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Rapid maxillary expansion in growing patients: Correspondence between 3-dimensional airway changes and polysomnography

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ABSTRACT

Objectives: The aim of the present prospective study was to investigate the effects of rapid maxillary expansion on the airway correlating airway volumes computed on cone beam computed tomography and polysomnography evaluation of oxygen saturation and apnea/hypopnea index.
Methods: The study group comprised 14 caucasian patients (mean age 7.1 ± 0.6 years) undergone to rapid maxillary expansion with Haas type expander banded on second deciduous upper molars. Cone beam computed tomography scans and polysomnography exams were collected before placing the appliance (T0) and after 12 months (T1). Landmarks localization and airway semiautomatic segmentation on cone beam computed tomography scans allowed airway volume computing and measurements.
Results: Increases of total airway volume, oxygen saturation and apnea/hypopnea index were statistically significant. No correlation was found among total airway volume, oxygen saturation and apnea/hypopnea index changes between the examined timepoints.
Conclusions: Computing airway volume on cone beam computed tomography allow to measure the amount of air that flows through nasal cavity, nasopharynx and oropharynx while oxygen saturation and apnea/hypopnea index could give information about functional parameters. In the present study all three variables investigated showed statistically significant differences between T0 and T1 but no correlation was found between increases of the different variables tested.

1. Introduction

Rapid maxillary expansion (RME) is a common orthodontic treatment to correct transverse maxillary discrepancy. It was suggested that RME might influence nasal morphology [1,2] and breathing pattern [3,4].

Wertz [5] investigated the advantages of RME in improving nasal airflow in patients with nasal stenosis. However, considering the V-shaped opening pattern of the midpalatal suture, he claimed that RME cannot be justified for the sole purpose of increasing nasal permeability unless the obstruction is in the lower anterior portion of the nasal cavity and bilateral maxillary arch-width deficiency.

Several studies investigated nasal airway resistance finding reduction of resistances after RME [6,7]. These results were confirmed by Warren et al. [8] who reported 45% increase in nasal cross-sectional areas after expansion.

Airway changes after RME have been studied with different means including acoustic rhinometry, 2d and 3d radiographic technique such as cone beam computed tomography (CBCT).

Other diagnostic tool can be employed to investigate the effects of RME on airflow from a more functional point of view. The measurement of the volumes of airway compartments may be biased by several factors such as head and tongue position during CBCT scan acquisition, breathing, swallowing movements, repositioning of the tongue and the mandible after treatment. Moreover threshold-based segmentation of airway may not be standardized although, the method errors were acceptable for the present study. The combination of morphological recording with functional respiratory analyses is therefore recommended. Polysomnography examinations (PSG), often employed in obstructive sleep apnoea (OSA) patients [9], could give further information about breathing pattern, showing quantitative data such as oxygen saturation (SpO_2) and apnea/hypopnea index (AHI).

The aim of the present prospective study was to investigate the effects of RME on the airway correlating airway volumes computed on CBCT and PSG examinations (SpO_2 and AHI).

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Table 1
Selection criteria.

1. Age (6–9 years)
2. CVS 1 skeletal maturation
3. Functional unilateral posterior crossbite
4. Early mixed dentition
5. Upper and lower first molars erupted
6. No systemic disease
7. No skeletal asymmetries
8. No previous orthodontic treatment
9. High risk of upper canine impaction

2. Methods

Ethical approval for this study was obtained from the local Ethical Committee (no. 5184) and informed consent forms were signed by the parents of all patients. The sample consisted of patients treated at the dental clinic.

The selection criteria for the present prospective study are shown in Table 1.

The initial study group comprised 21 caucasian patients. 7 patients were considered drop out for low quality of the CBCT scans. The final study sample comprised 14 patients (mean age 7.1 ± 0.6 years), who fully matched inclusion and exclusion criteria.

The maxillary expander (Snap Lock Expander 10 mm A167-1439, Forestadent, Pforzheim, Germany) used for all subjects was Haas type expander banded to the upper second deciduous molars (Fig. 1) as previously suggested [10]. The maxillary expanders were banded using glass ionomer cement (Multi-Cure Glass Ionomer Cement, Unitek, Monrovia, CA, USA) in accordance with the manufacturer's instructions. The screw of the palatal expander was initially turned two times (0.45 mm initial transversal activation). Afterwards patients were instructed to turn the screw once per each following day (0.225 mm activation per day). The maxillary expansion was performed until dental overcorrection (2 mm) was achieved or when occlusion relationship evaluated at the first permanent molars was cusp to cusp. At the end of the active expansion period (32 ± 5 days) the screw was locked with light-cure flow composite (Premise Flowable; Kerr Corporation, Orange, CA, USA). The palatal expander was removed 12 months after it was inserted, at the end of the retention period. During this period no other fixed orthodontic appliances were used in any patients.

CBCT scans (i-CAT, Imaging Sc. Int., Hatfield, PA, USA) were performed in seated position before inserting the maxillary expander (T0) and at the end of retention (T1), 12 months later when the expander was removed.

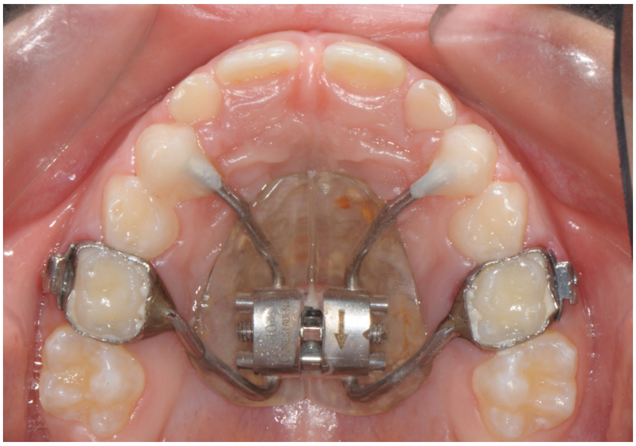

Fig. 1. RME on deciduous second molars.

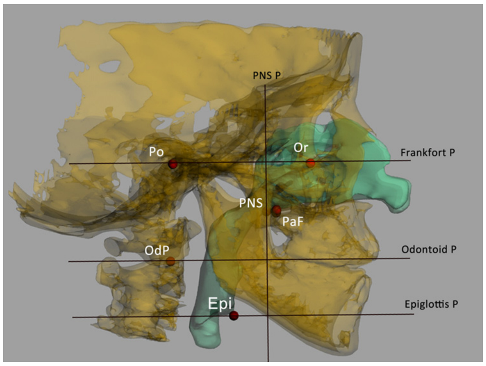

Fig. 2. 3d landmarks and planes.
Po: porion right and left; Or: orbitale right and left; PNS: posterior nasal spine; PaF: palatal foramen right and left; OdP: middle point of odontoid process of second cervical vertebra; Epi: top of the epiglottis. Frankfort plane: plane passing through PoR-PoL-OrR-OrL; PNS plane: projection on PNS of plane perpendicular to Frankfort passing through PoR-PoL; odontoid plane: passing through OdP and parallel to Frankfort; epiglottis plane: passing through top of the epiglottis and parallel to Frankfort.

PSG examination (Embletta-EMBLA, Thornton, CO, USA) was performed for all subjects at T0 and T1 to collect SpO_2 and AHI.

2.1. *Image processing*

Dicom images were processed in two steps.

2.1.1. *Landmarks localization and airway semiautomatic segmentation*

Dicom images were acquired in Mimics software (version 10.11, Materialise Medical Co, Leuven, Belgium). First a set of reproducible landmarks and planes was defined (Fig. 2). Distance between palatal foramens (PaF) right and left were used to assess total maxillary expansion (Fig. 2). Planes were used to obtain a reproducible position of head and to define airway compartments (Fig. 3).

The airway was segmented using thresholding based segmentation manually corrected slice by slice. The upper limit of UPPER AIRWAY was set at the edge between nasal bones and etmoid bone.

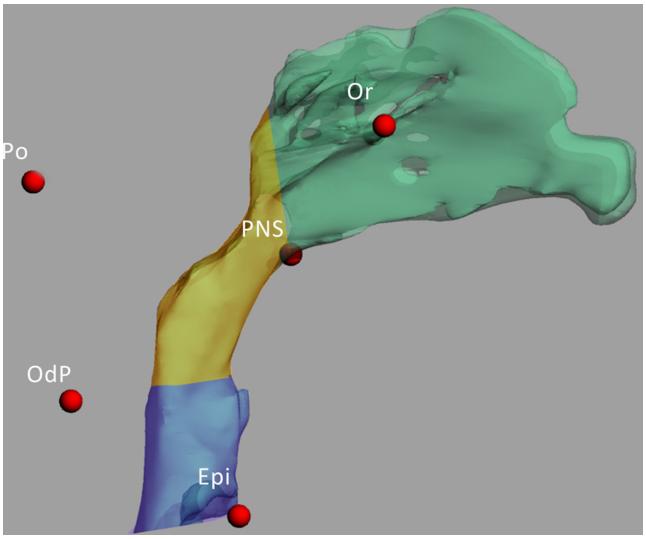

Fig. 3. Airway compartments.
Upper airway (green) from nares to PNS plane; middle airway (yellow) from PNS plane to OdP plane; lower airway (blue) from OdP plane to epiglottis plane; total airway (AIR) from nares to epiglottis plane. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of the article.)