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Comparison of Different Craniofacial Patterns with Pharyngeal Widths

Sarwat Memon, Mubassar Fida and Attiya Shaikh

ABSTRACT

Objective: To compare different craniofacial patterns with pharyngeal widths.

Study Design: Cross-sectional analytical study.

Place and Duration of Study: Orthodontic Clinic at the Aga Khan University Hospital, Karachi, from June 2002 to June 2010.

Methodology: Data were collected using pre-treatment records including orthodontic files and pre-treatment lateral cephalographs of 360 orthodontic patients. The inclusion criteria were subjects of Pakistani origin, aged between 14-20 years and having no pharyngeal pathology or complaints of nasal obstruction at the initial visit. The sample comprised a total of 360 subjects divided into 2 groups: skeletal Class I (n=180) and skeletal Class II (n=180) subdivided according to the vertical pattern into normodivergent, hyperdivergent and hypodivergent facial patterns. Upper and lower pharyngeal airways were measured using McNamara's airway analysis. The intergroup comparison of upper and lower airways was performed with oneway ANOVA and the Tukey test as the second step.

Results: There were 172 males and 188 females with average ages of 15.3 ± 1.3 and 15.4 ± 0.8 years respectively. Hyperdivergent facial pattern subjects belonging either to skeletal Class I or Class II malocclusion showed a statistically significant narrow upper pharyngeal airway width as compared to normodivergent and hypodivergent facial patterns. However, no statistically significant difference was found in lower pharyngeal airway widths in sagittal and various vertical facial patterns.

Conclusion: Sagittal malocclusion type does not influence upper pharyngeal width. However, hyperdivergent subjects have statistically significant narrower upper pharyngeal width when compared to other two vertical patterns.

Key words: Upper pharyngeal width. Lower pharyngeal width. Facial patterns.

INTRODUCTION

Respiratory function is highly relevant to orthodontic diagnosis and treatment planning. The growth and function of the nasal cavities, the nasopharynx, and the oropharynx are closely associated with the normal growth of the skull. In addition, the nasopharynx and the oropharynx have important locations and functions as they both form part of the unit in which respiration and deglutition are carried out.¹⁻³

Several studies have reported significant relationship between pharyngeal structures and both dentofacial and craniofacial structures.^{4,5} Furthermore, numerous researchers reported the interaction between pharyngeal dimensions and various sagittal and vertical facial growth patterns at varying degrees.^{6,7} Skeletal features such as retrusion of the maxilla and mandible and vertical maxillary excess in hyperdivergent patients may lead to narrower anteroposterior dimensions of the airway.⁸

There are various predisposing factors reported in the literature for obstruction of pharyngeal airways such as allergies, environmental irritants and infections. Alves *et al.* refuted a significant relationship between airway obstruction and frequency of malocclusion.⁹ Other reported association of vertical growth patterns with obstruction pharyngeal airways concomitantly with mouth breathing.^{10,11} However, several authors found that there is natural predisposition of narrower airway passages.⁴⁻⁷ As there is close association between pharynx and dentofacial structures, a mutual interaction is expected to occur between pharyngeal structures and the various dentofacial patterns, thus justifying orthodontic treatment.

Many reports have demonstrated that a significant relationship exists between airway space and facial morphology.⁴⁻⁷ Also, airway space may be affected by conditions such as functional anterior shifting head posture, sagittal skeletal relation, and vertical growth patterns. Thus the knowledge of the pharyngeal dimensions amongst the various sagittal and vertical facial types is very important and can help an orthodontist in various ways, especially during orthodontic diagnosis and treatment planning.

The aim of this study was to compare different craniofacial patterns with pharyngeal widths.

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METHODOLOGY

This cross-sectional analytical study was conducted using data from pre-treatment lateral cephalographs of patients who visited the Orthodontic Clinic from June 2002 to June 2010. Data was collected using non-probability purposive sampling technique with inclusion criteria: subjects of Pakistani origin, aged between 14-20 years and having no pharyngeal pathology or complaints of nasal obstruction at the initial visit. Patients having craniofacial syndromes were excluded. As per departmental protocol, an informed written consent was obtained from the parents before the subjects entered the study.

National Council for Social Studies, Powerful and Authentic Social Studies (NCSS PASS 2007) was used to calculate the sample size using means and standard deviations from a pilot study done by the principal examiner on a sample of 60 subjects (20 in each vertical group i.e. normodivergent, hyperdivergent and hypodivergent facial patterns). A sample size of 360 gave the power of > 90%.

The sample comprised a total of 360 subjects (selected after scrutinizing 500 files) divided into 2 groups: skeletal Class I (n=180) and skeletal Class II (n=180) subdivided according to vertical pattern into normodivergent, hyperdivergent and hypodivergent facial patterns. ANB angle was used to group the skeletal Class I and II subjects (ANB=0-4° and ANB > 4° respectively). SN-GoGn was used to divide the sample into hypodivergent, normodivergent, hyperdivergent facial patterns with values of < 32°, 33-37° and > 38° respectively. Upper and lower pharyngeal airways were measured using McNamara's airway analysis (Figure 1).¹²

Upper pharyngeal width was taken as the point on the posterior outline of the soft palate to the closest point on



Figure 1: Upper and lower pharyngeal airways using McNamara's airway analysis.

the posterior pharyngeal wall. The average nasopharynx is approximately 15 - 20 mm in width. A width of 2 mm or less in this region indicates airway impairment.

Lower pharyngeal width was measured from point of intersection of the posterior border of the tongue and the inferior border of the mandible, to the closest point on the posterior pharyngeal wall. The average measurement is 11 -14 mm, independent of age.

Greater than normal value or anterior positioning of tongue is either due to tonsillar enlargement or as a result of habitual posture.

Data analysis was carried out using the Statistical Package for Social Science (SPSS Inc., Chicago, Illinois USA) for windows (version 16.0). Means and standard deviations for ages and upper and lower airways were generated for each group. The intergroup comparison of upper and lower airways was performed with one-way ANOVA and the Tukey test as the second step. P-value of ≤ 0.05 was considered to be significant. To rule out measurement error 33 cephalographs were re-evaluated after one month by the principal investigator. Paired samples t-test was used to determine the measurement error for the SN.GoGn value, ANB angle and pharyngeal airways using McNamara's airway analysis. The results showed no significant difference between the sets of measurements.

RESULTS

The study sample comprised a total of 360 subjects (172 males and 188 females; average ages being 15.3 ± 1.3 and 15.4 ± 0.8 years respectively). The skeletal Class I and II groups consisted of 180 subjects each in the two horizontal groups. Subjects belonging to skeletal Class I were subdivided according to vertical pattern into normodivergent (n=60), hypodivergent (n=60) and hyperdivergent (n=60) facial patterns. Similarly, skeletal Class II subjects were also subdivided according to the vertical pattern into normodivergent (n=60), hypodivergent (n=60) and hyperdivergent (n=60) facial patterns.

The means and standard deviations of upper and lower pharyngeal airways was determined for the sample. The intergroup comparison of upper and lower airways was performed with one-way ANOVA and statistically significant difference was found for upper airways (Table I and II).

Table III and IV show comparison amongst various vertical facial patterns for skeletal Class I and II subjects. Hyperdivergent facial pattern subjects belonging either to skeletal Class I or Class II malocclusions showed a statistically significant narrow upper pharyngeal airway width as compared to normodivergent and hypodivergent facial pattern. However, no statistically significant difference was found in upper pharyngeal airway width between normodivergent and hypodivergent facial

pattern of skeletal Class I and II subjects. Furthermore, no statistically significant difference was found in lower pharyngeal airway widths in sagittal and all three vertical facial growth patterns.

Table I: Means and standard deviations of upper and lower pharyngeal airways in different vertical facial patterns of skeletal Class I subjects.

	Normodivergent n = 60		Hypodivergent n = 60		Hyperdivergent n = 60		p-value
	Mean	± SD	Mean	± SD	Mean	± SD	
Upper airway (mm)	14.21	±3.15	14.54	±1.83	11.06	±3.04	0.000
Lower airway (mm)	10.19	±2.78	10.42	±2.40	10.49	±2.43	0.866

N = 180
One-way ANOVA for comparison amongst vertical patterns.
Level of significance 0.05; SD: Standard Deviation.

Table II: Means and standard deviations of upper and lower pharyngeal airways in different vertical facial patterns of skeletal Class II subjects.

	Normodivergent n = 60		Hypodivergent n=60		Hyperdivergent n=60		p-value
	Mean	± SD	Mean	± SD	Mean	± SD	
Upper airway (mm)	15.03	±2.40	13.49	±2.80	11.67	±2.20	0.000
Lower airway (mm)	11.42	±2.92	11.81	±2.49	9.43	±3.01	0.003

N = 180
One-way ANOVA for comparison amongst vertical patterns.
Level of significance 0.05; SD: Standard Deviation.

Table III: Comparison amongst various vertical patterns for skeletal Class I subjects.

Pharyngeal airway	Vertical patterns	Mean difference	p-value
Upper airway	Hyperdivergent & Hypodivergent	-3.50	0.000*
	Hyperdivergent & Normodivergent	-2.97	0.000*
	Hypodivergent & Normodivergent	0.53	0.73
Lower airway	Hyperdivergent & Hypodivergent	0.67	0.99
	Hyperdivergent & Normodivergent	0.33	0.87
	Hypodivergent & Normodivergent	0.27	0.91

N= 180; *p-value is ≤ 0.05; Tukey test.

Table IV: Comparison amongst various vertical patterns for skeletal Class II subjects.

Pharyngeal airway	Vertical patterns	Mean difference	p-value
Upper airway	Hyperdivergent & Hypodivergent	-1.84	0.015*
	Hyperdivergent & Normodivergent	-3.34	0.000*
	Hypodivergent & Normodivergent	-1.50	0.56
Lower airway	Hyperdivergent & Hypodivergent	-2.37	0.67
	Hyperdivergent & Normodivergent	-1.97	0.78
	Hypodivergent & Normodivergent	0.40	0.85

N= 180; *p-value is ≤ 0.05; Tukey test.

DISCUSSION

Abnormal development of the upper airway is related to airway constriction, and the relationship relevance between reduced respiratory function and craniofacial growth has long been of interest to orthodontists. A number of researchers during last 50 years used variety

of radiographs to study the association between the obstruction of upper and lower pharyngeal airways with mouth breathing.⁶⁻¹³ This study was performed with two-dimensional cephalometric films to evaluate only pharyngeal airway width-not airway flow capacity, which would have required a more complex three-dimensional cone beam computed tomography (CBCT) and dynamic estimation. Cameron *et al.* in their study compared computed tomography (CT) and cephalometric films in subjects with skeletal malocclusion, found a significant positive relationship between nasopharyngeal airway size on cephalometric films and its true volumetric size as determined from CBCT scan in adolescents.¹³ The present study used lateral head cephalometric films for pharyngeal airway width measurement, according to the findings of Cameron *et al.*¹³

Associations of Class II malocclusions and vertical growth pattern with obstruction of the upper and lower pharyngeal airways and mouth breathing have been suggested. This means that these malocclusion characteristics have a predisposing anatomical factor for these problems.^{1,6-8,14} Raffat and Hamid evaluated the dentofacial morphology of adenoidal faces via linear and angular measurements on lateral cephalometric tracings and compared the extent of changes with control group normal (Class I and orthognathic profile).¹⁵ They concluded that the subjects with upper airway obstruction displayed excessive vertical dentofacial development, leading to a long face appearance. They suggested that this condition needs to be prevented by early recognition and treatment of the causative factor. Batool *et al.* compared the widths of the upper and lower pharyngeal airways in Class II malocclusion patients with low and high vertical growth patterns.¹⁶ They found subjects with Class II malocclusions and vertical growth patterns have significantly narrower upper and lower pharyngeal airways than those with Class II malocclusions and horizontal growth patterns. Freitas *et al.* used in their study McNamara's airway analysis to compare upper and lower pharyngeal airway widths in subjects with untreated Class I and Class II malocclusions, and normal and vertical growth patterns.¹⁷ They reported that the upper pharyngeal width in the subjects with Class I and Class II malocclusions and vertical growth patterns were significantly narrower than in the normal growth pattern groups. Yang-Ho Park *et al.* showed in their study that vertical growth patterns have significant correlations with the upper part of pharyngeal airways.¹⁸ Ucar *et al.* reported a decrease in upper airway space with functional anterior shifting.¹⁹ This reveals a close relationship between the upper airway passage and positioning of the jaws. Akcam *et al.* found a decrease in the upper airway dimensions of subjects who had posterior mandibular rotation.²⁰ Ucar in another study reported that nasopharyngeal airway space and upper pharyngeal airway space in Class I subjects were larger

in low angle subjects than in high angle subjects.²¹ In the present study, we found that the hyperdivergent facial pattern subjects belonging either to skeletal Class I or Class II malocclusions showed a statistically significantly narrow upper pharyngeal airway width as compared to normodivergent and hypodivergent facial patterns.

Several other researchers found that there is no relationship between upper airway space and the type of malocclusion.^{22,23} Gwynne-Evans concluded that facial growth is constant regardless of mode of breathing.²² Leech, in a study of 500 patients with upper airway problems discovered that 60% of the mouth breathing patients were Class I and concluded that mouth breathing has no influence on craniofacial growth.²³ However, in the present study no statistically significant difference was found in upper pharyngeal airway width between normodivergent and hypodivergent facial pattern of skeletal Class I and II subjects.

Kerr reported that Class II malocclusion subjects showed narrow nasopharyngeal airway space compared with Class I and normal occlusion subjects.²⁴ However, in his study, the vertical skeletal pattern was not emphasized. In the present study, vertical pattern affected the upper airway space, and greater upper pharyngeal airway width was found in low angle subjects than in high angle subjects.

In this study, no association of the lower pharyngeal airway space was seen with a different vertical growth pattern. This confirms the findings of previous studies of Freitas *et al.* and Ucar and Uysal.^{17,20} Batool *et al.* reported subjects with Class II malocclusions and vertical growth patterns have significantly narrower lower pharyngeal airways than those with Class II malocclusions and horizontal growth patterns.¹⁶

When diagnosing and treating pre-adolescent children with malocclusion, orthodontists should recognize pharyngeal airway morphologies that might be predisposing factors of undesirable craniofacial development in order to provide stability of the treatment results. Furthermore, it is recommended that a similar study with a larger sample size and equal distribution of subjects in various sagittal (Class I, Class II and Class III) and vertical facial growth patterns should be conducted to confirm the results of the present study.

CONCLUSION

Sagittal malocclusion type does not influence upper pharyngeal width. However, hyperdivergent subjects have statistically significant narrower upper pharyngeal width when compared to other two vertical patterns.

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