Effects of Rapid Maxillary Expansion on Nasal Cavity Dimensions and Resistance

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Abstract: Rapid maxillary expansion is a common treatment for posterior cross-bites that has also been shown to improve nasal breathing. Thirteen oral breather patients with posterior cross-bite were studied. Treatment consisted of rapid maxillary expansion with a fully bonded appliance including a bite-block and a hyrax expansion screw. Before and after treatment, CT scans and active anterior rhinomanometry were performed on each patient. Data were analyzed with the non-parametric Wilcoxon statistical test and correlation between palatal expansion and increase of airflow in each patient was assessed. Transversal dimensions were significantly increased (P<0.05) in all areas after treatment, considering the right and left side separately. Rhinomanometry parameters before and after treatment also showed statistical differences (P<0.001). Positive correlation was observed between palatal expansion and increased airflow. All patients improved his/her oral breathing habit clinically.

Keywords: Oral breathing, Rapid maxillary expansion, Rhinomanometry, Airway resistance, Face development.

INTRODUCTION

Normal breathing involves adequate utilization of the nasopharyngeal tract. The air must pass freely and fluently through the nostrils with minimal resistance [1]. Unusual enlargement of anatomical structures in this area, such as adenoids, hypertrophy of nasal turbinates or tonsils, nasal injury, nasal septum deviation, neoplasms, congenital nasal deformities, foreign bodies, polyps, or allergic rhinitis, can obstruct the airflow within the nasorespiratory channel [1-6]. This obstruction can impair nasal breathing, resulting in an oral mode of respiration [1]. Some authors contend that oral breathing can be a habit [7].

Oral breathing can result in developmental long-term alterations, causing postural adaptations of the vertebral column, thoracic cavity, and craniofacial structures [8]. Craniofacial anomalies typically include anterior head posture, reduced development of the middle third of the face, increased anterior face height, steep mandibular plane angle, narrow external nares, incompetent lip posture, protrusion of upper incisors, “V” shaped maxillary arch, increased palatal depth, and a tendency towards anterior open bite [9-16]. Because the mandible has a lowered position, the tongue often adopts a low position, resulting in an underdeveloped upper jaw, bilateral compression, and posterior unilateral or bilateral cross-bite [13].

Rapid maxillary expansion (RME) has been an efficient treatment for posterior cross-bites since its introduction by Angell in 1860 [17]. It corrects the maxillary arch configuration and improves nasal breathing as a consequence of the separation of the palatal suture that results in widening of the nasal cavity and increased air permeability [18].

The nasal valve area is the narrowest part of the nasal cavity and it is the most resistant site to airflow [19,20]. It is located between the superior and inferior lateral cartilages and the pyriform notch, just beneath the anterior edge of the inferior turbinate. RME has its greatest effect on the anterior aspect of the palate, thus increasing the nasal valve area, resulting in an increase in nasal permeability [21,22]. The increase in nasal width has
been traditionally measured by posteroanterior radiographs [23,24]. This exam has limitations due to superimposition of anatomical structures. Computerized tomography (CT) produces serial slices in the nasal cavity from the pyriform notch to the choanae and can be used to quantify changes obtained with treatment. Few studies have used CT scans to measure these changes [25,26].

Respiratory function can be characterized by measuring the resistance of the airflow at the nasal cavity by rhinomanometry. This exam quantifies air resistance [27,28]. Rhinomanometry can be passive or active. During active rhinomanometry, the patient breathes continuously through the nose and measurements are made at the anterior or posterior area of the nasal cavity. Posterior rhinomanometry can be very unpleasant for the patient, especially children, because the instrument must be placed through the mouth into the posterior area of the nasal cavity. Resistance in each nasal cavity must be measured individually [29]. Anterior active rhinomanometry measures the resistance of the airflow at the nostrils and can be done separately on each side, detecting which side is more obstructed [30,31]. Anterior active rhinomanometry is simple and easy to perform, and therefore commonly used for the study of the nasal cycle and comparison of pre- and post-treatment results [32].

Little research has combined CT scan imaging and rhinomanometry to evaluate the anatomical and functional changes of the nasal cavities after RME [33]. Our study aimed to evaluate the nasal cavity anatomical structures by CT scan and the respiratory function by active anterior rhinomanometry in patients with oral breathing and posterior cross-bite before and after RME treatment.

METHODS

Thirteen patients (4 male, 9 female, age range 7-12-years-old, mean 9-years-old) were included in this study. All patients were mouth breathers and had bilateral cross-bite. None of these patients had previously undergone otorhinolaryngologic or orthodontic treatment. Each patient was evaluated clinically by an orthodontist and an otorhinolaryngologist. Panoramic radiographs, lateral and posteroanterior cephalograms, occlusal maxillary radiographs, dental casts, and clinical photographs were obtained to determine if the patient needed treatment. Study subjects could not have any acute respiratory pathology and could not use any anti-allergic medicine for 24 hours before each exam.

This study was approved by the bioethical board of the School of Dentistry, University of Concepción and informed consent was obtained from all patients’ parents.

Clinical treatment consisted of RME with a fully bonded appliance, including a bite-block and an hyrax expansion screw (Figure 1). Each patient was instructed to turn the screw ¼ of a turn (0.25mm expansion) twice a day until the cross-
bite was corrected. The appliance was left in place as a retention device for four months after treatment. The hyrax screw was inactivated by adding acrylic to the mechanism.

Before- and after-treatment CT scans and active anterior rhinomanometry were performed on each patient.

Three coronal slices were obtained from each patient with a helicoidal CT scanner (Somatom Plus 4, Siemens, Berlin, Germany). The anterior coronal slice was taken at the nasolacrimal duct, located at the same level as the pyriform notch. The middle coronal slice was taken at the beginning of the maxillary sinus ostium, and the posterior coronal slice was taken at the posterior border of the choanae (Figure 2). At each coronal slice, the right and left nasal cavity dimensions were measured at the widest portion of each side.

Active anterior rhinomanometry was used to quantitatively assess the air pressure through the nasal cavities. Patients were seated with a natural head position and measurements were obtained for 20 seconds during inhalation and exhalation, before and after administration of a decongestant (oximetazoline chlorhydrate 0.05%), in each side separately. Individual orthodontic treatment was performed for each patient after RME to fully correct their malocclusion.

Non-parametric Wilcoxon test was used to determine statistical differences. Differences were considered statistically significant when \( P<0.05 \). Correlation (Spearman) between degree of palatal expansion and increase in rhinomanometry flow was assessed in each patient.

RESULTS

Transversal dimensions were significantly increased \( (P<0.05) \) after treatment in both sides (Table 1). Rhinomanometric parameters also increased (Table 2). When comparing the average amount of expansion with the increase of airflow in each patient, there was a positive correlation (Spearman, \( R=0.27 \)), but this correlation was not statistically significant (Spearman, \( p=0.36 \)) (Figure 3).

![Figure 2. Three coronal slices were taken at the anterior, middle and posterior aspect of the nasal cavity.](image)

Table 1. Mean Values and SD of CT Measurements before and after Rapid Maxillary Expansion

<table>
<thead>
<tr>
<th></th>
<th>Before</th>
<th>SD</th>
<th>After</th>
<th>SD</th>
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<th>P value*</th>
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<td>ACS right</td>
<td>10.3</td>
<td>1.2</td>
<td>11.9</td>
<td>1.4</td>
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<td>12.2</td>
<td>1.6</td>
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<td>&lt; 0.05</td>
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<td>MCS right</td>
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<td>&lt; 0.05</td>
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<tr>
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<td>13.6</td>
<td>1.3</td>
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<td>&lt; 0.05</td>
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A clinical case is presented in Figures 4-8.

**DISCUSSION**

The present study showed that RME helps increase nasal breathing by widening the nasal bony structure and allowing more air to enter the nasal cavity as previously reported [25,26]. The most important differences before and after treatment were at the anterior portion of the nasal cavity, where the nasal valve is located and the greatest resistance to airflow was observed. This explains the significant clinical improvement that patients experienced. The posterior portion of the palate is more difficult to expand because of a locking effect of the pyramidal processes of the palatal bones into the pterigoid plates of the sphenoid [34]. Several studies determined a functional improvement in respiration after RME [35-37]. The introduction of a decongestant like oximetazoline, however, is a significant aid to determining the cause of the increased nasal resistance. If the decongestant reduced nasal resistance, the obstruction may have been influenced by soft-tissue problems, especially at the anterior aspect of the nasal airway [21].

Each patient studied had an increase in the CT scan measurements and a functional improvement measured by rhinomanometry. However, patients with the smallest differences in the rhinomanometric results were patients that presented turbinate hypertrophy or allergies.

Cone-beam computed tomography is generally preferred for research due to lower radiation doses [38], however, it was not available for the present study. Although CT scan imaging is still more expensive than conventional radiography, it is, in many aspects, a superior radiographic technique [39,40]. When acquired for orthodontic diagnosis, additional conventional radiographs can

<table>
<thead>
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<th>Difference</th>
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<td>Left 119.5</td>
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</table>

*Wilcoxon test.

Figure 3. Correlation between amount of palatal expansion and increase in rhinomanometry flow in each patient (Spearman).
Figure 4. Pre-treatment clinical intraoral photographs.

Figure 5. Pre-treatment CT scan measurements. A. Anterior coronal slice. B. Middle coronal slice. C. Posterior coronal slice.
Figure 6. Post-treatment clinical intraoral photographs.

Figure 7. Post-treatment CT scan measurements. A. Anterior coronal slice. B. Middle coronal slice. C. Posterior coronal slice.
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CONCLUSIONS
All patients treated with RME improved their oral breathing habit clinically and there was also statistical evidence that the nasal cavity increased its transversal dimensions, and patients increased their airflow through the nasal cavity. Although this study was performed in a small number of patients, the results showed very clearly the importance of the orthodontist in the improvement of nasal breathing.

REFERENCES


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