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Evaluation of maxillary arch dimensions and palatal morphology in mouth-breathing children by using digital dental casts

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ABSTRACT

Objective: The aim of the present study was to analyze the variations of maxillary arch size and of palatal morphology in subjects with prolonged mouth-breathing due to allergic rhinitis when compared with a control group with normal breathing pattern by using a three-dimensional analysis on digital casts.
Methods: 26 Caucasian children (19 females and 7 males) with a mean age of 8.5 years (SD 1.6 years) were selected according to the following criteria: mouth-breathing pattern due to allergic rhinitis, early mixed dentition, skeletal Class I relationship and prepubertal stage of cervical vertebral maturation. The study group was compared with a control group of 17 nasal breathing subjects (9 females; 8 males, mean age 8.5 years SD 1.7 years). For each subject an initial dental cast was taken and the upper arch was scanned by using a tridimensional scanner. On each digital model linear measurements were performed to analyze maxillary arch dimensions and palatal morphology. Significant between-group differences were tested with the Student *t*-test ($p < 0.05$).
Results: the transverse dimension of the upper arch was significantly smaller in subjects of the study group thus confirming the influence of oral breathing on skeletal development with a significant constriction of the whole palate. The study group showed a higher and sharper palatal vault at the level of second deciduous molars and of first permanent molars.
Conclusions: Children with mouth-breathing pattern showed a significant constriction of the maxillary arch and an increased palatal height when compared with subjects with normal breathing pattern.

1. Introduction

The development of the craniofacial structures is the result of the continuous interactions between genetic and environmental factors. Mouth-breathing is a pathological alteration of the normal breathing pattern [1]. Prolonged mouth-breathing can produce muscular and postural alterations, which interacting with the craniofacial structures, can cause alterations on the morphology, position, and growth direction of the jaws [2]. Mouth-breathing causes the tongue to rest in a low position in the oral cavity. This will result in an imbalance of forces between the cheeks and the tongue, which can directly affect the growth and development of the upper and the lower jaws [3]. In mouth-breathing patients the tongue does not exert any force on the upper teeth, which allows the upper arch to remain undeveloped, directly influencing the skeletal development in preschool children [4]. Although mouth-breathing etiology is multifactorial, the most common causes are anatomical obstruction, such as palatine and pharyngeal tonsil hypertrophy, allergic rhinitis, nasal septal deviation, nasal polyps and nasal turbinate hypertrophy [5]. In particular allergic rhinitis, a chronic respiratory problem with a high prevalence, result from a complex, allergen-driven mucosal inflammatory process that can result in nasal obstruction with consequent transition from nasal to oral breathing [6].

In the literature the effects of the alteration of the normal breathing pattern on dental arches have generally been described as dimensional changes in intercanine and intermolar width and arch lengths by using traditional methods on dental casts measured with calipers [3–5,7,8]. Vieira et al. [3] and Harari et al. [6] found that a change in the breathing pattern of children can induce dental changes such as a narrowing of the maxillary arch at the level of the canine. Bresolin et al. [7] as well Mattar et al. [8], demonstrated that mouth-breathing individuals showed greater palatal height and narrower intermolar width than did

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nasal-breathing subjects. However, changes measured with a traditional measuring approaches might not always highlight the modification in the arch form [9,10] and these methods could not exclude bias in assessing the transverse dimension of the maxillary arch due to improper tooth position, such as the buccal tooth tipping [11,12]. To overcome these problems, an optical scanner can be used to obtain three-dimensional images of dental casts [13]. In fact, recent advances in digital technology have vastly improved the diagnostic phase of orthodontic treatment, and analog records have quickly been replaced by digital formats [14]. Several studies in the literature have verified the accuracy of angular and linear measurements on three-dimensional digital models with different software [15,16]. Three-dimensional images allow to assess linear and angular measurements that describe the arch form and the morphology of the palatal vault [16].

The aim of the present study was to analyze the variations of maxillary arch dimensions and of palatal morphology in a group of subjects with prolonged mouth-breathing due to allergic rhinitis when compared with a control group of subjects with normal breathing pattern and occlusion by using a three-dimensional analysis on digital dental casts.

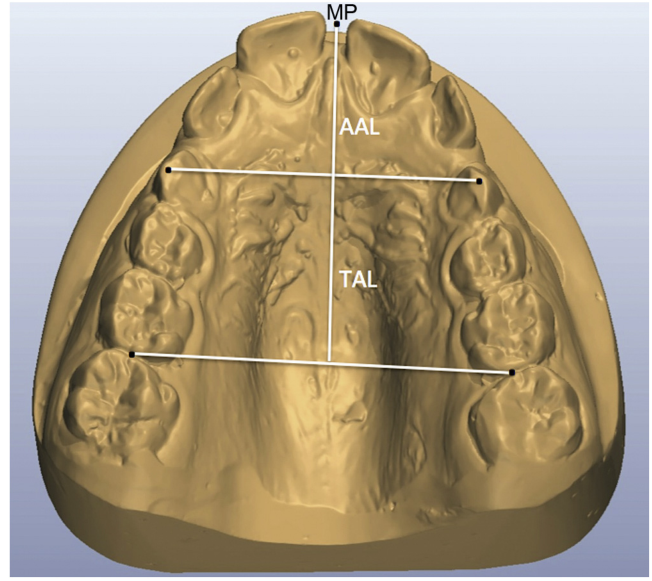

Fig. 1. Conventional measurements: AAL: distance from the midpoint (MP) to a line joining the cusps of upper deciduous canines; TAL: distance from MP to a line joining the mesial surfaces of the first permanent molars.

2. Materials and methods

26 Caucasian children (19 females; 7 males) with a mean age of 8.5 years (SD 1.6 years) who sought orthodontic treatment at the Department of Orthodontics at the University of Rome "Tor Vergata" were selected. The inclusion criteria for the enrollment of the subjects in the study group (SG) were mouth-breathing pattern due to allergic rhinitis, early mixed dentition with either a Class I or end-to-end molar relationship, skeletal Class I relationships and prepubertal stage of cervical vertebral maturation as assessed by the cervical vertebral maturation method (CS1, CS2) [17]. Mode of breathing was defined by an otorhinolaryngologist according to complete physical examination including skin testing, anterior rhinoscopy, rhinomanometry to measure nasal airflow and pressure during respiration, flexible nasopharyngoscopy or nasopharyngeal X-ray, and to history confirmed by questionnaire answered by the patients' parents. Only at the end of the complete examination the otorhinolaryngologist classified subjects as showing normal respiratory pattern or as exclusive mouth breathers. 44% of the subjects of the study group presented with palatine and/or pharyngeal tonsil hypertrophy. However, the pathological characteristic that was found in all subjects of the study sample was prolonged allergic rhinitis. Probably as a consequence of mode-breathing, 13 subjects of the study group presented with a unilateral posterior cross-bite, 8 with a bilateral posterior cross-bite and 5 without posterior cross-bite. In 5 patients with unilateral posterior crossbite an associated openbite due to lack of space for the complete eruption of the upper incisors was observed.

Exclusion criteria were: sucking habits, previous history of nasal respiratory surgery, previous orthodontic treatment, lip-palate cleft, and other genetic diseases. This project was approved by the Ethical Committee at the University of Rome, "Tor Vergata", and informed consent was obtained from the patients' parents.

The study group was compared with a control group of 17 prepubertal subjects (9 females; 8 males) presenting with normal breathing pattern and mean age of 8.5 years (SD 1.7 years). The control group matched the study group as to occlusal development, skeletal and occlusal relationships, and skeletal maturation. No subjects of the control group showed either transverse or vertical skeletal discrepancies.

For each subject of the study and control groups initial dental casts were available. In order to analyze the maxillary arch form and the palatal morphology, the upper dental casts were scanned by a tridimensional scanner (D800, 3Shape A/S, Copenhagen K Denmark, Scan time 25 s, Resolution 2 cameras 5.0 megapixels, Ultra high point accuracy <15 microns). Each cast was scanned from 10 or more views that were then combined and rendered into three-dimension by using a specific software (3shape-ScanItOrthodontics™ 2010 -2p3, 3Shape A/S, Copenhagen K, Denmark). The virtual three-dimensional models were measured and analyzed with a specific software (3Shape-OrthoAnalyzer™ 2010, 3Shape A/S, Copenhagen K, Denmark).

To analyze the transverse and the sagittal dimensions of the maxillary arch, a midpoint (MP) was identified on each digital model as the midpoint between the most mesial point of the incisal margin of both central incisors. Subsequently, conventional linear measurements according to Bu et al. [18], and Ahn et al. [11] were performed (Fig. 1):

- Anterior Arch Length (AAL): distance from MP to a line joining the cusp tips of the deciduous canines;
- Total Arch Length (TAL): distance from MP to a line joining the midpoints of the mesial margins of the first permanent molars.

As previously described by Primozic et al. (2013) [12,13], a gingival plane was constructed by connecting the center of the dento-gingival junction of all teeth (Fig. 2). After the identification of the gingival plane the following measurements were performed:

- D3: distance between the centers of dento-gingival junctions of right and left deciduous canines;
- D4: distance between the centers of dento-gingival junctions of right and left first deciduous molars;
- D5: distance between the centers of dento-gingival junctions of right and left second deciduous molars;
- D6: distance between the centers of dento-gingival junctions of right and left first permanent molars;
- H3: distance between the gingival plane and the highest point of the palatal vault on the midpalatal rafe at the level of deciduous canines;
- H4: distance between the gingival plane and the highest point of the palatal vault on the midpalatal at the level of first deciduous molars;