International Journal of Pediatric Otorhinolaryngology 75 (2011) 518–522

Contents lists available at ScienceDirect

International Journal of Pediatric Otorhinolaryngology

journal homepage: www.elsevier.com/locate/ijporl

Thin-plate spline analysis of craniofacial morphology in subjects with adenoid or tonsillar hypertrophy

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ARTICLE INFO

Article history:
Received 17 October 2010
Received in revised form 7 January 2011
Accepted 10 January 2011
Available online 18 February 2011

Keywords:
Adenoids
Tonsils
Airway
Craniofacial growth
Cephalometrics

ABSTRACT

Objective: To compare the skeletal features of subjects with adenoid hypertrophy with those of children with tonsillar hypertrophy using thin-plate spline (TPS) analysis.
Materials and methods: A group of 20 subjects (9 girls and 11 boys; mean age 8.4 ± 0.9 years) with adenoid hypertrophy (AG) was compared with a group of 20 subjects (10 girls and 10 boys; mean age 8.2 ± 1.1 years) with tonsillar hypertrophy (TG). Craniofacial morphology was analyzed on the lateral cephalograms of the subjects in both groups by means of TPS analysis. A cross-sectional comparison was performed on both size and shape differences between the two groups.
Results: AG exhibited statistically significant shape and size differences in craniofacial configuration with respect to TG. Subjects with adenoid hypertrophy showed an upward dislocation of the anterior region of the maxilla, a more downward/backward position of the anterior region of the mandibular body and an upward/backward displacement of the condylar region. Conversely, subjects with tonsillar hypertrophy showed a downward dislocation of the anterior region of the maxilla, a more upward/forward position of the anterior region of the mandibular body and a downward/forward displacement of the condylar region.
Conclusions: Subjects with adenoid hypertrophy exhibited features suggesting a more retrognathic mandible while subjects with tonsillar hypertrophy showed features suggesting a more prognathic mandible.

1. Introduction

The pharyngeal tonsils and the palatine tonsils, together with lateral pharyngeal bands and lingual tonsils are parts of the Waldeyer's ring. This is a complex of lymphoid tissue encircling the pharynx with an important role in the immunologic defense of the body [1,2]. Adenoids/pharyngeal tonsils are located at the upper posterior wall of the nasopharynx [3], while palatine tonsils are located in the oropharynx between the faucial pillars [4]. In some children excessive growth of lymphoid tissues can lead to obstruction of the pharyngeal airway space which may cause breathing problems [5].

Adenoid hypertrophy is reported as one of the main causes of respiratory obstruction and, consequently, mouth breathing in children [3,4,6,7]. Prolonged mouth breathing leads to muscular and postural alterations, which in turn, may cause dentoskeletal changes affecting the morphology, position and growth direction of both the maxilla and the mandible [6–11]. Mouth breathing due to adenoid hypertrophy is frequently associated with retrusion of the mandible relative to the cranial base, increased mandibular and palatine inclination, vertical growth pattern, increased lower facial height, decreased posterior facial height and narrow palate [6,7,12–15].

On the other hand, grossly enlarged tonsils may create an obstruction in the oropharyngeal space and may displace the tongue in a downward and forward direction to maintain an adequate respiratory space posteriorly [1,2,4,16,17]. However, there are still some doubts if tonsillar hypertrophy may determine significant craniofacial alterations [1,2,4,7,16,17].

Most investigations refer to changes in facial growth resulting from respiratory obstruction due to either enlarged adenoids or tonsils [1,6,12,13,15–18]. Studies comparing skeletal features associated with adenoid hypertrophy with those associated with tonsillar hypertrophy by means of classical cephalometric investigations are rare in the literature [7,19]. Trotman et al. [19] evaluated the association of lip posture, sagittal airway size and tonsil size with facial morphology in a sample of 207 children aged 3–13 years who presented for evaluation of tonsil and/or adenoid problems. Larger adenoid size was characterized by an en bloc backward rotation of

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0165-5876/$ – see front matter
doi:10.1016/j.ijporl.2011.01.010

the maxilla and the mandible relative to the cranial base, a shorter mandibular body and a more vertical facial growth direction. Larger size of the tonsils was associated with a forward relocation of the maxilla and the mandible relative to the cranial base, an increased mandibular length and a more horizontal growth of the face.

On the contrary Sousa et al. [7] compared 59 children with isolated adenoid hypertrophy and 58 children with adenotonsillar hypertrophy and found that the craniofacial growth pattern was similar in the two samples. Both groups showed a retrognathic mandible, a skeletal Class II disharmony and an increased mandibular plane angle. No significant differences were found between the two groups except for the length of mandibular ramus which was significantly larger in children with adenotonsillar hypertrophy aged 7–10 years.

A new morphometric approach (thin-plate spline, TPS, analysis) has been proposed by Bookstein for the comparison of configurations of landmarks in two or more specimens. It is a descriptive method of shape and shape changes that have been developed and implemented as major improvement when compared with conventional cephalometrics [20,21]. TPS analysis enables the construction of transformation grids that capture the differences in shape and are available for visual interpretation. In recent times TPS has become increasingly important in orthodontics as a mean of investigating modification in shape related both to facial growth and treatment [22,23].

The aim of this study was to compare the skeletal features of subjects with adenoid hypertrophy with those of children with tonsillar hypertrophy by using TPS analysis.

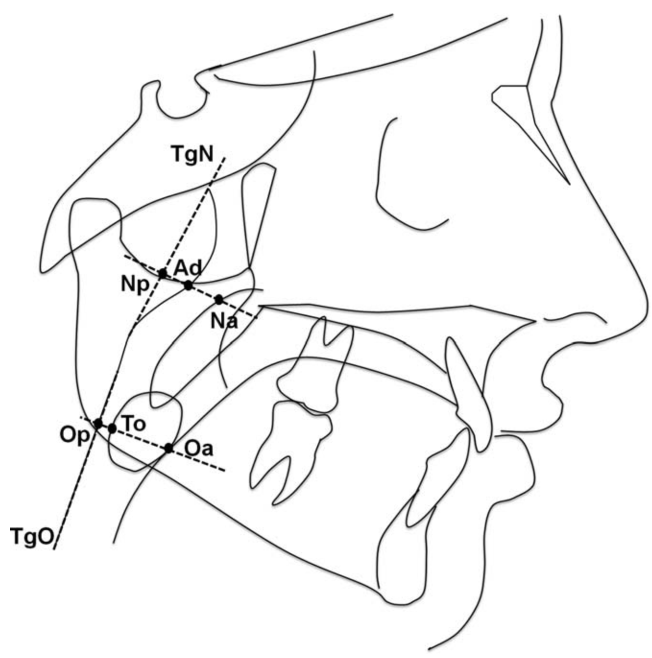

Fig. 1. Cephalometric reference points and lines on lateral cephalograms for measurements describing pharynx, adenoids and tonsils. TgN (tangent nasopharynx): line passing through the most superior and the most inferior point of the adenoid shadow, which represents the posterior wall of the nasopharyx without adenoids. Ad (adenoidal point): the most anterior point on the anterior outline of the adenoid shadow (nearest point to the soft palate). Ad–TgN (perpendicular nasopharynx): line perpendicular to TgN passing through Ad. Np (nasopharynx posterior): intersection of the lines Ad–TgN and TgN. Na (nasopharynx anterior): intersection of the posterior outline of the soft palate and the line Ad–TgN. TgO (tangent oropharynx): tangent line to the posterior wall of the oropharynx. To (tonsillar point): the most posterior point of the posterior outline of the tonsillar shadow (the nearest point to the posterior wall of the oropharynx). To–TgO (perpendicular oropharynx): line perpendicular to TgO passing through To. Op (oropharynx posterior): intersection of the lines TgO and To–TgO. Oa (oropharynx anterior): intersection of the line To–TgO and the posterior outline of the tongue (or the anterior outline of the tonsils).

2. Materials and methods

For this study the sample population was taken from the database of the Department of Orthodontics of the University of Rome "Tor Vergata" since 2001. The final sample of children was selected on the basis of the following inclusionary criteria: (1) history of respiratory problems due to adenoid or tonsillar hypertrophy; (2) otorhinolaryngological examination for adenoids and tonsils to confirm the anamnesis; (3) visibility of adenoid or tonsillar hypertrophy on lateral cephalograms; (4) technically adequate pre-treatment lateral cephalograms; (5) no history of adenoidectomy, tonsillectomy or adeno-tonsillectomy; (6) 6–10 years of age; (7) pre-pubertal stage of skeletal maturity according to the cervical vertebral maturation method (CS1 or CS2) [24]; (8) no history of previous orthodontic therapy.

Lymphoid tissue hypertrophy was assessed on the lateral cephalogram. Adenoid tissue appears as a somewhat convex prominence attached to the roof and the posterior wall of the nasopharynx and facing the superior surface of the soft palate [4,25], while palatine tonsils appear as an oval-shaped shadow in the oropharyngeal space dorsal to the root of the tongue [1,2,17].

Sagittal nasopharyngeal and oropharyngeal airway size, adenoid size and tonsil size were measured by tracing the reference points and lines illustrated in Fig. 1. The following measurements were performed:

Total Nasopharyngeal Airway Space (*TNAS*): the distance from nasopharynx posterior (Np) to nasopharynx anterior (Na);
Adenoid Size (*AS*): the distance from nasopharynx posterior (Np) to adenoidal point (Ad);
Total Oropharyngeal Airway Space (*TOAS*): the distance from oropharynx posterior (Op) to oropharynx anterior (Oa);
Tonsil Size (*TS*): the distance from tonsillar point (To) to oropharynx anterior (Oa).

The percentage of adenoid or tonsillar obstruction of the pharyngeal airway space was derived mathematically as follows: $(AS/TNAS) \times 100$ and $(TS/TOAS) \times 100$. Four degrees of obstruction of the pharyngeal airway space were detected:

Obstructive adenoids: when AS was larger than 50% of TNAS;
Non-obstructive adenoids: when AS was equal to or smaller than 50% of TNAS;
Obstructive tonsils: when TS was larger than 50% of TOAS;
Non-obstructive tonsils: when TS was equal to or smaller than 50% of TOAS.

The 40 patients satisfying the inclusionary criteria were divided into two study groups on the basis of the degree of obstruction due to either adenoid or tonsillar hypertrophy:

- *Adenoid Group* (AG) consisting of children with obstructive adenoids and non-obstructive tonsils;
- *Tonsillar Group* (TG) comprising children with obstructive tonsils and non-obstructive adenoids.

Based on lateral films, cephalograms of all the subjects were hand-traced on a 0.03 in.-thick frosted acetate paper by a single investigator and checked by another investigator. A cross-wires cursor was used to achieve digitization of landmarks. Landmarks for the description of the craniofacial region (Fig. 2) were identified and digitized by means of appropriate software (Viewbox 3.1, dHAL Software, Kifissia, Greece) and a digitizing table (Numonics, Lansdale, Pa). To increase the reliability of the landmarks selected the cephalograms were taped to a light box of uniform brightness in a darkened room.