Nasopharyngeal and facial dimensions of different morphological patterns

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Abstract

Objective: The purpose of this study was to compare the dimensions of the nasopharynx and the skeletal features—evaluated by cephalometric examination—of individuals with different morphological patterns. **Methods:** Were used cephalometric radiographs of 90 patients of both genders, aged 12 to 16 years, which were divided into three distinct groups, according to their morphological patterns, i.e., brachyfacials, mesofacials and dolichofacials. Measurements were performed of specific nasopharyngeal regions (ad_1-Ptm, ad_2-Ptm, ad_1-Ba, ad_2-S_0, (ad_1-ad_2-S_0-Ba-ad_1/Ptm-S_0-Ba-Ptm) X 100, and Ptm-Ba), and relative to the facial skeletal patterns. **Results:** Dolichofacial patients were found to have smaller sagittal depth of the bony nasopharynx (Ptm-Ba) and lower nasopharyngeal airway depth (ad_1-Ptm and ad_2-Ptm). Arguably, these differences are linked to a relatively more posterior position of the maxilla, typical of these patients. No differences were found, however, in the soft tissue thickness of the posterior nasopharyngeal wall (ad_1-Ba and ad_2-S_0), or their proportion in the whole area bounded by the nasopharynx [(ad_1-ad_2-S_0-Ba-ad_1/Ptm-S_0-Ba-Ptm) X 100]. **Conclusions:** We therefore suggest that the excessively vertical facial features found in dolichofacial patients may be the result, among other factors, of nasopharyngeal airway obstruction, since such dimensions were shown to be smaller in dolichofacials.

Keywords: Mouth breathing. Nasopharynx. Cephalometry.

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INTRODUCTION

A major difficulty encountered by researchers has been to determine the true role of airway obstruction in the development of craniofacial features. Experimental evidence suggests a strong correlation between mouth breathing and vertical face development.[8,12,14,20] Nonetheless, opinions differ when an attempt is made to establish a direct cause and effect link between these two variables.

While some authors[5,16,28] believe that mouth breathing is the major etiological factor in the development of "long face syndrome", others[20,24] ascribe to heredity the expression of these facial features, suggesting that mouth breathing may not be regarded as a cause, but rather an aggravating factor in a context that is already peculiar to individuals with a dolichofacial pattern. After evaluating the studies published hitherto,[5,8,12,14,16,20,23,24,26,28] one cannot state with any degree of certainty whether a specific facial pattern is directly related to an individual's respiratory capacity.

We therefore need to investigate whether or not patients with different facial patterns can display different nasopharyngeal dimensions. In view of the need to uncover new evidence to contribute to and assist in addressing this complex issue, this study aimed to compare different facial patterns in terms of nasopharyngeal dimensions and skeletal features as demonstrated by cephalometric examination.

MATERIAL AND METHODS

This is a cross-sectional, comparative and descriptive study previously approved by the Ethics in Research Committee of the institution where it was conducted (File No. 2003. 1. 1045. 58. 4).

We used lateral cephalometric radiographs of patients of both genders aged between 12 and 16 years. Patients who had undergone adenoidectomy or orthodontic treatment in the period prior to when the radiographs were taken were excluded from the final sample.

Once selected, the radiographs were divided into three groups consisting of 30 subjects each, according to the morphological patterns displayed by the patients (brachyfacial, mesofacial and dolichofacial). The criterion used to divide the sample into groups was the measurement of the facial axis (BaN.PtGn), indicative of mandibular growth direction, whose normal value is 90°.[19] The groups were defined taking into account the 3° variation proposed by McNamara,[17] as explained below.

- Brachyfacials: facial axis below 87°.
- Mesofacials: facial axis equal to or above 87° and equal to or below 93°.
- Dolichofacials: facial axis above 93°.

We subsequently took the angular (NSBa, SN.GoGn, NSGn, SNA, SNB, and ANB) and

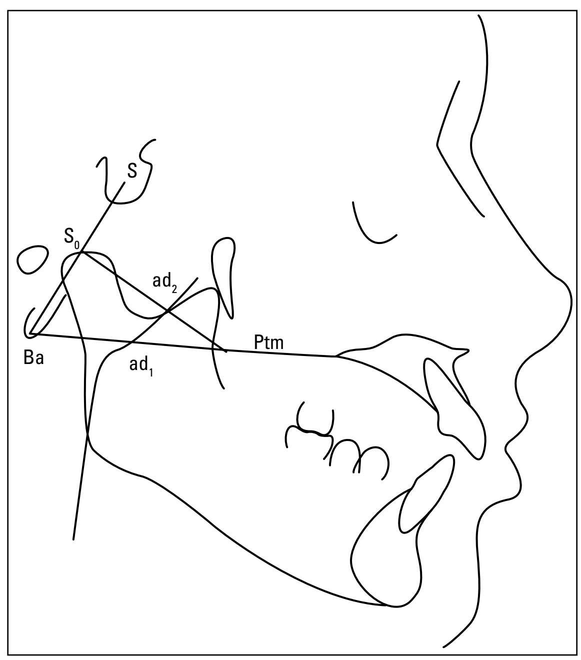

FIGURE 1 - Nasopharyngeal measurements.

linear (N-Me, ENA-Me, S-Go) skeletal cephalometric measurements.

The indices derived from the linear measurements were calculated as shown below.

- iAF (S-Go/N-Me): facial height index,
- iAFA (ENA-Me/N-Me): anterior facial height index.

Measurements of the nasopharyngeal dimensions[15] were taken by scanning the images into digital files for later perusal of the formation using Cad Overlay 2000 (Autodesk, USA) computer software (Fig 1):

- ad_1-Ptm: Depth of the airway through the nasopharynx.
- ad_2-Ptm: Depth of the airway through the nasopharynx.
- ad_1-Ba: Thickness of soft tissue in the posterior wall of the nasopharynx through the Ptm-Ba line.
- ad_2-S_0: Thickness of soft tissue in the posterior wall of the nasopharynx through the Ptm-S line.
- (ad_1-ad_2-S_0-Ba-ad_1/Ptm-S_0-Ba-Ptm) X 100: Area of soft tissue in the bony nasopharyngeal area.
- Ptm-Ba: Sagittal depth of the bony nasopharynx.

Measurements were performed by a single orthodontist trained for this purpose, who did not know to which group each of radiograph belonged.

Statistical analysis

Group characterization was conducted through descriptive data analysis. To check data normality the Shapiro-Wilks test was applied since there were fewer than 50 cases in each group. Due to the presence of normal distribution of data, parametric tests were used for inferential analysis.

Once assessed, the measurement values were compared between the groups. To assess the differences in sample characterization in terms of gender (categorical variable), the Chi-square test was applied, and for age (quantitative variable), analysis of variance (ANOVA). Comparisons between each of the cephalometric measurements (quantitative variable) and groups (categorical variable) were analyzed using ANOVA. For variables whose ANOVA value was significant ($p < 0.05$), we used the Tukey test for multiple comparison analysis. The level of significance set for statistical tests was 5% ($\alpha \leq 0.05$). All tests were performed with a computer program (SPSS 10.0 for Windows, Statistical Package for Social Sciences, version 10.0, 1999 – SPSS Inc., USA).

TABLE 1 - Characterization of children's gender groups relative to their morphological patterns.

Morphological pattern	Gender (n / %)		Chi-square (p-value)
	female	male	
Meso	12 (40.0%)	18 (60%)	0.873
Dolicho	13 (43.3%)	17 (56.7%)	
Brachy	14 (46.7%)	16 (53.3%)	

Level of significance = 5%.

TABLE 2 - Children's age groups relative to their morphological patterns.

Morphological pattern	Age (years)				ANOVA (p-value)
	minimum	maximum	mean	s.d.	
Meso	12	16	13.73	1.39	0.555
Dolicho	12	16	13.43	1.28	
Brachy	12	16	13.37	1.50	

Level of significance = 5%.

TABLE 3 - Comparison between morphological patterns in terms of angular measurements (degrees).

Angular measurements	Morphological pattern	mean	s.d.	minimum	maximum	ANOVA (p-value)	Tukey	
NSBa	MESO	128.417	6.435	119.0	143.0	0.215	-	
	DOLICHO	126.317	5.439	116.5	134.0			
	BRACHY	128.700	5.154	115.0	137.0			
SNGoGn	MESO	31.317	7.023	24.0	60.0	**< 0.001**	M-D	**< 0.001**
	DOLICHO	36.617	3.662	28.5	42.0		M-B	**0.002**
	BRACHY	26.750	3.674	17.0	33.0		B-D	**< 0.001**
NSGn	MESO	66.800	2.996	63.0	74.0	**< 0.001**	M-D	**< 0.001**
	DOLICHO	71.033	3.000	65.5	76.0		M-B	**< 0.001**
	BRACHY	62.450	2.440	56.0	67.0		B-D	**< 0.001**
SNA	MESO	81.883	4.586	70.5	91.0	**0.003**	M-D	0.137
	DOLICHO	79.667	3.909	70.5	85.0		M-B	0.253
	BRACHY	83.717	4.815	73.5	92.0		B-D	**0.002**
SNB	MESO	79.317	3.800	72.0	86.5	**< 0.001**	M-D	**0.001**
	DOLICHO	75.983	3.019	68.0	82.5		M-B	**0.001**
	BRACHY	82.817	3.497	75.0	91.0		B-D	**< 0.001**
ANB	MESO	2.733	1.700	-0.5	7.0	**< 0.001**	M-D	0.294
	DOLICHO	3.683	2.419	-1.0	8.0		M-B	**0.013**
	BRACHY	0.900	2.995	-6.5	5.0		B-D	**< 0.001**

Level of significance = 5%.

RESULTS

The three groups comprised a majority of male subjects aged between 13 and 14 years. They did not differ significantly from each other, both in terms of composition by gender or age (Tables 1 and 2).

Angular cephalometric measurements (Table 3)

Although the three facial patterns did not display statistically discrepant cranial base inclination angles (NSBa), they differed significantly from each other regarding SN.GoGn and NSGn. In this analysis, the dolichofacial group exhibited the greatest mandibular inclination, followed by the mesofacial patients. Compared with the other groups, brachyfacials had a significantly smaller mandibular angle. All mandibular plane angulation differences showed considerable statistical significance.

The SNA values in the brachyfacial group were even higher. Mesofacials showed intermediate values, whereas dolichofacial patients exhibited the lowest relative values. However, these differences could only be considered statistically significant when two groups at opposite extremes (brachyfacial and dolichofacial) were compared.

Regarding the anteroposterior position of the mandible (SNB) statistically significant differences were found in all pairwise comparisons. Once again, brachyfacials attained the highest values, followed by mesofacials and dolichofacials.

As regards the ANB angle, we detected a significant difference between mesofacials and brachyfacials, since the latter's values were lower

TABLE 4 - Comparison between morphological patterns in terms of linear measurements (mm) and facial indices.

Linear Measurements	Morphological Pattern	mean	s.d.	minimum	maximum	ANOVA (p-value)	Tukey	
N-Me	MESO	119.067	7.011	108.0	136.0	< 0.001	M-D	**0.043**
	DOLICHO	123.500	6.994	109.0	134.0		M-B	0.099
	BRACHY	115.300	7.011	102.0	132.0		B-D	**< 0.001**
ENA-Me	MESO	66.800	6.400	58.0	85.0	< 0.001	M-D	**0.003**
	DOLICHO	71.600	4.773	61.500	82.0		M-B	0.232
	BRACHY	64.450	5.297	55.000	75.0		B-D	**< 0.001**
S-Go	MESO	78.433	6.285	66.5	90.0	0.756	-	
	DOLICHO	77.333	4.973	67.0	89.0			
	BRACHY	78.150	6.367	66.5	90.0			
iAF S-Go/N-Me	MESO	0.65894	0.392	0.569	0.716	< 0.001	M-D	**0.003**
	DOLICHO	0.62665	0.308	0.583	0.609		M-B	0.119
	BRACHY	0.67789	0.392	0.605	0.776		B-D	**< 0.001**
iAFA ENA-Me/N-Me	MESO	0.56037	0.302	0.504	0.627	**0.003**	M-D	**0.012**
	DOLICHO	0.57983	0.222	0.535	0.628		M-B	0.964
	BRACHY	0.55865	0.237	0.509	0.607		B-D	**0.005**

Level of significance = 5%.

than the former's. Brachyfacials also displayed significantly lower ANB values when compared with dolichofacials. The latter, however, showed no differences with respect to mesofacials.

Linear cephalometric measurements (Table 4)

Mesofacials and brachyfacials were found to have no significant differences regarding total anterior facial height (N-Me). Dolichofacials, however, displayed considerably higher averages than the other two groups.

In a separate comparison with the other two groups, dolichofacial patients' lower anterior facial height (ENA-Me) again proved to be significantly higher. Once again, however, mesofacials and brachyfacials did not differ from each other significantly.

No statistically significant differences were found between the groups with respect to total posterior facial height (S-Go).

Facial indices (Table 4)

Dolichofacials' facial height (iAF and iAFA) indices differed from both mesofacials' and brachyfacials'. They showed lower iAF values and higher iAFA values. Nevertheless, mesofacials and brachyfacials exhibited no differences with regard to both indices.

Nasopharyngeal measurements (Table 5)

The groups did not differ in terms of soft tissue thickness in the posterior nasopharyngeal wall (ad_1-Ba and ad_2-S_0). Nor did they show any differences with respect to the soft tissue area in the bony nasopharyngeal region [(ad_1-ad_2-S_0-Ba-ad_1/Ptm-S_0-Ba-Ptm) X 100].

When dolichofacials were compared with brachyfacials in terms of ad_2-Ptm (airway depth through the nasopharynx), the discrepancy was found to be statistically significant. Regarding ad_1-Ptm (airway depth through the nasopharynx), a significant difference was found when

TABLE 5 - Comparison between morphological patterns in terms of nasopharyngeal measurements (mm).

Nasopharyngeal measurements	Morphological pattern	mean	s.d.	minimum	maximum	ANOVA (p-value)	Tukey	
ad_1-Ptm	MESO	25.2202	2.8125	16.8	29.5	**0.050**	M-D	0.071
	DOLICHO	22.9436	4.4868	9.2	28.9		M-B	0.985
	BRACHY	25.0527	4.3306	16.5	32.8		B-D	0.102
ad_2-Ptm	MESO	19.2648	2.7616	14.4	24.4	**0.039**	M-D	0.124
	DOLICHO	17.5871	4.0816	8.4	25.2		M-B	0.886
	BRACHY	19.6630	2.8402	14.1	24.7		B-D	**0.043**
ad_1-Ba	MESO	22.4617	2.8870	18.4	30.7	0.272	-	
	DOLICHO	22.4550	5.7209	13.3	36.8			
	BRACHY	24.0539	4.0864	17.1	35.7			
ad_2-S_0	MESO	23.1262	3.0702	16.8	28.7	0.784	-	
	DOLICHO	22.7854	4.5983	13.0	31.0			
	BRACHY	23.4690	3.54160	17.6	32.3			
(ad_1-ad_2-S_0-Ba-ad_1/Ptm-S_0-Ba-Ptm) X 100	MESO	74.7063	6.6228	55.3	87.1	0.793	-	
	DOLICHO	75.7773	10.9547	51.0	95.4			
	BRACHY	76.1653	7.5959	60.7	88.7			
Ptm-Ba	MESO	47.6820	3.4734	40.1	54.1	**< 0.001**	M-D	**0.034**
	DOLICHO	45.3987	3.4158	41.4	55.3		M-B	0.263
	BRACHY	49.0927	3.5361	43.040	56.680		B-D	**< 0.001**

Level of significance = 5%.

comparing the three groups in conjunction. In pairwise comparison, the difference was considered more meaningful, although not statistically significant when dolichofacials were compared with mesofacials. Mesofacials and brachyfacials did not differ with respect to both airway depth measurements.

As regards the sagittal depth of the bony nasopharynx (Ptm-Ba), dolichofacial patients had statistically lower means than mesofacials and brachyfacials. The latter two groups, however, did not differ significantly from each other.

DISCUSSION

The results obtained with posterior rhinoscopy when evaluating the size of the adenoids in the posterior wall of the nasopharynx are highly correlated with data derived from the cephalometric examination, although this is a two-dimensional test.[13] The cephalometric method is simple and yields satisfactory results in children of all ages.[4,29] Authors such as Jakhi and Karjodkar[7] and Wu et al[27] regard cephalometric radiography as an easy, affordable and appropriate exam that provides useful information about the nasopharynx. Moreover, it is a routine diagnostic tool and should therefore be considered a viable instrument for this study. It should be acknowledged, however, that the absence of an X-ray measurement method error test limits this study and does not allow its data to be extrapolated for purposes other than group comparison.

The data revealed that the criterion used for sample division (BaN.PtGn) should be considered an appropriate tool for the morphological classification of patients, since the groups determined by this criterion—especially those with extreme facial features (brachyfacials and dolichofacials)—showed differences in most of the facial parameters measured. Although no significant differences were found with respect to posterior facial height (S-Go), dolichofacials showed higher values compared to the other facial groups regarding total anterior (N-Me) and lower anterior (ANS-Me) facial height. Thus, iAF (S-Go/N-Me) was considerably lower for dolichofacials when compared with the other two groups separately. The anterior facial height (ANS-Me/N-Me) index also differed significantly when comparing brachyfacials with dolichofacials, and between the latter and mesofacials. The index was higher for the long faced patients. Moreover, the three groups classified according to the aforementioned criterion distinguished themselves in terms of mandibular inclination levels (SN.GoGn and NSGn). We therefore consider the measuring of the facial axis angle a suitable parameter to differentiate the facial groups, particularly to recognize dolichofacials among the other morphological patterns.

After analyzing the data, we found that the measurement corresponding to the sagittal depth of the bony nasopharynx (Ptm-Ba) showed significant variation between the specific facial groups, being significantly lower in dolichofacials. Bergland[2] found a positive correlation between the angle of inclination of the anterior cranial base (NSBa) and nasopharyngeal depth. According to him, the more obtuse the angle of the cranial base, the greater is the sagittal depth of the bony nasopharynx (Ptm-Ba). Although dolichofacials produced significantly lower Ptm-Ba values, the inclination of the anterior cranial base angle did not change significantly in the group comparisons. Other authors[3,9,10] further substantiate this finding, as they did not indicate any group differences in the cranial base plane inclination (NSBa). Tourné,[24] in turn, argued that the cranial base angle seems to exert less influence on the development of the vertical face than is commonly assumed.

Since the anterior cranial base angle did not undergo any significant differences between the groups, we would suggest maxillary anteroposterior positioning as a potential mechanism to justify the decreased sagittal dimension of the bony nasopharynx in dolichofacials. An analysis of the averages provided by the antagonist facial pattern group (brachyfacials) disclosed that dolichofacials—who had significantly smaller SNA values—also had the lowest bony nasopharynx depth. On the other hand, brachyfacials had higher SNA values and significantly greater bony nasopharynx depth compared with dolichofacials. Sosa et al[22] agrees with this theory and suggests that patients with a larger pharyngeal area and larger bony nasopharynx tend to have a more anteriorly positioned maxilla and mandible. It is therefore assumed that a more posteriorly positioned maxilla (which entails point Ptm) might have influenced the dolichofacials' bony nasopharynx depth since, the more posteriorly located is point Ptm, the smaller is its distance to point Ba.

The dolichofacials' more posteriorly positioned maxilla was accompanied, on an even larger scale, by a mandibular displacement in the same direction. The reduced SNB values found for this facial group may have resulted from a clockwise rotation of the mandible, as evidenced by high NSGn and SN.GoGn values. The opposite occurred with brachyfacials, who responded with an anterior displacement not only of the mandible, but of both maxillary bones. It is also likely that this group's anteriorly positioned mandible may result from a counterclockwise rotation, as suggested by the group's lower NSGn and SNGoGn values.

This combined "movement" of both maxillary bones, sometimes towards the posterior, as in the case of dolichofacials, sometimes anteriorly, like in the brachyfacial group, was also noted by Joseph et al[8] when comparing normodivergent and hyperdivergent individuals. This factor may have caused ANB values to remain within a pattern of relative normality since their means ranged from 0.9° to 3.6°, which is considered normal by advocates of this standard.[6,21] The mandibular movement "in response" to the maxillary movement may also have caused the changes observed in anterior facial heights and in the indices of the skeletal features described above.

Mergen and Jacobs,[18] Kerr[11] and Trotman et al[25] believe that the aforesaid dolichofacials' anteriorly repositioned maxilla and mandible may also be associated with a reduced sagittal dimension of the nasopharyngeal airway. Some studies[1,8,9,10] also reinforce the hypothesis that dolichofacials exhibit smaller nasopharyngeal airways. Joseph et al[8] found a narrowing of the pharyngeal airway in hyperdivergent patients, as indicated by a significantly lower ad_1-Ptm. Conversely, ad_2-Ptm did not differ significantly between groups. Kawashima et al[9] reported a narrower pharyngeal space in patients with pronounced vertical features, when compared to control patients. Akcam, Toygar and Wada[1] observed that patients with posterior mandibular rotation showed a decreased upper airway space. Kawashima et al[10] assessed three groups that were similar to the ones in the present study with respect to the aforesaid airway measurements. Although the authors did not detect any significant differences in ad_1-Ptm and ad_2-Ptm, they noted lower means in the group with predominantly vertical faces.

These data, in a sense, confirm the findings of this investigation on the effective size of the airway passage. Although dolichofacials were not statistically differentiated from the other groups in terms of ad_1-Ptm, a statistically significant difference was found in a joint comparison of the three groups. Furthermore, hyperdivergent patients had the lowest mean for this measurement. Additionally, long-faced patients distinguished themselves effectively with respect to their opposites, in terms of ad_2-Ptm.

This "reduction" of the nasopharyngeal airway among dolichofacials cannot be attributed to the larger adenoids or the presence of soft tissue in the posterior nasopharyngeal region. The reason for this is that the groups did not differ with respect to soft tissue thickness in the posterior nasopharyngeal wall (ad_2-S_0 and ad_1-Ba), nor with regard to their proportion relative to the entire area bounded by the nasopharynx [(ad_1-ad_2-S_0-Ba-ad_1/Ptm-S_0-Ba-Ptm) X 100]. The results indicate that the volume of soft tissue, including the adenoid, is constant for all facial groups, both in linear and proportional terms.

Therefore, the fact that dolichofacial patients display a smaller airway cannot be attributed to adenoid size. Dolichofacials' reduced airway may be the result of factors not fully accounted for—although perhaps suggested—by this research. The data mentioned above have led us to suspect that because dolichofacials exhibit a more posteriorly positioned maxilla, this condition may narrow the nasopharyngeal airway passage.

We therefore suggest that the excessively vertical facial features found in dolichofacial patients may be the result, among other factors, of nasopharyngeal airway obstruction, since such dimensions were shown to be smaller in dolichofacials. These considerations, therefore, are designed to motivate dentists to alert the parents and legal guardians of patients with typically dolichofacial features. These patients may be more prone to mouth breathing as a result of their relatively diminished nasopharyngeal dimensions.

CONCLUSIONS

Based on the assessment of the facial pattern data produced in this study, we found that dolichofacial patients had smaller bone depth sagitally as well as smaller nasopharyngeal airway depth, when compared with the distinct facial patterns of other patients. It could be argued that this difference is due to a distally positioned maxilla, typical of long-faced patients. Maxillary position, which proved different for each group, was accompanied by mandibular rotation, sometimes clockwise, as in the case of dolichofacial, sometimes counterclockwise (brachyfacials). Such mandibular rotation influenced the facial heights and indices, ensuring an appropriate maxillomandibular interrelationship, irrespective of facial pattern. Based on our review and the findings evidenced by the results, it would be plausible to ascribe the decreased size of dolichofacials' nasopharyngeal airway to their characteristically vertical facial pattern.

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