ORIGINAL ARTICLE POJ 2021:13(1) 12-18

Comparison of upper and lower pharyngeal airway dimensions in vertically high angle orthodontic patients with different sagittal skeletal pattern

Verda Ahmad Khan[a], Syeda Rabbab Hassan[b], Alvina Shahid Malik[c], Zainab Niazi[d], Eshfa Khalil[e], Shumaila Raheem[f]

Abstract

Introduction: Different skeletal and vertical patterns can influence the upper and lower airway linear dimensions. A short or retrognathic mandible can lead to a decreased airway while a long and prognathic mandible will have the opposite effect. The aim of this study was to measure the upper and lower airway in vertically high angle adult patients and compare the results among the different skeletal classes.

Material and methods: Lateral cephalograms were taken to measure the upper and lower airway dimensions with the help of a scale. The upper airway was measured from the point on posterior wall of the soft palate up to the point on posterior pharyngeal wall. The lower airway was measured from the point where the lower border of the mandible intersects the posterior border of the tongue to the point on the posterior pharyngeal wall. Only adult patients with a vertically high angle were included in the study. The upper and lower airway dimensions were compared among the three sagittal skeletal patterns.

Results: One-way Anova test was applied to compare the upper and lower airway dimensions among the three groups. Statistically insignificant difference was found among the groups with a p value of 0.67 and 0.94 for the upper and lower airway, respectively.

Conclusions: Upper and lower airway showed no significant difference among Classes I, II and III in subjects with a vertical high angle.

Keywords: Airway measurement; cephalometry; upper airway

Introduction

Vertical malocclusion develops predominantly because of the abnormalities in the skeletal growth pattern, or it might develop due to causes that are dentoalveolar in origin. Several etiological factors contribute towards the development of different vertical patterns, which can be genetic or environmental.[1] The genetic factors include growth of the jaws, eruption of the teeth and development of alveolus, whereas the environmental factors involve the function and the activity of the orofacial musculature, function of the nasal cavity as well as the effects of aberrant habits like thumb sucking and mouth breathing.[2]

The condyles act as a major growth site and center of the mandible. The rotation of the condyles in an anterior direction will cause a forward and upwards growth of the mandible, while a rotation in the posterior direction will cause the mandible to move downwards and backwards.[1] Similarly, an increased vertical growth of the maxilla will cause the mandible to rotate downwards

[a] Corresponding Author. BDS; Orthodontics Resident, Islamabad Medical and Dental College.
Email: verda.ortho16@iideas.edu.pk
[b] BDS, FCPS; Assistant Professor Orthodontics, HBS Medical and Dental College.
[c] BDS; Orthodontics Resident, Islamabad Medical and Dental College.
[d] BDS, MPhil; Assistant Professor, Department of Oral Pathology, Islamabad Medical and Dental College.
[e,f] BDS; House Officer, Islamabad Medical and Dental College.

while a decreased vertical growth will cause it to rise upwards. Thus, the interplay of both the vertical and the sagittal patterns can be a reason for the development of different patterns of malocclusions occurring.[1,2]

Airway evaluation has been carried out via different techniques, including nasopharyngoscopy, nasal airway resistance, polysomnography and cephalometry.[3] Cephalometry is the most common and easiest of methods that can be used for measuring airway dimensions using linear measurements.[4,5] The one of most common airway analyses utilized for this purpose was proposed by McNamara in 1984. He measured the upper airway as the closest distance between the point on the posterior border of the soft palate and the point on the posterior pharyngeal wall on the lateral cephalometric projection, while the lower airway was measured from the point where the lower border of the mandible intersects the posterior border of the tongue to the point on the posterior pharyngeal wall. The normal airway measurements are 15-20 mm for the upper airway and 11-14 mm for the lower airway, respectively.[2]

Normal airway dimension is an important factor for function. Moreover, a healthy functional environment is an absolute necessity for the normal growth and development of the craniofacial structures.[5] Changes in the airway size or any form of obstruction like adenoids, enlarged tonsil or deviated nasal septum will not only cause respiratory problems, but it can also lead to development of skeletal open bite malocclusion.[2] Pharyngeal airway dimensions are not only affected by the relative growth of the dentofacial skeleton but also by the growth and development of the neighboring soft tissues. Relative size, position and attachment of the tongue and frenum, tonicity, length and thickness of the lips as well as length of the soft palate are known factors associated with the development of certain malocclusions.[6] The soft tissues also undergo certain changes with age, like decreased tonicity of airway muscles that in combination with class II malocclusion might lead to the development of conditions like obstructive sleep apneoa.[5]

Craniofacial morphology and airway dimensions are closely related to each other. Craniofacial variations comprising of small mandibular body, posteriorly positioned mandible and maxilla, and clockwise rotated jaws have been linked to decreased pharyngeal airway dimensions.[1] It has been reported that a sagittal Class II and increased vertical growth pattern are the predisposing factors towards a narrow airway dimension. Various studies have demonstrated that the airway dimension increase in sagittal Class III cases, while it decreases in sagittal Class II cases.[1,6]

Celikoglu et al, compared the pharyngeal airway dimensions in patients with high and low angle pattern, and found that the measured values in high angle patients were significantly less than that of the low angle patients.[7] A similar study on subjects with skeletal Class II and different vertical patterns was conducted by Wang et al.[8] They also reported a statistically narrower airway in subjects with increased vertical dimensions when compared with decreased or normal vertical dimension subjects. Ucar et al compared the pharyngeal airway dimensions in subjects with sagittal Class I malocclusion with different vertical growth patterns. They found no significant difference among the low and normal angle cases, while the high angle subjects showed a narrow airway space.[9]

Majeed et al [2] assessed the upper and lower pharyngeal airway in skeletal Class I and II subjects with normal vertical pattern and found no difference among the sagittal groups. Bhagya et al [6] compared the pharyngeal widths in Class I and II subjects with different growth patterns and found the high angle subjects had a narrower airway dimension as compared to the other groups. Although various hard and soft tissue structures have been known to affect the airway space, no correlation has been found between gender and the airway space.[10]

As Orthodontists we deal with various types of malocclusions having different sagittal and vertical skeletal patterns. Many a times, cases even require growth modification or orthognathic surgery thus altering the hard tissue relationships along with associated soft tissue and airway changes. Although studies have been reported to investigate the pharyngeal airway dimension in relation to the sagittal and the vertical growth patterns,[2-3,6-13] but in literature the evidence is still limited regarding the effect of increased vertical dimension on pharyngeal airway for all the three sagittal craniofacial patterns. So, the aim of this study was to compare the upper and lower pharyngeal airway in vertically high angle adult patients having different sagittal skeletal patterns.

Material and Methods

This cross-sectional study was conducted after the ethical approval of institutional review board (Ref #IMDC/DS/IRB/156) on pre-treatment lateral cephalometric radiographs of 45 adult patients (≥18years) fulfilling the inclusion criteria who visited the Orthodontic department at Islamabad Dental Hospital from January 2013 till April 2020. The WHO sample size calculator was used with mean values for upper and lower airway kept at 14.07 and 11.47 and standard deviation of 3.13 and 1.46 respectively.[14] The power of test was kept at 80% and the level of significance at 5%. The sample consisted of vertically high angle cases with an MMA (Maxillomandibular angle) of >29˚ and was divided into three equal groups based on their sagittal classes. The group 1 was sagittal class I with an ANB angle of 0-4˚. Group 2 was sagittal Class II with an ANB angle of >4˚, and Group 3 was sagittal Class III with an ANB angle of <0˚. The pretreatment lateral cephalograms selected were of good quality and were standardized by selecting radiographs which had a scale ratio of 1:1 for the cepahlostat head positioning rod scale and the head positioning rod scale on the radiographic film. Lateral cephalograms of patients who had undergone any form of nasal or airway surgeries or were syndromic were excluded from the sample.

All the lateral cephalograms were traced by the principal investigator using a pencil on acetate paper. A millimetric scale was used to measure the linear dimensions according to McNamara analysis. The upper airway was measured from the point on posterior wall of the soft palate up to the point on posterior pharyngeal wall. The lower airway was measured from the point where the lower border of the mandible intersects the posterior border of the tongue to the point on the posterior pharyngeal wall. (Figure: 1)

Data were analysed using the SPSS Version 20. Means and standard deviations were calculated for both upper and lower airway.

One-way Anova test was applied to compare the upper and lower airway among all three groups. The intergroups comparisons were done using Post hoc Tukey test. P- value of ≤ 0.05 was considered statistically significant.

Results:

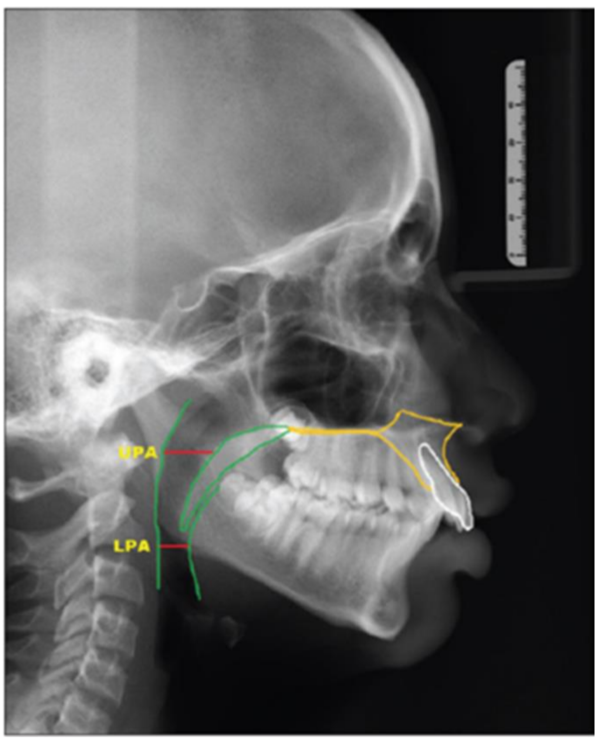
The total sample consisted of 45 patients with 15 patients per group. Among the 45 patients 32 were female (9 in Class I, 14 in Class II, and 6 in Class III respectively) and 13 were male (6,1, and 9 in Class I, II, III respectively). The percentage distribution in given in figure 2.

When we examined the mean values of upper and lower airways for all the three groups, it was observed that the mean values first decrease from group 1 to group 2 (for both upper and lower airway) then it increases from group 2 to group 3 (for both upper and lower airway). The mean values and standard deviations are given in table I.

The one-way ANOVA test was applied to compare the three groups of lower and upper airway (table I). These values suggested that there is no statistically significant difference in the airway dimensions among Classes I, II and III in vertically high angle patients.

Post hoc Tukey test was used for the intergroup comparison of upper and lower airway (Table II). Although the mean values decreased from class I to class II and increased from class II to class III, and class I to class III, but there was no statistically significant difference noted.

Group comparisons with the standard values of McNamara analysis are shown in table III. For upper airway measurement in all the three groups, majority of the patients had less than normal value (9 in Class I, 10 in Class II and 9 in Class III) indicating a narrower upper airway in most of high angle patients. For lower airway measurement the effect of increased vertical dimension was less profound on the individual groups with Class II group affected the most and Class I group affected the least.



Figures 1: UPA (upper pharyngeal airway), LPA (lower pharyngeal airway)

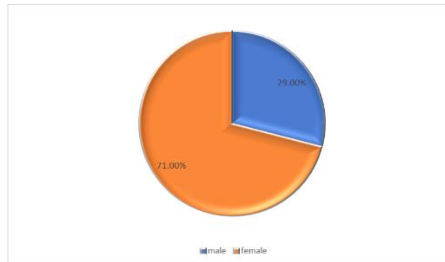


Figure 2: Gender distribution

Table I: Mean, standard deviation and One-way ANOVA

	Group 1(Class I)		Group 2 (Class II)		Group 3 (Class III)		One-way ANOVA (P- value)
	Mean	**S.D**	**Mean**	**S.D**	**Mean**	**S.D**	
Upper airway (mm)	12.86	3.52	12.46	3.29	12.93	3.73	0.926
Lower airway (mm)	11	2.72	9.80	2.73	12.33	3.77	0.096

Table II: Post hoc Tukey Test

	Groups	Sig.
Upper (mm)	Class I and II	0.948
	Class II and III	0.93
	Class I and III	0.999
Lower (mm)	Class I and II	0.547
	Class II and III	0.078
	Class I and III	0.476

Table III: Comparison with standard values (McNamara airway analysis)

	Upper airway		Lower airway	
	< 15	**> 20**	**< 11**	**> 14**
Class-1 (15)	9 (60%)	-	3 (20%)	1 (6.7%)
Class-2 (15)	10 (66.7%)	-	7 (46.7%)	1 (6.7%)
Class-3 (15)	9 (60%)	1 (6.7%)	6 (40%)	4 (26.7%)

Discussion

This study involved the use of lateral cephalograms for measuring airway dimension. These cephalograms belonged to healthy orthodontic patients with no history of any nasopharyngeal pathology or obstruction, to eliminate the impact of any pathological changes in the airway dimension. The influence of age and growth were eliminated by selecting adult subjects (above 18years). Good quality lateral cephalograms with films that fell within the standardization criteria were included to measure the airway.

As lateral cephalograms were used for this study, which allowed only 2- dimensional view and thus only linear dimensional changes in the upper and lower airway were measured utilizing McNamara analysis. [2] The airway volume study would have required a more advanced CBCT scan for a 3-dimensional view and measurements. Lateral cephalograms were selected because they were readily available, moreover they have widely been used previously for the measurement of airway dimensions and analysis.[12,13] Although studies like that of Lenza have concluded that the transverse view alone cannot portray the morphology of the airway, and that a 3-D view should be obtained for the analysis,[15] there are multiple studies who have reported positive findings with a lateral cephalogram.[9,16] Bronoosh analyzed the results of airway measurements on lateral and 3D-CT cephalograms, and indicated a strong correlation between 3D-CT and lateral cephalometric measurements.[17]

The results of the present study showed no significant difference in the linear airway dimensions when compared with each other for the three sagittal classes in high angle subjects. However, while measuring upper airway dimensions all the groups showed majority of the subjects to have less than the normal value of 15-20 mm (60%, 66.7%, 60% for class I, II and III respectively) (Table III). For lower airway measurement, the most subjects found to have less than normal value (11-14 mm) were in class II group (46.5%), followed by class III (40%), and least in class I (20%) (Table III). Thus, indicating that lower airway is less likely to be influenced by the vertical growth pattern in comparison with upper airway, with the class II group exhibiting the most change in comparison with the other two groups. These results are in similarity to the findings reported by Memon et al[12] who when compared the different craniofacial patterns with the pharyngeal width, concluded that the sagittal jaw relationship has the least impact on upper pharyngeal width in comparison with the vertical jaw relationship. Their results indicated that the high angle subjects had narrow upper airway dimension as compared to their counterparts. Ucar[9] and Wang[8] also reported similar findings in vertically high angle subjects. Wang used a 3-D reconstruction of the airways, while we used a 2-D lateral cephalogram.

A similar study conducted by Batool et al [16] compared the upper and lower pharyngeal airway dimensions in class II vertically high and low angle subjects. Their results showed that in Class II high angle malocclusion, subjects had a significantly narrow airway when compared with Class II malocclusion having low angle. Mani et al[13] also exhibited similar findings regarding narrowing of airway dimensions in Class II high angle cases.

For the present study, the mean values for all the groups were compared among each other to check for any pattern within the data. The results showed that the values decreased from group 1 to 2. However, the values were not statistically significant thus indicating that the class II subjects had slightly narrower airway dimensions as compared to class 1 subjects but were not clinically significant. These results are in similarity with those by Freitas et al,[18] who found no statistically significant difference in upper airway for high angle class I and class II subjects.

While comparing groups 2 and 3, the mean airway values increased but these changes were not statistically significant, thus suggesting lack of significant difference in the airway dimensions of Class II and Class III patients. These results are in contrast with the results of some previous studies which measured the pharyngeal volume and established that Class II skeletal cases have significantly narrower airway dimensions in comparison with Class III cases.[19-20] The difference in the results could be because 2-D linear measurements were used in the present study in contrast to volumetric data utilized by these studies.

The decrease in the airway dimension from group I to group II and increase in the mean airway dimension from group II to group III could be due to the fact, that in skeletal class II mandibular retrognathia is a common phenomenon, which can lead to a decreased airway space. While skeletal Class III can be accompanied by mandible prognathism thus providing the increased airway space. Muto et al, who evaluated the pharyngeal airway dimensions in subjects with protruded, retruded and normal mandible also reported similar findings. He concluded that the posterior pharyngeal airway dimension was greatest in the subjects with protruded mandible, followed by the subjects with normal mandible, while the subjects with retruded mandible had the shortest airway diameter. Thus, indicating the effects of mandibular position on the pharyngeal airway dimension.[21]

Limited studies have been conducted on the Pakistani population to assess the airway dimensional changes. This topic should be studied further to find any correlation between the craniofacial morphology and the airway dimensions. A subsequent study with a larger sample size including both sagittal and vertical growth patterns should be carried out in the future. This type of study will not only help in establishing their relationship with different physiological and pathological factors affecting the airway leading to the development of diseases like Obstructive Sleep Apnea but will also provide valuable information to evaluate the different treatment options.

Conclusions

While comparing the upper and lower airway dimensions among the three sagittal classes for high angle pattern, no statistically significant differences were found. For the upper airway measurement all the 3 groups showed majority of the cases to have less than normal value, indicating a narrow upper airway dimension for high angle cases.

References

1. Nielsen IL. Vertical malocclusions: etiology, development, diagnosis, and some aspects of treatment. Angle Orthod.1991;61(4):247-60.
2. Majeed O, Quadeer TA, Habib M, Jawaid M, Mujahid R. Evaluation of Upper and Lower Pharyngeal Airways in Normodivergent Class I and II Malocclusions in a Group of Pakistani Patients. J Pak Dent Assoc. 2017;26(1):22-5.
3. Nath M, Ahmed J, Ongole R, Denny C, Shenoy N. CBCT analysis of pharyngeal airway volume and comparison of airway volume among patients with skeletal Class I, Class II, and Class III malocclusion: A retrospective study. J Craniomandibular Pract.2019;37(5):2-13.
4. Tarkar JS, Parashar S, Gupta G, Bharadwaj P, Maurya RK, Singh A, et al. An evaluation of upper and lower pharyngeal airway width, tongue posture and hyoid bone position in subjects with different growth patterns. J Clin Diagn Res.2016;10(1):79-83.
5. Kaur S, Rai S, Sinha A, Ranjan V, Mishra D, Panjwani S. A lateral cephalogram study for evaluation of pharyngeal airway space and its relation to neck circumference and body mass index to determine predictors of obstructive sleep apnea. J Indian Acad Oral Med Radiol.2015;27(1):2-8.
6. Bhagya Lakshmi K, Yelchuru SH, Chandrika V, Lakshmikar OG, Lakshmi Sagar V, Vivek Reddy G. Comparison between growth patterns and pharyngeal widths in different skeletal malocclusions in South Indian population. J Int Soc Prev Community Dent.2018;8(3):224-8.
7. Celikoglu M, Bayram M, Sekerci AE, Buyuk SK, Toy E. Comparison of pharyngeal airway volume among different vertical skeletal patterns: A cone-beam computed tomography study. Angle Orthod.2014;84(5):782-7.
8. Wang T, Yang Z, Yang F, Zhang M, Zhao J, Chen J, et al. A three-dimensional study of upper airway in adult skeletal class II patients with different vertical growth patterns. Plos ONE.2014;9(4):1-9.

9. Ucar FI, Uysal T. Orofacial airway dimensions in subjects with Class I malocclusion and different growth patterns. Angle Orthod.2011;81(3):460-8.
10. Chavanavesh J, Petdachai S, Chuenchompoonut V. The effects of sex, skeletal age, and sagittal skeletal pattern on pharyngeal airway dimensions and related structures in growing Thai orthodontic patients. Orthod Waves. 2018;77(2):111-24.
11. Indriksone I, Jakobsone G. The upper airway dimensions in different sagittal craniofacial patterns: a systematic review. Stomatologija.2014;16(3):109-7.
12. Memon S, Fida M, Shaikh A. Comparison of Different Craniofacial Patterns with Pharyngeal Widths. J Coll Physicians Surg Pak.2012;22(5):302-6.
13. Mani P, Muthukumar K, Krishnan P, Kumar KPS. Upper and lower pharyngeal airway space in West-Tamil Nadu population. J Pharm Bioallied Sci. 2015;7(2):39-42.
14. Kaur S, Rai S, Kaur M. Comparison of reliability of lateral cephalogram and computed tomography for assessment of airway space. Niger J Clin Pract. 2014;17(5):629-36.
15. Lenza MG, de MM, Dalstra M, Melsen B, Cattaneo PM. An analysis of different approaches to the assessment of upper airway morphology: A CBCT study. Orthod Craniofac Res.2010;13(2):96-105.
16. Batool I, Shaheed M, Rizvi SAA, Assad A. Comparison of upper and lower pharyngeal airway space in clas II high and low angle cases. Pak Oral Dent J.2010;30(1):81-5.
17. Bronoosh P, Khojastepour L. Analysis of Pharyngeal Airway Using Lateral Cephalogram vs CBCT Images: A Cross-sectional Retrospective Study. Open Dent J.2015;9(1):263-66.
18. Freitas MR, Alcazar NMPV, Janson G, Freitas KMS, Henriques JFC. Upper and lower pharyngeal airways in subjects with Class I and Class II malocclusions and different growth patterns. Am J Orthod Dentofacial Orthop 2006;130(6):742-5.
19. Jadhav M, Bhosale V, Patil A, Shinde S. Comparison of Volumetric Dimensions of Pharyngeal Airway for Different Dentofacial Skeletal Patterns Using Cone Beam Computed Tomography. Folia Medica.2020;62(3):572-7.
20. El H, Palomo JM. Airway volume for different dentofacial skeletal patterns. Am J Orthod Dentofac Orthop.2011;139(6):511-21.
21. Muto T, Yamazaki A, Takeda S. A cephalometric evaluation of the pharyngeal airway space in patients with mandibular retrognathia and prognathia, and normal subjects. Int J Oral Maxillofac Surg.2008;37(3):228-31.