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Assessment Of Changes In Upper Airway Following Maxillary Expansion Using Cbct - Retrospective Study

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ABSTRACT

Introduction: RME can significantly enlarge nasal cavity volume and lower airflow resistance, thereby improving nasal breathing efficiency. Enhanced nasal patency following RME may contribute to improved airflow dynamics throughout the upper airway, potentially mitigating inspiratory effort and reducing the risk of pharyngeal airway collapse. The objective of this study was to evaluate volumetric changes in the upper airway using Cone Beam Computed Tomography (CBCT) in orthodontic patients undergoing Rapid maxillary expansion. Materials and methods: A total of 60 patient records which consisted of initial and final CBCT scans, photographs and proper follow up records were selected for the study. All CBCT images were acquired using a standardized iCAT CBCT device (Imaging Sciences International, Hatfield, PA, USA). The three-dimensional volumetric measurements were performed using InVivo Dental 5.0. The oro-pharyngeal, Naso-pharyngeal airway volume and posterior airway space were measured. All measurements were completed by an experienced orthodontist. Results: The present study showed a twofold increase in the NP volume after RME. This finding suggested that RME may be able to improve the breathing pattern by reducing nasal resistance, but further studies are needed to confirm such anatomical and functional correlations. Conclusion: Rapid maxillary expansion showed a significant increase in nasal airway volume but no significant change is observed in the oropharyngeal airway region.

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1. INTRODUCTION

Rapid maxillary expansion (RME) is routinely used in the orthodontic treatment of patients with transverse maxillary deficiency, dental crowding, and/or a mandibular functional shift. A common form of RME uses tooth-borne expanders with bands on molars and sometimes first premolars[1]. Transverse expansion is achieved through skeletal expansion, ie, opening of midpalatal sutures with separation of maxillary halves and dentoalveolar expansion, which can include buccal tipping of teeth and alveolar bending. Rapid expansion appliances produce varying amounts of dental and skeletal expansion[2]. Skeletal expansion is about half or less of the total amount of resulting expansion in adolescent patients[3].

Studies showed that heavy forces generated by expanders could impact the craniofacial structures beyond the midpalatal suture[4,5]. Following RME, high levels of stress were observed in surrounding structures, such as the zygomaticomaxillary, zygomaticotemporal, and frontomaxillary sutures, frontal process of the maxilla, and external wall of the orbits. Widening of nasal apertures, separation of the nasal floor, and displacement of the lateral nasal walls were also reported to be associated with sensation of pressure in the maxillary, nasal, or orbital areas[6,7]. A study by Garrett et al. showed that the average increase in nasal width following tooth-borne expansion with a hyrax was only 37% of the total appliance expansion[8].

As the hard palate is closely associated with the nasal cavity, maxillary expansion also leads to an expansion of the nasal upper airway. RME widens the palate, flattens the palatal arch with inferior displacement of the maxilla, and influences mandibular alignment[9,10]. Furthermore, RME has been found to have a positive impact on respiratory function and can contribute to the reduction of respiratory diseases. By widening the nasal airway and reducing air resistance, RME helps restore natural physiological function and improve overall respiratory health[11].

Numerous studies have demonstrated that RME can significantly enlarge nasal cavity volume and lower airflow resistance, thereby improving nasal breathing efficiency. Enhanced nasal patency following RME may contribute to improved airflow dynamics throughout the upper airway, potentially mitigating inspiratory effort and reducing the risk of pharyngeal airway collapse. The objective of this study was to evaluate volumetric changes in the upper airway using Cone Beam Computed Tomography (CBCT) in orthodontic patients undergoing Rapid maxillary expansion.

2. MATERIAL AND METHODS:

The study was approved by the Institutional Review Board of Ethical Committee. The study samples were obtained from the existing patient database of the Department of Orthodontics who underwent orthodontic treatment with rapid maxillary expansion. Control group included records of patients who underwent conventional orthodontic treatment without expansion. A total of 60 patient records which consisted of initial and final CBCT scans, photographs and proper follow up records were selected for the study.

All CBCT images were acquired using a standardized iCAT CBCT device (Imaging Sciences International, Hatfield, PA, USA). The acquisition settings involved an isotropic voxel size of 0.3 mm, an 8.9-s scan duration, a broad field of view, and parameters set to 120 kV and 20 mA. The images were taken in natural head position, with teeth in maximum intercuspation, and at the end of the exhalation period when the patient was not swallowing. Each scan was 9.6 seconds long, with a single rotation around the patient's head.

From the selected records, a group of 30 patients who underwent RME and a control group of 35 patients who underwent comprehensive orthodontic treatment were scrutinized. All participants had bilateral Class I malocclusion. Inclusion criteria for the test group were complete pre and post records, non-extraction treatment plan, and use of a Hyrax maxillary expander as part of the treatment provided. Exclusion criteria were history of craniofacial deformities, pharyngeal pathology and/or nasal obstruction, snoring, obstructive sleep apnea, adenoidectomy, and tonsillectomy. Any CBCT scans in which the airways were not clear, were not fully contained in the volume or contained artifacts were also excluded.

The test group consisted of patients with maxillary constriction treated with Hyrax maxillary expanders, and the control group consisted of patients who underwent regular orthodontic treatment without expanders. Expansion protocol consisted of twice per day screw activation until a slight amount of overcorrection was achieved. Screws were then stabilized, and the expander was passively left in place for 4–6 months. All subjects were treated with fixed MBT .o22 slot appliances and had good occlusion at the end of treatment.

The three-dimensional volumetric measurements were performed using InVivo Dental 5.0. The oro-pharyngeal, Naso-pharyngeal airway volume and posterior airway space were measured. The superior limit of the OP airway is the palatal plane (ANS-PNS), extending to the posterior wall of the pharynx, and the inferior limit is a line parallel to the palatal plane, touching the most anteroinferior point of the second cervical vertebrae. The superior limit of the NP airway is the last slice before the nasal septum fuses with the posterior wall of the pharynx, viewed on the axial slice first and then projected to the sagittal view. The inferior limit is the palatal plane.22 The posterior airway space (PAS) is defined as the most constricted space behind the base of the tongue and limited by soft tissues. All measurements were completed by an experienced orthodontist.

3. RESULTS:

Paired sample *t*-tests were used to compare changes from T0 to T1. The SPSS Statistics 17.0 (SPSS Inc, Chicago, Ill) software was used for all statistical analyses. P<.05 was considered to be statistically significant and P<.01 was considered to be statistically highly significant. The mean and standard deviation of oro pharyngeal airway, Naso-pharyngeal airway volume and posterior airway space volumes of both RME and control group at T0 and T1 were tabulated in table 1 and table 2. The mean and standard deviation of oro pharyngeal airway, Naso-pharyngeal airway volume and posterior airway space volumes of both RME and control group at T1- T0 were mentioned in table 3 which showed statistically significant difference in NP airway volume between RME and control group.

T0	RME group		Control group		P value
	Mean	SD	Mean	SD	
OP airway	7452	2415	7598	2081	0.78
NP airway	6771	5041	5742	2132	0.94
Posterior airway space	8.0	2.4	7.9	2.0	0.92

T1	RME group		Control group		P value
	Mean	SD	Mean	SD	
OP airway	9621	2872	9432	2420	0.83
NP airway	4432	2042	6548	2421	0.04
Posterior airway space	8.8	1.9	9.1	2.4	0.79

T1-T0	RME group		Control group		P value
	Mean	SD	Mean	SD	
OP airway	1472	1741	1274	2121	0.74
NP airway	1618	1532	842	1212	0.006**
Posterior airway space	0.2	1.4	1.1	2.3	0.41

4. DISCUSSION:

Rapid maxillary expansion is a conventional orthopedic treatment commonly performed in orthodontics to address maxillary constriction[12]. The main purpose of RME is to correct maxillary transverse deficiency and improve occlusion[13]. However, RME has been reported to improve nasal breathing other than arch expansion[14]. However, given the lack of robust long-term data, caution should be exercised when considering RME as a preventive approach for enhancing respiratory function in growing children.

The present retrospective study analyzed three-dimensional airway volume changes after RME treatment in teenage subjects. The present study used CBCT images taken before and after comprehensive orthodontic treatment in order to analyze the effects of a Hyrax maxillary expander. Given that all experimental subjects had orthodontic treatment in addition to RME, treatment may also have played a significant role in the results seen. To factor out changes introduced by comprehensive orthodontic treatment, a matched control sample was used.

The immediate and long-term effects of RME over the upper airway have been shown in previous studies[15,16,17]. The literature showed that patients presenting with maxillary constriction tend to have a higher nasal airway resistance[4]. The present study does not show a difference in nasal air passage volume at T0, but this may be due to the fact that patients with clinically normal respiratory functions for selected for both groups. The maxilla forms most of the lateral walls of the nasal cavity; therefore, an increase in volume in the nasal cavity would be an expected RME effect. The series of events that cause this phenomenon was mainly the triangular or parallel opening of the median palatal suture, which increased the width of the nasal floor and results in an increased volume of the nasal cavity. The present study showed a twofold increase in the NP volume after RME. This finding suggested that RME may be able to improve the breathing pattern by reducing nasal resistance, but further studies are needed to confirm such anatomical and functional correlations.

Zhao et al. assessed the changes of the OP airway on 24 patients with maxillary constriction treated with RME and compared them to 24 age- and sex-matched patients and found no significant increase[18]. They concluded that RME would not enlarge OP airway volume which was in accordance with the results of present study. Malkoç et al. evaluated the effects of mandibular symphyseal distraction osteogenesis followed by RME on pharyngeal size and concluded that RME did not significantly affect the pharyngeal dimensions[19]. The present study also confirmed such findings and also found no effect on pharyngeal airway when using RME.

5. CONCLUSION:

Rapid maxillary expansion showed a significant increase in nasal airway volume but no significant change is observed in the oropharyngeal airway region

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