Correspondence Between Subjective and Linear Measurements of the Palatal Airway on Lateral Cephalometric Radiographs

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Objective: To evaluate the correlation between and significance of 2 methods of palatal airway assessment on lateral cephalographs.

Design: Diagnostic lateral cephalometric imaging study that took place from January 1, 2006, to December 31, 2007.

Setting: American University of Beirut Medical Center.

Patients: Children with chronic mouth breathing referred by a pediatric otolaryngologist for cephalometric evaluation by participating orthodontists.

Main Outcome Measures: Two distances were measured on the digitized lateral cephalographs between the adenoid and soft palate: the shortest adenoid distance (SAD) and the most convex adenoid distance (CAD). The palatal airway was assessed on a grade-1 to grade-3 scale independently by the referring otolaryngologist and an orthodontist.

Results: A total of 200 children were included in the study (127 boys and 73 girls; mean age, 6 years; age range, 1.71-12.62 years). High correlations were observed between the airway ratings gathered by both examiners ($r=0.96$) and between SAD and CAD ($r=0.92$). Significant correlations were noted between the palatal airway grade and the SAD and CAD measurements ($r=-0.73$ and $r=-0.79$, respectively). Shortest adenoid distance measures of 2 mm or less corresponded mostly to grade 3 obstruction and were more prevalent in patients younger than 6 years. Age was inversely proportional to both the grade and SAD ($P < .001$).

Conclusions: Both methods are reliable for assessment of airway obstruction by the adenoid. Because SAD and CAD are highly correlated, we recommend the use of SAD as a more readily identifiable distance on cephalometric radiographs. Removal of adenoids when SAD is less than 2 mm may be indicated because this condition reflects a severe airway obstruction associated with potential changes in dentofacial structure.


ADENOID FACES, OR LONG face syndrome, is the ultimate dentofacial dysmorphic pattern related to chronic nasal obstruction, usually by an obstructive adenoid.1 The typical morphologic and dental characteristics of long face syndrome include increased lower facial height, increased divergence of the mandible relative to the cranial base and the maxilla, increase in the gonial angle (angle between mandibular ramus and corpus), retrognathic mandible, and backward rotation of the palatal plane. Even though radiographs have been used as early as the 1920s to detect the existence of enlarged adenoids and evaluate the size of the nasopharyngeal area, the possible link between nasal obstruction and altered facial growth was not immediately recognized. Roentgenography and eventually cephalometrics became important diagnostic tools that enabled orthodontists to gauge the hard and soft anatomical structures that contribute to facial growth and development and to investigate the relationship between nasal obstruction and craniofacial development.2-5 In various cephalometric studies, the degree of obstruction of the palatal airway by the adenoid has been assessed. Both objective cephalometric measures and subjective grading of the obstruction have been used, but the relationship between such methods has not been properly investigated. The aim of this article is to compare a subjective rating with a linear cephalometric method of palatal airway assessment.

METHODS

PATIENTS

Children aged 1 to 13 years diagnosed as having chronic (lasting for >3 months) mouth breathing and suspected of having obstructive adenoid were enrolled in the study after

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institutional review board approval was obtained. Initially screened by our pediatric otolaryngologist (M.A.B.) through routine history and physical examination, the patients were then referred to the Division of Orthodontics and Dentofacial Orthopedics, American University of Beirut Medical Center, for diagnostic lateral cephalometric imaging. The exclusion criteria were previous adenoidectomy, current medical treatment for nasal obstruction, systemic disease, and craniofacial abnormalities. Our study took place from January 1, 2006, to December 31, 2007.

**LATERAL CEPHALOMETRIC METHOD**

All patients wore a lead apron before x-ray exposure. The head of the patient was positioned in the (digital) cephalostat (GE/Instrumentarium, Helsinki, Finland) in a natural head position,6 with the midsagittal plane perpendicular to the machine platform. (The natural head position is a standardized orientation of the head achieved when one focuses on a distant point at eye level.6) Patients were instructed to keep their teeth occluded in the retruded contact position with the lips gently touching. The distance between the midsagittal plane of the face and the film (GE/Instrumentarium) is set by the manufacturer, and the corresponding radiographic magnification7 is adjusted for automatically. In the instance when the child could not stand alone, a parent volunteered to hold the child; both the parent and child were covered with lead aprons. The cephalographs were stored and saved spontaneously in the computer of the radiology unit.

**PALATAL AIRWAY ASSESSMENT**

One investigator (A.T.M.) imported and digitized the lateral cephalometric radiographs (Dolphin Imaging program; Dolphin Imaging and Management Solutions, La Jolla, California). Various orthodontic measurements were taken for a parallel orthodontic study. Two methods were used to quantify the palatal airway: a grading system based on direct observation and linear measurements.

Three grades were defined in the rating system: grade 1 indicates that less than 50% of the airway is obstructed, grade 2 indicates that more than 50% but less than 100% of the airway is obstructed, and grade 3 indicates that a near-total to total obstruction is observed (Figure 1). The degree of obstruction was rated independently by the orthodontist (A.T.M.) and the pediatric otolaryngologist (M.A.B.). Patient identity was kept anonymous during the scoring. Two linear measurements between the adenoid and soft palate were used to assess the patency of the palatal airway (Figure 2), the shortest adenoid distance (SAD), and the most convex adenoid distance (CAD).

**STATISTICAL ANALYSES**

The Pearson product moment correlation coefficient was used to test the interexaminer correspondence on palatal airway grading. The distribution of the palatal airway obstruction grade among the different age groups was compared with a χ² test. A 1-way analysis of variance was used to compare various obstruction grades among age means. Three categories of SAD were compared among the different age groups with the χ² test. The Pearson product moment correlation coefficient was computed for associations between the 2 methods of palatal airway assessment.

**RESULTS**

A total of 200 patients (127 boys and 73 girls), with a mean age of 6.0 years and an age range of 1.71 to 12.62 years, were enrolled in this study. Most patients (70.5%)
were younger than 7 years, with 93 patients (46.5%) younger than 5 years; the greatest percentage of patients (24.5%) were 4 to 4.9 years old (Figure 3). The correlation for interexaminer grading of the palatal airway was high ($r = 0.963$). Because no statistically significant difference was observed between the examiners, the grading of the pediatric otolaryngologist was used for the statistical computations.

Most patients had grade 2 obstruction (60.5%), followed by grade 1 (28.0%) and grade 3 (11.5%). The age was inversely correlated with the grade of airway obstruction, with a mean age of 4.6 years in those with grade 3 obstruction, 5.8 years in those with grade 2 obstruction, and 7 years in those with grade 1 obstruction ($P < .001$) (Table). The mean SAD was 3.8 (2.6) mm (range, 0-10.8 mm), and the mean CAD was 4.5 (3.1) mm (range, 0-14 mm). For SAD, a mean of 0.8 mm (range, 0-1.7 mm) was found in grade 3 obstruction, 3.01 mm (range, 0-6 mm) in grade 2 obstruction, and 6.7 mm (range, 6.7-108 mm) in grade 1 obstruction (Table). Because SAD and CAD measures correlated at $r = 0.915$, SAD measurements were chosen for statistical analysis. The prevalence of the lowest SAD measurements (0-2 mm), which encompassed all the patients with grade 3 obstruction but also some of those with grade 2, was highest at the younger ages (Figure 4). The palatal airway grading correlations with SAD and CAD measurements were $r = -0.73$ and $r = -0.79$, respectively, accounting for correspondence of evaluation in more than 50% of the population.

**COMMENT**

Edward Angle,8 known as the father of contemporary orthodontics, classified the occlusion into 3 categories still used by orthodontists today. Accounting for mouth breathing in relation to the malocclusion he labeled as class II, division 1, which corresponds to a more posterior position of the mandibular permanent first molar (specifically the mesiobuccal cusp) relative to its maxillary counterpart, and an increased horizontal overbite of the anterior teeth (incisors). Angle states, “This form of malocclusion is always accompanied and, at least in its early stages, aggravated, if not indeed caused by mouth breathing due to some form of nasal obstruction.”

Orthodontists are concerned with nasal obstruction because it may lead to morphologic characteristics that affect facial pattern and dental occlusion.3-9,13 Often, they alert the pediatric otolaryngologist to the importance of clearing the airway and restoring nasal breathing. The present findings underscore the importance of early diagnosis through credible methods of evaluation: the cephalometric linear measurements provide a reliable objective method, closely followed by the more subjective rating system.

Of interest in this study is the finding that the distances between the adenoid and soft palate (SAD and CAD), which correlated highly with each other ($r = 0.92$), also had good correlations with the observational rating ($r = -0.73$ and $r = -0.79$, respectively). We further analyzed all SADs of 2 mm or less because the grade 2 obstructions contained a number of SADs between 0 and 2 mm. Because no study or clinical experience suggests that the adenoid is the only obstacle to airway obstruction in any single patient, a clearance of 0 to 2 mm in SAD is considered close to full obstruction. Therefore, in these patients, the role of the adenoid in the impairment of nasal breathing would be primary and consequently the removal of the tissue recommended if accompanied by early signs of facial dysmorphologic features. Clearly, if other reasons are also identified, adenoidectomy would be part of the treatment strategy.

Our results emphasize the need for pediatricians and otolaryngologists to assess children early for impaired nasal breathing. Many physicians justify delaying the removal of the adenoids because of their pattern of growth. The adenoids increase in size during the prekindergarten through primary-grade years, then decrease during the preteen years and early adolescence.14 The relationship between the nasopharynx size and the adenoid size is of critical importance.4,14 The shape and size of the nasopharyngeal cavity can be defined in terms of depth and height in the sagittal plane and width in the frontal plane. Many authors studied the growth of the nasopharyngeal space on cephalographs. The total depth of the nasopharynx is established in the first or second year of life.15 In contrast to the early stabilization of nasopharyngeal depth, King15 demonstrated continued increase in nasopharyngeal height until maturity. He accounted for this increase by the descent of the hard palate and cervical vertebrae from the cranium.

As the nasopharynx enlarges to accommodate the growing adenoids, a patent nasopharyngeal airway is maintained.16 However, any imbalance between the developing airway and growing adenoids may result in nasopharyngeal obstruction or reduced patency.16 In this context, Linder-Aronson17 reported that enlarged adenoids lead to mouth breathing primarily in children with a small nasopharynx. Subtelny and Koepp-Baker17 described the growth changes of adenoid tissue in the mid-sagittal plane relative to the configurative changes in the nasopharyngeal cavity. They stipulated a delicate balance in the growth of the adenoids and the contiguous nasopharynx if the airway is to be maintained. If the adenoid mass increases faster than the nasopharynx size,
nasorespiratory function is impeded and mouth breathing may develop. On the other hand, some reports indicate that the adenoids do not follow a specific growth curve but respond individually to different environmental factors.

Multidisciplinary interaction among specialists (eg, orthodontists, otolaryngologists, and pediatricians) involves a process of reciprocal education with regard to evidence-based practice. Accordingly, parents educated in this manner typically become more receptive to surgical intervention for the correction of nasal respiratory impairment when indicated in younger children.

When observed in early childhood, morphologic changes would support early removal of the obstructive adenoid to avoid a permanent setting of 1 or more characteristics of long face syndrome that would be difficult to control orthodontically. Hence, any developing long face feature could be minimized or reversed through resumption of normal breathing, possibly aided by orthodontic or orthopedic treatment. Because SAD is a more objective way to measure palatal airway patency and because a SAD less than or equal to 2 mm includes all patients with grade 3 obstruction and some of those with grade 2 obstruction (with more severe obstruction), we advocate the use of SAD for evaluation. The applicability of this evaluation to magnetic resonance and computed tomographic records should be investigated, including differences, if any, between 3-dimensional and 2-dimensional images.

In conclusion, subjective grading of palatal airway obstruction correlates with the objective measurements of SAD and CAD. Although both methods are reliable in gauging particularly the more severe obstructions, SAD is a more favorable objective tool. A small SAD (less than or equal to 2 mm) should prompt consideration of early adenoidectomy. Because nasal obstruction from enlarged adenoids is reported to affect craniofacial morphologic features early in childhood (ages 2-3 years), physicians and parents must weigh any reluctance to use surgical intervention with the potential harms of facial morphologic features. With further research, predictive models should be developed to facilitate this task.

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Table. Linear Measurements Across the Various Obstruction Grades

<table>
<thead>
<tr>
<th>Variable</th>
<th>1 (n=56)</th>
<th>2 (n=121)</th>
<th>3 (n=23)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, mean (SD), y</td>
<td>7.0 (2.9)</td>
<td>5.8 (2.4)</td>
<td>4.6 (2.1)</td>
<td>.001</td>
</tr>
<tr>
<td>SAD, mean (SD), mm</td>
<td>6.7 (2.7)</td>
<td>3.0 (1.3)</td>
<td>0.8 (1.2)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>CAD, mean (SD), mm</td>
<td>8.2 (2.7)</td>
<td>3.4 (1.3)</td>
<td>0.9 (1.2)</td>
<td>&lt;.001</td>
</tr>
</tbody>
</table>

Abbreviations: CAD, most convex adenoid distance; SAD, shortest adenoid distance.

Figure 4. Percentage of children by age with a shortest adenoid distance (SAD) from the soft palate of less than or equal to 2 mm and greater than 2 mm.

REFERENCES