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

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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. 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. 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 surgically 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.

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 retrusion (Fig. 1). A decreased posterior pharyngeal airway space caused by retro positioning of the tongue base was confirmed on a lateral cephalogram (Table 1). He was diagnosed with OSA at...
Despite its prevalence and increased public awareness, only 25% to 36% of American males with OSA go undiagnosed.1 Obstructive sleep apnea is the most common type of “sleep-disordered breathing” with a prevalence of 2% in females and 4% in males.2 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%.5-8 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 suprahypoid and velopharyngeal musculature.9-10

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 experience resolution of symptoms.

The goals of CPAP AP compliance include claustrophobia, noise intolerance, 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 turbinectomy 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. A significant number of patients with OSA do not seek medical attention or are diagnosed late.1 The prevalence of OSA is higher in males and increases with age.2

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

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

A indicates innermost point of mandibular alveolar ridge; B, innermost point of maxillary alveolar ridge; P, posterior; and Or, orbital. N, nasion; Ns, nasofrontal junction; O, orbitale; A, anterior-most point of chin; P, pogonion; S, sella; R, 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 cranial base; SNPg, angle between points S, N, and Pg describes anterior-posterior relationship of chin in relation to cranial base.

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

FIGURE 2. Preoperative (top) and postoperative (bottom) lateral cephalograms and tracings 5 years after Le Fort I, mandibular, and genioplasty advancements for OSA.
of patients who fail phase 1 undergo phase 2 procedures.\textsuperscript{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.\textsuperscript{14} Holly and Guilleminault\textsuperscript{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\textsuperscript{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 in that time, his techniques have been revised and expanded with improved surgical success.\textsuperscript{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.\textsuperscript{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\textsuperscript{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.

**References**


**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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