Changes in Pharyngeal Airway Dimensions, Hyoid position, and Head Posture after Rapid Palatal Expansion and Face Mask Therapy.

Amjad Al Taki [1], Alya Thabit [2]

[1.] Associate Professor, Private Practice, Dubai, United Arab Emirates
[2.] Dentistry resident, College of Dentistry, Ajman University of Science and Technology, Ajman, United Arab Emirates
al_taki@hotmail.com

Abstract: The aim of this study was to investigate the effects of rapid palatal expansion (RPE) and facemask therapy on sagittal airway dimensions, hyoid position, and head posture in growing patients with skeletal Class III malocclusion. Fifteen cases (9 girls, 6 boys; mean age, 9.35 ± 1.53 years) treated with RPE and facemask therapy were included in this study. Pre-treatment, post-treatment cephalometric radiographs were obtained. Linear and angular measurements were traced. Data were analyzed statistically by means of Paired T-test. Treatment changes revealed a significant increase in nasopharyngeal and oropharyngeal airway dimensions. Significant increases also occurred in the sagittal growth of the maxilla, while a clockwise rotation and inhibition of sagittal growth were observed in the mandible. Significant change in head posture was observed while no significant positional change was noted in hyoid bone. **Conclusion**: Orthopedic treatment of Class III skeletal malocclusion with RPE and facemask therapy was able to produce a significant improvement in the nasopharyngeal and oropharyngeal airway dimensions and a significant change in the head posture.
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1. Introduction

Class III skeletal malocclusions are considered to be one of the most challenging malocclusions to treat. Studies have shown that the two-thirds of the skeletal Class III malocclusions in white individuals are due to maxillary hypoplasia or a combination of maxillary hypoplasia and mandibular prognathism.[1]In view of the high frequency of maxillary retrusion, maxillary advancement by reverse headgear has been considered a major treatment option in young patients.[2,3]

Pharyngeal size is very important for all subjects and especially for the patient with sleep apnea. The size of the nasopharynx may be of particular importance in determining whether the mode of breathing is predominantly nasal or oral. Oral breathers have to open their mouths and maintain an oral airway. Three changes in posture are needed to accomplish this: lowering the mandible, positioning the tongue downward and forward, and extending the head. These postural changes could affect dentofacial growth and development.[4]Early correction of a developing Class III malocclusion remains a complex challenge. Possible approaches include fixed appliances, removable appliances, removable functional appliances, chin cup, protraction headgear, and skeletal anchorage systems, or a combination of multiple of these treatment modalities. Orthodontic treatments, such as growth modification using a rapid palatal expander or an orthopedic appliance and orthognathic surgery, cause not only teeth movement but also a change in the skeletal dimension, leading to size and positional changes in the adjacent soft tissue as well as airway size.

Recent studies have revealed significant changes of both oral and nasopharyngeal dimensions have been reported after facemask therapy.[5-7]Thereare few studies that assess the effects of RPE and facemask therapy on the head position and hyoid bone position. Yagci et al[8] assessed the effects of modified and conventional facemask therapies with expansion on dynamic measurement of natural head position in Class III patients and found out a significant cranial flexion after the treatment. On the other hand, Oktay and Ulukaya[9] reported no significant change in head posture after face mask therapy.

The aim of this study was to investigate the effects of RPE and Facemask therapy on airway dimensions in patients with skeletal Class III malocclusions, and to examine the changes in head position and hyoid bone position.

2. Material and Methods

The sample was composed of the lateral cephalometric radiographs of fifteen subjects (9 girls, 6 boys) treated with RPE and facemask therapy. All

subjects were treated at the Department of Orthodontics, College of Dentistry, Ajman University of Science and Technology, Ajman, United Arab Emirates. Pre-treatment radiographs (T1) were taken before appliance therapy and post-treatment radiographs (T2) were taken after achieving a positive overjet but before a second phase of fixed appliance treatment. The selected patients were all skeletal class III cases with maxillary retrusion, an anterior crossbite with no functional shift, flat or concave facial profile, and no congenital anomalies in the medical history.

Treatment started with RPE which was achieved using a banded Hyrax expansion appliance. The first permanent molars and first premolars or the first primary molars were banded. After obtaining alginate impressions, a Hyrax screw was soldered to the bands on the models in an antero-posterior direction. Following cementation, an orthodontist first activated the appliance; the patients were then asked to activate the screw twice a day for 7 days. At the end of day 7, protraction therapy commenced. A Petit type facemask was used with a magnitude of the force was 600 grams at each side and its direction was 30º downward from the occlusal plane. The patients used their face masks 16 hours a day, and the treatment was continued until.

a normal overjet and Class I molar and canine relationships were obtained. The mean treatment was 6.94 ± 0.56 months.

Lateral cephalometric radiographs were taken in the natural head position with a Trophy Instrumentarium Cephalometer (OP 100, Finland) at 70 KVp, 16 mA/s, and all cephalograms were hand traced by the same investigator.

A horizontal reference plane (HRP) was drawn by rotating 7 degrees clockwise to the sella-nasion line at sella and a vertical reference plane (VRP) was drawn perpendicular to this line at sella.

Assessment of skeletal morphology:

The following cephalometric measurements were used to assess antero-posterior skeletal changes (Figure 1):

1. HRP-A: the distance from horizontal reference plane to Point A.
2. HRP-B: the distance from horizontal reference plane to Point B.
3. VRP-A: the distance from vertical reference plane to Point A.
4. VRP-B: the distance from Vertical reference plane to Point B.

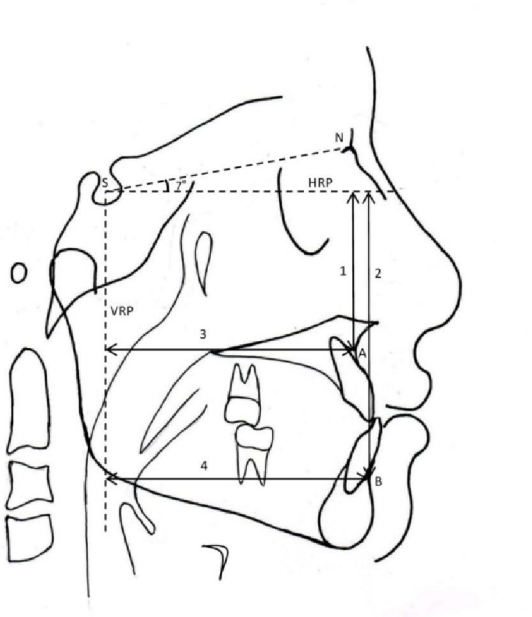

Figure (1): Cephalometric Measurements: Skeletal Morphology

Assessment of sagittal airway dimensions:

The following cephalometric measurements were used to assess nasopharyngeal airways (figure 2):

1. PNS-AD1: Lower airway thickness; distance between PNS and the nearest adenoid tissue measured through the PNS-Ba line (AD1).
2. PNS-AD2: Upper airway thickness; distance between PNS and the nearest adenoid tissue measured through a perpendicular line to S-Ba from PNS (AD2).

The oropharyngeal airway measurements were divided into 3 levels:

3. UPW (upper pharyngeal width): the thickness of the airways at the level of palatal plane.
4. MPW (middle pharyngeal width): the thickness of the airway at the level of occlusal plane
5. PAS (posterior airway space): the thickness of the airway along a line extending through the Go-B point plane.

The following cephalometric measurement was used to assess hyoid position (figure 3):

1. HRP-H: the distance from horizontal reference plane to hyoidale point.
2. VRP-H: the distance from vertical reference plane to hyoidale point.
3. RGN-H (horizontal hyoid position): distance from retrognathion which is the most posterior point of the symphysis to hyoidale which is the most superior anterior point of the body of hyoid bone.

The following cephalometric measurement was used to assess head posture (figure 3):

4. SN-CVT angle: the angle formed by the intersection of SN line with CVT line (the line between the most inferoposterior point of the second cervical vertebra and that of the fourth cervical vertebra).

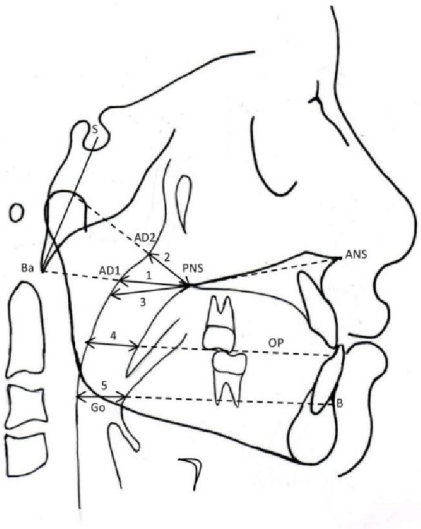

Figure (2): Cephalometric Measurements: Pharyngeal Airway Dimensions

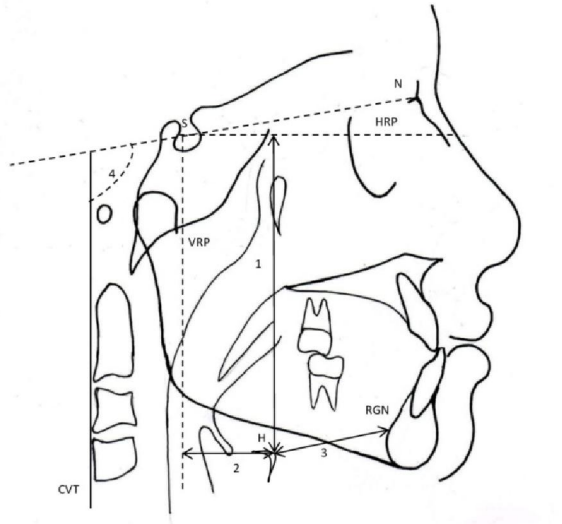

Figure (3): Cephalometirc Measurements: Hyoid Position and Head Posture

Statistical Analysis:

Statistical evaluation was performed using SPSS for Windows, version 17.0 (Chicago, USA). The effects of the facemask therapy on airway dimensions, head posture, and hyoid bone position were investigated by means of The differences between the parameters were analyzed using Paired T- test. The level of significance was established as $P < 0.05$.

Results:

The mean and standard deviation of each variable measured at the beginning (T1) and end (T2) of treatment and of the differences between them (T2 - T1) are shown in table 1. Comparisons results of the T2-T1 are also reported in table 1.

Skeletal Morphology:

Changes that occurred during RPE and facemask therapy showed significant changes in both maxillary and mandibular positions. The maxilla moved forward as revealed by the significant change in VRP-A ($P<0.05$), while the mandible demonstrated a clockwise rotation as shown by the significant increase in HRP-B variable ($P<0.05$).

Airway dimensions:

The nasopharyngeal airway measurement showed a significant increase in the dimension as revealed by PNS-AD1and PNS-AD2 variables changes by 2.8mm and 1.9mm respectively.

Regarding the oropharyngeal airway measurement, significant changes were shown in both superior and middle airway spaces ($P<0.05$), while no significant changes were noted in the inferior airway space.

Hyoid Position and Head Posture

Results have shown that there was no statistically significant change in hyoid position following facemask therapy.

Head posture was significantly changed as revealed by the significant decrease by 3.1° in SN-CVT angle ($P<0.05$).

4. Discussions

This study evaluated the effects of RPE and face mask therapy on skeletal morphology, pharyngeal airways, hyoid position, and head posture.

Changes in pretreatment and posttreatment were measured using lateral cephalometric radiographs. Measurements in airway space, hyoid position, and head posture using lateral cephalometric radiographs were known to be reproducible at the natural head position[10] and tend to vary depending on the head positon.[11] Therefore, the lateral cephalometric radiograph should be taken at the natural head position to ensure the exact evaluation of airway space components when using lateral cephalometric radiographs.

Several studies found that facemask therapy stimulated the forward displacement of the maxilla and reduced the forward displacement of the mandible by rotating it in a clockwise direction.[5-7]

The results of our study showed favorable skeletal maxillary and mandibular changes after facemask therapy, where the maxilla moved forward by 2.7 mm confirmed by the increase in VRP-A value, while the mandible demonstrated a significant clockwise rotation confirmed by the significant increase in the HRP-B value by 3.8 mm.

The treatment effects of RPE and facemask therapy on the airways increased the nasopharyngeal dimensions were PNS-AD1 value showed a significant increase by 2.8mm. On the other hand, oropharyngeal dimensions showed a significant increase at the upper and middle pharyngeal levels, while the lower level did not change significantly.

The findings for airway dimensions are consistent with previous results reported by Sayınsu et al[6] and Oktay and Ulukaya[7], who reported that maxillary protraction with or without rapid maxillary expansion induced statistically significant increments in the airway dimensions, and differ from those of Mucedero et al[12] and Baccetti et al[13], who demonstrated that no significant changes for the oropharyngeal and nasopharyngeal sagittal airway dimensions were induced by maxillary protraction.

Regarding hyoid position, there was no anteroposterior or vertical positional change which is in agreement with the results of Lee et al[14].

Evaluation of the head posture was carried out by using the SN-CVT angle which indicates the angle between the anterior cranial base plane and the connecting line between the top protruding point at the back of the second cervical vertebra and the lower protruding point at the back of the fourth cervical vertebra.

Our results showed a significant flexion of the head from pre- treatment to post treatment as revealed by the significant decrease of SN-CVT angle by 3.1°. The explanation of this change is that head extension is often seen in mouth breathers and could be an important physiologic compensation for nasal airway inadequacy; they tend to physiologically compensate by extending the head and breathe from the mouth. So once the airway dimensions were increased, these patients tend to tip their heads anteriorly.

Table (1): Comparisons of the T1 to T2 Changes (Paired T- test)

	T1		T2		T2-T1		*P-Value*
	Mean	SD	Mean	SD	Mean	SD	
Skeletal morphology							
HRP-A (mm)	62.8	9.7	60.3	8.5	-2.5	2.4	.475
HRP-B (mm)	90.1	6.8	93.9	6.6	3.8	4.1	.042*
VRP-A (mm)	67.8	5.4	70.5	5.3	2.7	3.7	.023*
VRP-B (mm)	71.1	10.5	69.3	10.7	-1.8	4.4	.263
Nasopharynx							
PNS-AD1 (mm)	21.9	3.3	24.7	2.7	2.8	1.6	.007**
PNS-AD2 (mm)	19.7	3.1	21.6	3.9	1.9	2.7	.043*
Oropharynx							
UPW (mm)	16.3	3.4	18.9	4.9	2.6	3.4	.012*
MPW (mm)	10.1	2.6	11.6	2.9	1.5	1.9	.026*
PAS (mm)	11.5	2.1	11.8	2.5	0.3	1.4	.705
Hyoid position							
HRP-H (mm)	101.1	5.9	103.4	6.1	2.3	6.4	.342
VRP-H (mm)	25.7	10.3	25.3	10.4	-0.4	6.7	.422
RGN-H (mm)	34.4	6.5	33.7	7.9	-0.7	7.1	.485
Head posture							
SN-CVT (°)	95.3	6.1	92.2	7.6	-3.1	3.7	.037*

Conclusion:

The findings of this study show that RPE and Facemask therapy produced significant improvement of the nasopharyngeal and oropharyngeal airway dimensions, which was associated with flexion of the head and no significant change in hyoid position.

Corresponding Author:
Dr. Amjad Al Taki, DDS, PhD
Associate Professor, Private Practice
P. O. Box 10462 Dubai, UAE
E-mail: al_taki@hotmail.com

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