A longitudinal evaluation of open mouth posture and maxillary arch width in children

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The influence of orofacial myofunctional factors on dentofacial development has continued to receive much attention. Suggestions that muscle function influences morphology have long been debated.[1] Recent experimental and clinical evidence suggest that in addition to hereditary influences, skeletal and dental development may be significantly influenced by changes in the local environment.[2] For example, negative oral habits and resting tongue position and swallowing patterns have been shown to have an effect on dentition and facial growth.[3,4]

Mouthbreathing may be a significant myofunctional factor in the etiology of malocclusion.[5] A number of dentoskeletal characteristics have been reported for children considered chronic mouthbreathers. These youngsters may exhibit an open mouth posture, a nose that appears to be flattened, nostrils that are small and poorly developed, a short upper lip, and a fuller lower lip. These individuals can also display retroclined maxillary incisors, a narrow V-shaped upper jaw with a high narrow palatal vault, a Class II skeletal relationship[6,7] or a posterior crossbite, and a tendency for openbite.[8]

Mouthbreathing is said to be the result of nasorespiratory impairment. A number of theories concerning the undesirable facial growth and dental malocclusion associated with mouthbreathing have been suggested. An impaired nasal airway may result in the alteration of normal air currents and pressures with the oral airstream interfering with normal palatal growth.[9] Nasal airway impairment may also result in a modification of the posture of the head and neck, producing a dorsal and caudal restraint on facial development.[10]

Current theory suggests that mouthbreathing results in changes in tongue posture and mandibular position.[11] A mouthbreather lowers his or

Abstract

Open mouth posture and maxillary arch width were assessed annually for 4 years in a group of children. While younger children exhibited high levels of open mouth posture, this behavior decreased significantly over time. Racial and sex differences, as well as a race-by-time interaction were also evident. The children displayed a significant increase in maxillary arch width across time with sex and racial differences in this growth pattern. Subjects were classified as exhibiting primarily open mouth or closed mouth posture. Although both groups showed increased maxillary arch widths over time, the closed mouth subjects showed significantly greater maxillary arch growth.

Key words

Maxillary arch width • Mouthbreathing • Open mouth • Children • Habit

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her mandible and frequently positions the tongue in a low forward plane. In this position the tongue does not offset the forces of the cheeks and lips upon the maxilla.[12]

Efforts to define mouthbreathing have led to an emphasis on improving assessment and definition of nasal airway impairment. Warren and Hairfield, et al.,[13] using a pressure flow technique to estimate nasal cross-sectional area and inductive plethysmography to assess nasal-oral breathing, reported that adult nasal airway size was generally related to nasal-oral breathing. They also noted that approximately 12% of their sample were habitual mouthbreathers despite having an adequate nasal airway.

Using similar technology Warren, Hairfield, and Dalston[14] examined nasal patency and nasal-oral breathing in a sample of 102 children. They reported that nasal cross-sectional area increased with age across years 6 to 14. Surprisingly, the percentage of children who were primarily nasal vs oral breathers was approximately equal until age 8. After 8 years of age most children were classified as nasal breathers.

Vig and Zajac[15] examined nasal respiratory function in 197 individuals ranging in age from 5 to 73 years. Similar to Warren et al.[13] they reported that nasal resistance decreased with age and nasal breathing increased with age. However, their data did not suggest a strong relationship between nasal resistance and breathing mode.

Although the data concerning nasal respiratory function are limited, they suggest that oral respiration is extremely common in children and not necessarily related to nasal airway impairment. While these factors are more closely associated in adults, a considerable number of adult oral breathers do not have impaired nasal airways.[13] Moreover, Vig and Zajac[15] suggested that while it is important to examine respiratory function, before classifying nasal function as impaired a classifying principle must be agreed upon. That is, nasal airway impairment should be defined statistically based on age and sex norms or as a clinical problem in need of treatment.

The correlation between mouthbreathing and dentofacial anomalies underscores the importance of a better understanding of the long-term impact of mouthbreathing. However, the limited availability of rhinometric assessment instrumentation coupled with the difficulty in defining nasal airway impairment suggest that the development of a behavioral index of mouthbreathing may be useful. The term "mouthbreathing" is frequently used to indicate an individual who displays open mouth posture. The purpose of the present investigation was to examine the relationship between open mouth posture and dentofacial development. In a longitudinal research design over a 4-year period, children were assessed on maxillary arch width and open mouth posture. It was predicted that children displaying consistently high rates of open mouth posture relative to youngsters exhibiting predominantly anterior lip seal posture would show significantly different maxillary arch width patterns.

Materials and methods

Subjects

Four hundred and forty youngsters attending three public elementary schools served as subjects. The children had been recruited to participate in a 5-year longitudinal study beginning during their kindergarten year in school. The majority of the youngsters were currently in the third grade. As a result of grade retention, a small number of the children were in the second grade.

During the first year of the study the children ranged in age from 5 to 7.5 with a mean of 5.8 years. The sample consisted of 127 African-American boys, 107 African-American girls, 104 Caucasian boys, and 102 Caucasian girls.

The analyses presented are based on subjects for whom assessment data were available for all four annual open mouth posture assessments. This subset included 214 youngsters: 72 African-American boys, 54 African-American girls, 48 Caucasian boys, 40 Caucasian girls.

Measures

Open mouth posture (OMP) was assessed using a standardized psychological interval observation procedure. Each assessment was divided into observations of 5 seconds and recording intervals of 5 seconds. Every observation interval was followed by a recording interval. Observation and recording intervals were cued via a tape recorder the observer listened to through an earphone. Observers monitored a child during the observation interval, and then during the subsequent recording interval, noted the occurrence of OMP. Observations were conducted in the child's classroom.

Each child was assessed for 30 observation intervals. In order to obtain a more representative sample of the target behavior, each subject was monitored on three occasions during the assessment period. That is, every subject was monitored for 10 consecutive intervals (observe + record). Following the completion of 10 observations on each child in the class, a second round of assessments was conducted. This format was followed until each subject was monitored for 30 observation intervals.

OMP was defined as a visible separation of the lips when the child was not talking. In order to be considered an instance of OMP the child had to be seen with the lips separated for any part of a 5-second interval. Intervals in which a child was talking, laughing, or had placed an object in his or her mouth were not scored. Observers sat in the classroom and sequentially observed the youngsters in a randomly determined order.

Maxillary arch width was determined by placing a millimeter boley gauge against the mesiolingual cusp at the cementoenamel junction of the maxillary first molar and measuring the distance to the cementoenamel junction of the opposite maxillary first molar. In instances where measurement was not possible due to partially erupted or unerupted teeth, subjects were excluded from the sample.

Procedures

A longitudinal research strategy was employed. In the fall of each academic year the children were assessed for open mouth posture and maxillary arch width.

Direct observation of OMP was performed by psychology graduate students. The same observers were used across the four annual assessments. Moreover, prior to initiating the project each fall the observers participated in an observer training program. Classroom assessment began when observers were able to monitor practice subjects at an agreement level of 90% or higher. Maxillary arch width measurement was conducted by an orthodontist and an orthodontic technician.

OMP assessment was conducted in the classroom. The observers entered the room and took seats along the wall on one side of the classroom. The observers did not interact with the children and the youngsters were not aware of the behavior being monitored. Observations were performed while the children observed a video. The youths sat in a semicircle in front of a 19-inch television monitor. As the youngsters watched the video, observers noted mouth posture. Children with nasal congestion due to allergies or colds were excluded from observation.

Maxillary arch width measurement was also conducted on the children in their classroom. The children sat at their desks and the orthodontic team assessed each child.

Reliability

OMP reliability was performed by having two observers independently monitor a child. Headphones were connected to a Y-jack, allowing the observers to be simultaneously cued to each interval. This insured that the same sample of the youth's behavior was being coded by each observer. Reliability was performed on 20% of the subjects each year. A Pearson product moment correlation was computed on observer ratings. The resulting correlations were .90 ($P < .001$), .89 ($P < .001$), .91 ($P < .001$), and .98 ($P < .001$) for the first, second, third, and fourth years, respectively.

Reliability was also obtained on maxillary arch width measures. A second measure of maxillary arch width was independently obtained on approximately 20% of the sample each year. Pearson product moment correlations were computed on pairs of ratings. The resulting correlations were .72 ($P < .01$), .73 ($P < .01$), .70 ($P < .01$), and .79 ($P < .01$) for years one, two, three, and four, respectively. The lower reliability found for maxillary arch width relative to OMP was likely due to the greater difficulty involved in performing this measure.

Table 1
Means and standard deviations for intervals in which children displayed OMP across years

	Boys				Girls			
	African-Amer		Caucasian		African-Amer		Caucasian	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Yr 1	42.9	4.0	67.5	4.9	36.9	4.6	59.1	5.4
Yr 2	51.67	4.1	56.4	5.0	35.8	4.7	43.5	5.5
Yr 3	38.5	4.0	49.9	4.9	29.7	4.6	46.5	5.4
Yr 4	46.7	4.2	54.2	5.1	34.1	4.9	41.4	5.7

Results

OMP data gathered for the children across 4 years were subjected to a 2 x 2 (Race x Sex) analysis of variance with repeated measures. Means and standard deviations are presented in Table 1. The analyses reveal significant between-subjects main effects for race [$F(1,210)=12.45$, $P < .001$] and sex [$F(1,210)=7.83$, $P < .006$]. Caucasian children exhibited greater OMP than African-American youngsters. Relative to girls, boys showed higher levels of OMP. The between-subjects interaction was not significant.

Within-group comparisons reveal a significant main effect for time [$F(3,630)=5.64$, $P < .001$] and a significant time by race interaction [$F(3,630)=4.45$, $P < .004$]. An orthogonal polynomial contrast indicates a significant decreasing linear trend across time for OMP [$F(1,210)=10.32$ $P < .002$]. The children displayed significantly lower levels of OMP across years. The orthogonal polynomial contrast also indicates a significant linear trend in the time by race interaction.

Figure 1 reveals that while the Caucasian youths exhibited a large decrease in OMP between year 1 and year 2, the rate of decline in OMP leveled off between year 2 and year 4. A different pattern was

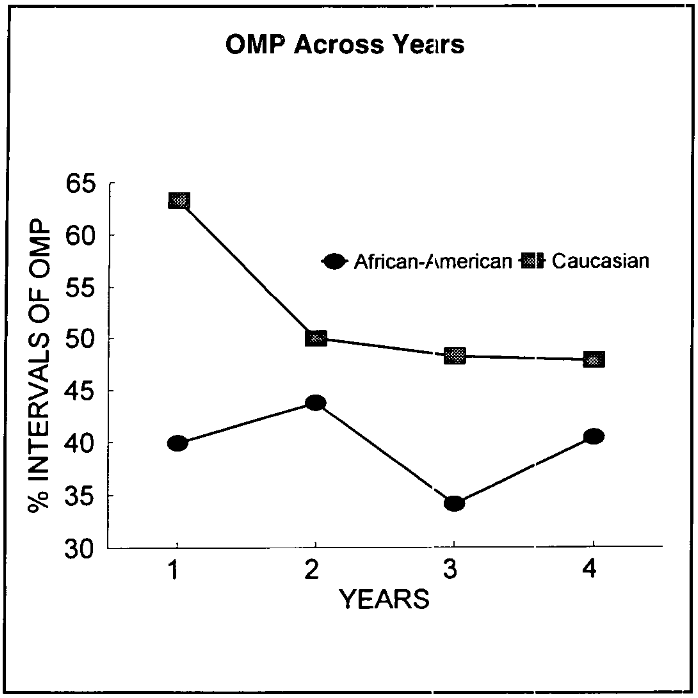

Figure 1

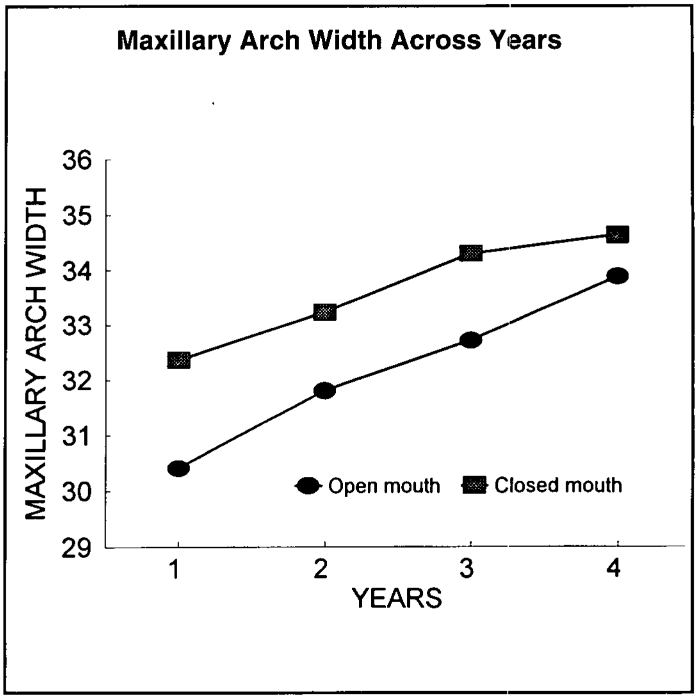

Figure 2

Figure 1
OMP across years.

Figure 2
Maxillary arch width across years.

shown by the African-American children. They displayed little change in OMP between year 1 and 2 but exhibited a large reduction in OMP between year 2 and year 3. This was followed by an increase in OMP in the following year.

Maxillary arch width data collected on the children across 4 years were subjected to a 2 x 2 (Race x Sex) analysis of variance with repeated measures. One hundred and seventy-eight of the current sample of subjects had data for each assessment. The analyses reveal significant between subject effects for race [$F(1,174)=62.50$, $P < .001$] and sex [$F(1,174)=10.78$, $P < .001$]. Compared to Caucasian youths, African-American subjects had larger maxillary arches. Boys also had significantly larger maxillary arches relative to girls.

Within-subject analyses reveal a significant effect for time [$F(3,522)=40.52$, $P < .001$]. Further examination of this effect was obtained via an orthogonal polynomial contrast. This analysis reveals a significant linear trend [$F(1,174)=191.61$, $P < .001$], indicating that across time maxillary arch width increased significantly.

Using the first year OMP data, subjects were classified as either open mouth or closed mouth. Subjects who displayed OMP on fewer than 20% of the observation intervals were considered closed mouth. Children observed showing OMP on less than 20% of the observation intervals were considered closed mouth. Children observed showing OMP on greater than 80% of the observation intervals were classified as open mouth subjects.

A repeated measures analysis of variance with group, race, and sex as the independent variables and maxillary arch width as the dependent variable was performed. Between-subjects analyses revealed a significant effect for group [$F(1,60)=4.32$, $P < .04$] and race [$F(1,60)=10.13$, $P < .002$]. Relative to closed mouth posture subjects, OMP youngsters displayed significantly smaller maxillary arch widths. African-American children exhibited maxillary arch widths that were larger than those of the Caucasian subjects.

Within-subject comparisons reveal a significant main effect for time [$F(3,180)=20.07$, $P < .001$]. Additional examination of the within-subject effect involved orthogonal polynomial contrasts.

A significant linear trend was discovered for time [$F(1,60)=59.45$, $P < .001$], suggesting that subjects exhibited increased maxillary arch width across years.

Discussion

A relatively large biracial sample of children was assessed annually for OMP and maxillary arch width over a 4-year period. Across time the children exhibited reduced levels of OMP and significant growth in maxillary arch width. Youngsters classified as displaying consistently high levels of OMP manifested significantly smaller growth of the maxillary arch relative to closed mouth posture children.

Although mouth posture associated with mouthbreathing has been suggested to be an important variable in dentofacial development, relatively few data have been presented concerning the occurrence of this behavior in the general population. A previous study[16] on this sample indicated a relatively high occurrence of this response. Moreover, an earlier report on the current sample following the third annual assessment indicated that although OMP is a fairly common behavior, as children get older they display lower rates of the response (Gross and Kellum, et al.[17]). The current data suggests that the gradual decline in frequency of OMP continues through age 9. These findings in conjunction with the absence of a reported relationship between OMP and cross-sectional nasal airway in young children[13,16] support the idea that resting mouth postures may be a significant environmental influence on the dentofacial structures.

Although OMP decreased over time it is important to note that African-American and Caucasian children display different patterns of this behavior. However, of greater interest is the within-subject interaction between race and time. Relative to African-American children, Caucasians show a more gradual and consistent pattern of reduced OMP.

Growth in maxillary arch width was observed over time. Interestingly, racial and sex differences were found. Boys displayed larger arch widths than girls. Given that boys tend to be physically larger then girls this finding is not surprising. African-Americans had larger maxillary arch width than Caucasian youths. These data suggest that race should be considered in discussions of myofunctional variables and dentofacial development.

Regardless of race or sex, OMP children were found to show significantly slower growth of the maxillary arch width relative to children who maintained closed mouth posture. A narrow maxillary arch commonly accompanies skeletal openbite and an anterior crossbite.[18] When children exhibit OMP it is common for them to position the tongue in a low forward horizontal plane rather than in a retroflexed position with alveolar contact. The present data along with the lack of a reported relationship between nasal patency and mode of respiration may be viewed as consistent with the emphasis concerning the role of the exertion of tongue forces on the bony palate in the development of the maxillary arch.

OMP may be due to a variety of factors. Enlarged tonsils and adenoids[19] and allergies[20] have been reported to influence OMP. Developmental factors, previous airway blockage which may initiate a habit pattern, or never being encouraged to engage in appropriate mouth posture may also contribute to this response. Regardless of etiology these data suggest that consistently high levels of OMP may be an important variable in dentofacial development.

Table 2
Means and standard deviations for maxillary arch width across years

	Boys				Girls			
	African-Amer		Caucasian		African-Amer		Caucasian	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Yr 1	33.5	.36	30.1	.43	31.6	.40	29.5	.45
Yr 2	34.3	.41	31.9	.49	33.2	.46	30.4	.51
Yr 3	35.9	.36	32.1	.43	34.2	.40	31.9	.45
Yr 4	35.9	.38	33.2	.46	34.7	.42	32.4	.48

In recent years interest in the impact of mouthbreathing on dentofacial development has prompted great interest in nasal airway patency. However, the absence of an accepted definition of impaired airway, lack of rhinometry equipment, as well as limited normative data concerning the nasal airway, hampers the usefulness of rhinometry as a diagnostic tool. The present data suggest that OMP with or without documented airway patency may be a potentially undesirable factor in dentofacial development. Using a standardized procedure, the assessment of OMP can be achieved easily and inexpensively by professional staff, parents or teachers. Given the high incidence of OMP in the orthodontic population[21] and the observed relationship between OMP and maxillary arch width, it may be appropriate for adults to observe and prompt children to maintain appropriate lip seal posture.

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