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Investigating the Correlations among Witt's and ANB Cephalometric Indices and the Upper Pharyngeal Airway Width in Individuals with Class III Malocclusion: A Cross-Sectional Study

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ABSTRACT

Background and aim: Craniofacial and airway structures are visible in lateral cephalometric radiography. Witt's appraisal and ANB angle are cephalometric analysis indicators, which play essential roles in diagnosing class III malocclusion. In the current study, the correlations among Witt's and ANB cephalometric indices and the upper pharyngeal airway width has been investigated in individuals with class III malocclusion.

Materials and methods: This cross-sectional study was performed on 110 lateral cephalometric radiographs of 11-14-year-old patients during 2017-2020. The upper pharyngeal airway width was determined by p index (the shortest distance between the soft palate and the posterior pharyngeal wall) and the t index (the shortest distance between the tongue base and the posterior pharyngeal wall) through lateral cephalometric radiography. The data were designated by central tendency indicators and measures of dispersion. The Shapiro-Wilk test evaluated data normality. Also, the Spearman correlation coefficient was used to determine the correlation rate.

Results: Investigating the correlations among indicators showed a direct but dramatically low relationship in ANB and p values and Witt's and p values. However, these relationships were not statistically significant. There was also an inverse linear relationship between ANB and t values and Witt's and t values. Nevertheless, the results showed the mean values of p, t, ANB, and Witt's indices were higher in females than males, yet, the differences in p and ANB values were not statistically significant.

Conclusion: Results showed the correlation coefficients among the upper pharyngeal airway width, and ANB and Witt's analyses were not significant. These results can reinforce the probability of class III malocclusion inheritance.

1. Introduction

Since the early 20th century, the relationship between craniofacial morphology and pharyngeal airways has been studied. Class III malocclusion (prognathism, negative overjet, and underbite) is a type of craniofacial morphology in which the anterior mandibular teeth are usually more prominent than the anterior maxillary teeth. Moreover, patients have larger mandibular bones and shorter maxillary bones.[1] The pharyngeal airways are made up of twenty or more muscles connected to the skeletal structures. The craniofacial skeleton evolution influences the size and shape of the airways.[2, 3] Respiratory problems can lead to increased mortality in conditions such as respiratory congestive apnea.[4] Numerous studies have shown that the upper pharyngeal airway's size is affected by the skeleton's sagittal pattern.[5-7] Also, the nasal cavity's growth and function, nasopharynx, and oropharynx are near related to skull growth.[8, 9] Also, many researchers have reported that the dimensions of the throat and pattern of sagittal and vertical facial growth can interfere with each other.[10, 11] Cephalometric information is beneficial for depicting the human head as a geometric design or map to evaluate the craniofacial structures and the upper pharyngeal airway. Both of these characteristics are visible in lateral cephalometric radiography.[12] A detailed assessment of the anterior-posterior jaw relationship is essential for diagnosis and orthodontic treatment planning. For this reason, cephalometric measurements are used in the sagittal and vertical dimensions of the

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craniofacial.[13] Most of the patients who receive orthodontic treatments are in the 10-14-year-old age groups, so the priority is to get these groups' norms.[14] The present study was conducted on lateral cephalometric radiographs of 11-14-year-old individuals. Respiratory functions and upper airway morphologies are related to diagnosis and orthodontic treatment planning. So, in the present study, the correlations among Witt's and ANB cephalometric indices and the upper pharyngeal airway width has been investigated in 11-14-year-old individuals with class III malocclusion from 2017-2020.

2. Materials and methods

The present cross-sectional study aimed to determine the correlations among Witt's and ANB cephalometric indices and the upper pharyngeal airway width in patients with class III malocclusion. The number of samples was 110. This size was taken from the results of a pilot study with a sample size of 10 patients, wherein lateral cephalometric radiographs of 10 patients were obtained at a confidence level of 0.95 and test power of 0.80 by using the sample size formula for measuring the correlation coefficients. A pilot study was used due to the lack of similar analyses. According to the Wu J study, most patients are in the 10-14-year-old age groups; thus, the priority is to get these groups' norms.[14] So, 110 lateral cephalometric radiographs of 11-14-year-old individuals were randomly selected from the archives at the Dental clinic of Golestan University of Medical Sciences. A radiologist and an orthodontist confirmed the patient's lateral cephalometric radiographs. The principles of the Helsinki Declaration conducted this study. All of the patients whose lateral cephalometric radiographs were used in this study had given future scientific research consent. The size of the upper pharyngeal airway was measured by the p index (the shortest distance between the soft palate and the posterior pharyngeal wall) and the t index (the shortest distance between the base of the tongue and the posterior pharyngeal wall) through lateral cephalometric radiographs. To achieve this, the narrowest areas (behind the palate and tongue) were selected. ANB is the difference between SNA (Sella turcica-Nasion-A point) and SNB (Sella turcica-Nasion-B point) angles, representing the skeletal relationship between jaws. For Witt's appraisal, the distance between perpendiculars from points A (the deepest point on the curved profile of the maxillary process) and B (the deepest point on the curvature of the mandible between the alveolar crest and the bony chin) on the occlusal plane was measured in millimeters which indicates anterior-posterior disharmony of jaws [Figure 1].

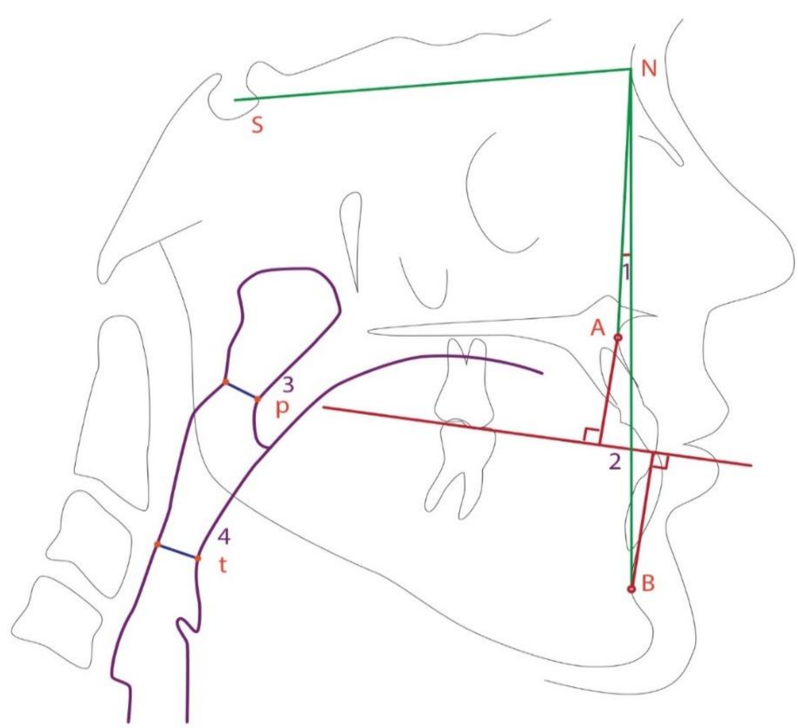

Figure 1. Measurements on lateral cephalograms: 1) ANB angle, 2) Witt's appraisal, 3 and 4) upper pharyngeal airway width.

The measurements were performed manually by a dental student using acetate tracing sheets and were confirmed by an orthodontist. The inclusion criteria included Iranian patients with class III malocclusion and symmetrical faces, no history of orthodontic and surgical treatments in the craniofacial and jaw area, no posterior crossbit, readable, and clear lateral cephalometric radiographs. Another inclusion criteria were subjects with ANB values less than or equal to 2 as well as Witt's values less than or equal to-1.

The collected data were entered into SPSS software (IBM SPSS version 20, Armonk, New York, USA) and designated by leading indicators such as mean and median and dispersion measures such as standard deviation and standard error. The Shapiro-Wilk test investigated data normality. The Pearson linear correlation coefficient, and then the Spearman correlation coefficient was used in the case of standard variables to determine the correlation rate. Also, the confidence interval of 0.95 was reported for correlation coefficients.

3. Results

Sixty-four females with an average age of 13.7 ± 1.04 years and 46 males with an average age of 13.8 ± 1.05 years were examined. There were 54 subjects in the 14-year-old age group, 21 in the 13-year-old age group, 25 in the 12-year-old age group, and 10 in the 11-year-old age group. The results revealed that the mean values of all p, t, ANB, and Witt's indices in females were higher than males; however, p and ANB values were lower and not statistically significant [Table 1].

Table 1. Averages of p, t, ANB, and Witt's indices in females and males.

	Number	p Average	t Average	ANB Average	Witt's Average
Female	64	9.73 mm	13.03 mm	-0.53 degree	-8.23 mm
Male	46	9.13 mm	11.30 mm	0.00 degree	-6.93 mm
P-value*		0.19	0.049	0.3	0.01

An evaluation of the relationships among the indices showed a mild linear relationship between ANB and p values, and Witt's and p values. In other words, higher p values were associated with higher values of ANB and Witt's, yet, these relationships were not statistically significant [Table 1]. It was also observed that there was an inverse linear relationship between ANB and t values, which indicated higher t values were associated with lower ANB values. This relationship was significant in males in contrary to females [Table 2].

Table 2. Relationships between the values of Witt's, ANB, p, and t indices by gender.

			p	t
ANB	Female	**Correlation coefficient	0.07	-0.03
		P-value	0.55	0.76
	Male	Correlation coefficient	0.06	-0.42
		P-value	0.69	0.00*
	Total	Correlation coefficient	0.78	-0.17
		P-value	0.41	0.07
Witt's	Female	Correlation coefficient	0.22	0.17
		P-value	0.69	0.16
	Male	Correlation coefficient	0.10	-0.30
		P-value	0.47	0.04*
	Total	Correlation coefficient	0.17	-0.05
		P-value	0.06	0.55

*Significant (P<0.05), **Spearman correlation coefficient.

Correlation strength:(negligible) 0-0.3, (low) 0.3-0.5, (moderate) 0.5-0.7, (high) 0.7-0.9, (very high)1-0.

Additionally, there was a mild and inverse linear relationship between t and Witt's values. This indicated that higher t values were associated with lower Witt's values. This relationship was inverse and significant in males. In females, there was a direct relationship that was not statistically significant [Table 2]. The correlations among Witt's appraisal and p and t indices were investigated in 11-14-year-old individuals, and no statistically significant relationships were found in all ages [Table 3]. In the 11-year-old age group, the ANB angle with the p index and the ANB angle with the t index had statistically significant and inverse relationships. In contrast, in other groups, the relationships were not statistically significant [Table 3].

Table 3. Relationships between the values of Witt's, ANB, p, and t indices by different age groups.

			p	t
Witt's	11-years-old	**Correlation coefficient	0.25	-0.51
		P-value	0.48	0.12
	12-years-old	Correlation coefficient	0.10	-0.11
		P-value	0.60	0.59
	13-years-old	Correlation coefficient	0.33	-0.12
		P-value	0.13	0.59
	14-years-old	Correlation coefficient	0.15	0.08
		P-value	0.27	0.54

ANB	11-years-old	Correlation coefficient *P*-value	-0.70 0.02*	-0.66 0.03*
	12-years-old	Correlation coefficient *P*-value	-0.01 0.95	-0. 31 0.12
	13-years-old	Correlation coefficient *P*-value	0.27 0.22	-0.32 0.14
	14-years-old	Correlation coefficient *P*-value	0.11 0.41	0.02 0.87

*Significant (P<0.05) **Spearman correlation coefficient.

Correlation strength:(negligible) 0-0.3, (low) 0.3-0.5, (moderate) 0.5-0.7, (high) 0.7-0.9, (very high) 1-0.

4. Discussion

Abnormal upper airway development is associated with airway stenosis; therefore, the relationship between decreased respiratory function and craniofacial growth has been considered by orthodontists.[15] Since the ANB angle is affected by the position of the nasion point (the vertical relationship of the jaws and vertical distance between points A and B), this angle is not a very reliable indicator for examining the anterior-posterior relationship of the jaws[7], so we measured Witt's appraisal for cases where ANB values do not exactly show the anterior-posterior jaw disorders. Based on Aboudara et al., two-dimensional lateral cephalometric radiographs were used to examine the dimensions of the upper pharyngeal airway.[16] Celikoglu et al. reported that cases with class II malocclusion had a narrower nasopharyngeal airway compared to the patients with class I occlusion.[17] Also, in several studies, results revealed patients with the vertical growth pattern of the face (hyperdivergent), irrespective of occlusion type, had narrower airway dimensions than normodivergent and hypodivergent individuals.[18, 19]

Due to the close relationship between the craniofacial morphology and upper airway dimensions in patients with malocclusion, Zheng et al. placed great emphasis on the effects of mandibular anterior-posterior position and vertical growth pattern of the face on the upper airway volume. In their study, cases with class I occlusion and class III malocclusion had statistically significant higher upper airway volume than Class II individuals.[8] However, some studies have proposed that the posterior position of the mandible and the increase in upper or lower face height might be the primary reasons for airway narrowing in patients with class III malocclusion. Interestingly, like the present study, these studies did not find a significant relationship between airway width and class III malocclusion or class II malocclusion.[10, 20]

Grauer et al. reported no difference in upper airway volume between patients with class III malocclusion and class I occlusion.[21] However, several studies have shown upper pharyngeal airway volume was greater in patients with class III malocclusion than in patients with class I occlusion.[22] Min G et al. showed the relationships between the craniofacial structures and upper airway dimensions were generally poor.[12] In the current study, there were no relationships between craniofacial indicators and upper airway dimensions. However, in terms of airway width, the results were different from the Alves et al. study results. They showed the volume and size of the airway were higher in males. However, similar to the current study, they did not find a significant relationship between airway width and malocclusion type.[6] Dimensions of the airways are also related to the patient's age. It has been observed that the growth of airways stops between the ages of 18 and 20.[9, 23] Gonçalves et al. reported that the upper pharyngeal airway's growth pattern at the age of 6-9 years old revealed a plateau, and it was approximately constant.[24] Schendel et al. reported similar results, wherein the growth of the airways continues until the age of 20. After the age of 40, the dimensions of the airways decrease to a minimal extent.[25]

Some studies reported that the throat size overgrows by the age of 13. Then, there is a reduction in throat size growth[26], while Mislik et al. observed no rapid changes in the retroglossal and retropalatal regions from the age of 6-17 years. In their opinion, dimensions of the upper pharyngeal airway were formed, and they became mature in the early period of growth.[27] The current study indicated that the p index did not significantly differ between the two genders. In contrast, the t index was higher in females than in males, which was statistically significant. Based on results reported by Min Gu et al., there were significant differences in upper airway dimensions between both genders in the Caucasian race. Likewise, in the Chinese race, males had a thicker soft palate and a lower retropalatal and retroglossal depth.[12] Accordingly, the current study proposes that the upper pharyngeal airway width is not significantly correlated with class III malocclusion and its indicators. Thus, it cannot be a good criterion for the diagnostic or therapeutic purposes of class III malocclusion. Limitations of the present study are the lack of vertical facial growth pattern records and two-dimensional lateral cephalometric radiographs for anatomical evaluation of the airway, which is a three-dimensional geometry. For future studies, it is recommended that CBCT (Cone Beam Computed Tomography) radiography can be used to evaluate the upper pharyngeal airway width by implementing three-dimensional geometry. Likewise, for further studies that examine the relationship between airflow and airway width, it is recommended to use the Finite Element Method (FEM) for both analytical and statistical methods.

5. Conclusion

The mean values of upper pharyngeal airway width, ANB angle, and Witt's index were higher in females than males. Correlation coefficients among the upper pharyngeal airway width and ANB and Witt's analyses were not significant in patients with class III malocclusion. These results can reinforce the effect of heredity in class III malocclusion patients.

Conflict of Interest

The authors declared that there is no conflict of interest.

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