Original Article

Rapid Maxillary Expansion and Surgically Assisted Rapid Maxillary Expansion Effects on Nasal Volume

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Abstract: The purpose of this study was to compare the effects of rapid maxillary expansion (RME) and surgically assisted rapid maxillary expansion (SARME) on nasal volume using acoustic rhinometric methods. Two groups of subjects were used in the study. Group 1 consisted of 10 subjects (mean age 12.30 ± 0.82 years) who were treated with RME, and group 2 consisted of 10 subjects (mean age 18.70 ± 2.54 years) who were treated by SARME. In both groups, all cases had a maxillary width deficiency with bilateral crossbites. Nasal volume records were taken by the same otorhinolaryngologist with an AR device. AR recordings were performed for each patient with and without the use of a decongestant. The first record was taken before expansion, and the second record was taken at the end of retention. The data for both groups were evaluated using Wilcoxon signed rank test and Mann-Whitney *U*-test. The nasal volume showed a significant increase in both the RME and the SARME groups ($P < .05$). The measurement with the use of decongestant was similar to that without use of decongestant on the both groups ($P < .05$), but the different increments in nasal volume between the RME and the SARME groups were not statistically significant. Although the mean ages between the RME and the SARME groups were different, the increase in nasal volume was similar in both groups. (*Angle Orthod* 2006;76:66–71.)

Key Words: Rapid maxillary expansion; Surgically assisted rapid maxillary expansion; Acoustic rhinometry

INTRODUCTION

Maxillary arch constriction or maxillary width deficiency associated with a high palatal vault is generally treated orthodontically by expansion of the midpalatal suture. This procedure, introduced by Angell[1] in 1860, was reintroduced during the 1960s by Haas.[2,3]

Maxillary width deficiencies are routinely corrected in growing patients with appliances that help in separation of the midpalatal and associated maxillary sutures. However, this technique is not useful in skeletally mature individuals. Alternatives in these situations include the use of surgically assisted rapid maxillary expansion (SARME) or a segmental LeFort I osteotomy in an attempt to overcome the resistance of the closed sutures.[4,5]

It has been noted that rapid maxillary expansion (RME) causes not only dentofacial changes but also craniofacial structure changes.[2,3] The effects of RME are not limited to the upper jaw because the maxilla is connected with many other bones.[6] RME separates the external walls of the nasal cavity laterally and causes lowering of the palatal vault and straightening of the nasal septum.[2,3,7–9] This remodeling decreases nasal resistance, increases internasal capacity, and improves breathing.[7,10,11]

Many investigators[7,12,13] have reported that RME reduces nasal airway resistance or increases nasal volume. Warren et al[10] found that nasal cross-sectional area increased after the RME. Similarly, surgical expansion increased the minimal nasal cross-sectional area approximately 55%. Hartgerink et al,[14] Hershey et al,[7] and Doruk et al[15] found a significant mean decrease in nasal resistance after RME. The patients were reevaluated one year after treatment, and the decreases in nasal resistance were found to be stable. Hartgerink and Vig[16] stated that it is not possible to predict percent nasality from nasal resistance data.

Methods of evaluating nasal airway began with lat-

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TABLE 1. Distribution, Average Ages, Expansion Periods, and Retention Periods of the Groups (Mean ± SD)[a]

	n	Mean Age (y)	Expansion Period (d)	Retention Period (mo)
RME	10	12.30 ± 0.82	25.20 ± 3.82	6.15 ± 0.17
SARME	10	18.70 ± 2.54	23.40 ± 1.57	6.19 ± 0.16

[a] RME indicates rapid maxillary expansion; SARME, surgically assisted rapid maxillary expansion.

eral cephalometric radiographs.[17,18] However, two-dimensional cephalometric radiographs do not show a clear connection between the oropharyngeal and the 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 are exposure to radiation and the high cost of this method.

Acoustic rhinometry (AR) was introduced by Hilberg et al[19] in 1989 as a simple, noninvasive, and objective method for measuring the dimensions of the nasal cavity. Therefore, AR became widely accepted in a short period of time. Previous investigations[20–22] have demonstrated reasonably good agreement between the cross-sectional areas in the anterior part of the nasal cavity determined by AR and those determined by imaging modalities such as magnetic resonance and CT.

The purpose of the study was to compare the effects of RME and SARME on nasal volume using AR methods.

MATERIALS AND METHODS

The study sample was divided into two groups. The first group (RME group) included 10 subjects, five girls and five boys, whose mean age was 12.30 ± 0.82 years. The second group (SARME group) included 10 subjects, six girls and four boys, whose mean age was 18.70 ± 2.54 years. Table 1 shows the distribution, average ages, average expansion periods, and average retention periods of the subjects.

Before the study, all the 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.

The subjects showed no history of nasal disease and no previous tonsillar, nasal, or adenoidal surgery. Furthermore, the presence of an adequate nasal cavity space was confirmed by an anterior rhinoscopic examination by a single qualified otolaryngologist. Each subject in both groups had skeletal maxillary constriction in addition to a bilateral posterior crossbite.

The principle of AR is based on 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 process data are converted into area-distance plot using a computer.[19] These data allow the computer to give three parameters of the nasal cavity: volume, area, and resistance.

FIGURE 1. Nasal volume measurement with the acoustic rhinometric device.

Pretreatment records were taken at the beginning of treatment (T_1). The nasal volume (in cc) of all subjects was measured with AR by the same otolaryngologist. The AR measurements were taken at the same room temperature (20°C). The subjects were allowed to rest for 30 minutes before recordings commenced, and the device was calibrated according to the manufacturer's instruction during this period. After calibration, the nosepiece was placed at the nostril, and the nasal volume was measured four times for each nostril (Figure 1). After this procedure, a decongestant nasal spray (Iliadin, Santa Farma, Istanbul, Turkey) was applied to the nostrils, and after a time delay of 10 minutes for the decongestant to take effect, the measurement process was repeated. The values with decongestant and without decongestant were averaged to obtain the mean nasal volume for each subject.

A modified bonded acrylic RME appliance was used for the expansion process in both groups (Figure 2). The rationale of the bonded appliance was to assist in providing control of the vertical dimensional changes that occur in growing patients during maxillary expansion.[23] The RME appliance was cemented with glass ionomer cement (Ketac-Cem, Espe Dental AG, Seefeld, Germany).

In the SARME group, the surgical procedure was performed as described in the literature.[24,25] The stan-

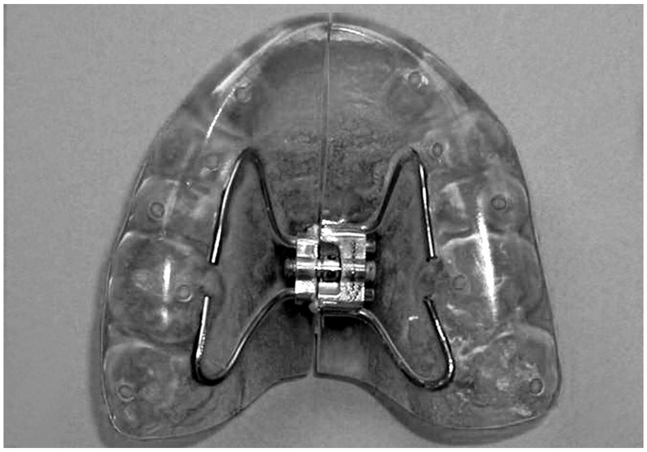

FIGURE 2. Modified acrylic bonded rapid maxillary expansion appliance.

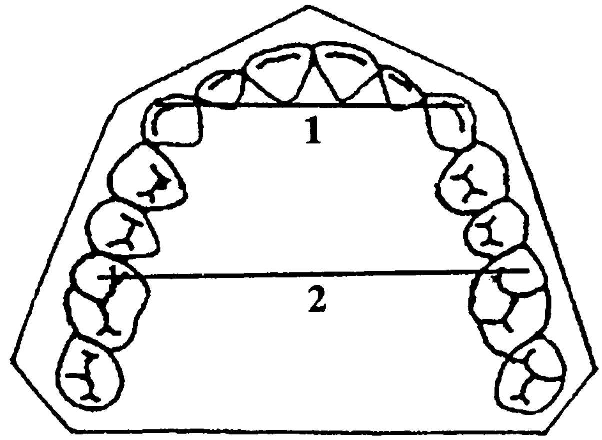

FIGURE 3. Transverse dental evaluations: 1, upper intercanine width and 2, upper intermolar width.

dard horizontal osteotomy, pterygomaxillary disjunction, and midpalatal suture separation were performed under sedation and local anesthesia.

In both groups, the expansion appliance was activated one-quarter turn daily during the expansion period, until the desired suture opening was achieved. At that time, the screw was fixed with 0.014-inch ligature wire, and the appliance was left for one week to minimize discomfort during removal. All the subjects demonstrated sutural opening, which was confirmed by an occlusal radiograph. After removal, the appliance used in active treatment was cleaned and reused as a removable retention appliance. The posttreatment records were taken at the end of the retention period (T_2). Fixed appliance treatment was started soon after the retention period.

Cast analysis

Study casts were taken before treatment and after retention period to analyze changes in intermolar and intercanine width. Direct measurements of maxillary casts were taken to the nearest 0.1 mm with vernier calipers. On the cast of the upper dental arch, the distance between the tips of the distopalatal cusps of the permanent first molars was measured. The width of anterior part of the dental arch was measured using the occlusal reference points on canines (Figure 3).

Statistical analysis

For error measurements, the before- and after-treatment dental casts of 10 patients were used. All measurements were recorded independently twice on two separate occasions with a two-week interval. The method error was calculated using the formula

$$\sqrt{\sum \frac{d^2}{2n}}$$

where d is the difference between two measurements of a pair and n is the number of double measurements.[26]

The results were calculated using the software SPSS for Windows (version 10.0; SPSS Inc, Chicago, Ill). The differences in the arithmetic mean and standard deviation between before expansion (T_1) and after retention period (T_2) measurements were studied by Wilcoxon signed rank test. The amount of expansion and nasal volume differences between the groups were evaluated using Mann-Whitney *U*-test.

RESULTS

The error measurement of dental casts was observed to vary between 0.192 and 0.441 mm. The distribution, average ages, expansion periods, and retention periods of subjects are shown in Table 1.

The mean intercanine expansion was 5.45 $\pm$ 2.62 mm for RME and 6.50 $\pm$ 1.97 mm for SARME. The mean intermolar expansion was 7.00 $\pm$ 4.61 mm for RME and 8.50 $\pm$ 3.82 mm for SARME. The pretreatment vs posttreatment intercanine and intermolar differences between the two groups were not statistically significant ($P > .05$) (Table 2).

Pretreatment vs posttreatment (T_1 vs T_2) RME

The pretreatment and posttreatment nasal volume measurements (in cc) are shown in Table 3. A significant volume increase was observed between the T_1 and T_2 measurements without decongestant (13.80%) and with decongestant (15.16%) ($P < .05$) (Figures 4 and 5).

Pretreatment vs posttreatment (T_1 vs T_2) SARME

The pretreatment and posttreatment nasal volume measurements (in cc) are shown in Table 3. A signif-

TABLE 2. Pretreatment (T_1) and Posttreatment (T_2) Intercanine and Intermolar Width Measurements of the Groups (mm, Mean ± SD)[a]

	Intercanine		Intermolar	
	T_1	T_2	T_1	T_2
RME	31.65 ± 2.80	37.70 ± 4.19	43.75 ± 4.29	50.75 ± 4.79
SARME	29.80 ± 2.75	36.40 ± 3.17	39.85 ± 2.29	48.35 ± 3.74

[a] RME indicates rapid maxillary expansion; SARME, surgically assisted rapid maxillary expansion.

TABLE 3. Pretreatment (T_1) and Posttreatment (T_2) Nasal Volume Measurements of the Groups (cc, Mean ± SD)[a]

	Without Decongestant		With Decongestant	
	T_1	T_2	T_1	T_2
RME	0.16 ± 0.02	0.18 ± 0.02	0.18 ± 0.02	0.21 ± 0.02
SARME	0.12 ± 0.02	0.14 ± 0.02	0.15 ± 0.02	0.17 ± 0.02

[a] RME indicates rapid maxillary expansion; SARME, surgically assisted rapid maxillary expansion.

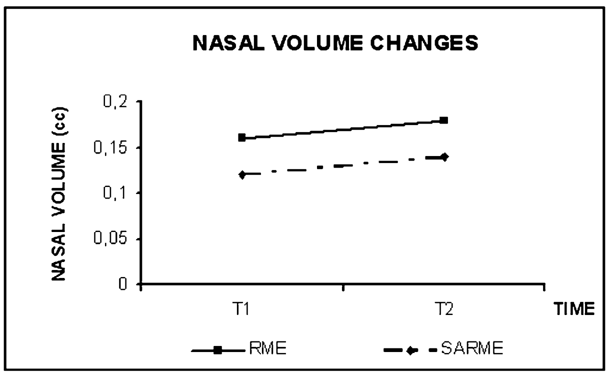

FIGURE 4. Changes in nasal volume measurement without decongestant.

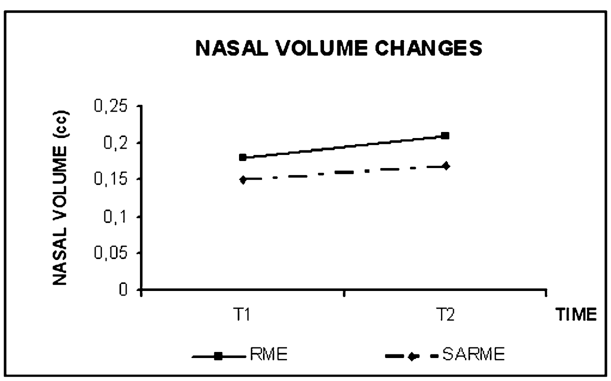

FIGURE 5. Changes in nasal volume measurement with decongestant.

icant volume increase was observed between the T_1 and T_2 measurements without decongestant (14.09%) and with decongestant (17.86%) ($P < .05$) (Figures 4 and 5).

The increase in nasal volume with decongestant and without decongestant was not significant for both groups ($P > .05$).

DISCUSSION

The expansion of the midpalatal suture has become an accepted procedure for maxillary constriction. RME promotes an increase in transverse dimensions and in the perimeter of the upper dental arch with a real gain of bone at the level of midpalatal suture.[2,3]

When a transverse maxillary deficiency is present in the adult patient, it is complicated by the ossification of the midpalatal, the maxillary buttress, and the pterygomaxillary sutures.[27] Isaacson et al[28] and Isaacson and Ingram[29] showed that the facial skeleton increases its resistance to expansion as it ages and matures. Although increasing the transverse dimension of the maxilla by surgical means is a procedure that has been performed for several years,[30,31] Capelozza Filho et al[32] and Handelman[33] have advocated RME as an acceptable alternative to SARME in adults for many cases of maxillary transverse arch deficiency. We agree with the approach that prefers SARME for adults with maxillary transverse deficiency.

The results with acoustic rhinometric (AR) method showed that the nasal volume increased significantly between T_1 and T_2 for both groups. Previous studies[10,34] have suggested that an increase in nasal width and volume are obtained with expansion. The traditional explanation for the action of RME on nasal resistance is based on the lateral separation of the walls of the nasal cavity, which occurs concurrently with the dental arch expansion.[14] Wertz[13] showed that the greatest expansion occurs at the lower anterior portion of the nasal cavity and, therefore, he did not justify expansion unless an obstruction was present in the anteroinferior aspect of the nose. Because maxillary constriction results in a narrow nasal valve, this concept has been supported by several studies.[15,35] The nasal valve is a region of the nasal airway extending from the caudal end of the upper cartilage to the end of the inferior turbinate. It is approximately 1.3 cm from the nares. Nasal resistance has the highest score in this region, and improvement in this region will reduce the nasal resistance and increase nasal volume. Clinically, reduction of nasal resistance may improve the nasal breathing. However, many patients do not consciously feel the improvement in the nasal breathing after expansion because of high variability in individual responses.[7,15]

Hartgerink et al[14] placed Tygon tubes in the nares before and after expansion and showed a decrease in nasal resistance similar to that in the control group. For some patients, RME may have an effect on nasal resistance similar to dilation of the anterior nares caused by placement of tubing. Turvey et al[36] also demonstrated a decrease in nasal resistance caused by dilation of the nares and an opening of the liminal valve.

In this study, the difference in the increase in nasal volume between the RME and the SARME groups was not statistically significant. Although the skeletal maturation of the SARME group was complete, the nasal volume increase was significant and similar with the RME group. Melsen[37] has shown internal resorption of the bony nasal cavity occurs up to the age of 15 years and, therefore, growth appears to decrease the nasal resistance until this age. Therefore, we believe that the improvement in nasal volume in the SARME group was because of the expansion only.

If the effects of RME result in an improved nasal volume, a reasonable assumption may be that the surgical procedure is useful only to overcome the resistance regions. A similar increase in nasal volume caused us to look for the same effect in the RME subjects. The amount of expansion, especially in the intercanine width, was similar in both the RME and the SARME groups. Doruk et al[15] stated that the decrease in nasal resistance was because of the expansion of the intercanine width. Because this region is situated anatomically on the inferior of the nasal valve, the effect of RME common to both groups may be an increase in nasal volume by expansion of the intercanine width. However, these effects are expected only in healthy persons without nasal polyps, enormous adenoids, turbine hypertrophy, etc. Also, in our study, all the patients had undergone a rhinoscopic examination.

Nasal decongestants have been recommended for the precise measurement of nasal resistance.[38] The use of vasoconstrictive nose drops was advocated by Linder-Aronson and Backstrom[12] to lessen the effect of mucosal swelling mainly at the anterior aspect of the inferior turbinates. Linder-Aronson and Aschan[11] and Doruk et al[15] found a significant decrease in nasal resistance using nasal decongestants after expansion. In our study, the nasal volume was greater with the use of a decongestant than without, but no statistically significant differences could be detected. It is very difficult to standardize nasal volume measurements and, therefore, we applied decongestant to increase the reliability of the measurements. However, the decongestant is not the only factor that increases the reliability of the measurements. Nasal volume measurements can depend on factors such as the head posture of subjects, enough rest time allowed for subjects during measurements, the training of the otolaryngologist, etc. In this study, we recognized and standardized these factors as much as possible.

CONCLUSIONS

- Both RME and SARME had increased the nasal volume significantly, thus the nasal resistance had decreased.
- Maxillary expansion improved the nasal volume; however, this improvement could not be predicted in all subjects.
- Nasal volume changes in SARME group were similar to those in RME group. Therefore, it was suggested that SARME in adults was as effective as RME in adolescents.
- Nasal volume measurement was higher with decongestant than without. However, using decongestant offered no further advantage to increase reliability.

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