ORIGINAL ARTICLE

Cephalometric evaluation of the airway dimensions in subjects with different growth patterns

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ABSTRACT

Objective: The purpose of this study was to compare the pharyngeal airway dimensions by cephalometric examination of individuals with different morphological patterns. **Materials and Methods:** The sample comprised pretreatment lateral cephalometric radiographs of 90 subjects, aged 16-25, which were divided into three distinct groups, according to their morphological patterns, that is, hypodivergent, normodivergent and hyperdivergent. The upper and lower pharyngeal airways were assessed according to McNamara's airways analysis. **Results:** The results showed that the upper and lower pharyngeal width in hyperdivergent growth patterns subjects was statistically significantly narrower than in the normodivergent and hypodivergent growth pattern groups ($P < 0.05$). **Conclusions:** Subjects with vertical growth patterns have significantly narrower upper and lower pharyngeal airways than those with Class II malocclusions and horizontal and normal growth patterns. These patients may be more prone to mouth breathing as a result of their relatively diminished pharyngeal dimensions.

Key words: Lateral cephalometry, pharyngeal airway space, vertical growth pattern

Introduction

Various methods have been used to evaluate the airway, including, cine-computed tomography (CT), lateral cephalogram, magnetic resonance imaging, as well as polysomnography.[1-4] Cephalometry is, however, the most commonly used of the above tests. Cephalometric measurements of the posterior airway space, although a two-dimensional analysis, have proved very reliable in diagnosing pharyngeal volumes.[5,6]

Cephalometry also offers considerable advantages over other techniques, including low cost, convenience and minimal exposure to radiation, as well as being able to simultaneously analyze head position, craniofacial morphology and pharyngeal airway. Normal airway is one of the important factors for the normal growth of the craniofacial structure. Any obstacle in the respiratory system causes respiratory obstruction and forces the patient to breathe through the mouth.[7] With the presence of mouth breathing, the mandible is lowered, and the lips are parted. Tongue assumes a lower position in the oral cavity reducing the support of the palate and maxillary arch. This result in alteration on the forces affecting the facial skeleton causing vertical development of the face, narrow maxilla and a steep mandibular plane.[8]

Various factors responsible for mouth breathing like hypertrophic adenoids and tonsils, chronic and allergic rhinitis, environmental irritants and infections have been reported.[9] However, jaw malpositions and jaw anomalies like retrusion of the maxilla and mandible, vertical maxillary excess and vertical growth pattern of the mandible may also

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lead to narrowing of the pharyngeal airway, predisposing patients to mouth breathing.[10,11]

Significant relationships between the pharyngeal structures and craniofacial structures have been reported in the literature.[12,13] Recently, an interest has been focused on pharyngeal dimensions because of a potential relationship between size and structure of upper airway and sleep-induced breathing disturbances.[14] Narrowing of the airway in individuals at a young age may predispose them to obstructive episodes as they mature. Because subjects with narrow airway may have aberrant skeletal and soft tissue patterns, it has been proposed that cephalometry may help to identify the patient in whom the skeletal anomalies contribute to airway obstruction. Therefore, to further investigate this assumption, our objective in this study was to compare the pharyngeal dimensions of subjects with different vertical growth patterns.

Materials and Methods

The sample comprised lateral cephalograms of 90 untreated patients, with the age range of 16-25 years having full complement of teeth (with the exception of third molars) and who were to undergo orthodontic treatment. Further screening of subjects for inclusion was done after detailed case history and clinical examination. A written informed consent was obtained from each participant or his or her parents, and an ethical clearance was obtained from the Institutional Ethical Committee before inclusion in our study.

Subjects having any history of congenital defect, orthodontic treatment, surgery in the head and neck region, joint disorder, cervical spine disorder and any neuromuscular disorder or history of nasal obstruction were excluded from the study group. Lateral cephalometric radiographs were taken using a standardized technique, with the jaw in centric relation and the teeth in occlusion, the lips relaxed, and the head in the natural head position[15] by the same operator with a cephalostat (Rotograph plus Villa system Medical, Italy).

Subjects were divided into three groups according to vertical growth pattern of mandible. SN-MP angle was used to divide the sample into hypodivergent, normodivergent, hyperdivergent growth patterns with values of $<26°$, 26-38° and $>38°$ respectively as proposed by Isaacson *et al*.[16] The upper and lower pharyngeal airways width were measured using McNamara's airway analysis [Figure 1].[17]

Upper pharyngeal width was taken as a point on the posterior outline of the soft palate to the closest point on the posterior pharyngeal wall. The average nasopharynx is approximately 15-20 mm in width. Lower pharyngeal width was measured from the 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.

Statistics

Continuous data were summarized as mean $\pm$ standard deviation while discrete (categorical) in percentage. Continuous variables were compared by one-way analysis of variance (ANOVA) and the significance of mean difference between the groups was done by Tukey's *post hoc* test after ascertaining the normality and homogeneity of variances by Shapiro-Wilk test and Levene's test, respectively. Categorical variables were compared by Chi-square (χ^2) test. A two-sided ($\alpha = 2$) $P < 0.05$ was considered statistically significant. All analyses were performed on statistica statistical software.

Results

Pharyngeal Airway Measurements

To ascertain reliability, cephalometric films of 12 randomly selected subjects were retraced and remeasured at 3 week's interval. A paired sample *t*-test was used to determine measurement accuracy. No statistically significant difference was found between the first and second measurements ($P > 0.05$).

Upper Airway Width

The upper airway widths of three groups are summarized in Table 1. The mean upper airway width of hypodivergent group was the highest followed by normodivergent group and least in hyperdivergent group. When comparing

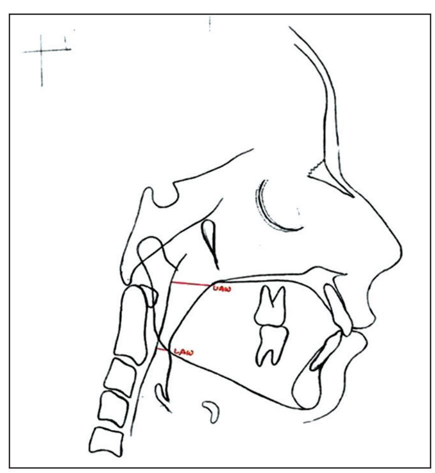

Figure 1: Upper and lower pharyngeal airways width

Table 1: Upper and LAW width (mean ± SD) of three groups

Characteristics	Hypodivergent	Hyperdivergent	Normodivergent	*P*
UAW (mm), mean±SD	20.55±3.94 (14-28)	16.75±3.39 (10-21)	18.75±2.51 (14-23)	0.003
LAW (mm), mean±SD	11.00±3.23 (5-17)	8.10±2.53 (4-13)	9.85±3.31 (5-19)	0.014

SD: Standard deviation, UAW: Upper airway, LAW: Lower airway

the mean upper airway width of three groups, ANOVA [Table 1] revealed significant difference in the upper airway width among the groups ($P < 0.01$). Further, Tukey test [Table 2] revealed that the mean upper airway width of hyperdivergent group was significantly lower as compared to hypodivergent group ($P < 0.01$). However, the mean upper airway width did not differ significantly between hypodivergent and normodivergent and hyperdivergent and normodivergent group ($P > 0.05$).

Table 2: Significance (*P*) of mean difference of upper airway width between the groups by Tukey test

Comparisons	*P*
Hypodivergent versus hyperdivergent	0.002
Hypodivergent versus normodivergent	0.211
Hyperdivergent versus normodivergent	0.148

Table 3: Significance (*P*) of mean difference of lower airway width between the groups by Tukey test

Comparisons	*p* value
Hypodivergent vs. Hyperdivergent	0.011
Hypodivergent vs. Normodivergent	0.461
Hyperdivergent vs. Normodivergent	0.173

Lower Airway Width

Comparing the mean lower airway width of three groups, ANOVA [Table 1] revealed a significantly different lower airway width among the groups ($P < 0.05$). Tukey test [Table 3] revealed that the mean lower airway width of hyperdivergent group was significantly lower as compared to hypodivergent group ($P < 0.05$). However, no significant difference was found in the lower airway width between hypodivergent and normodivergent and hyperdivergent and normodivergent ($P > 0.05$).

Discussion

Pretreatment lateral head cephalograms of subjects in natural head position were taken evaluate to pharyngeal airway dimensions in different vertical growth patterns. Controversy exists as the cephalogram depicts two-dimensional views of three-dimensional structures. We chose lateral cephalograms for this study because posterior airway space, as measured by lateral cephalometric radiography, was highly correlated with measurements using three-dimensional CT scan, with 92% accuracy in predictability.[18] Aboudara *et al*.[19] also compared CT and cephalometric films in subjects with skeletal malocclusion and found a significant positive relationship between nasopharyngeal airway size on lateral cephalogram and its true volumetric size as determined from CT scan in adolescents. Cephalometry also offers considerable advantages over other techniques, including low cost, and minimal exposure to radiation.

In the present study, we found that the mean upper airway width of hypodivergent group was the highest followed by normodivergent group and hyperdivergent group, the least. When comparing upper airway width among various growth patterns, hyperdivergent growth pattern subjects showed a statistically significant narrow upper airway width when compared to normodivergent and hypodivergent growth pattern ($P \leq 001$). However, no statistically significant difference was found in the upper airway width between normodivergent and hypodivergent growth pattern and, normodivergent and hyperdivergent growth pattern.

Similarly, the mean lower airway width of hypodivergent group was the highest followed by normodivergent group, and least in hyperdivergent group. The most significant difference was found between lower airway width of hyperdivergent and hypodivergent group ($P = 0.011$), However, the mean lower airway width did not differ significantly between hypodivergent and normodivergent, and hyperdivergent and normodivergent group. Analyzing these results, we can infer that the upper airway width is influenced by the craniofacial growth pattern.

Ucar *et al*.[20] studied Class I subjects with different vertical growth patterns (low, normal, and high angle). They reported be larger nasopharyngeal airway space and upper pharyngeal airway space in low angle subjects than in high angle subjects. Palatal tongue space and tongue gap were larger in high angle subjects than in low angle subjects and tongue gap was statistically greater in high angle than in normal angle subjects. Similarly Batool *et al*.[21] compared the subjects with Class II malocclusions with horizontal and vertical growth patterns and found that subjects with vertical growth patterns have significantly narrower upper and lower pharyngeal airways than those with horizontal growth patterns. Akcam *et al*.[22] reported a decrease in the upper airway dimensions of subjects who had posterior mandibular rotation. This reveals a close association between the pharyngeal airway and positioning of the jaws.

Joseph *et al*.[11] compared the pharyngeal dimensions of hyperdivergent and normodivergent facial types and found that hyperdivergent group had a narrower anteroposterior pharyngeal dimension than the normodivergent control group. Memon *et al*.[23] showed in their study that 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, he found no statistically significant difference in lower pharyngeal airway widths among three vertical growth patterns. Similar findings were reported by de Freitas *et al*.[24] in subjects with untreated Class I and Class II malocclusions, and normal and vertical growth patterns. They reported that the upper pharyngeal width was affected by vertical growth pattern but, growth pattern do not influence the lower pharyngeal airway width. However in the present study, we found that the hyperdivergent growth pattern subjects showed a statistically significantly narrow the lower pharyngeal airway width when compared to normodivergent and hypodivergent facial patterns.

As, hyperdivergent patients had the lowest mean for this measurement, these patients may be more prone to mouth breathing as a result of their relatively diminished pharyngeal dimensions. Small pharyngeal dimensions in hyperdivergent group may be attributed to downward and backward rotation of mandible that might lead to a posterior postured tongue, increasing the chances of impaired respiratory function. Therefore, the "reduction" of the pharyngeal airway in hyperdivergent patients cannot be attributed only to the larger adenoids or the presence of soft tissue in the posterior nasopharyngeal region. Reduced airway in vertical growth pattern subjects may be the result of other factors not fully understood.

The relationship between respiratory function and craniofacial morphology has been debated for more than a century. Normal respiratory function influences the growth of maxillofacial structures, favouring their harmonious growth and development.[25] The presence of any obstacle in the respiratory system, especially in the nasal and pharyngeal regions, causes respiratory obstruction and forces the patient to breathe through the mouth. This results in alteration on the forces affecting the facial skeleton. Linder-Aronson[26] compared mouth breathing children to an equal number of nasal breathers, to find any difference in craniofacial morphology between these groups. The findings of their study demonstrated that children with obstructed nasal breathing were characterized by increased lower face height, increased total facial height, and more retrognathic mandibles compared to the control group. In addition, the sagittal depth of the bony nasopharynx was found to be small in the mouth breathers when compared with the controls.

Narrow pharyngeal airway space is one of the predisposing factors for mouth breathing and obstructive sleep apnea.[27] Early diagnosis of the hyperdivergent skeletal pattern with a concomitant pharyngeal narrowing may identify individuals at risk for breathing disorder and cephalometrics radiographs may be useful in diagnosis such patients. When diagnosing and treating patients with malocclusion, orthodontists should recognize pharyngeal airway morphologies that might be predisposing factors of undesirable craniofacial development. Our study showed statistically significant differences in pharyngeal width among three different growth patterns. Hyperdivergent subjects have statistically significant narrower upper and lower pharyngeal width when compared to other two vertical patterns, revealing that growth pattern, whether low or high, has an effect on pharyngeal airway space. However, it is recommended that a similar study with a larger sample size should be conducted. This study was conducted to evaluate only pharyngeal airway widths, and not airway flow capacities, which would have required a more complex three-dimensional and dynamic evaluation.

Conclusion

Based on the assessment of the facial pattern data produced in this study, we found that hyperdivergent patients had statistically significant narrower upper and lower pharyngeal width a when compared to normodivergent and hypodivergent growth patterns.

References

1. Haponik EF, Smith PL, Bohlman ME, Allen RP, Goldman SM, Bleecker ER. Computerized tomography in obstructive sleep apnea. Correlation of airway size with physiology during sleep and wakefulness. Am Rev Respir Dis 1983;127:221-6.
2. Holmberg H, Linder-Aronson S. Cephalometric radiographs as a means of evaluating the capacity of the nasal and nasopharyngeal airway. Am J Orthod 1979;76:479-90.
3. Rodenstein DO, Dooms G, Thomas Y, Liistro G, Stanescu DC, Culée C, *et al.* Pharyngeal shape and dimensions in healthy subjects, snorers, and patients with obstructive sleep apnoea. Thorax 1990;45:722-7.
4. Johnson PL, Edwards N, Burgess KR, Sullivan CE. Detection of increased upper airway resistance during overnight polysomnography. Sleep 2005;28:85-90.

5. deBerry-Borowiecki B, Kukwa A, Blanks RH. Cephalometric analysis for diagnosis and treatment of obstructive sleep apnea. Laryngoscope 1988;98:226-34.
6. Riley R, Guilleminault C, Herran J, Powell N. Cephalometric analyses and flow-volume loops in obstructive sleep apnea patients. Sleep 1983;6:303-11.
7. Harvold EP, Tomer BS, Vargervik K, Chierici G. Primate experiments on oral respiration. Am J Orthod 1981;79:359-72.
8. Lampasso JD, Lampasso JG. Allergy, nasal obstruction, and occlusion. Semin Orthod 2004;10:39-44.
9. Stellzig-Eisenhauer A, Meyer-Marcotty P. Interaction between otorhinolaryngology and orthodontics: Correlation between the nasopharyngeal airway and the craniofacial complex. Laryngorhinootologie 2010;89 Suppl 1:S72-8.
10. Abu Allhaija ES, Al-Khateeb SN. Uvulo-glosso-pharyngeal dimensions in different anteroposterior skeletal patterns. Angle Orthod 2005;75:1012-8.
11. Joseph AA, Elbaum J, Cisneros GJ, Eisig SB. A cephalometric comparative study of the soft tissue airway dimensions in persons with hyperdivergent and normodivergent facial patterns. J Oral Maxillofac Surg 1998;56:135-9.
12. Grauer D, Cevidanes LS, Styner MA, Ackerman JL, Proffit WR. Pharyngeal airway volume and shape from cone-beam computed tomography: Relationship to facial morphology. Am J Orthod Dentofacial Orthop 2009;136:805-14.
13. Preston BC. Cephalometric evaluation and measurement of the upper airway. Semin Orthod 2004;10:3-15.
14. Bacon WH, Turlot JC, Krieger J, Stierle JL. Cephalometric evaluation of pharyngeal obstructive factors in patients with sleep apneas syndrome. Angle Orthod 1990;60:115-22.
15. Solow B, Tallgren A. Natural head position in standing subjects. Acta Odontol Scand 1971;29:591-607.
16. Isaacson JR, Isaacson RJ, Speidel TM, Worms FW. Extreme variation in vertical facial growth and associated variation in skeletal and dental relations. Angle Orthod 1971;41:219-29.
17. McNamara JA Jr. A method of cephalometric evaluation. Am J Orthod 1984;86:449-69.
18. Riley RW, Powell NB. Maxillofacial surgery and obstructive sleep apnea syndrome. Otolaryngol Clin North Am 1990;23:809-26.
19. Aboudara C, Nielsen I, Huang JC, Maki K, Miller AJ, Hatcher D. Comparison of airway space with conventional lateral headfilms and 3-dimensional reconstruction from cone-beam computed tomography. Am J Orthod Dentofacial Orthop 2009;135:468-79.
20. Ucar FI, Uysal T. Orofacial airway dimensions in subjects with Class I malocclusion and different growth patterns. Angle Orthod 2011;81:460-8.
21. Batool I, Shaheed M, Ali Rizvi AS, Abbas A. Comparison of upper and lower pharyngeal airway space in class II high andlow angle cases. Pak Oral Dent J 2010;30:81-4.
22. Akcam MO, Toygar TU, Wada T. Longitudinal investigation of soft palate and nasopharyngeal airway relations in different rotation types. Angle Orthod 2002;72:521-6.
23. Memon S, Fida M, Shaikh A. Comparison of different craniofacial patterns with pharyngeal widths. J Coll Physicians Surg Pak 2012;22:302-6.
24. de Freitas MR, Alcazar NM, Janson G, de Freitas KM, Henriques JF. Upper and lower pharyngeal airways in subjects with Class I and Class II malocclusions and different growth patterns. Am J Orthod Dentofacial Orthop 2006;130:742-5.
25. Yamada T, Tanne K, Miyamoto K, Yamauchi K. Influences of nasal respiratory obstruction on craniofacial growth in young Macaca fuscata monkeys. Am J Orthod Dentofacial Orthop 1997;111:38-43.
26. Linder-Aronson S. Adenoids their effects on mode of breathing and their relationship to characteristics of facial skeleton and dentition. Acta Otolaryngol 1970;265:1-132.
27. Jureyda S, Shucard DW. Obstructive sleep apnea – An overview of the disorder and its consequences. Semin Orthod 2004;10:63-72.

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