Case Report

Surgical treatment modality for facial esthetics in an obstructive sleep apnea patient with protrusive upper lip and acute nasolabial angle

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ABSTRACT

For patients with severe obstructive sleep apnea syndrome (OSAS), maxillomandibular advancement (MMA) offers a good treatment option by physically expanding the skeletal framework. However, facial esthetics can be aggravated by MMA in patients with OSAS who have a normally positioned maxilla, a protrusive upper lip, and an acute nasolabial angle. Therefore, surgical treatment planning should be customized according to diverse skeletodental and soft-tissue patterns to produce a favorable change in facial esthetics and sleep function in patients with OSAS. In this case report, good treatment results were achieved in a young female patient with OSAS and skeletal Class II, a normally positioned maxilla, a protrusive upper lip, and acute nasolabial angle by impaction of the maxilla, autorotation/advancement of the mandible, and advancement of the chin. A customized flowchart for surgical treatment planning in OSAS that considers facial esthetics was suggested. (*Angle Orthod.* 2013;83:355–363.)

KEY WORDS: Customized surgical treatment plan; Obstructive sleep apnea; Impaction of the maxilla; Autorotation/advancement of the mandible; Advancement of the chin

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INTRODUCTION

Obstructive sleep apnea syndrome (OSAS) is characterized by a temporary cessation of breathing (apnea) or shallow breathing (hypopnea) with accompanying hemoglobin oxygen desaturation.[1] Clinically significant OSAS occurs in 2% to 4% of the population and is strongly correlated with obesity and age.[2–4]

The gold standard for the diagnosis of OSAS is complete polysomnogram with an overnight sleep study.[5] In addition, two-dimensional (2D) lateral cephalograms have served as the traditional radiographic standard for airway assessment.[6] Although 2D lateral cephalograms are considered cost-effective and less invasive, they cannot accurately depict the three-dimensional (3D) airway anatomy, especially in the axial plane, which includes the most physiologically relevant information and is perpendicular to the direction of airflow.[7] Recently, 3D computed tomography (3D-CT) analysis has become a focus of attention for accurate evaluation of the 3D airway anatomy.[8–12]

There are various treatment options for patients with OSAS according to the severity, etiology, and collapse site, such as weight reduction, oral appliance, continuous positive airway pressure (CPAP) device, upper airway surgery, and maxillomandibular advancement (MMA).[13] Because MMA can enlarge the pharyngeal and hypopharyngeal airway by physically expanding the facial skeletal framework, it is logical to perform MMA in patients with OSAS and maxillomandibular hypoplasia or retrusion. However, facial esthetics can be aggravated by MMA in OSAS patients with a normally positioned maxilla, a protrusive upper lip, and an acute nasolabial angle. Therefore, surgical treatment planning should be customized according to diverse skeletodental and soft-tissue patterns to produce a favorable change in facial esthetics and sleep function in patients with OSAS. To the authors' knowledge, only a few studies have been published

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Table 1. Comparison of Polysomnography Data Between Initial Status and 6 Months After Surgery

Measurements	Initial Status	6 Months After Surgery
Total number of arousals	206	75
Arousal index	46.0	19.9
Respiratory efforts related to arousal	13.6	3.4
Apnea	95	7
Hypopnea	83	1
Apnea-hypopnea index	39.8	2.1
Respiratory disturbance index (RDI)	53.3	2.6
REM RDI	53.3	7.6
NREM RDI	53.4	1.2
Total snoring time of total sleep time (%)	60.3	25.6
Sleep time with saturation below 90% (%)	4.5	0.1
Lowest saturation (%)	82	91

NREM means non-rapid eye movement.

regarding facial esthetics for surgical planning in OSAS.[14,15]

The purposes of this case report were to evaluate the effect of surgery to achieve total impaction of the maxilla, autorotation/advancement of the mandible, and advancement of the chin (IMX-AAMN-AC) on a patient with OSAS using polysomnogram, 2D-cephalometric, and 3D-CT analyses, and to suggest a customized flowchart for surgical treatment planning for OSAS that considers facial esthetics.

DIAGNOSIS

A nonobese young adult woman (22 years old) was referred for preoperative orthodontic treatment (Pre-OP-OT) and postoperative orthodontic treatment (Post-OP-OT). Patient approval was obtained for this study. The results of the initial polysomnogram showed severe OSAS (apnea-hypopnea index [AHI] = 39.8; respiratory disturbance index [RDI] = 53.3; Table 1), which was aggravated in REM sleep, along with

Figure 1. Initial facial and intraoral photographs.

abnormal sleep architecture. Periodic leg movements without arousal were noted. Therefore, CPAP therapy (11cm H_2O mode 1 of C-Flex with a chin strap after CPAP titration record) was started; however, the patient did not tolerate the CPAP device and discontinued treatment.

Initial photographs showed mild anterior crowding, linguoversion of the maxillary anterior teeth, skeletal Class II and dental Class I relationships, a 1-mm midline shift of the mandibular dental midline to the right side, a short upper lip, slight lip protrusion, and a gummy smile (Figure 1).

A hyperdivergent facial pattern (Björk sum, 414.4°; FMA 46.7°), a retrognathic mandible (SNB, 72.9°; Pog-N perpendicular, −20.7 mm), a relatively normal sagittal position and vertical excess of the maxilla (SNA, 83.8°; maxillary incisor display, 4.3 mm), and a steep occlusal plane (FH-OP, 22.5°) were observed on the initial lateral cephalometric analysis (Table 2). The initial lateral cephalogram and orthopantomogram showed a retropositioned tongue, a decreased pharyngeal airway space (PAS), and degenerative change

Table 2. Lateral Cephalometric Analysis

Measurements		Norm	Initial	Final	1-year retention
Vertical skeletal pattern	Björk sum	393.97	414.41	411.51	411.98
	FMA	26.78	46.67	45.25	45.52
Horizontal skeletal pattern	SNA	81.77	83.83	85.20	85.25
	SNB	80.22	72.93	77.67	77.80
	ANB	1.78	10.90	7.53	7.45
	A to N perp	1.10	1.88	2.54	2.51
	Pog to N perp	−0.30	−20.67	−14.23	−14.87
Denture pattern	U1 to FH	113.80	98.47	98.84	98.67
	IMPA	91.62	93.28	93.70	94.24
	Interincisal angle	125.44	121.58	122.21	122.02
Soft-tissue profile	Upper lip to E line	−0.86	4.26	1.69	1.87
	Lower lip to E line	0.06	4.01	1.23	0.18
	Nasolabial angle	100.23	105.33	107.87	108.12

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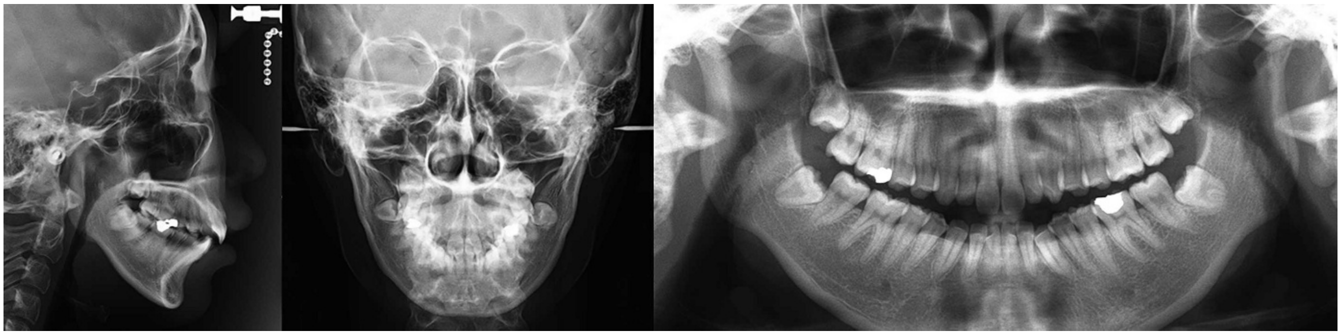

Figure 2. Initial lateral cephalogram (A), posteroanterior (PA) cephalogram (B), and orthopantomogram (C).

in both of the temporomandibular joints (TMJs) (Figure 2).

The patient received splint therapy for 3 months to stabilize the position of the mandible. After the CR splint treatment, the overjet was increased and a dental Class II relationship was obtained (Figure 3). Based on these findings, the patient was diagnosed with a skeletal and dental Class II malocclusion, a large centric relation-centric occlusion (CR-CO) discrepancy, degenerative TMJ, a gummy smile, and OSAS.

Treatment Objectives and Options

The treatment objectives were to resolve the symptoms of OSAS, to establish skeletal and dental Class I relationships, to achieve functional occlusion with a normal overjet/overbite, and to improve facial esthetics. Three treatment options were proposed to the patient.

The first option was orthodontic treatment with conservative approaches for OSAS. Less invasive treatment modalities for OSAS consist of behavior modification, oral devices, a CPAP device, and upper airway surgery, such as a tonsillectomy or uvulopalatopharyngoplasty. Because the patient was not obese and did not habitually consume alcohol or sedatives, it was not necessary for her to undergo behavior modification for weight loss or dietary control. The American Academy of Sleep Medicine has recommended the use of oral appliances in patients with primary snoring, mild to moderate OSAS, and healthy TMJs.[13] However, because she had severe OSAS (AHI = 39.8) and degenerative change in the TMJs, treatment with an oral appliance was not an option. The CPAP device can be an effective treatment tool for patients with moderate to severe OSAS but she did not tolerate it and refused to use it. The obstructive site was mainly at the oropharynx area, so upper airway surgery on the soft palate or tonsils was not indicated (Figure 4).

The second option was maxillomandibular advancement (MMA) surgery with Pre-OP-PT and Post-OP-OT. One of the primary causes of OSAS in this patient was a clockwise rotation and posterior positioning of the mandible due to degenerative TMJ in the condyles. Therefore, establishment of a skeletal Class I relationship by advancing the mandible and maintaining the TMJ status were considered. However, because the sagittal position of her maxilla was relatively normal, too much advancement of the maxilla would have aggravated her facial profile into maxillary protrusion.

The third option was IMX-AAMN-AC with Pre-OP-OT and Post-OP-OT. Total impaction of the maxilla with LeFort I osteotomy can resolve a gummy smile and vertical excess of the maxilla and induce a counterclockwise rotation of the mandible, eventually

Figure 3. Change in the overbite and overjet before (A,B) and after splint therapy for 3 months (C,D) due to a large centric relation-centric occlusion (CR-CO) discrepancy.

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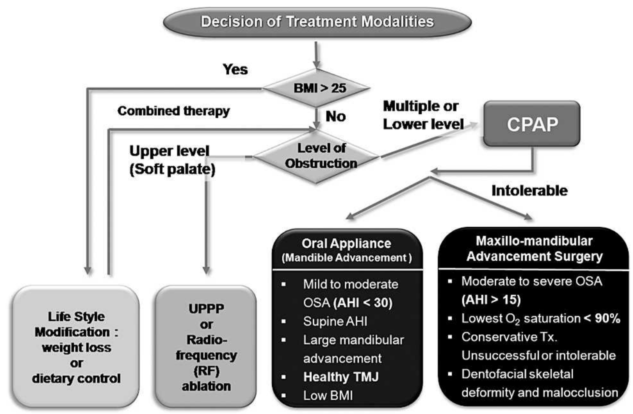

Figure 4. Conventional flowchart of treatment options for obstructive sleep apnea syndrome (OSAS).

increasing the chin projection. In addition, mandibular advancement with bilateral sagittal ramus osteotomy (BSSRO) and advancement genioplasty of the chin can increase the retrolingual airway dimensions. The patient accepted this option as the final treatment plan.

Treatment Progress

Three months after splint therapy, the fixed appliances (Damon III Mx, 0.022 inch slot; Ormco, Orange, Calif) were placed in both arches. High torque prescription on the maxillary anterior teeth and low torque prescription on the mandibular anterior teeth were applied for proper decompensation of the anterior teeth. After 4 months of leveling and alignment, the Pre-OP-OT was completed, and surgical wires with crimpable hooks (0.019 $\times$ 0.025 inch stainless steel wire) were inserted on both arches (Figures 5 and 6).

The surgical procedures included 3-mm total impaction of the maxilla with LeFort I osteotomy, autorotation and 5-mm advancement of the mandible with BSSRO, and 5-mm advancement genioplasty.

One month after orthognathic surgery, the Post-OP-OT was started (Figures 7 and 8). For this process, 0.018-inch Cupper NiTi archwires were inserted on both arches, and light vertical elastics (3/16 inch, 3 oz) were used on the maxillary and mandibular canine regions. Occlusal settling and final detailing were continued for 6 months.

Figure 5. Preoperative facial and intraoral photographs (4 months after bonding).

Treatment Results

Eight months after surgery, debonding was performed. Class I canine and molar relationships, normal overbite/overjet, coincidence of the facial and dental midlines, decrease in facial convexity, and profile improvement in the lower third of the face were obtained (Figures 9 and 10; Table 2).

Superimposition of the initial status and posttreatment cephalograms revealed total impaction of the maxilla (slightly more impaction on ANS than PNS), autorotation/advancement of the mandible, and advancement genioplasty. Although there was no forward movement of the maxilla, total impaction caused a slight increase of SNA (83.8° to 85.2°). Because the initial maxillary occlusal plane was so steep (FH-OP, 22.5°), the skeletal Class II relationship was not fully corrected (ANB, 7.5°). Pogonion moved forward farther than the B point because of the genioplasty (6.4 mm vs 4.8 mm). Inclinations of the maxillary and mandibular incisors were not significantly changed. Although the soft palate length (PNS-P) was not

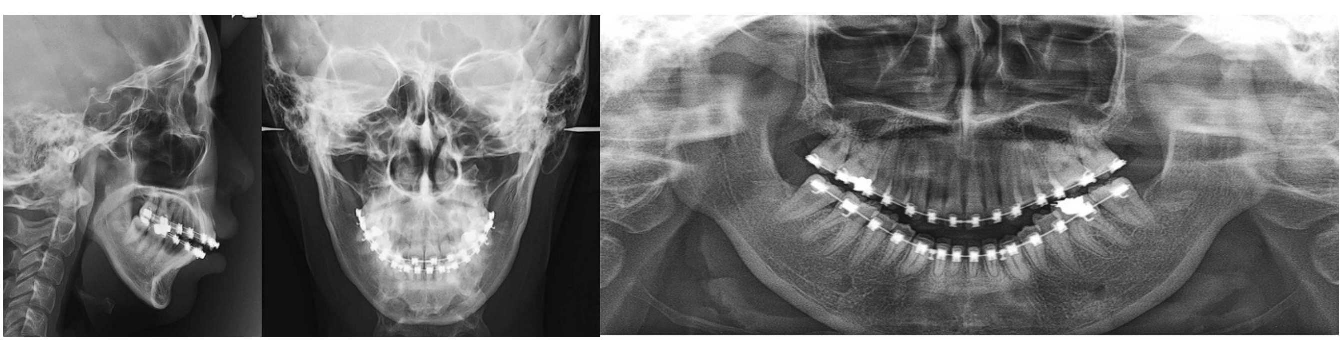

Figure 6. Preoperative lateral cephalogram (A), PA cephalogram (B), and orthopantomogram (C).

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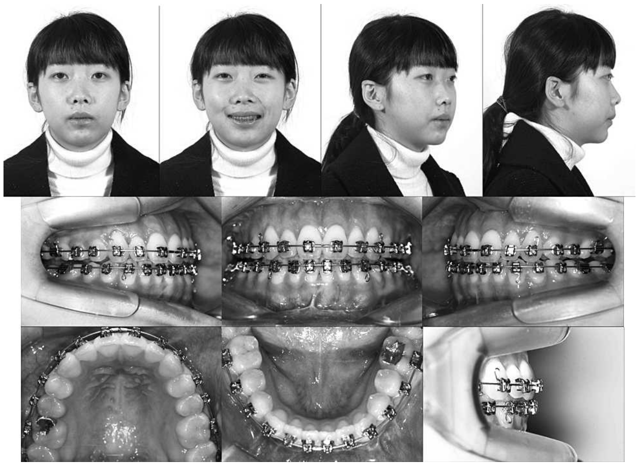

Figure 7. Postoperative facial and intraoral photographs (1 month after surgery).

changed (34.5 mm vs 34.0 mm), the PAS was increased at the retroglossal area (2.7 mm). Distance from the mandibular plane to the hyoid decreased (20.5 mm vs 14.0 mm), and the bony nasopharynx and oropharynx were slightly increased by movement of the maxilla (2.0 mm and 2.5 mm, respectively) (Figure 11).

Comparison of polysomnography data between initial status and 6 months after surgery showed that total number of arousals during sleep, AHI, RDI, and sleep time with saturation below 90% decreased significantly (from 206 to 75 times, from 39.8 to 2.1, from 53.3 to 2.6, and from 4.5% to 0.1%, respectively; Table 1). In addition, the lowest saturation was improved from 82% to 91% (Table 1).

The 3D volumetric evaluation of the PAS was performed at the nasopharynx, oropharynx, and hypopharynx (Figure 12). They were defined by four horizontal reference lines, such as PNS, the inferior border of the soft palate, the upper border of the epiglottis, and the most inferior border of the fourth cervical vertebra. Comparisons of the 3D-CT data between initial status and 6 months after surgery revealed that total volume of the PAS increased 248.6%, and the highest increase was observed at the oropharynx area (420.9%). Notably, the lateral expansion (mediolateral direction) of the airway was more obvious than the anteroposterior expansion at the oropharynx.

One year after debonding, treatment results were stable (Figures 13 and 14). The patient reported no symptoms of OSAS and was satisfied with her quality of life. Appropriate exposure of the maxillary incisor made the smile line more pleasant.

DISCUSSION

Usually, old age (older than 65 years) and obesity (body mass index $>$ 26) are known to be major risk factors for OSAS.[3,4] However, this patient did not have these risk factors. Because OSAS in nonobese patients may be more related to skeletal abnormality whereas OSAS in obese patients may be more influenced by soft-tissue factors, clinicians need to understand the underlying pathologic features of OSAS.

Because MMA can affect not only sleep function but also facial esthetics, MMA has to maintain and not aggravate facial esthetics in patients with OSAS. Generally, whites have a convex facial profile, retroclined maxillary incisors, and an obtuse nasolabial angle, which suggest that both the maxilla and mandible are in a retrognathic position. Conley and Boyd[15] reported that MMA decreased the nasolabial angle and that the ratio of soft tissue to hard tissue was about 0.9:1 for the upper lip, lower lip, and chin. Therefore, MMA in white patients with OSAS can improve the soft-tissue support and result in rejuvenation of the middle and lower third of the face.[16] On the contrary, Asian patients with OSAS usually have a normal or slightly protrusive maxilla, an acute nasolabial angle, and short nasal height.[17] Therefore, if MMA inadvertently places the maxilla in the sagittal position beyond the cephalometric norms, it carries the risk of maxillary protrusion in these patients.

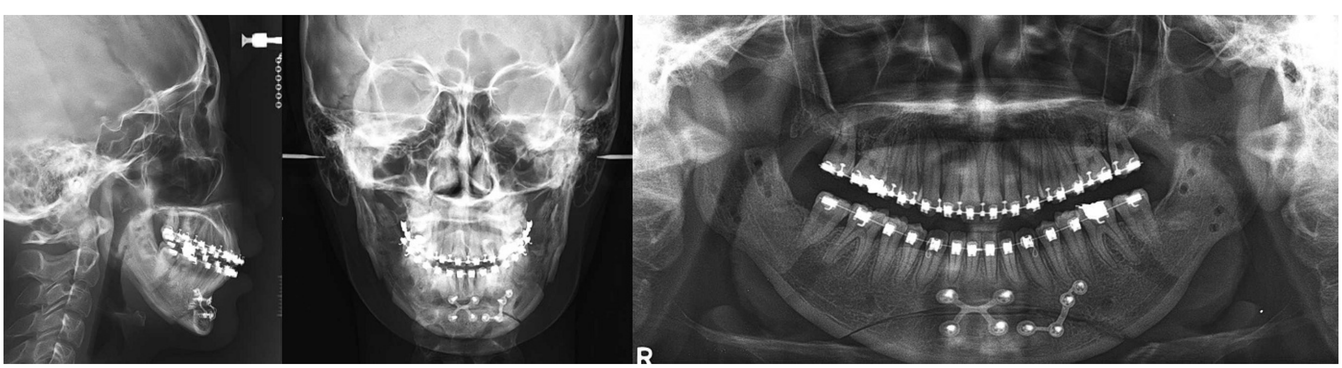

Figure 8. Postoperative lateral cephalogram (A), PA cephalogram (B) and orthopantomogram (C).

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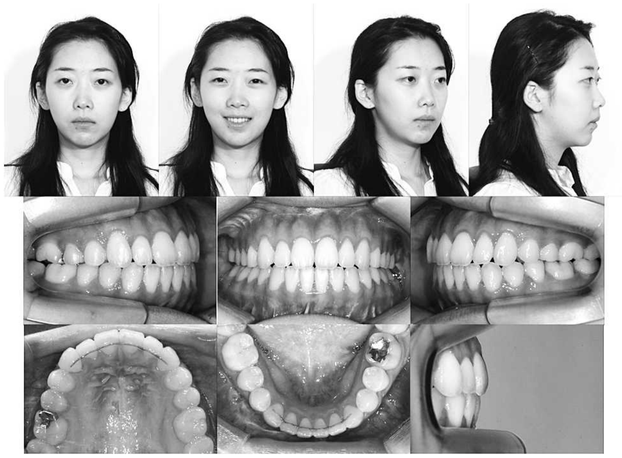


Figure 9. Posttreatment facial and intraoral photographs.

Because surgical treatment planning should be customized according to diverse skeletodental and soft-tissue patterns to produce favorable changes in facial esthetics and sleep function in patients with OSAS, a customized flowchart for surgical treatment planning in patients with OSAS is suggested as follows (Figure 15):

Step 1. The sagittal position of the maxilla and upper lip can be evaluated using SNA, A-N perp, nasolabial angle, and upper lip to the Ricketts' E line. If advancement of the maxilla compromises facial esthetics, advancement of the maxilla can be modified into combination with segmental osteotomy. Anterior segmental osteotomy (ASO) and space closure by advancement of the posterior segment of the maxilla can be used to increase the retropalatal airway, without forward movement of point A and the upper lip, and decrease the nasolabial angle.

Step 2. The vertical position of the maxilla can be determined using the amount of maxillary incisor display. If the patient has a vertical excess of the maxilla and excessive maxillary incisor display, these can be corrected by impaction of the maxilla. In addition, impaction of the maxilla can facilitate the counterclockwise rotation (autorotation) and resultant forward repositioning of the mandible. According to the sagittal position of the maxilla, the maxilla can be moved forward or backward.

Step 3. The status of TMJs and steepness of the maxillary occlusal plane should be evaluated to assess whether or not the maxilla should be rotated. Although counterclockwise rotation of the maxilla is needed in patients with a steep maxillary occlusal plane, downward movement of the posterior segment of the maxilla that causes stretching of the pterygomandibular sling and remodeling and/or resorption of the condyles should be avoided. However, slight counterclockwise

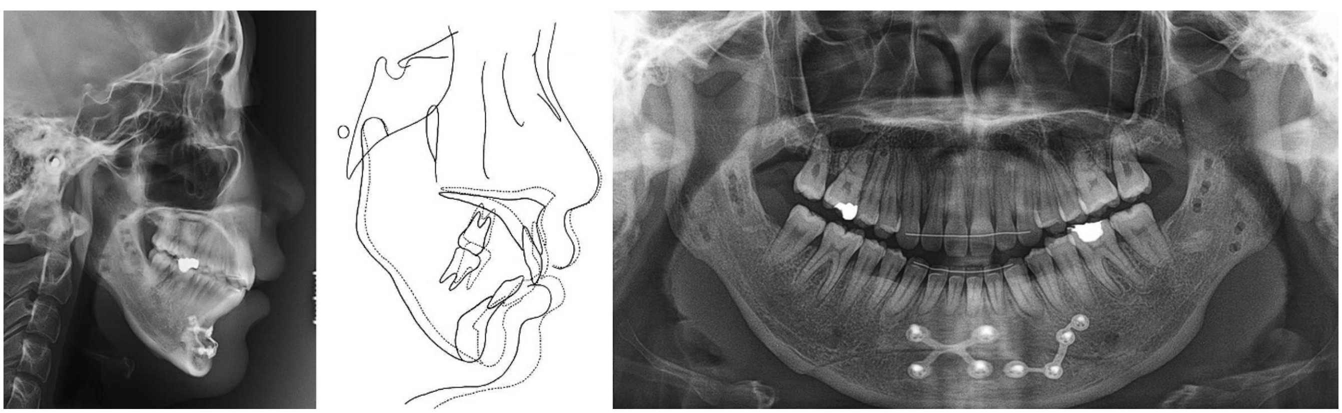
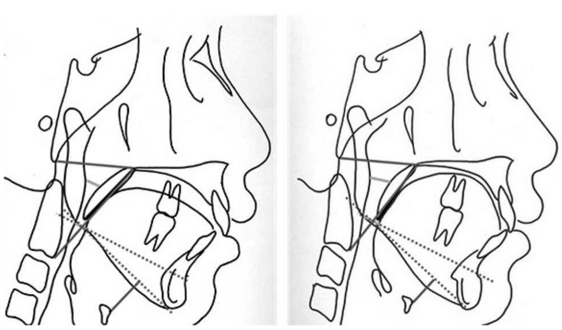


Figure 10. Posttreatment lateral cephalogram (A), superimposition between initial (solid line) and posttreatment tracings (dotted line) (B), and orthopantomogram (C).



Initial		Debonding
34.5	Soft palate length (PNS-P)	34.0
8.7 / 5.8	Posterior airway space (retropalatal / retroglossal)	9.5 / 8.5
20.5	Mn. pl to hyoid distance	14
39.0	Bony nasopharynx (PNS-Ba)	41.0
58	Bony oropharyx (PNS-AA)	60.5

Figure 11. Comparison of the airway space between initial and posttreatment on the lateral cephalogram tracings.

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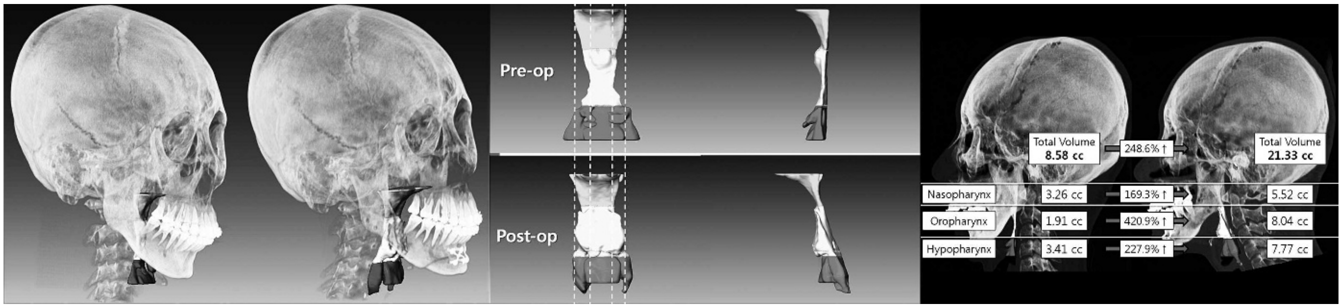

Figure 12. Comparison of the three-dimensional (3D) volumetric airway space (VAS) between the initial and 6 months after orthognathic surgery on the 3D-computed tomography at three different sites: nasopharynx (upper one, gray color), orophrynx (middle one, white color), and hypopharnx (lower one, dark gray color). 3D reconstruction of the whole facial skeleton (A), 3D airway reconstruction in the frontal and sagittal views (B), and the increase in 3D-VAS according to sites (C).

rotation of the maxilla with more impaction of the anterior segment than the posterior segment may be an option. Therefore, in the patient described in this case study, total impaction of the maxilla with slight counterclockwise rotation was selected because of the degenerative change in both TMJs.

Step 4. After setting the position of the maxilla, the mandible can be repositioned to establish the normal relationship of the maxillomandibular complex by considering SNB, Pog-N perp, ANB, and overbite/overjet. Autorotation and resultant advancement of the mandible can be determined based on whether or not impaction or rotation of the maxilla is performed.[18] ASO can be combined with BSSRO to increase the amount of mandibular advancement. In addition, advancement genioplasty can increase the advancement of pogonion and balance the lower lip/chin projection and facial height proportions. Arpornmaeklong et al.[19] reported that patients with a steep mandibular plane angle and greater than 10 mm of mandibular advancement experienced significant relapse due to remodeling and/or resorption of the condyle. Therefore, instead of excessive mandibular advancement, adjunctive advancement genioplasty can be performed to minimize relapse or TMJ overloading in patients with skeletal Class II.

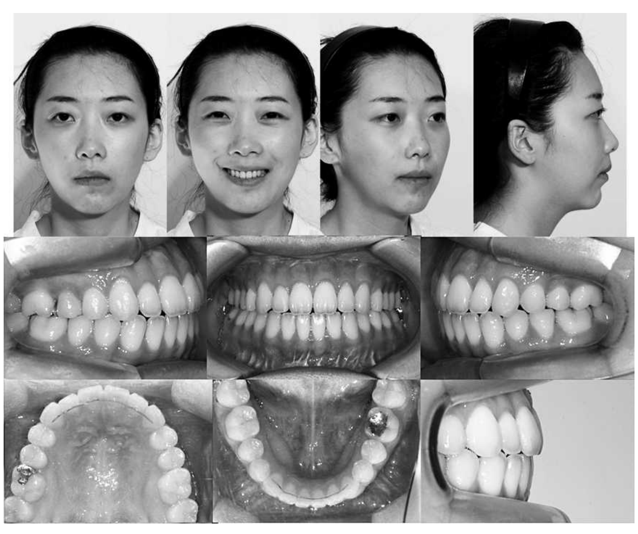

Figure 13. One-year retention facial and intraoral photographs.

Step 5. If the facial height proportion of the lower third of the face is excessive, counterclockwise rotation of the mandible and reduction genioplasty can be performed.

An accurate 3D image of the airway obtained via 3D-CT is effective for evaluating the anteroposterior and lateral dimensions of the airways space.[7,10–12] Airways that are elliptical and mediolaterally oriented have less tendency toward obstruction.[20,21] Comparison of the axial cuts at the same level between the initial status and postoperative 3D-CT revealed greater expansion in the mediolateral than anteroposterior dimension due to the reorientation of airway muscles after orthognathic surgery (Figure 12).

Although impaction of the maxilla can reduce the intranasal dimension, the contention that impaction of the maxilla can also decrease the upper airway volume is questionable. Kim et al.[22] reported that impaction of the maxilla did not affect the upper PAS, which was consistent with the patient in this case report (Figures 11 and 12). Guenthner et al.[23] and Erbe et al.[24] suggested that impaction of the maxilla increases the alar base width and nasal valve angle, thereby reducing nasal resistance to airflow. In addition, Turnbull and Battagel[25] suggested that impaction of the maxilla and counterclockwise rotation/advancement of the mandible seems to be effective for treating refractory OSAS by widening the PAS.

CONCLUSION

- IMX-AAMN-AC might be an effective surgical treatment modality rather than MMA in patients with OSAS and skeletal Class II, normally positioned maxilla, protrusive upper lip, and acute nasolabial angle.

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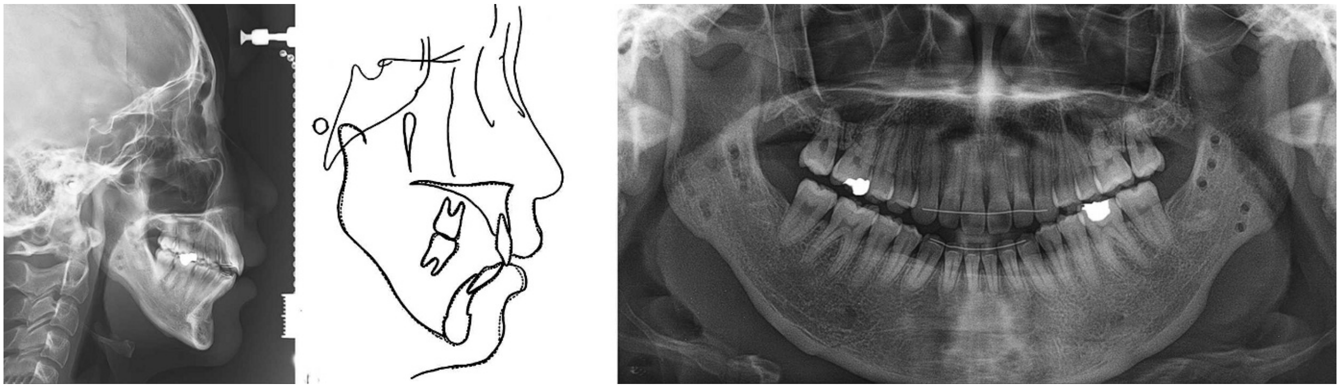

Figure 14. One-year retention lateral cephalogram (A), superimposition between debonding (solid line), and one-year retention tracings (dotted line) (B), and orthopantomogram (C).

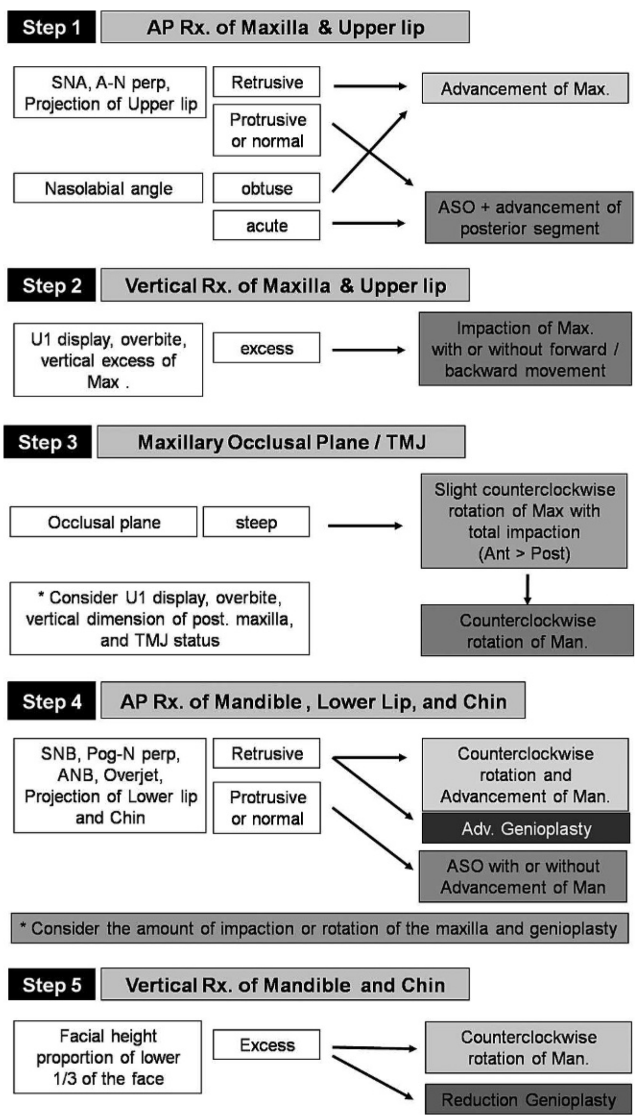

Figure 15. Customized flowchart for surgical treatment planning in patients with obstructive sleep apnea syndrome (OSAS).

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