Effects of Mandibular Retropositioning, With or Without Maxillary Advancement, on the Oro-Naso-Pharyngeal Airway and Development of Sleep-Related Breathing Disorders

Neophytos Demetriades, DMD, David Joey Chang, DMD,† Constantinos Laskarides, DMD, PharmD,‡ and Maria Papageorge, DMD, MS§*

Purpose: Literature suggests that patients without pre-existing sleep-related breathing disorders who undergo orthognathic surgery for treatment of facial asymmetry may experience changes in their oropharyngeal airway. Mandibular retropositioning can compromise the posterior airway space, alter the physiologic airflow through the upper airway, and predispose patients to development of obstructive sleep apnea syndrome (OSAS).

Patients and Methods: This study was a retrospective cohort analysis of 26 patients who underwent mandibular retropositioning with or without maxillary advancement within the past 5 years at Tufts University School of Dental Medicine. Pre- and postoperative lateral cephalometric radiographs were analyzed with digital DOLPHIN software (Dolphin Imaging, Chatsworth, CA) for evidence of changes to the posterior airway dimension. In addition, patients were evaluated postoperatively with SNAP polysomnography (model 4/6; SNAP Laboratories, Wheeling, IL) for evidence of OSAS.

Results: Results indicated that mandibular retropositioning greater than or equal to 5 mm decreased the posterior airway space below 11 mm (30.75%, $P = .03$) and showed evidence of soft palate elongation greater than 32 mm (15.39%, $P = .037$) in a significant number of patients. However, as determined by cephalometric analysis, mandibular retropositioning greater than or equal to 5 mm in combination with maxillary advancement had no significant effect on the posterior airway space or soft palate.

Conclusion: Postoperative SNAP polysomnography showed higher incidence of mild to moderate OSAS in patients who underwent mandibular retropositioning greater than or equal to 5 mm (69.25%) compared with patients who underwent mandibular retropositioning in combination with maxillary advancement (38.46%, $P = .039$).

J Oral Maxillofac Surg 68:2431-2436, 2010

Sleep-related breathing disorders such as obstructive sleep apnea syndrome (OSAS) have been identified as a major cause of sleep disturbance in more than 18 million American adults.[1] OSAS is typically recognized by symptoms such as extreme daytime sleepiness and drowsiness as well as disruptive snoring, upper airway obstruction, and hypoxemia during sleep.[2] The obstruction that causes the apnea episode is the result of an upper airway collapse that happens mostly during the rapid eye movement (REM) of sleep; it usually occurs at the oropharynx or velopharynx.[3] Genetic and environmental factors for the development of

Received from the Department of Oral and Maxillofacial Surgery, Tufts University School of Dental Medicine, Boston, MA.

*Instructor.

†Resident.

‡Assistant Professor.

§Professor and Chair.

Address correspondence and reprint requests to Dr Demetriades: Department of Oral and Maxillofacial Surgery, Tufts University School of Dental Medicine, 1 Kneeland Street, Boston, MA 02111; e-mail: neophytos.demetriades@tufts.edu

0278-2391/10/6810-0009$36.00/0

doi:10.1016/j.joms.2010.02.033

obstructive sleep apnea have been linked to increased neck circumference, obesity, smoking, retracted mandible, large tongue or uvula, age, and ethnicity.[1,3] Compromised airway dimension is considered one of the leading predisposing factors for the development of OSAS.[4]

During mandibular retropositioning, the position of the mandible is altered and brought in closer proximity to the pharyngeal wall. This new relationship of the upper airway structures can compromise the posterior airway space and predispose patients to development of OSAS. During the 3-dimensional movements of the maxillomandibular complex, the position of adjacent structures, such as the hyoid bone and soft palate, can be altered and further decrease the posterior airway dimension.

Many techniques have been used to diagnose OSAS. The Berlin questionnaire, which asks patients about various risk factors for OSAS, is currently the most widely used tool for identification of this syndrome.[5] However, the specificity and accuracy of polysomnography has made it the standard diagnostic test for OSAS. Polysomnography is a technique for measuring several physiologic characteristics during sleep, such as blood oxygen levels, body position, brain wave activity, respiratory rate, and heart rate. Unfortunately, the cost and inconvenience of this test to the patients has led to the development of alternative screening methods. Portable polysomnography has shown to be a good alternative initial screening technique for OSAS that is both more convenient and less costly to the patient.

In this study, a comparison of pre- and postoperative cephalometric radiographs showed changes in the position of the hyoid bone and posterior nasal spine to palate distance, as well as a reduction in the dimensions of the retrolingual and hypopharyngeal spaces. In addition, this study estimated the development of OSAS after mandibular retropositioning greater than or equal to 5 mm on the basis of evidence collected after examining patients with SNAP portable polysomnography (model 4/6; SNAP Laboratories, Wheeling, IL).

Patients and Methods

This study was a retrospective cohort analysis of 26 patients who were treated with mandibular retropositioning at Tufts University School of Dental Medicine within the past 5 years. Patients were divided into 2 groups: those who underwent mandibular retropositioning greater than or equal to 5 mm (group I) and those who underwent maxillary advancement in combination with mandibular retropositioning greater than or equal to 5 mm (group II). All patients were required to be at least 18 years of age, not pregnant at the time of surgery, and American Society of Anesthesiologists I or II. In addition, patients with a medical history positive for OSAS before surgery, as determined by the Berlin questionnaire, were excluded from this study.

Specifically, the Berlin questionnaire asks questions in 3 categories. The first inquires about the patient's snoring and breathing behavior while asleep; the second asks about daytime sleepiness and fatigue; and the third requests information regarding any history of high blood pressure and the patient's weight and height for the evaluation of body mass index.[2] Depending on the significance of their answers, patients are recognized as being at high or low risk for OSAS. In the first and second categories, a person is considered at high risk if he or she presents with significant symptoms (>3 to 4 times per week) on 2 or more questions. In the third category, a patient is considered at high risk if he or she is hypertensive or has a body mass index greater than 30 kg/m^2. To be considered at high risk for OSAS, the patient must be at high risk in 2 of the 3 categories. Patients who present with nonsignificant symptoms or who are only at high risk in 1 category are considered at low risk for OSAS. For this study, patients who presented with any risk of OSAS were excluded from the patient sample.

Pre- and postoperative lateral cephalometric radiographs of each patient were taken and analyzed using standard digital software (DOLPHIN; Dolphin Imaging, Chatsworth, CA) with double digitization of each point. Different measurements were obtained and compared with anatomic norms to evaluate the upper airway dimension: posterior airway space dimension (PAS), soft palate length (PNS-P), and mandibular plane–hyoid bone distance (MP-H) (Table 1).

Portable polysomnography units (model 4/6; SNAP Laboratories) were given to the patients postoperatively for evaluation of the presence of OSAS. While sleeping, the patient wore a blood oxygenation and pulse sensor on his or her finger and a sound/vibration sensor on the upper lip. These sensors measured several physiologic parameters including blood oxygen levels, heart rate, and extent of snoring. Data were collected and sent to SNAP Laboratories for analysis. The SNAP polysomnography analysis provided information regarding the Respiratory Disturbance Index (RDI), number of apneas and hypoapneas, snoring index, estimated palatal component of snoring, mean pulse rate, number of desaturations, and amount of time that oxygen saturation was under 90%. From this analysis, each subject was categorized to have negative (RDI 0-5), mild (RDI 5-15), moderate (RDI 15-30), or severe (RDI >30) OSAS on the basis of the RDI.

Table 1. PARAMETERS EVALUATED AND COMPARED IN THE PRE- AND POSTOPERATIVE CEPHALOMETRIC RADIOGRAPHS

PAS	The distance between the oropharynx and the most posterior surface of the tongue (numbers less than the norms indicate retropositioning of the tongue with possibility of obstruction of the oropharyngeal airway; norms 11 ± 1 mm)
SNA	The position of maxilla in relation to the base of the skull
SNB	The position of mandible in relation to the base of the skull
BaSN	The position of posterior pharyngeal wall (norms 129 mm)
PNS-P	The length of the soft palate (numbers greater than the norms indicate retropositioning of soft palate with obstruction of the nasopharyngeal airway; norms 37 ± 3 mm)
MP-H	The distance between the mandible and the hyoid bone (a distance greater than the norm indicates an inferiorly positioned hyoid bone that can position the tongue in closer proximity to the pharyngeal wall; norms 15.4 ± 3 mm)

Demetriades et al. Mandibular Retropositioning. J Oral Maxillofac Surg 2010.

Paired *t* test and Mann-Whitney *U* tests were used to compare the statistical significance of the changes in the upper airway space and the development of sleep-related breathing disorders between the 2 groups.

Results

On the basis of the cephalometric analysis, 30.75% (P = .03) of patients in group I experienced a decrease in the PAS (PAS <11 mm) following surgery. Furthermore, the mandibular plane to hyoid bone distance did not show a significant change in the same group of patients after surgery. However, we observed a 15.39% increase (P = .037) of soft palate length (PNS $P > 32$) in patients from group I following surgery (Fig 1; Table 1).

In contrast, 11% (P = .035) of the patients in group II showed an increase in the posterior airway space (PAS >11 mm), and 13% (P = .048) of the patients in this same group showed a decrease in the mandibular plane to hyoid bone distance (MP-H <15 mm) after surgery. In addition, 20% (P = .027) of the patients in group II showed a decrease in soft palate length (PNS $P < 32$; Fig 1).

Using SNAP polysomnography analysis, the evidence of sleep apnea between the 2 groups was compared. A significantly higher number of patients in group I were diagnosed with mild and moderate

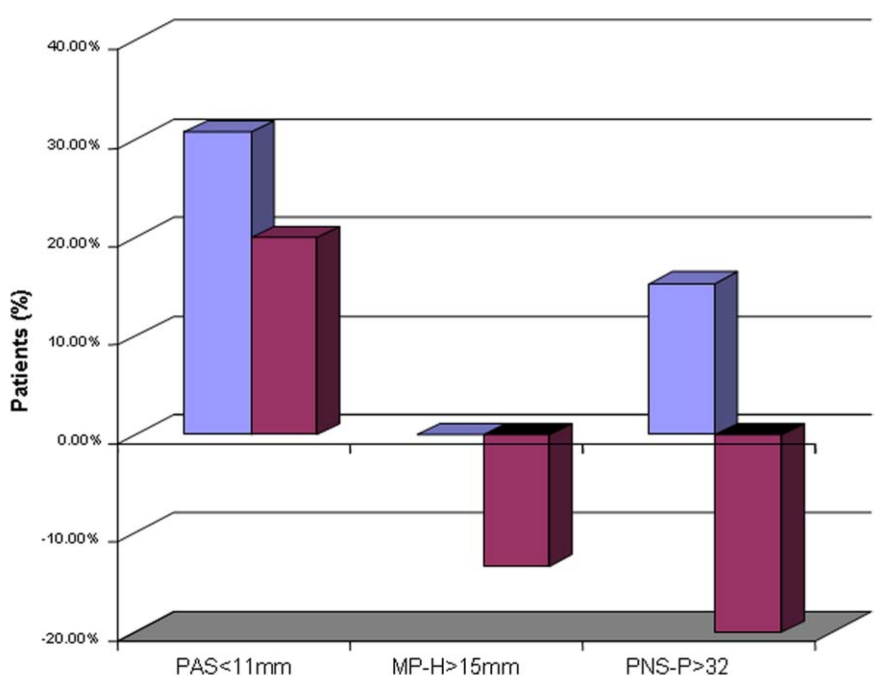

FIGURE 1. Unfavorable changes in cephalometric analysis (preoperative vs postoperative) in group I (single jaw) and group II (double jaw).

Demetriades et al. Mandibular Retropositioning. J Oral Maxillofac Surg 2010.

OSAS (76.52%; $P = .039$) compared with patients in group II (38.46%). A significantly higher percentage of patients in group I (30.77%; $P = .037$) experienced an oxygen desaturation (O_2 level <90%) during the study compared with patients in group II (46.15%). In addition, a higher percentage of patients in group I (69%; $P = .076$) had a palatal component of snoring compared with patients in group II (41%), which coincides with the elongation of the soft palate that was measured during the cephalometric analysis. The average snoring index was significantly higher ($P = .066$) in patients in group I (122.65) versus group II (104.34; Fig 2).

Discussion

The existing literature on orthognathic surgery's implications for OSAS is controversial; however, similar studies have shown that mandibular retropositioning can alter the posterior airway dimension and lead to the development of OSAS. Tselnik and Pogrel[6] studied the lateral cephalographs of 14 adults and found that the posterior airway space was constricted at the oropharyngeal level after mandibular retropositioning surgery. Hochban et al[7] evaluated the effect of mandibular retropositioning surgery on the posterior airway space of 16 patients with mandibular hyperplasia and showed that the posterior airway space decreased considerably at the oropharyngeal and hypopharyngeal levels. Saitoh[8] also found significant pharyngeal airway narrowing at the levels of the oropharynx and hypopharynx 3 to 6 months following mandibular retropositioning surgery. However, these studies compared the radiographic changes that patients experienced postoperatively without investigating the possibility of development of OSAS on the basis of polysomnography.

A study by Chung et al[9] considered the validity of the Berlin questionnaire in comparison with in-laboratory polysomnography. The study included 2,467 patients and determined a 78.6% sensitivity for those classified as moderate OSAS and a 87.2% sensitivity rate for those classified as severe OSAS. In our study, the purpose of the Berlin questionnaire was to identify patients who may have suffered from OSAS before surgery so that they could be appropriately excluded from the patient sample.

Following orthognathic surgery, patients were evaluated for evidence of OSAS through the use of SNAP portable polysomnography units (model 4/6; SNAP Laboratories). Controversy exists over the validity of SNAP polysomnography in identifying OSAS; however, a study by Su et al[10] indicates significant correlations between RDI, total number of apneas and hypoapneas, and minimum oxygen saturation in comparison with conventional laboratory polysomnography.

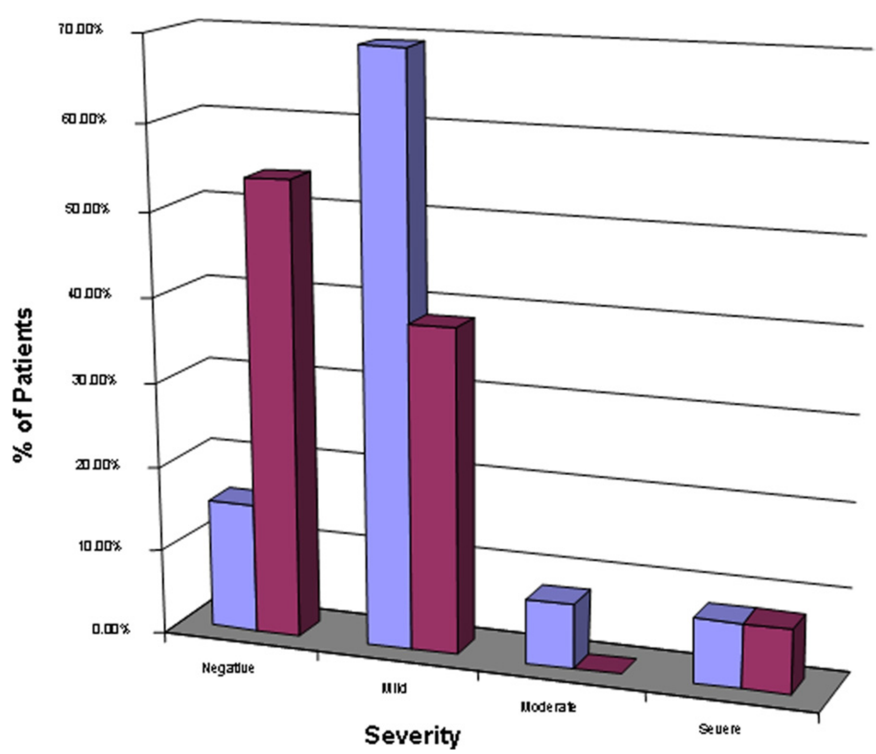

FIGURE 2. SNAP results of obstructive sleep apnea syndrome in group I (single jaw) and group II (double jaw) patients.

Demetriades et al. Mandibular Retropositioning. J Oral Maxillofac Surg 2010.

In addition to evaluating patients for evidence of OSAS, cephalometric radiographs were used to measure changes in the upper airway dimension. At the time of the study, cephalometric radiographs were considered the standard of care, primarily because of their wide availability, low cost to the patients, and ease for comparison on double digitalization software. Controversy exists over the integrity of two-dimensional cephalometric analysis compared with 3-dimensional computed tomographic (CT) scans. Olszewska et al[11] concluded that craniofacial computed tomography (CT) scan measurements proved to be easier and more accurate, especially with regard to soft tissues. One major benefit of the CT scan is that the image can be captured while the patient is in the supine body position; this advantage is critical because of the body posture changes that occur during breathing, which can alter the dimensions of the upper airways.[12,13] Specifically, while a patient is in the supine position, his or her tongue may retract, resulting in an occlusion in the already smaller airway space.[14] In addition, a CT scan can provide images throughout the patient's full breathing cycle.[15] This advantage is important because the pharyngeal lumen changes constantly throughout the respiration cycle. Although CT scans are advantageous in many ways, they still have disadvantages, the most important of which is that they cannot be performed while the patient is asleep, and therefore measurements of different sleep stages and body positions throughout the night cannot be obtained.[11] In addition, Pépin et al[16] concluded that a CT scan obtained while the patient is awake may not accurately indicate the development of airway occlusion below the soft palate. In addition, CT scans are accompanied by dental amalgam and beam hardening artifacts; however, these interferences are localized to the specific area of the artifact and do not disturb the entire image.[11] Although CT scans may be more accurate, cephalometric analysis is not completely unreliable. Studies have shown significant differences in cephalometric measurements between OSAS patients and patients who do not suffer from OSAS.[11,17,18]

This study showed that mandibular retropositioning greater than or equal to 5 mm can decrease the posterior airway space significantly and cause mild to moderate OSAS. In contrast, mandibular retropositioning in combination with maxillary advancement had no significant effect on the posterior airway space, and in some instances increased the posterior airway dimension. There was less evidence for OSAS among patients who had combination surgery (maxillary advancement along with mandibular retropositioning) compared with patients who underwent mandibular retropositioning without maxillary advancement.

Similar to these results, other studies indicate that mandibular retropositioning in combination with maxillary advancement may compensate for the narrowing of the posterior airway space and alleviate some of the airway obstruction caused by mandibular retropositioning. Cakarne et al[19] found a significant increase in nasopharyngeal airway space after bimaxillary surgery. Fengshan et al[20] showed that bimaxillary surgery caused an increase at the nasopharyngeal level and a decrease at the oropharyngeal and hypopharyngeal levels only in the short term, whereas no significant change was seen in the long term.

Although the data from our study are conclusive, only 26 subjects were studied. The sample size was limited because we no longer perform mandibular retropositioning without maxillary advancement because mandibular retropositioning without maxillary advancement may increase patient risk for development of OSAS. Even with a small sample size, this study was able to show statistical significance of P less than .05.

This study, together with much of the previous literature, shows that mandibular retropositioning can cause significant narrowing of the oropharyngeal conduit by positioning the tongue and soft palate in closer proximity to the pharyngeal wall.[6-8] This change can result in obstruction of the physiologic flow of air through the upper airway to the lungs, causing obstructive sleep disorders. Conversely, maxillary advancement in combination with mandibular retropositioning may compensate for the changes of the oropharyngeal conduit narrowing because the required mandibular retropositioning is decreased. Furthermore, maxillary advancement and impaction causes autorotation of the mandible, which positions the hyoid bone and genioglossus muscle, and the tongue, in a more anterior and superior location, thus increasing the posterior airway dimension. On the basis of our evidence, patients who require mandibular retropositioning greater than or equal to 5 mm should be considered candidates for combination surgery, that is, mandibular retropositioning along with maxillary advancement, to decrease the possibility of iatrogenic development of OSAS.

References

1. Pagel JF: Obstructive sleep apnea (OSA) in primary care: Evidence-based practice. J Am Board of Fam Med 20:392-8, 2007
2. Netzer NC, Stoohs RA, Netzer CM, et al: Using the Berlin questionnaire to identify patients at risk for the sleep apnea syndrome. Ann Intern Med 131:485, 1999
3. Prinsell J: Maxillomandibular advancement surgery for obstructive sleep apnea syndrome. Am Dent Assoc 133:1489, 2002
4. Weng KL: Effect of orthognathic surgery on the posterior airway space (PAS). Ann Acad Med Singapore 37:677, 2008
5. Chung F, Ward B, Ho J, et al: Preoperative identification of sleep apnea risk in elective surgical patients, using the Berlin questionnaire. J Clin Anesth 19:130, 2007

6. Tselnik M, Pogrel MA: Assessment of the pharyngeal airway space after mandibular setback surgery. J Oral Maxillofac Surg 58:282, 2000
7. Hochban W, Schurmann R, Brandenburg U, et al: Mandibular setback for surgical correction of mandibular hyperplasic. Does it provoke sleep disorder? Int J Oral Maxillofac Surg 25:333, 1996
8. Saitoh K: Long-term changes in pharyngeal airway morphology after mandibular setback surgery. Am J Orthod Dentofac Orthop 125:556, 2004
9. Chung F, Yegneswaran B, Liao P, et al: Validation of the Berlin questionnaire and American Society of Anesthesiologists checklist as screening tools for obstructive sleep apnea in surgical patients. Anesthesiology 110:194, 2009
10. Su S, Baroody F, Kohrmann M, et al: A comparison of polysomnography and portable home sleep study in the diagnosis of obstructive sleep apnea syndrome. Otolaryngology 31:844, 2004
11. Olszewska E, Sieskiewicz A, Rozycki J, et al: A comparison of cephalometric analysis using radiographs and craniofacial computed tomography in patients with obstructive sleep apnea syndrome: Preliminary report. Eur Arch Otorhinolaryngol 266:535, 2009
12. Oksenberg A, Khamaysi I, Silverberg DS: Apnoea characteristics across the night in severe obstructive sleep apnoea: Influence of body posture. Eur Respir J 18:340, 2001
13. Shepard JW Jr, Stanson AW, Sheedy PF, et al: Fast-CT evaluation of the upper airway during wakefulness in patients with obstructive sleep apnea. Prog Clin Biol Res 345:273, 1990
14. Battagel JM: Obstructive sleep apnoea: Fact not fiction. Br J Orthod 23:315, 1996
15. Schwab RJ: Imaging for the snoring and sleep apnea patient. Dent Clin North Am 45:759, 2001
16. Pépin JL, Ferretti G, Veale D, et al: Somnofluoroscopy compared with computerized tomography of the airway and cephalometry in obstructive sleep apnoea. Thorax 47:150, 1992
17. Shepard JW, Gefter WB, Guilleminault C, et al: Evaluation of the upper airway in patients with obstructive sleep apnea. Sleep 14:361, 1991
18. Tsuchiya M, Lowe AA, Pae EK, et al: Obstructive sleep apnea subtypes by cluster analysis. Am J Orthod Dentofac Orthop 101:533, 1992
19. Cakarne D, Urtane I, Skagers A: Pharyngeal airway sagittal dimension in patients with Class III skeletal dentofacial deformity before and after bimaxillary surgery. Stomatologija 5:13, 2003
20. Fengshan C, Terada K, Hua Y, et al: Effects of bimaxillary surgery and mandibular setback surgery on pharyngeal airway measurements in patients with Class III skeletal deformities. Am J Othodontics Dentofac Orthop 131:372, 2007