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Gender differences in morphological and functional outcomes after mandibular setback surgery

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A B S T R A C T

Purpose: The aim of this study was to examine and compare morphological and functional outcomes after either isolated mandibular setback or bimaxillary surgery in males and females.
Materials and methods: A retrospective study was done on 52 patients, in whom surgical correction for mandibular prognathism was performed either by isolated mandibular setback (30 cases) or by bimaxillary surgery (22 cases). Morphological changes were studied using cephalograms and functional changes studied using impulse oscillometry (IOS) taken before surgery (T0), 3 months (T1) and 1 year after surgery (T2). Also 3% oxygen desaturation index (ODI) was measured at T0 and T2.
Result: Posterior airway space decreased significantly in both groups and both sexes but more so in males after mandibular setback surgery and in females after bimaxillary surgery. Changes in supine R20 (central airway resistance at 20 Hz) and supine R5 (total airway resistance at 5 Hz) in IOS statistically significantly increased in the period T0–T1 in males compared with females after mandibular setback surgery ($p < 0.05$).
Conclusion: Gender dimorphism is present according to morphological and functional outcomes, with males at a higher risk for obstructive sleep apnea (OSA) after mandibular setback surgery and females after bimaxillary surgery; however, compensatory changes act as a barrier against this.

1. Introduction

Mandibular setback surgery can change the positions of the surrounding bony and soft structures, including the tongue and hyoid bone, accompanied by a consequent narrowing of the posterior airway space (PAS), which is one of the most important factors that cause obstructive sleep apnea (OSA) (Achilleos et al., 2000; Kawamata et al., 2000; Tselnik et al., 2000; Turnbull et al., 2000).

Functionally, OSA has been reported to be associated with the repeated falling of blood oxygen levels called desaturations, measured by the oxygen desaturation index (ODI) by an oximeter and also associated with increased airway resistance obtained in impulse oscillometry (IOS) (Huiguo et al., 2000).

IOS measures small-amplitude pressure oscillations on quiet breathing to measure the impedance of the respiratory system. It can distinguish impedance of central and peripheral airway to reflect the extent of airway obstruction indirectly. Airway obstruction in OSA patients can be evaluated by IOS (Cao et al., 2009).

Corrective surgery for mandibular prognathism now generally involves more commonly bimaxillary surgery or mandibular setback surgery alone (Chen et al., 2007). Many studies have reported sex differences in PAS change following orthognathic surgery (Nakagawa et al., 1998; Samman et al., 2001; Panou et al., 2013), but few studies have assessed the effect of mandibular setback surgery, by either one-jaw surgery or two-jaw surgery in

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males and females, and compared them in regard to airway resistance and arterial oxygen saturation (SpO_2) during sleep.

The aim of this study was to examine and compare morphological and functional outcomes after mandibular setback surgery or bimaxillary surgery in males and females. In addition, we aimed to determine whether there is gender dimorphism and also to identify any differences, either anatomically or functionally, between males and females after orthognathic surgery.

2. Materials and methods

2.1. Subjects

The samples consisted of 52 patients (34 females and 18 males) in whom orthodontic surgical treatment for mandibular prognathism was performed at 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 cases of cleft palate or craniofacial syndrome were included in this study. Patients were divided into 2 groups: one-jaw surgery group (30 patients; 11 male and 19 female) who underwent bilateral sagittal split ramus osteotomy (SSRO), intraoral vertical ramus osteotomy (IVRO) or intraoral vertical split ramus osteotomy (IVSRO); and two-jaw surgery group (22 patients; 7 male and 15 female) who underwent Le Fort I osteotomies combined with lower jaw operation. All of the subjects received standard pre- and postoperative orthodontic treatment.

2.2. Cephalometry

Morphological changes were studied using lateral cephalograms taken with the Frankfort horizontal (FH) plane parallel to the floor and with the patient in a centric occlusion at the end of expiration before surgery (T0), 3 months (T1), and 1 year after surgery (T2). The cephalograms were traced to identify hard and soft tissue landmarks. The measuring points were registered on each cephalogram; 8 variables related to both craniofacial skeletal and soft tissue morphology were measured as linear (millimeters) or area (square centimeters) by a single observer in a single-blind manner. Images were analyzed using ImageJ software (US National Institutes of Health [NIH], Bethesda, MD, USA). Every measurement was made by the same observer, who had no knowledge of the clinical status of the patient. The cephalometric landmarks and reference lines are illustrated anatomically in Fig. 1. The following dimensions were measured: TGL, the length of the tongue (distance between V and TT); MPH, vertical position of the hyoid bone (linear distance along the perpendicular plane from H to MP); H-VL, the anteroposterior 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, with the intraobserver and interobserver reliability of landmark identification; area measurements were assessed using interclass correlation (ICC) analysis.

2.3. IOS

We measured airway resistance by the respiratory resistance measurement device using IOS (Master screen IOS-J, Jaeger, Wurzburg, Germany) (Aihara et al., 2012), first in the sitting position and then in the supine position, before surgery (T0), 3 months (T1), and 1 year after surgery (T2).The impulse signal that contains a 0- to100-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 min. This method does not require effort respiration and needs only quiet breathing.

2.4. Measurement of SpO_2 during sleep

SpO_2 was measured overnight with a pulse oxymeter (Pulsox; Minolta, Osaka, Japan), before surgery (T0) and 1 year after surgery (T2) (Oga et al., 2009).

Measurements were carried out in hospital at T0 and at patients' homes at T2 after guidance on the proper use of the oxymeter by the doctor. The severity of OSA was quantified by the 3% oxygen desaturation index (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.

2.5. Statistical analysis

All statistical analyses were performed using SPSS software (SPSS 16.0, SPSS Inc, Chicago, IL), and the arithmetic means and standard deviations (SDs) were calculated for all variables. The Friedman test was used to determine whether changes in each parameter had significance in their groups. After the significance of the parameters was determined, the Wilcoxon signed-rank test was used to evaluate the changes in paired parameters in each group. Mann–Whitney U tests were used to compare the sample means between the sexes. A P value < 0.05 was considered statistically significant.

3. Results

The mean age at surgery was 27 ± 8.6 years (range 16–48 years) and mean body mass index (BMI) was 21.2 ± 2.4 kg/m^2 (range 16.8–28.6 kg/m^2). The mean setback distance was 6.7 mm. There were no significant differences in age and BMI, which were all possible confounding factors, between the two operative groups (Table 1).

Regarding cephalometric variables, ICCs ranged from 0.884 to 0.999, with strong reliability.

3.1. Cephalometric analyses

3.1.1. One-jaw surgery group

The Friedman test indicated significant changes in TGL, MPH, AW2, tongue area, and lower face cage area in both sexes; however, there were significant changes in AW1 and airway area in females only and in H-VL in males only (Table 2). In linear measurements,

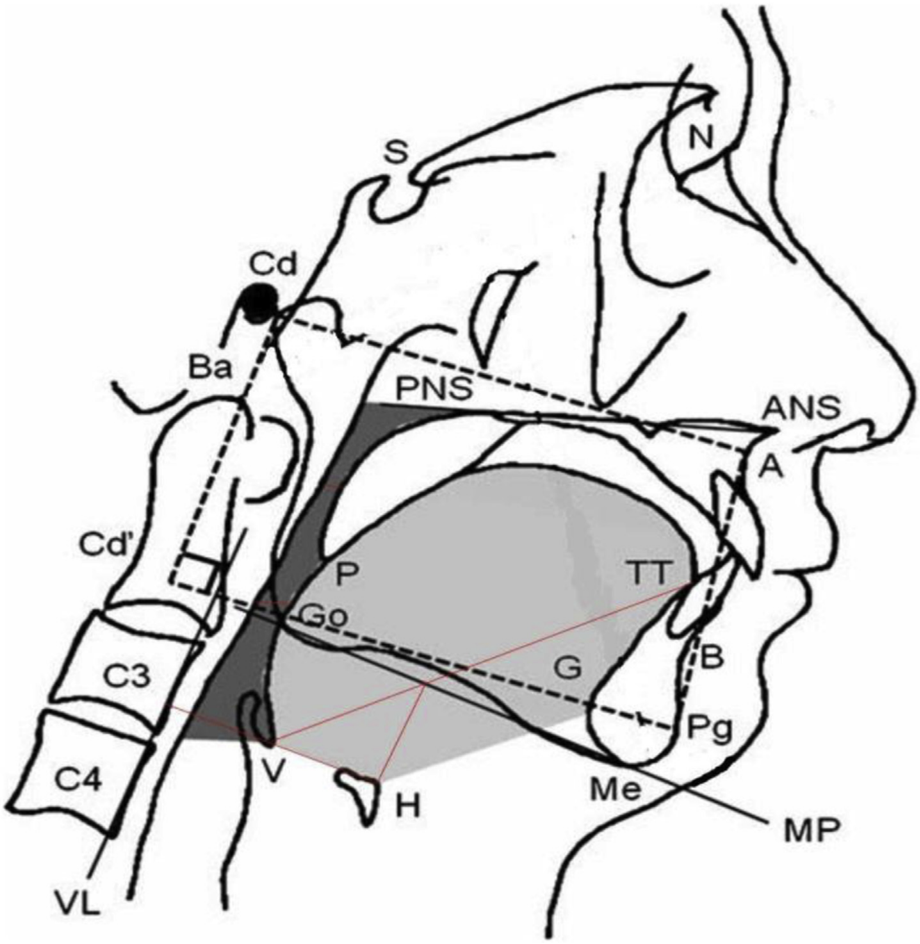

Fig. 1. Cephalometric landmarks and reference lines. Cephalometric landmarks: N, nasion; S, sella; ANS, anterior nasal spine; PNS, posterior nasal spine; Pg, prognathion (the most anterior point on the symphysis of the mandible); Ba, basion; Me, menton; Go, gonion (mid-plane point at the gonial angle located by bisecting the posterior and inferior borders of the mandible); Gn, gnathion (the most antero-inferior point of body chin); A, point A (deepest anterior point in the concavity of the anterior maxilla); B, point B (deepest anterior point in the concavity of the anterior mandible); G, most posterior point on the symphysis of the mandible; P, lowest point of the soft palate; TT, most anterior point of the tip of the tongue; V, most antero-inferior point of the epiglottic fold; H, most anterosuperior point of the hyoid bone; 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; MP, mandibular plane (a plane constructed from Me through Go); VL, line across C3 and C4. 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).

TGL significantly increased in the period T0–T1 by Wilcoxon signed-rank test in both sexes, and in T0–T2 only in males. MPH significantly increased in the period T0–T1 in females and in T0–T2 in males. HVL significantly decreased in the period T0–T1 only in males. AW1 significantly decreased in the period T0–T1 and significantly increased in the period T1–T2 only in females. AW2 significantly decreased in the period T0–T1and T0–T2 in both sexes. In area measurements, tongue area significantly increased in the period T0–T1 and in T0–T2 in both sexes. Airway area significantly decreased in the period T0–T1 and in T0–T2 only in females. Lower face cage area significantly decreased in the period T0–T1 and T0–T2 in both sexes.

The changes in the cephalometric measurements showed a statistically significant increase in H-VL ($P = 0.031$) in the period T0–T2 in males compared with females. There was a statistically significant increase in MPH ($P = 0.04$) in the period T1–T2 in females compared with males. AW1 statistically significantly increased ($P = 0.043$) in the period T1–T2 in males compared with females (Table 4).

3.1.2. Two-jaw surgery group

The Friedman test indicated significant changes in MPH, H-VL, AW2, tongue area and airway area in females only (Table 3). In linear measurements, MPH significantly increased in the period

Table 1
Patient characteristics.

	Patients (n)	Mean age (yr)	Mean BMI (kg/m^2)	Mean amount of setback (mm)
One-jaw group				
Males	11	26.2 ± 9	21.8 ± 2.3	7.5 ± 3.2
Females	19	30 ± 10.2	20.8 ± 2.2	6.6 ± 2.8
Two-jaw group				
Males	7	22.6 ± 4.3	21.5 ± 1.6	7.7 ± 4.3
Females	15	25 ± 6.9	21.1 ± 3.1	5.9 ± 3.7
All patients	52	27 ± 8.6	21.2 ± 2.4	6.7

Table 2
Changes in cephalometric measures in both sexes in mandibular setback surgery group.

	Pre	3 mo post	1 yr post
	T0	T1	T2
TGL			
Male	71.1 ± 5.2	77.5 ± 5.2	76.7 ± 4
Female	66.6 ± 3.7	68.2 ± 2.3	68.9 ± 5.1
MPH			
Male	10.1 ± 3.1	12.3 ± 4.3	14.7 ± 2.2
Female	9.6 ± 3.8	11.6 ± 1.4	12.1 ± 4.9
HVL			
Male	41.1 ± 2.4	39.1 ± 2.5	38.5 ± 2.5
Female	34.4 ± 4.2	34.1 ± 6.8	34.4 ± 3.
AW1			
Male	13.6 ± 3.7	12.8 ± 3.4	12.6 ± 2.9
Female	13.8 ± 3.5	10.3 ± 4.7	13.8 ± 4.2
AW2			
Male	15.3 ± 2.8	11.7 ± 2.5	12.3 ± 1.7
Female	14.4 ± 5.6	9 ± 6	11.8 ± 4.2
Airway area			
Male	10.5 ± 2.1	9 ± 2	9 ± 1
Female	9.4 ± 1.9	7.3 ± 2.4	8.2 ± 1.9
Tongue area			
Male	31.9 ± 2.4	36.4 ± 2.5	35.7 ± 2.6
Female	27.5 ± 2.9	31.6 ± 1	30 ± 3.8
Lower face cage area			
Male	60.1 ± 4.7	53.2 ± 5.2	53.5 ± 6.1
Female	55.2 ± 5.8	46.3 ± 1.1	48.4 ± 5.2

Values are given as mean ± SD.
*$P < 0.05$.

T0–T1 by the Wilcoxon signed-rank test. H-VL significantly decreased in the period T0–T1 and increased in the period T1–T2. AW2 significantly decreased in the period T0–T1. In area measurements, tongue area significantly increased in the periods T0–T1and T0–T2. Airway area significantly decreased in the period T0–T1.

The changes in the cephalometric measurements showed a statistically significant increase of Aw2 ($P = 0.029$) and airway area ($P = 0.04$) in the period T1–T2 in males compared with females (Table 5).

Table 3
Changes in cephalometric measures in both sexes in bimaxillary surgery group.

	Pre	3 mo post	1 yr post
	T0	T1	T2
TGL			
Male	71.8 ± 5.7	79 ± 8.4	76.4 ± 6
Female	69.9 ± 5.2	71.4 ± 10.5	72.7 ± 5.3
MPH			
Male	14.2 ± 3.2	19.1 ± 7	16 ± 4.7
Female	11.7 ± 5.7	16.3 ± 5.6	14.2 ± 6.6
HVL			
Male	41.1 ± 2.6	38.6 ± 2.5	41.5 ± 6.1
Female	33.8 ± 3.4	31.3 ± 2.2	34.4 ± 2
AW1			
Male	14.1 ± 2.3	11.8 ± 2.7	13.8 ± 3.1
Female	13.7 ± 3.7	11.3 ± 2.6	12.3 ± 2.4
AW2			
Male	14.8 ± 1.7	11.1 ± 2.7	10.4 ± 2.6
Female	15.4 ± 4.1	10.4 ± 2.3	12.5 ± 3.2
Airway area			
Male	11.3 ± 1.2	10.7 ± 2.7	9.6 ± 2.3
Female	9.8 ± 1.8	7.8 ± 1.5	8.9 ± 1.5
Tongue area			
Male	32.8 ± 3.6	38.4 ± 4.7	35.4 ± 3.4
Female	28.1 ± 2.2	33.6 ± 2.4	31.6 ± 3.6
Lower face cage area			
Male	59.4 ± 5.5	53.4 ± 4.4	55.1 ± 8
Female	54.3 ± 6.1	52.5 ± 6.1	48.4 ± 3.5

Values are given as mean ± SD.
*$P < 0.05$.

3.1.3. IOS

There was no statistically significant change among T0, T1 and T2 in both operative groups and both sexes in IOS parameters. However there was a statistically significant increase of the changes in supine R20 (central airway resistance at 20 Hz; $P = 0.042$), supine R5 (total airway resistance at 5 Hz; $P = 0.049$) in the period T0–T1 and supine R20 ($P = 0.04$) in the period T0–T2 in males compared with females in the one-jaw group (Table 4).

3.1.4. SpO2 during sleep

There were no statistically significant changes between T0 and T2 in both operative groups and both sexes in 3% ODI. There was also no statistically significant difference between the sexes in both operative groups in 3% ODI changes (Tables 4 and 5).

4. Discussion

PAS narrowing after mandibular setback surgery has received increasing attention in recent years (Degerliyurt et al., 2008; Kitahara et al., 2010). In regard to the lower face cage, including the tongue and hyoid bone, it is likely that the morphology of these structures may be influenced and compromised after mandibular setback surgery. Previous studies have investigated the changes in these structures after setback surgery (Wickwire et al., 1972; Athanasiou et al., 1991; Enacar et al., 1993; Nakagawa et al., 1997; Saitoh, 2004; Ishiguro et al., 2009).

Many studies have found that women have a structurally smaller pharyngeal airway, in addition to often greater obesity than men, which would likely to predispose them to airway collapse (Bradley et al., 1986; Young et al., 1993, 1997; Isono et al., 1997; Martin et al., 1997). However, pharyngeal airway patency is actually a dynamic interaction between anatomy and pharyngeal muscle activity (Popovic and White, 1995). OSA is more common in men than in women, despite the previously noted gender differences, so that the upper airway of females is more stable and less constricting than that of males (Trinder et al., 1997; Mohsenin, 2001; Rowley et al., 2001). This is demonstrated by the greater genioglossal muscle tone of females than that of males, suggesting a greater defense of the upper airway (Pillar et al., 2000).

A previous study by Mohsenin (2003) showed a greater reduction in pharyngeal airway dimensions with the retrusive movement of the mandible in males than in females, suggesting the possibility of a greater reduction in the pharyngeal airway with mandibular setback surgery in males than in females (Nakagawa et al., 1998; Samman et al., 2001). This result is similar to our own, which revealed that after mandibular setback surgery there was a significant reduction in the post airway space, airway area and lower face cage area in both sexes but more so in males and a tendency of revert to preoperative values in females. Also, there was a downward and backward position of the hyoid bone in both sexes but more so in males on both short-term and long-term follow-up. Tongue area and length of the tongue significantly increased in the mandibular setback surgery group at 3 months and 1 year postoperatively in both sexes but more so in males, and there was a tendency toward reversion to preoperative values in females. As regards airway resistance, there was a significant increase of supine R20 and R5 at 3 months postoperatively and supine R20 at 1 year postoperatively in males compared with females in the mandibular setback surgery group. These results were similar to OSA patients' morphological and functional characteristics as reported previously (Sakakibara et al., 1999; Achilleos et al., 2000;

Table 4
Comparison of changes in clinical characteristics and impulse oscillatory data in both sexes using Mann–Whitney U test in mandibular setback surgery group.

	T0-T1		T0-T2		T1-T2	
	Male (n = 11) Mean ± SD	Female (n = 19) Mean ± SD	Male (n = 11) Mean ± SD	Female (n = 19) Mean ± SD	Male (n = 11) Mean ± SD	Female (n = 19) Mean ± SD
IOS (kPa/L/s)						
Lie R20	0.03 ± 0.09*	−0.03 ± 0.06	0.04 ± 0.09*	−0.03 ± 0.05	0.005 ± 0.12	0.009 ± 0.06
Lie R5	0.03 ± 0.09*	−0.03 ± 0.07	0.034 ± 0.1	−0.02 ± 0.05	0.001 ± 0.15	0.01 ± 0.09
Sit R5	0.02 ± 0.02	−0.02 ± 0.07	0.03 ± 0.06	0.01 ± 0.05	−0.0001 ± 0.06	0.03 ± 0.06
Sit R20	0.012 ± 0.04	−0.003 ± 0.08	0.01 ± 0.05	0.001 ± 0.06	−0.006 ± 0.06	0.03 ± 0.06
SpO_2 (number/h)						
3% ODI			−1.2 ± 3.6	−0.8 ± 2.4		
Area (cm^2)						
Airway area	1.5 ± 1.3	2.1 ± 2.5	1.5 ± 2.1	1.2 ± 1.5	−0.2 ± 2	−0.8 ± 2.7
Tongue area	−4.1 ± 3.5	−4.2 ± 1.1	−3.8 ± 2.1	−2.6 ± 2.4	0.4 ± 3.3	1.6 ± 1.1
Lower face cage	6.9 ± 5.9	8.9 ± 1.2	6.5 ± 4.8	6.3 ± 5.7	−0.4 ± 5	−2.6 ± 1.1
Distance (mm)						
TGL	−6.4 ± 8.4	−1.5 ± 2.5	−5.6 ± 6.6	−2.4 ± 4.9	0.89 ± 5.5	−0.9 ± 2.4
MPH	−2.2 ± 5.1	−2.1 ± 1.4	−4.5 ± 3.3	−2.5 ± 4.4	−2.3 ± 4.2	−0.5 ± 1.4*
H-VL	1.9 ± 1.9	0.3 ± 5.1	2.5 ± 2.8*	0.001 ± 3.3	0.59 ± 1.7	−0.3 ± 5.6
AW1	0.79 ± 3.4	3.5 ± 4.1	1 ± 2	0.038 ± 2.4	0.23 ± 3.2*	−3.4 ± 4.8
AW2	3.6 ± 2.5	5.4 ± 4.8	3 ± 2.7	2.6 ± 3.9	−0.57 ± 2.5	−2.9 ± 6.3

Yu et al., 2003). Thus, males may have a higher risk of OSA after mandibular setback surgery.

After surgical correction of mandibular prognathism, gender may affect the morphology of the pharyngeal airway (Nakagawa et al., 1998; Samman et al., 2001). The present results were consistent with findings in these reports, in contrast to findings by Degerliyurt et al. (2009), who observed that some gender differences in the airway changes were evident after mandibular setback surgery or bimaxillary surgery. However, they found a significant reduction of the retro palatal and retro lingual spaces in both sexes in both groups.

Using cone-beam computed tomography (CBCT), Kim et al. (2016) showed that, following bimaxillary surgery, the oropharyngeal volume and the minimum cross-sectional area (CSA) did not decrease significantly in males, but both did in females. Moreover, the reduction in volume at 6 months after surgery was greater in females than in males. This is in agreement with our results, which indicated that post airway space and airway area significantly decreased in females compared with males after bimaxillary surgery. Also, the hyoid bone significantly descended to a lower position in relation to the mandible and in a backward position in females in the bimaxillary surgery group on short-term follow-up, with the tendency to revert to preoperative values on long-term follow-up, whereas there were no significant changes in males. Tongue area significantly increased in the bimaxillary surgery group at 3 months and 1 year postoperatively in females only. Thus, females may have a higher risk of OSA in the early postoperative period. In contrast, Panou et al. (2013) concluded that the volume of lower and total pharyngeal airway significantly decreased in males but did not change significantly in females.

The mean amount of setback in males and females were compared to find an explanation for this difference in morphological and functional outcomes in both operative groups, and to determine whether they had a significantly greater amount of setback in relation to each other. However, there was no significant difference between the setback amounts for males and females in both operative groups ($P = 0.4$ for mandibular setback surgery group, $P = 0.48$ for bimaxillary surgery group).

Table 5
Comparison of changes in the Clinical characteristics and impulse oscillatory data in both sexes by using Mann–Whitney *U* test in the bimaxillary surgery group.

	To-T1		T0-T2		T1-T2	
	Male (n = 7) Mean ± SD	Female (n = 15) Mean ± SD	Male (n = 7) Mean ± SD	Female (n = 15) Mean ± SD	Male (n = 7) Mean ± SD	Female (n = 15) Mean ± SD
IOS (kPa/L/s)						
Lie R20	−0.02 ± 0.08	−0.005 ± 0.09	−0.03 ± 0.1	0.02 ± 0.08	−0.012 ± 0.06	0.027 ± 0.08
Lie R5	−0.021 ± 0.09	0.021 ± 0.08	−0.03 ± 0.14	0.04 ± 0.09	−0.012 ± 0.08	0.022 ± 0.09
Sit R5	0.01 ± 0.04	0.017 ± 0.05	0.01 ± 0.05	0.03 ± 0.07	0.0003 ± 0.03	0.009 ± 0.08
Sit R20	−0.001 ± 0.06	0.007 ± 0.04	−0.01 ± 0.08	0.01 ± 0.05	−0.01 ± 0.04	0.009 ± 0.05
SpO_2 (number/h)						
3% ODI			1 ± 2.2	−0.5 ± 4.2		
Area (cm^2)						
Airway area	0.6 ± 2.9	1.9 ± 1.4	1.8 ± 2.5	0.9 ± 1.8	1.1 ± 2.5*	−1±1.7
Tongue area	−5.6 ± 3.2	−5.5 ± 2.8	−2.5 ± 3.8	−3.5 ± 3.7	3 ± 4.9	2 ± 2.8
Lower face cage	6 ± 6	6 ± 7.2	4.2 ± 7.2	1.9 ± 4.1	−1.8 ± 5.8	−4.1 ± 6.8
Distance (mm)						
TGL	−7.2 ± 4.4	−1.5 ± 1.4	−4.5 ± 5.9	−2.8 ± 4.1	2.7 ± 6.9	−1.3 ± 9.9
MPH	−4.9 ± 6.1	−4.6 ± 4.1	−1.7 ± 5.9	−2.5 ± 3.7	3.2 ± 4.4	2.1 ± 5.5
H-VL	2.4 ± 1.7	2.4 ± 2.9	−0.49 ± 4.6	−0.62 ± 3.7	−2.9 ± 6	−3.1 ± 2.4
AW1	2.4 ± 3.7	2.3 ± 3.8	0.3 ± 3	1.4 ± 3.1	−2±2.4	−0.98 ± 2.9
AW2	3.7 ± 3.7	5.1 ± 3	4.4 ± 3.5	3 ± 4.7	0.68 ± 2.4*	−2.1 ± 3.4

* $P < 0.05$.

There was no evidence of OSA in the postoperative period of both groups and both sexes. This is may be due to biological adaptation to the new environment or to other compensatory changes that occur in the uvulopalatogossal morphology and head position after orthognathic surgery (Athanasiou, 1993; Kawakami et al., 2005).

5. Conclusion

In this study, gender dimorphism was found to be present according to morphological and functional outcomes. Males had a higher risk of OSA after mandibular setback surgery and females after bimaxillary surgery; however, compensatory changes act as a barrier against this.

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Conflict of interest

None.

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