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Original Article

Evaluation of the Effects of Orthopedic Treatment on the Dentofacial Structure and Upper Airway of Subjects with Skeletal Class III Malocclusion

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Main Points

- In Class 3 anomalies with maxillary retrusion, ensuring early sagittal development of the maxilla has very positive effects on the upper airway.
- In skeletal treatments, airway evaluation before and after treatment, based on records obtained from the patient, is a crucial aspect that should not be ignored.
- Although there are many methods for airway measurement, it is important to choose a non-invasive and reliable method.

ABSTRACT

Objective: The present study aimed to evaluate the effect of rapid maxillary expansion (RME) and face mask treatment on the upper airway in patients with maxillary retrusion in two dimensions using digital cephalograms and volumetric evaluation using acoustic rhinometric measurements.

Methods: A total of 22 individuals with a concave profile and skeletal and dental Class III malocclusion during growth and development with a mean age of 9.9±1.38 years were included in the study. A bonded RME appliance and a petit face mask were adapted for the patients. Before treatment (T0) and after maxillary protraction (T1), lateral cephalometric films and acoustic rhinometric recordings were obtained. The dependent sample t-test was used for statistical evaluation.

Results: Cephalometric analysis revealed forward movement of the maxilla and backward downward rotation of the mandible. A significant increase was observed in the nasopharyngeal and oropharyngeal regions of the upper airway. Three-dimensional evaluation of the upper airway by acoustic rhinometry revealed only an increase in the volumes of the left nasal cavity after decongestant administration. A statistically significant increase in acoustic rhinometric measurements in nasal valves. When the correlation of the cephalometric findings of the nasopharyngeal region with the acoustic rhinometry findings was examined, no statistically significant relationship was found.

Conclusion: As a result of this study, we observed an increase in the cephalometric measurements of the nasopharyngeal and oropharyngeal areas. A significant increase was observed in the minimal cross-sectional area measured by acoustic rhinometry.

Keywords: Class III malocclusion, face mask, rapid maxillary expansion, upper airways

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INTRODUCTION

Skeletal Class III malocclusions are among the most difficult irregularities to correct in orthodontic treatment. These cases often present with skeletal features such as maxillary retrusion, mandibular protrusion, or a combination of both conditions.[1] When deciding on the treatment of Class III malocclusion, several factors, including age and various skeletal and dental characteristics, should be considered. Treatment options for patients with completed growth potential are limited to fixed orthodontic mechanics and camouflage,[2] or orthognathic surgery.[3] In the treatment of growing patients, orthopedic forces can effectively address skeletal problems through the use of functional appliances or extraoral appliances.[4-6] In order to stimulate the maxilla in the sagittal direction during growth and development, a face mask[4] can be used in patients with skeletal Class III malocclusion with mild or moderate maxillary retrusion.

In cases where there is maxillary retrusion in Class III patients, when orthopedic forces are applied to the maxilla with rapid maxillary expansion (RME) during the prepubertal and pubertal period, cellular activation in the sutures between the maxilla and the skull is increased, bone apposition is stimulated, and thus the growth of the relevant bones can be modified.[7-9] RME brings about significant changes in the craniofacial structures, such as increased intermolar width and nasal cavity volume, decreased nasal airway resistance, and increased nasal respiration.[10,11] It has been reported in the literature that the incidence of airway obstruction is increased especially in skeletal Class III individuals characterized by maxillary retrusion.[12] Nasal obstruction in children is believed to have a negative impact on orofacial development. Studies have pointed out that long face syndrome, maxillary stenosis, high palate, various anterior teeth, and lip structure disorders are encountered with nasal obstruction.[10,11,13] It has been suggested that the early development of the maxilla in the sagittal direction with face mask treatment positively affects the upper airway.[14]

Many different methods, such as lateral cephalometry,[15] computed tomography (CT),[16] magnetic resonance imaging (MRI),[17] and acoustic rhinometry (AR)[18] are used for the evaluation of the upper airway. The method should ideally be inexpensive and non-invasive, providing high-resolution information about the anatomy of the upper airways and surrounding soft tissues.

AR is an efficient, painless, non-invasive, and reliable method that can be performed easily and requires minimal patient cooperation. AR provides valuable information about the minimal cross-sectional area (MCA) and volume of the nasal cavity by using reflected sound waves. The size of the reflections may reflect changes in airway size, and the return time may provide the distance between the changes.[10,18]

The purpose of our prospective study was to evaluate the effect of RPE face mask treatment on the upper airways volumetrically using AR measurements. In addition, the changes caused by the RPE protocol in the MCAs of the nose, which is the narrowest part of the nose, were examined. In this study, the null hypothesis was that there would be no change in the volumetric measurements made with AR in the upper airways of patients who were wearing face masks.

METHODS

This prospective study included 22 patients with a concave profile and skeletal and dental Class III malocclusion who were referred to the Hacettepe University Faculty of Dentistry, Department of Orthodontics for treatment. All subjects (11 female and 11 male) were in the period of pubertal growth spurt, and their mean chronological age was 9.9±1.38 years at the beginning of the treatment. Developmental stages of the subjects were determined using hand-wrist radiographs.

The inclusion criteria for the patients were as follows; (1) patients with no systemic disease and congenital anomalies in the craniofacial region, (2) patients with an edge-to-edge relationship between incisors and who had not previously received orthodontic treatment, (3) patients with a concave profile during growth and development, (4) patients who had a skeletal and dental Class III relationship due to maxillary retrusion or mild mandibular protrusion with maxillary retrusion, (5) patients with negative overjet, mild narrow maxilla, or crossbite in the maxillary posterior region, and (6) no pathology found in the otolaryngology examination.

The ethics committee report dated 18.05.2010 (registration number: LUT 10/25 and decision number: LUT 10/25-7) was received by the Scientific Research Commission of Hacettepe University. A child information form and informed consent from parents were obtained from all patients.

Before starting treatment (T0) and after the completion of maxillary protraction (T1), the following records were obtained from the patients; intraoral and extraoral photographs, lateral cephalometric radiographs, hand-wrist radiographs, conventional maxillary occlusal radiographs, and acoustic rhinometric measurements.

Lateral cephalometric radiographs were obtained using a digital cephalometric X-ray device (Soredex, PO Box 148, 04301 Tuusula, Finland) under standard conditions with the teeth occlusion and the lips closed without tension. Patients were asked to look into the mirror of their own eyes after tilting their head up and down with decreasing amplitude until they felt relaxed. Acoustic rhinometric measurements were performed using an Ecco Vision AR device (Ecco Vision, Hood Instruments, Pembroke, MA) at Hacettepe University Faculty of Medicine, Department of Otorhinolaryngology.

A bonded RME appliance with a Hyrax screw (Dentsplay, GAC International, Bohemia, NY, USA) was used for the maxillary plaster models prepared in the laboratory (Figure 1). In order to facilitate the protrusion of the maxilla by creating mobilization in the circummaxillary sutures, the modified Alt- RAMEC protocol was applied with the RME appliance.[19] The patients were asked to turn the appliance screw one-quarter turn a day for the first week. After completing the opening process for 2 weeks, the screw was closed by turning it one -quarter turn per day for 2 weeks. Occlusal film was taken from the patients to assess any separation in the maxillary median suture at the end of the first week following the opening of the screw. This protocol was repeated by opening the appliance screw in the same way for 2 weeks and closing it for 2 weeks. Thus, a total of 8 weeks were required to open and close the RME appliance screw every 2 weeks. In patients with a narrow maxilla, the protocol was terminated by opening the screw.

A bonded RME appliance and a Petit-type face mask (Dentsplay, GAC International, Bohemia, NY, USA) were adapted for the patients. A 200-g force per side was applied on the maxilla via 3/16-inch 4-oz elastics from the hooks placed distal to the canines (Dentsplay, GAC International, Bohemia, NY, USA). Two weeks later, the force was increased to 400 g per side.

After maxillary protrusion was achieved, post-treatment records (T1) were obtained, and orthodontic treatment was continued by following the dentition. The mean time between the T0 (beginning of treatment) and T1 (post-maxillary protraction) periods was 8.9±0.85 months.

Hard and soft tissue measurements and upper airway measurements were made by the same investigator (H.K.) on the lateral cephalometric radiographs obtained at T0 and T1. The planes and measured distances used for changes in the upper airway, as well as measurements to assess dentofacial changes, are shown in Figure 2.

Acoustic rhinometric measurements were performed at Hacettepe University Faculty of Medicine, Department of Otorhinolaryngology, by the same researcher (T.S.) using the EccoVision AR device. AR measurements were performed in a quiet room away from environmental influences. The patient was seated on a chair to support his/her head, and breathing exercises were performed before the measurement. At the same time, the wave tube of the AR device was calibrated before each measurement. During the measurements, the patients were asked to breathe deeply and hold their breath. After AR measurements were made at the right and left nasal cavity entrances, a nasal spray containing oxymetazoline

Figure 1. Occlusal and frontal intraoral views of the Bonded RME appliances

RME, rapid maxillary expansion

(Oksinazal Spray, Eczacıbaşı İlaç Pazarlama, Turkey) that eliminated mucosal edema was administered as 2 puffs in both nostrils of the patients. After waiting for 15 min, the measurements were performed once more. The same procedures were repeated after the completion of maxillary protrusion.

In the acoustic sinogram, the "y" axis shows the cross-sectional area (cm^2), while the "x" axis shows the distance from the nostril. The area under this section is the volume (cm^3). The horizontal segment before the 0th point on the acoustic sinogram represents the nasal adapter. The MCA values in the acoustic sinogram and the volumes of the sections 10-30 mm, 30-60 mm, and 65-85 mm from the nasal cavity entrance were calculated (Figure 3). These regions were selected because they represent three clinically important and functionally relevant areas: the volume of the segment located from 10 to 30 mm from the nostril corresponding to the nasal valve region, the volume of the segment located between 30 and 60 mm from the nostril corresponding to the turbinate region, and the volume of the segment located between 65 and 85 mm from the nostril corresponding to the nasopharyngeal region.

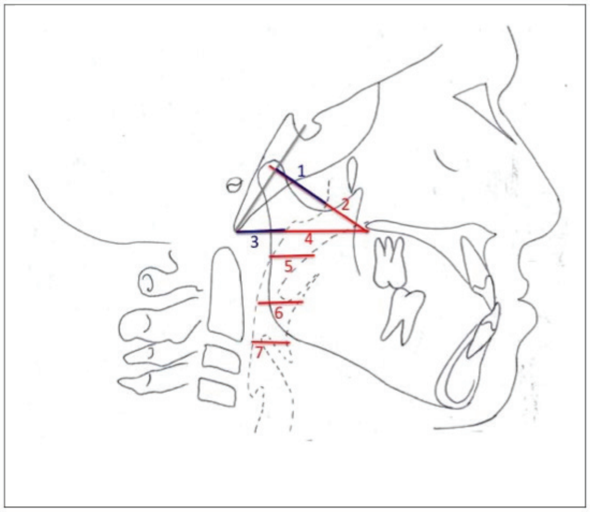

Figure 2. Planes used in airway evaluation in lateral cephalometric film analysis

1. AD2-H (upper adenoid thickness), 2. PNS-AD2 (upper airway distance), 3. AD1-BA (lower adenoid thickness), 4. PNS-AD1 (lower airway thickness), 5. SPS (superior pharyngeal space): anteroposterior width of the pharynx measured between the posterior pharyngeal wall and the dorsum of the soft palate on a line parallel to the Frankfort horizontal (FH) plane that runs through the middle of a line from PNS to pogonion (P), 6. MPS (middle pharyngeal space): anteroposterior width of the pharynx measured between the posterior pharyngeal wall and the dorsum of the tongue on a line parallel to the FH plane that runs through P, 7. IPS (inferior pharyngeal space): anteroposterior width of the pharynx measured between the posterior pharyngeal wall and the dorsum of the tongue on a line parallel to the FH plane that runs through C2

AD1, the point where posterior nasal spine (PNS) - basion (Ba) line intersects the posterior pharyngeal wall; AD2, the point where a line perpendicular to sella (S) - Ba plane passing through PNS intersects the posterior pharyngeal wall; H, the point where a line perpendicular to sella (S) - Ba plane passing through PNS

Statistical Analysis

To evaluate the changes from the beginning of the treatment to post-maxillary protraction, the data compliance with the assumption of normal distribution was tested using the Shapiro-Wilks goodness-of-fit test. The dependent samples t-test was used because the values showed a normal distribution. Mean, standard deviation, minimum, and maximum values are presented as descriptive statistics. For $p<0.05$, the results were considered statistically significant. Pearson's correlation coefficient was used to assess the correlation between cephalometric airway and AR volume assessments. Pearson's correlation test was also used to assess the correlation between the area and volume values of the narrowest regions of the nose in AR.

RESULTS

Significant changes were observed in all measurements of the maxilla according to the treatment protocol ($p<0.05$). A statistically significant increase of 3.14° in the SNA angle and 2.25° in the maxillary depth angle was observed ($p<0.05$). There was a statistically significant increase of 2.72 mm in A-Nperp ($p<0.05$). The convexity of the patients significantly increased, with an average of 0.3 mm ($p<0.05$) (Table 1).

Except for facial depth and the Pog-NB distance, all measurements of the mandible were statistically significant ($p<0.05$). A statistically significant decrease of 1.27° in the mean SNB angle was observed ($p<0.05$). At the end of treatment, a statistically significant increase of 2.89 mm in corpus length and 0.9 mm in SE distance was observed ($p<0.05$) (Table 1).

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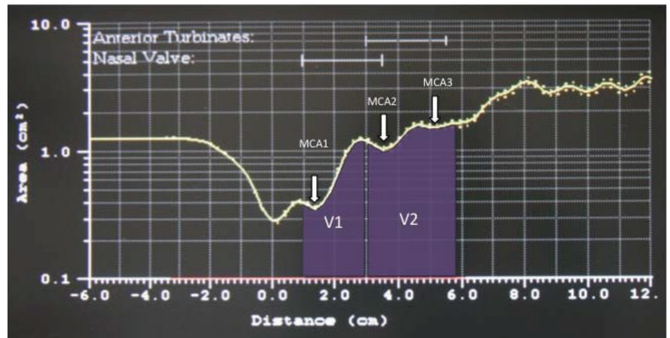

Figure 3. Acoustic rhinogram. The "y" axis shows the cross-sectional area (cm^2). The "x" axis shows the distance from the nostril. The area under this cross-section gives the volume (cm^3). The horizontal segment before the 0 point in the acoustic rhinogram represents the nasal adapter. The MCA values in the acoustic sinogram and the volumes of the sections 10-30 mm (V1), 30-60 mm (V2) from the nasal cavity entrance were calculated

MCA, minimal cross-sectional area

Table 1. Descriptive statistics and p-values for maxillary and mandibular measurements at the start of treatment (TO) and after maxillary protraction (T1)

Parameter		Average	Standard deviation	Distribution	Range	p-value
				Minimum	Maximum	
SNA (^{0})	T0	77.77	2.86	72	83	0.000*
	T1	80.91	2.70	75	85	
Maxillary depth (^{0})	T0	87.16	2.76	82	93	0.002*
	T1	89.41	2.90	83	96	
A-Nperp (mm)	T0	-3.02	2.78	-8	2	0.000*
	T1	-0.3	2.70	-6	6	
Convexity (mm)	T0	-1.86	1.92	-6	1	0.000*
	T1	-1.59	1.50	-1.5	4	
SNB (^{0})	T0	79.43	2.90	74	84	0.000*
	T1	78.16	2.88	73	83	
Facial depth (^{0})	T0	88.82	2.63	83	95	0.057
	T1	87.50	2.63	83	93	
Corpus length (mm)	T0	71.59	4.35	65	82	0.002*
	T1	74.48	4.68	64	85	0.171
Pog-NB distance (mm)	T0	0.68	1.07	-5	4	
	T1	0.90	1.25	-1.5	4.5	0.012*
SE distance (mm)	T0	17.30	2.28	13	22	
	T1	18.20	2.54	13	23	
*p<0.05						

Regarding the cephalometric values of the upper airway, all measurements except the AD1-Ba (lower adenoid thickness) and AD2-H (upper adenoid thickness) distances showed statistically significant increases (p<0.05). The PNS-AD1 (lower airway thickness) distance showed a statistically significant increase with an average of 3.75 mm (p<0.05). A statistically significant increase of 2.59 mm was also observed in the PNS-AD2 (upper airway thickness) distance (p<0.05). The superior pharyngeal space SPS), middle pharyngeal space (MPS), and nferior pharyngeal space (IPS) distances, showing the pharyngeal airway dimensions, also showed statistically significant increases. SPS increased by an average of 2.55 mm, MPS by an average of 2.32 mm and IPS by an average of 1.68 mm (p<0.05) (Table 2).

When the volume values of the upper airwat measured using AR were examined, statistically significant changes were observed only in the volume values of the left nasal cavity after decongestant administration. The post-decongestant volumes of 10-30 mm sections of the left nasal cavity showed a statistically significant increase of 0.9 mm^3 on average (p<0.05). A statistically significant increase of 1.33 mm^3 was observed in the section volumes of 30-60 mm of the left nasal cavity after decongestant administration (p<0.05) (Table 3). No correlation was found between the volume values measured by AR in the nasopharynx (65-85 mm part of the upper airway) and the cephalometric measurements (p<0.01, p<0.05) (Table 4).

In acoustic rhinometric measurements, the MCAs in the narrowest part of the nasal cavity (nasal valve) showed a statistically significant increase, except for pre-decongestant measurements of the right side of the nasal cavity. A significant increase of 0.16 cm^2 was observed in the narrowest MCA on the right side of the nasal cavity after decongestant administration (p<0.05). The MCA of the nasal valve region on the left side of the nasal cavity increased significantly by 0.21 cm^2 before and 0.25 cm^2 after decongestant administration (p<0.05) (Table 5).

Table 2. Descriptive statistics and p-values of upper airway cephalometric measurements (mm) at the start of treatment (T0) and after maxillary protraction (T1)

Parameter		Average	Standard deviation	Distrubution	Range	p-value
				Minimum	Maximum	
PNS-AD1	T0	16.82	6.68	2	27	0.000*
	T1	20.57	5.70	4	28	
PNS-AD2	T0	13.64	4.26	7	23	0.000*
	T1	16.32	3.87	9	24	
AD1-Ba	T0	21.20	4.16	14	32	0.833
	T1	21.32	4.13	15	35	
AD2-H	T0	21.68	3.25	15	28	0.880
	T1	21.59	3.29	14	30	
SPS	T0	9.70	2.33	4	13	0.000*
	T1	12.25	2.40	5	17	
MPS	T0	13.77	3.11	10	20	0.045*
	T1	16.09	4.85	8	26	
IPS	T0	9.59	2.99	5	17	0.046*
	T1	11.27	4.08	6	20	

*p<0.05
SPS, superior pharyngeal space; MPS, middle pharyngeal space; IPS, inferior pharyngeal space; PNS-AD1, lower airway thickness; PNS-AD2, upper airway distance; AD1-BA, lower adenoid thickness; AD2-H, upper adenoid thickness

Table 3. Descriptive statistics and p-values of pre-decongestant (DE) and post-decongestant (DS) volume values (mm^3) for the right and left nasal cavity at the start of treatment (T0) and after maxillary protraction (T1)

Parameter			Average	Standard deviation	Distrubution	Range	p-value
					Minimum	Maximum	
	10-30 mm DE	T0	3.49	0.87	1.6	5	0.109
		T1	3.13	0.75	1.6	4.7	
Right	10-30 mm DS	T0	3.57	1.01	0.4	4.9	0.185
		T1	3.93	0.77	2	5	
Nasal	30-60 mm DE	T0	6.75	1.36	3.9	9.4	0.156
		T1	6.12	1.51	2.5	8.2	
Cavity	30-60 mm DS	T0	6.73	1.72	1.9	9.3	0.426
		T1	7.17	1.78	2.8	9.4	

Table 3. Continued

Parameter			Average	Standard deviation	Distrubution	Range	p-value
					Minimum	Maximum	
	65-85 mm DE	T0	5.75	1.05	3	8	0.197
		T1	5.2	1.50	2.6	7.9	
	65-85 mm DS	T0	5.48	1.41	2.6	7.8	0.570
		T1	5.78	1.97	2.3	8.4	
	10-30 mm DE	T0	3.05	1.05	1.1	4.8	0.111
		T1	3.48	0.62	2.6	4.8	
Left	10-30 mm DS	T0	3.1	0.63	1.8	4.4	0.000*
		T1	4	0.71	2.7	5.5	
Nasal	30-60 mm DE	T0	5.9	1.95	1.9	8.3	
		T1	6.6	1.15	4.4	8.2	0.203
Cavity	30-60 mm DS	T0	6.4	1.39	3.4	8.5	0.024*
		T1	7.73	2.04	3	12.3	
	65-85 mm DE	T0	4.8	1.5	2	7	0.169
		T1	5.39	1.18	3.4	7.8	
	65-85 mm DS	T0	4.8	0.99	3.2	7.1	0.077
		T1	5.63	1.66	2	8.4	

*p<0.05

Table 4. Correlation coefficients and p-values of the correlation of nasopharynx pre-decongestant (DE) and post-decongestant (DS) acoustic rhinometric volume values (65-85 mm) and cephalometric values (PNS-AD1, PNS-AD2)

		65-85 mm DE right T1	65-85 mm DE left T1	65-85 mm DS right T1	65-85 mm DS left T1
PNS-AD1 T1	r	0.312	0.227	0.345	0.053
	p	0.158	0.310	0.115	0.813
PNS-AD2 T1	r	0.372	0.206	0.028	-0.197
	p	0.088	0.357	0.902	0.380

Table 5. Descriptive statistics and p values of pre-decongestant (DE) and post-decongestant (DS) minimal cross-sectional area (MCA) (cm) values for the right and left nasal cavity at the start of treatment (T0) and after protraction (T1)

Parameter			Average	Standard deviation	Distribution	Range	p-value
					Minimum	Maximum	
	DE	T0	0.66	0.18	0.3	1	0.401
Right MCA		T1	0.7	0.18	0.3	1	
	DS	T0	0.68	0.19	0.2	1	0.012*
		T1	0.84	0.26	0.1	1.2	
		T0	0.59	0.21	0.2	0.9	0.001*
Left MCA	DE	T1	0.8	0.15	0.5	1.2	
	DS	T0	0.67	0.16	0.3	1	0.000*
		T1	0.92	0.18	0.5	1.2	

*p<0.05
MCA, minimal cross-sectional area

When the correlation between the MCAs and volumetric sections (10-30 mm) of the nasal valve region pre-decongestant (DE) and post-decongestant (DS) values was examined, there was a correlation between the right and left volumes and MCAs before decongestant (p<0.01, p<0.05). Likewise, a correlation was found between the volume and area values in the left part of the nasal cavity after decongestant administration (p<0.01, p<0.05) (Table 6).

Table 6. Correlation coefficients and p-values of the correlation of minimal cross-sectional areas (MCA) and volumetric sections (10-30 mm), pre-decongestant (DE) and post-decongestant (DS) values of the nasal valve region

		10-30 mm DE Right T1	10-30 mm DE Left T1	10-30 mm DS Right T1	10-30 mm DS Left T1
Right MCA DE T1	r	0.820**	0.034	0.339	-0.073
	p	0.000	0.882	0.123	0.747
Right MCA DS T1	r	0.523	-0.045	0.328	-0.009
	p	0.012	0.841	0.136	0.969
Left MCA DE T1	r	0.458*	0.472*	0.062	0.042
	p	0.032	0.027	0.783	0.851
Left MCA DS T1	r	0.408	0.248	0.250	0.601**
	p	0.059	0.265	0.261	0.003

*p<0.05, **p<0.01
MCA, minimal cross-sectional area

DISCUSSION

Skeletal Class III malocclusions result from maxillary retrusion in 65-67% of cases.[3] In this study, sagittal forward movement of the maxilla was achieved, in line with other face mask studies in the literature.[20,21] This significant forward movement in the maxilla can be attributed to the fact that the patients were in their growth and development period, as well as to the separation of the sutures made by the adjacent bones of the maxilla using the AltRAMEC protocol.

It has been reported that the mandible is displaced downward and backward as a result of the force passing under the condylar region in face mask applications that receive support from the chin tip and forehead.[22] Angular and dimensional measurements of the mandible used in the present study showed that the mandible rotated downward and backward in accordance with the literature.[21,22] The rotation observed in the mandible also contributed to Class III correction.

When the effects of the present treatment protocol on the upper airway were evaluated cephalometrically, significant increases were determined in the nasopharyngeal and oropharyngeal airway dimensions, in line with the literature.[23,24] It is thought that the increase detected cephalometrically in the upper airway was due to the increase in the distance between the posterior part of the maxilla and the posterior pharyngeal wall during the anterior movement of the maxilla. Even though the cephalometric films used in the present study to determine the changes in the airway provide information in two dimensions, this method, which is used in many studies, is advantageous due to its ease of application and low cost.[14,25] In addition, it has been stated that there is a significant relationship between cephalometric films and CT imaging techniques.[26]

Studies in the literature have evaluated nasal volumes in adults[27] and nasopharyngeal geometry after adenoidectomy and tonsillectomy[28] using AR. However, no study has evaluated the changes in the upper airway as a result of applying a face mask with a bonded RME appliance volumetrically using AR. In the present study, statistically significant increases were observed in the volumes of the 10-30 mm (nasal valve) and 30-60 mm sections of the left nasal cavity after decongestant administration. Nasal decongestants are recommended for precise measurement of nasal resistance. These medications work by constricting blood vessels in the nasal passages, thereby reducing swelling and congestion. The temporary opening of the nasal airway allows for more accurate measurements of nasal resistance.[29] It is thought that this increase in nasal volume may have been obtained by applying RME in parallel with other studies in the literature.[14,15]

When we examined the relationship between the results of increased nasopharynx size in the cephalometric measurements and the volume findings in AR, no correlation was found. The lack of correlation between the increase detected cephalometrically and AR may be due to disturbances during the measurement of the nasopharynx volume caused by the movement of the soft palate. It is also stated that the MCAs of the nose and nasal passage are the two most important factors affecting the accuracy of AR measurements and that AR cannot provide reliable information for evaluating the posterior parts of the nasal cavity.[30,31]

The MCA, often called the "nasal valve", is an important formation located between the nasal cartilage and aperture pyriformis and is the narrowest point of the nasal cavity. This area has a significant effect on nasal breathing because of its narrowed structure.[31,32] In the study of Cakmak et al.,[32] it was determined that there was a significant correlation between CT and AR measurements performed to evaluate nasal valve areas. It has also been reported that AR can be a valid method for evaluating the nasal valve area. Approximately 50% of the anatomical structure of the nasal cavity is formed by the maxillary bones. Therefore, treatment options that cause changes in the morphological structure of the maxillary dental arch, such as RME, may affect the geometry and function of the nasal cavity. The RME procedure provides triangular separation of the maxillary bones at the level of the incisors, which coincides with the lower part of the nasal valve area. With this separation in the midpalatal suture, displacement also occurs in the lateral walls, leading to an increase in nasal cavity volume. In the present study, a statistically significant increase was observed in some nasal valve areas.

When we looked at the correlation between the area and volume values of the nasal valve section, which is the narrowest part of the nasal cavity, it was expected that the statistically significant volumetric and area (MCA) increases observed in the nasal valve region of the left nasal cavity (10-30 mm) would correlate with each other. Since no significant increase in volume was detected in the nasal valve area of the right nasal cavity, it can be considered that there was no correlation with the MCA after decongestant.

The airflow through the nasal passages is commonly found to be asymmetric in normal individuals. This phenomenon, known as the nasal cycle, is considered a physiological phenomenon. However, most subjects were completely unaware of any changes in nasal airflow because the total resistance to airflow remained relatively constant owing to a reciprocal relationship between the nasal passages. It has been noted that the nasal cycle may not always be detectable or may not always be reciprocal at all between the two sides of the nose.[33]

Study Limitations

Since the short-term results of maxillary expansion and protraction were examined in our study, the fact that long-term treatment results were not known and that tomographic evaluation could not be performed at the same time could be considered limitations of our study. Additionally, repeating the AR measurements after RPE application could have helped improve the evaluation of the results.

CONCLUSION

In the present study, the following results were obtained:

• While forward movement of the maxilla was evident, downward and backward movements were observed in the mandible. The soft tissue relationship showed positive development in parallel with the skeletal and dentoalveolar changes.

• In cephalometric findings of the upper airway, a significant increase in two dimensions was observed in the nasopharyngeal and oropharyngeal regions.

• In the AR evaluation of the upper airway, an increase was observed only in the post-decongestant volumes of the left nasal cavity. No statistically significant relationship was found between the cephalometric and AR findings of the nasopharyngeal region. A significant increase was observed in the MCA measured by AR.

• When we examined the correlation of the area and volumes values of the nasal valve section, which is the narrowest part of the nasal cavity, it was determined that there was a correlation between the measurements of the right and left sides before decongestant.

Ethics

Ethics Committee Approval: The ethics committee report dated 18.05.2010 (registration number LUT 10/25 and decision number LUT 10/25-7) was received by the Scientific Research Commission of Hacettepe University.

Informed Consent: A child information form and informed consent from parents were obtained from all patients.

Author Contributions: Concept - S.C., O.Ö.; Design - S.C., O.Ö.; Data Collection - H.K., Analysis - H.K., T.S. - Writing - H.K.

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