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 tonsillecтомy, 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

<p>| TABLE 1 | Analysis of airflow permeability the subjects. |</p>
<table>
<thead>
<tr>
<th>Jarabak Ratio</th>
<th>Nasopharynx Permeability</th>
<th>Oropharynx Permeability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average</td>
<td>61.348</td>
<td>8.978</td>
</tr>
<tr>
<td>Median</td>
<td>61.150</td>
<td>8.600</td>
</tr>
<tr>
<td>Maximum</td>
<td>73.500</td>
<td>19.700</td>
</tr>
<tr>
<td>Minimum</td>
<td>52.300</td>
<td>2.300</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>3.878</td>
<td>3.372</td>
</tr>
<tr>
<td>Flattness</td>
<td>0.458</td>
<td>0.518</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>3.390</td>
<td>3.289</td>
</tr>
</tbody>
</table>

Note: The variables related to the nasopharynx and oropharynx permeability are described in millimeters.

<p>| TABLE 2 | Correlation between airway permeability and Jarabak ratio. |</p>
<table>
<thead>
<tr>
<th>Jarabak Ratio</th>
<th>Nasopharynx Permeability</th>
<th>Oropharynx Permeability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average</td>
<td>0.0718 (0.3698)</td>
<td>1.000</td>
</tr>
<tr>
<td>Median</td>
<td>-0.040 (0.6172)</td>
<td>0.190 (0.0165)</td>
</tr>
</tbody>
</table>

Note: The correlation levels are measured by the Pearson coefficient; in parentheses are p values indicated.

<p>| TABLE 3 | Statistics for nasopharyngeal permeability. |</p>
<table>
<thead>
<tr>
<th>Test Statistics</th>
<th>df</th>
<th>Value</th>
<th>Prob</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pearson X2</td>
<td>2</td>
<td>0.958254</td>
<td>0.6193</td>
</tr>
<tr>
<td>Likelihood Ratio G2</td>
<td>2</td>
<td>1.533475</td>
<td>0.4645</td>
</tr>
</tbody>
</table>

<p>| TABLE 4 | Statistics for oropharyngeal permeability. |</p>
<table>
<thead>
<tr>
<th>Growth Direction</th>
<th>Nasopharynx</th>
<th>Orofarynx</th>
<th>Nasopharynx and Oropharynx</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vertical</td>
<td>30</td>
<td>4</td>
<td>3</td>
<td>31</td>
</tr>
<tr>
<td>Intermediate</td>
<td>92</td>
<td>14</td>
<td>13</td>
<td>94</td>
</tr>
<tr>
<td>Horizontal</td>
<td>33</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Total</td>
<td>155</td>
<td>21</td>
<td>19</td>
<td>158</td>
</tr>
</tbody>
</table>

| TABLE 5 | Airway permeability and growth directions recorded in the subjects. |
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 ($\chi^2$) 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 faces 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