Orthognathic Surgery for Obstructive Sleep Apnea: Applying the Principles to New Horizons in Craniofacial Surgery

Brian T. Andrews, MD, MA, Gregory E. Lakin, MD,† James P. Bradley, MD,† and Henry K. Kawamoto Jr, MD, DDS†*

Abstract: This article is dedicated to the senior author Dr. Henry K. Kawamoto, Jr, who pioneered the use of orthognathic surgery to treat severe obstructive sleep apnea in 1981. Since that time, his techniques for maxillomandibular advancement have been revised and expanded for improved surgical success. Obstructive sleep apnea is a growing public health concern because it can cause hypertension, cardiac arrhythmias, heart attack, stroke, and, in rare circumstances, sudden death if untreated. When less invasive options fail such as weight loss or dental devices for mandibular repositioning, maxillomandibular advancement is a valuable treatment option for severe obstructive sleep apnea.

Key Words: Obstructive sleep apnea, orthognathic surgery, maxillomandibular advancement

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Obstructive sleep apnea (OSA) is a growing public health concern and is thought to affect 24% of middle-aged men and 9% of middle-aged women.[1] Obstructive sleep apnea is characterized by a cessation of airflow for greater than 10 seconds despite a respiratory effort. Signs and symptoms of OSA include daytime somnolence, difficulties concentrating, morning headache, irritability, mood changes, decreased energy, and erectile dysfunction. The consequences of prolonged untreated OSA are hypertension, cardiac arrhythmias, heart attack, stroke, and, in rare circumstances, sudden death.

The etiology of OSA is typically multifactorial and requires a comprehensive workup involving a history, physical examination, endoscopy, and cephalometric imaging. Identifying the areas of anatomic obstruction is essential for surgical planning and success. The oropharynx is the most commonly involved location for airway obstruction. In this location, the posterior airway space is reduced by the base of the tongue.[2] The soft palate is the second most common location of obstruction. Other common areas of obstruction are the nose, tonsils, lateral pharyngeal walls, and parapharyngeal fat pads. When lifestyle change (weight loss or prone/side bed position) or medical treatment options (continuous positive airflow pressure [CPAP] or a dental device for mandibular repositioning) fail, then surgical options should be considered.

Reducing or repositioning the soft tissue of the upper airway, thus enlarging the space, is the goal of OSA surgery. Historically, surgical procedures have been met with limited success at alleviating airway obstruction. "First-line" or "phase 1" surgeries target the soft tissues of the pharynx. These procedures include the uvulopalatopharyngoplasty, tonsillectomy, laser-assisted uvulopalatoplasty, tongue base reduction, septoplasty, and turbinate reduction. These procedures provide modest OSA improvement such as a 50% reduction in apneic events per hour. This reduction is significant if the OSA is mild or moderate, but it is often inadequate when OSA is severe.

When these phase 1 surgeries fail, patients are often referred for "phase 2" or "second-line" surgeries. These procedures include orthognathic (jaw surgery), genioglossal advancement, and hyoid suspension. Orthognathic surgery is a craniofacial surgical technique used to reposition the upper and/or the lower jaw to a desired presurgically planned location. The result is a change in the facial skeleton as well as the soft tissues that insert upon these structures. This surgical modality has been used for decades to correct skeletal anomalies and severe malocclusions. Recently, indications for orthognathic procedures have expanded to include the treatment of OSA. The initial results have proven that orthognathic advancement may be an effective and reliable method for the treatment of moderate to severe OSA. Interestingly, this procedure was first performed to treat OSA by the senior author (H.K.K.) in 1981. We will document this historic case and review current advancements.

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From the *Department of Plastic Surgery, University of Kansas Medical Center, Kansas City, Kansas; and †Division of Plastic and Reconstructive Surgery, David Geffen School of Medicine, Los Angeles, California.
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Address correspondence and reprint requests to Brian T. Andrews, MD, MA, Department of Plastic Surgery, University of Kansas Medical Center, 3901 Rainbow Blvd, Kansas City, KS 66160; E-mail: bandrews@kumc.edu
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CLINICAL REPORT

D.T. is a 50-year-old man who had a history of a mandibular tumor resection at age 2 years. The pathology was unknown but was thought to be benign. He developed micrognathia and a left chin deviation. As an adult, he developed significant sleep apnea over a 2-year period. He could not sleep in the supine position. He suffered from daytime somnolence: falling asleep while playing tennis and while driving on the interstate. On clinical examination, he was found to have a chin deviation to the left, microgenia, class I malocclusion, and retrognathia (Fig. 1). A decreased posterior pharyngeal airway space caused by retropositioning of the tongue base was confirmed on a lateral cephalogram (Table 1). He was diagnosed with OSA at

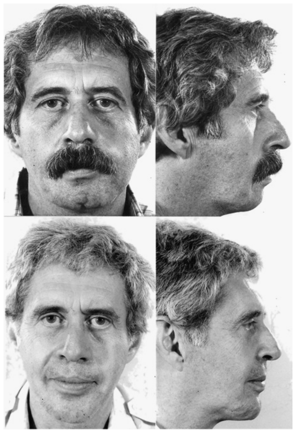

FIGURE 1. Preoperative (top) and postoperative (bottom) photographs 5 years after Le Fort I, mandibular, and genioplasty advancements for OSA.

2 independent medical facilities. An oral appliance was fit by his orthodontist to reposition his mandible and relieve his obstructive symptoms. Although this appliance was successful in relieving his sleep apnea symptoms, he did not tolerate the device well and was considered for surgical advancement of both jaws as a more permanent correction. He was referred to Dr. Kawamoto for an orthognathic surgery evaluation, who performed the following procedures:

(1) Le Fort I osteotomy with maxillary advancement.
(2) bilateral sagittal split osteotomies with mandibular advancement.
(3) horizontal osteotomy of the mandible (genioplasty).
(4) iliac bone graft harvest and placement above the horizontal osteotomy site.
(5) occlusal acrylic splint fabrication.

There were no intraoperative or postoperative complications. His postoperative course was uneventful. Within several weeks, his

TABLE 1. Preoperative and Postoperative Cephalometric Measurements 5 Years After Le Fort I, Mandibular, and Genioplasty Advancements for Obstructive Sleep Apnea

Measurement	Definition	Normative	Preoperative	Postoperative
SNA	Maxilla to cranial base, degrees	82 ± 2	80	85
SNB	Mandible to cranial base, degrees	80 ± 3	74	78
ANB	Maxilla to mandible, degrees	2	6	7
SNPg	Chin to cranial base, degrees	80 ± 3	74	80
Facial convexity	N-A-Pg, degrees	0 ± 8	13	10
Facial depth	FH-N-Pg, degrees	88 ± 3	78	87
Upper facial height (UFH)	N-A, mm		64	66
Lower facial height (LFH)	A-Me, mm		77	74
UFH/LFH	UFH/LFH ratio	0.95–1.0	0.83	0.89

A indicates innermost point of mandibular alveolar ridge; B, innermost point of maxillary alveolar ridge; FH, horizontal plane between Po and Or; Me, menton, inferior-most point of chin; N, nasion, nasofrontal junction; Or, orbitale, inferior-most point of orbit; Pg, pogonion, anterior-most point of chin; Po, porion, superior point of external auditory meatus; S, sella, center of sella turcica; SNA, angle between points S, N, and A describes anterior-posterior relationship of maxilla in relation to cranial base; SNB, angle between points S, N, and B describes anterior-posterior relationship of mandible in relation to cranial base; ANB, angle between points A, N, and B describes anterior-posterior relationship of maxilla in relation to mandible; SNPg, angle between points S, N, and Pg describes anterior-posterior relationship of chin in relation to cranial base

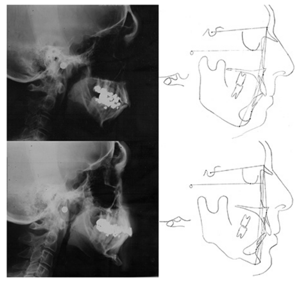

FIGURE 2. Preoperative (top) and postoperative (bottom) lateral cephalograms and tracings 5 years after Le Fort I, mandibular, and genioplasty advancements for OSA.

OSA completely resolved. At a 5-year follow-up evaluation, a lateral cephalogram revealed a stable maxilla, mandible, chin, and a corrected occlusion (Fig. 2). His posterior pharyngeal airway space remained adequate over time. Subsequently, he had 1 secondary procedure for nasal obstruction that involved a septoplasty and inferior turbinate reduction for improved breathing.

DISCUSSION

Obstructive sleep apnea is the most common type of "sleep-disordered breathing" with a prevalence of 2% in females and 4% in males.[1] Despite its prevalence and increased public awareness, approximately 80% of American males with OSA go undiagnosed.[3] Obstructive sleep apnea is typically caused by soft tissue collapse in the oropharynx (base of tongue) and nasopharynx (soft palate), leading to increasing airway pressures. Because the site of airway obstruction is unique in each patient, the surgery must be individualized to be successful.[4]

The initial treatment for OSA should be conservative and involves weight loss, exercise, and improved sleep hygiene. If OSA persists despite these measures, medical intervention with CPAP should be tried. Continuous positive airway pressure acts as a pneumatic splint to the soft tissues of the oropharynx and nasopharynx. Compliance with CPAP is often limited and ranges from 50% to 89%.[5,6] Issues related to CPAP compliance include claustrophobia, dry mouth, mask leaks, epistaxis, difficulty exhaling, and machine noise intolerance.

Surgery is indicated when the above conservative measures fail or cannot be tolerated, or when patients have an identifiable anatomic abnormality that is surgically correctable.[7] The goals of surgery are to increase the posterior pharyngeal airway size and cross-sectional area, thus decreasing airway resistance. Phase 1 procedures are intrapharyngeal and target the soft tissue obstruction directly. Phase 2 procedures are extrapharyngeal and involve skeletal modifications with a resulting increase in fairway space as the soft tissues move forward with their bony attachments. Maxillomandibular advancement (MMA) is a type of skeletal modification that involves advancing segments of the maxilla and mandible using surgical osteotomies, repositioning, and rigid fixation. Maxillomandibular advancement alleviates airway obstruction by increasing the anteroposterior pharyngeal dimensions and improving the tension and collapsibility of the suprahyoid and velopharyngeal musculature.[8–10]

Phase 1 procedures are traditionally performed as a first-line surgical treatment. Maxillomandibular advancement is reserved for those patients who have failed prior surgical interventions or have an obvious congenital abnormality, such as micrognathia. When phase 1 procedures fail, patients are typically referred for consideration of phase 2 procedures. Utilization of this protocol established a success rate of 60% for phase 1 and 97% for phase 2 procedures.[11] However, studies have shown that only 25% to 36%

of patients who fail phase 1 undergo phase 2 procedures.[11–13] This may be due to a number of reasons such as limited accessibility to a craniofacial or oral surgeon, third-party reimbursement, perception of invasiveness, and existing referral patterns.

Success rates for patients with severe OSA undergoing phase 1 procedures have been poor. In contrast, phase 2 MMA has shown significant improvements in similar patients with severe OSA. A meta-analysis demonstrated that two thirds of patients undergoing MMA for OSA had previous failed or concurrent phase 1 procedures.[14] Holty and Guilleminault[14] conducted a meta-analysis and found that 86% of subjects had a significant reduction in obstructive episodes after MMA with the average apnea hypopnea index being reduced from 63.9 to 9.5. A second meta-analysis by Pirklbauer et al[15] showed that MMA was the most successful surgical intervention for OSA.

The senior author (H.K.K.) has been performing craniofacial and orthognathic surgery for nearly 4 decades. His career has involved the training of 33 fellows and countless residents in the techniques and intricacies of craniofacial and orthognathic surgery. He first used orthognathic surgery to treat OSA in 1981 as documented above. Since that time, his techniques have been revised and expanded with improved surgical success.[16] Several points merit special discussion.

Cephalometric Analysis

The lateral cephalogram is essential for diagnosis and surgical planning. Cephalometric analysis compares the position of fixed skeletal structures (skull base or Frankfort horizontal line) to the position of the upper and lower jaw and their occlusion. They can be used to identify potential sites of upper airway obstruction such as a reduced posterior airway space, long soft palate, inferior positioned hyoid, micrognathia, and maxillary hypoplasia.[17] Techniques such as Steiner, Down, Ricketts, and Soussini analysis are used to compare skeletal and soft tissue landmarks to "predetermined societal norms." These measurements are guidelines from which experienced craniofacial surgeons make surgical decisions. An important principle taught by Dr. Kawamoto is that "cephalometric values represent average facial proportions; however, few persons undergoing orthognathic surgery desire to look average."

Presurgical Planning and Occlusal Splint Fabrication

Successful orthognathic surgery is predicated upon thoughtful preoperative surgical planning. This planning is performed by taking dental models, performing model surgery using 1- or 2-jaw articulators, and fabricating an occlusal splint for the indicated movements. In the case of 2-jaw surgery, this involves fabricating both an intermediate and final splint to accurately position each jaw successfully. If expansion or multisegment advancement of the maxilla is planned, the final surgical splint is secured to the orthodontic wire for 6 weeks to allow for rigid fixation.

Poor postoperative facial aesthetics has been a concern when using MMA to treat OSA. In a postoperative questionnaire, Li et al[18] identified that half of the patients undergoing MMA perceived improvement in their facial aesthetics. Very few patients felt that their facial change was unfavorable. Excessive mandibular protrusion was the most common concern. In general, significant movements such as those resulting in SNAs (angle between points S, N, and A) and SNBs (angle between points S, N, and B) greater than 90 degrees should be avoided.

Jaw Advancement and Impaction With Rigid Fixation

The Le Fort I osteotomy and bilateral sagittal split osteotomy procedure, as performed by Dr. Kawamoto, have been previously described.[16,19] Currently, it is Dr. Kawamoto's preference, per discussions with Dr. Hugo Obwegeser, to perform mandibular advancement before Le Fort I osteotomy when 2-jaw surgery is required. Advancing the mandible before the maxilla establishes a more stable occlusal platform and allows for easier occlusal adjustability with maxilla on the second jaw movement.[9] The exact amount of mandibular or maxillary movement will vary depending on the patient. Mandibular advancements of 1 cm or more will improve the posterior airway but can often result in a prognathic appearance. Maxillary movements of greater than 1 cm may be difficult technically and may be associated with speech complications, such as velopharyngeal insufficiency.

Posterior maxillary impaction is an important movement that may be just as beneficial as maxillary advancement. Impaction of the maxilla results in counterclockwise rotation of the occlusal plane. The result is a repositioning of the tongue base in a more anterosuperior position. Brevi et al[20] demonstrated that maxillary impaction with minimal advancement was successful at alleviating OSA when combined with mandibular advancement. Counterclockwise rotation also provides an aesthetic improvement as well.

Rigid fixation is traditionally performed with 1.5- or 2.0-mm miniplates in the maxilla at both the nasomaxillary and zygomaticomaxillary buttress using L-shaped plates. Mandibular advancement can be rigidly fixated with two 2.0 plates using monocortical screws or using 3 bicortical screws. Despite improvements in rigid fixation, surgical relapse still occurs. Postoperative orthodontic adjustment is often necessary to compensate for this postoperative occlusal movement.

Preoperative and Postoperative Orthodontics

All patients undergoing orthognathic surgery require a comprehensive orthodontic workup before surgical intervention. In most cases, a period of presurgical dental alignment is required before jaw repositioning. In the case of patients with sleep apnea, maximizing the mandibular movement is beneficial and may require overcorrection into a more severe class II malocclusion before surgical intervention. Mandibular bicuspid extraction could be considered to maximize the preoperative class II relationship before advancement. Commonly, several months of orthodontics are required after orthognathic surgery to finalize an accurate class I dental relationship. A small amount of surgical relapse is not uncommon even with solid rigid fixation. Recognition and orthodontic treatment are typically successful at addressing this common postoperative occurrence. Expedited treatment using arch bars instead of orthodontics often results in a malocclusion, open bite, temporomandibular joint problems, and poor aesthetics.

CONCLUSIONS

Obstructive sleep apnea is a common and growing global health problem. Orthognathic surgery to reposition the upper and lower jaw and move the associated soft tissues has proven to be extremely successful at correcting OSA. Successful orthognathic surgery is dependent on the surgeon utilizing appropriate surgical planning (orthodontic evaluation and treatment, dental model surgery, cephalogram tracings), perioperative execution (precise jaw movements, occlusal splint fabrication, rigid fixation, and aesthetic analysis), and postoperative management (orthodontic elastics). This article described the earliest description of MMA used to successfully treat OSA.

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