P. Fernandes, J. Pinto, J. Ustrell-Torrent

Oporto University – Medicine Faculty; University of Barcelona

e-mail: pmmfernandes@sapo.pt

Relationship between oro and nasopharynx permeability and the direction of facial growth

ABSTRACT

Aim *Most scientific literature relates vertical growth to individuals with decreased upper airway permeability. However, we often find subjects with a long face and a normal breathing pattern, most likely caused by other aetiological factors. And, frequently, we also find decreased upper airway permeability with horizontal growth. The aim of the study was to compare the cephalometric measurements of the oro and nasopharynx permeability with the facial growth direction and to identify the most common facial growth direction in individuals with decreased upper airway permeability.*

Materials and methods *Cephalometric analysis was carried out in 158 pre-adolescent patients at the Orthodontic appointment, using facial profile teleradiographs. Parameters used were Jabarak's ratio and measurement of oro-nasopharynx space. Data collected were submitted to statistical treatment.*

Results *This study points to the presence of an intermediate growth in individuals with diminished oro and nasopharynx permeability, either simultaneous or separate. The number of individuals with diminished permeability and vertical growth is close to the number of individuals with horizontal growth.*

Conclusions *The individuals with diminished permeability of the upper airway present an intermediate growth direction, representing the most frequent type. In the less common growth directions, there is a slight tendency to horizontal facial growth verified in individuals with diminished nasopharynx permeability. Also, a light tendency to vertical facial growth is present when oropharynx permeability is reduced.*

Keywords *Cephalometric measurements; Facial growth; Upper airway permeability*

Introduction

The study of growth and development of facial structures and the way it relates to the development and treatment of malocclusions is important towards understanding the aetiology and treatment of orthodontic problems.

A major advancement has been achieved with the concept of Moss' functional matrix: the bone grows in response to the functional demands of all soft tissues that operate associated to that same bone [Moss, 1997].

Influenced by the direction of growth, the cephalic pattern may be divided into three groups: dolichocephalic (21.90%), brachicephalic (13.54%) and mesocephalic (64.56%) [Silva-Filho et al., 2008].

Facial growth can be affected by multiple factors: respiratory modifications [Tsuda et al., 2011], mandibular and head posture, and lingual function generating changes to the stomatognathic system and conditioning diagnosis. These alterations may be present in sleep apnoea, although improvements can be observed after adenoid and tonsil surgery [Ahn, 2010] or maxillary advancement [Lee et al., 2011], mandibular advancement [Foltán and Rybiniová, 2007] or advancement of both jaws [Schendel et al., 2011]. Specific orthodontic appliances and techniques may minimise apnoeas, particularly those aiming at mandibular advancement [Schwarting et al., 2007]. The identification of these respiratory alterations is of particular relevance in children [Janicka and Halczy-Kowalik, 2006].

Some authors defend that there is no statistically significant variation in the permeability of the nasopharynx and the oropharynx, when compared to the three facial pattern types [Castro and Vasconcelos, 2008]. The common mandibular posture of mouth-breathing subjects may be caused by an insufficiency of the lumen in the nasopharyngeal airway and by the need to increase permeability [Finkelstein et al., 2001].

In children, tonsils are commonly enlarged, which leads to mouth breathing [Valera et al., 2003]. If this kind of breathing persists after tonsillectomy, it should be considered as a habit.

Despite differing opinions, in the area of dentofacial orthopaedics the prevailing theory is that mouth breathing associated to upper airway obstruction is correlated to mandibular retrusion and clockwise rotation [Stellzig-Eisenhauer et al., 2010], micro-rhino dysplasia, maxillary compression, protrusion of the upper incisors, elevated bony palate, short and hypotonic upper lip, adenoid facies or long face syndrome [Raffat and Hamid, 2009], flaccid perioral musculature and common open mouth posture [Shikata et al., 2004]. A study reports that in tonsillar hypertrophy there is a tendency towards mandibular prognathism, while in adenoidal hypertrophy it is towards mandibular retrognathia [Baroni et al., 2011].

Subjects with skeletal Class III malocclusion may present greater permeability in the upper part of the pharynx [Hong et al., 2011]. Some studies suggest there is scientific evidence showing differences in facial growth of patients with tonsil hypertrophy, depending upon they had tonsillectomy performed or not [Arun et al., 2003].

Solow [1992] considers that airway obstruction leads to the increase of the craniocervical angle by means of neuromuscular control.

We use cephalometry for assessment of growth, as this is the method commonly used by orthodontists to diagnose nasopharyngeal obstructions [Barbosa et al., 2009]. However, it may lead to errors (radiographic distortion and measuring errors) and influence diagnosis [Silva and Ustrell-Torrent, 2004]

Jarabak has associated the morphological features of the lower jaw to the remaining structures of the craniofacial complex and presented a cephalometric analysis that highlights the posterior portion of the face, due to its importance in growth. This analysis uses reference landmarks points, such as S (Sella), N (Nasion), Me (Menton) and Go (Gonion). From this analysis, we used the Jarabak Ratio, which relates the Posterior Facial Height (S-Go) and the Anterior Facial Height (N-Me). The result of dividing the former by the latter is a morphological indicator of the facial growth direction [Jarabak and Fizzel, 1972].

In 1987 McNamara published a lateral cephalometric analysis, with an average nasopharyngeal space of 17.4 mm in both genders [McNamara, 1984]. Contrarily to what occurs with the nasopharynx, a dramatic decrease in the oropharynx' dimensions would hardly cause an obstruction to the airflow. In the standard analysis of the Faculty of Medicine of Porto University, the norm is 13.5 mm [Furfuro et al., 2010]. A width greater than this value would suggest an anterior positioning of the tongue due to tonsil hypertrophy or a posture habit.

The general aim of the study was to compare the cephalometric measurements of the oro- and nasopharynx permeability with the facial growth direction. The specific aim was to identify the most common facial growth direction in individuals with decreased upper airway permeability.

Material and Methods

The sample included 158 lateral head teleradiographs of Caucasian patients (8 to 14 years old; 80 males and 78 females) attending an orthodontic appointment at the Faculty of Medicine of Porto University. The average age was 11.65 years and the standard deviation was 1.93.

Exclusion criteria were the following: previous tonsil and/or adenoid surgery; previous maxillofacial surgery; patients bearing some form of syndrome or sequence; and patients

	Jarabak Ratio	Nasopharynx Permeability	Oropharynx Permeability
Average	61.348	8.978	10.185
Median	61.150	8.600	10.000
Maximum	73.500	19.700	17.700
Minimum	52.300	2.300	4.500
Standard Deviation	3.878	3.372	2.838
Flatness	0.458	0.518	0.327
Kurtosis	3.390	3.289	2.621
Note: The variables related to the nasopharynx and oropharynx permeability are described in millimeters.			

TABLE 1 Analysis of airflow permeability the subjects.

	Jarabak Ratio	Nasopharynx Permeability	Oropharynx Permeability
Jarabak Ratio	1.000		
Nasopharynx Permeability	0.0718 (0.3698)	1.000	
Oropharynx Permeability	-0.040 (0.6172)	0.190 (0.0165)	1.000
Note: The correlation levels are measured by the Pearson coefficient; in parentheses are p values indicated			

TABLE 2 Correlation between airway permeability and Jarabak ratio.

Test Statistics	df	Value	Prob
Pearson X2	2	0.958254	0.6193
Likelihood Ratio G2	2	1.533475	0.4645

TABLE 3 Statistics for nasopharyngeal permeability.

Test Statistics	df	Value	Prob
Pearson X2	2	0.718667	0.6981
Likelihood Ratio G2	2	0.766119	0.6818

TABLE 4 Statistics for oropharyngeal permeability.

Growth Direction	Nasopharynx	Orofarynx	Nasopharynx and Oropharynx	Total
Vertical	30	4	3	31
Intermediate	92	14	13	94
Horizontal	33	3	3	3
Total	155	21	19	158

TABLE 5 Airway permeability and growth directions recorded in the subjects.

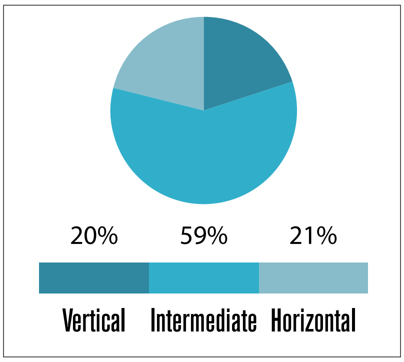

FIG. 1 Growth direction in subjects with reduced nasopharyngeal permeability.

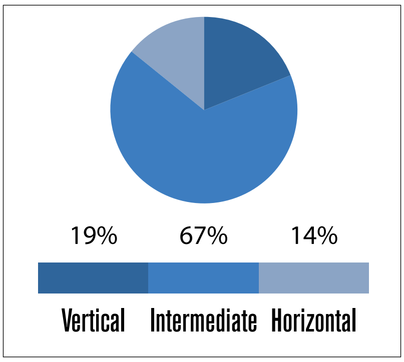

FIG. 2 Growth direction in subjects with reduced oropharyngeal permeability.

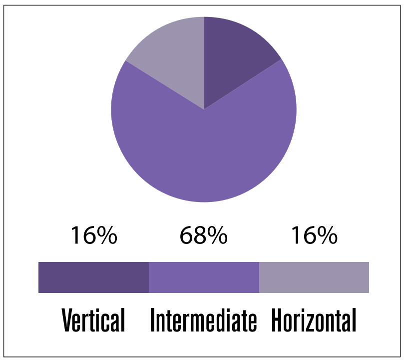

FIG. 3 Growth direction in subjects with reduced airflow permeability.

with cleft lip and palate. Patients whose radiographic documentation did not allow the intended study or with incomplete documentation were also excluded.

Cephalometry was performed with the NemoCeph® programme. Subsequently, the following landmarks were identified.

- Jarabak analysis: S (Sella); N (Nasion); Me (Menton); Go (Gonion);
- McNamara analysis: AUA (anterior upper airway - point on the soft palate anterior half and close to the nasopharynx posterior wall); PUA (posterior upper airway - nearest point of AUA located on the pharyngeal posterior wall); ALA (anterior lower airway - point located at the insertion of the tongue posterior edge with the mandibular edge); PLA (posterior lower airway - point nearest ALA located on the pharyngeal posterior wall).

Results

On average, we obtained the following results: Jarabak Percentage 61.348%; oropharyngeal permeability 10.185 mm; nasopharyngeal permeability 8.978 mm (Table 1).

From the sample analysis we can infer a negative correlation between oropharyngeal permeability and the Jarabak Percentage. The correlation between nasopharyngeal permeability and the Jarabak Percentage is positive. One should note, however, that both correlation coefficients are low, which means a weak correlation between the variables in this sample. This is confirmed by the high p value ($p>0.05$), which revealed that the correlation is statistically non-significant. Conversely, the correlation between oropharyngeal and nasopharyngeal permeability is positive and statistically significant.

The sample used in this research was divided into three groups according to the craniofacial growth direction.

Due to the variability of the sample in the three groups, the chi-square test (χ^2) was performed to determine if it would be possible to compare permeability in the different growth directions [Armitage et al., 2002].

On the null hypothesis of independence between the types of growth shown by the subjects included in the sample and permeability, the chi-square statistics presents values of 0.96 with p=0.619 (Table 3) and 0.72 (Table 4) with p=0.698 for nasopharyngeal and oropharyngeal permeability, respectively. Therefore, these results lead to the non-rejection of the null hypothesis, since the permeability values are independent from the type of growth of the sample and, as such, the samples are comparable.

It is important to stress that there are subjects in the sample who can present a reduced permeability only on nasopharynx, only on oropharynx or on both.

Table 5 shows a reduction of permeability on nasopharynx in a high number of subjects included in the sample. It also states that the most common growth direction is the intermediate one.

Figure 1 shows that intermediate growth is the most frequent in the sample (59%) followed by horizontal growth, in subjects with reduced nasopharyngeal permeability. Figure 2 also shows that intermediate growth is the most frequent in the sample (67%) followed by vertical growth (19%), when subjects with reduced oropharyngeal permeability are analysed.

Figure 3 shows that intermediate growth is the most frequent in the sample (68%), when analysing subjects with reduced nasopharyngeal and oropharyngeal permeability.

Discussion

The scientific literature reports that a person's normal growth may be influenced by respiratory modifications [Tsuda et al., 2011]. The persistence of these changes may cause a clockwise mandibular rotation, since craniofacial growth occurs in the vertical direction. The study by Finkelstein [2001] includes a sample of 100 subjects, which is smaller than the 150 subjects included in the present study.

Subjects with Class I and Class II malocclusion have less permeability in the upper region of the pharynx in case of vertical growth.

The relationship between mouth breathing and malocclusion development is controversial, since the studies that have been carried out include only some of these variables. Despite differing opinions, in dentofacial orthopaedics the notion still prevails that mouth breathing, associated with upper airway obstruction, is correlated to the clockwise rotation of the lower jaw, adenoid faceis or the long face syndrome [Stellzig-Eisenhauer et al., 2010]. However, we often find subjects with a long face and a normal breathing pattern, being the first caused by other aetiological factors, as this study's results are able to demonstrate. The results clearly indicate the presence of intermediate growth in subjects with reduced oropharyngeal and nasopharyngeal permeability.

The number of subjects with reduced permeability and vertical growth is close to the number of subjects with horizontal growth. This statement partially agrees with the authors defending that there is no statistically significant variation in airway permeability on nasopharynx and oropharynx, when compared to the three types of facial patterns. The studies by Castro and Vasconcelos [2008] and Bianchini [2007] include 90 and 119-subject samples, respectively.

The results obtained in this study and the ones obtained by Hong et al. [2011] are opposite to those achieved by Baroni et al. [2011], when comparing two 20-subject groups and analysing the craniofacial morphology in subjects suffering from tonsillar and adenoidal hypertrophy. The cases with tonsillar hypertrophy demonstrate a tendency towards mandibular prognathism, while subjects with adenoidal hypertrophy present a tendency towards mandibular retrognathia. Other studies reach a similar conclusion [El and Palomo, 2011].

Conclusions

The analysis of the results of this study allow us to conclude that subjects with reduced permeability of the upper airways show an intermediate growth direction and that is the most common type.

Among the less frequent growth directions, a slight tendency towards horizontal growth is observed in subjects with reduced nasopharyngeal permeability.

We can additionally observe the tendency, also slight, towards vertical growth in subjects with reduced oropharyngeal permeability.

References

› Ahn Y. Treatment of obstructive sleep apnea in children. Korean J Pediatr 2010;53(10):872-9.
› Armitage P, Berry G, Matthews J. Statistical Methods in Medical Research. 4th ed. Oxford: Blackwell Science Ltd. 2002.
› ArunT, Isik F, Sayinsu K. Vertical growth hanges after adenoidectomy. Angle Orthod 2003;73(2):146-50.
› Barbosa M, Knop L, Lessa M, Araujo T. Avaliação da radiografia cefalométrica lateral como meio de diagnóstico da hipertrofia de adenóide. R Dental Press Ortodon Ortop Facial 2009;14(4):83-91.
› Baroni M, Ballanti F, Polimeni A, Franchi L, Cozza P. Thin-plate spline analysis of craniofacial morphology in subjects with adenoid or tonsillar hypertrophy Int J Pediatr Otorhinolaryngol 2011;75(4):518-22.
› Bianchini A, Guedes Z, Vieira M. Estudo da relação entre a respiração oral e o tipo facial. Rev Bras Otorrinolaringol 2007;73(4):500-5.
› Castro A, Vasconcelos M. Avaliação da influência do tipo facial nos tamanhos dos espaços aéreos nasofaríngeo e bucofaríngeo. R Dental Press Ortodon Ortop 2008;13(6):43-50.
› El H, Palomo J. Airway volume for different dentofacial skeletal patterns. Am J Orthod Dentofacial Orthop 2011 Jun;139(6):511-21.
› Finkelstein Y, Wexler D, Horowitz E, Berger G, Nachmani A, Shapiro-Feinberg M, et al. Frontal and lateral cephalometry in patients with sleep-disordered breathing. Laryngoscope 2001 Apr;111:634-41.
› Foltán R, Rybínová K. The impact of mandibular advancement on the upper airway patterns-cephalometric study. Prague Med Rep 2007;108(2):147-54.
› Furfuro R, Carneiro J, Correia Pinto J. Cefalometria e diagnóstico em Ortodontia – Aplicação do Padrão FMUP de cefalometria. Revista da Associação dos Médicos Estomatologistas Portugueses 2010; 1:2-19.
› Hong J, Oh K, Kim B, Kim Y, Park Y. Three-dimensional analysis of pharyngeal airway volume in adults with anterior position of the mandible. Am J Orthod Dentofacial Orthop 2011 Oct;140(4):161-9.
› Janicka A, Halczy-Kowalik L. Hyoid bone position and tongue size and patency of upper airway structures. Ann Acad Med Stetin 2006; 52(3):53-9.
› Jarabak J, Fizzel J. Technique and treatment with light wire edgewise appliances. 2nd ed. St. Louis: Mosby; 1972.
› Lee J, Park K, Kim S, Park Y, Kim S. Correlation between skeletal changes by maxillary protraction and upper airway dimensions. Angle Orthod 2011 May;81(3):426-32.
› McNamara J. A method of cephalometric evaluation. Am J Orthod 1984;86:449-69.
› Moss M. The functional matrix hypothesis revisited. Am J Orthod Dentofac Orthop 1997;112(3):338-42.
› Raffat A, Hamid W. Cephalometric assessment of patients with adenoidal faces. J Pak Med Assoc. 2009 Nov;59(11):747-52.
› Schendel S, Powell N, Jacobson R. Maxillary, mandibular, and chin advancement: treatment planning based on airway anatomy in obstructive sleep apnea. J Oral Maxillofac Surg 2011 Mar;69(3):663-76.
› Schwarting S, Huebers U, Heise M, Schlieper J, Hauschild A. Position paper on the use of mandibular advancement devices in adults with sleep-related breathing disorders. Sleep Breath 2007;11:125-6.
› Shikata N, Ueda HM, Kato M, Tabe H, Nagaoka K, Nakashima Y, Matsumoto E, Tanne K. Association between nasal respiratory obstruction and vertical mandibular position. J Oral Rehabil 2004 Oct;31(10):957-62.
› Silva C, Ustrell-Torrent J. A Distorção Geométrica na Cefalometria. Revista da Sociedade Portuguesa de Ortopedia Dento Facial 2004;(1):4-21.
› Silva-Filho O, Herkrath F, Queiroz A, Aiello C. Padrão facial na dentadura decídua: estudo epidemiológico. R Dental Press Ortodon Ortop Facial 2008 Jul/Ago;13(4):45-59.
› Solow B. Upperway obstruction and facial development. In: Davidovitch Z (ed). The biological mechanisms of tooth movement and craniofacial adaptation. Columbus. Ohio: The Ohio State University College of Dentistry; 1992:571-9.
› Stellzig-Eisenhauer et al. Interaction between otorhinolaryngology and orthodontics: correlation between the nasopharyngeal airway and the craniofacial complex. Otorhinolaryngology - Head and Neck Surgery 2010;89(1):572-8.
› Tsuda H, Fastlicht S, Almeida F, Lowe A. The correlation between craniofacial morphology and sleep-disordered breathing in children in an undergraduate orthodontic clinic. Sleep Breath 2011 May;15(2):163-71.
› Valera F, Travitzki L, Mattar S, Matsumoto M, Elias A, Anselmo-Lima W. Muscular, functional and orthodontic changes in pre school children with enlarged adenoids and tonsils. Int J Pediatr Otorhinolaryngol 2003 Jul;67(7):761-70.