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ORIGINAL ARTICLE / ARAŞTIRMA MAKALESİ

Comparison of Differential Maxillomandibular Movements on the Upper Airway in Anteroposterior Dimensions After Bimaxillary Surgery for Class III Correction

Sınıf III Maloklüzyonun Cerrahi Düzeltiminde Farklı Maksillomandibuler Hareketlerin Üst Havayolu Anteroposterior Boyutları Üzerindeki Etkilerinin Karşılaştırılması

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ÖZ

Amaç: Sınıf 3 maloklüzyonun düzeltilmesi için farklı bimaksiller cerrahi planların üst hava yolunun ön-arka boyutlarına etkisini değerlendirmek.

Gereç ve Yöntem: Sınıf 3 düzeltimi için bimaksiller cerrahi ile tedavi edilen 59 birey (ortalama yaş: 23.11±1.85 yıl) dahil edildi. Ameliyat öncesi (T1) ve ameliyat sonrası (T2) lateral sefalogramlar analiz edilerek kafa kaidesi üzerinde çakıştırıldı. A ve B noktalarının yatay hareketlerinin miktarlarına göre 3 grup oluşturuldu. Grup-1: (n=21) B noktasının yer değiştirmesi A noktasından büyüktü. Grup-2: (n=13) A ve B noktalarının yer değiştirmeleri arasındaki fark ≤1mm idi. Grup-3: (n=25), A noktasının yer değiştirmesi B noktasından büyüktü. Ön-arka faringeal hava yolu boyutları (mm), arka (PAS), üst-arka (SPAS), orta (MAS), alt (IAS), epiglottik (EAS) hava yolu boşluklarında ölçüldü. Sınıf içi değerlendirme Paired sample t testi ve Wilcoxon testi ile yapıldı. Sefalometrik değişiklikler için sınıflar arası karşılaştırmalar ANOVA ve Tukey testi ile değerlendirilirken, hava yolu değişiklikleri için Welch ANOVA ve Kruskal-Wallis testleri yapıldı. Hava yolu parametrelerinin ikili karşılaştırmaları Bonferroni düzeltmeli Mann-Whitney u-testi ile yapıldı. Birincil yordayıcı ve sonuç değişkenleri arasındaki ilişkiyi değerlendirmek için Pearson korelasyon analizi yapıldı.

Sonuçlar: Maksiller yükseklik, palatal düzlem, SNA, SNB, ANB, Wits, N-Perp, maksiller derinlik toplam örnekte önemli ölçüde değişti. Mandibular düzlemdeki ve SNB'deki değişiklikler Grup-1'de daha yüksekti (p<0.05). SNA, N-PERP, maksiller derinlikteki değişiklikler Grup-3'te daha yüksekti (p<0.05). Toplam örnekte PAS (ortalama:2.44±2.21mm; medyan:2.17mm) ve SPAS (ortalama:1.07±2.31mm; medyan:1.14mm) oldukça anlamlı artış gösterdi. Grup-1'de İAS anlamlı olarak azaldı (ortalama: – 1,98±3,68 mm; ortanca: – 1,36 mm). Grup-2'de önemli bir faringeal değişiklik yoktu. Grup-3'te PAS (ortalama:3.03±2.20mm, ortanca:2.63mm) ve SPAS (ortalama:1.64±1.81mm, ortanca: 1,74mm) anlamlı olarak arttı. Toplam örnek, PAS ve SNA arasında (r=0.335); ve IAS ve B noktası arasında (r=0.275) anlamlı pozitif doğrusal zayıf ilişki ortaya koydu. Grup-3'te PAS ve SNA ölçümleri arasında anlamlı pozitif doğrusal orta ilişki vardı (r=0.613).

Sonuç: Farklı kombinasyonlardaki maksillomandibular hareketler üst hava yolunun ön-arka boyutları üzerinde belirgin olarak farklı etkiler göstermiştir. Klinisyenler, hava yolu üzerindeki etkilerini göz önünde bulundurarak ameliyat planlamasını dikkatli bir şekilde yapmalıdır.

Anahtar Kelimeler: Ortognatik cerrahi işlemler, LeFort osteotomi, Angle sınıf 3, Farinks

ABSTRACT

Objective: To evaluate the effect of different surgery plans on anteroposterior dimensions of upper airway in bimaxillary surgery for correction of Class III malocclusion.

Materials and Methods: 59 subjects (mean age: 23.11±1.85years) treated with bimaxillary surgery for Class III correction were included. Preoperative (T1) and postoperative (T2) lateral cephalograms were traced and superimposed. 3 groups were formed according to different relative horizontal movements of A and B-points. Group-1: (n=21) displacement of B-point was greater than A-point. Group-2: (n=13) difference between displacements of A and B-points were ≤1mm. Group-3: (n=25), displacement of A-point was greater than B-point. Anteroposterior pharyngeal airway dimensions(mm) were measured at

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posterior(PAS), superoposterior(SPAS), middle(MAS), inferior(IAS), epiglottic(EAS) airway spaces. Intraclass evaluation was performed with Paired sample t-test and Wilcoxon's test. Interclass comparisons were evaluated with ANOVA and Tukey test for cephalometric changes while Welch ANOVA and Kruskal-Wallis tests were performed for airway changes. Pairwise comparisons of airway parameters were made with Mann-Whitney u-test with Bonferroni correction. Pearson correlation analysis was performed to evaluate relationship between primary predictor and outcome variables.

Results: Maxillary-height, palatal-plane, SNA, SNB, ANB, Wits, N-Perp, maxillary-depth changed significantly in total sample. Changes in Mandibular-plane and SNB were higher in Group-1 (p<0.05). Changes in SNA, N-PERP, maxillary-depth were higher in Group-3 (p<0.05). In total sample, PAS (mean:2.44±2.21mm; median:2.17mm) and SPAS (mean:1.07±2.31mm; median:1.14mm) showed highly significant increase. In Group-1, IAS decreased significantly (mean:-1.98±3.68mm; median:-1.36mm). Group-2 had no significant pharyngeal changes. In Group-3, PAS (mean:3.03±2.20mm, median:2.63mm) and SPAS (mean:1.64±1.81mm, median: 1,74mm) increased significantly. Total sample revealed significant positive linear weak relationship between PAS and SNA (r=0.335); and between IAS and B-point (r=0.275). Group-3 had significant positive linear moderate relationship existed between PAS and SNA measurements (r=0.613).

Conclusion: Differential maxillomandibular movements showed distinctly different effects on anteroposterior dimensions of upper airway. Clinicians should prepare surgery planning carefully, considering its effects on the airway.

Keywords: Orthognathic surgical procedures, Le Fort Osteotomy, Angle Class III, Pharynx

INTRODUCTION

The relationship between craniofacial morphology and airway has been well documented in literature (Lowe et al., 1997). Along with increased understanding of these factors, effects of different orthodontic and surgical interventions on airway resistance and dimensions have been studied. Rapid maxillary expansion, orthodontic tooth extraction, and orthopaedic orthodontic treatments are reported to affect airway dimensions (Kilic et al., 2008; Germec-Cakan et al. 2011; Kilinc et al., 2008).

Skeletal Class III malocclusion often requires a multidisciplinary approach including orthognathic surgery in adult patients. Craniofacial characteristics, like size of maxilla, mandible and soft palate are found to substantially affect anteroposterior dimension of pharyngeal airway space (Muto et al., 2006). Surgical changes in jaw positions create reorganization in surrounding tissues i.e. soft palate, tongue and pharynx; depending on magnitude and direction of correction. More extensive effects of surgery like backward rotation of cervical spine with respect to skull base, a backward shift in hyoid bone, and a change in head position have also been reported after single jaw surgery along with a decrease in pharyngeal cavity volume (Hasebe et al. 2011; Hochban et al., 1996; Kawamata et al. 2000; Kitagawara et al., 2008).

Regarding orthognathic surgery, contemporary findings agree on the following outcomes: isolated mandibular setback surgery generally decreased the airway volume; whereas isolated maxillary or mandibular advancement, and especially bimaxillary advancement generally increased the total airway and oropharynx airway volumes (Steegman et al., 2022)

Hwang et al have found that changes in positions of hyoid bone and tongue are gradually restored following single jaw surgery without obvious restoration of pharyngeal volume (Hwang et al., 2010). Bimaxillary surgery is reported to cause a smaller decrease in airway compared to isolated mandibular setback surgery. Azevedo et al reported that oropharyngeal volume change after bimaxillary surgery was not significant, while Uesugi et al reported a significant decrease in pharyngeal airway capacity (Azevedo et al., 2016; Uesugi et al., 2014).

Bimaxillary surgery for Class III correction describes a combination of simultaneous mandibular setback and maxillary Le Fort I osteotomy advancement. However, different combinations of movements in all 3 dimensions are possible during this correction according to characteristics of deformity and individual needs. We hypothesized that differential maxillomandibular movements might induce different effects on airway. Present study aims to answer the following clinical question: In patients with skeletal Class III malocclusion undergoing bimaxillary surgery, how do different surgery plans affect anteroposterior dimensions of upper airway?

MATERIALS AND METHODS

Study design and sample

The present cohort retrospective study was approved by ethical committee of Marmara University, Dental School (Decision date: 01/06/2020; Id number: 2020-400).

Study sample was derived from population of patients who presented to Department of Orthodontics in Marmara University, Dental School for evaluation and management of skeletal Class III malocclusion from January 1, 2010 through

January 1, 2019. Signed informed consent was obtained from all patients. Inclusion criteria were adult patients with skeletal Class III malocclusion, orthodontic decompensation followed by bimaxillary orthognathic surgery, complete records. Exclusion criteria were craniofacial syndrome, history of facial trauma, missing records, poor radiographic quality. 11 subjects were excluded and 59 subjects (28 male, 31 female; mean age: 23.11 ± 1.85 years) were included in study group. Preoperative (1-2 month before surgery; T1) and 6-12 months postoperative (T2) lateral cephalometric radiographs were retrieved from archive of Orthodontics department. All patients had bimaxillary surgery consisting of advancement of maxilla with Le Fort I maxillary osteotomy and mandibular set-back with bilateral sagittal split osteotomies. Surgical plans were determined on NemoStudio NX Pro v.10.4.2 (Software Nemotech SL, Madrid, Spain). Rigid intermaxillary fixation was applied for first two weeks postoperatively. Light elastics were continued for four more weeks for fixation.

Data collection, Management and Analyses

T1 and T2 lateral cephalometric radiographs were taken in same centre by same machine (Morita Veraviewepocs, J Morita Corp) in natural head position by positioning patients looking directly into reflection of their own eyes in mirror opposite to cephalostat. Lateral cephalograms were traced and superimposed on Sella-Nasion on NemoStudio NX Pro 10.4.2 cephalometric tracing software (Nemotech, Madrid, Spain) by same examiner.

In cephalometric analysis, vertical relationship was evaluated using mandibular plane angle, maxillary height angle and sum of inner angles. SNA, SNB, ANB and maxillary depth angles and linear distance of A-point to Nasion perpendicular (N-Perp; McNamara analysis) were used to evaluate sagittal relationship. Occlusal changes were evaluated using palatal plane and occlusal plane angles in vertical and Wits appraisal in sagittal. On T1-T2 superimposition, horizontal displacement of A-point and B-point were measured parallel to Frankfort Horizontal plane (FH) using ruler of software. (Figure 1) Patients were then divided into 3 groups according to different relative movements of A and B points. Group-1 (n=21) consisted of patients where absolute displacement of B-point was greater than that of A-point and difference between two values was greater than 1 mm. In Group-2, (n=13) displacements of A and B-points were almost equal (the difference between two values was 0 to 1mm). In Group-3 (n=25), displacement of A-point was greater than B-point and difference between two values was greater than 1 mm.

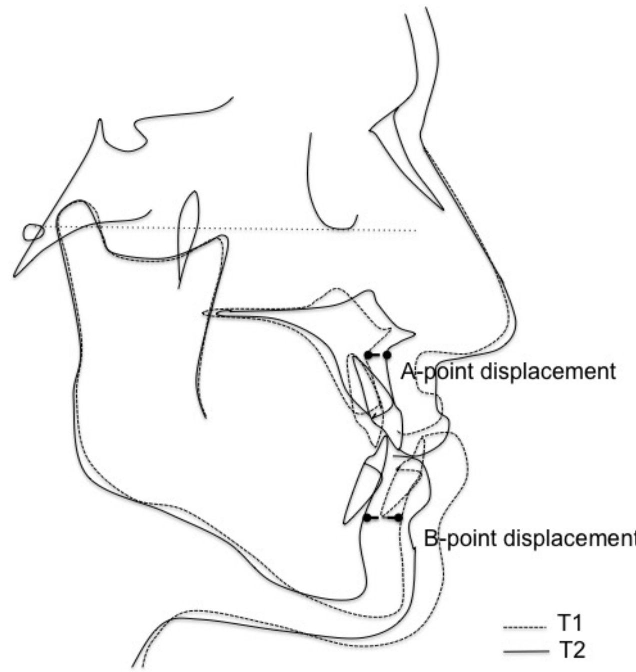

Figure 1. Horizontal displacement of A-point and B-point, measured on T1-T2 superimposition

At T1 and T2, anteroposterior pharyngeal airway dimensions (mm) were measured based on method of Mochida et al. (Mochida et al., 2004) at level of posterior airway space (PAS; anteroposterior depth of pharynx measured between posterior pharyngeal wall and posterior nasal spine on a line parallel to Frankfort horizontal plane through posterior nasal spine), superoposterior airway space (SPAS; anteroposterior depth of pharynx measured between posterior pharyngeal wall and dorsum of soft palate on a line parallel to Frankfort horizontal plane through middle of line from posterior nasal spine to tip of soft palate), middle airway space (MAS; anteroposterior depth of pharynx measured between posterior pharyngeal wall and dorsum of tongue on a line parallel to Frankfort horizontal plane through tip of soft palate), inferior airway space (IAS; anteroposterior depth of pharynx measured between posterior pharyngeal wall and surface of tongue on a line parallel to Frankfort horizontal plane through most anteroinferior point on body of second cervical vertebra) and epiglottic airway spaces (EAS; anteroposterior depth of pharynx measured between posterior pharyngeal wall and surface of tongue on a line parallel to Frankfort horizontal plane through tip of epiglottis) (Figure 2) One investigator performed all measurements and 50% of records were randomly selected and re-measured 1 week after first measurements.

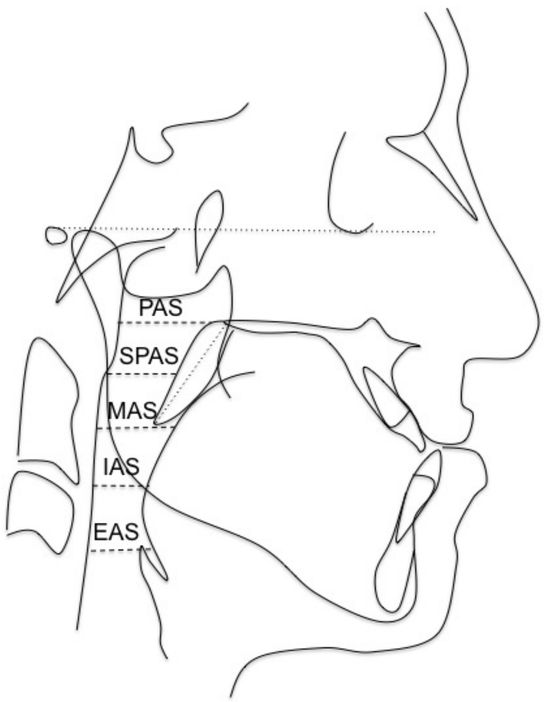

Figure 2. Anteroposterior pharyngeal airway dimensions (mm) on a presurgery cephalometry, measured at level of posterior (PAS), superoposterior (SPAS), middle (MAS), inferior (IAS) and epiglottic airway spaces (EAS).

The primary predictor variables were cephalometric skeletal parameters (A-point, B-point, SNA and SNB) and primary outcome variable was change in airway parameters.

Statistical analysis

IBM SPSS software (IBM SPSS Statistics for Windows, Version 22.0. Armonk, NY: IBM Corp) was used for statistical analysis. Shapiro-Wilks test was used to evaluate normal distribution of data. To evaluate intraclass measurements at two time points, Paired sample t-test was used for normally distributed data and Wilcoxon's test for data that did not show normal distribution. For interclass comparison of cephalometric changes in time, ANOVA was used to analyse presence of significant changes and Tukey test was used to determine between which groups differences were. Welch ANOVA and Kruskal Wallis tests were performed for intergroup comparisons of airway changes in time. Pairwise comparisons of airway parameters were made with Mann-Whitney u test and Bonferroni correction was applied to p values. Pearson correlation analysis was performed to evaluate relationship between primary predictor and outcome variables. Significance was evaluated at a level of $p<0.05$. Data reliability was assessed with intraclass correlation coefficient. Results were evaluated at a 95% confidence interval and a P value less than 0.05 was accepted as statistically significant.

RESULTS

The intraclass correlation coefficient ranged between 0.99 and 0.89 indicating high similarity between measurements at two time points. Table 1 displays displacement of A – and B-points for total sample and each group.

Table 1: Displacement of A-point and B-point on T2-T1 superimposition

		Total Sample		Group 1		Group 2		Group 3	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD
Amount of displacement (mm)	A-point	4.1	1.7	3.4	1.2	3.1	1.2	5.2	1.7
	B-point	-4.3	2.6	-7	2.1	-3.3	1.3	-2.6	1.5

SD: Standard deviation

Table 2: Cephalometric characteristics at T1 and T2, and intraclass and interclass comparisons of the T2-T1 changes

		Total sample			Group 1			Group 2			Group 3		
		Mean	SD	P	Mean	SD	P	Mean	SD	P	Mean	SD	P
Inner angles (°)	T1	394.6	7.4	0.40	393.2	8.6	**0.02***	395.6	6.2	0.96	395.2	6.9	0.48
	T2	395.1	6.3		395.1	7.2		395.7	6.7		394.6	5.5	
	Difference	0.5	3.5		1.9	3.4		0.1	5.2		-0.6	3.9	

Mandibular plane (°)	T1	37.4	6.3	0.82	36.1	7.7	0.08	37.8	4.7	0.70	38.2	5.7	0.07
	T2	37.5	5.4		37.5	6.4		38.2	5.6		37.1	4.5	
	Difference	0.1	3.3		1.4[a]	3.4		0.4[a,b]	3.5		-1.1[b]	2.9	
Maxillary height (°)	T1	62.8	3.4	**0.00***	63.0	4.0	0.17	62.7	3.6	**0.04***	62.6	2.8	**0.00***
	T2	61.1	3.4		62.1	3.5		61.2	4.0		60.4	3.0	
	Difference	-1.7	1.7		0.9	2.9		-1.5	2.4		-2.2	2.1	
Palatal Plane (PP-SN) (°)	T1	9.4	3.8	**0.02***	9.5	3.5	0.53	10.5	4.3	0.49	8.7	3.7	**0.07***
	T2	10.2	3.9		10.0	4.8		11.1	3.5		10.0	3.4	
	Difference	0.8	1.8		0.4	3.1		0.5	2.7		1.3	2.2	
Occlusal plane (OP-SN) (°)	T1	16.8	4.9	0.21	16.2	6.5	0.07	17.1	4.0	0.85	17.0	3.8	0.94
	T2	17.2	4.6		17.5	6.2		17.2	4.9		17.0	2.8	
	Difference	0.4	2.4		1.3	3.2		0.2	3.1		0.0	2.7	
Sella-Nasion-A point (SNA; °)	T1	78.1	4.2	**0.00***	79.4	4.1	**0.00***	77.0	3.9	0.00*	77.6	4.4	**0.00***
	T2	81.7	4.3		82.2	4.7		80.0	4.0		82.2	4.1	
	Difference	3.6	2.1		2.8[a]	1.3		3.0[a]	1.1		4.6[b]	1.7	
Sella-Nasion-B point (SNB; °)	T1	82.5	4.4	**0.00***	83.9	5.4	**0.00***	80.9	3.8	**0.00***	82.2	3.6	**0.00***
	T2	80.2	4.0		80.1	4,9		78.9	3.7		80.9	3.3	
	Difference	-2.3	2.1		-3.8[a]	1.4		-2.0[b]	1.1		-1.3[b]	1.4	
A point – Nasion-B point (ANB; °)	T1	-4.4	3.3	**0.00***	-4.4	3.2	**0.00***	-3.9	2.8	**0.00***	-4.6	3.6	**0.00***
	T2	1.5	2.1		2.1	2.2		1.1	1.4		1.2	2.2	
	Difference	5.9	1.6		6.5	2.4		4.9	2.0		5.8	2.5	
Wits appraisal (mm)	T1	-11.1	4.0	**0.00***	-12.2	4.4	**0.00***	-9.0	2.8	**0.00***	-11.3	3.8	**0.00***
	T2	-3.5	2.4		-3.2	2.3		-2.8	1.6		-4.1	2.7	
	Difference	7.6	3.0		9.0	3.8		6.3	2.4		7.2	3.3	
Nasion Perpendicular to A-point (mm)	T1	-5.4	4.1	**0.00***	-4.4	3.5	**0.00***	-5.6	3.8	**0.00***	-6.1	4.7	**0.00***
	T2	-1.4	4.1		-1.3	4.1		-2.2	3.8		-1.0	4.4	
	Difference	4.0	2.0		3.1[a]	1..3		3.4[a]	1.6		5.1[b]	1.8	
Maxillary depth (°)	T1	85.0	3.8	**0.00***	86.1	3.2	**0.00***	84.6	3.6	**0.00***	84.3	4.4	**0.00***
	T2	88.7	3.9		88.8	3.7		87.9	3.8		89.1	4.1	
	Difference	3.7	1.8		2.7[a]	1.3		3.3[a]	1.5		4.8[b]	1.7	

T1: Preoperative; T2: Pstoperative; SD: Standard Deviation. *P <0.05. Superscript letters (a) and (b) reflect the results of paired intergroup comparisons: Having same superscript letters symbolize "no statistically significant intergroup difference" and different letters symbolize "statistically significant intergroup difference". Group with both letters (a,b) has no statistically significant difference with neither (a) nor (b).

Table 2 summarizes cephalometric characteristics of total sample and each group at T1 and T2, and documents interclass comparison of T2-T1 changes. For cephalometric parameters that measure in vertical plane, Inner angles showed significant increase in Group-1 (1.9±3.4°, p=0.02); maxillary height showed significant decrease in total sample (-1.7±1.7°, p=0.00), Group-2 (-1.5±2.4°, p=0.04) and Group-3 (-2.2±2.1°, p=0.00). Palatal plane increased significantly in total sample (0.8±1.8°, p=0.02) and in Group-3 (1.3±2.2°, p=0.01). All changes in sagittal plane (SNA, SNB, ANB, Wits, N-PERP, maxillary depth) were highly significant in all groups (p=0.00). Between groups, Mandibular plane (p=0.04), SNA, SNB, N-PERP and maxillary depth (p=0.00) changes showed significant difference. Multiple comparisons showed that changes in Mandibular plane and SNB were significantly higher in Group-1 (p<0.05). Changes in SNA, N-PERP and maxillary depth were significantly higher in Group-3 (p<0.05).

Table 3 shows changes (T2-T1) in airway parameters. In total sample, PAS (mean: 2.44±2.21mm; median: 2.17mm) and SPAS (mean: 1.07±2.31mm; median: 1.14mm) showed highly significant increase while changes in MAS, IAS and EAS were insignificant (p>0.05). In Group-1, IAS decreased significantly (mean: – 1.98±3.68mm; median: – 1.36mm; p=0.01). There were no significant changes in pharyngeal parameters in Group-2 (p>0.05). In Group-3, PAS (mean: 3.03±2.20mm, median: 2.63mm; p=0.01) and SPAS (mean: 1.64±1.81mm, median: 1,74mm; p=0.04) increased significantly. Between groups, only ΔPAS showed significant difference (p=0.02). Paired comparisons showed that there was significant difference between Group-2 and 3. ΔPAS in Group-2 was significantly lower than Group-3 (p<0.05).

Table 3: Changes in airway parameters (T2-T1) and the intergroup comparisons

	Group	Mean	SD	Median	P value
ΔPAS	1	2.41	2.28	2.19 ^{x,y}	0.52
	2	1.36	1.80	0.71 ^{x}	0.06
	3	3.03	2.20	2.63 ^{y}	**0.01***
	Total	2.44	2.21	2.17	**0.00***
ΔSPAS	1	0.57	3.13	1.03	0.12
	2	0.77	1.31	0.77	0.28
	3	1.64	1.81	1.74	**0.04***
	Total	1.07	2.31	1.14	**0.00***
ΔMAS	1	0.11	3.19	-0.04	0.16
	2	-0.70	3.20	-0.28	0.60
	3	0.97	1.81	1.04	0.10
	Total	0.30	2.72	0.44	0.09
ΔIAS	1	-1.98	3.68	-1.36	**0.01***
	2	-0.28	3.44	-0.11	0.84
	3	0.03	1.94	-0.19	0.70
	Total	-0.75	3.09	-0.4	0.14
ΔEAS	1	-1.42	3.31	-0.89	0.31
	2	0.48	2.14	-0.4	0.89
	3	-0.10	2.50	-0.32	0.99
	Total	-0.44	2.81	-0.46	0.23

SD: standard deviation. *P <0.05 . ΔPAS: Change in posterior airway space; ΔSPAS: Change in superoposterior airway space; ΔMAS: Change in middle airway space; ΔIAS: Change in inferior airway space; ΔEAS: Change in epiglottic airway space. Superscripts letters (^{x}) and (^{y}) reflect the results of paired intergroup comparisons: same superscript letters symbolize "no statistically significant intergroup difference" and different letters symbolize "statistically significant intergroup difference". Group with both letters (^{x,y}) has no statistically significant difference with neither (^{x}) nor (^{y}).

The correlation between skeletal changes (primary predictors: SNA, SNB, A-point and B-point) and airway parameters (primary outcome variables) revealed statistically significant positive linear weak relationship between PAS and SNA (r=0.34); and between IAS and B-point (r=0.28) in total sample. Within groups, only in Group-3, statistically significant positive linear moderate relationship existed between PAS and SNA measurements (r=0.61).

DISCUSSION

To date, there is still controversy in literature regarding the effects of surgical Class III correction on upper airway (Steegman et al., 2022; Hwang et al., 2010; Azevedo et al., 2016). Bimaxillary surgery for correction of skeletal Class III has been evaluated as a generalized combination of maxillary advancement and mandibular setback, regardless of the relative movements of jaws. It has been overlooked that effects of differential maxillomandibular movements in bimaxillary Class III surgery might induce different effects. And this aspect, which might be the reason of controversial results in literature, has not been evaluated previously. Therefore, primary aim of this study was to investigate influence of different combinations of maxillary advancement and mandibular setback in terms of magnitudes of horizontal movement.

Lateral cephalometric radiographs are amongst conventional routine orthodontic records for diagnosis and treatment results. Previous studies used them for assessment of airway changes and evaluated as accessible and suitable tools for evaluation of craniofacial and soft tissue deformities in their correlations with obstructive sleep apnea syndrome (OSAS) severity (Jakobsone et al., 2010). Although cephalograms cannot display 3D volume of airway, a significant correlation was reported between pharyngeal airway space measurements on cephalometric radiography and hypopharyngeal airway volume measured on computed tomography (CT) (Ryu et al., 2015). In present study, several measures were taken to standardize head posture. All radiographs were taken at same centre with a standard procedure. Patients with questionable head posture were eliminated during initial phase of data collection. After cephalometric analysis and superimposition, patients with more than 10° discrepancy between true vertical lines at two time points were excluded. Linear airway measurements that were proposed by Mochida et al were adopted (Mochida et al., 2004).

Isolated mandibular setback has been associated with a decrease in region of soft palate and base of tongue; and maxillary advancement plus mandibular setback has been associated with an increase in posterior nasal spine region and decrease in soft palate, tongue, and vallecula regions in studies performed on cephalometric analyses (Riley & Powell, 1990). In present study, when whole sample was evaluated as a bimaxillary Class III correction group, PAS and SPAS showed highly significant increase while changes in MAS, IAS and EAS were insignificant. This result was similar to findings of Jakobsone et al, who observed a substantial increase in volume in oropharyngeal and hypopharyngeal areas and concluded that bimaxillary surgery for Class III correction did not cause decrease of posterior airway space (Jakobsone et al., 2010). Burkhart et al also detected a significant increase of upper airway at level of PNS (Burkhard et al., 2014). They also reported a slight narrowing at level of epiglottic vallecula. This narrowing effect was only present in Group-1 at the level of IAS in this study.

However, when data was categorized in groups according to relative jaw movements, significant differences were observed between groups. IAS reduced significantly in Group-1 where mandibular setback amount was greater (-7±2.1 mm) than maxillary advancement (3.4±1.2 mm). In Group-2, where maxilla and mandible moved equal amounts in opposite directions (3.1±1.2 and 3.3±1.3 mm respectively), airway parameters did not show significant change. In Group-3, where amount of maxillary advancement was greater than mandibular setback (5.2±1.7 mm and – 2.6±1.5 mm respectively), PAS showed a significant increase. Differences between whole sample and study groups supported study hypothesis that differential maxillomandibular movements might induce different effects on airway. These results are important to document selective quantitative effects of jaw movements on anteroposterior airway dimensions in Class III correction with bimaxillary surgery. Clinical significance of these changes on airway function as experienced by patients should be evaluated by prospective controlled studies.

On a cone beam CT study, Hart et al recorded linear changes in positions of A-point and D-point (midpoint of internal symphysis) using reference planes (Hart et al., 2015). For their whole sample, including Class II and Class III individuals, they concluded that horizontal movement of mandible and vertical movement of posterior maxilla significantly affected total airway volume. In present study, amount of horizontal movements in A-point and B-point were used for grouping the sample and for airway correlation along with other cephalometric parameters. Similar to Hart et al, a relationship was found between IAS and B-point (r=0.275). While A-point showed no correlation, a moderate positive correlation between PAS and SNA (r=0.335) was present in total sample. This relationship was more pronounced in Group-3 (r=0.613) where maxillary advancement was greater than setback.

The 2D evaluation of airway can be counted as a limitation of this study since volumetric measurements could not be performed. In a retrospective study design, obtaining CBCT data was not possible. Future three-dimensional studies can be conducted in the light of these findings to quantify volumetric outcomes and to clarify conflicting reports on effects of bimaxillary Class III surgery. Weight change, as a confounding variable was not evaluated. Medium weight loss (5-10%) is reported to decrease severity of obstructive sleep apnoea and collapse tendency of airway space (Hart et al., 2015). Data regarding weight change was not present in patient files. However, we can confirm that during treatment, none of patients were on a diet for weight loss purposes. As a general observation from our practice, patients usually recover their weight after removal of splints even if they lost weight postoperatively due to intermaxillary fixation. Cephalometric radiographs included in this study were taken 6-12 months after surgery, with an interval of minimum 8 months between two time-points. Muscle adaptation is reported to happen during first 6 months after surgery (Schwartz et al., 1992). In post-surgical period, 85-90% of swelling resolves during first 6 months and remaining swelling diminish at second 6-month period. A minimum of 12 months post-surgery would be ideal, however, a post-surgical period of 6 months has been reported to be acceptable for evaluation of soft tissue changes (van der Vlis et al., 2014).

CONCLUSIONS

This study is the first to analyse and document the effects of differential magnitudes of maxillomandibular movements in bimaxillary orthognathic surgery and to show their impact on upper airway anteroposterior dimensions. In the total sample of surgical Class III correction, posterior and superoposterior airway spaces showed highly significant increase while changes in middle, inferior and epiglottic airway spaces were insignificant. When the study sample was categorized according to the magnitude of intervention on both jaws, the locations of the significant changes in airway spaces changed considerably.

Knowing the effect of selective movements is important to guide the clinicians during the surgical planning in cases where airway dimensions are critical presurgically and also to understand the postoperative results of the intervention.

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