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AIRWAY CHANGES WITH SURGICAL ORTHODONTIC TREATMENT OF CLASS III MALOCCLUSION

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Abstract

Objective: *To determine changes in the oropharyngeal airway in Class III patients treated by bimaxillary surgery, and to find possible correlation between oropharyngeal airway changes and the skeletal movements.*

Materials and Methods: *Lateral cephalograms of 30 class III patients (16 females, 14 males, age: 18-25 years old) treated with maxillary advancement and mandibular set-back were evaluated pre- surgery (T1), post-surgery (T2) and 12 months post-surgery (T3). The anteroposterior oropharyngeal airway and skeletal changes of the maxilla and mandible were measured. ANOVA was performed to determine significant differences between the different time points. Pearson correlation coefficient was used to assess correlations between the changes in oropharyngeal airway and the amount of jaws movements.*

Results: *Parameters indicating anteroposterior maxillary position showed significant increase from T1 to T2 and from T1 to T3. Parameters indicating antero-posterior mandibular position showed significant decrease from T1 to T2 and from T1 to T3. Anteroposterior oropharyngeal airway space showed significant increase from T1 to T2 and from T1 to T3. All measured variables in the study showed insignificant differences between T2 and T3 indicating insignificant relapse of the surgically induced changes.*

Pearson's correlation analysis showed a statistically significant moderate positive correlation between the oropharyngeal airway increase and the amount of the maxillary advancement, while no correlation was found with the amount of mandibularsetback.

Conclusions: *Combined maxillary advancement and mandibular setback surgeries lead to an increase in the anteroposterior dimension of the oropharyngeal airway. Which is positively correlated to the amount of maxillary advancement only.*

Introduction

Skeletal class III malocclusion is manifested as a discrepancy in the anteroposterior relationship of the maxilla and mandible. The severity of the deformity, the amount of the desired correction, and the expected facial improvement after surgery, affect the treatment of choice[1]. Surgical correction of skeletal class III cases by a combination of bimaxillary surgery has a great effect on the facial esthetics and the patient's self-esteem. However, it has another functional effect on the oropharynx.

The complex anatomy of the oropharynx is pivotal to its function. The pharyngeal muscle tone essential to its patency is reduced during sleep, thus substantiating the role of proper pharyngeal anatomy to guard against airway collapse[2,3]. Therefore objectives as improving occlusion and aesthetics, should be planned with attention to the pharyngeal function.

Several studies[4,5,7,8,9] reported a reduction of the pharyngeal airways after mandibular setback surgery. Long follow-up showed maintenance of this reduction[10,11,12]. At the same time, Mao et al[13] found that although there was some increase in both the airway space width and area during the follow-up period, they did not increase to their original values. On the other hand, some studies[14,15,16,17,18,19] suggested that the changes in the oropharyngeal complex are temporary as the tissues re-adapt, leading to self-correction.

Findings of studies addressing the relationship between double jaw surgery and pharyngeal airway are contradicting, maybe due to the complex anatomy and physiology of the pharynx, together with the different methods of measuring the airway, and differences in the amounts of surgical jaw movements. Some studies[20,21.] reported

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significant decrease of the upper pharyngeal airway dimensions, while others[22,23,24,25] have indicated that the decrease in the pharyngeal airway space after double jaw surgery was less than with mandibular setback alone, other studies[19,26,27,28,29,30] reported increase in the pharyngeal airway space after bimaxillary surgery, while others[31,32] found no effect on the airway.

Hence, this study was designed to answer the question; how does maxillary advancement and mandibular set back affect the oropharyngeal airway space?

Aim of the work

To determine the changes in the oropharyngeal airway in Class III cases treated by maxillary advancement and mandibular setback surgery, and to find any possible correlation between the skeletal movements and the amount of change.

The null hypothesis was that bimaxillary osteotomies involving maxillary advancement and mandibular setback will not induce any changes in the anteroposterior oropharyngeal airway dimensions.

Materials and Methods

In this retrospective study, the oropharyngeal airway changes accompanying maxillary advancement and mandibular setback surgery were measured on lateral cephalometric radiographs of 30 subjects (16 females, 14 males, age range: 18-25 years old) treated at the Faculty of Dentistry, Alexandria University. Patients who met the following criteria were included in the study:

1. Skeletal class III malocclusion showing maxillary deficiency and mandibular prognathism.
2. Surgical orthodontic treatment involving both maxillary advancement and mandibular setback.
3. Stable occlusion after completion of the treatment.
4. Presence of complete records before and after surgery including lateral cephalometric radiographs.

The exclusion criteria included cleft lip and palate, or other syndromes, history of tonsillectomy or adenoidectomy, or history of any other head or neck surgery performed during the duration of the study.

The oropharyngeal anteroposterior dimension was assessed on lateral cephalometric radiographs obtained at T1 Before surgery, T2 After surgery, T3 12 months after surgery. All radiographs were taken with the same x-ray machine, with the patients occluding in maximum intercuspation. The lateral cephalometric radiographs could not be blinded across different time points because the surgical effect on the jaws could not be masked in the cephalogram.

The oropharynx was measured by drawing a perpendicular line from the middle pharyngeal wall (MPW) to the tip of the soft palate (U) (Figure 1)[19,20,22].A horizontal reference line (HRL) was drawn by rotating the SN line 7 degrees clockwise at nasion. A vertical reference line (VRL) was drawn perpendicular to HRL at nasion (Figure1)[21,33,34]. The anteroposterior skeletal changes of the maxilla were assessed by measuring the distance from A point (Subspinale), ANS (Anterior nasal spine), and PNS (Posterior nasal spine) relative to the VRL. Similarly, the anteroposterior skeletal changes of the mandible were evaluated by measuring the distance from B point (Supramentale), Me (Menton), and Pg (Pogonion) relative to the VRL (Figure 1). Negative values were given to measurements posterior to the VRL line.

Sample Size Calculation

G*Power software was used to estimate the sample size (Dusseldorf, Germany). Based on the calculations (28) cases were required, for a study with 80% power and an α of 0.05, Thus, a total of 30 cases were used.

Repeatability and intra-rater agreement:

All measurements for all cephalograms were made twice by the same investigator at 2 settings with a 2-week interval in between, intra-class correlation coefficient and paired t-tests were used to compare the measurements between the 2 settings. There was good intra-rater agreement with no statistically significant differences between the 2 measurements.

Statistical analysis was performed using SPSS software, version 20 (SPSS Inc, Chicago, Ill) The significance level was set at $p \leq 0.05$. Data normality was tested using descriptive statistics, plots and Shapiro-Wilk test. Analysis of variance (ANOVA) was performed to determine significant differences between the different time points. Significant ANOVAs were followed by post hoc pairwise comparisons with Bonferroni adjustment. Correlations between the changes in oropharyngeal airway space dimensions and the different measurements of hard tissue movements were done using Pearson correlation coefficient. Correlation was referred to according to the following ranges:

Strong correlation: (r > 0.6)

Moderate correlation: (r = 0.3 - 0.6)

Weak or no correlation: (r < 0.3)

Results

All variables showed normal distribution, using Shapiro-Wilk test, so means, standard deviations (SD), were calculated, and parametric tests were used. A point worth mentioning is that in table 1 and 2 reporting the mean and standard deviation of maxillary and mandibular parameters, at first glance it could be seen that in some readings the standard deviation is way larger than the mean, giving the impression of extreme data spread and non-normal distribution of the data. This is true if all the data has positive values ,It should be noted that the data in the current study contains positive and negative values therefore the comparison of the standard deviation to the mean stops having any significance.

Changes in the parameters indicating anteroposterior maxillary position are shown in table 1. All parameters indicating antero-posterior maxillary position showed statistically significant maxillary advancement from T1 to T2 and from T1 to T3, where a significant increase was found for ANS-VRL, PNS-VRL and A-VRL following surgical forward movement of the maxilla. On the other hand, the change from T2 to T3 was statistically insignificant.

The results in table 2 demonstrate a significant posterior movement of the mandible post- surgically, as shown by the significant decrease in B-VRL, Pg-VRL, and Me-VRL from T1 to T2, and from T1 to T3. and a non-significant change in position 12 months post-surgery from T2 to T3.

The anteroposterior oropharyngeal airway space (U-MPW) showed a significant increase after surgery while it's change at T3 was not statistically significant as shown in table 3.

Pearson's correlation analysis (Table 4) between the oropharyngeal airway changes and the changes in parameters indicating anteroposterior position of the maxilla showed a statistically significant moderate positive correlation. On the other hand, Pearson's correlation analysis between the oropharyngeal airway changes and the changes in parameters indicating anteroposterior position of the mandible, showed no correlation (Table 5)

Discussion

The present study used lateral cephalograms to evaluate changes in the oropharyngeal airway concomitant with bimaxillary surgical correction of skeletal class III cases. Despite of being a 2-dimensionsional representation of the 3-dimensoinal airway, lateral cephalograms are used extensively in airway studies due to its ease, low radiation, and low-cost relative to 3-dimensoinal CT's. In addition, Jackobson et. al.[19] compared cross sectional areas of the airway measured on CT's to airway anteroposterior measurements on lateral cephalograms and found statistically significant correlation (r = 0.7).

In the present study, changes of the oropharyngeal airway space, as well as the amount of bimaxillary movement measured at various treatment stages were assessed and correlated with each other. Similar to previous studies[19,22,33] U-MPW was selected to represent the pharyngeal airway dimensions at the level of oropharynx because the oropharynx is the most common site of airway obstruction as reported in a systematic review by Rama et.al[35].

The amount of maxillary advancement and mandibular setback was statistically significant with a mean maxillary advancement of 4.34mm and mandibular set back of 6.88mm , the oropharynx showed a statistically significant mean increase of 1.9mm this is in agreement with other studies[19,27,28,29,30,36].

On the other hand, a Jakobson et.al.[33] and Tan et.al[37]. reported that the oropharyngeal airway decreased after maxillary advancement and mandibular setback. This probably could be attributed to the relatively small amount of maxillary advancement relative to the large amount of mandibular setback used in both studies, as in Jakobson et.al[33] study the mean amount of maxillary advancement was in the range of 2mm while the mandibular setback was about 3 folds with a mean of 6.7mm, the same is true for Tan et.al.[37] were the mean of maxillary advancement was 2.26mm and the mean mandibular set back was 5.85mm. in addition, both studies had maxillary impactions which might have had a role in changing the airway dimension when combined with maxillary advancement[38]. Other studies by Moscarino et.al[31]. and Azevedo et.al[32] reported that bimaxillary surgical correction of class III had no effect on the airway, probably this could be attributed to the small sample size (N=13) in Azevedo et.al. study, and division of the airway into 6 levels on the cephalogram and using the root of the tongue as an anterior boundary for the airway in Moscarino et.al. study.

Many studies[9,25,39,40] reported that treating skeletal class III cases by mandibular setback alone without maxillary advancement had a negative impact on the airway, so it could be assumed that the effect on the airway accompanying surgical correction of class III depends on the ratio of maxillary advancement to mandibular setback, with the extreme negative effect being in cases of mandibular setback alone, followed by slight decrease in the airway in cases treated mostly with mandibular setback accompanied by minimal maxillary advancement, and finally those cases treated with more maxillary advancement with mandibular setback like the current study in which the airway increased.

Pearson's correlation analysis performed in the current study demonstrated a statistically significant moderate positive correlation between the magnitude of maxillary advancement and the increase in the oropharyngeal airway, this is in concordance with Kongsong et.al.[41]. On the contrary no correlation was found between the amount of mandibular set back and the increase in the oropharyngeal airway, this goes with Chang et.al[42], and is explained by the fact that mandibular setback tends to decrease the airway when performed alone, but in the current study the oropharyngeal airway increased due to a good balance between maxillary advancement and mandibular setback.

Despite the relapse tendency of surgical jaw movements, in the current study there was no statistically significant relapse after 12 months, this may be attributed to the balance between both jaws movements because the larger the amount of jaw movement, the larger the anticipated relapse[43,44].

Conclusions

- Simultaneous maxillary advancement and mandibular setback surgeries used for the treatment of skeletal class III cases caused the oropharyngeal airway to increase significantly.
- There was statistically significant moderate correlation between the amount of maxillary advancement and the increase in the oropharyngeal airway.
- No correlation was found between the amount of mandibular setback and the increase in the oropharyngeal airway.
- Relapse of the jaws after 12 months was not significant and did not have an impact on the increase in the oropharyngeal airway dimension.

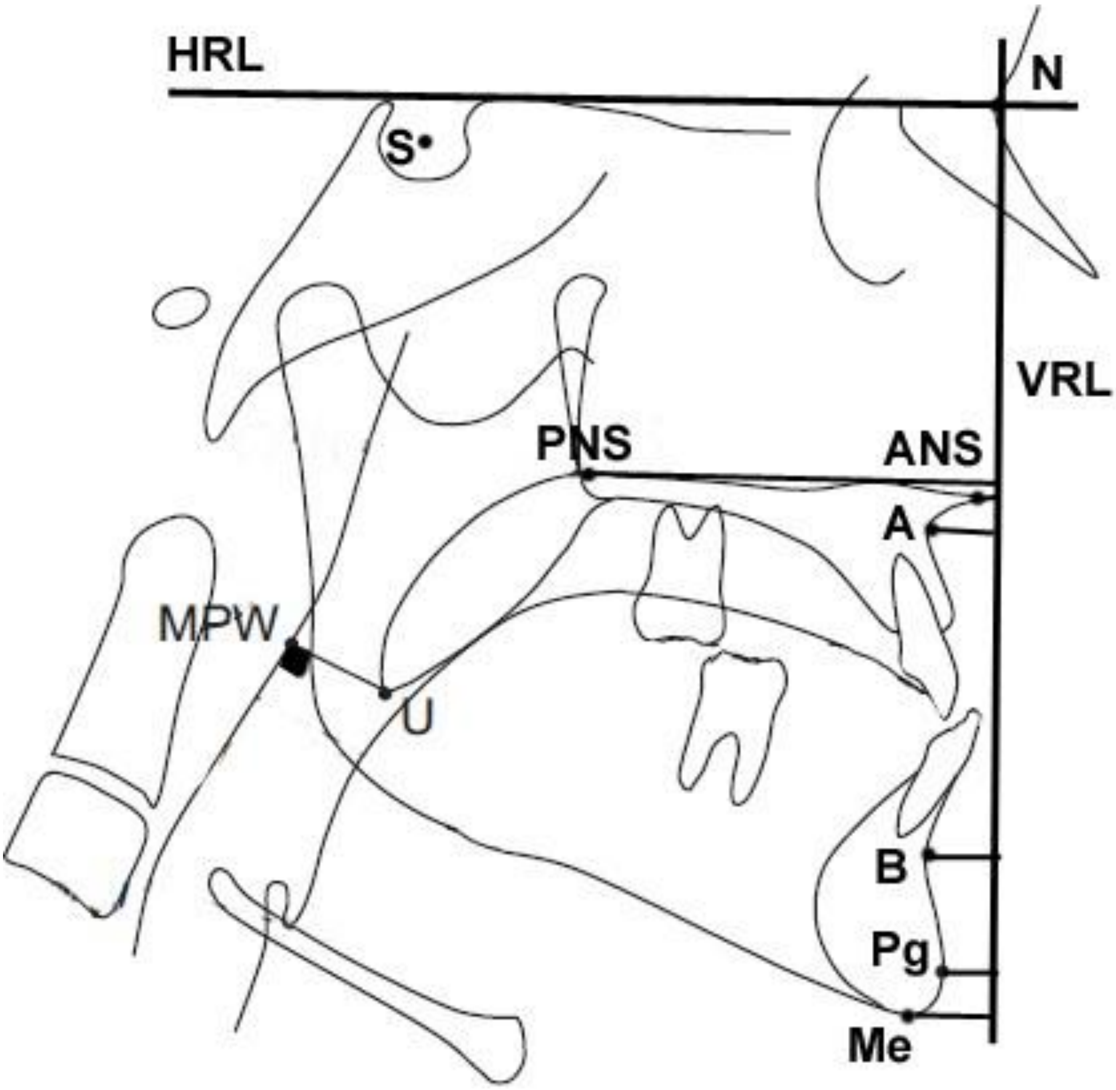

Figure 1: The landmarks and reference lines used to assess skeletal movements and oropharyngeal airway space: *HRL*, Horizontal reference line constructed by raising a line 7° from the sella-nasion (S-Na) line at nasion (Na); *VRL,* Vertical reference line constructed perpendicular to the (HRL) at nasion. Points used to assess maxillary position: *A*, Subspinale point; *ANS*, Anterior nasal spine; *PNS*, Posterior nasal spine. Points used to assess mandibular position: *B*, Supramentale; *Me*, Menton; *Pg*, Pogonion. Measurement of the oropharynx. *U-MPW*, the distance from U (uvula) to MPW (middle pharyngeal wall).

Tables:

Table 1. Comparisons of parameters indicating anteroposterior maxillary position before surgery **(**T1), after surgery (T2) and 12 months after surgery (T3) using ANOVA. *(Post-hoc is denoted by superscript letters*)

	Mean† (SD)			***P value***
	Before surgery (TI)	***After surgery (T2)***	***12 months after surgery (T3)***	
ANS-VRL	1.85 (2.14) [a]	5.98 (2.43) [b]	4.21 (2.25) [b]	<0.0001*
PNS-VRL	-42.42 (3.56) [a]	-38.76 (3.32) [b]	-39.37 (3.66) [b]	<0.0001*
A-VRL	-1.13 (3.26) [a]	3.21 (3.17) [b]	2.89 (3.17) [b]	<0.0001*

A, Subspinale point; *ANS*, Anterior nasal spine; *PNS*, Posterior nasal spine; *VRL*, Vertical reference line.
*Statistically significant at $p \leq 0.05$
† Measurements in mm, Negative values indicate posterior position to vertical reference line. a, b: Different letters indicate statistically significant difference.

Table 2. Comparisons of parameters indicating anteroposterior mandibular position before surgery (T1), after surgery (T2) and 12 months after surgery (T3). ANOVA. *(Post-hoc is denoted by superscript letters*)

	Mean† (SD)			***P value***
	Before surgery (TI)	***After surgery (T2)***	***12 months after surgery (T3)***	
B-VRL	6.13 (4.32) [a]	-0.75 (3.21) [b]	0.86 (3.14) [b]	<0.0001*
Pg-VRL	5.15 (4.54) [a]	-0.86 (3.13) [b]	0.65 (3.58) [b]	<0.0001*
Me-VRL	-2.12 (2.56) [a]	-7.03 (3.32) [b]	-6.19 (3.36) [b]	<0.0001*

B, Supramentale; *Me*, Menton; *Pg*, Pogonion; *VRL*, Vertical reference line.
*Statistically significant at $p \leq 0.05$
† Measurements in mm, Negative values indicate posterior position to vertical reference line. a, b: Different letters indicate statistically significant difference.

Table 3. Changes of oropharyngeal airway space horizontal linear measurements before surgery (T1), after surgery (T2) and 12 months after surgery (T3). ANOVA. *(Post-hoc is denoted by superscript letters*)

	Mean† (SD)			***P value***
	Before surgery (TI)	***After surgery (T2)***	***12 months after surgery (T3)***	
U-MPW	13.07 (1.04)a	14.97 (1.30)b	14.31 (1.43)b	<0.0001*

U-MPW, the distance from U (uvula) to MPW (middle pharyngeal wall) representing the oropharyngeal airway space.
† Measurements in mm.
*Statistically significant at $p \leq 0.05$
a, b: Different letters indicate statistically significant difference.

Table 4: Pearson correlation between airway changes and parameters indicating maxillary advancement.

		T2- T1 ***Surgical change***	***T3-T1 Overall change***
ANS-VRL	r	0.46	0.43
	P value	0.01*	0.01*
PNS-VRL	r	0.42	0.4
	P value	0.02*	0.02*
A-VRL	r	0.52	0.49
	P value	0.003*	0.006*

* Statistically significant at p≤ 0.05

A, Subspinale point; *ANS*, Anterior nasal spine; *PNS*, Posterior nasal spine; *VRL*, Vertical reference

Table 5: Pearson correlation between airway changes and parameters indicating mandibular setback.

		T2- T1 Surgical change	***T3-T1 Overall change***
B-VRL	r	0.16	0.14
	P value	0.40	0.43
Pg-VRL	r	-0.23	-0.20
	P value	0.18	0.15
Me-VRL	r	-0.20	-0.17
	P value	0.28	0.26

B, Supramentale; *Me*, Menton; *Pg*, Pogonion *VRL*, Vertical reference line.
*Statistically significant at p ≤ 0.05

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