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New insights on age-related association between nasopharyngeal airway clearance and facial morphology

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Structured Abstract

Objectives – To evaluate the relation between adenoid hypertrophy and facial morphology across age in a pediatric population.
Setting and Sample Population – The American University of Beirut Department of Otolaryngology. Two-hundred consecutive children (age 6.00 ± 2.62 years) referred from the Pediatric Otolaryngology unit to the Orthodontic division and requiring a lateral cephalogram for adenoid hypertrophy assessment.
Methods – Cephalometric measurements included relations among cranial base, maxilla and mandible, and airway clearance measured from adenoid to soft palate (AD). The children were classified into two age groups, Group 1: ≤ 6 years (n = 124) and Group 2: ≥ 6.01 years (n = 76), and also stratified in four subgroups (A, B, C, D) based on maxillo-mandibular divergence (palatal to mandibular plane angle, PP-MP): A- PP-MP ≤ 27.5°, n = 34; B- 27.5° < PP-MP ≤ 32°, n = 68; C- 32°<PP/MP<36.5°, n = 67; D- PP-MP ≥ 36.5°, n = 31. Statistics included t-tests and ANOVA for group differences.
Results – Differences between groups 1 and 2 were statistically significant ($p < 0.05$) for AD (Group 1: 3.19 ± 2.32 mm, Group 2: 4.78 ± 2.80 mm), ANB (5.38 ± 2.24°, 4.38 ± 2.54°), LFH (56.61 ± 1.95%, 55.38 ± 1.84%), PP-H (−8.41 ± 3.28°, −6.49 ± 3.46°), and overbite (0.55 ± 2.00 mm, 1.16 ± 2.36 mm). Among subgroups, statistically significant differences ($p < 0.05$) occurred mainly between the most hyperdivergent group (D) and the hypodivergent (A) and normodivergent (B) groups.
Conclusions – Airway measurements were smallest in children ≤ 6 years and those presenting severe hyperdivergent pattern, which denoted the most severe airway obstruction. The findings suggest airway clearance before age 6 in the most severely affected children, but follow-up research on actual adenoidectomies in younger children is needed to determine guidelines.

Key words: adenoid; facies; jaw relation; malocclusion; nasal obstruction

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Introduction

Adenoid hypertrophy is the source of various diseases because of consequent nasal obstruction and oral respiration. The medical symptoms (snoring, otitis media, sinusitis, sleep apnea) affect the well-being of the patient but also of the family, often placing in second order the long-term effects on facial morphology, such as aberrant development of maxillary and mandibular structures. Yet, such alterations can lead to permanent dysmorphology that might require orthognathic surgery in adulthood, when it may have been partially or totally avoided in childhood. A revealing reference to the long-standing association between airway clearance and facial morphology is the description of 'adenoid facies' or long-face syndrome (1). This 'hyperdivergent' skeletal pattern characteristically includes increased lower face height, constriction of the maxillary arch, open bite between the anterior teeth, increased gingival display above the maxillary anterior teeth, and retrognathic mandible. Hence, the fully developed long-face syndrome includes both functional and esthetic impairment. Orthodontic results do not achieve optimal esthetic outcome because facial elongation, particularly subnasal, gingival smile, and chin retrusion may not be adequately corrected. Orthognathic surgery better addresses the skeletal deviations.

The relationship between mouth breathing and malocclusion is not clear-cut (1–3), probably because the extent and severity of morphologic alterations depend on timing, duration, and rate of oral respiration. The issue is further confounded by the diagnostic accuracy of mouth breathing (4). Quantitative definitions of this condition have been advocated but have yet to be proven effective or practical (rhinometry, nasal flow, nasal resistance), especially in children. Newer devices that are easier to use discern differences between nasal and oral breathing during clinical examination (5–7) but apparently need additional validation for universal application.

Otolaryngologists and orthodontists regularly use lateral cephalometric imaging to evaluate adenoid contribution in blocking normal respiration (8). Correspondence of cephalometric measurement and subjective rating of airway clearance indicates the practicality of cephalometric imaging as a guide to diagnosis and decision making (8). This finding is supported by systematic review of the literature regarding the validity of lateral cephalograms in diagnosing enlarged adenoids and obstructed posterior nasopharyngeal airways in children and adolescents (9). Moderate to strong correlations were noted between actual adenoid size (determined post-adenoidectomy) and both quantitative measures of adenoid area and subjective grading of adenoid size on lateral cephalographs. The shortest distance between adenoid and soft palate (termed in our study AD) was the principal measurement validated from various studies (9).

The evidence from post-surgical studies in children (10, 11) revealed a more anterior symphyseal growth, reversal of the tendency to posterior mandibular rotation, increased mandibular growth, and unchanged direction of maxillary growth. In addition, our clinical observations, indirectly supported by research (12, 13), indicated that late removal of the adenoids does not improve the set orofacial dysmorphology. Despite such findings, timing the adenoidectomy on individual basis has yet to be achieved. While a significant amount of evidence is available on the relation between mode of breathing and orofacial morphology, a number of research limitations are difficult to overcome. The collection of cephalographs in younger children who normally breath through their nose is understandably restrained by the reluctance of Internal Review Boards and parents to accept the procedure. Available investigations in early childhood relied on pre-existing cephalometric or other imaging (MRI) records (14, 15). Small samples or inconclusive results point to the need for more generalizable research findings. Finally, there is a need to determine earlier morphological effects of altered respiration than available in the literature. Extensively quoted in the orthodontic and otolaryngology literature, the key studies by Linder-Aronson and co-workers do not include children younger than age 6 years (16).

In this context, we hypothesized that the recognition of severe morphological deviations in children younger than age 6 should lay the ground for future investigation of the optimal timing of adenoidectomy that would prevent the attainment of irreversible or non-improvable orofacial alterations. Also, regardless of the existence of clinically diagnosed mouth breathing, we sought to evaluate the association between the cephalometric measurement of airway patency and orofacial deviations from normal relation, particularly in children below age 6.

Therefore, our specific aims were to 1-evaluate, in a prepubertal population diagnosed with chronic mouth breathing, the association between facial morphology and airway obstruction by the adenoid across age, including ages younger (< 6 years) than available in the literature and 2-compare dysmorphologic features according to severity of facial morphological pattern.

Patients and methods

Patients

The study population consisted of 200 consecutive children (127 boys, 73 girls) referred by the pediatric otolaryngologist to the Division of Orthodontics and Dentofacial Orthopedics, American University of Beirut Medical Center, for cephalometric imaging of pharyngeal airway impingement by the adenoid. The otolaryngologist (MAB) had diagnosed these children as having chronic mouth breathing (> 3 months duration) based on the history taken. On physical examination, the adenoid was suspected as the only contributor to the airway obstruction, after ruling out the presence of other causes (as detailed in the exclusion criteria). No reference was made to lip posture as not all children with open lip are mouth breathers. Adenoid hypertrophy is commonly evaluated by soft tissue nasopharyngeal radiographs (10), but the lateral cephalogram used by orthodontists is more dependable because of controlled head position in the cephalostat. Although regularly requested and taken, and not an addition for research purposes, institutional approval of the radiograph is required for any research usage of the data; thus, the Institutional Review Board clearance was obtained and required standards followed.

Exclusion criteria were as follows: septal deviation, bilateral inferior turbinate hypertrophy, kissing tonsils, previous surgery related to nasal obstruction (including adenoidectomy and tonsillectomy), recent medical treatment of nasal airway impairment, systemic disease, congenital malformations.

The mean age of the children was 6.0 years (range: 1.71–12.61; Fig. 1). Most patients (62%, n = 124) were below age 6. Nearly half (46%; n = 93) were < 5 years and the greatest percentage (24.5%, n = 49) ranged between 4 and 4.9 years.

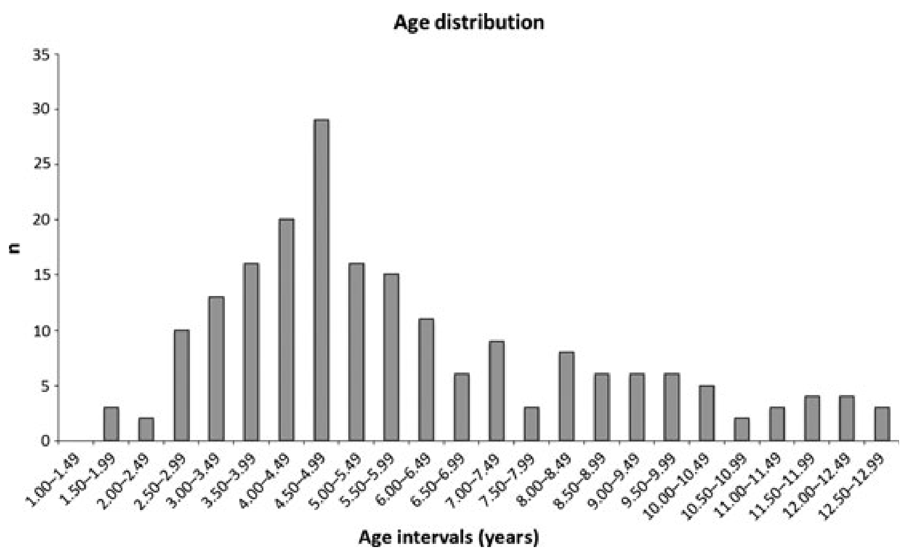

Fig. 1. Age distribution intervals by increment of 6 months.

Lateral cephalometry

The cephalographs were taken in the same digital cephalostat (GE, Instrumentarium, Tuusula, Finland) following a uniform procedure. With the body covered by a lead apron, the head of the child was placed in natural head position, which is a standardized orientation when one focuses on a distant reference at eye level (17). This positioning helps determine the horizontal reference (H) as defined by Moorrees et al. (17). This 'true' or 'corrected' plane is prone to less error than the Frankfort horizontal defined by two variable landmarks, nasion and porion (18).

The children were guided to occlude their teeth in the retruded contact position and keep the lips in gentle touch. As the distance between the facial midsagittal plane and the film is set by the manufacturer, the corresponding radiographic magnification is adjusted for automatically. Images were saved and stored directly in a dedicated computer.

To avoid inter-examiner variation, a single investigator (ATM) imported and digitized the radiographs into the imaging program (Dolphin Imaging and Management Solutions, La Jolla, California). Angular and linear measurements were computed to evaluate the sagittal and vertical positions of the maxilla, the mandible, and their dental components, relative to the cranial base and to each other (Fig. 2A). Selected measurements included in this article are SNA, SNB, ANB, palatal plane (ANS-PNS) to horizontal (PP-H); mandibular plane (menton-gonion: Me-Go) to SN (MP-SN), to horizontal (MP-H), and to palatal plane (PP-MP); ratio between lower and total facial heights (LFH).

The shortest distance between adenoid and soft palate (AD) and the distance between the most convex adenoid point and soft palate (CD) were used to quantify airway clearance (Fig. 2). The occlusion of the children was examined and noted.

Taking cephalograms on children who must keep the teeth in contact and be still during exposure was difficult in several patients below age 5. When the teeth were apart more than 2 mm, the radiographs were discarded, reducing the total number to the reported 200. In a small number (17 of 200), the imaging program allowed 'autorotation' of the parted mandible for measurement of parameters related to the mandible. In 14 children, all below 5 years, who would not be alone when taking the radiograph, a parent volunteered to hold the child; both were covered with lead aprons. Many children who could not remain still for taking the cephalograph were not

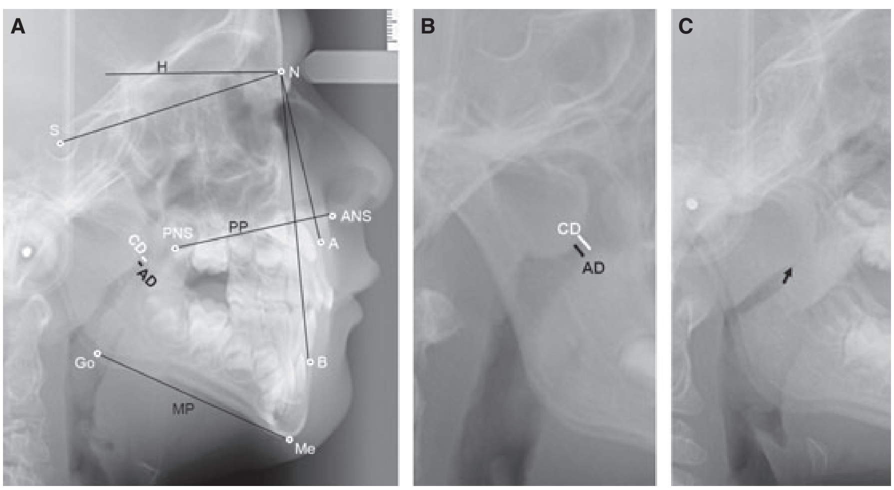

Fig. 2. (A) Cephalogram of 4.39-year-old boy. Landmarks: N (nasion), S (sella), ANS (anterior nasal spine), PNS (posterior nasal spine), A (deepest point on the premaxilla between anterior nasal spine and dental alveolus), B (deepest midline point on the mandible between infradentale and pogonion), Me (menton- most inferior point on mandibular symphysis), Go (gonion- external angle of the mandible, bisecting the angle formed by tangents to the posterior border of the ramus and the inferior border of the mandible), H (horizontal corresponding to natural head position), PP (palatal plane through ANS and PNS), MP (mandibular plane through Me and Go), selected measurements: SNA; SNB; ANB; PP-H; MP-SN; MP-H; PP-MP; AD- shortest distance between adenoid and soft palate. CD- distance between most convex adenoid point and soft palate. Various airway clearances are shown in B and C. The latter is most severe, nearly total as indicated by arrow.

recruited for the study. To determine intra-observer reliability, the same investigator repeated the entire cephalometric procedure and measures on 20 randomly selected cephalographs (10% of sample).

Study groups

The children were classified into two age groups: Group 1: ≤ 6 years (n = 124; 75 boys, 49 girls) and Group 2: > 6 years (n = 76; 52 boys, 24 girls). They were also categorized into four subgroups: A (n = 34), B (n = 68), C (n = 67), and D (n = 31), based on cephalometric vertical divergence derived from the angle between mandibular (MP) and palatal (PP) planes. Though the normative angulation could have been used (Björk: 29°± 5.4°), we stratified the subgroups on the average angulation within our population: 32° ± 4.5°. This mean was higher than the norm, favoring an error toward increased hyperdivergence commensurate with the long-face syndrome.

The angle PP-MP sums up various characteristics of this syndrome: it is related to the lower face height, and maxillary inclination is factored in, avoiding the classification on mandibular angle only. Furthermore, the dentition is contained between the jaws, affecting and affected by their positions. The categorization yielded two groups (A, B) at one and two standard deviations lower than the mean, and two groups (C, D) at one and two standard deviations higher than the mean. The extreme groups represented severe hypodivergent (A) and hyperdivergent (D) patterns.

Statistical methods

To assess examiner variability of repeated measurements, the intraclass correlation coefficients were calculated for each of the parameters studied. Differences between age groups for different measurements were evaluated by *t*-tests. Where applicable, the analysis of variance (ANOVA) gauged differences for all measurements between various age and vertical pattern groups, as well as gender differences within age and vertical pattern groups. Statistical significance was set at $p \leq 0.05$.

Results

The intraclass correlation coefficients for the intra-examiner repeated measurements were high, with $0.91 < r < 0.99$ for the reported measurements, except for PP-H ($r = 0.88$), which included the horizontal H and thus was more closely related to reproducing the orientation on natural head position in the imaging program.

Differences between groups 1 and 2 were statistically significant for AD and CD, ANB, LFH, PP-H, and overbite (p = 0.05–0.000; Table 1). Both groups had measurements of mandibular plane that were on average compatible with hyperdivergence. Accordingly, the corresponding values (MP-SN, PP-MP) were not statistically significantly different. Posteroinferior tip of the palatal plane (PP-H) was observed in both groups, but was less severe in the older group ($p = 0.000$). The tilt was highest (−8.9°) between 4 and 4.9 years.

The groups stratified on mandibular divergence showed age similarities and statistically significant differences between younger and older groups in each subgroup (A-D; Table 2). The ANOVA revealed statistically significant differences among these groups for all measurements except for age, AD,

Table 1. **Means of age and selected cephalometric measurements in age groups**

	Group 1 N = 124		Group 2 N = 76		
	Mean	SD	Mean	SD	*p*
Age (years)	4.30	0.99	8.79	1.00	0.000
AD (mm)	3.19	2.32	4.78	2.80	0.000
CD (mm)	3.83	2.74	5.54	3.21	0.000
Sagittal measurements					
SNA (°)	81.04	3.69	80.73	4.01	0.58
SNB (°)	75.68	3.56	76.35	3.38	0.21
ANB (°)	5.38	2.24	4.38	2.54	0.004
Overjet (mm)	2.7	1.82	2.78	2.31	0.78
Vertical measurements					
LFH (%)	56.61	1.95	55.38	1.84	0.000
PP-H (°)	−8.41	3.28	−6.49	3.46	0.000
MP-SN (°)	39.64	4.85	39.56	5.63	0.91
PP-MP (°)	32.25	4.35	31.48	4.82	0.25
Overbite (mm)	0.55	2.00	1.16	2.36	0.05

Table 2. **Descriptive statistics of groups stratified on PP/MP**

Groups	A PP/MP ≤ 27.5°	B 27.5° < PP/MP ≤ 32°	C 32° < PP/MP < 36.5°	D PP/MP ≥ 36.5°	$p^{††}$
N	34 (17%)	68(34%)	67 (33.5%)	31 (15.5%)	
Group 1 (< 6 years)					
n = 124	n = 20 [16.12%]	n = 38 [30.64%]	n = 47 [37.90%]	n = 19 [15.32%]	
Age (years)	4.46 ± 0.74	4.27 ± 1.05	4.26 ± 1.12	4.28 ± 0.77	NS
[range]	[2.89–5.94]	[1.94–5.85]	[1.71–5.98]	[3.17–5.87]	
Group 2 (> 6 years)					
n = 76	n = 14 [18.42%]	n = 30 [39.47%]	n = 20 [26.31%]	n = 12 [15.78%]	
Age (years)	9.91 ± 1.73	8.61 ± 2.06	8.39 ± 1.75 [6.02–12.52]	8.58 ± 2.19	NS
[range]	[7.06–12.01]	[6.09–12.62]		[6.15–12.59]	
$p^{†}$	0.000	0.000	0.000	0.000	

†Statistically significant differences for age between age groups 1 (age < 6 years) and 2 (age > 6 years).
††Statistically significant differences for age among subgroups (A–D).

CD, and overjet (Table 3). Differences were statistically significant (p = 0.02–0.000) for all vertical measurements (LFH, PP-H, MP-SN, PP-MP, and overbite) among all group comparisons (except overbite between groups A,B and B,C, and PP-H between A and B); for AD and CD only between the most severe group (D) and the hypodivergent and normodivergent groups (A and B, respectively); and for sagittal measurements mainly between groups D and A, and D and B.

As might be expected, gender differences ($p < 0.05$) within age groups were limited to linear measurements such as SN, ANS-PNS, NGn and were found for all measurements between age groups. In the divergence-stratified groups, gender differences occurred only in the B group (44 boys, 24 girls) for the distances AD (male: 4.59 ± 2.57 mm; female: 3.01 ± 2.25 mm; p = 0.02) and CD (male: 5.50 ± 3.18 mm; female: 3.63 ± 3.23 mm; p = 0.03).

Table 3. **Means of age and selected cephalometric measurements in groups stratified on PP/MP**

	A PP/MP ≤ 27.5°		B 27.5° < PP/MP ≤ 32°		C 32° < PP/MP < 36.5°		D PP/MP ≥ 36.5°			p Comparisons among groups A, B, C, D					
Groups	Mean	SD	Mean	SD	Mean	SD	Mean	SD	p_{ANOVA}	AB	AC	AD	BC	BD	CD
Age (years)	6.70	2.99	6.19	2.67	5.49	2.31	5.94	2.58	NS	NS	0.03	NS	NS	NS	NS
AD (mm)	4.30	2.83	4.03	2.55	3.81	2.67	3.11	2.38	NS	NS	NS	0.01	NS	0.03	NS
CD (mm)	4.94	3.039	4.84	3.3	4.22	2.92	3.76	2.74	NS	NS	NS	0.03	NS	0.04	NS
Sagittal measurements															
SNA (°)	81.49	4.32	81.72	3.78	80.61	3.39	79.25	3.98	0.02	NS	NS	0.03	0.074	0.004	NS
SNB (°)	77.05	4.31	77.06	3.45	75.46	2.84	73.26	3.88	0.000	NS	NS	0.000	0.004	0.000	0.002
ANB (°)	4.45	2.19	4.68	2.16	5.14	2.68	5.98	2.38	0.03	NS	NS	0.009	NS	0.008	NS
Overjet (mm)	3.18	2.186	2.65	2.01	2.55	1.99	2.81	1.89	NS	NS	NS	NS	NS	NS	NS
Vertical measurements															
LFH (%)	55.85	1.76	56.83	1.76	58.02	2.12	59.18	1.65	0.000	0.009	0.000	0.000	0.000	0.000	0.02
PP-H (°)	−6.24	3.03	−6.19	3.19	−8.46	3.16	−10.94	2.38	0.000	NS	0.001	0.000	0.000	0.003	0.000
MP-SN (°)	33.68	3.35	37.72	3.37	41.30	2.93	46.62	3.73	0.000	0.000	0.000	0.000	0.000	0.000	0.000
PP-MP (°)	25.72	1.82	29.79	1.23	33.91	1.25	39.31	2.66	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Overbite (mm)	1.87	1.88	1.09	2.44	0.58	1.75	−0.67	1.74	0.000	NS	0.000	0.000	NS	0.000	0.001

Dental relations ranged from normal occlusion with adequate overjet/overbite to malocclusions with one or more of the following characteristics: posterior crossbite, overjet, distoclusion, open bite, anterior crossbite.

Discussion

This study yielded important contributions reported for the first time because the significant number of children < age 6 years (most of whom are below 5 years – Fig. 1) allowed the description of very early stages of morphologic alteration.

Association between nasal obstruction and facial dysmorphology

Many differences between younger and older age groups could be related to the effect of normal growth of the nasopharynx leading to increase in airway clearance (11). Other ameliorations with age include decreases in the lower face height and in the postero-inferior tilt of the palatal plane (Table 1). However, both age groups include important characteristics ascribed to hyperdivergence (MP-SN, PP-MP), suggesting that this pattern on average would persist. Chosen at more than one SD of the total sample average and exceeding the one SD of normative data, Group D possessed, at statistically significant levels, the most severe airway obstruction (AD and CD), and the most severely associated characteristics of the long-face syndrome, both skeletal (LFH, PP-H, MP-SN) and dental (overbite), as well as mandibular retrognathism (SNB) (Table 3). While hyperdivergence occurred less in group 2 (n = 12) than in group 1 (n = 19), percentages were similar: 15.78 and 15.32%, respectively (Table 2).

The findings suggest that facial dysmorphology develops in a sequential process, apparently starting in structures closest to the obstruction namely the maxilla, which tilted postero-inferiorly as gauged by the inclination of the palatal plane, with a maximal tilt (−8.41°) in the younger group, mostly between 4 and 4.9 years (−8.9°), compared to the Caucasian norm [PP-H = 0° ± 2.5° (19)].

The oropharyngeal space is a primary entity that influences the position and behavior of the surrounding soft tissues, which in turn shape the associated skeletal units (20). Impingement on the oropharyngeal space leads to adaptive reorganization of adjacent structures, the long-face syndrome representing the extreme expression of prolonged functional disturbance. Conversely, any degree of adaptive morphologic change may result in a level of restoration of nasal breathing. As adaptation to either total or partial airway obstruction is an individual response to preserve the oropharyngeal matrix, the occlusal variation from normal relation to different malocclusions is not surprising. Similar variations were found in experimental animal studies whereby the nostrils of monkeys were obstructed to induce oral respiration (21).

Longitudinal data are not available on normal growth of the distances AD and CD, which increased between ages 4.3 years (Group 1 average) and 8.79 years (Group 2 average) by 50% (4.78–3.19 = 1.59 mm) and 45% (5.54–3.83 = 1.71 mm), respectively (Table 1). In contrast, longitudinal data on a corresponding hard tissue measurement, such as the distance between PNS and hormion (at the bottom of the spheno-occipital synchondrosis), indicate an increase of nearly 13% (14% in males, 12% in females) between ages 4 and 9 years (22). The seemingly smaller percentage increase in the hard tissue parallel to AD and CD would suggest that the soft tissue airway clearance improved at a proportion greater than the underlying skeletal structures. Given that the skeletal distance is nearly 24 mm at younger ages (range: 23–26 mm) (22, 23), 13% would correspond to approximately 3 mm. The 1.6–1.7 mm (45–50%) improvement in AD or CD is less than the skeletal change, notwithstanding the fact that the skeletal data were derived from individuals who did not necessarily have mouth breathing, the prevailing condition of the children in this study.

Clinical implications

Primary care physicians often delay or oppose removal of the adenoids because these tissues contribute to immunological defenses and are expected to decrease in size around adolescence (15). Medical and craniofacial characteristics are not competitive reasons for adenoidectomy. Medical reasons may dictate the surgery without craniofacial alterations having risen to the primary cause of the surgery. Yet, nasal airway obstruction, of any etiology, has the potential to severely affect only craniofacial morphology, justifying intervention.

Stating that adenoids lead to mouth breathing primarily in children with a small nasopharynx, Linder-Aronson advocates adenoidectomy in these children (15, 16), but this recommendation is not tested in clinical trials. Our research indicates that the children in group D, who combined both the severe vertical pattern (beyond 1 SD) and the smallest distances between the adenoid and soft palate (AD and CD), are probably the likeliest candidates for adenoidectomy for reasons that include facial dysmorphology. The deviant features were present below and above age 6 years.

These data would suggest that: 1 – decreased airway clearance in the presence of dysmorphology would warrant adenoidectomy, at least for the cohort already exhibiting severe characteristics of long-face syndrome least affected by orthodontic treatment (e.g. gummy smile in conjunction with anterior open bite and overerupted posterior teeth); 2 – the optimal timing of the surgery should be before age 6 years. The average age of the children in group D below age 6 years was 4.37 years, ranging from 3 to 6 years (Table 2). Perhaps this age bracket should be considered for future research on optimal timing of early adenoidectomy.

A later surgery, such at the average age of group 2 (8.79 years), would not lead to reversal of the dysmorphology. In a 6-year longitudinal study (12) in which adenoidectomy was recommended for 26 children with nasal obstruction, half had surgery within the first year of diagnosis (age 9.1 ± 2 years), and the other half served as controls (9.4 ± 1.5 years). The results indicated that adenoidectomy may change the breathing pattern without a significant effect on malocclusion and facial type.

The suspicion of enlarged adenoids as the predominant reason for the diagnosed mouth breathing may be questioned in at least the children with wider airway clearance (groups A, B, C) unless other obstructions justify intervention. Upon evaluation of the x-rays of these children, tonsillar and/or inferior turbinate hypertrophy was documented when present. The former is readily diagnosed clinically, and the latter is best confirmed with endoscopy. The referring pediatric otolaryngologist followed up on these findings, having requested the cephalograph to image the adenoid as the only or combined cause of mouth breathing for a complete diagnosis and a comprehensive treatment plan.

A clear differentiation between the effects of enlarged tonsils and hypertrophied adenoids is not available in the literature. When either enlarged adenoids, tonsils, or both block nasal breathing, the effect on facial morphology is commonly thought to include characteristics toward the long-face syndrome. However, in his pioneering description of the Class III malocclusion, Angle relates its early origin, at or before the age of emergence of the permanent first molars, solely to enlarged tonsils 'and the habit of protruding the mandible' to afford 'relief in breathing.' (24) Research is needed to discern these possibilities.

Research considerations

The study supports findings from systematic reviews that AD best reflects the status of airway clearance in a two-dimensional record (9). Three-dimensional imaging of nasopharyngeal space and structures may yield more accurate information (25), but their potential association with mouth breathing still requires quantitative assessments of respiration.

A cause-and-effect relationship between nasal airway obstruction and dysmorphology is both difficult and unethical to investigate with longitudinal radiation in children with untreated obstruction (26). The difficulty in recruiting normally breathing children with normal occlusion, particularly between the ages of 2 and 5 years, who would be subjected to cephalometric radiation, precluded the inclusion of a control group. Also, defining normal 'nasal' respiration is questionable in the absence of objective assessment, which remains difficult to obtain in younger children. Although no matched controls were available, the stratification on vertical pattern discriminated between the children with long-face syndrome characteristics and those with less severe or no dysmorphology.

Research, particularly longitudinal, is needed to formulate definitive projections of irreversible changes that would warrant the timely early adenoidectomy.

Conclusions

In a study that included for the first time a significant number of children early in childhood (ages 2–6 years), initial stages of morphologic alteration from nasal obstruction were described. Narrowing of the posterior pharyngeal airway by enlarged adenoids apparently leads to a sequential process of morphologic alteration, starting with the closest structure (maxilla), and encompassing variable occlusal changes. Facial adjustments were more severe with greater airway obstruction (group D). These findings suggest early clearance of the nasal passageway to avert, arrest, or reverse facial alterations in the most severely affected children.

Guidelines must be defined for early adenoidectomy in relation to facial morphology, notwithstanding the medical imperatives for the surgery. Research to determine such guidelines should be based on the premise that optimal conditions may include severe airway obstruction at age < 6 years in individuals on track to develop irreversible characteristics of the long-face syndrome.

A set dysmorphology is difficult to resolve with increasing age. While primary care physicians do not readily accept the tenet that prevention of craniofacial dysmorphology represents an indication for adenoidectomy (and/or tonsillectomy), the potential craniofacial problems and associated difficulty in treatment (including eventual orthognathic surgery) cannot be dismissed and require due attention.

Clinical relevance

We evaluated the cephalometric relationship between nasopharyngeal obstruction by adenoid hypertrophy and facial morphology in children referred by the otolaryngologist. Long-face syndrome characteristics are difficult to treat back to normal in late childhood. Decreased airway clearance in children with most severe hyperdivergent features suggests removing obstacles to nasal respiration early (age < 6 years), laying the ground for more longitudinal research.

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