Cephalometric Assessment of Upper Airway Effects on Craniofacial Morphology

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Abstract: To investigate craniofacial growth deformities in children with upper airway obstruction, this controlled study was performed. Cephalometry is used as a screening test for anatomic abnormalities in patients with obstructive sleep apnea syndrome. Therefore, the current work selected this method to investigate the effect of upper airway obstruction on craniofacial morphology.

Patients with upper airway obstruction (104) were compared with 71 controls. Patients with upper airway compromise had mandibular hypoplasia, mandibular retrognathism, and higher hard palates in comparison with controls with no history of airway obstruction. The difference was higher in the older age group.

Airway obstruction has significant correlation craniofacial morphology. Our findings support the idea of early assessment and thorough management of mouth breathing in children.

Key Words: Adenoid hypertrophy, cephalometry, nasal obstruction, retrognathia, upper airway compromise

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Postnatal facial growth is a multifactorial complex phenomenon, which its pathophysiology has always been a subject of controversies. It is believed to be influenced by environmental factors and genetic. Mostly occurring during childhood, facial growth has 2 peaks: between 5 and 10 years (during transition from primary to permanent teeth) and between 10 and 15.[1] Mouth breathing has always been believed of as an important influencing factor on facial growth.

A wide variety of craniofacial deformities because of mouth breathing have been described to date, including, absent nasal airflow, which causes narrowing of the nasal fossae, hypoplasia of the paranasal sinuses, and chronic inflammation of the nasal mucosa, leading to misuse rhinitis, high arch palates, and mandibular retrognathism.[2,3]

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Although there is evidence in the literature for these findings, there are lots of controversies. Some studies have not found any association between respiratory obstruction and its effects on craniofacial growth.[4–6] On the contrary, some findings have reported that genetic factors may play a main role; as a longer face is associated with a higher probability of mouth breathing.[7]

All of these diverse findings testify to the challenge of systematically studying this important issue. It must be emphasized that the wide interpersonal variability in adaptation and compensation may be responsible for this clinical diversity.[2]

To investigate craniofacial morphologic deformities in children with upper airway obstruction, this controlled study was performed. Because cephalometry has been proven as a useful screening test for anatomic abnormalities in patients with obstructive sleep apnea syndrome, this method was chosen to investigate skeletal and soft-tissue deformities in the current work.[8,9]

MATERIALS AND METHODS

Patients who had been referred to a tertiary referral center of otolaryngology between 2006 and 2007 were included in this prospective cross-sectional study. Adenoidectomy candidates with upper airway obstruction at Amir Alam Hospital (affiliated with Tehran University of Medical Sciences) were studied by the same cephalometric technique for craniofacial growth indexes.

These children were clinically evaluated, regarding the nasal septum and tropism of the turbinates with anterior rhinoscopy, and the degree of hypertrophy of the palatine tonsil with oroscopy. Patients with tonsillar hypertrophy or nasal septal deviation or other etiologies of airway obstruction were excluded from study, and only patients with adenoid hypertrophy as the sole etiology of upper airway obstruction were included. Patients with a chief complaint of snoring and sleep apnea because of palatine tonsil hypertrophy and nasal septal deviation were excluded only by clinical examination and no other evaluation was performed. Furthermore, patients with an uncertain history underwent polysomnography.

Radiographic method of Cohen and Konak was used to study adenoid hypertrophy degree,[10] it is shown to have the highest predictive value in this regard.[3] To avoid interobserver discrepancy, all patients were visited and selected by 1 attending physician.

To investigate the effects of age and prolonged airway compromise on the facial skeleton, patients were divided into 2 age groups (below and above 10 years). Each group were compared with the age-matched control group who were visiting pediatric outpatient clinic regarding complaints not related to upper airway disease without a history of prolonged respiratory obstruction (more than 15 days) in the same ethnic region. All of control group had negative clinical examination and nasopharyngeal x-ray for adenotonsilar hypertrophy.

Total number of 104 patients (82 younger than 10 and 22 older than 10) with upper airway obstruction and 71 control persons (33 younger than 10 and 38 older than 10) were studied. Table 1 shows mean age of different patient group.

TABLE 1. Mean, Standard Deviation and Range of Age for Different Patients Groups

Patient Category	Sex	Number	Age Mean	SD	Range
<10 years	Male	52	6.95	2.287	4.1–9.8
	Female	30	7.51	2.274	4.8–9.9
	Total	82	7.21	2.337	4.1–9.9
>10 years	Male	14	11.24	2.243	10–11.7
	Female	8	12.55	2.154	10–12.8
	Total	22	11.94	2.342	10–12.8
Total	Male	66	7.86	2.259	4.1–11.7
	Female	38	8.57	2.266	4.8–12.8
	Total	104	8.21	2.363	4.1–12.8

Cephalometric parameters were used to evaluate craniofacial growth differences among patients and control groups. To prevent radiographic magnification difference, all radiographs were taken on the same cephalostat using standard cephalometric techniques. The following cephalometric measures were analyzed (Fig. 1):

The anteroposterior relationships:

- S-N-A angle: angle at the intersection between the sellanasion (S-N) and nasionsubspinal (NB) lines. Indicates angle between the maxilla and the cranial base.
- S-N-B angle: angle at the intersection between the sellanasion (S-N) and nasionsupramental (N-B) lines. Indicates angle between the mandible and the cranial base.

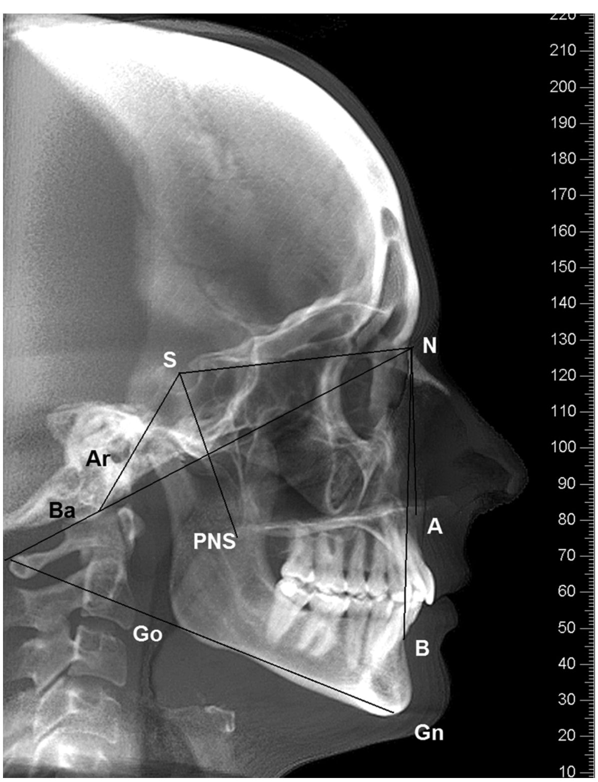

FIGURE 1. Basic points in cephalometric graphy. S: sella turcica central point; N: nasion; A: subspinal point, the most posterior point in superior incisive fossae; B: supramental point, most posterior point in the inferior incisive fossa; Gn: gnathion; Go: gonion; PNS: posterior nasal spine; Ar: midpoint of clivus arc. Me: mentom.

- Ba-S-N: it is the angle between anterior and posterior skull base. This angle defines the retrognathism or prognathism of the face in the lateral view.

The vertical relationships:

- Ba-N-Go-Gn angle: determined by the intersection of the mandibular plane (Go-Gn) with the Ba-N line. This angle expresses the degree of inclination of the mandible in relation to the cranial base.
- Ar-Go-Go-Me: determined by the intersection between the Ar-Go and Go-Me lines. This angle measures the opening between the gonial and mandibular angle (Me = mentom).
- Ba-S-PNS: indicates angular relationship between hard palate and the skull base.

Linear measures:

- Go-Gn: linear measurement determined by the union of the gonial and gnathion points corresponding to the mandibular plane (Steiner).

To avoid inter-rater errors, all of the cephalometric landmarks' assessments and measurements were performed by 1 individual and intra-rater reliability was checked by reassessing some randomly selected cephalometry images.

Informed consent to participate in the study was obtained from the parents of all children. Regional Ethics Committee has approved this study. Statistical Package for Social Sciences (SPSS; version 16; IBM, Armonk, NY) was used for data analysis. Sample size was calculated by estimating standard deviation from previous similar studies, *P* value of 0.05 was considered significant and power was set to 80%.

RESULTS

Tables 2 to 4 show cephalometric results. As is shown in the tables, length of mandibular plane (Gn-Go) was significantly shorter in both patient age groups. This was true for both age groups. Patients have decreased mandibular protrusion (lower S-N-B) and this difference is statistically significant. The hard palate is significantly higher in patients (lower Ba-S-PNS angle) and this difference is greater among older patients, which indicates an increasing pattern of hard palate height with age (Table 3).

Therefore, in our study, patients with upper airway compromise had mandibular hypoplasia, mandibular retrognathism, and high arch palates in comparison with controls with no history of airway obstruction.

DISCUSSION

The most important etiologies of respiratory obstruction in children are allergic rhinitis and tonsillar hypertrophy.[1,11] Although craniofacial growth alterations with respiratory obstruction in children have been extensively studied during the last years, there are great amount of controversies remained in this field, partly because of the absence of a direct relationship between the cause of respiratory obstruction and its effect on craniofacial growth.[4,12]

Wang et al[7] showed that the pharyngeal dimensions were significantly correlated with skeletal class, showing the effects of genetic factors on airway corridor. Kluemper et al[5] showed that facial morphology and respiratory mode are unrelated. There are other studies, too showing that obstruction itself may not be the cause of morphologic differences.

In the contrary, it is proposed in some studies that mouth-breather children may have some structural problems more than

TABLE 2. Cephalometric Parameters in Different Groups

		Patients		Controls		
Parameter	Patient Category	Mean	SD	Mean	SD	*P* Value
S-N-A	All	80.250	3.7488	80.085	4.4151	0.796
	<10	80.000	3.4175	79.303	4.9100	0.388
	>10	81.182	4.7673	80.763	3.8743	0.728
S-N-B	All	73.202	2.6343	75.718	4.5824	0.000
	<10	73.159	2.7102	74.212	4.3320	0.119
	>10	73.364	2.3814	77.026	4.4402	0.001
Gn-Go	All	66.21	5.954	73.31	8.928	0.000
	<10	64.59	5.164	68.42	8.573	0.004
	>10	72.27	4.713	77.55	6.888	0.001
Ba-N-Gn-Go	All	57.84	5.841	56.25	5.749	0.078
	<10	57.72	5.563	57.24	5.579	0.680
	>10	58.27	6.909	55.39	5.829	0.108
Ar-Gn-Go	All	128.298	5.8557	127.465	8.1488	0.460
	<10	128.390	5.3835	129.833	9.1059	0.295
	>10	127.955	7.4991	125.408	6.6757	0.195
Ba-S-PNS	All	60.721	7.2573	58.141	6.3590	0.014
	<10	60.171	7.2073	59.394	5.2138	0.575
	>10	62.773	7.2370	57.053	7.0976	0.005
Ba-S-N	All	131.53	5.591	130.68	5.204	0.310
	<10	131.17	5.367	130.61	5.117	0.600
	>10	132.86	6.312	130.74	5.346	0.192

Standard deviation; parameters are described in methods part; all of linear measurements unit are in millimeter. Ar, midpoint of clivus arc; Ba, basion; Gn-Go, gnathion-gonion; N, nasion; PNS, posterior nasal spine; SD, standard deviation; S-N-A, sella turcica central point-nasion-subspinal point; S-N-B, sella turcica central point-nasion-supramental point.

nonmouth breather children.[13] The exact mechanism of these structural problems effects on craniofacial growth, however, is unknown.

Although there are lots of theories described for this phenomenon, the most accepted is that mouth-breather child has altered position of the muscles and mandible, a lower or anterior tongue, and posteroinferior rotation of the mandible to stabilize the airway.[12] This can, in turn, influence mastication, deglutition, and phonation[14]; these soft-tissue alterations alters the pressure equilibrium of the facial skeleton resulting in the occlusal and skeletal deformities.[15] Nasal obstruction and absent nasal air flow in association with labial occlusion and altered mandibular muscle tone results in maxillary changes.[12,16]

TABLE 3. Comparison of Results Among Patients Younger and Older Than 10-year-old

	Age <10 years (N = 82)		Age >10 years (N = 22)		
Parameter	mean	SD	Mean	SD	*P* Value
S-N-A	80.000	3.4175	81.182	4.7673	0.522
S-N-B	73.159	2.7102	73.364	2.3814	0.667
Gn-Go	64.59	5.164	72.27	4.713	0.000
Ba-N-Gn-Go	57.72	5.563	58.27	6.909	0.678
Ar-Gn-Go	128.390	5.3835	127.955	7.4991	0.457
Ba-S-PNS	60.171	7.2073	62.773	7.2370	0.142
Ba-S-N	131.17	5.367	132.86	6.312	0.363

Standard deviation; parameters are described in methods part; all of linear measurements unit are in millimeter. Ar, midpoint of clivus arc; Gn-Go, gnathion-gonion; N, nasion; PNS, posterior nasal spine; SD, standard deviation; S-N-A, sella turcica central point-nasion-subspinal point; S-N-B, sella turcica central point-nasion-supramental point.

TABLE 4. Comparison of Results Among Male and Female Patients

	Men (N = 66)		Women (N = 38)		
Parameter	Mean	SD	Mean	SD	*P* Value
S-N-A	80.076	3.4477	79.857	3.6553	0.771
S-N-B	73.394	2.5291	72.686	2.8571	0.222
Gn-Go	66.12	6.588	65.83	4.429	0.791
Ba-N-Gn-Go	57.44	5.938	58.11	5.692	0.578
Ar-Gn-Go	128.439	5.6245	127.543	5.7922	0.457
Ba-S-PNS	60.909	7.3038	60.857	7.0841	0.972
Ba-S-N	130.94	5.527	133.09	5.365	0.062

Standard deviation; parameters are described in methods part; all of linear measurements unit are in millimeter. Ar, midpoint of clivus arc; Gn-Go, gnathion-gonion; N, nasion; PNS, posterior nasal spine; SD, standard deviation; S-N-A, sella turcica central point-nasion-subspinal point; S-N-B, sella turcica central point-nasion-supramental point.

Alterations in mandibular growth can occur due to tongue problems. Prognathism can be the results of the anterior tongue, whereas an underdeveloped mandible can be due to posterior tongue forces. Occlusal anomalies can be seen due to an interposing tongue.[2,17]

Similar to other works, a large group of the current study's patients presented a high arch palate.[7,11,12] In addition, mandibular hypoplasia and mandibular retrognathism were more common among these patients. Increased mandibular inclination in relation to the skull base results in increased lower anterior face height, and consequently in the total facial height.

Some data indicate that in patients with obstructive respiration, with resulting skeletal deformities, normalization of respiration can result in a process that tends to normalize craniofacial problems.[12,18,19] It seems that complete normalization of craniofacial morphology does not occur in all of the patients; however, in those who have not entered the first facial growth spurt, this normalization is higher.

Unfortunately, polysomnography as an objective assessment of breathing during sleep was not done in all patients; therefore, our result may just show a more prevalent craniofacial morphology alteration in patients with clinical symptoms of airway obstruction.

There seems to be some differences between boys and girls with sleep-related breathing disorders. It is shown that boys have more facial skeletal problems whereas girls have more airway and pharyngeal risk factors resulting to breathing disorder.[20] This finding is not congruent with ours. In this patient group, no sex-related differences were seen.

CONCLUSIONS

In this study, the cephalometric data have a significant correlation with clinical signs in children with obstructive sleep disorders, thus showing that airway obstruction can strongly affect craniofacial morphology. If a cause and effect relationship can be proved in further studies, the early assessment and thorough management of mouth breathing in children will be critical in preventing more aggressive surgeries, which, of course, may not be as effective.

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