Effects of Airway Problems on Maxillary Growth: A Review

Ahmet Yalcin Gungor[a]
Hakan Turkkahraman[b]

ABSTRACT

The volume of air passing through the nose and nasopharinx is limited by its shape and diameter. Continuous airflow through the nasal passage during breathing induces a constant stimulus for the lateral growth of maxilla and for lowering of the palatal vault. Maxillary morphological differences exist between patients with airway problems and control groups, identifying a potential etiological role in these patients. The purpose of this article was to review the literature on the interaction between airway problems and expressed maxillary morphology including specific dental and skeletal malocclusions. Statistically significant differences were found between patients with airway problems and control groups, in maxillary skeletal morphology including shorter maxillary length, more proclined maxillary incisors, thicker and longer soft palate, narrower maxillary arch and higher palatal vault. (Eur J Dent 2009;3:250-254)

Key words: Airway problems; Growth and development; Maxilla; Obstructive sleep apnea.

INTRODUCTION

The volume of air passing through the nose and nasopharinx is limited by its shape and diameter.[1] The causes of nasal obstruction and mouth breathing may be hypertrophied adenoids and tonsils, chronic and allergic rhinitis, nasal traumas, congenital nasal deformities, foreign bodies, polyps, and tumors.[2] One of the most common causes of mouth breathing in children is hypertrophy of pharyngeal tonsils.[3]

According to Moss's functional matrix concept,[4] nasal breathing allows proper growth and development of the craniofacial complex. Thus, continuous airflow through the nasal passage during breathing induces a constant stimulus for the lateral growth of maxilla and for lowering of the palatal vault.[5] On the other hand, midface hypoplasia can lead to upper respiratory tract obstruction.[6]

[a] Research Assistant, Suleyman Demirel University, Faculty of Dentistry, Department of Orthodontics, Isparta, Turkey.
[b] Associate Professor, Suleyman Demirel University, Faculty of Dentistry, Department of Orthodontics, Isparta, Turkey.

Corresponding author: Ahmet Yalcin Gungor
Suleyman Demirel Universitesi
Dişhekimligi Fakultesi Ortodonti Anabilim Dali
Dogu Kampusu 32260, Isparta, Turkey.
Phone: +90 246 2113696
Fax: +90 246 2370607
E-mail: aygungor@hotmail.com

Naso-respiratory function and its relation to craniofacial growth are of great interest from 1980's to present, not only as an example of basic biological relationship of form and function but also because of great practical concern to pediatricians, otorhinolaryngologists, allergists, speech therapists, orthodontists, and other members of health-care community as well.[7]

Most of the literature examining the relation between airway problems and craniofacial morphology are interested in obstructive sleep apnea. Obstructive sleep apnea, one of the most common airway problems, is a potentially life-threatening condition in which the patient suffers periodic cessation of breathing during sleep, which impairs the quality of life.[8]

The purpose of this article was to review the literature on the interaction between airway problems and expressed maxillary morphology including specific dental and skeletal malocclusions.

EFFECTS ON SAGITTAL PLANE

Lateral cephalometry is one of the most important imaging techniques that has been used to investigate the facial characteristics of patients with airway problems.[9] Several cephalometric differences between patients with airway problems and control samples and a variety of morphologic characteristics specific to these patients have been reported[7,9-27] but little information has been presented concerning maxillary growth.

McNamara[7] reported that in patients with airway obstruction, superimposition on the internal structures of the maxilla reveals a slight downward and forward movement of the maxillary molars and a lesser extent of the upper incisors, and even with a normal antero-posterior relationship between mandible and maxilla the increase in anterior facial height and the slight relative posterior displacement of the maxillary complex caused the face to become more retrognathic.

Pae at al[9] investigated the cephalometric characteristics of patients with severe obstructive sleep apnea and they showed that patients with severe obstructive sleep apnea may have a short facial height and a deep overbite, the antero-posterior relationship of the mandible to the maxilla may not be the primary reason for the large overbite, and they speculated that obstructive sleep apnea problems in patients may be associated with the vertical skeletal disharmony of the oral cavity.

Most of authors reported that the PNS-posterior pharyngeal wall measurements were reduced in all obstructive sleep apnea subjects.[28-30] Seto et al[30] and Lowe at al[31] reported a statistically significant shorter ANS-PNS length in obstructive sleep apnea patients. Lowe at al[31] reported that the position of the maxilla did not show any significant difference from the control subjects, however, it was smaller antero-posteriorly. Some of the authors observed changes in the inclination of the hard plate.[32-37]

Race is an important factor on craniofacial morphology even both in patients with airway problems and normal population. Wong at al[1] made an inter-ethnic comparison of craniofacial morphology of patients with obstructive sleep apnea and they reported that Malay subjects with obstructive sleep apnea had a shorter maxillary length compared with other racial groups. This is surprising because Chinese morphology is generally less prognathic than that of Malays.[1]

Lam et al[38] made a computed tomographic evaluation of the role of craniofacial and upper airway morphology in obstructive sleep apnea in Chinese population and they concluded that craniofacial factors and upper airway morphology contributed to severity of obstructive sleep apnea in Chinese subjects. Similarly, Endo et al[39] made a cephalometric evaluation of craniofacial and upper airway structures in Japanese patients with obstructive sleep apnea and they stated that the morphological characteristics specific to Japanese patients with obstructive sleep apnea.

Lateral cephalometric characteristics of the soft tissue structures include a long soft palate, a long large tongue, and a long pharynx.[9] Some of the studies reported that soft palate length was increased in patients with airway problems.[10,16,19,20,22,28,30,31,40] In addition, soft palate length increases with age,[41] and so that studies must match control subjects for age.[28] Soft palate area was increased in all obstructive sleep apnea patients.[28,42] Increase in soft palate thickness in obstructive sleep apnea patients was not statistically significant in some studies,[28,29] and was significant in others.[16,20 31] Johal and Conaghan[28] reported that palatal angle (ANS-PNS-uvula) was significantly more obtuse in male obstructive sleep apnea subjects and because all other maxillary skeletal measurements detected no significant differences, the discrepancy appeared to be with the soft palate and its orientation.

EFFECTS ON TRANSVERSAL PLANE

Maxillary transverse deficiency is one of the most common skeletal anomalies in craniofacial region.[43] The relationship between maxillary constriction and the etiology of airway problems is not clear.[28] There are not enough studies evaluating transverse dimensions of the maxilla in patients with airway obstruction. Mouth-breathing individuals have been classically described as narrow, V-shaped maxillary arch, a high palatal vault, proclined upper incisors and a Class II occlusal relationship.[7]

There are some studies showing that there is a strong relationship between air way resistance and high palatal vault.[28,44] However, these results were not in agreement with other studies who did not find differences in palatal heights between patients with airway problems and control subjects.[30,45] Although Cistulli et al[45] examined the influence of maxillary morphology in sample of patients with Marfan's syndrome and a high vaulted palate is very characteristic of this syndrome, they surprisingly did not find any differences in palatal heights.

Johal and Conaghan[28] evaluated the maxillary morphology in obstructive sleep apnea with a cephalometric and model study and the made following conclusions:

- Maxillary morphological differences exist between obstructive sleep apnea and control subjects, identifying a potential etiological role in obstructive sleep apnea.
- Statistically significant differences exist between obstructive sleep apnea and control subjects, in both maxillary skeletal morphology and oropharyngeal dimensions.
- Study model analyses demonstrated that obstructive sleep apnea subjects differ significantly from control subjects in palatal height measurements.

Principato[46] evaluated the upper airway obstruction and craniofacial morphology and he reported that low tongue posture seen with oral respiration impedes the lateral expansion and anterior development of the maxilla. Neeley at al[47] stated that the effects upon nasal airflow resistance and subsequent growth are unpredictable and therefore airflow issues alone may not be a primary reason to increase the transverse dimension of the nasal base. In some of the studies, authors observed maxillary construction in patients who presented with constricted nasopharingeal dimensions and altered respiratory function.[30,48,49] On the other hand Shanker et al[50] found no relationship between palatal arch width and respiratory function.

CONCLUSIONS

The review of the literature indicates the interaction between respiratory function and maxillary growth pattern. Maxillary morphological differences exist between patients with airway problems and control groups, identifying a potential etiological role in these patients. Statistically significant differences were found between patients with airway problems and control groups, in maxillary skeletal morphology. In sagittal plane; maxillary length was shorter, maxillary incisors were more proclined, soft palate length and thickness were increased. In transversal plane; patients with airway problems presented narrow, V-shaped maxillary arch, and a high palatal vault.

REFERENCES

1. Wong ML, Sandham A, Ang PK, Wong DC, Tan WC, Huggare J. Craniofacial morphology, head posture, and nasal respiratory resistance in obstructive sleep apnoea: An inter-ethnic comparison. *Eur J Orthod* 2005;27:91-97.
2. Schlenker WL, Jennings BD, Jeiroudi MT, Caruso JM. The effects of chronic absence of active nasal respiration on the growth of the skull: A pilot study. *Am J Orthod Dentofacial Orthop* 2000;117:706-713.
3. Lopatiene K, Babarskas A. [malocclusion and upper airway obstruction]. *Medicina (Kaunas)* 2002;38:277-283.
4. Moss-Salentijn L. Melvin l. Moss and the functional matrix. *J Dent Res* 1997;76:1814-1817.
5. Kilic N, Oktay H. Effects of rapid maxillary expansion on nasal breathing and some naso-respiratory and breathing problems in growing children: A literature review. *Int J Pediatr Otorhinolaryngol* 2008;72:1595-1601.

6. Graewe FR, Morkel JA, Hartzenberg HB, Ross RJ, Zuehlke AE. Midface distraction without osteotomies in an infant with upper respiratory obstruction. *J Craniofac Surg* 2008;19:1603-1607.
7. McNamara JA. Influence of respiratory pattern on craniofacial growth. *Angle Orthod* 1981;51:269-300.
8. Ang PK, Sandham A, Tan WC. Craniofacial morphology and head posture in chinese subjects with obstructive sleep apnea. *Semin Orthod* 2004;10:90-96.
9. Pae EK, Ferguson KA. Cephalometric characteristics of nonobese patients with severe osa. *Angle Orthod* 1999;69:408-412.
10. Jamieson A, Guilleminault C, Partinen M, Quera-Salva MA. Obstructive sleep apneic patients have craniomandibular abnormalities. *Sleep* 1986;9:469-477.
11. Tsuchiya M, Lowe AA, Pae EK, Fleetham JA. Obstructive sleep apnea subtypes by cluster analysis. *Am J Orthod Dentofacial Orthop* 1992;101:533-542.
12. Lowe AA, Santamaria JD, Fleetham JA, Price C. Facial morphology and obstructive sleep apnea. *Am J Orthod Dentofacial Orthop* 1986;90:484-491.
13. Andersson L, Brattstrom V. Cephalometric analysis of permanently snoring patients with and without obstructive sleep apnea syndrome. *Int J Oral Maxillofac Surg* 1991;20:159-162.
14. Tangugsorn V, Skatvedt O, Krogstad O, Lyberg T. Obstructive sleep apnoea: A cephalometric study. Part i. Cervico-craniofacial skeletal morphology. *Eur J Orthod* 1995;17:45-56.
15. Solow B, Ovesen J, Nielsen PW, Wildschiodtz G, Tallgren A. Head posture in obstructive sleep apnoea. *Eur J Orthod* 1993;15:107-114.
16. Lyberg T, Krogstad O, Djupesland G. Cephalometric analysis in patients with obstructive sleep apnoea syndrome: Ii. Soft tissue morphology. *J Laryngol Otol* 1989;103:293-297.
17. Tangugsorn V, Skatvedt O, Krogstad O, Lyberg T. Obstructive sleep apnoea: A cephalometric study. Part ii. Uvulo-glossopharyngeal morphology. *Eur J Orthod* 1995;17:57-67.
18. Maltais F, Carrier G, Cormier Y, Series F. Cephalometric measurements in snorers, non-snorers, and patients with sleep apnoea. *Thorax* 1991;46:419-423.
19. Zucconi M, Ferini-Strambi L, Palazzi S, Orena C, Zonta S, Smirne S. Habitual snoring with and without obstructive sleep apnoea: The importance of cephalometric variables. *Thorax* 1992;47:157-161.
20. Pae EK, Lowe AA, Sasaki K, Price C, Tsuchiya M, Fleetham JA. A cephalometric and electromyographic study of upper airway structures in the upright and supine positions. *Am J Orthod Dentofacial Orthop* 1994;106:52-59.
21. Guilleminault C, Stoohs R. Obstructive sleep apnea syndrome in children. *Pediatrician* 1990;17:46-51.
22. Bacon WH, Turlot JC, Krieger J, Stierle JL. Cephalometric evaluation of pharyngeal obstructive factors in patients with sleep apneas syndrome. *Angle Orthod* 1990;60:115-122.
23. Guilleminault C, Partinen M, Praud JP, Quera-Salva MA, Powell N, Riley R. Morphometric facial changes and obstructive sleep apnea in adolescents. *J Pediatr* 1989;114:997-999.
24. Partinen M, Guilleminault C, Quera-Salva MA, Jamieson A. Obstructive sleep apnea and cephalometric roentgenograms. The role of anatomic upper airway abnormalities in the definition of abnormal breathing during sleep. *Chest* 1988;93:1199-1205.
25. deBerry-Borowiecki B, Kukwa A, Blanks RH. Cephalometric analysis for diagnosis and treatment of obstructive sleep apnea. *Laryngoscope* 1988;98:226-234.
26. Bacon WH, Krieger J, Turlot JC, Stierle JL. Craniofacial characteristics in patients with obstructive sleep apneas syndrome. *Cleft Palate J* 1988;25:374-378.
27. Guilleminault C, Riley R, Powell N. Obstructive sleep apnea and abnormal cephalometric measurements. Implications for treatment. *Chest* 1984;86:793-794.
28. Johal A, Conaghan C. Maxillary morphology in obstructive sleep apnea: A cephalometric and model study. *Angle Orthod* 2004;74:648-656.
29. Battagel JM, Johal A, Kotecha B. A cephalometric comparison of subjects with snoring and obstructive sleep apnoea. *Eur J Orthod* 2000;22:353-365.
30. Seto BH, Gotsopoulos H, Sims MR, Cistulli PA. Maxillary morphology in obstructive sleep apnoea syndrome. *Eur J Orthod* 2001;23:703-714.
31. Lowe AA, Ono T, Ferguson KA, Pae EK, Ryan CF, Fleetham JA. Cephalometric comparisons of craniofacial and upper airway structure by skeletal subtype and gender in patients with obstructive sleep apnea. *Am J Orthod Dentofacial Orthop* 1996;110:653-664.
32. Linder-Aronson S. Adenoids. Their effect on mode of breathing and nasal airflow and their relationship to characteristics of the facial skeleton and the denition. A biometric, rhino-manometric and cephalometro-radiographic study on children with and without adenoids. *Acta Otolaryngol Suppl* 1970;265:1-132.
33. Hannuksela A. The effect of moderate and severe atopy on the facial skeleton. *Eur J Orthod* 1981;3:187-193.
34. Bresolin D, Shapiro PA, Shapiro GG, Chapko MK, Dassel S. Mouth breathing in allergic children: Its relationship to dentofacial development. *Am J Orthod* 1983;83:334-340.

35. Trask GM, Shapiro GG, Shapiro PA. The effects of perennial allergic rhinitis on dental and skeletal development: A comparison of sibling pairs. *Am J Orthod Dentofacial Orthop* 1987;92:286-293.
36. Subtelny JD. Oral respiration: Facial maldevelopment and corrective dentofacial orthopedics. *Angle Orthod* 1980;50:147-164.
37. Tarvonen PL, Koski K. Craniofacial skeleton of 7-year-old children with enlarged adenoids. *Am J Orthod Dentofacial Orthop* 1987;91:300-304.
38. Lam B, Ooi CG, Peh WC, Lauder I, Tsang KW, Lam WK, Ip MS. Computed tomographic evaluation of the role of craniofacial and upper airway morphology in obstructive sleep apnea in chinese. *Respir Med* 2004;98:301-307.
39. Endo S, Mataki S, Kurosaki N. Cephalometric evaluation of craniofacial and upper airway structures in japanese patients with obstructive sleep apnea. *J Med Dent Sci* 2003;50:109-120.
40. Riley R, Guilleminault C, Herran J, Powell N. Cephalometric analyses and flow-volume loops in obstructive sleep apnea patients. *Sleep* 1983;6:303-311.
41. Johnston CD, Richardson A. Cephalometric changes in adult pharyngeal morphology. *Eur J Orthod* 1999;21:357-362.
42. Battagel JM, L'Estrange PR. The cephalometric morphology of patients with obstructive sleep apnoea (osa). *Eur J Orthod* 1996;18:557-569.
43. McNamara JA. Maxillary transverse deficiency. *Am J Orthod Dentofacial Orthop* 2000;117:567-570.
44. Guilleminault C, Partinen M, Hollman K, Powell N, Stoohs R. Familial aggregates in obstructive sleep apnea syndrome. *Chest* 1995;107:1545-1551.
45. Cistulli PA, Richards GN, Palmisano RG, Unger G, Berthon-Jones M, Sullivan CE. Influence of maxillary constriction on nasal resistance and sleep apnea severity in patients with marfan's syndrome. *Chest* 1996;110:1184-1188.
46. Principato JJ. Upper airway obstruction and craniofacial morphology. *Otolaryngol Head Neck Surg* 1991;104:881-890.
47. Neeley WW, 2nd, Edgin WA, Gonzales DA. A review of the effects of expansion of the nasal base on nasal airflow and resistance. *J Oral Maxillofac Surg* 2007;65:1174-1179.
48. Kellum GD, Gross AM, Walker M, Foster M, Franz D, Michas C, Bishop FW. Open mouth posture and cross-sectional nasal area in young children. *Int J Orofacial Myology* 1993;19:25-28.
49. Gross AM, Kellum GD, Michas C, Franz D, Foster M, Walker M, Bishop FW. Open-mouth posture and maxillary arch width in young children: A three-year evaluation. *Am J Orthod Dentofacial Orthop* 1994;106:635-640.
50. Shanker S, Vig KW, Beck FM, Allgair E, Jr., Vig PS. Dentofacial morphology and upper respiratory function in 8-10-year-old children. *Clin Orthod Res* 1999;2:19-26.