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Original Article

Evaluation of olfactory threshold changes in patients treated with rapid maxillary expansion

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Abstract

Aim: Rapid maxillary expansion (RME) provides an orthopedic effect that solves the problem of transverse deficiency of the maxilla. Moreover, it contributes positively to the functioning of the entire nasopharynx by increasing the cross-sectional area and volume of the nasal tract, thus reducing airway resistance. The aim of this study was to evaluate the changes in olfactory threshold after RME treatment of patients with maxillary transverse deficiency.

Methodology: Olfactory threshold and identification tests as well as acoustic rhinometry parameter (Volume1, MCA1, Volume2, MCA2) measurements were conducted for 40 patients (11-16 years) before treatment (T0) and 6 months after (T1) rapid maxillary expansion application.

Results: A significant improvement was observed when the olfactory threshold values at T0 (0.96 ± 0.07) and T1 (0.79 ± 0.13) ($p < 0.001$) were compared. A significant improvement was also observed upon comparing the identification test results at T0 (0.63 ± 0.13) and T1 (0.79 ± 0.11) ($p < 0.001$). The acoustic rhinometry results showed a significant increase in Volume 1, MCA1, Volume 2 and MCA2 in the right and left nasal cavities after treatment ($p < 0.001$).

Conclusion: In this study, acoustic rhinometry showed that nasal cavity area and volume increased in patients who underwent rapid maxillary expansion therapy. Further, the olfactory functions measured by the olfactory threshold test and identification test improved significantly.

Keywords: Rapid maxillary expansion, olfactory threshold, n-butanol, acoustic rhinometry

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Introduction

Chronic oral breathing can lead to undesirable developments in muscle functions as well as soft and hard tissue morphology. During the growth and development period of individuals, oral breathing causes maxillary hypoplasia (1, 2). This habit can affect upper airway resistance and the position of the tongue, leading to severe malocclusion and aesthetic problems (3-9). Treatment of these problems requires a multidisciplinary approach involving pediatricians, otolaryngologists, speech therapists and orthodontists. Rapid maxillary expansion (RME) has been used as a treatment method since the 1980s. Flattening of the nasal septum, lowering of the palate dome, and an increase in nasal dimensions (area and volume) have been detected after treatment all of which have been reported to facilitate nasal breathing in patients who breathe through the mouth and reduce negative pressure during ventilation (10). Thus, RME is effective in addressing obstructive sleep apnea problems, reducing snoring, correcting nasal septum curvature and reducing adenoid hypertrophy and upper respiratory tract infections (11-17). Along with its

positive effects on nasal physiology, RME also increases mucociliary clearance in patients by increasing nasal cavity volume (18). The present study was designed to further investigate this treatment method, considering that RME, which is effective for nasal function, may affect olfactory sensitivity.

Olfaction is very important for orientation, nutritional and defensive functions. To date, various tests have been developed to evaluate odor sensitivity. The Sniffin' Sticks test developed for children aged 6 years and over in European countries is frequently used. This test consists of odor threshold, odor discrimination and odor identification subtests (19, 20). In addition, nasal patency measurement is also very important. Hilberg et al. introduced acoustic rhinometry for measuring nasal airway resistance. This is a noninvasive, reliable and quick method that measures nasal cross-sectional area and volume in different parts of the nose based on an acoustic wave reflection of the cavity walls, and it requires minimal patient cooperation (21). Measurements are graphically expressed in relation to the cross-sectional area and distance to the cavity. The aim of this study was to evaluate the olfactory threshold changes in patients after RME treatment.

Materials and Methods

This study was ethically approved by Necmettin Erbakan University, Faculty of Dentistry Clinical Research Ethics Committee (2021/10-85). The study included 40 patients aged 11–16 years who were to undergo RME treatment.

The inclusion criteria were as follows:

(1) the completion of permanent dentition,

(2) no previous Ear, Nose and Throat (ENT) surgeries,

(3) no orthodontic treatment received,

(4) the presence of transversal insufficiency in the maxillary apical base,

(5) adequate oral hygiene,

(6) an absence of any oral or systemic disease,

(7) no pathology in the adenoid and/or paranasal sinuses and no operation over them. Informed consent forms were obtained from the patients who met these criteria and were included in the study.

Clinical and radiographic examinations of the 40 patients included in the study were performed. Patients with a crossbite of at least 4 mm transverse deficiency in the maxilla and who were categorized as Grade 3c or 4c according to the treatment need index were included. To exclude any nasal pathology in the patients, parents were asked to answer the SNOT 22 questionnaire. All of the children in the study scored < 1 and were reported to have healthy noses. Olfactory threshold and identification tests as well as acoustic rhinometry parameter (VOL1, MCA1, VOL2, MCA2) measurements were performed before (T0) and 6 months (T1) after RME at Selçuk University Faculty of Medicine, Department of Otorhinolaryngology.

Rapid maxillary expansion (RME):

The McNamara maxillary expansion appliance with maxillary screw (11 mm) was used for the RME procedure (Fig. 1). For vertical control during maxillary expansion, the occlusal surfaces of the maxillary first premolars and molars were covered with acrylic up to the buccal and palatal surfaces, and the maxillary screw was placed in the middle of the palatal. The appliance was bonded with glass ionomer cement. The maxillary was expanded by 0.5 mm per day, ¼ turn in the morning and evening in the first week, and 0.25 mm once a day in the second and third weeks.

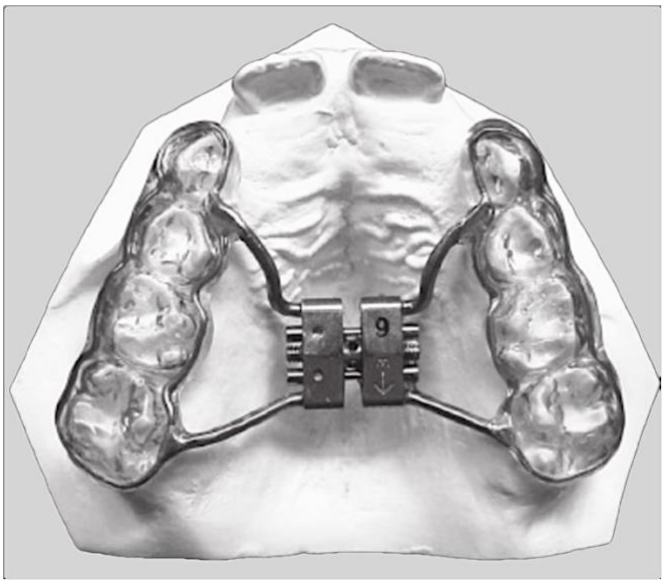


Figure 1. Rapid maxillary expansion appliance (RME)

N-butanol threshold test:

Using bottles of the same color and size and made of black glass, butanol 4% solution was diluted 1/3 with distilled water. Eight separate bottles of butanol were prepared with repeated 50% dilutions. The first bottle had the highest concentration, while the eighth bottle had the lowest concentration (Fig. 2). The bottle numbered 0 consisted of distilled water. Each patient was asked to sniff the bottles from a distance of 3–5 cm, starting from the lowest dilution. Bottles 0 and 8 were sniffed first. The patient was asked whether the smells were different from water. If the patient did not know, they continued to sniff bottles 7, 6, 5, etc., and the threshold value at which the patient noticed the smell of butanol in higher concentrations was recorded.

Identification test:

In the identification test, the patients were made to smell eight scents: Vicks®, Turkish coffee, naphthalene, cinnamon, powder, soap, cocoa and peanut butter. The containers were kept tightly closed. Each odor was specified in four multiple-choice options (Fig. 3).

Figure 2. N-butanol threshold test vials

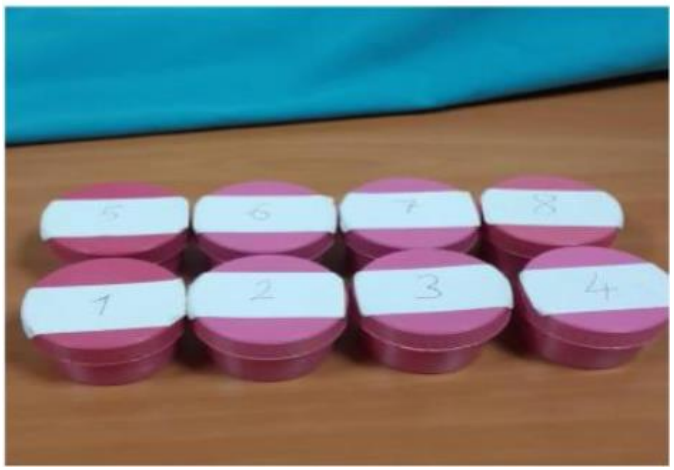
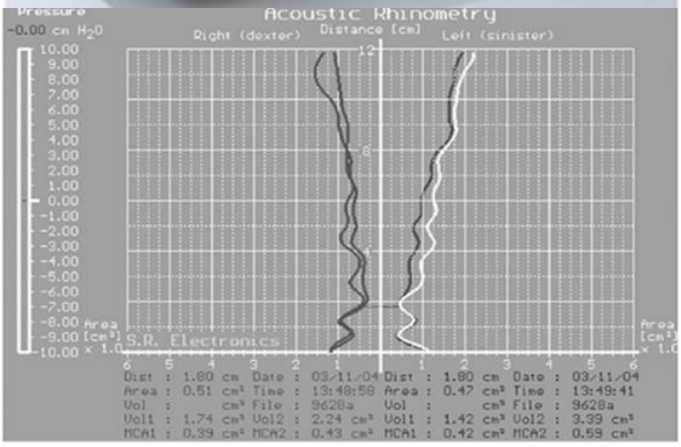


Figure 3. Identification test boxes and multiple-choice questions



Acoustic rhinometry:

ENT triage was performed by a specialist physician under standard conditions using the same device (Rhino brand Metrics SRF 2000 model) before and 6 months after the treatment (Fig. 4). It has been reported that this triage should be performed after nasal vasoconstrictor administration to exclude the effects of mucosal variations from patient data and to monitor changes to the skeleton (22).

Statistical analysis

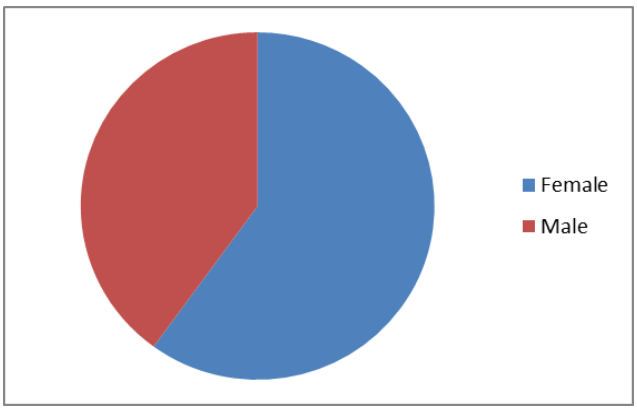
Statistical analysis of the data obtained in our study was performed using the SPSS 21.0 program (IBM SPSS Inc., Armonk, NY, USA). The sample distribution does not fit the normal distribution parameters. Descriptive statistics are reported as mean and standard deviation. Therefore, the Wilcoxon test, which is a test of significance between nonparametric dependent groups, was chosen. A *p*-value < 0.05 was considered statistically significant.

Figure 4. Acoustic rhinometry device and rhinometric tracing

Results

Forty patients, 24 women (60%) and 16 men (40%), participated in the study (Fig. 5). The age range of the female patient group was 10–16 years, with a mean of 13.6±2.1 years. The age range of the male patient group was 10–16 years, with a mean age of 12.8±2.6 years (Table 1).

Figure 5. Distribution by gender of patients



The difference between pre-treatment T0 (0.79±0.13) and post-treatment T1 (0.96±0.07) in the N-butanol threshold test (detection) values was statistically significant ($p < 0.001$). The difference between pre-treatment T0 (0.63±0.13) and post-treatment T1 (0.79±0.11) in identification test (discrimination) values was found to be statistically significant ($p < 0.001$) (Table 2). Significant improvement was observed in all parameters of acoustic rhinometry (MCA1, MCA2, VOL1, VOL2) after treatment ($p < 0.001$) (Table 3).

Table 1. Mean age of patients

Gender	Age	
	Min-Max	Mean
Female	10-16	13.6 ±2.1
Male	10-16	12.8 ±2.6

Table 2. Evaluation of olfactory threshold test and olfactory discrimination before treatment (T0) and after treatment (T1).

	Mean ± SD (T0)	Mean ± SD (T1)	*p*
Olfactor Threshold	0.79 ± 0.13	0.96 ± 0.07	<0.001
Identification	0.63 ± 0.13	0.79 ± 0.11	<0.001

N-butanol olfactor threshold test = olfactor detection, Identification test = olfactor discrimination, $p < 0.05$ was considered statistically significant

Table 3. Evaluation of mean values and standard deviation data of acoustic rhinometry results before and after treatment

	Mean ± SD	*p*-value
MCA1 R T0 MCA1 R T1	0.28±0.14 0.44±0.16	<0.001
MCA1 L T0 MCA1 L T1	0.28±0.12 0.41±0.12	<0.001
MCA2 R T0 MCA2 R T1	0.50±0.36 0.68±0.37	<0.001
MCA2 L T0 MCA2 L T1	0.39±0.25 0.57±0.29	<0.001
VOL1 R T0 VOL1 R T1	1.20±0.49 1.70±0.56	<0.001
VOL1 L T0 VOL1 L T1	1.19±0.50 1.65±0.56	<0.001
VOL2 R T0 VOL2 R T1	3.01±1.57 3.30±1.52	<0.001
VOL2 L T0 VOL2 L T1	2.73±1.47 3.9±1.35	<0.001

$p < 0.05$ was considered statistically significant, R:right, L:left, MCA : minimal cross-sectional area, VOL: volumeter T0: pre-treatment, T1: post-treatment

Discussion

Rapid maxillary expansion (RME) is a treatment method that has been used in orthodontics for many years (10). The purpose of RME is to provide correct, stable maxillary width by opening the mid-palatal sutures in cases of maxillary transversal deficiency (23). Oral breathing during the growth and development period causes maxillary hypoplasia (1–2). It has been reported in studies that the prevalence of oral breathing is high in cases of malocclusion with maxillary transversal deficiency (24–27). Oral breathing is also a sign of inadequate nasal airflow. It has been suggested that treated dental and skeletal maxillary transversal incompatibilities facilitate nasal breathing as a result of increased nasopharyngeal airway dimensions. Gray reports that 80% of patients switch from oral to nasal breathing after RME treatment (16). There is an increasing research interest in examining the effects of RME on nasal structures. Many studies have reported increased nasal width and volume after treatment (28–30). However, limited data have been reported on the effects of increased nasal patency on the olfactory threshold. The aim of this study is to examine this subject further.

PNIF is a method used to evaluate nasal structures in pediatric patients (31, 32). After maxillary enlargement treatment, patients' PNIF and olfactory thresholds were compared, and significant improvements were observed in these values after treatment. Studies have reported that PNIF and acoustic rhinometry are well correlated in the evaluation of nasal structures (33).

Acoustic rhinometry was chosen in this study because it is a reliable, low-cost method for examining nasal structures. It is also easy to use, non-invasive, and requires minimal patient cooperation (21, 23). Nasal area (MCA) and nasal volume (VOL) data were evaluated in this study. Measurements of these parameters were taken after nasal vasoconstrictor administration to exclude the effects of mucosal variations from patient data and to monitor changes to the skeleton.

Measurement of MCA gives information about how resistance changes inversely with nasal resistance. This shows that treatments that increase MCA lead to a decrease in resistance. In this study, a significant increase was found (34–37), similar to the results of studies that found an increase in nasal width and volume after RME application.

In the study, an identification test was performed to evaluate the olfactory capacity of the patients. In this test, the olfactory capacity of the patients was evaluated rapidly. Vicks®, Turkish coffee, naphthalene, cinnamon, powder, soap, cocoa, and peanut butter, which were stored with their odor-proof lids tightly closed, were sniffed. All patients were aware of these factors prior to participation in the study. The Vicks® odor was not included in the calculation because it is transmitted over the trigeminal nerve. The N-butanol odor threshold was evaluated for olfactory sensitivity. The olfactory detection threshold was determined by having patients sniff bottles containing certain percentages of butanol. In this test, the patients were asked to indicate whether their olfactory sense was present or absent.

The strength of this study is that it is the first orthodontics study to examine the effects of RME treatment on olfactory threshold in patients. The weaknesses of this study are the relatively short-term evaluation of follow-up results and the absence of a control group. Therefore, it is not possible to exclude the possibility that the improvements seen in the results are secondary to a "learning" effect. Children's and adults' evaluations of the olfactory sense are different. It has been reported that children's ability to distinguish odors increases with age. In the same study, it was shown that the incidence of olfactory disorders increases with increasing age (38). This result can be attributed to the fact that it is easier for children to identify the signs of a disordered olfactory sense due to their development of olfactory discrimination ability. For this reason, further studies with a matched control group in terms of age, growth stage, and dentoskeletal characteristics are needed. In addition, although the odor test results are reliable in our study, the clinical use of olfactory tests from region to region is limited because odor identification is closely related to different cultural and experiential aromatic figures. Because there are no olfactory tests adapted to Turkish children that have been proven to be reliable, more reliable results can be achieved by developing these tests.

Conclusions

In this study, acoustic rhinometry showed an increase in nasal cavity area and volume in patients undergoing rapid maxillary expansion therapy. It was observed that olfactory functions, measured by olfactory threshold testing and identification testing, improved significantly. However, studies with a larger study group and with a control group are needed.

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Ethical Approval: Ethics committee approval was received for this study from Necmettin Erbakan University, Faculty of Dentistry Scientific Research Ethics Committee, in accordance with the World Medical Association Declaration of Helsinki, with the approval number: 2021/10-85).

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