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Original Article

A comparison of transversal changes occurring in the treatment of rapid maxillary expansion with acoustic rhinometry

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Abstract

Aim: The aim of this study was to determine the relationship between cephalometric transversal measurements and nasal patency before and after rapid maxillary expansion (RME) treatment applied to patients with maxillary transversal deficiency.
Methodology: The records of 30 patients with maxillary transversal insufficiency and 20 patients without normal dentofacial and nasal symptoms were used. Acoustic rhinometry (MCA1, MCA2, VOL1, VOL2) and cephalometry measurements (JR-JL, MMTI, nasal width) were analyzed before (TO) and six months after (T1) RME.
Results: There were no significant differences in age and gender between the groups. After the RME treatment of the patients in the study group, there was a significant increase in the cephalometric measurement (JL-JR, MMTI, nasal width) and acoustic rhinometry measurement parameters (MCA1, MCA2, VOL1, VOL2). Cephalometric measurements showed consistent changes in the patients in the study group, suggesting that RME treatment increased the maxilla's growth capacity. The posteroanterior cephalometry results improved after RME treatment and approached those of the control group.
Conclusion: Significant improvement was observed in the cephalometric transversal measurements after RME treatment. This improvement indicated that RME increases maxillary growth capacity. There was no correlation between cephalometric and acoustic rhinometry. This result may be due to the inability of posteroanterior cephalometry to effectively evaluate the maxilla-related part of the nasal structures.

Keywords: Rapid maxillary expansion, acoustic rhinometry, nasal patency, posteroanterior cephalometry

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Introduction

Maxillary transversal deficiency is seen as a unilateral or bilateral posterior crossbite in different types of malocclusions. Its etiology is complex and involves many factors (1, 2). Clinically, it is seen as a high, narrow palate vault, a posterior uni- and bilateral crossbite, and incompatibility between the jaws (3, 4). In addition to these dentofacial anomalies, a nasal cavity and alar base are present. Major craniofacial changes, such as narrowing, may also be present. These changes reduce nasal permeability and increase airflow resistance. Together with skeletal tooth malocclusions, they lead to oral breathing (5-7). Rapid maxillary expansion has been used in orthodontics since the 1860s to eliminate maxillary transversal deficiency (8, 9). Research has reported that nasal soft and hard tissues significantly expand after rapid maxillary expansion. It has been reported that all of these facilitate nasal breathing for people who breathe orally (10, 11).

Acoustic rhinometry is a technique for evaluating the area and volume of nasal structures by measuring the reflections of acoustic waves sent to the cavity walls. It is a fast, reliable, easy-to-use method that requires minimal patient cooperation. Measurements are expressed graphically on the results sheet (12, 13). Postero-anterior cephalometric analysis is used in the diagnosis and treatment planning of maxillary transversal deficiency in orthodontics (14, 15). Three measurements are useful for evaluation: maxillary width (distance from the left to right jugale points), the maxillomandibular transverse index (MMTI; effective mandibular width—the distance between the left and right antagonist points), and nasal width. The aim of this study was to use acoustic rhinometry to evaluate the relationship between cephalometric transversal measurement variations and nasal patency before and after rapid maxillary enlargement in patients with maxillary transversal insufficiency.

Materials and Methods

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).

This study was planned retrospectively. Information was obtained from a posteroanterior cephalogram and acoustic rhinometry from normal dentofacial individuals (n = 20) and patients with dentofacial anomalies (n = 30). A power analysis determined that the sample size of 30 patients with an effect width of 0.45 and a significance level of α = 0.05 constituted more than 80% power. Considering the data of 30 patients with rapid maxillary enlargement indications, the inclusion criteria were as follows: (1) complete permanent teeth, (2) no previous ENT surgery, (3) no orthodontic treatment, (4) maxillary apical transversal insufficiency at the base, (5) good oral hygiene, (6) no oral or systemic disease, (7) no pathology in the adenoid and region and paranasal sinuses, and no surgery performed on them. The data of the patients in the study were included if they had at least a 4 mm transversal deficiency in the maxilla and a unilateral and bilateral crossbite (grade 3c or 4c IOTN, Treatment Needs Index). In the study, acoustic rhinometry (AAR) was performed before RME (T0) and six months after RME (T2) at Selçuk University, Faculty of Medicine, Department of Ear, Nose and Throat (ENT).

Acoustic rhinometry: The ENT triage was performed by a specialist physician using the same device (Rhino brand Metrics SRF 2000 model) before and six months after treatment under standard conditions. Individuals in the control group were examined only once. It has been performed after nasal vasoconstrictor administration to exclude the effect of mucosal variations in the data of patients and to monitor skeletal changes (Fig. 1).

Posteroanterior cephalometry: The posteroanterior cephalometric measurements of patients using the Planmeca Romexis® Cephalometric Module, Planmeca Romexis version 3.8.3.R from x-ray records, the maxillary width (JR-JL), the maxillomandibular transversal index (MMTI), and the nasal width were obtained (Fig. 2).

Statistical analysis

All analyses were performed using SPSS 21.0 for Windows (IBM SPSS Inc., Armonk, NY, USA). The age difference between the groups was tested using the Student’s t-test. The gender frequency distribution among the groups was tested using the x2 test. The data obtained before and after treatment were compared to the control group data. The T test was used on independent groups for data fitting normal distribution parameters, while the Mann-Whitney U test was used for data that was not normally distributed. p values < 0.05 were considered statistically significant.

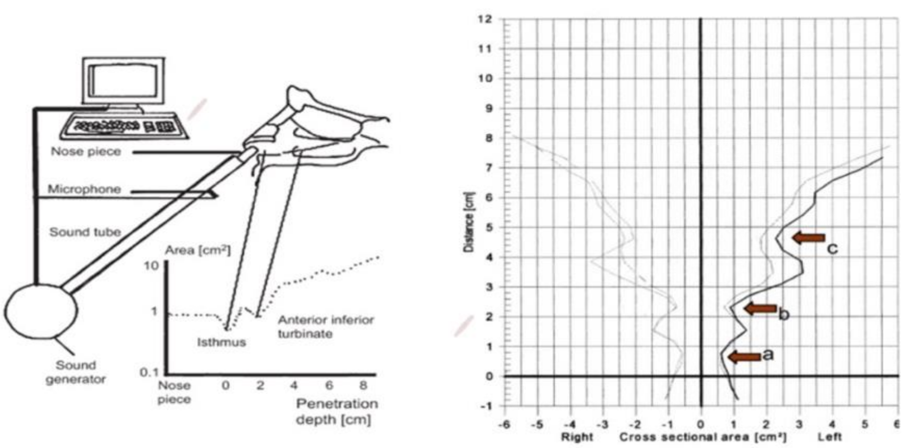

Figure 1. Diagram of the acoustic rhinometry device and computed acoustic rhinometry of a patient of the study sample. (a) The arrows point to the MCA in the regions suggested as the nasal valve. (b) The head of inferior turbinate. (c) The third area of narrowing.

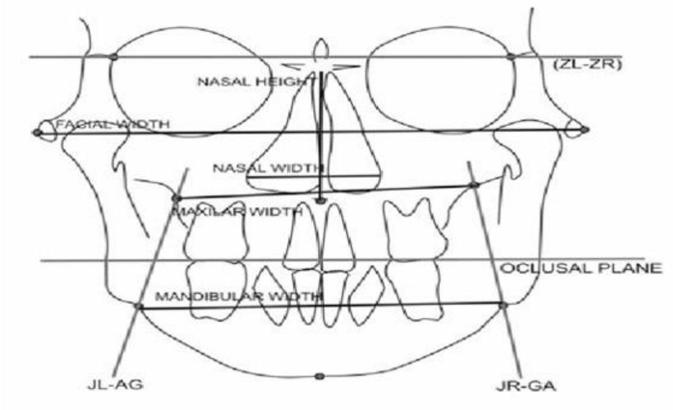

Figure 2. Posteroanterior cephalogram with representatives of the landmarks used

Results

Tables 1 and 2 indicate the age and gender differences between the groups. There was no significant difference between the groups ($p > 0.05$). Tables 3 and 4 show the acoustic rhinometry and posteroanterior cephalometry results of the study group before and after treatment. All results increased were significant after RME treatment ($p < 0.001$).

Table 5 shows the relationship between the pre-treatment and post-treatment values of the study and control groups. According to these results, the maxillary width ($p = 0.007$), the MMTI ($p = 0.002$), and the nasal width ($p = 0.02$) were significantly different from the control group before treatment (T0). There was no significant relationship in T1 after treatment (Maxiller width $p = 0.80$, MMTI $p = 0.74$, nasal width $p = 0.74$). After treatment, the values approached the control group. No significant correlation was observed between the control group before and after treatment in MCA1 right (T0 $p = 0.12$, T1 $p = 0.25$), the MCA1 left (T0 $p = 0.10$, T1 $p = 0.98$), and the MCA2 right (T0 $p = 0.20$, T1 $p = 0.50$), MCA2 left (T0 $p = 0.42$, T1 $p = 0.79$). The difference between the VOL1 right (T0 $p = 0.05$, T1 $p = 0.85$) and the VOL1 left (T0 $p = 0.05$, T1 $p = 0.98$) values and the control group was significant before treatment, but not after it. In the control group, there was no significant relationship between the VOL2 right (T0 $p = 0.72$, T1 $p = 0.36$) and the VOL2 left (T0 $p = 0.88$, T1 $p = 0.52$) values before and after treatment.

Overall, 50 patients (30%) had at least 1 new filling restoration in the last recording. Of those 50 patients, 18 (10.8%) had 1 new restoration and 32 (19.2%) had 2 or more new restorations.

Four (2.6%) patients had their teeth extracted during orthodontic treatment. A significant increase in the DMFT index was observed ($p < 0.001$). Table 1 presents the various changes (means and standard deviations) in tooth status for each patient. Table 2 presents the relationship between lesions observed during treatment and the independent variables. Age and gender had no significant relationship with new lesions.

There was a significant relationship between increased treatment duration and the number of newly developed decalcified lesions ($p = 0.03$). Age and gender were found to have no relationship with newly developed lesions.

A relationship was found between treatment duration and the number of newly developed lesions ($p = 0.03$). Patients whose treatment duration was less than 18 months had a new lesion development per capita of 3.02. However, this incidence increased to 5.32 for patients whose treatment duration was more than 24 months. There was no relationship between newly developing lesions and whether or not tooth extraction was performed during the treatment ($p = 0.25$). Lesion development had a significant relationship with oral hygiene instructions provided to patients during treatment ($p < 0.01$*). The mean number of newly decalcified lesions was 3.12 in patients without oral hygiene instructions in their charts, but it increased to 6.92 in patients who received three or more oral hygiene instructions. There was no significant correlation between the number of new lesions and the topical fluoride treatments ($p = 0.1$).

Table 1. Demographic data: age (years) of the sample

Pre-treatment (n=30)	Post-treatment (n=30)	Control (n=20)	p
12.85 ± 2.5	13.35 ± 2.48	13.10 ± 2.12	p>0.05*

* Student's t-test.

Table 2. Demographic data: gender of the sample

RME (n=30) %	Control (n=20) %	p
F=20 (66) *M*=10(33)	*F*=12(60) *M*=8(40)	p>0.05*

* x^2 -square test.

Table 3. Mean values and standard deviation data of acoustic rhinometry results before and after RME treatment of the study group

	Mean and Std. Deviation	p-value
MCA1 Right T0 MCA1 Right T1	0,28±,14 0,44±,16	p<0.001
MCA1 Left T0 MCA1 Left T1	0.28±,12 0,41±,12	p<0.001
MCA2 Right T0 MCA2 Right T1	0,50±,36 0,68±,37	p<0.001
MCA2 Left T0 MCA2 Left T1	0,39±,25 0,57±,29	p<0.001
VOL1 Right T0 VOL1 Right T1	1,20±,49 1,70±,56	p<0.001
VOL1 Left T0 VOL1 Left T1	1,19±,50 1,65±,56	p<0.001
VOL2 Right T0 VOL2 Right T1	3,01±1,57 3,30±1,52	p<0.001
VOL2 Left T0 VOL2 Left T1	2,73±1,47 3,19±1,35	p<0.001

*p-value significant at <0.05

Table 4. Comparison of posteroanterior cephalometry results before and after treatment in the study group patients

	Pre-treatment (T0)	Post-treatment (T1)	p-value
Maxillary Width	6.42±0.18[a]	6.92±0.25[a]	p<0.001
MMTI	4.82±0.20[a]	5.08±0.28[a]	p<0.001
Nasal Width	2.64±0.12[a]	2.86±0.15[a]	p<0.001

*p-value significant at <0.05, MMTI: maxillomandibular transverse index

Table 5. Comparison of the relationship between pre-treatment and post-treatment values between the study and control groups

	Pre-treatment (T0)	Post-treatment (T1)
Maxillary Width	0.007[a]	0.80[a]
MMTI	0.002[a]	0.74[a]
Nasal Width	0.02[a]	0.74[a]
MCA1 Right	0.12[b]	0.25[b]
MCA1 Left	0.10[b]	0.98[b]
MCA2 Right	0.20[b]	0.50[b]
MCA2 Left	0.42[b]	0.79[b]
VOL1 Right	0.05[a]	0.85[a]
VOL1 Left	0.05[a]	0.98[a]
VOL2 Right	0.72[b]	0.36[b]
VOL2 Left	0.88[b]	0.52[b]

*T test was used in independent groups for data matching normal distribution parameters and Mann-Whitney U test was used for data not normally distributed. *p value significant at <0.05, MMTI:maxillomandibular transverse index, MCA:minimal cross-sectional area , a: T test in independent groups, b: Mann-Whitney U test

Discussion

Rapid maxillary expansion (RME) has been a routinely used orthodontic treatment method for many years (16). RME's aim is to open the midpalatal sutures in cases of maxillary transversal deficiency and provide correct and stable maxillary width (1, 17). According to the literature, the ideal age for obtaining effective RME treatment results is between 8 and 15 (1, 18, 19). They reported that RME can be attempted until age 25, with a 5% probability that the midpalatal suture can be opened and will not close. We evaluated patients between the ages of 10 and 15 who were treated with maxillary expansion. Oral breathing during the growth and development period causes maxillary hypoplasia. Studies have shown that oral breathing prevalence is high in malocclusions with maxillary transversal deficiency (17-20). Oral breathing is also a sign of inadequate nasal airflow (21, 22). Wert and Dreskin suggested that with maxilla enlargement, there was an increase in nasal width and volume (23). This RME effect is based on the separation seen in the lateral walls of the nasal structures during the expansion of the maxilla. As the lateral walls separate, the nasal volume and area increase, making it easier for patients to breathe. According to Doruk et al., these changes in nasal structures decrease nasal resistance. The maxillary expansion of the nasal structures with the anterior nostrils contribute to nasal resistance reduction (24). Sökücü et al. stated that nasal airway dimensions increased after RME in their acoustic rhinometry measurements (25). Oliveira et al. examined the effects of three appliances and found that all three increased airway volume and decreased nasal resistance (26). Basciftci et al., in their study evaluating the airway effects of the RME and SARME methods, found that both methods increased the airway area, and there was no significant difference between them (27). In our study, the airway values increased significantly after treatment in the group treated similarly to other studies.

Hilberg et al. reported that acoustic rhinometry is reliable for evaluating nasal structures (12). This method was chosen for its easy application, rapidity, painlessness, non-invasive nature, and minimal patient cooperation requirements (28). AR was used to analyze the nasal cavity geometry and measure the degree of nasal obstructions, surgical outcomes, and response to it (29). Therefore, ENT departments have accepted the AR method (30).

Frontal cephalograms are used for preoperative and postoperative examinations of maxillary transversal insufficiency (2, 31). This study's aim is to evaluate the relationship between cephalometric transversal measurement data before and after rapid maxillary enlargement and acoustic rhinometry measurement results for nasal patency. In this study, significant differences were found between the control and pre-RME groups in terms of maxillary width, MMTI, and nasal width. These values significantly increased after RME treatment, approaching those of the control group.

The acoustic rhinometry results showed a significant increase in VOL1, VOL2, MCA1, and MCA2 after treatment compared to before treatment in the study group. When the results were compared with those of the control group, the VOL values approached those of the control group after treatment and showed significant improvement. However, there was no significant relationship between MCA1 and MCA2. The fact that the MCA increase was not statistically significant compared to the control group may be due to the small sample size and AR technical limitations. Due to these limitations, Djupesland and Rotnes reported AR narrowing of less than 3–4 mm and showed that it could not accurately detect expansions. Single cross-sectional areas, such as MCA, are more error-sensitive than volume, based on the integration of several cross-sectional areas (32, 33). No significant results were found for the VOL 2 values. Mitsuda et al. and Wriedt et al. reported that other rhinological factors, such as inferior concha hypertrophy, may affect free air volume (34, 35). According to the results of this study, 1) MCA measured by acoustic rhinometry did not differ between the study and control groups before or after treatment, and 2) the cephalometric measurement results of patients with maxillary transversal deficiency showed improvement after rapid maxillary expansion treatment, approaching the control group data. This shows that the treatment is effective in increasing the maxilla's transversal dimensions. 3) No correlation was found between the cephalometric and rhinometric measurements.

Conclusions

Significant improvement was observed in the cephalometric transversal measurements after RME treatment. This shows that RME increases the maxillary transversal capacity. There was no correlation between cephalometric and acoustic rhinometry. This result may be due to the inability of posteroanterior cephalometry to effectively evaluate the maxilla-related parts of the nasal structures.

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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, with the approval number: 2021/10-85).

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