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Craniofacial growth in children with nasal septum deviation: A cephalometric comparative study

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ABSTRACT

Objective: Nasal-breathing impairment has been described as a possible determinant of maxillofacial development in children with adenoids/tonsils hypertrophy. However little is known about the possible influence of nasal septum deviation on craniofacial growth in childhood. We conducted a multicenter cephalometric study to compare skeletal and dental features in children with chronic nasal-breathing obstruction secondary to nasal septum deviation and nose-breathing controls.

Methods: Ninety-eight children (59M, 39F; mean age 8.8 years; age range 7–12 years) with obligate mouth-breathing secondary to nasal septum deviation (group 1) and 98 age- and sex-matched nasal-breathing controls (group 2) were evaluated. Nasal-breathing function was assessed in all patients with clinical history, ENT instrumental examination and anterior active rhinomanometry. Cephalometric parameters were recorded in all subjects.

Results: Patients of group 1 showed a statistically significant increase of upper anterior facial height (N-palatal plane) and total anterior facial height (N-Me) with regards to group 2. The angular relationships of the sella-nasion, palatal, and occlusal planes to the mandibular plane were greater in group 1 in comparison to controls. The gonial angle (Ar-Go-Me), palatal height and overjet were significantly higher in the mouth-breathing group. A significantly retrognatic position of the maxilla and mandible was recorded in group 1 in comparison to group 2. Most mouth-breathing children showed class II malocclusion, while the majority of control subjects presented normal occlusion. The prevalence of cross-bite was higher in group 1 with respect to controls ($p = 0.02$).

Conclusion: Children with obligate mouth-breathing due to nasal septum deviations show facial and dental anomalies in comparison to nose-breathing controls. Possible physiologic explanations of our findings are reported.

1. Introduction

Nasal respiratory function and its relationship with the development of craniofacial structures have been a subject of interest and controversy in the last decades [1]. Nasal airway inadequacy is responsible of obligate mouth-breathing habit, which has been described as a possible environmental cause of malocclusion and disharmonious development of the facial skeleton (the so-called "long-face syndrome" of patients with the typical adenoid facies) observed in growing children [2–6]. In particular, Harvol et al. demonstrated that obligated oral respiration can produce major malocclusion in primates [7]. Investigations carried out on this issue have pointed out the role of enlarged adenoids, allergic rhinitis and enlarged tonsils on the effective mode of breathing and have shown the effects on facial skeleton development in children submitted to adenoidectomy/tonsillectomy. In particular, Linder-Aronson et al. showed varying degrees of recovery from steep mandibular plane angle, narrow maxillary arches, and retroclined maxillary and mandibular incisors during the 5 years following adenoidectomy with consequent change from mouth to nose-breathing ($p < 0.01$) [2,8].

Despite the amount of studies on craniofacial growth after resolution of nasal-breathing impairment due to adenoids/tonsils hypertrophy, only few authors investigated the possible relations of nasal-breathing obstruction due to septal deviations with craniofacial growth in childhood [9–12]. Such lack in medical investigation is likely due to the common habit of most practitioners to attribute nasal-breathing impairment in children

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to adenoids/tonsils hypertrophy or allergy, without considering other possible causes of chronic nasal obstruction [1–6]. In particular, the role of nasal septum deviations as a cause of nasal-breathing impairment in children is often underestimated. This attitude may be related to the little knowledge of most physicians on the growth pattern of nasal septum and, consequently, on the appropriate surgical approach to correct the deviated septum in childhood [13,14].

Aim of this multicenter case–control study is to compare, with an accurate cephalometric analysis, dentofacial parameters in children with nasal-breathing obstruction secondary to nasal septum deviation with respect to nasal-breathing controls.

2. Methods

2.1. Sample

Between 1996 and 2005 we examined 657 consecutive Caucasian children (mean age 5.7 years; range 2–12 years) with chronic nasal-breathing obstruction. A careful history and complete otorhinolaryngological examination with mouth evaluation, flexible nasal endoscopy, otoscopy, tympanometry, and anterior active rhinomanometry (AAR) were carried out in all patients to diagnose the cause and severity of nasal-breathing impairment [13,14]. Children with craniofacial syndromes or history of orthodontic treatment and/or facial trauma and/or thumb-sucking after the age of 3 years were excluded from the study, since these factors directly influence the pattern of facial development [5,12].

Among our patients, 98 subjects (59 M, 39 F; mean age 8.8 years; age range 7–12 years) presented severe chronic nasal-breathing obstruction secondary to nasal septum deviations with absence of other possible causes of nasal-breathing impairment, such as adenoids/tonsils hypertrophy, nasal polyps or allergic rhinitis (group 1). The severity and chronicity of nasal-breathing obstruction were determined with AAR (nasal-breathing resistance $> 0.40\ \mathrm{Pa/cm^3/s}$ at 150 Pa on each nostril) [13] and anamnesis reporting children's permanent mouth-breathing habit.

After otorhinolaryngological diagnosis, all patients of group 1 were subjected to an orthodontic evaluation with anamnesis, clinical examination, and cephalometric analysis. Cephalometric assessment was carried out also in 98 age- and sex-matched nasal-breathing controls (group 2), who performed radiographic examinations during childhood for reasons unrelated to nasal diseases. Normal breathing function in group 2 was determined with ENT examination, nasal endoscopy and AAR.

Approval of the Ethics Committee was obtained. The consent of parents and children was obtained as appropriate, after explanation of the purpose of the examination.

2.2. Cephalometric analysis

Standard lateral cephalometric radiographs were obtained to evaluate the skeletal and dental characteristics of both groups. Radiographs were taken with the children's teeth in centric occlusion and with lips relaxed. Cephalometric radiographs were traced on 0.002 in. acetate paper. In order to avoid possible bias, the tracings were performed in random order with soft-tissue profiles excluded. After all the radiographs had been traced, dental and skeletal anatomic landmarks were located and used for angular and linear measurements (Table 1 and Fig. 1).

2.3. Statistical analysis

Means and standard deviations were calculated for each cephalometric variable in both groups. Statistically analysis was performed using Statistical Package for Social Sciences Software (SPSS 10.0 for Windows; SPSS, Inc., Chicago, IL). The comparison between anthropometric parameters of the two groups was assessed using "Student's *t*-test" for unpaired data and "Chi-squared test". A value of $p < 0.05$ was considered as statistically significant.

Table 1
Angular and linear measurements. S = sella; N = nasion; A = position of the deepest concavity on anterior profile of maxilla; B = position of the deepest concavity on anterior profile of mandibular symphysis; Pg = pogonion; Go = gonion; Me = menton; S = anterior nasal spine; Ar = condylar point.

Angular	Linear
S-N-A	Total anterior facial height (N-Me)
S-N-B	Upper anterior facial height (N-palatal plane)[a]
A-N-B	Percent nasal height = N-palatal plane/N-Me $\times$ 100
S-N-Pg	Posterior facial height (S-Go)
S-N to palatal plane	Palatal height (occlusal plane-palatal raphe)[b]
S-N to occlusal plane	Mandibular body height (occlusal plane-mandibular plane)[b]
S-N to mandibular plane	Mandibular body length (Go-Me)
Palatal plane to occlusal plane	Mandibular length (Ar-Me)
Palatal plane to mandibular plane	Mandibular ramus height (Ar-Go)
Occlusal plane to mandibular plane	Overjet and Overbite
Gonial angle (Ar-Go-Me)	Maxillary and mandibular intermolar widths

[a] Measured on the N-Me line.
[b] Measured perpendicular to the occlusal plane.

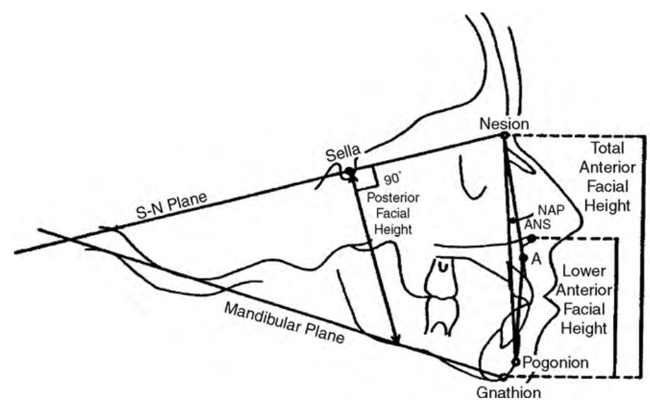

Fig. 1. Dental and skeletal anatomic landmarks. S = sella; N = nasion; A = position of the deepest concavity on anterior profile of maxilla; Pg = pogonion; ANS = anterior nasal spine; Gn = gnathion.

2.4. Error analysis

In the attempt to find out possible errors in landmark identification and measurement, 10 randomly selected head films were retraced and remeasured by the same physician (L.D.) The reliability of cephalometric measures was determined by calculating Pearson product–moment correlation coefficient *r* between the first and second measurements, as suggested by Bresolin et al. [5]. A high degree of reliability (*r* values between 0.88 and 0.99) was noticed for all variables.

3. Results

3.1. Skeletal relationships

Vertical skeletal measurements (Table 2) showed a statistically significant increase of upper anterior facial height (N-palatal

Table 2
Cephalometric data in both groups of children. S = sella; N = nasion; A = position of the deepest concavity on anterior profile of maxilla; B = position of the deepest concavity on anterior profile of mandibular symphysis; Pg = pogonion; Go = gonion; Me = menton; S = anterior nasal spine; Ar = condylar point; Percent NH = (N-palatal plane)/(N-Me).

Parameter	Group 1	Group 2	p
Linear variables for anterior facial height (mm)			
N-palatal plane	50.19 (±2.89)	47.96 (±2.32)	<0.01*
N-Me	114.46 (±5.94)	108.86 (±6.43)	<0.01*
Percent NH	0.43 (±0.02)	0.44 (±0.03)	0.79
Relationships of sella-nasion (SN), palatal (PP) and occlusal (OP) planes to the mandibular (MP) plane (°)			
SN to MP	38.25 (±3.77)	32.74 (±2.50)	<0.01*
PP to MP	30.73 (±3.37)	25.76 (±2.84)	<0.01*
OP to MP	18.64 (±3.71)	14.17 (±2.64)	<0.01*
Gonial angle values (°)	135.23 (±3.61)	129.16 (±4.31)	<0.01*
S-N-A values (°)	79.01 (±3.69)	81.78 (±1.67)	0.03*
S-N-B values (°)	75.36 (±4.89)	79.54 (±2.18)	<0.01*
S-N-Pg values (°)	75.62 (±4.22)	78.98 (±2.10)	<0.01*
Palatal height values (°)	16.47 (±1.58)	15.74 (±1.93)	<0.01*
Overjet values (mm)	5.77 (±1.23)	4.81 (±1.31)	<0.01*
Overbite values (mm)	3.05 (±0.77)	3.26 (±0.63)	0.07
Maxillary intermolar width (T6–T6) (mm)	48.03 (±1.89)	49.62 (±2.18)	0.04*
Mandibular intermolar width (T6–T6) (mm)	43.60 (±1.94)	44.95 (±2.18)	0.07

* Statistically significant.

plane) and total anterior facial height (N-Me) in group 1 with regards to group 2. The ratio of upper to total anterior facial height was similar in the two groups, indicating that in group 1 the increase in upper anterior facial height was accompanied by a proportional increase in lower anterior facial height. As to angular measurements, the angular relationships of the sella-nasion, palatal, and occlusal planes to the mandibular plane were greater in group 1 in comparison to controls. The gonial angle (Ar-Go-Me) was significantly larger in group 1.

Anteroposterior skeletal measurements (S-N-A, S-N-B, and S-N-Pg) showed a significantly retrognatic position of the maxilla and mandible in group 1 in comparison to group 2. Furthermore, in group 1, 65 (66.3%) subjects presented a class II skeletal malocclusion, 24 (24.5%) a class III malocclusion, and 9 (9.2%) a normal occlusion. Among controls, 17 (17.3%) children showed a class II skeletal malocclusion, 4 (4.1%) a class III malocclusion, and 77 (78.6%) a class I occlusion [15].

3.2. Dental relationships

Palatal height and overjet were significantly higher in group 1 in comparison to controls (Table 2). Maxillary intermolar width was significantly narrower in the mouth-breathing group in comparison to controls. Mandibular intermolar width was inferior in group 1 with respect to group 2, though the difference was not statistically significant. Among group 1 patients, 13 (13.2%) presented posterior cross-bites, 9 unilateral and 4 bilateral. Three (3.1%) unilateral cross-bites were noticed in subjects of group 2. The difference in prevalence of cross-bite between the two groups was statistically significant ($p = 0.02$).

4. Discussion

Our results on children with nasal septum deviation are comparable with those reported by other authors on offspring with adenoids hypertrophy or allergic rhinitis [2–5], thus suggesting a difference of craniofacial development in children with obligate mouth-breathing with respect to nasal-breathing controls [9,10,12,16,17]. In particular, our findings show that children with obligate mouth-breathing secondary to nasal septum deviations present an increase of upper and lower anterior facial height, a larger gonial angle and a significantly retrognatic position of the maxilla and mandible in comparison to nose-breathers of the same age. Moreover, most patients of group 1 displayed a class II skeletal malocclusion, while most control subjects showed normal occlusion [15]. This study also shows an association between breathing modalities and dental relationships: palatal height and overjet were significantly higher in mouth-breathers, while maxillary intermolar width was significantly narrower in the mouth-breathing group in comparison to controls. Cross-bite was statistically more frequent in mouth-breathers with respect to nose-breathers.

The physiologic bases of this association between craniofacial parameters and chronic nasal obstruction in childhood [12,16,17] are still poorly understood [1]. Two components of chronic oral respiration seem to influence facial development: firstly, the enduring absence of nasal airflow itself can affect the growth of the maxillofacial skeleton, as shown by Schlenker et al. [18]. Secondly, mouth-breathing leads to a new posture in order to compensate the decrease in nasal airflow and allow respiration [19]. Posture changes include a lower position of the mandible and an anterior-lower position of the tongue, usually associated with reduced orofacial muscle tonicity [12,20]. Such face position during mouth-breathing affects the balance of tongue and facial musculature/soft tissues (''Moss's functional matrix''), which influence the development of the skull [1,18] and may cause a disharmony in the growth of orofacial structures. As a result, narrowing of the maxilla with higher palatal height, increased gonial angle (causing increased facial height, augmented overjet, anterior open-bite and tendency towards class II malocclusion), and protrusion of the upper incisors may develop [12,21].

Our results, in agreement with those reported by other authors [2,3,6,8,22], suggest a correlation between breathing modalities and dentofacial growth in childhood. Since breathing habit may represent one of the factors influencing craniofacial development, a precocious identification and correction [22–25] of factors causing severe chronic nasal-breathing obstruction may favor a physiological and harmonious development of craniofacial and dental structures in children. Further studies are needed to understand the factors influencing craniofacial growth in offspring with chronic nasal obstruction and to assess the cephalometric effects of nasal-breathing restoration after precocious septoplasty in children.

Conflict of interest

None.

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