Original Article

Correlation between oral cavity volume and upper airway changes in skeletal Class III patients undergoing bimaxillary orthognathic surgery: a pilot cone-beam computed tomography study

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ABSTRACT

Objectives: To evaluate changes of the upper airway and oral cavity volumes in patients with skeletal Class III malocclusion undergoing bimaxillary orthognathic surgery, and to analyze the correlation between postoperative upper airway decrease and the amount of jaw movement and oral cavity volume reduction.

Materials and Methods: Thirty patients (16 males and 14 females) undergoing bimaxillary surgery were included. Three-dimensional reconstruction of the upper airway and oral cavity were performed using preoperative (T0) and postoperative (T1) (6 months) cone-beam computed tomography scans.

Results: The volume, sagittal area and minimum cross-sectional area of the upper airway were diminished ($P < .001$). The decrease in volume and minimum cross-sectional area in the oropharyngeal region of the upper airway were weakly correlated with B-point posterior movement ($P < .05$). Total oral cavity volume was decreased, with maxillary oral volume increasing and mandibular oral volume decreasing ($P < .001$). Upper airway decrease was highly correlated with total oral volume reduction and mandibular oral volume reduction, with the most significant correlation being with total oral volume reduction ($P < .001$).

Conclusions: Class III bimaxillary surgery reduced the volume, sagittal area, and minimum cross-sectional area of the upper airway as well as oral cavity volume. Upper airway changes were weakly correlated with anterior-posterior mandibular movement but significantly correlated with oral cavity volume changes. Thus, oral cavity volume reduction is a crucial factor of upper airway decrease in patients with skeletal Class III malocclusion undergoing bimaxillary orthognathic surgery. (*Angle Orthod*. 2024;94:432–440.)

KEY WORDS: Bimaxillary orthognathic surgery; Upper airway; Oral cavity volume; Skeletal Class III malocclusion; Cone-beam computed tomography

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INTRODUCTION

Orthopedic surgery can improve facial esthetics and occlusal function in skeletal Class III malocclusion, a common dentofacial abnormality.[1] During surgery, movement of the jaws and pharyngeal muscles may change the structure of the airway.[2,3] Snoring and sleep apnea are related to upper airway volume and narrowing the airway may lead to obstructive sleep apnea syndrome).[4,5] Therefore, any unfavorable influence on the upper airway must be evaluated before surgery.[6,7]

Evidence suggests that mandibular setback reduces airway dimensions.[8,9] Conversely, maxillary advancement surgery improve the airway.[10] However, most Class III skeletal patients require bimaxillary surgery and, therefore, there may be a more complex effect on the airway. Some studies reported that patients did not experience a reduction in airway size or an increase in total volume after bimaxillary surgery,[10,11] while others showed a reduction in postoperative airway dimensions.[12,13] The effect on the airway due to bimaxillary surgery is clinically important.

The oral cavity proper is connected to the oropharynx via the oropharyngeal isthmus, which directly or indirectly influences upper airway morphology.[14,15] Several studies demonstrated that orthognathic treatment can alter oral volume.[4,16,17] Mandibular setback reduces oral volume; however, maxillary advancement surgery increases it.[16,18] Since the oral cavity is anatomically close to the upper airway, oral volume changes may affect airway changes after Class III bimaxillary surgery.

Class III bimaxillary surgery affects the airway and the oral cavity, which is anatomically related to the upper airway. However, there are few studies on the effects of orthognathic surgery on oral volume and the relationship between oral volume and the upper airway. Thus, this study used cone-beam computed tomography (CBCT) to examine upper airway morphology and oral volume changes after Class III bimaxillary surgery.

MATERIALS AND METHODS

Ethical Approval

The study was approved by the Ethics and Research Committee, Nanjing Medical University, and was conducted in accordance with the tenets of the Declaration of Helsinki for research involving human subjects.

Subjects

Thirty skeletal Class III adult patients attending the Department of Orthodontics, Affiliated Stomatological Hospital of Nanjing Medical University from 2016 to 2022 were selected.

Inclusion Criteria

(1) Class III malocclusion corrected by bimaxillary surgery with LeFort I osteotomy maxillary advancement and BSSO mandibular setback.
(2) CBCT scan available that included the fourth cervical vertebra.
(3) Consistency of head posture that was assessed by measurement of craniocervical angle (N-S-Ba), craniocervical tilt (CVT/NSL) (patients $<5°$) to interpret changes in head position.

Exclusion Criteria

(1) Cleft lip and palate, congenital craniofacial anomalies, severe facial asymmetries.
(2) A history of adenoidectomy or tonsillectomy.
(3) Severe temporomandibular joint disorder or respiratory disease.

Reconstruction of Three-Dimensional Images

Subjects were scanned with the NewTOM VG preoperatively and within 6 months postoperatively. The DICOM-formatted CBCT data were imported into Dolphin Imaging 11.9.5. After calibrating CBCT images, landmarks and a coordinate system were created to measure preoperative and postoperative landmark location changes (Figure 1) (Supplementary Table 1).

Airway Measurements

Dolphin software airway analysis was used to measure airway morphological changes. Using manual segmentation, the oropharyngeal, upper, lower, and hypopharyngeal airways were measured. The reference plane for airway delineation was the FH plane, and the other reference planes were parallel to it (Figure 2) (Supplementary Table 2).

Oral Cavity Construction and Measurement

Dolphin-calibrated CBCT images were imported into Mimics (v.21.0; Materialise, Leuven, Belgium) for oral cavity analysis. The dentition, maxilla and mandible lingual surfaces defined the anterior, left and right boundaries, while the PNS plane defined the superior boundary. For the posterior margin (coronal plane), the intersection of the PtmsR and PtmsL points, perpendicular to the FH plane was used. The inferior border (mandibular plane) was the intersection of the GoR, GoL, and Me points. The limits were used to draw the oral cavity and

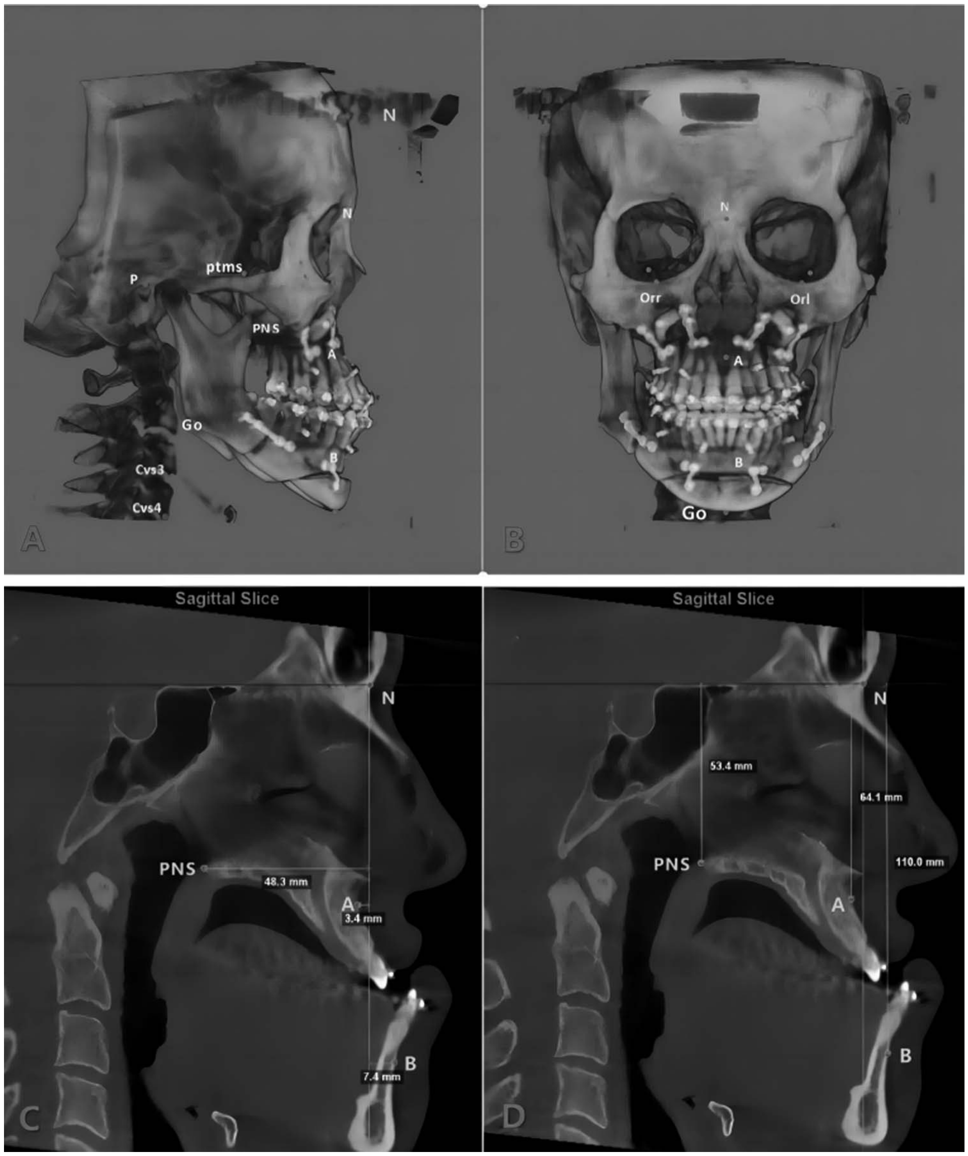

Figure 1. Landmarks and jaw measurements. (A) (B) Landmarks positioned on the three-dimensional (3D) model. (C) Horizontal surgical measurements. (D) Vertical surgical measurements.

landmarks on the three-dimensional (3D) model. Different axial views were used to carefully identify the landmarks on the 3D model to build the oral cavity model and then calculate the volume size (Figure 3).

Statistical Analysis

Analyses were performed using SPSS 26.0 (SPSS Inc., Chicago, IL, USA). One researcher measured all parameters. A Shapiro-Wilk test was used to assess data normality. Coefficients of intraclass correlation were used to measure intraexaminer reliability. Pairwise *t*-tests were performed to compare T0 and T1 jaw position, upper airway morphology, and oral cavity volume (OCV) after bimaxillary surgery. Correlations between variables were assessed by Pearson correlation. All analyses were judged significant at $P < .05$.

RESULTS

Sample Characteristics and Surgical Skeletal Changes

An intraclass correlation coefficient of $\geq$0.9 indicated high intraobserver reliability across measurements. ANB angle and Wits increased significantly between pre- (T0) and postoperative (T1) timepoints. A-point, PNS-point, and B-point anteroposterior movement differed significantly. Additionally, B-point moved posteriorly by 4.39 $\pm$ 3.78 mm sagittally from A-point. Table 1 shows sample characteristics and skeletal mean shifts.

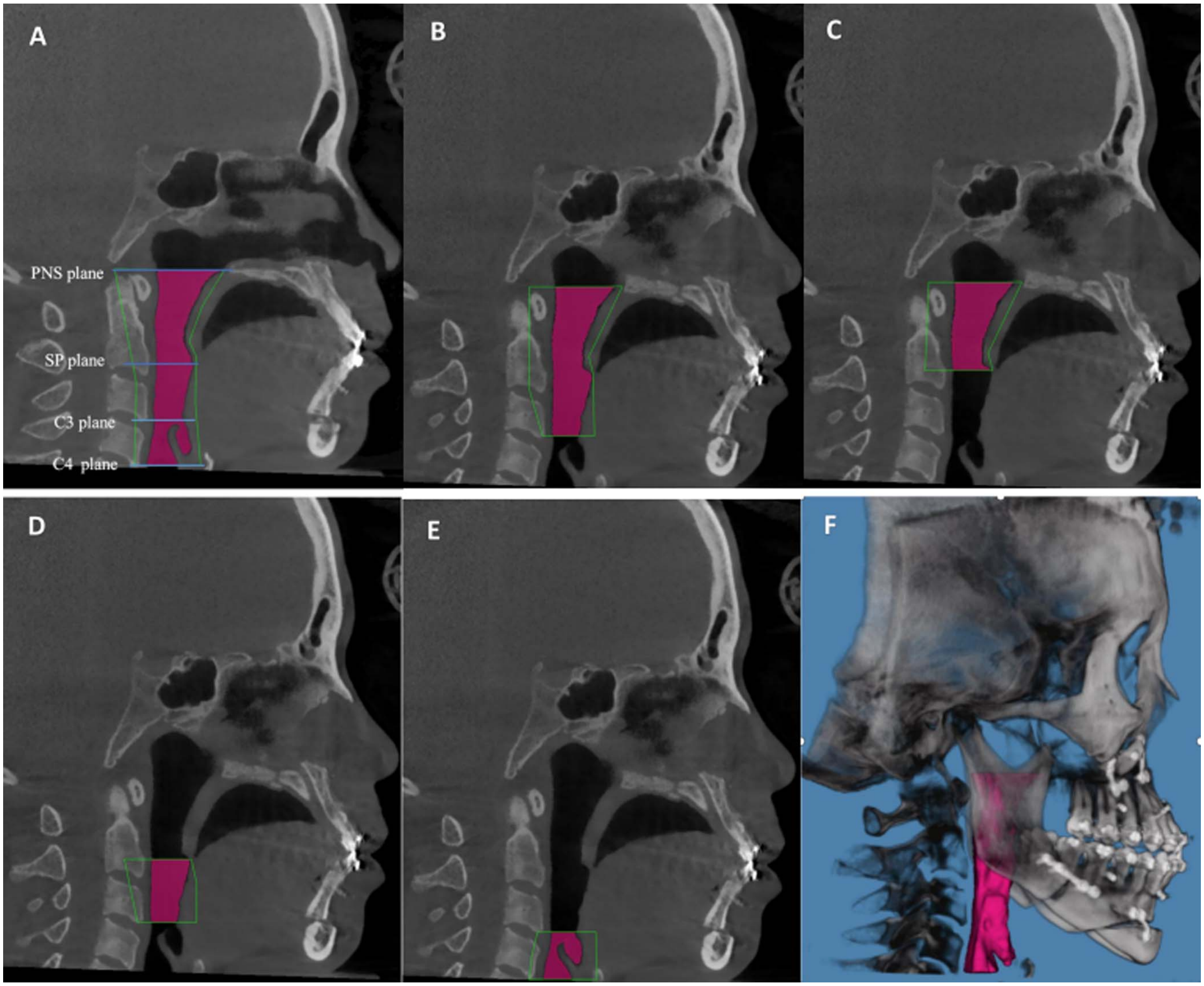

Figure 2. Delimitation of pharyngeal airway space (PAS) volume. (A) Pharyngeal airway space and segments. (B) Oropharyngeal airway: level of posterior nasal spine (PNS) to C3 plane. (C) Upper oropharyngeal airway: level of posterior nasal spine (PNS) to SP plane. (D) Lower oropharyngeal airway: level of SP plane to C3 plane. (E) Hypopharyngeal airway: level of C3 plane to C4 plane. (F) 3D reconstruction of pharynx.

Upper Airway Changes after Bimaxillary Orthognathic Surgery

Table 2 shows upper airway alterations of each segment from T0 to T1. The reduction in upper airway volume was significant, with the greatest decrease in lower oropharyngeal region. The median sagittal airway cross-sectional area decreased in all regions, with the oropharyngeal region decreasing the greatest amount, followed by the lower oropharyngeal and upper oropharyngeal regions. The minimum cross-sectional area of all upper airway regions changed, with the oropharyngeal region decreasing the most.

Given the small AP change in A point, categories were stratified based on the amount of maxillary change. As shown in Supplementary Table 3, the sample was divided into two groups. The results showed that there was no significant difference in the amount of preoperative and postoperative airway changes between the two groups, demonstrating that airway changes would have negligible differences based on the differing amounts of LeFort I osteotomy maxillary advancement in this study.

Correlation Between the Surgical Skeletal Changes and the Upper Airway Changes

The correlation between upper airway changes from T0 to T1 and jaw movements are shown in Table 3. There was a correlation between posterior movement of B-point and the decrease in total airway volume and oropharyngeal volume. In terms of minimum axial area

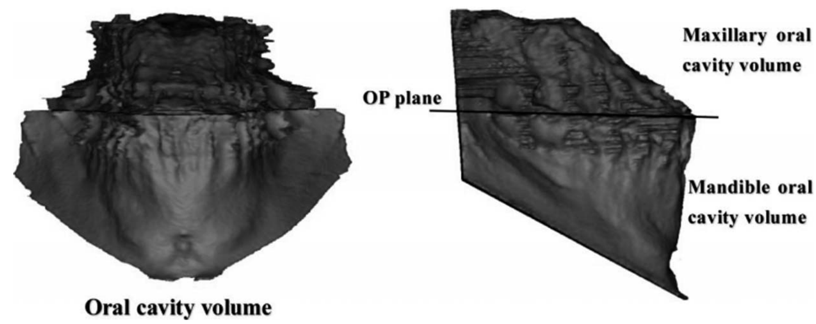

Figure 3. 3D image reconstruction of oral cavity proper 3D views of the oral cavity proper: maxillary oral cavity (blue); mandibular oral cavity (red).

(MAA), the minimum cross-sectional area reductions of the total, oropharyngeal and hypopharyngeal airways showed a correlation with posterior movement of B-point. Interestingly, the amount of posterior movement of B-point relative to A-point also showed a correlation with airway volume changes.

Changes in Oral Cavity Volume after Bimaxillary Orthognathic Surgery

The results showed a low correlation between airway changes and jaw movement after bimaxillary surgery. Therefore, pre- and post-operative changes of OCV were measured (Table 4). Total OCV was significantly decreased (−5.61%). The mandibular OCV showed a decreasing trend (−12.64%), while the maxillary OCV showed a trend of increasing (10.12%).

Correlation Between Surgical Oral Cavity Volume Changes and Upper Airway Changes

Decreases in airway volume, sagittal area, and MAA from before to after surgery (T1–T0) were significantly associated with decreases in total and mandibular OCV. The degree of reduction observed was slightly associated with an increase in maxillary OCV (Table 5).

Volume changes in all regions of the upper airway were moderately correlated with decreases in total OCV and mandibular OCV, except in the hypopharynx and lower oropharynx, which were less correlated with total OCV and mandibular OCV reduction. Compared to mandibular OCV change, total OCV change was more strongly correlated with upper airway volume decrease. In sagittal area, decreases in most regions showed a moderate correlation with total OCV reduction and a relatively weak correlation with mandibular OCV reduction. In terms of changes in MAA of each airway segment, the upper airway segments were moderately correlated with total OCV decrease, but relatively weakly correlated with changes in mandibular OCV. Finally, the degree of reduction in airway volume and minimum cross-section in the oropharyngeal region seemed to decrease with increasing maxillary OCV.

Correlation Between Surgical Skeletal Changes and Oral Volume Changes

Anteroposterior advancement of A-point was negligibly correlated with total OCV, maxillary OCV, and mandibular OCV. Posterior movement of B-point showed a moderate correlation with decrease in total OCV and mandibular OCV. In addition, the anteroposterior changes in the B-A point relationship showed a high correlation with the changes in total OCV and mandibular OCV. Thus, the relative movement of the maxilla and mandible in the

Table 1. Sample Characteristics and Surgical Skeletal Changes[a]

	T0		T1		T1–T0		T-test
	Mean	SD	Mean	SD	Mean	SD	*P*
ANB (°)	−4.62	2.63	0.48	1.79	5.10	2.04	**0***
Wits (mm)	−11.68	6.32	−4.62	2.65	7.06	5.95	**0***
A point (AP) (mm)	1.35	3.20	2.79	3.68	1.44	1.64	**0***
A point (vertical) (mm)	−61.49	4.43	−62.47	5.46	−0.98	2.29	**.026***
PNS point (AP (mm)	−42.92	3.93	−40.08	4.17	2.83	1.61	**0***
PNS point (vertical) (mm)	−52.66	4.11	−53.02	4.39	−0.36	1.54	.211
B point (AP) (mm)	9.18	6.13	3.27	5.63	−5.83	3.25	**0***
B point (vertical) (mm)	−100.84	8.36	−100.17	7.47	0.67	2.47	.148
B-A (AP) (mm)	10.45	4.50	6.06	3.71	−4.39	3.78	**0***

[a] Note: B-A (AP) indicates the anteroposterior movement of B-point relative to A-point; SD, standard deviation.
* Statistically significant $P < .05$.

Table 2. Airway Changes After Bimaxillary Orthognathic Surgery[a]

	T0		T1		T1–T0			*t*-test
	Mean	SD	Mean	SD	Mean	SD	Rate (%)	*P*
Volume (mm^3)								
Total pharynx	21537.40	9544.76	17326.43	6769.84	−4210.97	5362.59	−15.88%	**0***
Oropharynx	15968.00	7556.21	12560.33	5523.59	−3407.67	4310.35	−17.25%	**0***
Upper oropharynx	8482.87	4612.16	6529.47	3243.10	−1953.40	2962.74	−17.26%	**.001***
Lower oropharynx	7575.93	3579.87	5781.53	2781.95	−1794.40	2333.30	−19.03%	**0***
Hypopharynx	5608.70	2297.36	4721.70	1849.98	−887.00	1447.13	−11.86%	**.002***
Sagittal area (mm^2)								
Total pharynx	959.27	248.09	851.67	204.06	−107.60	147.24	−9.32%	**0***
Oropharynx	723.67	190.65	636.60	163.65	−87.07	110.39	−10.22%	**0***
Upper oropharynx	390.73	108.27	340.90	77.62	−49.83	78.75	−9.77%	**.002***
Lower oropharynx	339.23	116.18	294.63	104.58	−44.60	68.61	−10.51%	**.001***
Hypopharynx	239.97	74.80	219.83	62.29	−20.13	58.97	−3.27%	.072
Minimum Axial Area (MAA) (mm^2)								
Total pharynx	172.70	91.78	120.00	69.76	−52.70	64.04	−22.93%	**0***
Oropharynx	186.03	105.07	127.80	74.84	−58.23	72.89	−27.10%	**0***
Upper oropharynx	195.60	107.61	146.53	91.69	−49.07	63.36	−21.83%	**0***
Lower oropharynx	216.00	108.08	147.53	72.76	−68.47	87.18	−25.15%	**0***
Hypopharynx	224.17	110.74	185.50	98.84	−38.67	79.35	−8.08%	**.012***

[a] Note: SD indicates standard deviation.
* Statistically significant $P < .05$.

anterior-posterior position was an important factor leading to changes in OCV (Table 6).

DISCUSSION

As shown in previous studies,[6] orthognathic surgery may significantly reduce the airway. To investigate how surgery affected upper airway morphology, Pearson's coefficient was applied to examine jaw movements and airway changes. A significant correlation was seen between backward movement at point B and airway volume reduction. However, this correlation was not very significant and experimental studies do not always show the relationship between jaw movements and airway changes.[12] This may be due to the combined effect of upper and lower jaw movement on the airway, making it difficult to clarify the link between jaw movements and airway changes. Given that bimaxillary surgery has complex effects on the airway and that jaw surgery does have a significant effect, it is worth investigating if a mediator with a strong airway link modulates the jaw-airway effect.

Iwasaki et al. found that Class III patients had a larger oral cavity and upper airway than Class I and II patients.[19] The current investigation focused on the impact of OCV alterations on the upper airway, given their close physiological link.[15] This study demonstrated a significant correlation between reduced total OCV and airway volume ($P < .001$), indicating that total oral volume plays an important role in the influence of orthognathic surgery on upper airway. The upper oropharyngeal airway, which is closely associated with the maxilla, was diminished even with maxillary advancement,[5] probably due to a reduction in total oral volume. Some patients with mandibular posterior movement had improvement in lower oropharyngeal airway.[10] This may have been because the increase in maxillary oral volume was greater than the decrease in mandibular oral volume, resulting in an increase in total oral volume that could be achieved by increasing maxillary advancement and decreasing mandibular setback (Table 6). In conclusion, jaw movement may indirectly diminish upper airway size by reducing oral cavity volume rather than by directly affecting the airway.

Dolphin software has been used to measure upper airway reliably in many investigations.[20] However, upper airway borders are disputed, which may affect measurements.[21] Previous research indicated that orthognathic surgery increased oropharyngeal vertical height and lowered minimum cross-sectional area after Class III bimaxillary surgery but did not change airway volume.[22] An increase in upper airway volume due to increases in vertical height may not result in airway patency benefits. Selection of measuring planes with relatively consistent vertical upper and lower airway borders may improve reliability. Various studies used the C3 and C4 planes for airway delineation because they are stable following surgery.[23–25] Additionally, Some studies demonstrated that mandibular setback surgery reduced C3 and C4 plane cross-sectional area.[13] Therefore, the C3 and C4 planes were used as reference planes in this investigation to improve measurement consistency and accuracy.

The current study modified the approach used by Teramoto et al.[16] in which OCV was defined with the posterior boundary as the plane perpendicular to the occlusal plane across the upper second molar distal cusp; this

Table 3. Correlation Between Surgical Skeletal Changes and Upper Airway Changes[a]

		A point (x) (T1–T0)	A point (y) (T1–T0)	PNS point (x) (T1–T0)	PNS point (y) (T1–T0)	B point (x) (T1–T0)	B point (y) (T1–T0)	(B–A) point (X) (T1–T0)
Volume (mm^3) (T1–T0)								
Total pharynx	r_s	0.073	0.240	−0.015	0.128	**.413**	0.049	**.386**
	P	.701	.201	.938	.499	**.026***	.797	**.035***
Oropharynx	r_s	0.122	0.180	0.027	0.145	**.407**	0.058	**.402**
	P	.521	.342	.886	.446	**.029***	.763	**.028***
Upper oropharynx	r_s	0.161	0.102	0.092	0.223	0.225	-0.041	0.263
	P	.394	.592	.629	.236	.241	.830	.159
Lower oropharynx	r_s	−0.128	0.230	−0.183	0.061	0.285	0.057	0.189
	P	.499	.221	.333	.748	.134	.766	.316
Hypopharynx	r_s	−0.113	0.338	−0.227	0.139	0.261	−0.053	0.176
	P	.554	.067	.228	.464	.171	.780	.353
Sagittal area (mm^2) (T1–T0)								
Total pharynx	r_s	0.155	0.165	−0.052	0.213	0.257	0.018	0.289
	P	.413	.384	.783	.258	.178	.925	.122
Oropharynx	r_s	0.220	0.065	−0.004	0.200	0.249	0.048	0.31
	P	.242	.735	.982	.288	.192	.800	.096
Upper oropharynx	r_s	0.317	−0.062	0.138	0.269	0.072	−0.129	0.2
	P	.087	.745	.467	.151	.712	.496	.29
Lower oropharynx	r_s	−0.084	0.174	−0.258	0.067	0.181	0.091	0.118
	P	.660	.358	.168	.726	.347	.634	.535
Hypopharynx	r_s	0.020	0.218	−0.162	0.191	0.076	−0.095	0.074
	P	.915	.248	.393	.312	.697	.618	.699
Minimum Axial Area (MAA) (mm^2) (T1–T0)								
Total pharynx	r_s	0.170	0.143	0.100	0.075	**.393**	0.018	**.402**
	P	.370	.450	.598	.692	**.035***	.923	**.027***
Oropharynx	r_s	0.092	0.196	0.088	0.012	**.398**	0.034	**.374**
	P	.630	.299	.642	.951	**.033***	.857	**.042***
Upper oropharynx	r_s	0.185	0.154	0.080	0.150	0.339	0.074	**.364**
	P	.328	.415	.674	.430	.072	.699	**.048***
Lower oropharynx	r_s	0.008	0.158	−0.065	0.046	0.278	0.061	0.241
	P	.965	.403	0.731	.810	.144	.749	.199
Hypopharynx	r_s	−0.117	0.226	−0.140	−0.081	**.423***	0.052	0.313
	P	.537	.230	.460	.670	**.022***	.784	.092

[a] Note: rs value: .9–1, very high correlation; .7–.9, high correlation; .5–.7, moderate correlation; .3–.5, low correlation; 0–.3, negligible correlation.

* Statistically significant $P < .05$.

definition has limitations. Orthognathic surgery would move the posterior border of the oral cavity forward as the second molar came forward. The definition, therefore, underestimated maxillary oral volume increase and overestimated mandibular volume loss. To avoid this, the current study changed the posterior oral cavity border to the Ptms plane. Thus, the investigation showed a smaller decrease in total oral cavity capacity than Teramoto et al.

The current study also had limitations. First, the limited sample size prevented the study from grouping surgeries by mandibular movement, which reduced the ability to analyze jaw movement and upper airway changes in different groups. Second, due to its complex borders, this study did not assess tongue volume or its ratio to oral cavity volume after surgery, despite its importance. These aspects need to be investigated in future research.

Table 4. Analysis of Oral Volume in Class III Patients Before (T0) and After (T1) Surgery[a]

	T0		T1		T1–T0			*t*-test
	Mean	SD	Mean	SD	Mean	SD	Rate%	*P*
Total OCV (mm^3)	94842.03	16209.38	89287.47	14753.65	−5554.57	5753.94	−5.61%	**0***
Maxillary OCV (mm^3)	30587.97	5602.08	33493.97	5749.66	2906.00	2602.04	10.12%	**0***
Mandibular OCV (mm^3)	64181.17	12404.78	55802.83	10309.62	−8378.33	5299.45	−12.64%	**0***

[a] Note: OCV indicates oral cavity volume; SD, standard deviation.

* Statistically significant $P < .05$.

Table 5. Correlation Between Surgical Oral Cavity Volume Changes and Upper Airway Changes[a]

		Total OCV (mm^3) (T1–T0)	Total OCV (%) (T1–T0)	Maxillary OCV (mm^3) (T1–T0)	Maxillary OCV (%) (T1–T0)	Mandibular OCV (mm^3) (T1–T0)	Mandibular OCV (%) (T1–T0)
Volume (mm^3) (T1–T0)							
Total pharynx	r_s	**.657**	**.689**	0.334	**.385**	**.516**	**.562**
	P	**0***	**0***	.072	**.036***	**.004***	**.001***
Oropharynx	r_s	**.646**	**.684**	0.346	**.413**	**.504**	**.554**
	P	**0***	**0***	.061	**.023***	**.005***	**.001***
Upper oropharynx	r_s	**.599**	**.628**	**.363**	**.443**	**.459**	**.507**
	P	**0***	**0***	**.049***	**.014***	**.011***	**.004***
Lower oropharynx	r_s	**.374**	**.404**	0.060	0.114	0.343	**.372**
	P	**.042***	**.027***	.752	.549	.063	**.043***
Hypopharynx	r_s	**.497**	**.483**	0.141	0.171	**.431**	**.412**
	P	**.005***	**.007***	.457	.365	**.017***	**.024***
Sagittal area (mm^2) (T1–T0)							
Total pharynx	r_s	**.508**	**.538**	0.194	0.246	**.416**	**.454**
	P	**.004***	**.002***	.305	.191	**.022***	**.012***
Oropharynx	r_s	**.457**	**.495**	0.197	0.253	**.362**	**.407**
	P	**.011***	**.005***	.298	.178	**.049***	**.026***
Upper oropharynx	r_s	**.479**	**.503**	0.253	0.336	**.374**	**.414**
	P	**.007***	**.005***	.178	.070	**.042***	**.023***
Lower oropharynx	r_s	0.153	0.173	−0.136	-0.107	0.197	0.208
	P	.418	.361	.475	.575	.297	.269
Hypopharynx	r_s	**.367**	**.378**	0.128	0.154	0.320	0.336
	P	**.046***	**.040***	.502	.416	.085	.069
Minimum Axial Area (MAA) mm^2) (T1–T0)							
Total pharynx	r_s	**.512**	**.508**	0.266	0.324	**.413**	**.419**
	P	**.004***	**.004***	.156	.080	**.023***	**.021***
Oropharynx	r_s	**.679**	**.684**	**.448**	**.510**	**.504**	**.518**
	P	**0***	**0***	**.013***	**.004***	**.005***	**.003***
Upper oropharynx	r_s	**.610**	**.638**	**.418**	**.449**	**.438**	**.481**
	P	**0***	**0***	**.021***	**.013***	**.016***	**.007***
Lower oropharynx	r_s	**.541**	**.578**	0.216	0.287	**.452**	**.497**
	P	**.002***	**.001***	.252	.123	**.012***	**.005***
Hypopharynx	r_s	0.334	0.309	-0.016	0.051	0.350	0.314
	P	.071	.096	.934	.790	.058	.091

[a] Note: rs value: .9–1, very high correlation; .7–.9, high correlation; .5–.7, moderate correlation; .3–.5, low correlation; 0–.3, negligible correlation. OCV indicates oral cavity volume.

* Statistically significant $P < .05$.

CONCLUSIONS

- Class III bimaxillary surgery reduced the volume, sagittal area, and minimum cross-sectional area of the upper airway, as well as the OCV.
- Upper airway changes were weakly correlated with anterior-posterior mandibular movement but significantly correlated with OCV changes.
- Thus, oral cavity volume reduction is a crucial factor correlated to upper airway decrease in skeletal Class III patients undergoing bimaxillary surgery.

SUPPLEMENTAL DATA

Supplemental Tables 1, 2, and 3 are available online.

Table 6. Correlation Analysis Between Skeletal Movement and Oral Volume Changes[a]

		Total OCV (mm^3) (T1–T0)	Maxillary OCV (mm^3) (T1–T0)	Mandibular OCV (mm^3) (T1–T0)
A point (Ap) (T1–T0)	r_s	**.390**	0.294	0.302
	P	**.033***	.115	.105
A point (vertical) (T1–T0)	r_s	0.278	0.024	0.270
	P	.137	.898	.150
B point (Ap) (T1–T0)	r_s	**.619**	0.018	**.653**
	P	**0***	.928	**0***
B point (vertical) (T1–T0)	r_s	0.088	−0.237	0.174
	P	.642	.207	.358
B-A point (Ap) (T1–T0)	r_s	**0.702**	0.144	**0.690**
	P	**.000***	.446	**0***

[a] Note: rs value: .9–1, very high correlation; .7–.9, high correlation; .5–.7, moderate correlation; .3–.5, low correlation; 0–.3, negligible correlation. OCV indicates oral cavity volume.

* Statistically significant $P < .05$.

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