic variables of sleep.

Polysomnography (PSG) (sleep study): A mechanical recording of a person's sleep using many criteria, such as the amount of oxygen in bloodstream, pulse, brain waves, and eye movement, among others. Polysomnography continuously and simultaneously records physiologic variables during sleep (Fig. 5).

Full-night polysomnography: Uninterrupted overnight sleep studies compared to split-night studies, during which time patients are awakened to try using continuous positive airway pressure (CPAP) for the second half of their sleep (Fig. 6).

Electroencephalogram (EEG): Recording of electrical potentials from the brain through the scalp and the changes in these potentials. The EEG is one of the three basic variables (along with the electro-oculogram and electromyogram) used to score sleep stages and waking. Surface electrodes are used to record sleep in humans and record potential differences between brain regions and a neutral reference point or between brain regions.

Electromyogram (EMG): Recording of electrical activity from the muscular system; in sleep recording, synonymous with resting muscle activity or potential. The chin electromyogram, along with EEG and electro-oculogram, is one of the three basic variables used to score sleep stages and waking. Surface electrodes are used to record sleep in humans and measure activity from the submental or masseter muscles. These records reflect the changes in resting muscle activity. During REM sleep, the chin/cheek electromyogram is tonically inhibited.

Electro-oculogram (EOG): Recording of voltage changes that result from shifts in position of the eyeball, which is possible because each globe is a positive (anterior) and negative

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Fig. 5. In an overnight standard polysomnography (sleep apnea study), patients are monitored both visually and electronically. The patient's 24-channel multilevel monitoring and direct visualization using a computer monitor are shown here.

(posterior) dipole. Along with the EEG and the electromyogram, one of the three basic variables used to score sleep stages and waking. Human sleep recordings use surface electrodes placed near the eyes to record the movement of the eyeballs. REM in sleep indicates a certain stage of sleep (usually REM sleep).

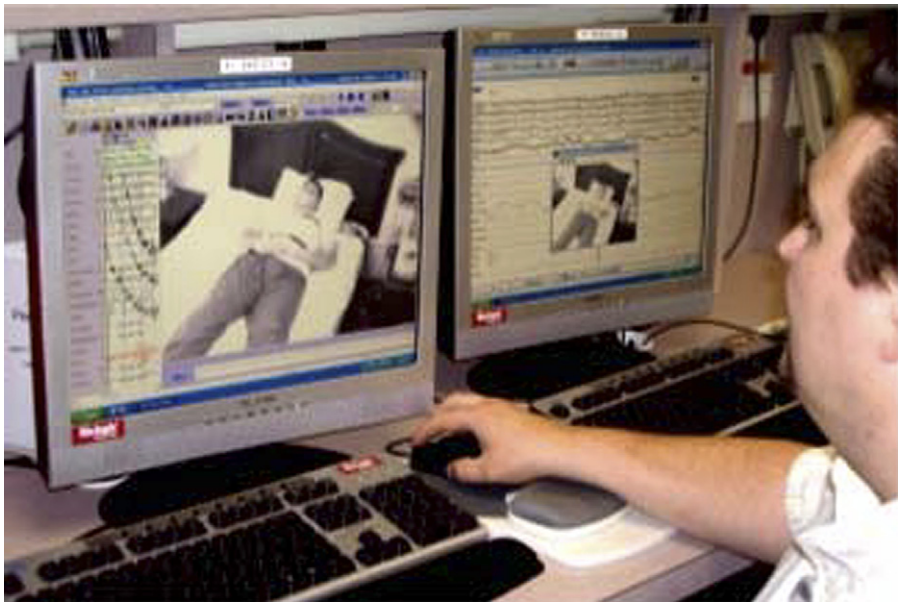

Fig. 6. Polysomnography requires an overnight technician trained in monitoring patients to asses each individual and, in some cases, score the results. The more modern devices will perform complete scoring automatically.

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Electrocardiogram: A graphic measurement of cardiac myoneural electrical activity.

Pulse oximetry (OX): A noninvasive measurement of the estimated level of arterial oxygenation in circulating blood SaO_2 (saturation of oxygen) A measure of blood oxygenation.

Home sleep monitoring: Sleep studies performed at home are gradually modernized and used as an alternative to polysomnography (Fig. 7). Some of the devices have been approved by the US Food and Drug Administration for screening and diagnosis of sleep apnea.

CPAP (NCPAP, nCPAP): A device that is used to alleviate symptoms of sleep apnea by providing a continuous, stable, predetermined volume of air to a nasal mask that the patient wears while asleep (Fig. 8). This continuous pressure keeps the airway from collapsing, as it does during obstructive sleep apnea. The pressure of CPAP is expressed in centimeters of water (cm H_2O). The positive pressure can range from 5 to 20 cm H_2O. Different patients require different pressures. The value is determined in a CPAP titration study.

BIPAP (bilevel positive airway pressure): Bilevel pressure device used to treat sleep apnea. The "bi" refers to two pressures: a lower pressure for exhalation and a higher pressure for inhalation. Bilevel machines are more expensive than a standard CPAP, but some patients tolerate it better because they can exhale comfortably against the constant inhalation pressure. The BIPAP can be set to drop the level at specific intervals or on demand.

Auto-PAP (APAP, automatic titrating [autotitrating] positive airway pressure): Also used to treat obstructive sleep apnea by positive airway pressure in which air pressure levels are automatically adjusted according to the patient's breath-to-breath requirements.

Periodic limb movement syndrome (PLMS): Characterized by leg movements or jerks that typically occur every 20 to 40 seconds during sleep. Periodic limb movement disorder causes sleep to be disrupted. These movements are typically reported by the bed partner. They fragment sleep and leave the person with excessive daytime sleepiness. This condition is related to restless leg syndrome.

Restless leg syndrome (RLS): A disorder of wakefulness in which leg movement may impede sleep onset. This feeling is difficult to describe and commonly is referred to as a crawling, tingling, or prickling sensation.

Fig. 7. Home sleep monitoring: one of the latest technology to asses, monitor, and diagnose sleep apnea. It eliminates overnight stay in a lab or hospital. It is a wrist-worn device that allows patient to be tested at the convenience of their home. The PAT 100 device comes with a memory card that, once connected to a computer, will score and create a report within minutes.

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Fig. 8. There are various designs of CPAP (Continuous Positive Airway Pressure), although considered "the gold standard" for treatment of obstructive sleep apnea, CPAP has poor patient compliance and acceptance because it is considered cumbersome and, in some cases, intrusive.

Upper airway resistance syndrome (UARS): Excessive daytime sleepiness (with or without other consequences of sleep fragmentation) caused by repetitive sleep arousals related to airway-resistive breathing disturbances, with respiratory disturbance index less than five per hour and in the absence of oxygen desaturations less than 90%. Snoring is generally (but not necessarily) present. Presumptively, "nonapneic snoring" with excessive daytime sleepiness.

Velopharyngeal incompetency or insufficiency (VPI): A dysfunction of the sphincteric closure action of the soft palate that allows regurgitation of fluid into the nose during swallowing and air escape into the nose during speech (open rhinolalia or "cleft palate speech"). This condition has been reported to be associated with excess tissue removal of soft palate during traditional uvulopalatopharyngoplasty.

Indexes of importance to sleep apnea

As a general rule, knowing various indexes is one of the most important tools of communication among interdisciplinary teams that manage patients with sleep-related disorders. We briefly describe a few important indices.

Apnea Index (AI): The number of apneic episodes that occur per hour during sleep. A measure of the severity of sleep apnea.

Hypopnea Index (HI): Mean number of hypopneic episodes per hour of sleep.

Apnea-Hypopnea Index (AHI): The number of apneic plus hypopneic episodes that occur per hour during sleep; 5 to 20 = mild, 21 to 50 = moderate, more than 51 = severe.

Body Mass Index (BMI): A measure of weight compared with height, calculated as weight in kilograms divided by height in meters squared. Some researchers believe that chances of heart attack and stroke increases ninefold for patients with morbid obesity. The categories for body mass index are as follows:

Healthy (desirable): 18.5–24.9 kg/m2
Overweight: 25–29.9
Obesity: ≥ 30
Morbid obesity: ≥ 35

Oxygen Desaturation Index: The number of oxygen desaturations less than 90% that occur per hour of sleep.

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Respiratory Arousal Index: The number of breathing-related sleep arousals or respiratory event arousals (alterations of sleep stages) per hour of sleep. This is the best measure correlated to excessive daytime sleepiness.

Respiratory Disturbance Index (RDI): Also called the apnea-hypopnea index (AHI), it is the mean number of respiratory disturbances per hour of sleep. The respiratory disturbance index is a calculation of the total number of apneas and hypopneas divided by number of hours of sleep.

Epworth Sleepiness Scale (ESS): Index of sleep propensity during the day as perceived by patients and derived from the answers to eight questions. This subjective score ranges from 0 to 24 and is not considered a reliable score.

Flattening Index: Number indicating the amount of airflow limitation caused by partial closure of the upper airway; 0.3 indicates an open airway, 0.15 is mildly obstructed, 0.1 is severely limited airflow, and 0.0 reflects a totally closed airway. Flattening index is used to identify the condition known as upper airway resistance syndrome and is continuously recorded in diagnostic sleep studies and CPAP titrations.

PLMD Arousal Index: Number of sleep-related periodic leg movements per hour of sleep that are associated with an EEG arousal.

Multiple sleep latency tests (MSLT): Measurements of the time required for sleep onset, which indicate a person's tendency to fall asleep.

Neck circumference: Not truly an index of apnea but clearly an important measure of estimated upper airway obstructions. As a general rule, neck size of more than 16.5 inches may correlate with obstructive sleep apnea in male patients. In women this correlation may be much lower neck size.

Retrognathic jaw position: Not an index but an orthodontically relevant measuring ratio that correlates with retropositioning of the jaw and the tongue base, which creates upper airway obstruction.

Procedures terminology

Various surgical procedures and hundreds of devices and inventions are designed to correct, reduce, or even eliminate snoring and sleep apnea. No claim has ever been proved to effectively eliminate the problem of obstructive sleep apnea completely, however. The reason is simply the multisite factors of apnea and inability of a single procedure or device to address them all. We briefly describe a few procedure terms:

Mandibulomaxillary advancement: A surgical procedure to advance either one or both jaws forward in addition to positioning the chin forward. The effectiveness of this procedure in corrected selected patients is equal to CPAP.

The illustration in Fig. 9A depicts an open bite deformity with retrognathic mandible and maxillary vertical excess. Note narrow airway in the retropharynx area. By performing maxillary impaction and advancement genioplasty and mandibular forward expansion, not only is the obstructed airway corrected but also the patient's functional and cosmetic enhancement are appreciated (Fig. 9B).

Genioglossus advancement (GGA): Advancement genioplasty to include genioglossus muscle to reposition the tongue in a forward position for treatment of obstructive sleep apnea.

Hyoid advancement: A surgical procedure to advance the hyoid bone and open the airway passage to improve obstructive sleep apnea.

Oral appliance therapy: A dental device designed to advance the position of the tongue and lower jaw forward to improve breathing and reduce snoring sound in patients with obstructive sleep apnea or various other disorders. Unfortunately, a patient's long-term compliance is an important issue when the appliance is given to most patients.

Radiofrequency ablation or radioablation: A thermal ablative treatment method to reduce hypertrophy of soft tissues (Fig. 10A–C). It also has been termed "somnoplasty and coblation" based on the makers of the devices. Long-term success of these procedures in most

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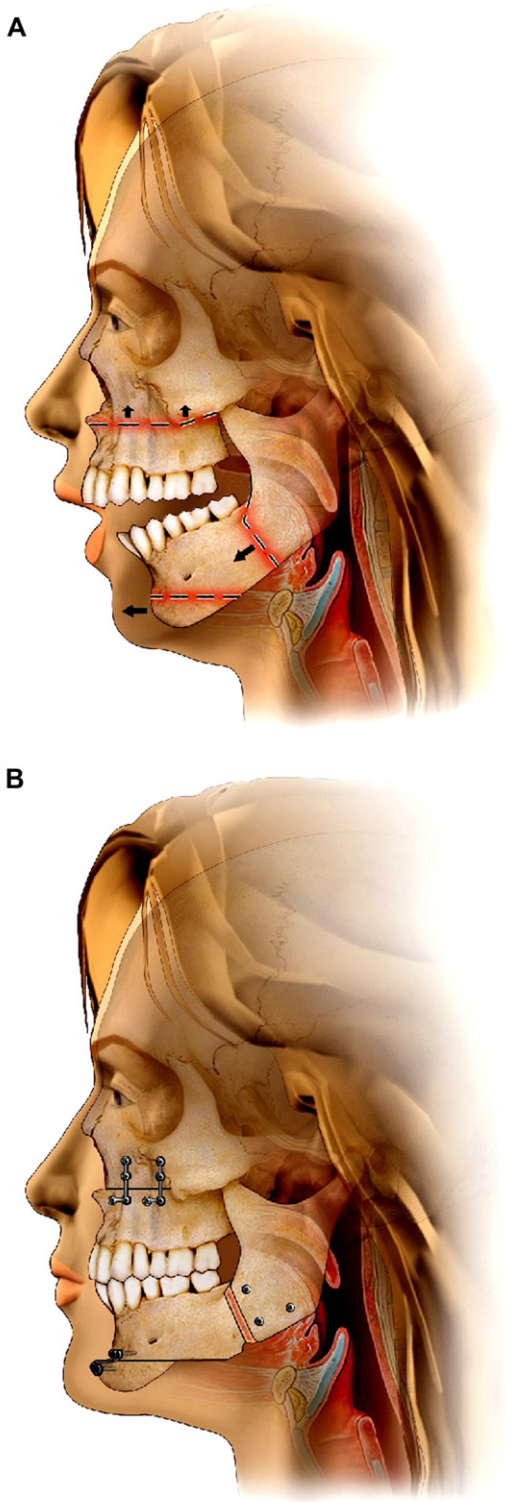

Fig. 9. (*A*) Mandibular micrognathism or bimaxillary retrognathism and a receded chin create a narrowing of the pharyngeal airway. Typically, patients have a retropostioning hyoid bone and very narrow airway. (*B*) A combination of maxillomandibular osteotomy and genioplasty, as well as advancement of genioglossus and geniohyoid muscles can significantly improve the upper airway. (*Courtsey of* Mansoor Madani, DMD, MD, Bala Cynwyd, PA, all rights reserved; with permission.)

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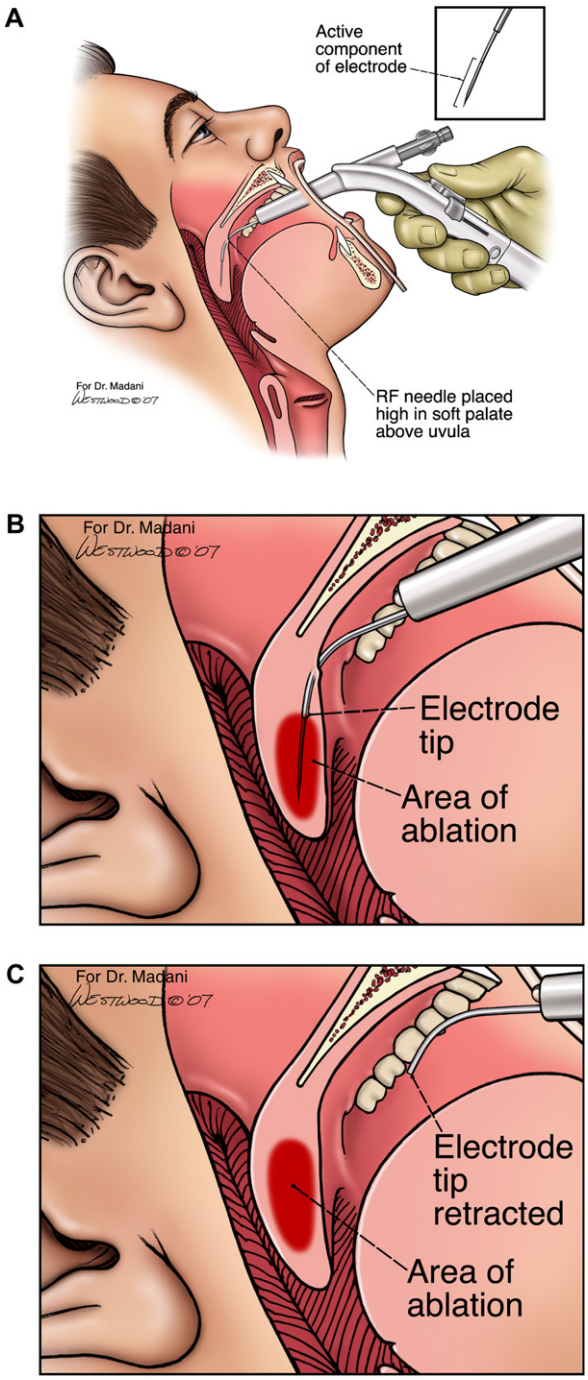

Fig. 10. Palatal radioablation: one of techniques utilized to stiffen the tissues of the soft palate in an attempt to reduce snoring intensity. (*A*) The position and direction of the radiofrequency device (RF) and patient position is shown. Note that these procedures are most beneficial for patients with small-sized uvula and very thick but floppy soft palate. (*B*) The RF delivers heath energy to the site and an internal scar formation leads to tissue stiffing. Note that poor angulation could cause the probe to extrude to the opposite part of the soft palate, creating an unfavorable result. (*C*) Once the RF probe is removed, the patient will have surface tissue charring and mild to moderate pain. Healing will take about 1 to 3 months.

patients is discussed in this issue and seems to be unsatisfactory in case of palatal and base-of-the-tongue ablations.

Uvulopalatopharyngoplasty (UPPP or UP-3): A surgical procedure in which the tissues of the soft palate, including the uvula and possibly the tonsils, are removed to improve upper airway obstruction (Fig. 11A–C). The removal of these redundant/flaccid pharyngeal tissues

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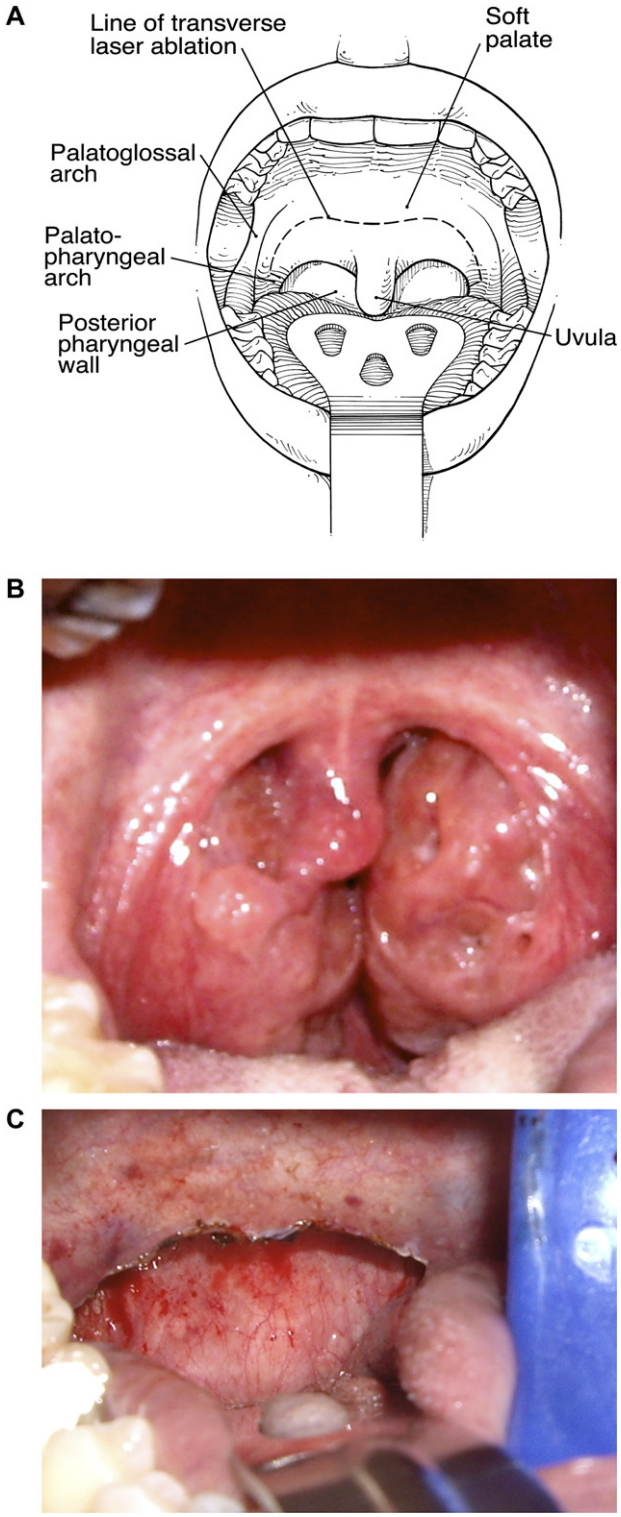

Fig. 11. LA-UPPP and tonsillectomy: two of the most effective soft tissue surgical procedures for the treatment of snoring and obstructive sleep apnea. (*A*) The anatomic landmarks to perform LA-UPPP. Note that excessive soft palate reduction could lead to velopharyngeal insufficiency, nasal fluid reflux, and voice change. (*Modified from* Madani M. Surgical treatment of snoring and mild obstructive sleep apnea. Oral Maxillofacial Surg Clin N Am 2002;14:333–50.) (*B*) A patient with obstructive tonsils enlarged uvula, and extremely narrow airway could obviously benefit from surgical procedures. (*C*) Immediate postoperative view of the LA-UPPP procedure. Note lack of bleeding, excessive tissue charring, and clean surgical cut.

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when indicated reduces the sound of snoring significantly. Traditionally this procedure was performed in the operating room. Elsewhere in this issue, laser-assisted UPPP is explained in detail (Fig. 11A).

Laser-assisted uvulopalatoplasty (LAUP): A staged laser surgical procedure designed to reduce the length of the uvula only and alter the soft palate to reduce snoring. It must be noted that this procedure is falling out of favor because it does not address the lateral boundaries of the soft palate. Some authors believe that it narrows the airway after scar contraction.

Uvulopalatoplasty (UPP): A limited adaptation of UPPP designed to shorten and stiffen the uvula and soft palate without involvement of the lateral pharyngeal walls. Many practitioners also have modified LAUP to perform this procedure with laser.

Radiofrequency-assisted uvulopalatoplasty (RAUP): A procedure similar to laser-assisted uvulopalatoplasty. It is done with a radiofrequency (RF) instrument instead of a laser. A special RF electrode is used to make two vertical cuts on either side of the uvula, which are joined by a horizontal cut. The uvula is then removed. Occasionally, the edge of the soft palate is also trimmed.

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