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The Relationship Between Cephalogram Analysis and Oxygen Desaturation Index During Sleep in Patients Submitted for Mandibular Setback Surgery

Khaled Gamal Dahy, MD,[*†]
Katsu Takahashi, DDS, PhD,[*] *Kazuyuki Saito, DDS,*[*]
Azumi Kakeno, DDS,[*] *Honoka Kiso, DDS, PhD,*[*]
Yu Isobe, DDS,[*] *Sayaka Mishima, DDS,*[*] *Keita Asai, DDS, PhD,*[*]
Abd-Elmateen Moussa, MD, PhD,[†]
Badawy Shahat, MD, PhD,[†] *Ibrahim Rezk, MD, PhD,*[†]
Toru Oga, MD, PhD,[‡] *Satoshi Morita, MD, PhD,*[§]
Kazuo Chin, MD, PhD,[‡] *and Kazuhisa Bessho, DDS, DMSc*[*]

Objectives: The aim of this study was to examine the relationship between morphologic factors of mandibular protrusion patients and clinical indices of obstructive sleep apnea (OSA).
Methods: Fifty-two Japanese patients divided into 2 groups: 1 jaw surgery group (30 patients) and 2 jaw surgery group (22 patients). Morphologic changes were studied using cephalograms taken before surgery and 1 year after surgery. Functional changes studied using impulse oscillometry and pulse oximetry during sleep, both of which are clinically useful measures in assessing OSA, taken before surgery and 1 year after surgery.
Result: Lower face cage area significantly decreased in 1 jaw group than in 2 jaw group patients. Positive significant correlation was found between changes in 3% oxygen desaturation index (ODI) and changes of tongue area and vertical position of the hyoid bone in 1 jaw surgery group. Multiple regression analysis indicates that tongue area and airway area were independently significant predictors of 3% ODI in 1 jaw group patients.
Conclusion: In 2 jaw surgery, maxillary surgery compensated for the effect of mandibular setback surgery. Mandibular setback surgery to mandibular protrusion patients was performed within the range of adequate movement distance, but precautions for risk of postoperative obstructive sleep apnea syndrome should be considered.

Key Words: Cephalometry, impulse oscillation, mandibular setback surgery, obstructive sleep apnea, oxygen desaturation

Mandibular setback surgery is considered treatment of choice for mandibular prognathism, this type of surgery produces changes in the bony and soft tissue components of the lower face cage that results in cosmetic and functional improvements.[1] Many studies have shown changes in the positions of the tongue and the hyoid bone and consequent narrowing of the pharyngeal airway space that could trigger obstructive sleep apnea (OSA).[2–5]

People with untreated OSA face a greater risk of stroke and are more likely to have heart disease, along with hypertension and arrhythmia.[6] Patients with OSA characteristically tend to show repetitive oscillations in oxyhemoglobin saturation during sleep that were called desaturations (oxygen desaturation index [ODI]), which correlates highly with the apnea–hypopnea index obtained by polysomnography so it has been considered to be an effective screening test for OSA.[7,8] With regard to the severity of OSA, anatomic craniofacial abnormalities measured by cephalometry and functional impairments such as increased airway resistance measured by impulse oscillometry (IOS) that play important roles in the pathogenesis of OSA are considered significant features in addition to obesity.[9]

Surgical correction of mandibular prognathism can be achieved using either mandibular setback surgery or bimaxillary surgery,[10] but there have been few studies assessed the effect of mandibular setback surgery either by 1 jaw surgery or 2 jaw surgery and compare them on arterial oxygen saturation (SpO_2) and airway resistance during sleep.[11–14]

The aim of this study was to examine the relationship between morphologic factors of mandibular protrusion patients and the effects of their changes on those functional parameters of OSA after surgical-orthodontic treatment.

MATERIALS AND METHODS

Subjects

We recruited 52 patients (34 females and 18 males) in whom surgical-orthodontic treatment for mandibular prognathism was

From the *Department of Oral and Maxillofacial Surgery, Graduate School of Medicine, Kyoto University, Kyoto, Japan; †Department of Otolaryngology, Sohag University, Sohag, Egypt; ‡Department of Respiratory Care and Sleep Control Medicine, Graduate School of Medicine, Kyoto University.; and §Department of Biomedical Statistics and Bioinformatics, Kyoto, Japan.
Received July 25, 2017.
Accepted for publication December 27, 2017.
Address correspondence and reprint requests to Khaled Gamal Dahy, MD, Department of Oral and Maxillofacial Surgery, Graduate School of Medicine, Kyoto University, Syogoin Kawaramachi, Sakyo-Ku, Kyoto 606-8507 Japan; E-mail: khgamal@kuhp.kyoto-u.ac.jp
The authors report no conflicts of interest.

ISSN: 1049-2275
DOI: 10.1097/SCS.0000000000004386

performed, treated in the Department of Oral and Maxillofacial Surgery, Kyoto Graduate School of Medicine, Kyoto University, from March 2010 to February 2012. This study was approved by the institutional review board of Kyoto University, Ethics Committee No. R0029. Informed consent was obtained from all patients. No patients with cleft palate or craniofacial syndrome were included in this study. Patients were divided into 2 groups: 1 jaw surgery group (30 patients) who underwent bilateral sagittal split ramus osteotomy, intraoral vertical ramus osteotomy, or intraoral vertical split ramus osteotomy and 2 jaw surgery group (22 patients) who underwent Le Fort I osteotomies combined with lower jaw operation. All of the subjects received standard pre- and postoperative orthodontic treatment.

Cephalometry

Morphologic changes were studied using lateral cephalograms taken with the Frankfort horizontal plane parallel to the floor and with the patient in a centric occlusion at the end of expiration before surgery (T0) and 1 year after surgery (T1). The cephalograms were traced to identify hard and soft tissue landmarks. The measuring points were registered on each cephalogram 22 variables related to both craniofacial skeletal and soft tissue morphology were measured as angular (°), linear (mm), or area (cm^2) by a single observer in a single-blind manner. Images were analyzed using Image J software (US NIH, Bethesda, MD). Every measurement was made by the same observer, who had no knowledge of the clinical status of the patient as stated by our previous report.[9] The cephalometric landmarks and reference lines are defined in Table 1 and illustrated anatomically in Figure 1. The following angles and dimensions were measured: SNA, antero-posterior position of the maxilla in relation to the anterior cranial base (angle between S–N and N–A); SNB, antero-posterior position of the mandible in relation to the anterior cranial base (angle between S–N and N–B); ANB, relative position of the mandible to the maxilla (angle between N–A and N–B); facial axis, vertical position of the mandible in relation to the skull (angle between Pt–Gn and N–Ba); G–VL, antero-posterior position of the chin in relation to the vertebra (linear distance along the perpendicular plane from G to VL); N–Ba, the length of the cranial base (distance between N and Ba); S–N, the length of the anterior cranial base (distance between S and N); ANS–PNS, the length of the hard palate (distance between ANS and PNS); PNS–Ba, bony nasopharynx (distance between PNS and Ba); PNS–P, the length of the soft palate (distance between PNS and P); PNS–V, the length of the pharyngeal airway (distance between PNS and V); MPT, greatest thickness of the soft palate; TGL, the length of the tongue (distance between V and TT); TGH, height of the tongue (linear distance along the perpendicular bisector of the V–TT line to the tongue dorsum); Me–Go, the length of the mandible (distance between Me and Go); MP–H, vertical position of the hyoid bone (linear distance along the perpendicular plane from H to MP); H–VL, antero-posterior position of the hyoid bone (linear distance along the perpendicular plane from H to VL); AW1, upper oropharyngeal airway caliber (narrowest part of the airway between PNS and P); AW2, lower oropharyngeal airway caliber (narrowest part of the airway between P and Go); airway area, dimensions of the oropharynx (area outlined by the inferior border of the nasopharynx, the posterior surface of the soft palate and tongue, the line parallel to the palatal plate through the point V, and the posterior pharyngeal wall); tongue area, dimensions of the tongue (area outlined by the dorsal aspect of the tongue surface and lines that join TT, G, H, and V); and the lower face cage, the maxillomandibular enclosure size of the upper airway (cross-sectional area of the trapezoid enclosed by Cd–A– Pg–Cd′). Cephalograms were measured twice by the same examiner and by a more experienced examiner, the intraobserver and interobserver reliability of landmark identification; area measurements were assessed using intraclass correlation (ICC) analysis.

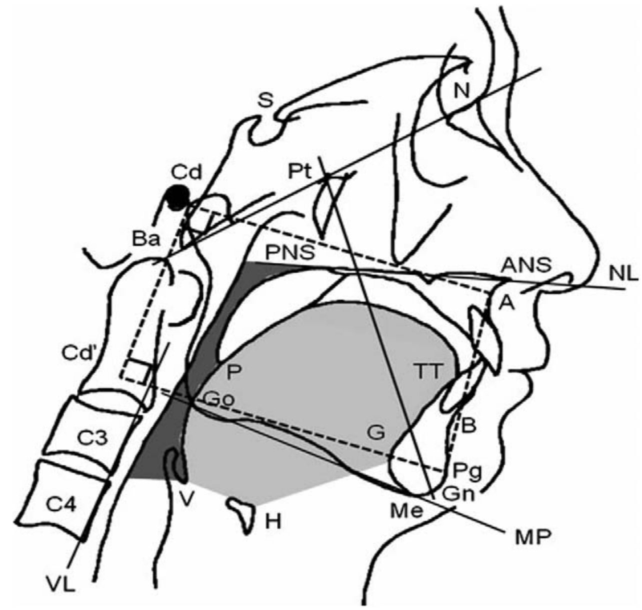

FIGURE 1. Cephalometric landmarks and reference lines. For definitions, see Table 2. Shaded area indicates a cross-sectional area of the tongue. Dark-stained area indicates a cross-sectional area of the airway. Lower face cage was defined as a trapezoid formed by Cd–A–Pg–Cd′ (dotted lines).

TABLE 1. Definitions of Cephalometric Landmarks and Reference Lines

S	Sella, midpoint of the fossa hypophyseal
N	Nasion, anterior point at the frontonasal suture
ANS	Anterior nasal spine, most anterior point of the nasal spine
PNS	Posterior nasal spine, most posterior point of the nasal spine
A	Deepest anterior point in the concavity of the anterior maxilla
B	Deepest anterior point in the concavity of the anterior mandible
Cd	Medial condylar point of the mandible
Cd′	A point that Pg projects onto the perpendicular line to the Cd–A line at the Cd point
Go	Gonion, a mid-plane point at the gonial angle located by bisecting the posterior and inferior borders of the mandible
Me	Menton, most inferior point of the chin bone
Ba	Basion, most posteroinferior point on the clivus
G	Most posterior point on the symphysis of the mandible
Pg	Prognathion, most anterior point on the symphysis of the mandible
P	Lowest point of the soft palate
TT	Most anterior point of the tip of the tongue
H	Most antero-superior point of the hyoid bone
V	Most antero-inferior point of the epiglottic fold
Pt	Intersection of the posterior pharyngeal wall and most inferior margin of the foramen rotundum
Gn	Gnathion, the most antero-inferior point of body chin
NL	Nasal line, a line through ANS and PNS
MP	Mandibular plane, a plane constructed from Me through Go
VL	A line across C3 and C4

Impulse Oscillometry

We measured airway resistance by the respiratory resistance measurement device using IOS (Master screen IOS-J, Jaeger, Wurzburg, Germany),[9] first in the sitting position and then in the

TABLE 2. Background of the Patients

	Patients, n	Mean Age		Sex		Mean BMI, kg/m^2		Mean Amount of Setback, mm
		Pre	1 y Post	Male	Female	Pre	1 y Post	
1 Jaw group	30	28.6 ± 9.8	29.6 ± 9.8	11	19	21.1 ± 2.3	20.8 ± 1.9	5.6 ± 3.2
2 Jaw group	22	24.9 ± 6.3	25.9 ± 6.3	7	15	21.2 ± 2.7	21.8 ± 3.1	8.3 ± 3
All patients	52	27 ± 8.6	28 ± 8.6	18	34	21.2 ± 2.4	21.2 ± 2.5	6.7
P^*		0.311		0.719		0.487		0.078

BMI, body mass index
*Comparison between 1 jaw and 2 jaw groups.

supine position before surgery (T0) and 1 year after surgery (T1). The impulse signal that contains a 0 to 100 Hz frequency component is delivered into the oral cavity. We analyzed the respiratory impedance by measuring the intraoral pressure and flow rate. The resistance (R) of each frequency is calculated; respiratory resistance at 5 Hz (R5) represents the total airway resistance, and at 20 Hz (R20) demonstrates the central airway resistance. In IOS, low-frequency oscillations are transmitted to the lung periphery, while those at frequencies ≥20 Hz are thought to be damped out before reaching the peripheral airways.

The measurement time is about 5 minutes. This method does not need effort respiration and needs only quiet breathing.

Measurement of SpO_2 During Sleep

SpO_2 was measured overnight by a pulse oxymeter (Pulsox; Minolta, Osaka, Japan), before surgery (T0) and 1 year after surgery (T1).[15]

Measurements were carried out in hospital at T0 and at patients' homes at T1 after guidance on its proper use by the doctor. The severity of OSA was quantified by the 3% ODI, which is the number of desaturation events of 3% or more below the baseline level per hour during sleep. This index represents the principal marker of the severity of intermittent hypoxia and reoxygenation in patients with OSA.

Statistic Analysis

All statistical analyses were performed using SPSS software (SPSS Inc, Chicago, IL), and the arithmetic means and standard deviations were calculated for all variables. Wilcoxon signed-rank test was used to evaluate the changes in paired parameters in each group. Comparisons of the pre- and postoperative values of the parameters between both groups were done using the Mann–Whitney U test. Correlation studies were performed using the Spearman rank test. Stepwise multiple regression analyses were performed to identify variables that could predict 3% ODI. P value < 0.05 was considered significant.

RESULTS

The mean age at surgery was 27 ± 8.6 years (range 16–48) and mean body mass index (BMI) values before surgery and 1 year after surgery were 21.2 ± 2.4 kg/m^2 (range 16.8–28.6) and 21.2 ± 2.5 kg/m^2 (range 17.7–31.5), respectively. The mean setback distance was 6.7 mm. There were no significant differences in age, sex, BMI, and amount of setback, which were all possible confounding factors, between 2 operation groups (Table 2).

Regarding cephalometric variables, ICCs ranged from 0.884 to 0.999 with strong reliability. Cephalometric variables were compared between T0 and T1 in both groups (Tables 3 and 4). The changes in the clinical characteristics and impulse oscillatory data

TABLE 3. Comparison of Measurements Between T0 and T1 in 1 Jaw Group

Variables	T0, Mean ± SD	T1, Mean ± SD	Variables	T0, Mean ± SD	T1, Mean ± SD
IOS, kPa/L/s			Distance, mm		
R20 (supine)	0.30 ± 0.08	0.30 ± 0.07	G–VL	75.6 ± 6.2	74.2 ± 6.7
R5 (supine)	0.33 ± 0.09	0.32 ± 0.07	N–Ba	109.1 ± 4.8	106.6 ± 5
R5 (sitting)	0.29 ± 0.07	0.27 ± 0.07	S–N	71 ± 3.7	71.6 ± 3.8
R20 (sitting)	0.27 ± 0.07	0.27 ± 0.07	ANS–PNS	53.4 ± 4	53.8 ± 2.9
SpO_2, number/h			PNS–Ba	46.3 ± 2.9	46.9 ± 3.8
3% ODI	1.9 ± 1.6	2.9 ± 2.3	PNS–P	30.5 ± 3.8	31.5 ± 5.1
Angle, °			PNS–V	63.8 ± 5.2	64.1 ± 5.4
SNA	79.6 ± 4.4	82.7 ± 4.6	MPT	9.8 ± 2.1	9.6 ± 1.7
SNB	81 ± 4.4	83.3 ± 5*	TGL	68.2 ± 4.8	71.8 ± 6*
ANB	−1.3 ± 3.1	−0.67 ± 3.6	TGH	40.3 ± 4.8	38.4 ± 4.3*
Facial axis	92.1 ± 4.7	91.5 ± 5	Me–Go	76.8 ± 4.5	79.7 ± 8.9
Area, cm^2			MP–H	9.8 ± 3.5	13.1 ± 4.2*
			H–VL	36.9 ± 4.9	35.9 ± 4
Airway area	9.8 ± 2	8.5 ± 1.6*	AW1	13.7 ± 3.5	13.3 ± 3.7
Tongue area	29.1 ± 3.5	32.1 ± 4*	AW2	14.8 ± 4.2	12 ± 3*
Lower face cage	57 ± 5.9	50.6 ± 5.9*			

IOS, impulse oscillometry; ODI, oxygen desaturation index; SD, standard deviation.
*$P < 0.05$.

TABLE 4. Comparison of Measurements Between T0 and T1 in 2 Jaw Group

Variables	T0, Mean ± SD	T1, Mean ± SD	Variables	T0, Mean ± SD	T1, Mean ± SD
IOS, kPa/L/s			Distance, mm		
R20 (supine)	0.29 ± 0.09	0.29 ± 0.06	G–VL	77.6 ± 7.2	75.7 ± 5.2
R5 (supine)	0.34 ± 0.11	0.32 ± 0.09	N–Ba	106.9 ± 5.2	105.6 ± 4.3
R5 (sitting)	0.28 ± 0.06	0.26 ± 0.07	S–N	69.2 ± 3.8	70 ± 3.6
R20 (sitting)	0.27 ± 0.05	0.26 ± 0.05	ANS–PNS	53.1 ± 3.5	52.5 ± 4.4
SpO_2, number/h			PNS–Ba	45.6 ± 3.9	47.3 ± 3*
3% ODI	2.2 ± 2.3	2.2 ± 2.8	PNS–P	30.2 ± 2.8	32 ± 5.7
Angle, °			PNS–V	65.5 ± 6	66.8 ± 6.2*
SNA	81.4 ± 3.1	86 ± 4.4*	MPT	9.3 ± 1.9	9.3 ± 1
SNB	83 ± 4.1	84.3 ± 4.8	TGL	70.5 ± 5.3	73.9 ± 5.7*
ANB	−1.7 ± 3.2	2.1 ± 3*	TGH	40.6 ± 4.4	38.4 ± 4.1*
Facial axis	91.9 ± 5	92 ± 4	Me–Go	77.1 ± 4.5	78.8 ± 8
Area, cm^2					
			MP–H	12.5 ± 5.1	14.8 ± 6*
Airway area	10.3 ± 1.8	9.1 ± 1.7*	H–VL	36.1 ± 4.7	36.7 ± 5
Tongue area	29.6 ± 3.6	32.8 ± 3.9*	AW1	13.8 ± 3.3	12.7 ± 2.7
Lower face cage	55.9 ± 6.2	53.3 ± 6.7	AW2	15.2 ± 3.5	11.8 ± 3.1*

IOS, impulse oscillometry; ODI, oxygen desaturation index; SD, standard deviation.
*$P < 0.05$.

on both groups between T0 and T1 and the differences between groups are listed in (Table 5).

Cephalometric Analyses

Cephalometric variables were compared between T0 and T1 in 1 jaw group and 2 jaw groups. In 1 jaw group (Table 3), with regard to angular measurements, a significant increase was observed in SNB angles ($P < 0.05$) indicating that some sorts of relapse occur at T1 after mandibular setback. In linear measurements, TGL and MP–H significantly increased, and TGH and AW2 significantly decreased ($P < 0.05$), indicating downward position of the hyoid bone, increased the length of the tongue, decreased the height of the tongue, and decreased posterior airway space occurred at T1. In area measurements, tongue area significantly increased and airway area and lower face cage area significantly decreased at T1 ($P < 0.05$).

In the 2 jaw surgery group (Table 4), with regard to angular measurements, SNA and ANB angle significantly increased ($P < 0.05$), indicating that maxilla moves forward at T1 with mandibular setback occurred at T1. In linear measurements, PNS–Ba, PNS–V, TGL, and MP–H significantly increased, and TGH and AW2 significantly decreased ($P < 0.05$), indicating that downward position of the hyoid bone, increased the length of pharyngeal airway, increased the length of the nasopharynx, increased the length of the tongue, decreased the height of the tongue, and decreased posterior airway space occurred at T1. In area measurements, tongue area significantly increased and airway area significantly decreased at T1.

TABLE 5. Comparison of Changes in the Clinical Characteristics and Impulse Oscillatory Data in Both Groups

Postoperative Change	1 Jaw Group (n = 30), Mean ± SD	2 Jaw Group (n = 22), Mean ± SD		1 Jaw Group (n = 30), Mean ± SD	2 Jaw Group (n = 22), Mean ± SD
IOS, kPa/L/s			Distance, mm		
Lie R20	0.002 ± 0.07	−0.005 ± 0.09	G–VL	−1.4 ± 6.1	−1.5 ± 6.7
Lie R5	−0.001 ± 0.08	−0.018 ± 0.11	N–Ba	−2.6 ± 3.5	−1.3 ± 2.9
Sit R5	−0.015 ± 0.05	−0.021 ± 0.06	S–N	−0.06 ± 3.2	0.26 ± 1.9
Sit R20	−0.003 ± 0.05	−0.007 ± 0.06	ANS–PNS	0.39 ± 3	−0.59 ± 2.7
SpO_2, number/h			PNS–Ba	0.62 ± 3.2	1.7 ± 3.4
3% ODI	0.93 ± 2.8	0.03 ± 3.7	PNS–P	1 ± 3.4	1.8 ± 5.6
Angle, °			PNS–V	0.30 ± 4	1.3 ± 3.5
SNA	3.1 ± 3.8	4.6 ± 4.3	MPT	−0.13 ± 1.3	−0.06 ± 1.7
SNB	2.3 ± 4.4	1 ± 4.2	TGL	3.5 ± 5.7	3.3 ± 4.7
ANB	0.62 ± 3	3.7 ± 2.6*	TGH	−1.9 ± 4.6	−1.6 ± 3.6
Facial axis	−0.61 ± 4	0.12 ± 5.3	Me–Go	2.9 ± 7.6	1.6 ± 7.9
Area, cm^2			MP–H	3.3 ± 4.1	2.2 ± 4.4
Airway area	−1.3 ± 1.7	−1.1 ± 2	H–VL	−0.93 ± 3.5	0.58 ± 3.9
Tongue area	3 ± 2.3	3.2 ± 3.7	AW1	−0.40 ± 2.3	−1 ± 3
Lower face cage	−6.4 ± 5.3	−2.6 ± 5.2*	AW2	−2.7 ± 3.5	−3.4 ± 4.3

IOS, impulse oscillometry; ODI, oxygen desaturation index; SD, standard deviation.
*$P < 0.05$.

The changes in the cephalometric measurements showed a statistically significant increase of ANB angle ($P = 0.001$) and lower face cage ($P = 0.022$) in the 2 jaw surgery group than in 1 jaw group (Table 5).

Impulse Oscillometry

There is no statistically significant change between T0 and T1 in both groups in IOS parameters. There is no statistically significant difference between 1 jaw group and 2 jaw groups in IOS parameters (Tables 3–5).

SpO_2 During Sleep

There was no statistically significant change between T0 and T1 in both groups in 3% ODI (Tables 3 and 4). There was also no statistically significant difference between 1 jaw group and 2 jaw groups in 3% ODI changes (Table 5).

Correlations

Positive significant correlations were found between changes in 3% ODI (difference before and after surgery) and changes of tongue area (Spearman correlation coefficient $[r_s] = 0.420$, $P = 0.021$) and MP–H (Rs = 0.593, $P = 0.001$) among cephalometric variables in the 1 jaw surgery group. In 2 jaw groups, there were no significant correlations between changes in 3% ODI and changes in any cephalometric variables.

Regression Analysis

Stepwise multiple regression analysis indicates that tongue area and airway area changes were statistically significant predictors of 3% ODI changes in 1 jaw group patients. Tongue area and airway area changes significantly explained 20.8% and 13.1% of the 3% ODI variance in 1 jaw group patients, respectively.

In 2 jaw group, there were no significant predicted variables for 3% ODI variance.

DISCUSSION

Narrowing of the upper pharyngeal airway is one of the most serious and dangerous outcomes of mandibular setback surgery, which will increase airway resistance and may lead to OSA.[16–18] Although age, sex, and BMI were found to be the most important risk factors for OSA,[19,20] considered the confounding factors in our results, we compared both groups according to these factors we did not found a significant difference between groups (Table 2).

Changes in the position of the tongue and hyoid bone are the common causes of pharyngeal upper airway narrowing.[21–26]

Our results showed that downward and backward position of the hyoid bone, decreased posterior airway space, increased the length of the tongue, increased tongue area, decreased airway area, and lower face cage area. With a significant difference in the postoperative period compared with preoperative status (Tables 3 and 4). These results were similar to obstructive sleep apnea syndrome (OSAS) patients' morphologic characteristics that reported previously.[2,27,28] Thus, mandibular protrusion patients may have a risk for OSAS in the postoperative period.

Lower face cage area significantly decreased in 1 jaw group patients, unlike 2 jaw group patients that had no significant changes in lower face cage area and also had a significant increase in length in the pharyngeal airway and increased the diameter of the nasopharynx that can be explained by the maxillary operation. Although we did not find a significant difference in the amount of setback between 1 jaw surgery and 2 jaw surgery groups of our study ($P = 0.078$). This is similar to previous studies by Abdelrahman et al[29] and Hong et al[30] in which they concluded that the amount of narrowing of the pharyngeal airway was smaller in patients undergoing bimaxillary surgery than in the patients undergoing mandibular setback surgery alone.

Hasebe et al[1] studied the effects of mandibular setback surgery on pharyngeal airway space and respiratory function during sleep. They noted that a large amount of mandibular setback might cause OSA and it might be better to consider maxillary advance that does not reduce the airway, similarly with our results that revealed a significant increase of ANB angle and lower face cage area in the 2 jaw group than in 1 jaw group. In order to prevent the postoperative OSA after mandibular setback surgery, we performed Le Fort I advancement in compensatory for severe mandibular protrusion patients in which setback distance was more than 10 mm.

There was no evidence of OSAS in the postoperative period of either all patients or both groups. This coincides with Hochban et al[31]; they reported that there was no evidence of postoperative OSA after mandibular setback surgery, though the pharyngeal airway decreased after surgery.

Turnbull and Battagel[5] reported the influence of setback surgery on breathing parameters during sleep, using a mini sleep study (ie, overnight oximetry and respiratory noises). Their sample consisted of 9 subjects; they measured SpO_2 before and 1 month after mandibular setback surgery and found no significant change despite identifying a reduction in the retro lingual airway diameter in all patients. On the other hand, Foltán et al[12] indicated that bimaxillary surgery for class III malocclusion with mandibular bilateral sagittal split ramus osteotomy setback and Le Fort I advancement can significantly increase upper airway resistance and cause deterioration of breathing parameters. This indicated that the potential impact of orthognathic surgery on the upper airways should be included within treatment plans. In a recent polysomnography study by Gokce et al,[32] sleep quality and efficiency improved significantly after bimaxillary surgery with significant increases in SpO_2 and decreases in apnea–hypopnea index.

In our study, we compared patients according to the type of surgery and found that there is no statistically significant difference between preoperative and postoperative results of central airway resistance (supine R20), and 3% ODI or between 1 jaw group and 2 jaw group results. An indication that either it is a biological adaptation to the new environment or the change caused by the surgery has a relatively small effect on functional parameters of OSA.

The position of the hyoid bone is thought to be one of the important factors for maintaining the airway space,[33] inferior displacement of the hyoid bone may also be biological adaptations to maintain the airway space.[34] Increased tongue area resulted in increase soft tissue area, thereby leaving less space for airway patency and this is could be explained on the basis of compensatory functional readjustment of hyoid and lingual musculature to maintain the airway space after surgical correction.[2] So careful assessment of the preoperative size of the tongue should be done and avoid the possibility of association of preoperative macroglossia with mandibular protrusion patients and hence the occurrence of postoperative OSAS. Within this study, we did not find out any severe macroglossia patient based on clinical features. We found that positive significant correlation was found between changes in 3% ODI (difference before and after surgery) and changes of tongue area and vertical position of hyoid bone in the 1 jaw surgery group unlike the 2 jaw group patients that had no significant correlations that indicated that maxillary surgery does not affect the overall hyoid and tongue response.[35] Stepwise multiple regression analysis indicates that tongue area and airway area changes were statistically significant predictors of 3% ODI changes in the 1 jaw surgery group. On the other hand, in 2 jaw groups, there was no significant predicted variable for 3% ODI variance.

CONCLUSION

In 2 jaw surgery, maxillary surgery compensated for the effect of mandibular setback surgery on changes of postoperative morphologic factors. In 1 jaw surgery, 3% ODI changes were closely related to changes in tongue area, the vertical position of the hyoid bone and tongue area, airway area changes were its main determinants. Mandibular setback surgery to mandibular protrusion patients was performed within the range of adequate movement distance, but precautions for risk of postoperative OSAS should be considered.

ACKNOWLEDGMENT

The authors thank Toru Yamazaki, Masashi Yamori, and Kayo Tamura for their collaborations.

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