Original Article

Comparison of the effects of RME and fan-type RME on nasal airway by using acoustic rhinometry

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ABSTRACT

Objective: To evaluate and compare the nasal airway changes following rapid maxillary expansion (RME) and fan-type RME using acoustic rhinometry (AR).

Materials and Methods: The study sample consisted of three groups. The RME group comprised 15 subjects with maxillary transverse discrepancies and posterior crossbites. The fan-type RME group comprised 15 subjects, who had an anteriorly constricted maxilla with a normal intermolar width. The third group included 15 patients who had an ideal occlusion and received no orthodontic treatment and served as the control group. AR was used to measure nasal volume and the minimal cross-sectional area (MCA) before expansion (T1), after expansion (T2), and 6 months after expansion (T3). Each AR recording was performed with and without the use of a decongestant. Two-way analysis of variance was used to determine differences among the groups and three-way analysis of variance was used for the differences between groups. If evidence of statistically significant differences was found, a Bonferroni test was used.

Results: The results showed that nasal volume and MCA were significantly increased with RME and fan-type RME immediately after expansion (P < .05). At the end of retention, nasal volume and MCA values of RME showed significant differences with both expansion fan-type RME and control groups (P < .05).

Conclusions: RME and fan-type RME had similar effects on the nasal airway immediately after expansion. The increase in nasal volume and MCA was more stable in the RME group than in the fan-type RME group at the end of the retention period. (*Angle Orthod.* 2010;80:870–875.)

KEY WORDS: RME; Fan-type RME; Acoustic rhinometry; Nasal airway

INTRODUCTION

Rapid maxillary expansion (RME) has become an accepted procedure for the treatment of maxillary arch constriction or maxillary width deficiency.¹ Although the main object of RME is to correct a narrow maxillary arch, its effects are not limited to the upper jaw. The maxilla is associated with 10 bones in the face and head, so the RME may affect structures directly or indirectly related to many other bones.² It has been shown that an RME separates the external walls of the

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nasal cavity laterally and causes lowering of the palatal vault and straightening of the nasal septum. This remodeling decreases nasal resistance, increases internasal capacity, and improves breathing.³

In orthodontics, some patients require only expansion of the maxillary anterior region. In treatment of these patients with conventional RME appliances, the orthodontist is forced to accept an undesired expansion of the posterior region of the maxilla. In 1996, Schellino et al.⁴ designed a spider screw, which they named "Ragno." This device worked asymmetrically and allowed a "fan opening." The development of this expansion screw, which mainly affected the anterior region of the maxilla, represented a significant improvement over conventional RME screws. Doruk et al.5 evaluated the effects of this fan-type RME and noted significantly greater expansion in intercanine width than in intermolar width. However, the effect of the fan-type RME on the nasal airway remains unclear because previous studies focused on its effects on other dentofacial structures.5,6

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Methods used to evaluate the nasal airway began with lateral cephalometric radiographs.7 However, a two-dimensional cephalometric radiograph is not able to show the connection between the oropharyngeal and hypopharyngeal areas. In the past decade, computerized tomography (CT) has become very popular in the diagnosis of deformities and structures of the body, but the disadvantages of CT include exposure to radiation and high costs.8 Acoustic rhinometry (AR) was introduced by Hilberg et al.⁹ in 1989 as a simple, noninvasive, and objective method for measuring the dimensions of the nasal cavity and nasal airway resistance. The principle of AR is based on the reflection of sound waves within the nasal cavity. Acoustic pulses, which are generated by a spark, pass through the wave tube and enter the nasal passage to the nosepiece of the AR device. The sound is reflected as the waves impact structures in the passage. The reflected waves are detected by a microphone and are then amplified, low-pass filtered, and digitized. Finally, the processed data are converted into an area-distance plot with the use of a computer. These data allow the computer to provide two parameters: nasal volume and minimal crosssectional area (MCA). The MCA distance is matched to the nasal valve area of patients that is the narrowest segment of the nasal airway. The nasal valve lies obliquely in the sagittal plane and in the region between the caudal end of the upper lateral cartilage, the septum, and the inferior rim of the piriform aperture, just beyond the anterior ends of the inferior turbinates. Nasal airway resistance is affected mostly by the anterior segment of the nasal cavity, where the narrowest segment MCA is located.¹⁰ A review of the literature reveals that AR methods are reliable and can be successfully applied in orthodontics.^{11,12}

The aim of this study was to evaluate nasal volume and MCA using AR in RME and fan-type RME groups before, during, and 6 months after expansion.

MATERIALS AND METHODS

The study sample was divided into three groups. The first group (RME group) included 15 subjects (eight girls and seven boys) whose mean age was 12.41 \pm 0.98 years. All patients in this group had bilateral posterior crossbites. The second group (fantype RME group) included 15 subjects (eight girls and seven boys) whose mean age was 12.26 \pm 1.03 years. All patients had an anteriorly constricted maxillary arch (V shaped), normal intermolar width, and no crossbite in the posterior region. The third group (control group) included 15 patients (eight boys and seven girls) whose mean age was 12.46 \pm 0.56 years. These patients had an ideal occlusion, received no orthodon-

tic treatment, and served as the control group. Before the study was begun, all subjects gave their informed consent after receiving a full explanation of the aim and design of this study. The study protocol was approved by the local ethics committee.

An acrylic-bonded full tooth and a tissue-borne RME appliance containing a Hyrax screw (Dentaurum, Pforzheim, Germany) were positioned parallel to the second premolars and were used to correct the posterior crossbite.

A fan-type acrylic-bonded full tooth and a tissueborne RME appliance⁴ were used to correct the anterior narrowness. The Ragno screw (Leone, Florence, Italy) was placed in the acrylic plate parallel to the occlusal plane of the upper teeth. The hinge point of the screw was positioned tangent to the distal surfaces of the permanent upper first molars. The anterior arms of the screw were bent mesially, and the posterior arms were bent perpendicular to the screw body to standardize the position of the jackscrew. All expansion appliances were cemented with glass ionomer cement (Ketac-Cem, Espe Dental AG, Seefeld, Germany) and were activated one-fourth turn twice per day.

In the RME group, the expansion was completed when the occlusal aspect of the maxillary lingual cusp of the upper first molars contacted the occlusal aspect of the facial cusp of the mandibular first molars. In the fan-type group, the expansion was completed when a premolar cusp of overcorrection at the first premolar area was achieved.

Following the expansion, in both groups the screw was fixed with 0.014-inch ligature wire and the appliance was left for 1 week to minimize discomfort during removal. After removal, the appliance used in active treatment was cleaned and reused as a removable retention appliance. The distribution, mean age, average expansion period, and average retention period of the subjects are shown in Table 1.

Acoustic Rhinometry Measurement

The personal computer–based Eccovision (Model AR-1003) from E Benson Hood Laboratories Inc (Pembroke, Mass) was used in this study. Measurements were taken before treatment (T1), immediately after successful expansion with the appliance (T2), and approximately 6 months after the expansion period (T3). All AR measurements were taken by the same otolaryngologist. AR measurements were taken at the same room temperature (20°C). Subjects were allowed to rest for 30 minutes before recordings commenced, and the device was calibrated during this period according to the manufacturer's instructions. After calibration, the nosepiece was placed at

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		Age	Expansion Time	Retention Time
	n	Mean \pm SD, y	Mean \pm SD, d	Mean \pm SD, mo
Group I, RME	15	12.41 ± 0.98	22.40 ± 4.01	6.20 ± 0.16
Group II, Fan-type RME	15	12.26 ± 1.03	24.26 ± 4.33	6.28 ± 0.28
Group III, Control	15	12.46 ± 0.56	28.06 ± 1.75	6.13 ± 0.08

^a RME indicates rapid maxillary expansion; SD, standard deviation; y, year; d, day; m, month and n, number.

the nostril, and nasal volume and MCA were measured four times for each nostril. Following these measurements, a decongestant nasal spray (Iliadin, Santa Farma, Istanbul, Turkey) was applied to the nostrils, and, after a delay of 10 minutes for the decongestant to take effect, the measurement process was repeated. This was done to eliminate mucosal variations attributable to the nasal cycle.¹³

Mean values of all measurements were used in this study. Nasal volume and MCA were calculated by adding the values obtained for the left and right nasal nostrils, respectively. The values achieved with decongestant and without decongestant were averaged to obtain the mean nasal volume for each subject.

Statistical Analysis

Results were calculated using the Statistical Package for the Social Sciences (SPSS) software for Windows (version 10.0; SPSS Inc, Chicago, III).

Table 2. Nasal Volume in Nondecongestant Groups, cca

Differences among groups (decongestant and nondecongestant) were determined with two-way analysis of variance. Differences between groups were evaluated using three-way analysis of variance. If evidence of statistically significant differences among or between groups was found, a Bonferroni test was used to assess these differences.

RESULTS

Mean intercanine expansion (T2-T1) was 5.45 \pm 2.62 mm for the RME and 7.50 \pm 1.77 mm for the fantype RME. Mean intermolar expansion was 7.00 \pm 2.61 mm for the RME and 2.90 \pm 0.82 mm for the fantype RME.

Pretreatment vs Posttreatment (T1 vs T2)

Group I (RME group). Nasal volume and MCA values increased significantly in both decongestant and nondecongestant groups (P < .05) (Tables 2 through 5).

	RME Group $\bar{X} \pm$ SD	Fan-Type RME Group X \pm SD	Control Group $\bar{X} \pm SD$	Between Groups	
T1	0.172 ± 0.042	0.155 ± 0.028	0.156 ± 0.017	F = 1.320	
T2	0.220 ± 0.044	0.205 ± 0.035	0.161 ± 0.016	F = 12.147*	
Т3	0.205 ± 0.043	0.172 ± 0.026	0.162 ± 0.016	F = 7.929*	
Among groups	F = 50.647*	F = 25.544*	F = 5.688*		

^a RME indicates rapid maxillary expansion; SD, standard deviation; * Significant; X mean values.

Table 3. MCA	in	Nondecongestant	Groups,	$\rm mm^{2a}$
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	RME Group $\bar{X} \pm$ SD	Fan-Type RME Group $\bar{X} \pm$ SD	Control Group $\bar{X} \pm SD$	Between Groups
T1	1.052 ± 0.277	0.960 ± 0.173	1.078 ± 0.071	F = 1.576
T2	1.364 ± 0.259	1.160 ± 0.185	1.081 ± 0.069	F = 11.816*
Т3	1.114 ± 0.185	1.020 ± 0.178	1.082 ± 0.066	F = 5.251*
Among groups	F = 25.524*	F = 22.937*	F = 5.917*	

^a MCA indicates minimal cross-sectional area; RME, rapid maxillary expansion; and SD, standard deviation; * Significant; X mean values.

Table 4. Nasal Volume in Decongestant Groups, cca

	RME Group $\bar{X} \pm$ SD	Fan-Type RME Group ${ar X}\pm$ SD	Control Group $\bar{X} \pm SD$	Between Groups
T1	0.198 ± 0.048	0.178 ± 0.032	0.216 ± 0.021	F = 2.984
T2	0.266 ± 0.047	0.248 ± 0.047	0.214 ± 0.022	F = 8.827*
Т3	0.242 ± 0.041	0.184 ± 0.032	0.218 ± 0.021	F = 5.913*
Among groups	F = 50.755*	F = 73.695*	F = 4.837*	

^a RME indicates rapid maxillary expansion; SD, standard deviation; * Significant; X mean values.

	RME Group $\bar{X} \pm$ SD	Fan-Type RME Group $\bar{X} \pm SD$	Control Group $\bar{X} \pm SD$	Between Groups
T1	0.871 ± 0.019	0.823 ± 0.015	0.777 ± 0.081	F = 1.379
T2	1.120 ± 0.019	1.049 ± 0.014	0.784 ± 0.075	F = 20.457*
Т3	1.027 ± 0.021	0.897 ± 0.015	0.789 ± 0.077	F = 8.648*
Among groups	F = 33.079*	F = 38.932*	F = 5.688*	

Table 5. MCA in Decongestant Groups, mm²

^a MCA indicates minimal cross-sectional area; RME, rapid maxillary expansion; and SD, standard deviation; * Significant; X mean values.

Group II (fan-type RME group). Nasal volume and MCA values increased significantly in both decongestant and nondecongestant groups (P < .05) (Tables 2 through 5).

Group III (control group). Nasal volume and MCA values did not change in the decongestant and nondecongestant groups (P > .05) (Tables 2 through 5).

Pretreatment vs Retention Period (T1 vs T3)

Group I (RME group). Nasal volume and MCA values increased significantly in both decongestant and nondecongestant groups (P < .05) (Tables 2 through 5).

Group II (fan-type RME group). Nasal volume and MCA values increased significantly in both decongestant and nondecongestant groups (P < .05) (Tables 2 through 5).

Group III (control group). Nasal volume and MCA values did not change in the decongestant and nondecongestant groups (P > .05) (Tables 2 through 5).

Posttreatment vs Retention Period (T2 vs T3)

Group I (RME group). Nasal volume and MCA values decreased significantly in both decongestant and nondecongestant groups (P < .05) (Tables 2 through 5).

Group II (fan-type RME group). Nasal volume and MCA values decreased significantly in both decongestant and nondecongestant groups (P < .05) (Tables 2 through 5).

Group III (control group). Nasal volume and MCA values did not change in the decongestant and nondecongestant groups (P > .05) (Tables 2 through 5).

Between Groups

Pretreatment (T1). All groups' nasal volume and MCA values did not show significant differences between decongestant and nondecongestant groups (P > .05) (Tables 2 through 5).

Posttreatment (T2). RME and fan-type RME groups' nasal volume and MCA values showed differences with the control group (P < .05). RME and fan-type RME groups' values did not show differences on posttreatment (P > .05) (Tables 2 through 5).

Retention period (T3). RME groups' nasal volume and MCA values showed differences with both fantype RME and control groups (P < .05). Fan-type RME and control groups' nasal volume and MCA values did not show differences on posttreatment (P > .05) (Tables 2 through 5).

DISCUSSION

Maxillary arch constriction or maxillary width deficiency concomitant with a high palatal vault is a manifestation of a skeletal development syndrome that causes some rhinologic problems and has certain negative effects on dentofacial pattern.¹⁴ RME is the traditional method used for treating this syndrome.15 Studies have reported that after RME, improvement is observed not only in correction of the maxillary arch, but also in breathing, physical development, athletic performance, and general health, because the expansion allows increased airflow through the nose.16 Cephalograms, tomography, and rhinomanometry methods are used to examine the nasal airway and related dentofacial structures.8 AR is a method that allows quick, painless, and noninvasive application and requires minimal patient cooperation. AR showed a reasonable correlation with CT in a cadaver.¹⁷

In the present study, nasal airway changes following RME with two different appliances were assessed. Fan-type RME studies have shown that the midpalatal suture separated anteriorly rather than posteriorly.^{5,6} However, cephalograms showed that nasal cavity width increased more in the RME group than in the fan-type RME group.⁵ The aim of this study was to evaluate and compare the effects of these two types of RME on nasal airway dimensions. This study showed that nasal volume was increased by 29% and 34%, and MCA values were increased by 29% and 28%, in nondecongestant and decongestant RME groups, respectively.

The fan-type RME group and the RME group showed similar results. Nasal volume was increased by 32% and 39%, and MCA values were increased by 20% and 27% in nondecongestant and decongestant groups, respectively. These results demonstrate that the expansion procedures have the same effects on the nasal airway immediately after expansion. The traditional effect of RME is increased distance between the lateral walls of the nasal cavity and the nasal septum. This effect may decrease nasal resistance by enlarging the cross-sectional area of the nasal passage, which facilitates breathing.¹⁸ In another study, Warren et al.¹⁹ found that RME increased MCA values by around 45%. It is clear that the smallest cross-sectional area of the nasal airway is the nasal valve. The most significant airflow resistance occurs in this part of the nasal airway during breathing, according to aerodynamic studies.¹⁷ Our findings showed that nasal volume and MCA of the nasal valve areas significantly increased with both RME and fantype expansion.

Turvey et al.²⁰ showed that RME remodeling allows opening of the nasal valve. In another study, Doruk et al.²¹ concluded that the increase in intercanine width, which accounts for the significant decrease in nasal resistance, has a direct effect on the nasal valve area. Our findings supported these results in that immediate intercanine width changes after expansion were similar with the two methods.

Differences between the two types of RME were clearly observed at the end of the retention period. A significant amount of relapse in nasal volume and MCA occurred in both groups. However, the relapse in nasal volume and MCA in the fan-type group was dramatically higher than in the RME group. At the end of the retention period, the fan-type RME group values decreased to nearly the same values recorded before treatment and did not show differences with the control group. Although nasal volume and MCA both showed some decrease, this improvement was only partially stable in the RME group. It is known that intermolar width shows slight expansion with a fan-type RME when compared with a conventional RME. Therefore, the opening of the midpalatal suture is more parallel in the usual RME than in the fan-type RME when viewed from the coronal and frontal plane. In another study, Iseri et al.²² used the finite element method to show that RME application caused high stress on the lateral nasal wall. In the retention period, this stress may cause remodeling of the nasal valve back to its original position.

The RME is more stable than the fan-type RME because of the parallel expansion type of RME. The skeletal effect of RME provides resistance to relapse of the nasal airway during the retention period. Doruk et al.⁵ hypothesized that the fan-type RME appliance required a lower orthopedic force range than the RME appliance. Therefore, although the fan-type RME appears to induce expansion at a more dentoalveolar level, the RME was associated with significant widening of the maxilla at a skeletal level.

Nasal volume and MCA values increased after nasal decongestant application. All nasal volume and MCA

results were higher in the decongestant group than in the nondecongestant group; the results were not statistically different.

Linder-Aranson and Backstrom²³ recommended applying vasoconstrictors to decrease the effects of mucosal swelling on the anterior aspect of the inferior turbinates, to provide a better indication of the effects of cartilaginous or bony structures of the nasal cavity on nasal resistance. In the previous study, nasal valve volume and MCA increased after decongestant application.¹⁹ Therefore in the literature, nasal resistance values decreased by around 45% after decongestant application in the same subject. In our study, the nasal valve area volume and MCA increased after decongestant application. Application of decongestant is a useful method for improving the reliability of results. However, this study showed that if ideal conditions are supplied, reliable results can be achieved despite decongestant nonusage. The control group revealed no changes in nasal volume and MCA parameters, which were stable for all measurements.

CONCLUSIONS

- RME and fan-type RME significantly increased the nasal volume and MCA of subjects.
- Increases in nasal volume and MCA were more stable in the RME group than in the fan-type RME group.
- A significant amount of relapse was observed in the fan-type RME group, and values returned to initial values after 6 months of retention.
- Using decongestant decreases nasal volume and MCA values in both RME groups.

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