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Upper Airway Dimensions in Patients With Class II and Class I Skeletal Pattern

Sanaz Soheilifar [1]; Sepideh Soheilifar [2,*]; Sara Soheilifar [3]

[1]Department of Orthodontic, Dental Faculty, Hamadan University of Medical Sciences, Hamadan, IR Iran
[2]Department of Orthodontic, Dental Faculty, Shahid Beheshti University of Medical Sciences, Tehran, IR Iran
[3]Department of Periodontic, Dental Faculty, Hamadan University of Medical Sciences, Hamadan, IR Iran

*Corresponding author: Sepideh Soheilifar, Department of Orthodontic, Dental Faculty, Shahid Beheshti University of Medical Sciences, Tehran, IR Iran. Tel: +98-9121944033, Fax: +98-8138223750, E-mail: sepid_1988@yahoo.com

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Background: Pharynx is located in close proximity of dentofacial structures. Therefore, a relationship might exist between skeletal malocclusions and the size of the pharyngeal airway.
Objectives: The aim of the present study was to assess and compare the upper airway dimensions and characteristics of skeletal Class I and Class II patients using cephalometric analysis.
Patients and Methods: In this retrospective study, lateral cephalograms of 24 Class I and 26 Class II patients, Who were 9-11 years old and had the inclusion criteria, were used for analysis. Cephalograms were traced manually. Depth of the nasopharynx, oropharynx, and hypopharynx, soft palate dimension and position, and hyoid position were measured on the cephalograms. Independent-samples t-test was used for analyzing the differences in the variables of the two groups and Pearson correlation analysis was used for finding any association between the variables.
Results: No significant difference in the upper airway, soft palate, and hyoid variables was found between the two groups ($P > 0.05$) and no correlation was found between ANB difference and the other variables ($P > 0.05$).
Conclusions: Pharyngeal airway dimensions, soft palate length, thickness, and position, and hyoid position are not significantly different between skeletal Class I and Class II prepubertal children.

*Keywords:*Pharynx; Cephalometry; Hyoid Bone; Soft Palate

1. Background

Pharynx, a tube-shaped structure formed by muscles and membranes, is located behind nasal and oral cavities, and extends from the cranial base to the level of the sixth cervical vertebra. Because of the close relationship between the pharynx and dentofacial structures, a mutual interaction between them is expected (1). It has been claimed that pharyngeal airway affects the growth of craniofacial structures (2). lip incompetency, increased anterior facial height, maxillary constriction, upper incisor protrusion, class II molar relationship, and open bite were reported in patients with impaired respiratory function who were mouth breathers (1, 2). Most clinicians now understand that respiratory function is highly relevant to the orthodontic diagnosis and treatment planning (3).

Pharyngeal space size is determined primarily by relative growth and size of the soft tissues surrounding the dentofacial skeleton. Craniofacial anomalies such as mandibular or maxillary retrognathism, short mandibular body, and backward and downward rotation of the mandible might lead to reduction of the pharyngeal airway space (4). In addition, different anatomic features of the maxilla and mandible could change the position of the hyoid and soft palate and lead to decreased dimension of posterior airway space (5).

Retention of the airway in the correct position is necessary for the completion of normal dentition, maxillofacial and cranial growth, and harmony of the masticatory and perioral muscles. Deficient upper airway function could lead to mouth breathing, which decreases the amount of oxygen in the brain and causes severe snoring, sleep apnea syndrome, and daytime lethargy. In children, mouth breathing could lead to problems such as insufficient sleep and crying at nights (6).

In some studies, it has been shown that in patients with obstructive sleep apnea syndrome (OSA), an association exists between upper airway dimension and craniofacial skeletal morphology. In these patients, upper airway is narrowed anteroposteriorly and lengthened vertically and hyoid is located more inferiorly and anteriorly than usual. Furthermore, different anatomical characteristics are reported in patients with OSA such as deficient maxilla, deficient and retrognathic mandible, steep occlusal and mandibular planes, and long and thick soft palate (7-10). Association of vertical growth pattern with obstruction of the upper and lower pharyngeal airways and mouth breathing have been assessed in some studies. Healthy patients with vertical growth pattern might have narrower airway than patients with normal growth pattern might do (4, 11).

On the other hand, it is reported that decreased mandibular body length could influence available space for the airway because it places the facial complex closer to the cervical spine (9). Decreased space between the mandibular corpus and the cervical column might lead to changes in posture of the tongue and soft palate posteriorly and might impair respiratory function (4). Some studies have evaluated upper airway dimension of patients with Class II malocclusion (1, 11-14); however, controversy surrounds their results. Kim et al. reported that the mean airway volume, from the anterior nasal cavity and nasopharynx to epiglottis, is significantly smaller in retrognathic patients than in skeletal Class I patients (12). Angle showed that Class II Division 1 malocclusion was associated with upper airway obstruction and mouth breathing (12). Kirjavainen et al. showed that Class II division 1 malocclusion was associated with a narrower upper airway structure, even without retrognathia (13). Mergen and Jacobs reported that nasopharyngeal depth was significantly larger in patient with normal occlusion than in Class II malocclusion (14).

On the other hand, Ceylan and Oktay have shown that pharyngeal structures are not affected by changes in the ANB angle (1) and de Freitas et al. reported that malocclusion type did not influence upper pharyngeal airway width (11). Lateral cephalometry is one of most important radiographic techniques for evaluating facial characteristics of patients with airway problems. Many studies have used cephalometric analysis for evaluating upper airway dimension in different levels, hyoid position, and soft tissue measurements (4-11, 13-15).

2. Objectives

The goal of the present study was to compare the upper airway dimensions and characteristics of skeletal class I and class II patients using cephalometric analysis.

3. Patients and Methods

According to the formula for sample size and based on a previous study (14), 23 cephalograms in each group were sufficient for performing this study. The samples were selected from the patients of the Orthodontic Department of Hamadan Dental Faculty from the year 2010 to 2013. Inclusion criteria were: 1) Iranian nationality; 2) no history of adenoidectomy and/or tonsillectomy; 3) no pharyngeal pathology such as adenoid hypertrophy and/or tonsillitis; 4) normal growth pattern (FMA = 22-28) (16); 5) aging nine to 11 years and not having passed growth spurt (in CS1, CS2, CS3 stages) (3); and 6) breath comfortably through the nose. Since this study was retrospective, the data in the clinical chart of the patients were used.

All of the cephalograms were taken with the same digital radiographic equipment in the dental faculty and had a true size. They were taken with the standard method in natural head position and the teeth were in centric occlusion. All of the Class I and Class II patients who met the inclusion criteria were selected. These patients were divided into two groups based on the ANB angle (skeletal Class I: $1 \leq ANB \leq 4$ and skeletal Class II: $ANB > 4$). Finally, 24 patients were assigned to Class I and 26 to Class II groups. These groups were matched based on sex and cervical vertebra maturation stages (Table 1).

Pharyngeal airway width in the level of nasopharyx, oropharynx, and hypopharynx, soft palate length, thickness, and angle, and hyoid position were evaluated on the cephalograms with the analyses used in the previous studies (Figure 1) (2, 4, 5, 8, 10, 13). All the cephalograms were traced manually. For evaluating systematic error, ten radiographs were selected randomly, and the measurements were done twice on them with one-week interval.

3.1. Statistics

Data were analyzed with SPSS 13 (SPSS Inc., Chicago, IL, USA). Paired-samples t-test was used for estimating systematic error. Independent-samples t-test was used for analyzing the differences in the variables between groups and Pearson correlation analysis was used for finding any correlation between the variables. The level of significance for all tests was set at $P < 0.05$.

4. Results

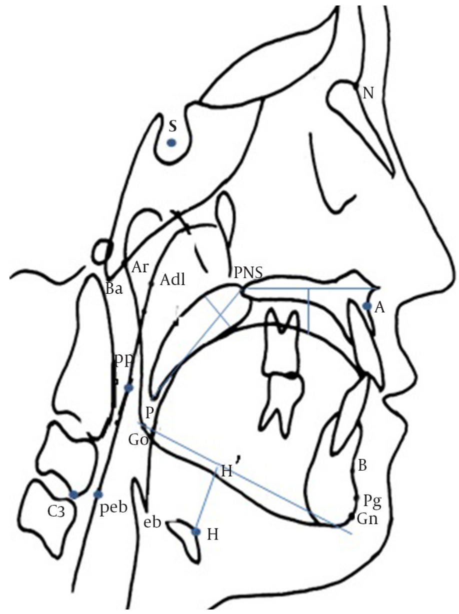
Paired-samples t-test showed that systematic error was not significant ($P = 0.321$); therefore, the measurements were highly reproducible. The results of this study showed that airway dimensions were not significantly different between patients with skeletal Class I and Class II (nasopharynx: $P = 0.506$, $P = 0.344$; oropharynx: $P = 0.190$, $P = 0.264$; and hypopharynx: $P = 0.1$) (Table 2). Furthermore no significant differences could be detected in hyoid position and soft palate dimension and position between the two groups (hyoid position: $P = 0.284$, $P = 0.790$; soft palate dimension: $P = 0.234$, $P = 0.373$; and soft palate position: $P = 0.271$) (Table 2). None of the variables was affected by sex in the groups ($P > 0.05$).

On the other hand, by increasing the ANB difference, there were not any clear and predictable changes in other variables ($P > 0.05$), which meant that increasing the ANB difference did not have any direct effect on airway dimensions, hyoid position, and soft palate dimension and

Table 1. Number of Patients in the Groups and Sex Distribution

Group	Sex		Total
	Male	Female	
Class I	8	16	24
Class II	9	17	26
Total	17	33	50

Figure 1. Landmarks, Linear, and Angular Measurements



1) The distance of ad1 to posterior nasal spine (PNS). Ad1 is the intersection point of posterior pharyngeal wall and the line from posterior nasal spine (PNS) to basion (Ba). 2) S-PNS: The distance of sella (S) to PNS. 3) p-pp: The distance of the tip of soft palate (p) perpendicular to posterior pharyngeal wall (pp). 4) Pas: The distance of the intersection points on anterior and posterior pharyngeal wall of the line from supramentale (B) to gonion (Go). 5) eb-peb: The distance from vallecula of epiglottis (eb) perpendicular to the posterior pharyngeal wall (peb). 6) ANS-PNS-p: The angle of anterior nasal spine (ANS) to PNS to palate point (p). 7) PNS-p: The distance of PNS to tip of soft palate (p). 8) MPT: Maximum soft palate thickness perpendicular to PNS-p, 9) H-H': The distance from the most anterior and superior point of hyoid bone (H) perpendicular to mandibular plane (MP). 10) H-C3: Distance between most anterior and superior point of hyoid bone (H) and C3; C3: the most anterior and inferior point on the corpus of the third cervical vertebra. 10) SNA: The angle sella (S) to nasion (N) to subspinale (A). 11) SNB: The angle sella (S) to nasion (N) to supramentale (B). 12) ANB: The angle subspinale (A) to nasion (N) to supramentale (B).

position. Vertical position of hyoid (H-H distance) had weak but significant correlation with p-pp (R = 0.377, P = 0.007), PAS (R = 0.492, P = 0.000), and eb-peb (R = 0.336, P = 0.017). Horizontal position of hyoid (H-C3 distance) had weak but significant correlation with ad1-PNS (R = 0.310, P = 0.028), PAS (R = 0.340, P = 0.016), and eb-peb (R = 0.449, P = 0.001).

5. Discussion

Normal respiration shows that nasal structures are being used sufficiently (1). The size of the nasopharynx is an important factor for determining mode of breathing, i.e. nasal or oral (1). Since patients with mouth breathing might have decreased airway dimension, only children with normal nasal breathing were included in this study to eliminate the interfering factors. Patients with nine to 11 years old were selected for this study. Parents of children in this age group usually seek for orthodontic treatment of their skeletal malocclusion, and if growth modification treatment were planned, this age would be the best time. Kim et al. (12) also studied upper airway dimension of children in this age group. In this age, maxillomandibular growth rate is steady and constant before the adolescent growth spurt (12). King (17) and Tourn (18) have stated that nasopharyngeal depth is established early in life, and then it usually remains the same. Oropharyngeal depth is also stable because of the constant position of hyoid to cervical column (18). Therefore, it seems that growth in the depth of upper airway is not a problem in these ages. In this study, Iranian norms for ANB angle were used based on a previous study (19). ANB angle is commonly used in clinical orthodontics and Ishikawa et al. reported that it is reliable for determining the anteroposterior relationship of the jaws (20).

Table 2. Mean and Standard Deviation of the Variables and P Value From t-Test

Variable, mm	Class I	Class II	P Value
Nasopharynx			
ad1-PNS	20.9167 ± 5.26404	21.9423 ± 5.54496	0.506
S-PNS	43.5208 ± 2.02420	44.2115 ± 2.95355	0.344
Oropharynx			
P-PP	9.6875 ± 2.48392	8.8077 ± 2.20035	0.190
PAS	11.5000 ± 4.06202	10.3654 ± 2.98850	0.264
Hypopharynx			
Eb-peb	14.9167 ± 2.92540	13.5577 ± 2.80117	0.100
Soft Palate			
ANS-PNS-P	135.7500 ± 7.93040	133.6154 ± 5.48508	0.271
MPT	8.6667 ± 1.49395	9.0577 ± 1.57688	0.373
PNS-P	33.4750 ± 1.56679	34.1236 ± 1.12452	0.234
Hyoid			
H-H'	11.6875 ± 4.01847	10.3269 ± 4.79363	0.284
H-C3	30.9375 ± 3.90739	31.2115 ± 3.30809	0.790
Skeletal			
SNA	78.6250 ± 2.69157	80.0000 ± 2.79643	0.083
SNB	75.5208 ± 2.53016	73.8269 ± 2.76023	0.029
ANB	3.1042 ± 0.97779	6.1731 ± 0.92674	0.000

Cephalometric measurements were used for assessing airway dimensions in the present study. Although caphalometric films give two-dimensional picture of a three-dimensional object, Malkoc et al. (21) stated that cephalometric film were reliable in determining airway dimensions and Aboudara et al. (22) found a significant positive association between nasopharyngeal airway size on cephalometric films and its true volumetric size on CBCT (cone beam computed tomography) scan in adolescents. On the other hand, lateral cephalometry has the advantages of wide availability, simplicity, low cost and ease of comparison with other studies (7).

Since it is reported that patients with vertical growth pattern have narrower upper airway (4, 10), only children with normal growth pattern were included in this study to eliminate the effect of changes in the vertical plane. The results of this study showed that depth of the pharyngeal airway was not significantly different in patients with skeletal Class I and II and increase in the ANB difference did not affect the dimension and characteristics of upper airway. This result was in agreement with some other studies (2, 10, 11, 23).

Ceylan and Oktay (1) reported that oropharyngeal area was smaller in skeletal Class II patients; however, the sagittal measurements of oropharynx were not affected by the ANB angle. They stated that a number of postural changes might occur in the structures of head and neck in response to the changes in sagittal jaw relationships that result to constant depth of upper airway (1). Kim et al., who performed three-dimensional analysis of pharyngeal airway, reported that the mean total airway volume in patients with retrognathia was significantly smaller than in patients with a normal anteroposterior skeletal relationship. Nevertheless, they did not find any significant difference in the volume of subregions of airway (12).

In his three-dimensional airway study Kikuchi found that airway morphology, rather than size, was influenced by the anteroposterior position of the mandible and suggested that airway volume would remain constant by horizontal and vertical compensation mechanisms of the muscles adjacent to the pharynx (6). However, our findings contradicted some other studies that found association between upper airway and class II malocclusion. Kirjavainen et al. (13), who showed that Class II malocclusion was related to a narrower oral and hypopharyngeal space than Class I malocclusion did, differed in case selection with the present study. They classified their samples according to the dental malocclusion, which was molar relationship and overjet. Mergen and Jacob (14) also selected the patients based on the occlusion and reported that nasopharyngeal depth was significantly narrower in patients with Class II malocclusion than in normal occlusion; furthermore, they performed their study on older patients (13 years old). In the present study, pharyngeal structures have not been affected by sex at this age group. This finding was in agreement with the results of Solow et al. (24). According to the results of Kim (12) and Ceylan and Oktay (1) studies, length, thickness, and position of soft palate was not significantly different between Class II and Class I patients. This result was in agreement with some other studies (2, 13).

Hyoid has the characteristic of having no osseous continuity and its position is maintained with soft tissues. Therefore, head posture influences its position (6). In the present study, weak but significant correlations were found between horizontal and vertical position of the hyoid and depth of nasopharynx, oropharynx, and hypopharynx that verified the association between hyoid and surrounding soft tissues. No significant difference was found in hyoid position between class II and class I subjects. In contrast, Kirjavainen et al. (13) found significant differences in hyoid to mandibular distance between Class I and Class II patients but not in the interval between hyoid and the third vertebra. In the study performed by Abu Allhaija et al. (2) most of the differences in hyoid position were found between Class II and Class III patients and only the interval between hyoid and the third vertebra was different between Class II and Class I subjects. In contrast to the present study, natural head position was not considered for taking the radiographs in these studies.

Finally, we concluded that pharyngeal airway dimensions, soft palate length, thickness, and position, and hyoid position were not significantly different between skeletal Class I and Class II prepubertal children.

Authors' Contributions

Sanaz Soheilifar: performing the study, statistical analysis, and preparing the manuscript. Sepideh Soheilifar and Sara Soheilifar: preparing the manuscript.

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