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Assessment of airway dimensions in skeletal Class I malocclusion patients with various vertical facial patterns: A cephalometric study in a sample of the Saudi population

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Abstract:

OBJECTIVE: To compare airway widths among skeletal Class I malocclusion patients with different vertical facial patterns.

MATERIAL AND METHODS: A total of 103 lateral cephalograms of skeletal Class I patients (mean age of 20 ± 2.3 years) with no history of orthodontic treatment, trauma, facial syndromes, or nasopharyngeal dysfunction were included. Based on the Frankfort–mandibular plane angle measurements, the sample was divided into three groups: low-angle, high-angle, and normal-angle groups. Upper and lower pharyngeal airway widths were measured as described by McNamara. The analysis of variance test was performed to compare the means of groups. Pairwise comparisons were performed using Tukey's post-hoc test. Differences were considered statistically significant at $P < 0.05$.

RESULTS: ANOVA showed a significant mean difference between the groups for both the upper and lower airway widths with P values of 0.011 and 0.003, respectively. Tukey Pairwise comparisons showed the upper airway width to be significantly narrower in the high-angle group compared to the normal-angle ($P=0.021$) and low-angle groups ($P=0.013$). Furthermore, the lower airway width in the high angle group was significantly narrower than the normal angle ($P=0.020$) and low-angle groups ($P=0.017$). There were no statistically significant differences between normal and low angle groups.

CONCLUSIONS: The upper and lower pharyngeal widths in the Class I high-angle group were significantly narrower than those in the normal-angle and low-angle groups.

Keywords:

Lateral cephalometry, lower pharyngeal airway, upper pharyngeal airway, vertical facial pattern

Introduction

The airway system plays an important role in craniofacial growth and the development of a respiratory function.^[1] Many studies have been conducted to assess the relationship between respiratory

functions and craniofacial growth; some of these studies revealed a positive correlation between the airway system and the craniofacial morphology, while others did not reveal any relationship.^[2,3] Adenoid hypertrophy, tonsillar hypertrophy, and allergic rhinitis can cause mouth breathing, snoring, or sleep apnea.^[4]

Anatomically, the respiratory tract is separated into the upper part, comprising

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the mouth, nose, pharynx, and larynx, and the lower respiratory tract, comprising trachea, bronchi, bronchioles, alveolar duct, and alveoli.^[5-7]

The pharynx is an irregular fibromuscular tube lined by the mucous membrane. Its average length is approximately 12–14 cm, and it is divided into three sections: the nasopharynx, oropharynx, and laryngopharynx.^[5] Its oral part is located behind the opening of the oral cavity, while its laryngeal part is located behind the inlet of the larynx.^[8] Its dimensions are affected by the relative growth, soft tissue capsule, position, and morphology of the mandible.^[9,10]

McNamara^[11] proposed an airway analysis to evaluate the widths of the upper and lower pharyngeal airways. A deviation from the normal dimension was considered to be a sign of airway impairment.

Various angular and linear measurements have been used to assess the skeletal vertical facial patterns. Tweed^[12] used the angle formed by the intersection of the Frankfort horizontal plane and the mandibular plane to assess the mandibular plane inclination. The Y-axis is used to assess the growth pattern in Down's analysis.^[13] The sella-nasion to mandibular plane angle (SN-MP) is used in the Steiner analysis^[14] for the evaluation of the mandibular plane inclination. Linear measurements, such as the Jarabak ratio and facial height ratio, were also used to assess the facial vertical growth of the individual.^[15]

The present study was designed to assess the pharyngeal airway dimensions among Class I subjects with different vertical facial patterns.

Subjects and Methods

The sample comprised lateral cephalograms of 103 untreated patients (45 women and 58 men; mean age of 20 ± 2.3 years) that were obtained from the Department of Orthodontics, Eastern Riyadh Specialist Dental Center, Riyadh, Kingdom of Saudi Arabia. The study was approved by the Dental Ethics Committee of College of Dentistry in Ar Rass, Qassim University, Ar Rass, Saudi Arabia (Code # DRC/003FA/19, Date of approval: 22-10-2019).

Inclusion criteria were as follows: lateral cephalometric radiograph with an acceptable diagnostic contrast, mature patients with a skeletal Class I relationship based on the ANB value ($2^\circ \pm 2^\circ$), with no history of previous orthodontic treatment, trauma, facial syndromes, or pathological or developmental nasopharyngeal dysfunction.

To evaluate measurement errors, 20 cephalometric radiographs were randomly selected and traced for angular and linear variables. The same observer repeated the tracing after 10 days; no significant differences were found using the concordance correlation coefficient test. Cephalometric radiographs were traced using the Quick Ceph Studio program. Measurements used for this study were the anteroposterior positions of the maxilla (SNA) and mandible (SNB), basal arch relation (ANB), Frankfort mandibular plane angle (FMA), and upper and lower airway widths [Figure 1]. The upper (nasopharynx) and lower (oropharynx) pharyngeal airway widths were measured as described by McNamara.^[11] The upper pharyngeal airway (UPA) width was measured as the shortest distance between the posterior outline of the soft palate to the posterior pharyngeal wall. The lower pharyngeal airway (LPA) width was measured from the point of intersection of the posterior border of the tongue and inferior border of the mandible to the nearest point on the posterior pharyngeal wall. Regarding the vertical facial patterns, based on the Frankfort mandibular plane angle, the sample was divided into low-angle, normal-angle, and high-angle groups, using Tweed's standard range of FMA (22° – 28°).^[12] FMA between 22° and 28° was considered to be a normal angle. FMA above 28° was considered to be a high angle, while FMA below 22° was considered to be a low angle. The means, standard deviations, and minimum and maximum values were calculated. Before making any group comparisons, consistency with the assumptions of normality and homogeneity of variances with the Shapiro–Wilk and Levene's test were assessed. The analysis of variance (ANOVA) test was performed to compare the means of groups, and the significance of the mean difference between the groups was calculated with Tukey's post-hoc test. Analyses were performed using SPSS, version 22.0 (IBM SPSS Statistics for Windows, version 22.0; IBM Corp., Armonk, NY, USA). Differences were considered statistically significant at $P < 0.05$.

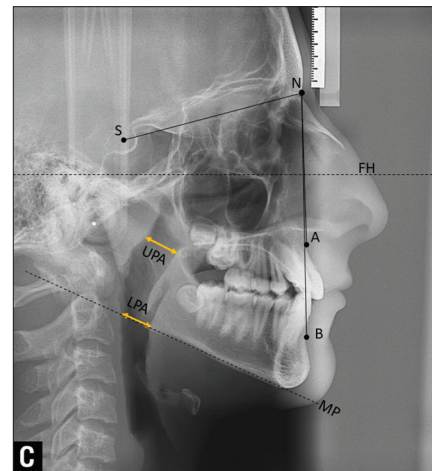


Figure 1: Reference points and lines used for this study

Results

The study sample consisted of 103 skeletal Class I patients (ANB: $1.3^\circ \pm 0.9^\circ$). According to the vertical facial pattern, the normal, low, and high angles were seen in 37 (Mean age: 18.7 ± 2.1 years, Mean FMA: $25^\circ \pm 2.4^\circ$), 30 (Mean age: 18.9 ± 3.4 years, Mean FMA: $18^\circ \pm 1.6^\circ$), and 36 (Mean age: 19.9 ± 1.8 , Mean FMA: $35^\circ \pm 1.9^\circ$) patients, respectively.

Table 1 shows the mean and standard deviation of the upper and lower airway measurements for different vertical facial pattern groups. The mean upper airway width was the highest for the low-angle group and the lowest for the high-angle group. According to ANOVA results, statistically significant differences were found in the upper airway width among the three groups ($P < 0.05$).

When comparing the mean upper airway widths of subjects with a high angle to subjects with a normal or low angle, the Tukey test revealed that the mean upper airway width was significantly lower in the high-angle group than in the normal-angle or low-angle group ($P < 0.05$). The mean upper airway width did not differ significantly between the normal-angle and low-angle groups ($P > 0.05$; Table 2). The upper pharyngeal airway dimension decreased as the vertical facial pattern increased.

Statistically significant differences were found in the lower airway width among the three groups ($P < 0.05$; Table 1). The Tukey test showed that the mean lower airway width was significantly lower in the high-angle group than in the normal-angle or low-angle group ($P < 0.05$). The mean lower airway width did not differ significantly between the normal-angle and low-angle groups ($P > 0.05$; Table 3).

Discussion

Orthodontists and sleep medicine specialists are concerned regarding the relation between craniofacial morphology and airway dimensions. There is no final agreement on the effect of respiratory function abnormalities on craniofacial growth. Bresolin *et al.*^[16] stated that mouth breathing is a predisposing factor for long face syndrome. In contrast, Emslie *et al.*^[17] excluded the relationship between mouth breathing and long face syndrome.

In the present study, cephalometric radiographs were used to measure airway dimensions. In their 2011 study, Parkkinen *et al.*^[18] supported the reliability of the lateral cephalometric radiography technique to measure nasopharyngeal and retropharyngeal dimensions.

Table 1: Comparison of airway dimensions among the three groups

Airway	Normal angle group	Low angle group	High angle group	P
Upper airway width (mm)	12.3±2.4	12.6±3.7	10.1±2.6	0.011
Lower airway width (mm)	11.3±3.2	11.9±1.4	8.7±2.7	0.003

Table 2: Comparison of upper airway dimensions among subjects with various vertical facial patterns

Vertical Facial pattern	P
High angle vs. Low angle	0.013
High angle vs. Normal angle	0.021
Normal angle vs. Low angle	0.232

Table 3: Comparison of lower airway dimensions in subjects with various vertical facial patterns

Vertical Facial pattern	P
High angle vs. Low angle	0.017
High angle vs. Normal angle	0.020
Normal angle vs. Low angle	0.421

The current study revealed that the mean horizontal upper airway dimensions were the highest in the low-angle group (12.6 ± 3.7 mm), followed by the normal-angle group (12.3 ± 2.4 mm) and then the high-angle group (10.1 ± 2.6). These findings are similar to those of Ucar *et al.*^[9] who found that the upper posterior airway space was the highest in the low-angle group (12.9 ± 3.2 mm) followed by the normal-angle group (12.2 ± 2.8 mm) and then the high-angle group (10.8 ± 3.2 mm).

Similarly, the mean lower airway width was the highest in the low-angle group (11.9 ± 1.4 mm), followed by the normal-angle group (11.3 ± 3.2 mm) and then the high-angle group (8.7 ± 2.7 mm), contrary to Ucar *et al.*'s^[9] findings of the least lower posterior airway space in the normal-angle group (9.9 ± 2.7 mm) and the highest lower posterior airway space in the low-angle group (10.4 ± 3.2 mm) followed by the high-angle group (10.8 ± 3.1 mm).

The examination of upper airway dimensions in subjects with different vertical facial patterns showed that subjects with a high angle had a statistically significant narrow upper airway width compared to subjects with a low or normal angle ($P = 0.013$, $P = 0.021$, respectively). However, no statistically significant difference was found in the upper airway width between the low and normal angle groups ($P = 0.232$).

A significant difference was found between the lower airway widths in the high-angle and low-angle groups and high-angle and normal-angle groups ($P = 0.017$, $P = 0.020$, respectively). However, no statistically significant difference was found in the upper airway

width between the low-angle and normal-angle groups ($P = 0.421$). According to the results by Freitas *et al.*^[19] with a larger vertical pattern, increased narrowing of the upper airway is expected. Ucar *et al.*^[9] reported statistically significant variations between the low-angle and normal-angle facial patterns for the nasopharyngeal airway space but no significant differences in the oropharyngeal airway widths contradictory to the present study.

Besides, Ceylan and Oktay^[20] reported that an increase in the ANB angle decreases the oropharyngeal space. In a study involving Class II malocclusion patients, Batool *et al.*^[21] found that those with vertical growth patterns have remarkably narrower upper and lower pharyngeal airways than those with horizontal growth patterns. In the present study, only skeletal Class I individuals were included. In agreement with our study, Akcam *et al.*'s^[21] study showed that subjects with posterior mandibular rotation had a narrower upper airway dimension. Joseph *et al.*^[31] found that the hyperdivergent group had a narrower anteroposterior pharyngeal dimension compared to the normodivergent control group. Memon *et al.*^[22] showed that Class I and Class II malocclusion subjects with a hyperdivergent facial pattern had a statistically significant narrow upper pharyngeal airway width compared to those with a normodivergent or hypodivergent facial pattern.

Deficient anteroposterior development of the craniomaxillary complex in hyperdivergent patients could be linked to the decrease in the superior part of the upper airway dimensions.^[23] Downward and backward rotations of the mandible might be related to the narrowing of the pharyngeal airway.

Therefore, the decreased pharyngeal airway in hyperdivergent subjects cannot be attributed only to the larger adenoids or presence of soft tissues in the posterior nasopharyngeal region but may also be the consequence of other factors that are not fully understood.^[24]

A narrow pharyngeal airway space increases the susceptibility for mouth breathing and obstructive sleep apnea.^[2] The orthodontist should be aware of the effect of airway deficiency, which might be a predisposing factor for craniofacial defects and its effect on orthodontic treatment stability.

Conclusions

The following conclusions can be drawn from this study:

- The upper and lower airway widths are seen to be narrower in subjects with Class I high-angle patients than those in the normal-angle and low-angle patients

- Similar studies are recommended to assess the volumetric capacity of the airway.

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Conflicts of interest

There are no conflicts of interest.

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