Lower anterior face height and lip incompetence do not predict nasal airway obstruction

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Mouth breathing" has long been assumed to influence facial form, and in particular, to predispose to the development of the "long face syndrome" or "adenoid facies."[1-7] Deformities in facial anatomy considered to be characterisitc of mouthbreathing subjects include increased lower anterior facial height, retrognathic mandible, proclined maxillary incisors, high V-shaped palatal vault with a constricted maxillary arch, flaccid and short upper lip, flaccid perioral musculature and a somewhat dull appearance due to a constant open-mouthed posture.[8]

Attempts have been made to establish a cause-and-effect relationship between nasal obstruction, craniofacial form and occlusal features. However, as yet, these efforts have been unsuccessful in providing unequivocal conclusions. Much of the controversy stems from the lack of a precise definition of "mouth breathing." Normal nasorespiratory function has not been adequately defined, and despite claims to the contrary, it is still unknown to what extent cranio- or dentofacial form may be influenced by respiratory mode.

Even though causal associations between respiration and the growth pattern have not been established, assumptions continue to be made.[6,9-17] Other investigators have disagreed that mouth breathing can affect the form of the jaws or create malocclusion.[18-25]

This report deals with one aspect of a larger study, which was to measure the nasal airway resistance of patients before and after rapid

Abstract

The controversy regarding nasal obstruction and malocclusion has been largely due to the inability to quantitate nasal airway function and hence objectively determine the mode of breathing. The purpose of this study was to measure the nasal airway resistance of patients before and after rapid maxillary expansion (RME), to compare them to a control group of subjects not receiving RME, and to measure oral/nasal airflow ratios (respiratory mode). An evaluation of the statistical associations between anterior facial height, lip posture, oral/nasal airflow ratios, and nasal resistance was undertaken.

The effects of RME on nasal resistance have been reported elsewhere. We found that variation, for resistance values, was very high, and thus the median response for the group was not an adequate estimation of individual response. In this paper we describe associations between lip posture, lower anterior facial height, and nasal resistance. No significant correlations could be established between respiratory and morphologic features. Lower anterior facial height was greater in the lips apart posture group. However, there was no significant correlation between percent nasality and lower anterior facial height. A small negative correlation ($r = -0.47$) existed between nasal resistance and percent nasality, but this relationship was not linear. Thus, it was not possible to predict percent nasality from nasal resistance data. Furthermore, no correlation was found between the amount of expansion and changes in nasal resistance.

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Key Words

Respiration • Airway resistance • Respiratory mode • Lower anterior face height • Lip posture

maxillary expansion (RME), to compare them to a control group not receiving RME, and to quantatively measure nasal/oral airflow ratios. Investigation of associations between anterior facial height, lip posture, oral/nasal airflow ratio (respiratory mode), and nasal resistance was performed. The specific objectives were to address the following questions:

1. Is lip posture related to nasal resistance or respiratory mode?
2. Is a measure of lower anterior facial height associated with nasal resistance or percent nasality?
3. Does a correlation exist between nasal resistance and percent nasality?
4. Can maxillary width changes occurring with rapid maxillary expansion, or type of expansion device, be correlated with changes in nasal resistance?

Materials and methods

The sample consisted of 38 orthodontic patients and 24 controls whose ages ranged from 8-14 years and who were not receiving rapid maxillary expansion. The expansion group was treated with fixed rapid maxillary expansion devices, either bonded or banded. Patients were instructed to activate the appliance either once or twice a day, producing approximately 0.25 mm to 0.5. mm expansion per day. After the desired expansion was achieved two to six weeks later, most cases were over-expanded until maxillary and mandibular cusps were in an end-to-end bucco-lingual relationship. Appliances were rendered passive and retained in situ for at least three months. Subsequently these patients were either provided with removable retainers or orthodontic treatment was continued with fully banded edgewise appliances.

The time periods in this study were: T1 — just prior to expansion, T2 — within one week following expansion, and T3 — 9 to 12 months following expansion.

Respiratory parameters were determined under four different experimental conditions, or modes as described by Hartgerink,[26] and Hartgerink, Vig and Abbott.[27] These conditions included the natural condition of breathing as well as the use of a nasal decongestant spray, the dilation of the nares to reduce liminal valving and the combination of the decongestant and nares dilation. Use of all modes is routine in our respirometric studies, and it also permits the comparison of our data with the data of other workers, whether they use decongestants in their studies or not. Such a protocol also facilitates attempts to distinguish between the relative contribution to nasal resistance of constrictions which are due to mucosal swelling, restriction to flow at the nares and the other anatomical constrictions along the nasal air passage.

Nasal resistance was measured by posterior rhinomanometry using the PERCI II C (Microtronics) as described by Warren.[8,28] The Simultaneous Nasal and Oral Respirometric Technique (SNORT), described by Gurley and Vig,[29] and modified by Keall and Vig,[30] was used to quantify oral and nasal airflow characteristics for the control group at T1 and T2, and for some of the expansion group at T3. This technique enables the continuous monitoring of both nasal and oral airflow, and generates data on flow, volume and rates, typically for a two- to three-minute period per recording. Both of the respiratory techniques have acceptably low method errors. Pilot studies to assess the repeatability of measures over time showed high intraindividual consistency in respiratory mode as defined by the nasal/oral ratios obtained over several days and also over the course of a single day for individuals. Resistance was more variable over time, but individuals classified either as high or low with respect to resistance remained within their category at each time point.

Resting lip posture was assessed for each subject while they were relaxed and seated in the room prior to testing nasal resistance. Lip posture was also assessed while the subject was seated in the SNORT apparatus during the actual recording of oral and nasal airflow. The subject was classified as lip competent (lips together) if the lips appeared to be contacting each other, and lip incompetent (lips apart) if the lips appeared at all separated.

Lateral cephalograms were obtained (for the expansion group only). Lower anterior facial height (from anterior nasal spine to menton), in relation to total anterior facial height (from nasion to menton), was calculated as a percentage for each individual to serve as an assessment of anterior facial height. Measurement of maxillary canine and first permanent molar width was made clinically for each subject, and type of expansion appliance used was recorded.

Oral and nasal airflow was quantified with the SNORT apparatus. Airflow ratios will be discussed as percent nasality:

$$\text{Percent Nasality} = \frac{\text{Nasal Airflow}}{[\text{Oral + Nasal Airflow}]} \times 100$$

where "airflow" is the volume of air inspired and expired and for the number of breaths sampled during the >2 min. test period.

Statistical considerations

Assessments of frequency distribution revealed that both the expansion and control groups consisted of skewed samples (for nasal resistance at T1). Thus the data were analyzed using non-parametric statistics. Linear regression analysis and non-parametric correlation coefficients (Spearman's coefficient of rank correlation) were employed to determine if one sample variable was correlated with any other sample variable. Correlation coefficients were considered to be significant at $p < 0.05$ or less. Scattergrams were used to determine if any nonlinear correlations existed. Anterior facial height showed a normal distribution and thus tests assuming normality were used when appropriate, with mean values being reported.

Results

The associations between RME and nasal resistance were reported previously.[27] Two subgroups within the expansion group were identified. A "lo" expansion subgroup consisted of individuals with an initial nasal resistance in the natural state of less than or equal to 5.5 cm H2O/L/sec. A "hi" expansion subgroup consisted of individuals with an initial nasal resistance in the natural state of greater than 5.5 cm H2O/L/sec. This value was also found to be compatible with predominant nasal breathing quantified with the SNORT apparatus as several individuals were identified who demonstrated 80-100 percent nasal breathing despite a nasal resistance of 5.5 cm H2O/L/sec.

For the nasal resistance data, intra-individual variation was high for all modes and time periods tested, and averaged approximately +/— 0.5 cm H2O/L/sec for both the expansion and control groups.

1. Lip posture

Nasal resistance values were generally not found to be significantly different for either the control or expansion groups for either the lips apart or lips together posture. In fact, one half of the individuals in both the "lo" and "hi" expansion subgroups were lip incompetent, indicating a lack of association with lip posture and nasal resistance values. Anterior facial height was, however, found to differ according to lip posture. For the expansion group, the lips apart posture group had a significantly larger ($p < 0.005$) percent lower anterior facial height/total facial height. This comparison is shown in Figure 1.

2. Percentage of lower anterior facial height as a fraction of total anterior face height

Percent lower anterior facial height was calculated only for the expansion group as lateral cephalograms were not available for the control group. No relationship could be demonstrated between nasal resistance values and the percentage of lower anterior facial height/total anterior face height. A box plot showing nasal resistance for the two subgroups ("lo" and "hi") of the expansion group, as related to the percentage of anterior facial height/total anterior face height, is shown in Figure 2. The differences in facial height were nonsignificant for the subgroups.

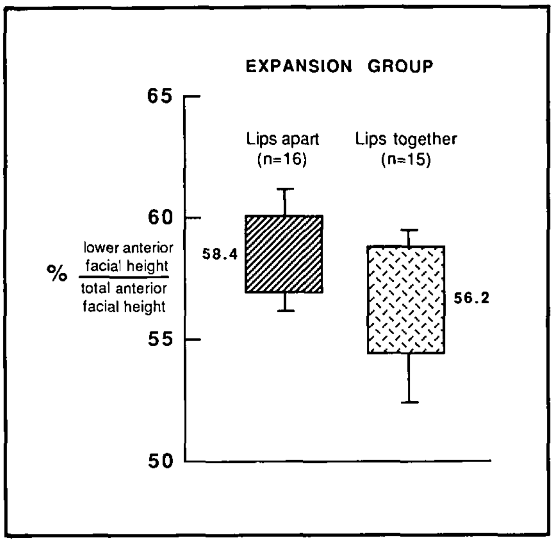

Figure 1
Comparison of percent lower anterior facial height/total anterior facial height for the lips apart and lips together posture.

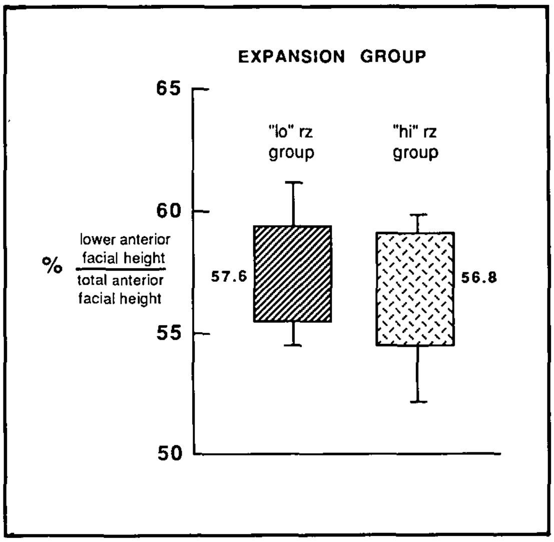

Figure 2
Comparison of percent lower anterior facial height/total anterior facial height for the "lo" and "hi" nasal resistance subgroups of the expansion group.

3. Percentage nasality: nasal/oral respiratory ratios

No significant correlation was demonstrated between percent nasality and nasal resistance for the expansion group, but a slight correlation ($r = -0.47$) was found between nasal resistance and percent nasality (inspiration) at T1 for the control group (for the natural state and spray-assisted only).

Significant correlations were demonstrated between percent nasality and the percentage of

Table 1
Median percentage nasality (inspiration) for the control and expansion groups: lips apart vs. lips together posture.

Control T1:		
Natural state:	63.0% vs. 94.3%	$p < 0.05$
Tube assisted:	70.6% vs. 97.1%	$p = 0.05$
Spray assisted:	89.5% vs. 92.9%	ns
Spray + tube:	65.1% vs. 97.6%	$p < 0.005$
Control T3:		
Natural state:	73.2% vs. 99.2%	ns
Tube assisted:	72.2% vs. 95.3%	ns
Spray assisted:	84.0% vs. 97.0%	ns
Spray + tube:	79.8% vs. 98.6%	ns
Expansion T3:		
Natural state:	49.9% vs. 88.0%	$p < 0.05$
Tube assisted:	60.7% vs. 77.8%	$p < 0.05$
Spray assisted:	62.7% vs. 93.2%	$p < 0.05$
Spray + tube:	66.8% vs. 80.5%	ns

lower anterior facial height/total anterior facial height for the expansion group. There were some differences found for both the control and expansion groups for percent nasality (assessed for inspiration) between the lips apart and lips together posture. It should be stressed that the range of individual variation was very high for both groups. For the control group at T1 (see Table 1), the lips apart group tended to have a lower median percent nasality than did the lips together group. At T3 these differences were significant only at $p < 0.10$. At T1 and T3, the median percent nasality in the natural state, for the group with lips apart posture was 63.0 percent and 73.2 percent, respectively (ranging from 34.8 percent to 100.0 percent for T1, and 26.9 percent to 99.0 percent for T3) whereas the median percent nasality for the lips together group was 94.3 percent and 99.2 percent, respectively (ranging from 50.1 percent to 100.0 percent for T1, and from 84.8 percent to 99.8 percent for T3).

For the expansion group, the lips apart group also tended to have a lower percent nasality than did the lips together group. At T3, in the natural state, the median percent nasality (inspiration) for the group with lips apart posture was 49.9 percent (ranging from 21.0 percent to 100 percent, whereas the median percent nasality for the group with lips together posture was 88.0 percent (ranging from 50.7 percent to 99.4 percent). See Table 1.

4. Banded vs. bonded rapid maxillary expansion

The bonded group consisted of 24 subjects with a median age of 8.75 years. The banded group consisted of 14 subjects with a median age of 12.75 years. These groups were not found to differ significantly in nasal resistance values for any of the time periods tested, or for any of the four experimental conditions.

5. Dental arch measurements: inter-cuspid and inter-molar widths

A mean increase of 4.5mm at the canines, and a mean increase of 6.5mm at the molars was seen after maximum expansion (T2). Measurements 9 to 12 months later (T3) showed a mean increase of 4.6mm at the canines and 6.3mm at the molars from the initial (T1) to final time period (T3). No relationship could be demonstrated between inter-canine or inter-molar width and nasal resistance, or changes in these linear dimensions from one measurement period to another. **Note:** Data for all subjects are available.[26]

Discussion

Lip posture, skeletal, and dental relationships

It is frequently assumed that the individual presenting with the lips apart posture in the relaxed state maintains this posture due to high nasal resistance. Theoretically the lips are kept open as there is a need to breathe through the mouth for adequate air intake. In addition, these individuals may also be described as having the "long-face syndrome". Our study, however, did not find significant differences in nasal resistance between lip competent/incompetent subjects. The equal distribution of lip incompetent subjects between the "lo" and "hi" expansion subgroups further substantiated the finding of a lack of association between nasal resistance and lip posture.

The lips apart posture group did have a greater mean percent lower anterior facial height/total anterior facial height than the lips together posture group. It is to be expected, however, that increased lower anterior facial height could result in a physical separation of the lips, especially in the growing child where vertical lip growth lags behind and has not yet caught up with skeletal growth. Vig and Cohen[31] have shown that lip incompetence diminishes with age in the absence of any treatment irrespective of skeletal type. It has been assumed that a lips apart posture results in a greater oral component of respiration, although this is not always the case as the tongue can occlude the oral airway and allow for nasal respiration in spite of an anterior opening.[8]

The prevalent belief that the long-faced appearance and lips apart posture ("adenoid facies") is causally associated with mouth breathing, due to increased nasal resistance, was not supported in this study. No correlations were found between nasal resistance in relation to percent lower anterior facial height/total anterior facial height. Thus, at the specific time of our study, vertical facial morphology was not related to nasal resistance. Other investigators have found similar results. In a study of normal and long-faced individuals, Vig, et al.[25] found that the long-faced group had a higher mean value of nasal resistance but that the individual range of variation was too great to make a diagnosis of nasal obstruction from an assessment of facial morphology. In an assessment of anterior-posterior relationships, Watson, et al.[28] found that the magnitude of nasal resistance and the subject's anterior-posterior skeletal classification were independent of one another.

The amount of maxillary dental expansion and changes in nasal resistance were also found to lack significant correlation. Decreases in nasal resistance could not be predicted by changes in width of the dental arch. This is in agreement with the findings of Linder-Aronson and Aschan[5] and Turbyfill.[32]

Nasal resistance, percent nasality, and facial morphology

The negative correlation ($r = -0.47$) found between percent nasality and nasal resistance for the control group (T1), indicates that, as nasal resistance increases, percent nasality tends to decrease. For both the control and expansion groups, low values of nasal resistance were highly variable in relation to percent nasality. Individuals with nasal resistance greater than 5.5 cm H2O/L/sec did tend to have lower percent nasality than those individuals with nasal resistance less than or equal to 5.5 cm H2O/L/sec, however, this was highly variable and several of these high resistance subjects actually had percent nasality values greater than 80 percent.

It is important to note that a nasal respiratory component was found in all subjects tested, but the magnitude of that component showed no predictable relationship to the magnitude of nasal resistance. For the range of nasal resistance data obtained in this study, percent nasality could not be predicted from nasal resistance. Keall[33] also found that no linear or non-linear relationship between nasal resistance and percent nasality can be shown to exist, and therefore stated that it is not possible to predict the respiratory mode from nasal resistance values.

Of equal importance was the lack of association between percent nasality and percent lower anterior facial height/total anterior facial height. Individuals with increased lower anterior facial height did not have a predominantly oral breathing mode. A nasal component of respiration was present in all individuals tested, but the degree of nasality was highly variable for the entire range of values of percent lower anterior facial height/total facial height. Associations existed between lip posture and respiratory mode. A greater oral component of respiration was found with the lips apart posture. Patients with lips apart posture also tended to have a longer lower anterior facial height. However, these findings were not sufficient to demonstrate a significant correlation between anterior facial height and percent nasality. Increased anterior lower facial height, sometimes called the "long-face syndrome", was not characterized by a predominantly oral breathing mode (ie. "mouth breathing").

An interesting difference was noted between the banded and bonded expansion treatment responses. Patients treated with bonded expanders had a more parallel expansion of the canines and molars than those treated with the banded appliance. In the banded group the mean expansion was 4.5mm at the canines and 7.4mm at the molars. Corresponding values for the bonded group were 4.4mm and 5.0mm. There was however, no significant correlation, at either T1 or T2, between dental arch width changes and nasal resistance when these groups were considered separately.

Our findings thus indicate considerable variability in nasal resistance, a lack of systematic relationships between facial morphology, nasal resistance and respiration in general, and also fail to demonstrate any obvious mathematical relationships between values of nasal resistance and the ratio of nasal to oral airflow in breathing. Although such results may be unexpected in light of "common sense", and contradict some currently prevalent orthodontic beliefs, they do nevertheless agree with a large body of data from several other respiratory studies conducted in our laboratory, over the last five years.

An untested but widely held belief is that a principal or even the sole determinant of airflow through the nose or mouth, is the airway resistance of the nasal passage. If this were entirely true, our results would indeed be paradoxical and thus defy explanation. We however suspect that a predominantly nasal mode of breathing can be, and indeed is generally maintained, for a range of resistance values. Unless the resistance is so high as to virtually preclude airflow through the nose, it can be overcome by increasing the work of respiration. Such compensatory adaptations will not be directly revealed by measuring either nasal resistance or oro-nasal airflow ratios. They may however be perceived by patients as being more or less comfortable or easy.

Conclusions

The following conclusions were derived from our study:

1. Lip posture (apart or together) was not related to nasal resistance. Lip posture was, however, related to respiratory mode.
2. There was no significant correlation between lower anterior facial height and nasal resistance. Lower anterior facial height was, however, greater in the lips apart group.
3. No significant correlations were found between percent nasality and lower anterior facial height. Those individuals with increased lower anterior facial height did not have greater nasal resistance or a greater oral component to their respiration than individuals in the normal range of anterior face height.
4. No significant correlations were found between nasal resistance and percent nasality for the expansion group or the control group at T3. A slight correlation (r = −0.47) was found between nasal resistance and percent nasality for the control group at T1. However, a systematic or consistent mathematical relationship did not exist and it was not possible to predict percent nasality from nasal resistance data.
5. No significant correlations were found between the amount of inter-molar or inter-canine expansion and changes in nasal resistance.
6. There was also no significant difference in nasal resistance changes observed between the amount, or type, of expansion with banded or bonded expansion appliances.

It is clear that respiratory mode and nasal resistance can only be determined with suitable instrumentation. Thus, neither orthodontists nor otolaryngologists, can predict or accurately diagnose nasal airway impairment from the patient's facial proportions or lip separation at rest.

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