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The Relationship of Craniofacial Structure Changes in Mouth Breathing Patients to Pharyngeal Airway Dimensions: A Lateral Cephalometric Study

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ABSTRACT

Background: Prolonged airway obstruction during facial growth can influence the development of craniofacial structures. Conversely, craniofacial deformities may contribute to reduced airway dimensions. Understanding the relationship between craniofacial morphology and pharyngeal airway space is essential, particularly in individuals with altered breathing patterns such as mouth breathing. **Objective:** This study aimed to determine the differences and relationships between craniofacial structures and pharyngeal airway dimensions in patients with mouth breathing compared to those with normal nasal breathing. **Methods:** This study employed a descriptive-analytic research design. A total of 20 lateral cephalograms were analyzed—10 from patients with normal breathing and 10 from mouth-breathing patients, all presenting with skeletal class II malocclusion. Landmarks were identified manually, and measurements were carried out using the CorelDRAW application. The Unpaired T-test was used to assess differences between groups. The Pearson correlation test was used to examine the relationship between craniofacial structures and airway dimensions in the mouth-breathing group. **Results:** Significant differences were found in mandibular structure and the oropharyngeal U-MPW plane angle ($p < 0.05$) between mouth breathers and nasal breathers. However, no statistically significant correlation was observed between craniofacial measurements and pharyngeal airway dimensions within the mouth-breathing group. **Conclusion:** This study concludes that increased anteroposterior skeletal measurements and vertical facial height are not significantly associated with narrowing of pharyngeal airway dimensions in mouth-breathing patients. Further studies with larger sample sizes are recommended to explore this relationship more comprehensively.

Keywords: Mouth breathing; Craniofacial structure; Pharyngeal airway; Cephalogram; Skeletal class II

1. Introduction

The human respiratory system comprises the respiratory tract, lungs, and respiratory muscles, with normal respiration typically initiated through the nasal cavity.[1] Air then travels through the pharynx, a fibromuscular structure that serves as a common passageway for both air and food.[2] Nasal breathing, along with proper mastication and swallowing, plays a crucial role in the optimal development of the craniofacial complex.[3] Obstruction of the nasal airway, particularly in children, can lead to a shift from nasal to mouth breathing.[4] One common cause is the enlargement of adenoid tissue, which can partially block airflow, leading to a habitual mouth-breathing pattern.[5] Prolonged nasal Obstruction during critical growth periods can disrupt the balance of jaw and facial development, leading to adaptive changes in head, jaw, and tongue posture.[6,7]

Mouth breathing is associated with some dentofacial abnormalities, including increased anterior lower facial height, mandibular retrognathism, narrow palatal arches, and backward mandibular rotation.[8,9] These skeletal changes are often accompanied by narrowing of the pharyngeal airway, which may further contribute to respiratory problems such as obstructive sleep apnea.[10] Cephalometric radiography is widely used to assess craniofacial morphology and airway dimensions.[11,12] It enables the analysis of anteroposterior and vertical relationships of the jaws, and the evaluation of soft tissue profiles and pharyngeal airway space.[12] Previous studies have shown that children with mouth breathing patterns often exhibit narrower upper pharyngeal airway dimensions and more pronounced vertical skeletal patterns than those with normal nasal breathing.[13,14,15]

Although some studies have demonstrated significant correlations between craniofacial measurements and airway dimensions,[16,17] others have found only weak or insignificant relationships.[18,19] These inconsistencies highlight the need for further investigation into the relationship between craniofacial morphology and pharyngeal airway dimensions, particularly in pediatric populations with skeletal Class II malocclusion. This study aims to evaluate the differences and relationships between craniofacial structure and pharyngeal airway dimensions in children with mouth-breathing habits compared to those with normal nasal breathing. By analyzing cephalometric radiographs, this research seeks to contribute to the early identification and management of dentocraniofacial changes associated with altered breathing patterns.

2. Materials and Methods

Research Design and Ethical Approval

A descriptive analytic study with a cross-sectional design was conducted to assess the differences in craniofacial structures and pharyngeal airway dimensions between children with mouth breathing and those with normal nasal breathing. Ethical clearance and research permits were obtained from the Faculty of Dentistry and the Faculty of Medicine, Universitas Sumatra Utara (USU), Medan, Indonesia. Data were collected from student and patient records that met the inclusion criteria.

Study Population and Sampling

The study population consisted of pediatric patients aged 8 to 12 years with skeletal Class II malocclusion. A total of 20 cephalograms were selected and divided into two groups: Group A (n = 10) consisted of patients with normal nasal breathing. Group B (n = 10): Mouth-breathing patients. The samples were obtained using purposive sampling. Mouth-breathing subjects were selected based on confirmation from interviews with their parents. In contrast, normal-breathing subjects were identified from patient records at the Orthodontic Clinic of RSGM USU between November 2013 and November 2023.

Data Collection Procedure

Lateral cephalometric radiographs were manually traced using a pencil, ruler, adhesive tape, tracing paper, and a tracing box. Predefined anatomical landmarks were marked on each tracing. The traced images were then scanned and imported into CorelDRAW software, where measurements of linear distances and angles were performed according to cephalometric parameters.

Statistical Analysis

All collected data were first subjected to a normality test. If data were found to be normally distributed, the Unpaired T-test was applied to evaluate differences between the two groups. For non-normally distributed data, the Mann–Whitney U test was used. The correlation between craniofacial measurements and pharyngeal airway dimensions was examined using the Pearson correlation test for normally distributed data and the Spearman correlation test for non-normally distributed data. A significance level of $p < 0.05$ was considered statistically significant.

3. Result and Discussion

This study compared craniofacial structures and pharyngeal airway dimensions between children with mouth breathing and those with normal nasal breathing. Significant differences were found in mandibular structure and the U-MPW angle, indicating altered craniofacial growth in mouth-breathing patients. However, no significant correlation was observed between craniofacial structure and airway dimensions within the mouth-breathing group. These results suggest that while mouth breathing affects facial morphology, it does not necessarily predict pharyngeal airway narrowing. Early detection and interdisciplinary management are crucial for preventing long-term complications.

Table 1 displays the mean and standard deviation of craniofacial structures and pharyngeal airway dimensions in children with normal breathing (Group A) and mouth breathing (Group B), all of whom were classified as skeletal Class II and aged 8–12 years. In the anteroposterior relationship, the ANB angle and NPog-FH values were slightly higher in the mouth-breathing group. Vertical skeletal parameters such as the Ar-Go-Me angle and mandibular plane angle were also higher in Group B, indicating a more vertical facial growth pattern among mouth breathers. Notably, the mandibular plane angle in Group B reached an average of 38.232 ± 4.080 compared to 35.588 ± 2.211 in Group A. In terms of airway dimensions, both the nasopharynx (PM-UPW) and oropharynx (U-MPW) were narrower in mouth-breathing children. The U-MPW measurement showed a substantial reduction in Group B (7.707 ± 2.629) compared to Group A (11.674 ± 1.430), suggesting that oropharyngeal airway narrowing is more evident in mouth breathers.

Table 1. The mean and standard deviation of craniofacial structures and pharyngeal airway dimensions in normal breathing and mouth breathing patients

Variabel		Group	Mean	SD
Craniofacial Structures in Anteroposterior Relation	ANB	A	5.993	1.30905
		B	6.430	1.01483
	NPog-FH	A	84.705	1.90273
		B	84.876	3.10124
Craniofacial Structures in Vertical Relation	Ar-Go-Me	A	129.405	2.67852
		B	133.943	6.67592
	FMA	A	32.455	1.62204
		B	32.822	5.25055
	SGo:NMe	A	60.746	2.07701
		B	59.882	2.48518
	Mandibular plane angle	A	35.588	2.21199
		B	38.232	4.08066
Pharyngeal Airway Dimensions	PM-UPW	A	26.742	3.07943
		B	24.648	3.07311
	U-MPW	A	11.674	1.43001
		B	7.707	2.62977

Data Processing, 2025

Table 2 outlines the statistical comparison of craniofacial structural and airway measurements between the normal and mouth-breathing groups using the Unpaired T-test. Most craniofacial and airway variables showed no statistically significant differences between the two groups ($p > 0.05$), except for two key measurements. The mandibular plane angle demonstrated a statistically significant difference with a p-value of 0.049, indicating that mouth breathers had a significantly steeper mandibular plane than normal breathers. The most notable finding was the U-MPW (oropharyngeal airway dimension), which showed a highly significant difference between groups ($p = 0.000$), with mouth breathers exhibiting much narrower oropharyngeal airways. These findings support the theory that mouth breathing is associated with both skeletal vertical growth and reduced airway space, particularly in the oropharyngeal region.

Table 2. Differences in craniofacial structures and pharyngeal airway dimensions in normal breathing and mouth breathing patients

Variabel		Group	*p-Value*
Craniofacial Structures in Anteroposterior Relation	ANB	A	0.415
		B	
	NPog-FH	A	0.884
		B	
Craniofacial Structures in Vertical Relation	Ar-Go-Me	A	0.096
		B	
	FMA	A	0.538

Variabel		Group	*p-Value*
		B	
	SGo:NMe	A	0.410
		B	
	Mandibular Plane Angle	A	0.049*
		B	
Pharyngeal Airway Dimensions	PM-UPW	A	0.145
		B	
	U-MPW	A	0.000*
		B	

Data Processing, 2025

Table 3 presents the correlation between anteroposterior craniofacial structure parameters (ANB and NPog-FH) and pharyngeal airway dimensions (PM-UPW and U-MPW) in mouth-breathing patients. The results indicate that there were no statistically significant correlations between these variables. The correlation coefficients were weak for all comparisons, with values ranging from $r = -0.323$ to $r = 0.055$, and all p-values well above 0.05. These findings suggest that variations in anteroposterior skeletal relationships such as the positioning of the maxilla and mandible relative to the cranial base—do not have a strong or consistent relationship with nasopharyngeal or oropharyngeal airway dimensions in mouth-breathing children.

Table 3. Relationship of anteroposterior relation of craniofacial structures to pharyngeal airway dimensions in oral breathing patients

Variable	Craniofacial Structure Anteroposterior Relations			
	ANB		**NPog-FH**	
	r	***P***	**r**	***P***
Nasopharynx (PM-UPW)	-0.279	0.435	-0.323	0.363
Oropharynx (U-MPW)	0.055	0.881	-0.042	0.907

Data Processing, 2025

Table 4 examines the relationship between vertical craniofacial structure parameters (Ar-Go-Me, FMA, SGo: NMe, and mandibular plane angle) and airway dimensions (PM-UPW and U-MPW) in the mouth-breathing group. Among the vertical measurements, the Ar-Go-Me angle showed the highest correlation with the nasopharyngeal dimension (PM-UPW), with a moderate positive correlation ($r = 0.576$). However, it did not reach statistical significance ($p = 0.081$). The remaining vertical variables including FMA, SGo: NMe, and mandibular plane angle—exhibited weak and statistically non-significant correlations with both nasopharyngeal and oropharyngeal airway dimensions ($p > 0.05$). These findings suggest that, although there may be a tendency for a relationship between vertical facial growth and airway narrowing, the correlation is not strong enough to be considered clinically predictive in this sample of mouth-breathing children.

Table 4. The relationship of the vertical relation of craniofacial structure to pharyngeal airway dimension in oral breathing patients

Variable	Craniofacial Structure Vertical Relations							
	ArGoMe		**FMA**		**SGo:NMe**		Mandibular Plane Angle	
	r	***P***	**r**	***P***	**r**	***P***	**r**	***P***
Nasopharynx (PM-UPW)	0.576	0.081	0.383	0.275	-0.204	0.571	0.213	0.555
Oropharynx (U-MPW)	0.297	0.405	0.321	0.365	-0.115	0.751	-0.061	0.868

Data Processing, 2025

Based on Table 1, the ANB angle in the mouth-breathing sample group (Group B) has a higher mean value compared to Group A, which consists of normal-breathing samples. This finding aligns with the systematic review and meta-analysis conducted by Zhao et al., which states that ANB is one of the indicators of mouth breathing, showing higher measurement values compared to ANB in normal breathing.[18] The results of this study show that the ANB angle in Group B has a mean value of 6.430 ± 1.014, which is higher than that of Group A. According to Table 2, the increase in ANB angle in Group B does not show a statistically significant difference between the groups. This finding is consistent with a study by Lysy et al., which was conducted on children under 13 years old and also found that the ANB values did not differ significantly between the mouth-breathing group and the control group with nasal breathing. Genetic factors are the primary determinants influencing skeletal changes; however, mouth breathing is a functional factor with a significant impact on skeletal alterations.[19] Habitual mouth breathing forces individuals to keep their mouths open continuously, both during the day and while sleeping, leading to a lowered tongue position, which contributes to these changes. The head moves forward, and the hyoid muscles contract, pulling the mandible in a clockwise direction, which, overall, can trigger skeletal changes in most individuals with mouth breathing.[20]

The increase in the mandibular plane angle and the ArGoMe angle in Group B, or patients with mouth breathing, can be observed in Table 1, where the mandibular plane angle has a mean value of 38.232 ± 4.080, and the ArGoMe angle has a mean value of 133.943 ± 6.675. These values indicate an increase in vertical facial dimensions, which is one of the impacts of mouth breathing, as individuals must lower their mandible and tongue and tilt their head upward to breathe effectively through their mouth.[5,10] Based on Table 2, the mandibular plane angle in the vertical craniofacial structure relationship shows a significant difference between the groups. This result is consistent with a study conducted by Shetty et al. on children aged 9-13 years with skeletal class II malocclusion, who exhibited habitual mouth breathing. The study reported that vertical dentofacial parameters, such as the SN-MP angle, exhibited significant increases in mouth-breathing samples.[13]

Table 1 also indicates that in this study, the group of patients with mouth breathing had lower nasopharyngeal and oropharyngeal dimensions compared to the control group. Table 2 presents the findings, showing a significant difference in the oropharyngeal dimension between the groups. This result is consistent with the study by Shetty et al. on children aged 9-13 years, which reported that children with a mouth-breathing pattern tend to have a significantly narrower upper pharyngeal airway. The study also highlighted that skeletal changes and the positioning of the tongue base further posteriorly and lower can also reduce airway dimensions.[13]

The relationship between the anteroposterior and vertical craniofacial structure with pharyngeal airway dimensions, as presented in Tables 3 and 4, shows no significant correlation between any measurement parameters of the craniofacial structure (anteroposterior and vertical) with nasopharyngeal or oropharyngeal dimensions. These findings contradict the study conducted by Shetty et al., which reported a significant correlation between the narrowing of the upper pharyngeal airway dimensions and craniofacial structural parameters, particularly SNB, ANB, SN-MP, and N-GO.[13] Additionally, this study does not align with the findings of Lopatiene et al., who reported a correlation between increased ANB values and the narrowing of both upper and lower airway dimensions.[15]

However, the current study is consistent with the findings of Gu et al., who studied 12-year-old Chinese children and concluded that the relationship between upper airway and craniofacial structures is weak and insignificant.[17] Another study that supports these findings is the research by Kumar and Nandi, which stated that there is no significant correlation between SNA, ANB, and the mandibular plane angle with pharyngeal airway dimensions.[16] Similarly, Lopatiene et al. also concluded that there is no significant correlation between vertical craniofacial morphology and airway dimensions.[15] Studies by Shetty et al. and Lopatiene et al. stated that higher ANB values negatively impact the airway, particularly the oropharynx, as per Shetty et al.[13,15] However, it is important to note that skeletal changes are just one of the factors affecting airway dimensions, alongside variations in uvula size among individuals. A long soft palate is associated with smaller oropharyngeal dimensions, which is often found in patients who snore or suffer from obstructive sleep apnea.[21,22]

The differences between this study and previous research may be attributed to variations in the age range of study samples. The pharyngeal structure continues to grow rapidly until it peaks at the age of 13, followed by a plateau period between ages 14 and 18.15 This study did not include that age interval, based on Freud's theory, which suggests that this period marks the onset of puberty, with changes predominantly driven by hormonal fluctuations. The current study focuses purely on observing changes caused by habitual mouth breathing. Freud's theory also suggests that growth is generally less dominant between the ages of 6 and 12. Therefore, the chosen age range of 8-12 years in this study yields more valid results for assessing the relationship between craniofacial structural changes resulting from mouth breathing and pharyngeal airway dimensions.[9]

4. Conclusion

This study found that children with mouth-breathing habits exhibited significant differences in mandibular plane angles and oropharyngeal airway dimensions compared to those with normal nasal breathing, indicating an association between altered breathing patterns and vertical craniofacial growth, as well as airway narrowing. However, no significant correlations were observed between craniofacial structure and airway dimensions within the mouth-breathing group, suggesting that skeletal morphology alone may not fully predict changes in airway space. The absence of indicators to assess the duration of the mouth breathing habit and the lack of malocclusion severity classification are notable limitations. These factors are important, as prolonged nasal obstruction during periods of active facial growth can influence jaw posture, tongue position, and upper lip pressure, ultimately contributing to skeletal Class II Division 1 malocclusion and reduced airway dimensions. Future research with larger sample sizes and more comprehensive classifications is needed to understand better the complex relationship between mouth breathing, craniofacial development, and airway morphology.

5. Limitations

This study has several limitations that should be considered when interpreting the findings. First, the small sample size (n = 20) may limit the generalizability of the results to a broader population. Future studies with larger and more diverse samples are recommended to validate these findings. Second, the study did not assess the duration of the mouth breathing habit in the participants. The length of time an individual has exhibited mouth breathing is an important factor, as prolonged nasal obstruction during key growth periods can have a more pronounced impact on craniofacial morphology and airway dimensions. Third, there was no classification of malocclusion severity among the patients with mouth breathing. Different degrees of Class II malocclusion, particularly Division 1 characterized by lip imbalance and dental protrusion, may have varying influences on both craniofacial structure and airway dimensions. Lastly, the cross-sectional design of the study only captures a snapshot in time, making it difficult to establish causal relationships between breathing patterns and anatomical changes. Longitudinal studies would be beneficial to assess developmental changes over time.

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Authors Contribution

Contribution	Lubis MM	Bahirrah A	Lubis HF	Rumaisha K
Concepts or ideas	√			√
Design	√			
Definition of intellectual content	√		√	√
Literature search	√	√	√	√
Experimental studies	√		√	√
Data acquisition	√	√		
Data analysis	√	√	√	√
Statistical analysis	√	√	√	√
Manuscript preparation	√			√
Manuscript editing	√		√	
Manuscript review	√	√		√

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