

Surgical Management of Obstructive Sleep Apnea

Neil Tanna, M.D., M.B.A.
Benjamin D. Smith, B.S.
Philip E. Zapanta, M.D.
Irena Karanetz, M.D.
Brian T. Andrews, M.D.
Mark M. Urata, M.D.,
D.D.S.
James P. Bradley, M.D.

New York, N.Y.; Washington, D.C.;
Kansas City, Kan.; Los Angeles, Calif.;
and Philadelphia, Pa.



Summary: Surgical management of snoring and obstructive sleep apnea is indicated when a surgically correctable abnormality is believed to be the source of the problem. Many patients opt for surgical treatment after noninvasive forms of treatment have been proven ineffective or difficult to tolerate. With increasing frequency, functional rhinoplasty, septoplasty, turbinoplasty, palatal surgery, and orthognathic surgery are being used in the management of snoring and obstructive sleep apnea. Plastic surgeons' experience with aesthetic nasal surgery, nasal reconstruction, palatal surgery, and craniofacial surgery puts them at the forefront of performing surgery for snoring and sleep apnea. The role of functional septorhinoplasty, turbinoplasty, palatal surgery, genioglossal advancement, and orthognathic surgery is indispensable in the surgical management of obstructive sleep apnea. Multidisciplinary management of these patients is critical, and plastic surgeons are encouraged to work collaboratively with sleep medicine clinicians and centers. (*Plast. Reconstr. Surg.* 137: 1263, 2016.)

Obstructive sleep apnea is the most common form of sleep disordered breathing.¹ This highly prevalent condition is described as repetitive pharyngeal collapse during sleep, leading to disrupted gas exchange and fragmented sleep. Subsequent arousal from sleep restores airway patency.²

Airway collapse frequently causes snoring and is often the reason that a patient seeks treatment. However, obstructive sleep apnea has been associated with much more insidious conditions, including hypertension,^{3,4} diabetes,⁵ heart disease,⁶ stroke,⁷ and daytime somnolence⁸—which

can lead to a dramatically increased risk of motor vehicle accidents.⁹ Slight impairment of cognitive function has also been shown to be associated with obstructive sleep apnea.¹⁰ Of note, snoring in isolation, without documented sleep apnea, is rarely treated surgically. It is often reserved for severe cases, when conservative treatment options have failed.

Many risk factors for obstructive sleep apnea have been identified, with the strongest being obesity.¹¹ Markers of obesity such as waist or neck circumference have been shown to have a causal relationship with obstructive sleep apnea.^{12–15} The exact mechanism is not completely understood, but obstructive sleep apnea is likely caused by excess tissue altering the shape and function of the airway.¹ Gender is another commonly cited

From the Division of Plastic and Reconstructive Surgery, Northwell Health, Hofstra Northwell School of Medicine, Hofstra North Shore-Long Island Jewish Health System School of Medicine; the Division of Otolaryngology–Head and Neck Surgery, The George Washington University; the Division of Plastic and Reconstructive Surgery, University of Kansas Medical Center; the Division of Plastic and Reconstructive Surgery, University of Southern California; and the Division of Plastic and Reconstructive Surgery, Temple University. Received for publication June 13, 2015; accepted November 20, 2015.

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risk factor, with male subjects at a severalfold higher risk. Social, anatomical, and hormonal differences have been hypothesized, but the exact mechanism has not reached consensus.¹⁶

Craniofacial abnormalities are another risk factor of particular relevance to plastic surgeons.¹¹ Both hard- and soft-tissue alterations can lead to an increased risk of obstructive sleep apnea.^{17,18} Ethnic differences in anatomy have also been explored, with Asian populations at increased risk of obstructive sleep apnea.^{19,20} Increased age, genetics, menopause, nasal congestion, alcohol use, and smoking have also been implicated as risk factors for obstructive sleep apnea.^{1,2,11,21}

EVALUATION OF SUSPECTED OBSTRUCTIVE SLEEP APNEA

History

Patients suffering from obstructive sleep apnea commonly give a history of snoring, witnessed apneas by a bed partner, awakening themselves to gasping or choking, disrupted sleep, morning headaches, excessive daytime somnolence or fatigue, frequent napping, and even memory impairment.^{2,22,23} However, although many of these symptoms are sensitive, specificity is poor.²²

Physical Examination

Body mass index, waist circumference, and neck circumference (at the superior border of the cricothyroid membrane) should be recorded. Anterior rhinoscopy and a general inspection of the nasopharynx are warranted when obstructive sleep apnea is suspected. Septal deviation,

turbinate hypertrophy, and nasal valve compromise can be detected as contributing factors (Fig. 1).

The oropharynx should be examined, and classifications exist that can aid in the annotation of these physical findings. The Mallampati score, modified by Friedman et al., describes the relationship of the palate to structures in the oropharynx.²⁴ The evaluation is performed by asking the patient (in a sitting posture) to open his or her mouth, without protrusion of the tongue. This score helps objectively characterize the oropharyngeal space. In addition, some simple measurements such as the cricomenal space (distance between the neck and the bisection of a line from the mentum to the cricoid with the head in a neutral position) and the thyromental angle (distance between the soft-tissue plane of the anterior neck and a plane running through the soft-tissue mentum and the thyroid prominence) can be obtained.²² These physical findings are not diagnostic and are usually used to guide treatment.

Sleep Testing

In-laboratory polysomnography is the gold standard in the diagnosis of obstructive sleep apnea. Several monitoring devices record physiologic data from the patient, including airflow, during overnight sleep. Other monitored body functions include brain (electroencephalography) activity, eye movements (electrooculography), muscle activity or skeletal muscle activation (electromyography), and heart rhythm (electrocardiography) during sleep. The latter is used to detect any underlying heart abnormality.

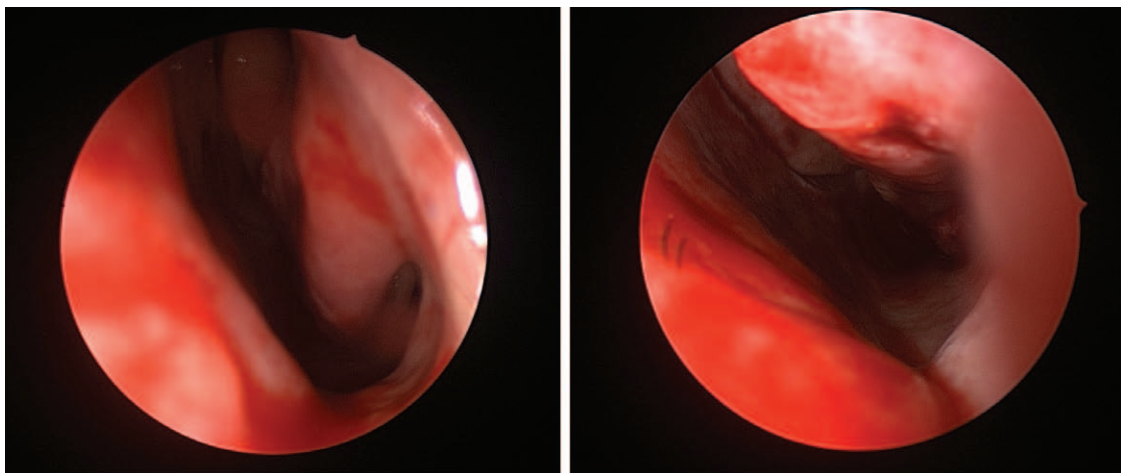


Fig. 1. (Left) Left nasal cavity septal deviation and turbinate hypertrophy can be seen in a patient with obstructive sleep apnea. (Right) There is a patent left nasal cavity after septoplasty and submucosal inferior turbinate reduction.

Table 1. Obstructive Sleep Apnea Severity Categorized According to Apnea Hypopnea Index

AHI	OSA Category
<5	Normal
≥5 and <15	Mild
≥15 and <30	Moderate
≥30	Severe

AHI, Apnea-Hypopnea Index; OSA, obstructive sleep apnea.

The number of times airflow stops or is reduced per hour determines the Apnea-Hypopnea Index. Apnea is defined as no airflow despite inspiratory effort. Hypopnea is defined as a reduction of 30 percent or more in airflow over 10 seconds, with a resulting 4 percent or more oxygen desaturation.²⁵ Obstructive sleep apnea severity is categorized based on the Apnea-Hypopnea Index (Table 1).

Polysomnography differentiates obstructive from central sleep apnea. In the latter, there is cessation of airflow for 10 seconds or longer without an identifiable respiratory effort. In comparison, an obstructive apneic event has a respiratory effort during the period of airflow cessation.

Ancillary Testing

Surgical treatment plans are tailored to the area of anatomical obstruction. There is no gold standard test to evaluate the site(s) of obstruction. Several methods have been suggested. However, proving causality of this site with obstructive sleep apnea has stimulated a contentious debate.^{26,27} Standard imaging techniques, such as cephalometry (radiography), computed tomographic scanning, and magnetic resonance imaging, have been used to evaluate the anatomical relationship of airway structures in patients in various positions and states of wakefulness, although their benefit is not universally recognized.²⁷

Flexible endoscopy with the Müller maneuver is a simple test that can be performed in the office and involves having the patient attempt to take a breath with the mouth and nose closed. The rationale is that this will induce airway collapse and the site of the collapse can be viewed with the endoscope. Similarly, the clinical utility of this procedure is in question.^{28,29}

Drug-induced sleep endoscopy has emerged as the modality of choice in evaluating patients for obstructive sleep apnea surgery. Sleep is induced with a sedative, and an endoscope is used to visualize the upper airway. Although it has been shown to have some role in surgical planning, it is criticized for not representing true physiologic sleep.³⁰

TREATMENT OF OBSTRUCTIVE SLEEP APNEA

Nonsurgical

Once a diagnosis of obstructive sleep apnea is made, several lifestyle modifications can be recommended, including weight loss, cessation or reduction of alcohol and other sedatives, and changing sleep position from supine to lateral.²³ However, further treatment is usually necessary. Continuous positive airway pressure is the first-line treatment for obstructive sleep apnea.³¹ When used properly, continuous positive airway pressure can relieve daytime somnolence and reduce hypertension.^{8,32} However, up to 25 percent of patients decline continuous positive airway pressure treatment, and between 40 and 70 percent of those who do initiate treatment are not fully compliant.³³ This leaves many patients with obstructive sleep apnea effectively untreated and susceptible to the sequelae described above.

Dental and oral appliances have gained popularity. These devices usually involve optimizing the position of the tongue or mandible to improve airflow. Some patients respond very well to these devices, but there is no consensus on the ideal design.³⁴

Surgical

Many patients who fail medical treatment, do not tolerate continuous positive airway pressure, or desire a long-term solution seek surgical management. Traditionally, the Stanford Protocol guided surgical planning, in which the most conservative procedure was chosen and performed first, with additional procedures performed as necessary.³⁵ Although that is still a valuable philosophy, contemporary surgical treatment plans aim to identify and treat the specific site or sites of the obstruction.³⁶ Despite this trend, an unresolved issue in the field is the relative difficulty in comparing results. Different outcome measures have been used, including subjective symptom resolution, objective improvement of clinical signs, and improvement of Apnea-Hypopnea Index.³⁷ As a result, clinical data supporting the efficacy of these procedures is controversial, with success rates varying between 40 and 100 percent.³⁸ Therefore, before any surgical intervention, patients should be informed about potential efficacy of the procedure and other nonsurgical alternatives.

Surgical procedures play an important role in the treatment of obstructive sleep apnea. The sequence of treatment is beyond the scope of this article. However, surgical treatment typically

targets three critical obstructive sites: the nose, oropharynx, and hypopharynx.³³ Historically, tracheostomy has been described as an effective single-stage salvage procedure when the other options have failed.³⁹ However, tracheostomy is not well accepted by most patients because of its impact on the quality of life and continuous supportive care, and thus should not be considered as a primary treatment option.

Nasal Surgery

Nasal obstruction can be a contributing factor for developing obstructive sleep apnea because the nasal cavity provides up to one-half of total airway resistance.⁴⁰ Nasal abnormalities such as alar collapse, nasal valve compromise, nasal polyps, bony deformities, inferior turbinate hypertrophy, and septal deviation can increase negative intraluminal pressure, causing airway collapse at the level of the oropharynx or hypopharynx. Therefore, nasal operations including septoplasty, rhinoplasty, and inferior turbinate reduction should be considered to correct these structural abnormalities and improve nasal patency.⁴¹ (See **Video, Supplemental Digital Content 1**, which depicts a septoplasty, available in the “Related Videos” section of the full-text article on PRSJJournal.com or, for Ovid users, available at <http://links.lww.com/PRS/B659>. See **Video, Supplemental Digital Content 2**, which depicts a submucous reduction of inferior turbinates, available in the “Related Videos” section of the full-text article on PRSJJournal.com or, for Ovid users, available at <http://links.lww.com/PRS/B660>.) Even though the efficacy of isolated nasal surgery is controversial, several studies show significant improvement in sleep study parameters and

continuous positive airway pressure compliance in obstructive sleep apnea patients.⁴² Of note, caudal septal deviation can be challenging to treat. There are both functional (airway obstruction) and aesthetic considerations when treating this deformity.

Uvulopalatopharyngoplasty

Uvulopalatopharyngoplasty is one of the most commonly performed surgical treatments for obstructive sleep apnea. (See **Video, Supplemental Digital Content 3**, which depicts a uvulopalatopharyngoplasty, available in the “Related Videos” section of the full-text article on PRSJJournal.com or, for Ovid users, available at <http://links.lww.com/PRS/B661>.) However, evidence for using uvulopalatopharyngoplasty as a singular therapy is relatively weak, with success rates varying between 16 and 83 percent.^{43,44} Originally described by Fujita et al. in 1981, uvulopalatopharyngoplasty involves surgical excision of uvula and tonsils, and lateral pharyngoplasty (trimming and reorientation of the posterior and anterior tonsillar pillars).⁴⁵ The procedure is typically performed under general anesthesia (Fig. 2). It can be combined with other nasal or oropharyngeal procedures if necessary.⁴² Uvulopalatopharyngoplasty is associated with significant postoperative pain and possible long-term complications, including nasal reflux, pharyngeal stenosis, dysphonia, and velopharyngeal insufficiency.⁴⁶ Uvulopalatal flap surgery is a less invasive procedure that widens the airway, but removes less tissue than a uvulopalatopharyngoplasty.⁴⁷ (See **Video, Supplemental Digital Content 4**, which depicts a uvulopalatal flap, available in the “Related Videos” section of the full-text article on PRSJJournal.com or, for Ovid users, available at <http://links.lww.com/PRS/B662>.)



Video 1. Supplemental Digital Content 1 depicts a septoplasty, available in the “Related Videos” section of the full-text article on PRSJJournal.com or, for Ovid users, available at <http://links.lww.com/PRS/B659>.



Video 2. Supplemental Digital Content 2 depicts a submucous reduction of inferior turbinates, available in the “Related Videos” section of the full-text article on PRSJJournal.com or, for Ovid users, available at <http://links.lww.com/PRS/B660>.



Video 3. Supplemental Digital Content 3 depicts a uvulopalatopharyngoplasty, available in the “Related Videos” section of the full-text article on PRSJJournal.com or, for Ovid users, available at <http://links.lww.com/PRS/B661>.

Palatal Implants

Effectiveness of palatal implants for treatment of obstructive sleep apnea has been demonstrated in some clinical trials.^{48–50} These centers have shown improvement in Apnea-Hypopnea Index. This office-based procedure involves insertion of polyethylene terephthalate implants into soft palate, which stiffens the palate and decreases palatal fluttering.⁴⁹ This procedure also generates an inflammatory reaction, leading to the formation of a fibrous capsule that provides further structural support to the palate and prevents airway collapse. Complications of palatal implants include extrusion, prolonged pain, perforation or necrosis of the nasal floor, palatal mucosal necrosis, and altered sensation of the palate.

Genioglossus Advancement

Because of the variable success rates of uvulopalatopharyngoplasty, genioglossus advancement

and hyoid suspension have been described to address hypopharyngeal airway collapse. Genioglossus advancement entails a rectangular osteotomy of the anterior mandible and forward advancement of the genial tubercle where the genioglossus tendons insert (Fig. 3). This places the tongue under tension, thus preventing airway collapse during sleep-induced hypotonia.⁵¹ Based on the concept that the hyoid arch and its muscle attachments strongly affect hypopharyngeal airway resistance, Riley et al. developed a hyoid suspension technique that advances hyoid bone over the thyroid ala, thus expanding the hypopharyngeal airway lumen.⁵²

Hypoglossal Nerve Stimulator

Recently, several companies have developed hypoglossal nerve stimulation devices that improve upper airway patency by means of electrical stimulation of the genioglossus muscle, resulting in

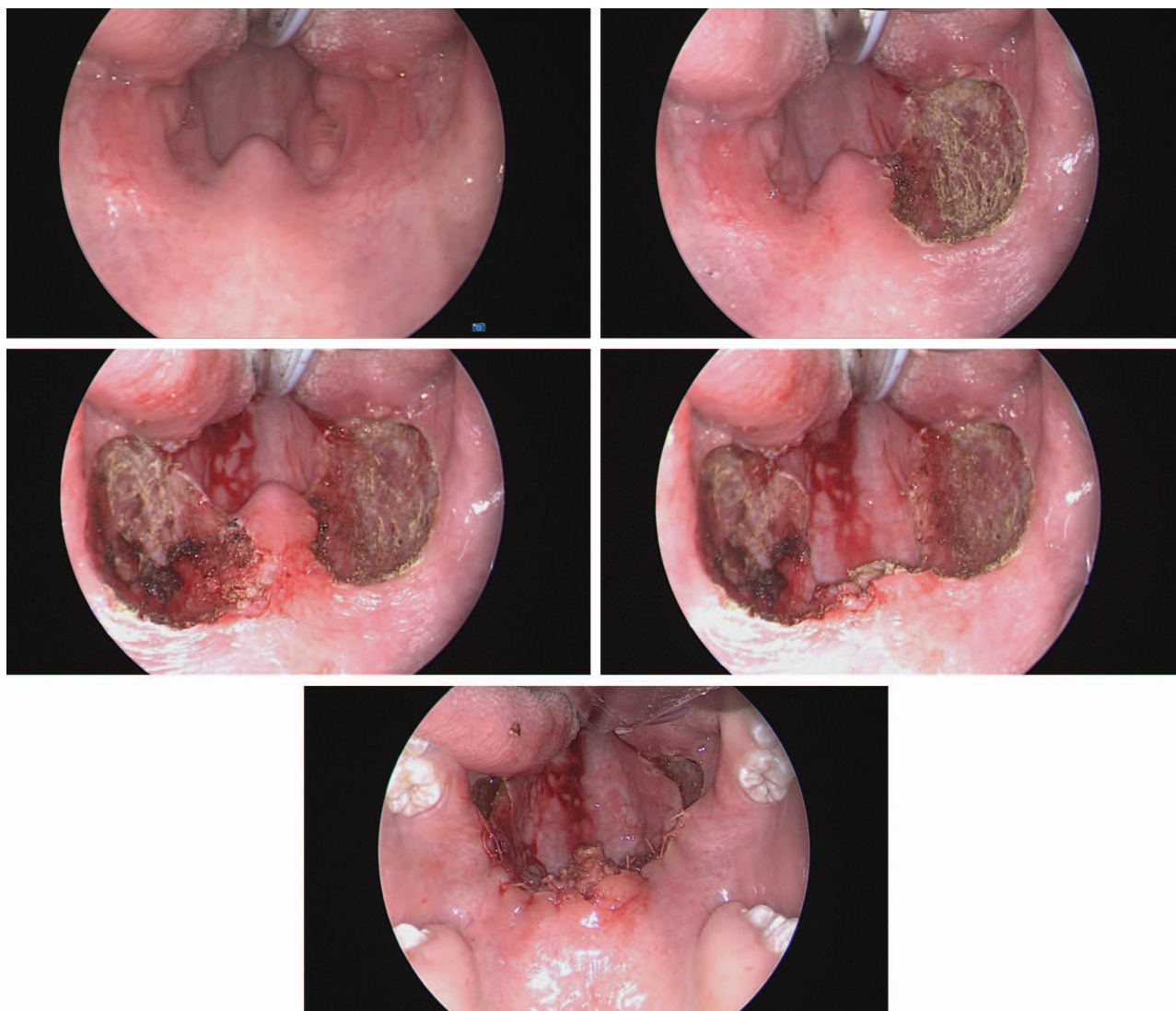


Fig. 2. (Above, left) Intraoperative view demonstrates areas of surgical intervention during uvulopalatopharyngoplasty, including tonsils, uvula, and soft palate. (Above, right) The right tonsil and soft palate have been modified. (Center, left) The left tonsil and soft palate have been modified. (Center, right) The uvula is excised. (Below) The raw edges are approximated to one another.

tongue protrusion.⁵³ This neurostimulator device is implanted similarly to a cardiac pacemaker. A stimulation electrode is placed on the hypoglossal nerve, and a sensing lead is implanted between the internal and external intercostal muscles to detect ventilatory effort. Recent data demonstrate that hypoglossal nerve stimulation devices may offer an effective therapy for carefully selected overweight patients with moderate to severe obstructive sleep apnea who are intolerant of continuous positive airway pressure therapy.⁵⁴

Orthognathic Surgery

Expansion of the skeletal framework plays an important role in the correction of obstructive sleep apnea and can significantly enlarge

the upper airway by advancing forward the tongue and pharyngeal soft tissues. Maxillomandibular advancement is a highly effective treatment modality with success rates between 75 and 100 percent.⁵⁵ Most commonly, it consists of bilateral split sagittal osteotomies of the mandible and a Le Fort I osteotomy of the maxilla, which advance both the mandible and the maxilla. In addition, the hyoid and larynx can be elevated and rotated with maxillomandibular advancement, especially if a maxillary impaction is used. The literature suggests that maxillomandibular advancement is most successful when the maxilla, the mandible, or both is/are advanced 1 cm.⁵⁶ However, this 1-cm movement must be based on cephalometric measurements, facial aesthetics



Video 4. Supplemental Digital Content 4 depicts a uvulopalatal flap, available in the “Related Videos” section of the full-text article on PRSJournals.com or, for Ovid users, available at <http://links.lww.com/PRS/B662>.

and, most importantly, presurgical occlusion. The importance of presurgical and postsurgical orthodontics cannot be underestimated in any maxillomandibular advancement procedure. Planned dental extractions of either select maxillary and/or mandibular bicuspid followed by orthodontics to move the dental arch posterior is often necessary to allow 1-cm skeletal movements and maintain occlusion. Several studies report 10 to 20 percent surgical relapse after maxillomandibular advancement, but without apparent worsening of the Apnea-Hypopnea Index.^{57,58}

Mandibular advancement using bilateral sagittal split osteotomy is a valuable alternative to two-jaw surgery, especially in patients with retrolingual obstruction alone. It can considerably advance the

base of the tongue and improve velopharyngeal airway patency.⁵⁹ In addition, single-jaw surgery avoids midfacial advancement, thereby reducing surgical morbidity and operating time associated with bimaxillary operations. Bilateral sagittal split osteotomy can also offer a more permanent solution to patients who have benefitted from mandibular devices in the past.^{60,61} Obstructive sleep apnea patients with isolated class III skeletal abnormality may benefit from Le Fort I osteotomy and advancement to correct maxillary deficiency. Advancing the maxilla anterosuperiorly tightens the soft palate, which is suspended from the palatine bone of the maxilla, and opens the velopharynx, potentially avoiding the need for further soft palate surgery.^{62,63}

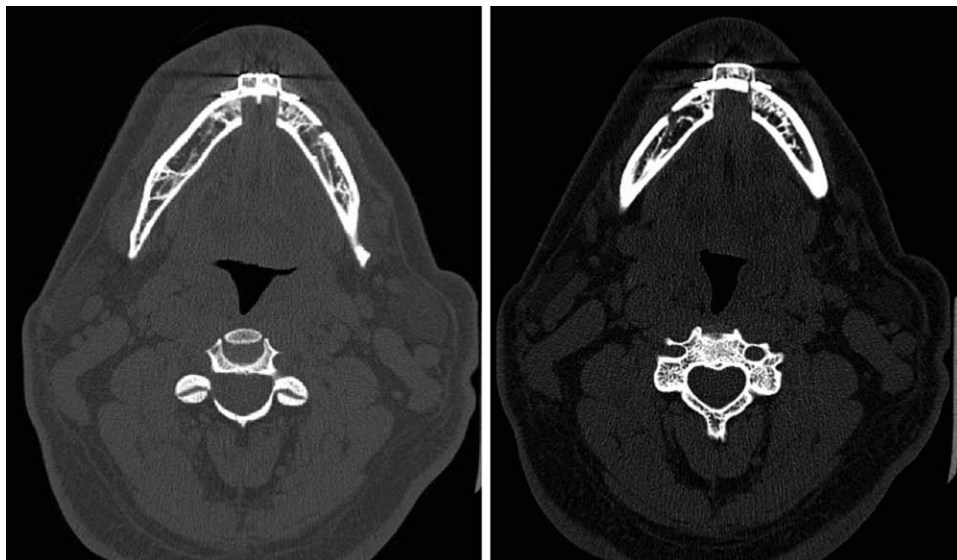


Fig. 3. Axial images demonstrate osteotomy of the anterior mandible and anterior displacement of the genioglossus muscle.

Bariatric Surgery

Obesity is a well-known risk factor for obstructive sleep apnea because deposition of excess adipose tissue in the neck changes soft-tissue properties and increases the likelihood of upper airway collapse.^{64–66} Several studies have demonstrated that weight loss leads to long-term improvement of obstructive sleep apnea as measured by reductions in the Apnea-Hypopnea Index.^{67–69} Dietary or surgical weight loss by means of bariatric surgery can be considered as a supplemental treatment modality and has been shown to produce dose-dependent improvement in obstructive sleep apnea severity. However, despite significant reduction in weight, the majority of the patients still suffer from residual obstructive sleep apnea and require additional treatments.⁷⁰

CONCLUSIONS

There is a role for functional septorhinoplasty, turbinoplasty, palatal surgery, genioglossal advancement, and orthognathic surgery in the surgical management of obstructive sleep apnea. Plastic surgeons are poised to be at the front line with these procedures, given their experience with aesthetic nasal surgery, nasal reconstruction, palatal surgery, and craniofacial surgery. Sleep medicine specialists and plastic surgeons can work collaboratively to provide multidisciplinary care to these patients.

Neil Tanna, M.D., M.B.A.

Division of Plastic & Reconstructive Surgery
Northwell Health
Hofstra Northwell School of Medicine
1991 Marcus Avenue, Suite 102
Lake Success, N.Y. 11042
ntanna@gmail.com

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