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International Journal of Orthodontic Rehabilitation

Original Research

Airway Analysis in Different Malocclusions - A Cephalometric Study

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How to cite this article: R. Hellweg Sheraffin, Mary Sheloni Missier, S.D.Milling Tania, I. Bevin Shaga, S. Veerasankar, A. Jebilla Pringle. Airway Analysis in Different Malocclusions - A Cephalometric Study. *Int J Orthod Rehabil 2024; 15 (1) 51-63.*
Doi: 10.56501/intjorthodrehabil.v15i1.1011.

Received: 21-02-2024 *Accepted: 01-05-2024* *Web Published: 13-05-2024*

ABSTRACT

Background: It was essential to evaluate respiratory function when diagnosing and planning orthodontic treatment. Based on the correlation between pharyngeal airway space and craniofacial structure, airway width was hypothesized to be an indicator of airway patency in different groups of skeletal malocclusion.

Aim: The purpose of this study was to investigate age and gender related changes in pharyngeal airway dimensions in different sagittal skeletal relationships

Materials and Methods: Sixty lateral cephalograms of patients aged 10-30 years with no pharyngeal pathology or nasal obstruction were retrospectively selected and categorized into skeletal Class I (n = 20), Class II (n = 20), and Class III (n = 20) malocclusion based on ANB angle. McNamara's airway analysis was used to quantify upper- and lower-airway dimensions. The analyses of intergroup differences were performed using a one-way ANOVA, an independent t-test, and Tukey's test as a post-hoc test.

Results: Participants in the study ranged in age from 20.57 ± 5.41 years (males) and 20.03 ± 4.58 years (females) were included in the study. The upper pharyngeal airway (UPA) dimensions demonstrated a positive correlation with age. In both genders, the mean upper pharyngeal airway (UPA) size exceeded the lower pharyngeal airway (LPA) size, but neither age nor gender was associated with statistically significant differences in skeletal malocclusion.

Conclusion: It was shown that skeletal malocclusions of different types have no effect on the upper and lower pharyngeal airways and that the upper and lower pharyngeal airways are not influenced by age or gender.

Keywords: Upper pharynx width, Lower pharynx width, Skeletal malocclusion groups, Cephalometry.

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INTRODUCTION:

Previous studies have suggested a potential link between respiratory function and the development of facial structures and occlusion [1]. Research has shown a close association between normal skull growth and the growth of structures involved in respiration, such as nasal cavities, nasopharynx, and the oropharynx [2]. Notably, both nasopharynx and oropharynx play an integral role in both respiration and deglutition [3].

The pharyngeal airway space, a key parameter for upper airway anatomy, is determined by the relative growth of the dentofacial skeleton and surrounding soft tissue [4]. Several craniofacial anomalies, including mandibular or maxillary retrognathism, a shortened mandibular body, and a backward and downward rotation of the mandible, have been linked to a reduction in the pharyngeal airway passage [5]. A narrow pharyngeal airway is a characteristic feature in patients diagnosed with obstructive sleep apnea/hypopnea syndrome (OSAHS) [6, 7].

Several researchers have emphasized the importance of respiratory function in orthodontic diagnosis and treatment planning [8]. Studies have shown that upper airway obstruction can be characterized by specific facial features, including an abnormally high anterior face height, a narrowed upper dental arch, a higher palatal vault, steeper mandibular-maxillary plane angles, and incompetent lip seal [9]. The normal dimensions of the upper pharyngeal airway space have been reported to range from 15–20 mm, while their lower pharyngeal airway space is typically 11–14 mm [10].

Previous investigations have suggested that the premolar extraction and bimaxillary retraction can decrease arch length leading to a posterior tongue position and potential airway obstruction [11]. Similarly, mandibular setback surgery has been linked to a permanent reduction in upper airway size due to a posterior and inferior tongue displacement following surgery [12]. Furthermore, research has indicated that patients with Class II malocclusions and vertical growth patterns may have narrower airways compared to those with normal occlusions and Class I malocclusions. [13] Conversely, maxillary protraction treatment for Class III malocclusion has been shown to potentially increase upper airway dimensions. [14]

The lateral cephalometric method had been the simplest, most affordable, and most informative diagnostic technique, and the 2D images obtained were considered reliable enough. These images had been proposed as an alternative to 3D imaging for evaluating soft tissue morphology and upper airway obstruction [15]. Prior studies have investigated the influence of malocclusions and sex on the pharyngeal width dimensions [16, 17]. However, inconclusive evidence remained regarding the correlation between pharyngeal width in different malocclusions with sex, especially considering variations between ethnicities. Therefore, this study aimed to examine variations in the pharyngeal air space in relation to age and sex among individuals with skeletal malocclusions (Class I, Class II, and Class III) within a South Indian population sample.

MATERIAL AND METHODS:

Study design and setting: In this cross-sectional retrospective study, patients who visited the Department of Orthodontics and Dentofacial Orthopedics, Rajas Dental College and Hospital, Tamil Nadu between February 2023 and December 2023 were examined using pre-treatment lateral cephalograms. The study adhered to the Declaration of Helsinki, Finland. Following departmental protocol, informed written consent was obtained from participants before they enrolled in the study. The Institutional Ethics Committee (RDCH/IRB/EC/04/23) approved the study protocol (RDCH/IRB/EC/04/23).

Participants: A total of 60 subjects, aged 10 to 30 years (30 males and 30 females), who met the inclusion criteria were included in this study. Based on cephalometric analysis, skeletal Class I, II, and III patients of either sex were included, as long as they did not have a prior orthodontic history and did not suffer from pharyngeal pathology, nasal obstruction, or palatal/lip cleft symptoms. The exclusion criteria were any presence of pharyngeal pathology All participants underwent clinical examinations before cephalometric radiographs. Cephalometric radiographs with unclear soft tissue landmarks and magnification other than 100% scale were excluded.

Source of data: A lateral cephalogram was acquired for each subject using established techniques. All subjects stood upright in a cephalostat with the Frankfort horizontal plane paralleled to the floor. Patients were instructed to refrain from swallowing, head movement, or tongue movement. Centric occlusion was maintained, and subjects were asked to make light contact with their lips. A standardized exposure parameter (80 kVp and a total filtration of 2.5 mm aluminium) was utilized for all of the cephalograms, which were captured with a single machine (ORTHOPHOS XG Sirona Dental System, Germany). Following image acquisition, each radiograph underwent calibration and was subsequently printed on hard copy format using a DRYPIX Lite printer (Fujifilm Corporation). A 0.3 mm hard black lead pencil was then employed manually to perform all cephalometric tracings, landmark identifications, and measurements.

Parameters assessed:

McNamara airway analysis was used to measure the upper pharyngeal airway and lower pharyngeal airway [18] as described in the Figure 1, 2, and 3 for Skeletal malocclusion I, II, and III respectively.

1. **Upper pharyngeal airway analysis:** Measured from the point on the soft palate's posterior outline to the closest point on the posterior pharyngeal wall.

2. **Lower pharyngeal airway analysis:** The point at which the posterior tongue border and inferior mandible border intersect with the closest point on the posterior pharyngeal wall.

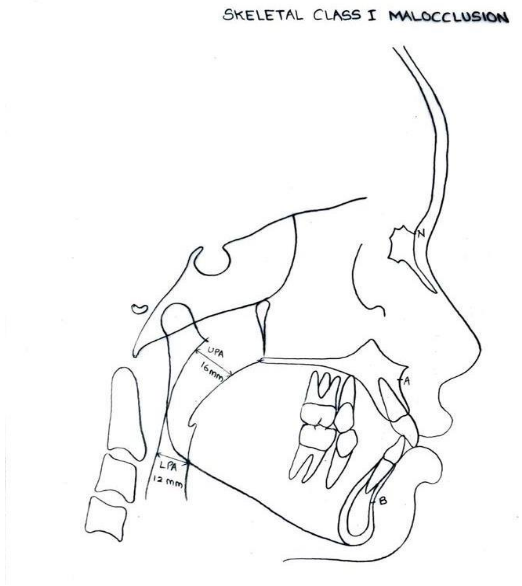

Figure 1: Upper and lower airway analysis using McNamara analysis in Skeletal Class I Malocclusion

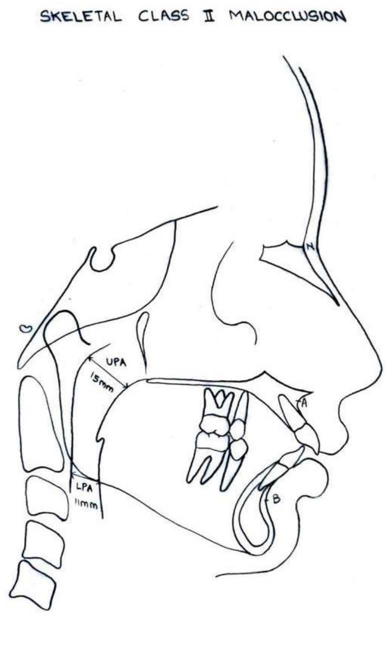

Figure 2: Upper and lower airway analysis using McNamara analysis in Skeletal Class II Malocclusion

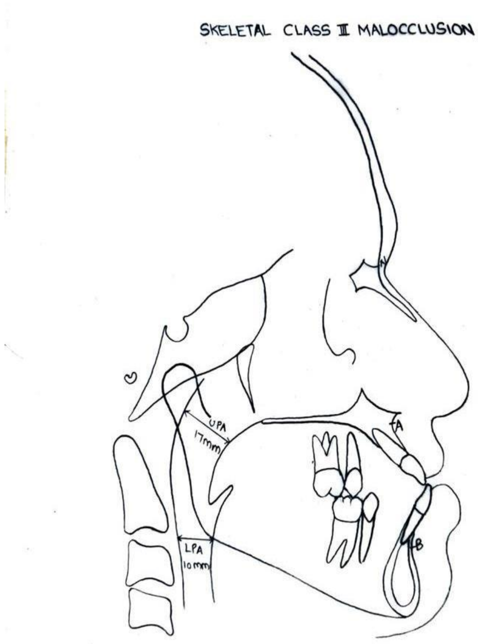

Figure 3: Upper and lower airway analysis using McNamara analysis in Skeletal Class III Malocclusion

Sample size estimation:

A minimum sample size was estimated a priori using G*Power software [10]. Parameters from a previous study [10] were used to inform the power analysis. A significance level of 0.05 and power of 80% were set within a 95% confidence interval. This analysis determined that a minimum sample size of twenty individuals was required for each state of skeletal malocclusion (Class I, II, and III). A total of 60 individuals were subsequently recruited to represent the three different skeletal malocclusion groups.

Statistical analysis:

Data collection for upper and lower pharyngeal airway dimensions in skeletal Class I, Class II and Class III individuals was performed. The data was entered into Microsoft Excel and analyzed using IBM SPSS Statistics for Windows, Version 20 (IBM Corp., Armonk, N.Y., USA). Normality of data was checked using Kolmogorov-Smirnov test. Descriptive statistics were calculated, including mean, standard deviation, 95% confidence interval, frequencies and percentages. To investigate group differences, airway dimensions (mm) were compared between skeletal Class I, Class II, and Class III individuals, as well as between skeletal classes and sex. Multiple pairwise comparisons were conducted using Tukey's Honest significant difference test (HSD) An Independent t-test was used to analyze the intergroup comparison between skeletal classes and age groups. The level of statistical significance was set at $p \leq 0.05$.

RESULTS:

Demographic characteristics		Frequency (n)	Percent (%)
Gender	**Male**	30	50
	Female	30	50
	Total	60	100
Age (Mean ± SD)	**Class I Malocclusion (n = 20)**	20.55 ± 4.49	11 – 29
	Class II Malocclusion (n = 20)	20.40 ± 5.38	12 – 28
	Class III Malocclusion (n = 20)	19.95 ± 4.80	12 - 28
Mean Age (in males and females)	**Male**	20.57 ± 5.41	11 – 29
	Female	20.03 ± 4.58	12 - 28
Age groups	**10-20 years**	30	50
	21-30 years	30	50

Table 1: Demographic details of the included participants

Sixty individuals (30 males and 30 females) aged 10-30 years were included in this analysis of cephalometric measurements. The mean age for males was 20.57 ± 5.41 years, and for females, it was 20.03 ± 4.58 years. Based on the cephalometric analysis, the subjects were classified into three skeletal malocclusion groups (Class I, II, and III) with 20 participants in each group. Age was further categorized into two groups 10-20 years and 21-30 years, with 30 subjects in each group (Table 1).

Dimensions of the upper and lower pharyngeal airway in the various skeletal malocclusion classes are described in the Table 2. It was noted that the mean dimensions of upper pharyngeal airway were higher than lower pharyngeal airway. The overall mean value for the upper pharyngeal airway was 15.32 ± 3.22 mm, while the mean value for lower pharyngeal airway was 10.58 ± 2.33 mm. Intergroup comparison of upper and lower pharyngeal airway with respect to skeletal malocclusion classes revealed no statistically significant differences ($p = 0.082$ for upper pharyngeal airway and $p = 1.747$ for lower pharyngeal airway).

Airway dimensions (mm) in Skeletal malocclusion cases		**n**	**Mean ± SD**	**95% Confidence Interval for Mean**		**p -Value**
				Lower Bound	**Upper Bound**	
Upper Pharyngeal airway	**Class I**	20	16.35 ± 3.43	14.74	17.96	0.082
	Class II	20	15.50 ± 3.25	13.98	17.02	
	Class III	20	14.10 ± 2.69	12.84	15.36	
	Total	60	15.32 ± 3.22	14.48	16.15	
Lower Pharyngeal airway	**Class I**	20	10.90 ± 2.12	9.91	11.89	1.747
	Class II	20	9.80 ± 2.01	8.86	10.74	
	Class III	20	11.05 ± 2.72	9.78	12.32	
	Total	60	10.58 ± 2.33	9.98	11.19	

Table 2: Intergroup comparison of Airway dimensions (mm) between various classes of Skeletal malocclusion. n stands for number of participants. SD stands for Standard Deviation. Statistical test used: One-way ANOVA. p value less than 0.05 was considered statistically significant.

In this study, we investigated the dimensions of the upper and lower pharyngeal airway in both males and females across different skeletal malocclusion classes (Table 3). Females exhibited a trend towards larger upper pharyngeal airway dimensions compared to males in all skeletal classes, although these differences were not statistically significant ($p = 0.276$). Conversely, males displayed a slight tendency towards larger lower pharyngeal airway dimensions, but again, these differences lacked statistical significance within skeletal class II and III ($p = 0.496$). Table 3 presents the mean airway dimension values along with their upper and lower bounds at the 95% confidence interval.

Airway dimensions (mm) in Skeletal malocclusion cases			**n**	**Mean + SD**	**95% Confidence Interval for Mean**		**P-Value**
					Lower Bound	**Upper Bound**	
Upper Pharyngeal airway	**Male**	**Class I**	10	15.90 + 2.92	13.81	17.99	0.276
		Class II	10	14.80 + 2.94	12.67	16.93	
		Class III	10	13.00 + 2.84	11.86	15.94	
	Female	**Class I**	10	16.80 + 3.99	13.94	19.66	
		Class II	10	16.20 + 3.52	13.68	18.72	
		Class III	10	14.30 + 2.66	12.39	16.21	
Lower Pharyngeal airway	**Male**	**Class I**	10	10.90 + 2.13	9.38	12.42	0.496
		Class II	10	10.10 + 1.91	8.73	11.47	
		Class III	10	11.50 + 2.87	9.44	13.56	
	Female	**Class I**	10	10.90 + 2.23	9.30	12.50	
		Class II	10	9.50 + 2.17	7.95	11.05	
		Class III	10	10.60 + 2.63	8.72	12.48	

Table 3: Intergroup comparison of Airway dimensions (mm) between various classes of Skeletal malocclusion according to males and females. n stands for number of participants. SD stands for Standard Deviation. Statistical test used: One-way ANOVA. p value less than 0.05 was considered statistically significant.

Also, dimensions of upper and lower pharyngeal airway were compared with the age group of included participants. Mean values for the upper pharyngeal airway were higher in the 21-30 year age group, but this difference was not statistically significant (p = 0.406). Conversely, mean values for the lower pharyngeal airway were higher in the 10-20 year age group, also without statistical significance (p = 0.412). Details of the mean airway dimensions according to age group are presented in Table 4.

Airway dimensions (mm) in Skeletal malocclusion cases	Age groups	n	Mean ± SD	95% Confidence Interval of the Difference		Independent t-test value	p-Value
				Lower	Upper		
Upper Pharyngeal airway	10-20 years	30	14.97 ± 3.57	-2.373	0.973	-0.838	0.406
	21-30 years	30	15.67 ± 2.85				
Lower Pharyngeal airway	10-20 years	30	10.83 ± 1.94	-0.712	1.712	0.826	0.412
	21-30 years	30	10.33 ± 2.68				

Table 4: Intergroup comparison of Airway dimensions (mm) between various classes of Skeletal malocclusion according to males and females. n stands for number of participants. SD stands for Standard Deviation. Statistical test used: Independent t-test. p value less than 0.05 was considered statistically significant.

DISCUSSION

In previous research, a complex interaction between the pharyngeal airways and skeletal class malocclusions (Classes I, II, and III) has been identified. This interaction involves bone positioning, soft tissue interactions, and airway function. Several studies conducted in recent years suggested an association between variations in skeletal patterns and upper airway obstructions. The current study aimed to investigate the relationship between pharyngeal air space and age and sex in individuals with previously diagnosed skeletal malocclusions.

Cephalometric radiographs have been established as a method to assess the airway dimensions and correlate them with vertical skeletal patterns and facial morphology [19, 20]. Zhang et al compared cephalometric radiographs with digital photography data and found no significant differences between the two methods [21]. To measure the upper and lower pharyngeal airways, a McNamara airway analysis was performed on cephalometric radiography [22].

Several studies have investigated the relationship between malocclusion type and pharyngeal airway width. While some reported minimal association [23-24], others described significant differences based on skeletal classifications. For instance, Hakan El et al [25] found that subjects with Class I and Class III, using Angle classification, exhibited larger airway volumes compared to those with Class II. Chan et al [26] reported a narrower nasopharyngeal airway in skeletons with Class II compared to other skeletal patterns.

No statistically significant differences in mean pharyngeal width were observed among the three skeletal malocclusion groups (Class I, II, and III) for either the upper ($p = 0.082$) or lower ($p = 1.747$) airway space. These findings align with previous studies by Acharya et al [27] and Navreet et al [28], who reported no significant differences in upper and lower airway dimensions across various skeletal malocclusions.

Shalu et al [29] reported a statistically significant ($p < 0.05$) wider lower pharyngeal airway in males compared to females within Class III skeletal malocclusion. This was followed by Class I and Class II, which had the narrowest width. Similarly, Gaurav Acharya et al [27] observed a high mean lower pharyngeal width in males compared to females. In contrast, the present study did not find a significant difference ($p > 0.05$) in cephalometric variables of both the upper and lower pharyngeal airway were not found to differ significantly between males and females within each skeletal malocclusions.

Previous research suggests a period of quiescence in pharyngeal structures between 14 and 18 years of age [30]. Fernando C et al [31] reported a statistically significant correlation between increased upper pharyngeal airway dimensions and ages 13-23. This present study observed that the upper airway dimension increased from 14.97 + 3.57 in the 10-20-year age range to 15.67 + 2.85 in the 21-30-year age range. However, the present study did not observe any statistically significant changes in the upper or lower pharyngeal airways (0.4060 and 0.412, respectively), regardless of the malocclusion or age group.

Due to being conducted at a single tertiary center with relatively smaller sample size, the present study findings might not be generalizable to the broader population. Lateral cephalograms, employed in this study, are two-dimensional representations and lack the capability for volumetric measurements. Cone-beam computed tomography (CBCT) could have provided a more comprehensive three-dimensional evaluation of the airways. Furthermore, this study solely focused on anatomical assessment. Evaluating airflow function alongside skeletal malocclusions would provide further insight into airway status.

CONCLUSION:

The present study did not identify significant differences in upper and lower pharyngeal airway dimensions across Class I, II, and III skeletal malocclusion types. No statistically significant associations were observed between airway morphometrics and age or sex within the malocclusion groups. While upper pharyngeal dimensions exhibited a trend of increasing with age to a greater extent compared to lower pharyngeal dimensions, this difference did not reach statistical significance.

SOURCE OF FUNDING

Nil

CONFLICT OF INTEREST

The authors have no conflict of interest to declare.

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